



## Scholars' Mine

---

[Professional Degree Theses](#)

[Student Theses and Dissertations](#)

---

1905

### The manufacture of coal gas in St. Louis

Albert Dyke Wilson

Follow this and additional works at: [https://scholarsmine.mst.edu/professional\\_theses](https://scholarsmine.mst.edu/professional_theses)

 Part of the [Metallurgy Commons](#)

Department:

---

#### Recommended Citation

Wilson, Albert Dyke, "The manufacture of coal gas in St. Louis" (1905). *Professional Degree Theses*. 30. [https://scholarsmine.mst.edu/professional\\_theses/30](https://scholarsmine.mst.edu/professional_theses/30)

This Thesis - Open Access is brought to you for free and open access by Scholars' Mine. It has been accepted for inclusion in Professional Degree Theses by an authorized administrator of Scholars' Mine. This work is protected by U. S. Copyright Law. Unauthorized use including reproduction for redistribution requires the permission of the copyright holder. For more information, please contact [scholarsmine@mst.edu](mailto:scholarsmine@mst.edu).

T H E S I S

THE MANUFACTURE OF COAL GAS IN ST. LOUIS.

B Y

A. D. WILSON.

1905

THE LAOLEDE GAS LIGHT COMPANY.

MEMORANDUM.

The Manufacture of Coal Gas in St. Louis

Coal Gas is made by heating Bituminous Coal in closed fire-clay retorts, for four or five hours, at a bright red heat. An exhauster pulls the gas from the retort as fast as it is generated in order to prevent, as much as possible, the breaking up of the hydrocarbons into carbon and hydrogen by the hot walls of the retort.

A good gas coal will have, among others, the following properties;-

- (1) Yield 4 1/2 to 5 cubic feet of gas, per pound of coal, having a lighting power of 16 to 18 candles and a net heating value of 600 or more British Thermal Units.
- (2) Yield 55 to 65 per cent of good coke.
- (3) Contain little Sulfur, Ash and Moisture.
- (4) Yield 12 to 15 gallons of a Tar that will not stop up the mains. (Per ton)
- (5) Yield 5 to 6 pounds of anhydrous Ammonia per ton of coal.

The best gas coal and that which is used as a standard of comparison for all other gas coals comes from Pennsylvania and W. Virginia and is known as Pittsburg or Youghiogheny bituminous coal. This coal is used, almost exclusively, in St. Louis. Over 100000 tons were brought down the Ohio and up the Mississippi and unloaded at the two manufacturing stations during the summer of 1905. The following analysis is the average of tests from 150 barges or 75000 tons of this coal.

Pittsburg Gas Coal

|                                      |         |
|--------------------------------------|---------|
| Moisture - - - - -                   | .93%    |
| Volatile Combustible Matter- - - - - | 34.01%  |
| Fixed Carbon- - - - -                | 59.69%  |
| Ash - - - - -                        | 5.87%   |
| Heat units per Pound - - - - -       | 13566.0 |
| Sulfur - - - - -                     | 1.22%   |

THE LACLEDE GAS LIGHT COMPANY.

MEMORANDUM.

One ton of this coal will yield, according to the temperature at which it is distilled, and the amount charged, 9700 to 10300 cubic feet of gas- 14 to 16 gallons of tar- 5 1/2 to 6 pounds of ammonia- and about 60% of coke.

Sketch #1 shows an outline of one of the coal gas houses, a description of which is given in the following pages.

The retorts, into which the coal is shoveled in lots of 450 to 525 pounds according to the temperature and time of heating, are about 10 feet long-15 inches high-31 inches wide and of the form shown in sketch #2. As the open end has to support a heavy cast iron mouth piece and stand pipe, it is made extra heavy.

Four retorts are grouped together in what is called a "bench" Each bench is heated by a direct fired furnace, the bench being built in such a manner that the flames and hot gases have to pass all around the retorts before they can enter the flue. The benches also have several openings for secondary air and large pans under the grate bars which are kept full of water in order to prevent the formation of clinkers. A bench is never allowed to cool until it is worn out or there is a lack of coal. A good bench will last 3 or 4 years.

A "stack" consists of several benches built together-side to side and back to back. Each of the stacks shown in sketch #1 consists of 16 benches, 8 on a side, or 64 retorts.

Rising from the mouth-piece of each retort is a 6 inch stand-pipe which is connected with the dip-pipe by the bridge-pipe. (See sketch #3) Running along the top of each side of the stack is the "Hydraulic Main". This is a pipe about 20 inches in diameter which is kept perfectly level and partly filled with water and tar. It is pierced by each of the dip-pipes to the same distance so that each is sealed by the same depth of water. The seal is set so that the gas in the retorts is at atmospheric pressure or a little less and is kept constant by an over-flow.

THE LACLEDE GAS LIGHT COMPANY.

MEMORANDUM.

The dip-pipe has two parts to play: (1) when the retort is open it prevents the escape of gas from the hydraulic main, (2) when the retort is closed it helps to purify the gas by causing it to bubble through the tar and water in the hydraulic main. A small stream of fresh water is kept running into the main to replace that carried off by the over-flow and the hot gas and in some cases the hot liquor from the over-flow is bumped back through the main to wash out the tar. All the hydraulic mains lead to the foul main.

As stated before, 450 to 525 pounds of coal are charged into each retort. The higher the temperature and the longer the time of heating (burning), the larger the amount of coal charged. The reason for this is that a small charge heated for a long time in an extra hot retort will yield a large volume of a poor gas while a large charge in a cooler retort for a shorter time will yield a smaller volume of a richer gas. The present practice is to charge about 500 pounds into each retort five times in every 24 hours.

Only two retorts in one bench are opened at a time and these on diametrically opposite sides so as not to cool the bench unequally. A certain order is observed in charging so that the work is distributed evenly over the 24 hours and the composition of the gas remains practically constant. Two 12 hour shifts attend to the drawing, charging and firing.

In order to determine the quality of the gas given off during different hours of the carbonizing period, we made a number of tests on the gas from an upper and a lower retort. Two retorts were tested because the upper retorts are usually hotter than the lower ones. The samples were taken by water displacement in tanks holding about 5 cubic feet. The temperature tests were made with a Le Chatelier pyrometer at a point 3 feet back from the mouth and 6 inches above the bottom of the retort. The walls of the retorts were much hotter than the coal at this point.

THE LACLEDE GAS LIGHT COMPANY.

MEMORANDUM.

A chilling effusion apparatus was used in making the density tests; the S. J. U.'s were determined with a Junker calorimeter, and the analyses were made with Hempel's apparatus. The following figures are the averages from a number of tests.

Tests on Pittsburg Coal Gas--Samples Taken Every 30 Minutes

|                                    | <u>1st</u>  |             | <u>2nd</u>  |             | <u>3d</u>   |             | <u>4th</u>  |             |
|------------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Temp. Fahr.                        | 625°        |             | 1210°       |             | 1460°       |             | 1645°       |             |
| Candle Power                       | 22.11       |             | 17.11       |             | 8.60        |             | 1.85        |             |
| S. J. U.                           | 301         |             | 652         |             | 523         |             | 353         |             |
| Density                            | .549        |             | .445        |             | .835        |             | .210        |             |
|                                    | <u>Vol.</u> | <u>Wgt.</u> | <u>Vol.</u> | <u>Wgt.</u> | <u>Vol.</u> | <u>Wgt.</u> | <u>Vol.</u> | <u>Wgt.</u> |
| CO <sub>2</sub> & H <sub>2</sub> O | 2.9         | 3.06        | 2.2         | 7.56        | 1.8         | 5.16        | .6          | 4.87        |
| Alumin.                            | 10.1        | 20.67       | 5.4         | 11.69       | 1.7         | 15.80       | .3          | 5.95        |
| Oxygen                             | .2          | .41         | .2          | .50         | .2          | .57         | .2          | 1.05        |
| CO                                 | 3.8         | 15.43       | 3.1         | 17.60       | 7.1         | 17.84       | 4.0         | 13.43       |
| Methane                            | 46.1        | 46.60       | 40.1        | 50.10       | 30.0        | 43.82       | 11.0        | 29.12       |
| Hydrogen                           | 29.0        | 3.66        | 41.2        | 6.44        | 56.7        | 10.24       | 30.3        | 26.74       |
| Nitrogen                           | 2.9         | 5.12        | 2.8         | 6.11        | 3.0         | 7.57        | 2.1         | 14.84       |

About 50% of the gas comes off during the first hour and the rate then decreases rapidly until at the end of 4 to 5 hours there is hardly any gas given off. The retort is then opened, the coke raked out and a new charge of coal introduced.

For comparison with the above analyses I give below an average analysis of the purified gas as it leaves the works.

THE LAOLEDE GAS LIGHT COMPANY.

MEMORANDUM.

Finished Pittsburg Coal Gas

|                           |       |       |
|---------------------------|-------|-------|
| Candle Power - - - - -    | 17.41 |       |
| B.S.U. - - - - -          | 617   |       |
| Density- - - - -          | .436  |       |
| Carbon Dioxide - - - - -  | 1.5   | Wgt.  |
| Aluminants - - - - -      | 4.7   | 19.97 |
| Oxygen - - - - -          | .2    | .51   |
| Carbon Monoxide - - - - - | 7.0   | 17.41 |
| Methane- - - - -          | 33.7  | 43.02 |
| Hydrogen - - - - -        | 50.8  | 3.02  |
| Nitrogen - - - - -        | 2.6   | 5.81  |

The foul gas passes from the hydraulic main, where it loses some of its ammonia, hydrogen sulfide, carbon dioxide, tar and naphthalene, through the foul main to the exhauster. The exhauster serves the double purpose of drawing the gas from the retorts as fast as it is generated and forcing it through the purifying apparatus. At present the inlet side is kept at atmospheric pressure while the outlet will show from 12 inches (water pressure) up according to the resistance thrown by the purifying apparatus. The exhauster reduces the amount of carbon that would otherwise deposit on the sides of the retorts but does not entirely prevent it, so a thick coating is formed in time which reduces the efficiency of the retort. This is loosened every 3 or 4 months by partial burning with an air blast and then cut loose with a long chisel bar and, when several tons have been collected, sold to manufacturers of batteries. A cross section of an exhauster is shown in sketch #4. They are driven by direct connected steam engines and the speed is regulated by a governor on the exhauster which is attached to a throttle on the engine.

THE LACLEDE GAS LIGHT COMPANY.

MEMORANDUM.

The condensers are vertical iron cylinders about six feet in diameter and 15 to 20 feet high. There are water compartments at the top and bottom which are connected by vertical iron tubes through the cooling water rises and then over-flows from the top compartment. The gas enters at the top, passes down around the cooling tubes and out at the bottom.



THE LAOLEDE GAS LIGHT COMPANY.

MEMORANDUM.

From the exhauster the gas passes to the first condenser (see sketch #5) where it is partially cooled. Here the gas loses a large percent of its tar and some of the other impurities. This precipitation is caused not only by the cooling but also the compressing of the gas. The flow of water through the different condensers, which is opposite in direction to the flow of the gas, is regulated so that the gas is slowly cooled as it passes through the system. If the gas were cooled suddenly, the tar would carry down some of the valuable constituents of the gas such as benzene so the temperature is kept as high as will allow complete condensation of the tar. A small pipe in the bottom of the condenser carries the tar and ammonia liquor to the seal pot and from there it flows to the separator and wells while the gas passes on to the P and Q tar extractor where a large part of the remaining tar is taken out.

The P & Q tar extractor consists essentially of a number of concentric cylinders or prisms made of sheet metal and pierced by a large number of small offsetting slots. The gas, which contains the tar in the form of minute particles, passes through these openings at a high velocity and the impact of the tar particles against the metal opposite each slot causes them to stick and run together. The gas passes from the inside out and the cylinders are balanced like the bell of a governor so that the area exposed varies directly with the rate of flow so that the gas receives the same treatment all the time. The extractor is shown in sketch #6.

Following the extractor is a second condenser similar to the first, where the gas is further cooled and from here it passes to the wash-box. The tar and ammonia are drained from #2 condenser as from #1 but the P & Q is fitted with an over flow as the tar acts as a seal pot the lower end of the shell. The pipes connecting the condensers are also drained and all the drains run to the seal pot. The seal pot is a small cement lined cistern which is full of tar and ammonia and has an over-flow which carries the tar and ammonia liquor to the separator. The drain pipes dip into this cistern and thus prevent the escape of gas.

WHEN USING THIS MEMORANDUM, ONE OR MORE CARBON COPIES MUST BE MADE, SUFFICIENT TO GIVE A COPY TO EACH HEAD OF DEPARTMENT IN ANY WAY INTERESTED, INCLUDING THE WRITER.

THE LACLEDE GAS LIGHT COMPANY.

MEMORANDUM.

The wash-box (see sketch #7) is a large rectangular iron box which is partially filled with ammonia liquor from #1 scrubber. The depth of the liquor is kept by an overflow leading to the seat-pot. Running across the bottom of the box and a little above the bottom are a number of four inch pipes containing a number of various sized holes along the bottoms and sides, those on the bottom being the largest in size. The gas from #2 condenser enters these pipes at one end and escapes by bubbling up through the liquor in the box which takes out some more of the tar, ammonia, and sulfur and carbon dioxide. Most of the ammonia liquor comes from the wash-box and it is this liquor that is the main source of aqua and anhydrous ammonia.

From the wash-box the gas passes to the scrubbers (see sketch #8) which are three in number and of the style known as "Dower" scrubbers. These are cylindrical iron shells containing a number of wooden trays which are filled in between with excelsior. They are arranged in series and the gas passes in at the bottom of each and out at the top. Fresh water is sprayed in the top of #3, the amount being regulated so that the liquor leaving the wash-box is of 6 or 7 ounce strength. (This means that 6 or 7 ounces by weight of pure sulfuric acid would be necessary to neutralize the ammonia from one gallon of the liquor.) The gas leaving the scrubbers is tested often with turmeric paper for ammonia and if any shows the water is increased. The liquor from the bottom of scrubber #3 is pumped into the top of #2 and from #2 it is pumped to the top of #1 from the bottom of which it runs to the wash-box. The scrubbers remove the last traces of tar and ammonia and also some of the sulfur compounds and carbon dioxide.

In the other plants a different form of scrubber is used called the "standard Washer scrubber" (see sketch #9). These are built up of sections the partitions between which, have large circular openings in the centre. Running through the centre of these openings is a heavy steel shaft all around which are fastened long bristle brushes or bunches of thin sheet iron that revolve in the compartments.

WHEN USING THIS MEMORANDUM, ONE OR MORE CARBON COPIES MUST BE MADE, SUFFICIENT TO GIVE A COPY TO EACH HEAD OF DEPARTMENT IN ANY WAY INTERESTED, INCLUDING THE WRITER.

THE LACLEDE GAS LIGHT COMPANY.

MEMORANDUM.

Where brushes are used, there are projections around the sides of the scrubber that cause the brushes to throw off the tar that deposits on them. The bundles of iron have to be taken out once in a while and the tar cleaned off with a steam jet. The object of both the brushes and bundles is to offer a large absorption surface for the ammonia. Fresh water is run into the outlet end of the scrubber and this overflows from one compartment to the next and finally flows from the scrubber to the wash-box. The shaft is slowly revolved so as to keep the brushes wet with weak liquor and the gas is forced into intimate contact by the partitions.

The gas leaving the scrubbers is free from tar and ammonia but still contains about 60% of the hydrogen sulfide originally present in the gas. This amounts to .6% to .8% by volume or 300 to 400 grains per 100 cubic feet. This is removed by the purifiers through which the gas passes after leaving the scrubbers.

"Purification" has been restricted in meaning until it now includes only the removal of sulfur compounds and in St. Louis it is still further restricted to the extraction of hydrogen sulfide only, for the amounts of other sulfur compounds present are usually within the figures allowed by ordinance.

The purifiers are built in sets of two boxes each and each box contains about 10,000 cubic feet of oxide arranged in two equal layers. They are circular in shape and are fitted with valves, bypasses, and center-seals in such a way that the gas can be sent through either box first and in any direction (see sketch #10).

The oxide mentioned above is made by mixing shavings (planer chips) with cast iron borings (3 or 10 pounds to 1 cu. ft. of chips) and then rusting the iron with salt and water. The oxidation is so rapid at first that the mixture has to be turned over often and kept thoroughly wet or it will take fire. About 75% of the iron is oxidized during the first 10 days after which the oxidation is very slow. All the authorities state that the formula of this oxide is  $3Fe_2O_3 \times 4H_2O$  but analyses which we have made recently, show it to be a mixture of Ferric and Magnetic oxides.

WHEN USING THIS MEMORANDUM, ONE OR MORE CARBON COPIES MUST BE MADE, SUFFICIENT TO GIVE A COPY TO EACH HEAD OF DEPARTMENT IN ANY WAY INTERESTED, INCLUDING THE WRITER.

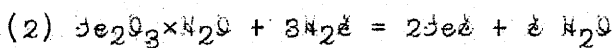
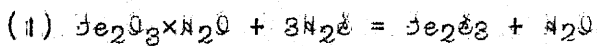
THE LACLEDE GAS LIGHT COMPANY.

MEMORANDUM.

The gas in passing through the oxide, loses all its hydrogen sulfide, a large part of the cyanogen, and a little of the other sulfur compounds such as carbon disulfide, thiophene and mercaptan. The hydrogen sulfide and cyanide are removed by chemical action while the <sup>other</sup> sulfur compounds are most probably removed by absorption in the free sulfur for if a box remains cool for some time and then becomes warmer, the oxide gives up large amounts of these compounds to the gas that is passing through.

In works where the gas contains large amounts of these compounds, they are removed by passing the gas through sulfided lime after it has passed through the oxide. The sulfided lime is made by passing foul gas through slaked lime which is thus changed into Calcium sulfide and then into the hydrosulfide. Lime could be used for extracting all the sulfur from the gas but oxide is used where-ever possible because it is cheaper, easier handled, and in some places a valuable by-product when no longer useful as purifying material.

There are several different opinions as to the reactions that take place between iron oxide and hydrogen sulfide but as far as I can learn, no one has proven any of them by experiment so I am starting an investigation along this line. The following equations are taken from different authorities.



(3) .8 according to #1 and .2 according to #2-

I have not attempted to balance the above equations because the disposition of the water is not known. The few experiments which we have made so far, lead me to believe that, if there is no oxygen present in the gas, hydrated sulfides similar to the oxides will be formed and no free sulfur. The sulfide which is formed from the magnetic oxide is also magnetic.

As soon as the oxide loses its efficiency it is removed from the box and spread out on the ground in a layer about two feet deep. Revivification then starts

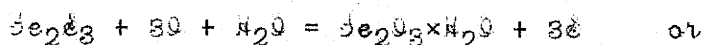
WHEN USING THIS MEMORANDUM, ONE OR MORE CARBON COPIES MUST BE MADE, SUFFICIENT TO GIVE A COPY TO EACH HEAD OF DEPARTMENT IN ANY WAY INTERESTED, INCLUDING THE WRITER.

THE LACLEDE GAS LIGHT COMPANY.

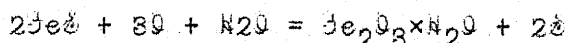
MEMORANDUM.

in and, as when making new oxide, the fouled oxide has to be kept wet and turned from time to time in order to oxidize it thoroughly and prevent it from taking fire.

Revivification takes place as follows; -



assuming that we have ferrous sulfide,



The above is sometimes effected without removing the oxide, by shutting off the gas and blowing air through the oxide with a steam jet (the steam prevents the ignition of the oxide) or by introducing small amounts of air into the gas before it enters the purifiers. We are limited to .75% air but in some works as high as 2-1/2% is used. These two methods lengthen the time that the oxide is kept in the box but it has to be removed in time on account of the back pressure caused by the separated sulfur.

From the equation -  $2H_2S + O_2 = 2H_2O + 2S$  - we see that, theoretically, 2-1/2% of air for every 1% of hydrogen sulfide should keep the oxide fresh and it would probably do so if the sulfur could be removed as fast as it was formed so that it would not coat the oxide. The main objection to this method however, is that the nitrogen in the used, lowers the lighting and heating value of the gas. At some of the continental works they have tried to make oxygen cheaply so as to get around this trouble but I do not think that they have made a success of it.

If the oxide is of good quality and is kept free of tar, it can be used until it contains 50-60% of free sulfur when it is thrown away as there is no market for it.

The cyanogen which is taken up by the oxide, thereby having its efficiency lowered, is present as Prussian blue and old oxide sometimes contains as high as 15% of the blue. As far as I know there is no place in this country where the cyanide is extracted but on the continent they either extract it before the gas reaches the

THE LACLEDE GAS LIGHT COMPANY.

MEMORANDUM.

purifiers, by passing <sup>the gas</sup> it through a rotary scrubber containing ferrous sulfate solution, or else they extract it from the old oxide with lime. They also use the old oxide in manufacturing sulfuric acid.

From the purifiers the gas goes to the meter and then to the storage holder where it is mixed with carburetted water gas. The daily (24hr.) out-put of coal gas from all the plants is 4,300,000 cubic feet. About 7 to 3 million feet of carburetted water gas is mixed with this before it is sent out.

The tar and ammonia liquor from the different parts of the condensing and scrubbing system, run together into the seal pot and from there to the separator (see sketch #11). From the separator the ammonia flows to the ammonia well and is sold to the National Ammonia Co. who turn it into anhydrous ammonia for refrigerating purposes. The tar flows to the tar well where it is allowed to stand for some time to let the water separate more completely. It is then sold to the Barrett Mfg. Co. who work it up into pitch and benzol.

Part of the coke is used in making water gas and the remainder is contracted for by one of the coal dealers.