History of the Manufactured Gas Business in the United States

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Manufactured gas made from coal, coke and oil was the source of fuel for lighting and cooking throughout the 19th century. In the United States the first uses of gas for the purposes of lighting appear to have been in Philadelphia in 1796 and in Richmond in 1803. The first gas company was organized in Baltimore in 1816. During the latter half of the 19th century the manufactured gas industry expanded in the urban industrial areas of the country.

Toward the end of the 19th century, the light bulb was invented. Because of electricity's ease of use in lighting, the gas industry gradually lost its lighting business and instead expanded into new markets, primarily domestic and commercial heating and cooking. Before gas entered into those two areas coal and wood were the principal fuels used, but because stove gas was easier to use, its temperature easier to regulate, and it required little maintenance, the gas industry had little difficulty taking over those markets. At the turn of the century almost every good sized city had its own manufactured gas plant.

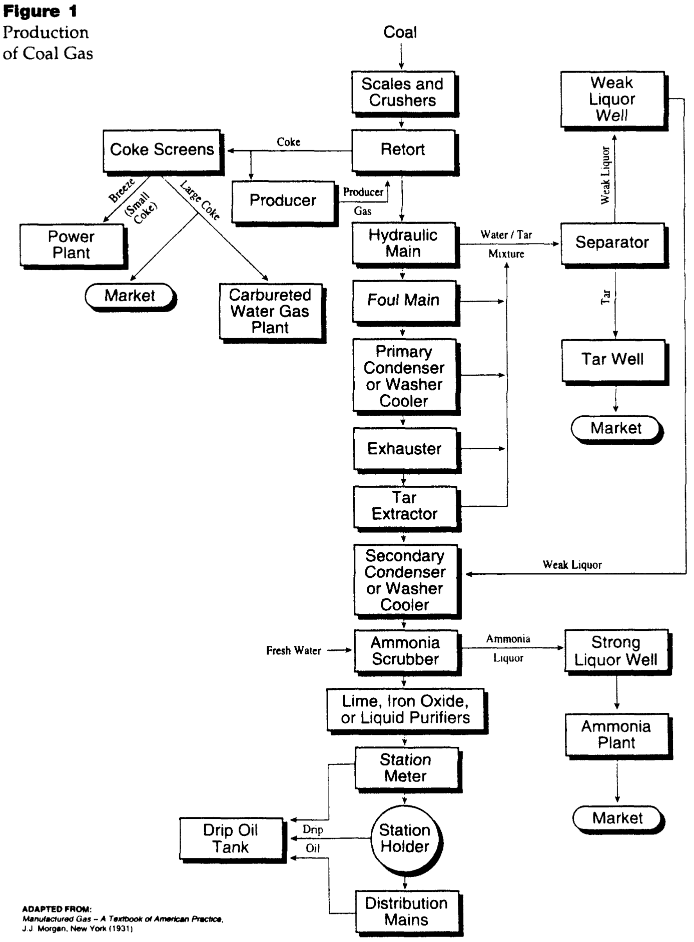
During the 1940s and 1950s natural gas was being made available through the construction of large interstate pipelines. Since natural gas was cheaper and had a higher BTU content, it replaced manufactured gas as the base fuel. For the next several years manufactured gas was only used to supplement natural gas in periods of high demand such as in extremely cold weather.

Town gas, or manufactured gas in the United States, was produced mainly by three major processes; coal carbonization, carbureted water gas, and oil gas. Coal gas was used exclusively from 1816 to 1875 when the carbureted gas was developed.

COAL GAS PROCESS

Coal gas is normally produced by the distillation of bituminous coal in retorts. This process could be better defined as the decomposition of coal into volatile products by the action of heat in the absence of air or oxygen. The retorts used for the distillation of coal are made of clay and usually have an oval or D form and are arranged in a furnace as a bench and

Figure 1
Production
of Coal Gas



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heated by coke. The coal is charged into the retorts at fixed intervals.

During heating, about two-fifths of the coal's weight is converted into products which are vapors at the temperature of the retorts, and the remaining three-fifths is left in the retorts as a porous mass known as coke.

After the volatile matter has been driven off, the coke is drawn from the retorts and quenched with water, and is either stored for sale or used for heating the bench.

The vapors given off in the retorts are removed by vertical pipes which rise from one end and are connected to the hydraulic main placed horizontally above the bench. In the hydraulic main some of the vapors are condensed into liquids. These liquids are partially water and partially tar; the gas leaving the hydraulic main still contains large amounts of condensable materials.

From the hydraulic main, the gas passes through a condenser. This is usually of such form that the gas passes through a long series of pipes which are either exposed to the air or surrounded by water, where the temperature of the gas is greatly reduced. By this cooling, more water and tars are condensed and removed.

Next to the condenser or, in some gas works, between the gas condenser and the hydraulic main, there is an exhauster. The purpose of the exhauster is to relieve the pressure on the retorts. This pressure is caused by the friction of the gas in the pipes and various parts of the purifying apparatus where the gas is forced to pass through water and layers of solid materials. The exhauster draws the gas from the retorts and forces it through the rest of the train.

The gas, now freed from most of the liquid impurities, still contains ammonia and gaseous sulfur compounds which must be removed before the gas is commercially acceptable.

The removal of the ammonia is easily accomplished by washing the gas with water. The water, after it has absorbed the ammonia, combined with the water product from the hydraulic main, is then known as ammonial liquor. When properly treated, ammonia is recovered from this liquor.

Two substances were commonly used to remove sulfur compounds: moist lime or moist iron oxide. These are arranged in iron vessels, called purifiers, through which the gas is forced. The hydrogen sulphide is then absorbed by (reacts with) the purifying materials.

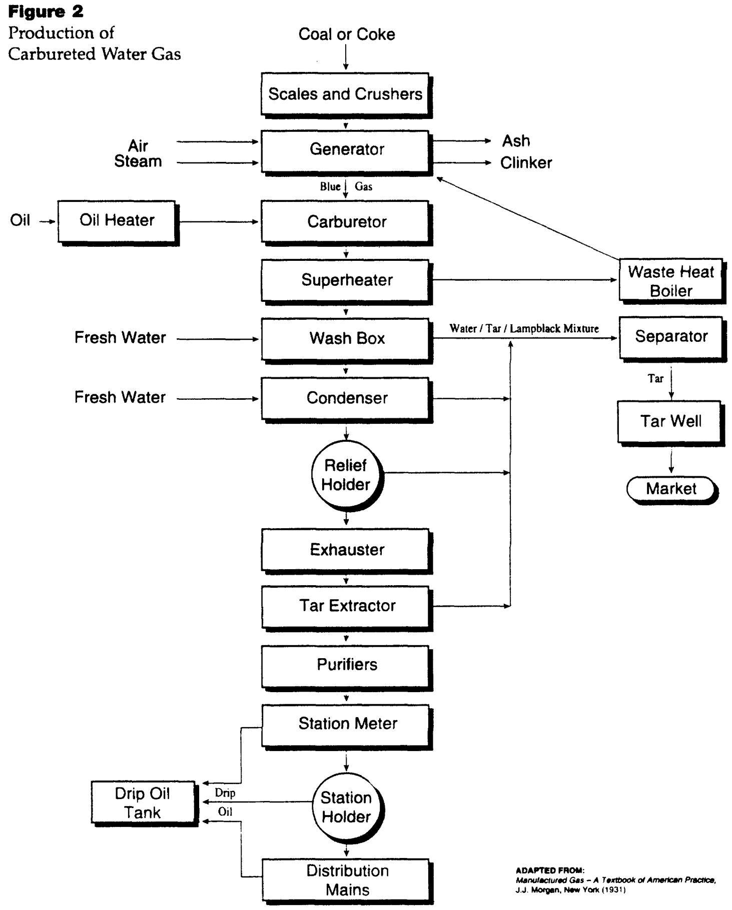
From the purifiers, the gas passes to the station meter where it is measured and is then sent to the gas storage holder. From the holder, the gas is sent through the street mains to the customers.

CARBURETED WATER GAS PROCESS

The carbureted water gas process consists of spraying oil into water gas (blue gas) in a hot vessel to increase the calorific value of the blue gas.

Initially, many attempts were made to enrich the blue gas by the use of light oil vapors or the gases resulting form the cracking of heavier oils. It was not, however, until 1873 that in Pennsylvania, Professor Lowe discovered how to make the producer gas made during the blows to heat the checkerbrick where enriching oil gas is made during the runs. The invention of the carbureted water gas process by Lowe and an

Figure 2
Production of
Carbureted Water Gas



abundant supply of gas oil from the petroleum industry soon made carbureted water gas the most important manufactured gas in the United States in its time.

The process is an intermittent one, consisting of alternate ‘blows’ or blasting periods and ‘runs’ or gas making periods. The typical carbureted water gas generating equipment consists of three brick-lined cylindrical steel vessels—the generator, the carburetor and the superheater.

The generator has a blast connection, top and bottom steam inlets, a fuel bed (typically coke or anthracite) and bottom and top offtake pipes, the top of the carburetor is connected to the gas off-take from the generator and provisions are made for the introduction of enriching oil at the top of the carburetor. At the top of the superheater there is a stack valve and a gas connection to the wash box.

The apparatus is heated by alternate blows and gas is made by alternate runs. During the blow a producer gas high in carbon dioxide is formed in the generator by passing air through an incandescent mass of coke or anthracite. This gas is burned by secondary air. The hot products of combustion heat the checkerbrick of the carburetor and superheater and then pass from the top of the superheater to the stack.

During the run, water gas is made in the generator and then passes into the top of the carburetor where oil is sprayed. This mixture passes down through the carburetor and up through the superheater. In their pass through the hot checkerbrick, the oil vapors are thermally cracked and fixed into gases. The carbureted water gas, a mixture of blue and oil gas, passes from the top of the superheater through a water sealed wash box where the gas is initially cooled and some of the heavy tars are condensed and removed.

After the wash box, the gas passes through condensers where it is normally cooled to ambient temperature. The condensers cause water vapor and tars to condense into a light tar which is then removed from the condensers. The condensers that transferred heat from the gas to the air were the first type employed for cooling the gas. Water cooled condensers were basically of the shell and tube construction type with cooling water passing through the tubes and gas flowing through the shell.

Direct contact with water was also used to cool and scrub the gas. The water is heated as it absorbs heat from the gas and additional condensed water vapor and tars are removed by the circulating water. The direct cooling of the gas is usually accomplished in a counter-current packed scrubber to increase the contact surface area between the gas and the water.

The gas then passes into the relief holder. The function of the relief holder is to provide a continuous gas supply to the exhauster and smooth the intermittent gas making runs of the gas making process.

From the relief holder the gas is forced by the exhauster through the rest of the purification equipment, the station meter, and into the storage holder.

For the removal of tar mist from the gas, three types of scrubbing apparatus may have been used: 1) the ‘wire drawing’ or friction for the separation of fine particles of tar in which the friction generated by the gas passing through fine orifices, the impact of the particles on the surface opposite to the orifices, and the sudden change in velocity of the gas, cause the separation of the tar particles; 2) the shaving scrubber which removes the tar mist by adsorption of the fine particles on the surface of shavings through which the gas is passed; and 3) the modern direct current electrical precipitation of suspended particles from gases invented by Cottrell in 1912–1913.

Tar extractors were used in large plants. For example, by 1926 Cottrell electrical precipitators had been installed in ten plants in the United States with capacities of over 6 million cubic feet of gas per precipitator per day.

Naphthalene scrubbers were also used in larger plants to remove naphthalene which was one of the main causes of trouble in the distribution system. After the naphthalene scrubbers, the gas was forced through a series of boxes filled with lime or a mixture of iron oxide and wood shavings to remove the hydrogen sulfide from the gas.

Large plants with capacities of over 20 million cubic feet per day may have used liquid purification systems to remove the bulk of the hydrogen sulfide after which the gas was passed through a dry (iron oxide) purification system.

After the hydrogen sulfide removal the gas was metered in the station meters and sent to the storage holders for its eventual distribution through the distribution gas mains to the customers.

OIL GAS

The first patent to manufacture oil gas was obtained by L. Lowe in 1889 and the first large gas plant for the production of oil gas was built in Oakland in 1902.

The oil gas process consists of the thermocracking of oil in a steam atmosphere. The generating equipment is similar to the one used for carbureted water gas; the generator was replaced by a vaporizer similar to the carburetor, filled with checkerbrick and equipped with an oil spray; the carburetor was replaced by a vaporizer followed by the superheater as in the carbureted water gas process. The vaporizers and superheater are interconnected at their bases.

The process is cyclical and consists of blows and runs. During the blow, oil is combusted (burned) in the vaporizers and the products of combustion heat the checkerbrick of the vaporizers and superheater and then pass from the top of the superheater to the stack. During the run, oil is sprayed in the vaporizers in the absence of air and presence of steam. In their passage through the hot checkerbrick the oil vapors are thermally cracked and fixed into gases. During the run the stack valve is closed and the oil gas passes to the washbox. The rest of the oil gas process is essentially the same as the carbureted water gas process.

In its day, manufactured gas provided a source of energy that was far more efficient and cleaner than coal. Initially manufactured gas was used extensively in the lighting of streets for example, thereby making a significant contribution to the public in the area of safety. Later on manufactured gas replaced coal and wood for heating and cooking purposes. Indeed, manufactured gas made a number of positive contributions to society until the 1950s when its use was largely replaced by natural gas.