Kansas Department of Health and Environment

Bureau of Environmental Remediation/Remedial Section

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The Manufactured Gas Industry in Kansas

For 60 years, many Kansans depended on manufactured gas to light and heat their homes, and to cook their food. Manufactured gas, produced in factories called gas works, was considered one of the most civilizing improvements a frontier city could make.

Imagine your city as it may have been in the 1860s. Horse-drawn buggies and wagons travel down unpaved streets, which were a sea of mud after it rained. At night it was very dark, because there were no streetlights. What little light there was came from lanterns, fueled by kerosene or candles, placed in windows or in front of whatever businesses were open late. Most people stayed home at night, choosing to go out only when a full moon lit the sky. The dark streets could be dangerous—if you didn't get robbed or lose your way, you could fall into a pothole or get run down by a carriage.

But then gas comes to town and the streets are lined with stately lamp-posts that turn night into day. Homes were lit with a cheery flame that was almost as bright as sunlight, and businesses could stay open later in the evening. Community life flourished as people spent their evenings attending theatre and lectures or socializing.

Gas light was considered far superior to candles or kerosene lanterns. The Kansas Daily Tribune wrote on July 1, 1869:

"There is nothing that will contribute so much to beautify our city, and make life pleasant and agreeable, as gas light. It is a steady, handy and constant light, and not near so wearing to the eyes as candle or oil light. Then one need not worry himself about oil cans, lamps or lamp chimneys. He may go home with his mind at rest, sure that when the shades of night are closing in around him, his faithful spouse (if he has one, or, in lieu thereof, a mother or sister, or some other man's sister) will have the gas lit, his slippers and gown ready, and a generous welcome in store for the weary toiler (of the Kaw), instead of a lecture on female suffering, caused by his forgetting to bring home the can of oil and the chimneys. In the long run, it is as cheap or cheaper than oil, and not near so destructive in its results. Insurance is always reduced on a building where gas is in use. It is always clean; while with oil you are always spilling, breaking lamps, getting it into your dough and spoiling the hot biscuits, &c., &c."

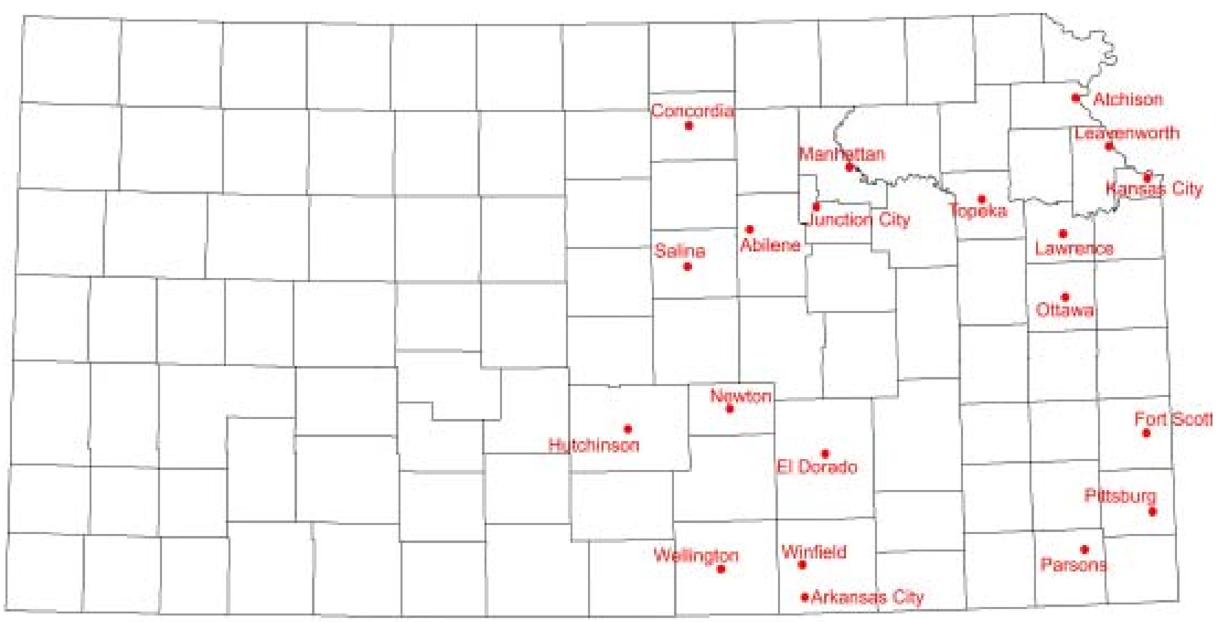
Not only was gas light considered a superior form of lighting, it was one way of demonstrating that a city was up-to-date. Kansans of the 19th century, much like Kansans of the 21st century, were interested in technological gadgets and conveniences. They were also very interested in extolling the benefits of Kansas to those who might like to move here. A city that could advertise that it had gas lighting, a municipal water supply, paved streets, modern schools, plenty of churches, and a vibrant community could attract settlers who were seeking a new life but weren't quite ready to rough it out on the prairie.

Locations of Manufactured Gas Plants

Gas was manufactured in Kansas from 1869 until 1930.

The first big push for building manufactured gas plants was in the late 1860s, after the Civil War, when Kansas was experiencing a huge growth in population. So many people were settling in Kansas that cities were competing with one another to see which would grow in population and influence the fastest, and wanted to be able to advertise modern conveniences. There was a certain rivalry between cities—Topeka and Leavenworth were both constructing gas works, so of course Lawrence had to do the same.

The first boom in manufactured gas plant construction lasted from 1868 to 1871, when four communities, Leavenworth, Topeka, Lawrence, and Fort Scott, invested in gas. From 1880 to 1890, 13 more plants were built, primarily in the eastern and southeastern parts of the state. In the 1890s natural gas was being discovered and developed, and proved to be an excellent fuel for industry and heating although it did not produce as much light when burned as manufactured gas. Twelve manufactured gas plants had closed by 1908. However, when the shallow, easily tapped gas fields began to fail in the early 1910s, prices for natural gas rose to the point where manufactured gas could again compete. Four more gas works were constructed in 1912 and 1913, and remained in operation at least until 1928.



Leavenworth	1868-1906	Hutchinson	1885-1906	Pittsburg	1887-1905
Topeka	1869-1908	Kansas City	1886-1905	Arkansas City	1890-1904
Fort Scott	1871-1905	Wellington	1886-1906	Salina	1881-1928
Atchison	1880-1905	El Dorado	1886-1907	Manhattan	1912-1928
Emporia	1880-1927	Lawrence	1869-1905	Abilene	1913-1928
Parsons	1884-1900	Newton	1886-1917	Junction City	1913-1928
Winfield	1884-1916	Ottawa	1886-1917	Concordia	1913-1930

The Gas Works

Gas was manufactured in a factory called a gas works. The factory usually consisted of one or two buildings, some sheds for storing coal, and a distinctive cylindrical structure called a gas holder or gasometer. Leavenworth's Times and Conservative newspaper described the construction of a new gas holder on April 23, 1869:

"The Gas Company are adding a gas holder to their works, their present one being inadequate to supply the increasing demand for gas. The excavation for the new holder has been made and workmen were busy laying the inlet and outlet pipes. The dimensions of this addition are as follows: brick tank 66 ½ feet in diameter by 20 feet in depth; gas holder 40 feet high by 61 ½ feet in diameter. The gas holder is of the kind known as telescope holder being in two sections linked together by a hydraulic cup. There are six iron columns placed at equal distances around the holder, each column being 40 feet in height and 15 inches in diameter. The columns are connected at the top by iron truss girders 33 feet long by 30 inches high. The counter balance weights will be in the columns and out of sight. The capacity of the holder will be 250,000 feet per day. The cost of the improvement aggregates $50,000 and it is expected connexion will be made with the works and street about the first of September. When completed the new holder will be quite an ornament to that part of the city—in all the gorgeousness of red paint contrasting sharply with the black of the columns and girder."

An excavated gas holder tank in Kansas City. In this picture is the "dumpling," made of bedrock or concrete, usually left in the holder tank in order to support the gas holder framework and piping.

The gas holder was often built over a large underground tank. Quite often, a knob of rock or concrete, called the "dumpling," would be left behind to save on excavation costs and to provide a foundation for the framework. The tank would be lined with brick or concrete and made watertight by adding a layer of hydraulic cement. The gas holder itself was a wooden shell, sometimes in two or three telescopic sections, that floated in water that filled the tank. As the holder filled with gas, it rose in the tank. A framework of steel girders surrounded the holder to prevent it from toppling over, and the weight of the holder and counterweights pressurized the gas as it flowed outward through the distribution piping. An engineer could estimate the amount of gas on hand by the height of the gas holder.

Manufacturing Gas

Coal Carbonization Method

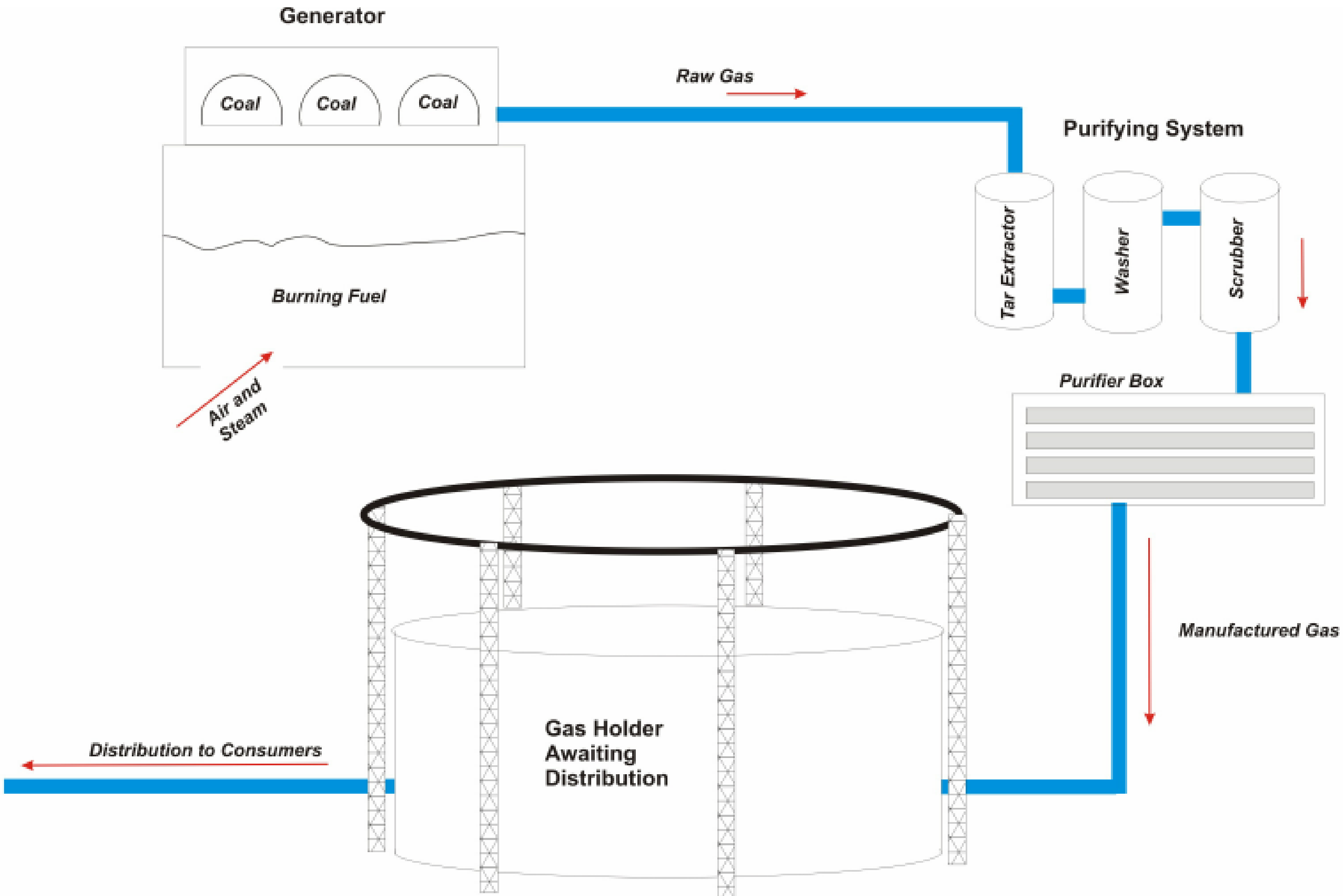
The earliest method of gas manufacture was a relatively straightforward process known as coal carbonization. The figure labeled "The Gas Manufacturing Process: Overview" on the next page demonstrates the process.

The generator consists of one or more "benches", each one consisting of a coal fired furnace and up to six cylindrical ceramic containers known as retorts. The retorts would be loaded with oily bituminous coal. Beneath the bench was an iron pan which would be filled with water. When the fire was lit in the bench, the water would boil and become steam, which mixed with the air entering the furnace.

By carefully controlling the amounts of air and stem entering the fire, the engineer could control the relative amounts of carbon monoxide (CO) and carbon dioxide (CO_2) produced. These hot fumes passed through the retorts packed with coal, and reacted with the carbon in the coal to produce CO and hydrogen, both of which are flammable and were the primary constituents of gas. Also, by becoming red hot, the coal in the retorts gave off vapors rich in hydrocarbons. These hydrocarbons made the gas flame brighter, an important quality when the gas was intended for lighting. Once the coal in the retorts had given off all its volatile gasses, it could be used in the furnace as fuel.

After leaving the retorts, the carbon-rich gas was cooled to between 100° and 60° Fahrenheit, and sent through a set of purifiers. The first stage, condensation, simply cooled the gas, allowing the heavier hydrocarbons to condense into tiny droplets of tar aerosolized in the gas. The tar extractor, the second stage, removed this tar. One popular model did so by forcing the gas through hundreds of tiny holes, forcing the tar droplets to collide and merge, precipitating out of the gas completely. This coal tar was collected and could be used as fuel or sold as feedstock to the chemical industry.

The third stage of purification, washing and scrubbing, removed ammonia compounds from the gas. Ammonia dissolves easily in cool water, so the gas would be bubbled through a tank of water (washing), then pass through a scrubber which acted by spraying water through the gas. The wash water was called ammoniacal liquor, and would be condensed and sold.



The Gas Manufacturing Process: Overview

Finally the gas needed to have hydrogen sulfide (H_2S) removed from it. Hydrogen sulfide has a strong rotten egg smell and is toxic in high doses. Even low doses cause irritation, headaches, and dizziness, so it was important to remove it before delivering the gas to consumers' homes.

This was done through a fairly simple process. Iron oxide (Fe_2O_3) shavings, obtained by mixing iron filings with damp wood chips and letting them rust, were placed in trays in a series of purifier boxes. The gas passed through the purifier boxes, and the hydrogen sulfide would react with the iron oxide from the damp wood chips to form iron sulfide (Fe_2S_3). Any cyanide (CN) compounds in the gas would also be removed by the iron oxide filings, producing a ferricyanide.

At least once a week, when the iron oxide in the box was exhausted, the material could be "revivified" by placing it in heaps on the floor. Oxygen in the air would combine with the iron sulfide, reducing it back to iron oxide, and producing elemental sulfur as a byproduct. The iron oxide could then be reused several times until saturated with sulfur and discarded or sold.

If chemical analysis showed the gas contained too much carbon dioxide, it could be removed by sending the gas through another set of purifier boxes filled with trays of hydrated lime.

The finished gas could now be sent to the gas holder to await distribution to consumers.

Carburetted Water Gas Method

After 1875 the carburetted water gas (CWG) method became the most commonly used in the United States. CWG contained more illuminating hydrocarbon compounds than coal gas, producing the brighter flame that consumers wanted for illumination, and could be manufactured more efficiently.

In the CWG process, the generator was modified to include a carburettor and a superheater. Both of these structures were built of firebrick laid in a checker board pattern. The carburettor and superheater would both be heated to high temperatures during the manufacturing process. The figure on the next page demonstrates CWG manufacturing.

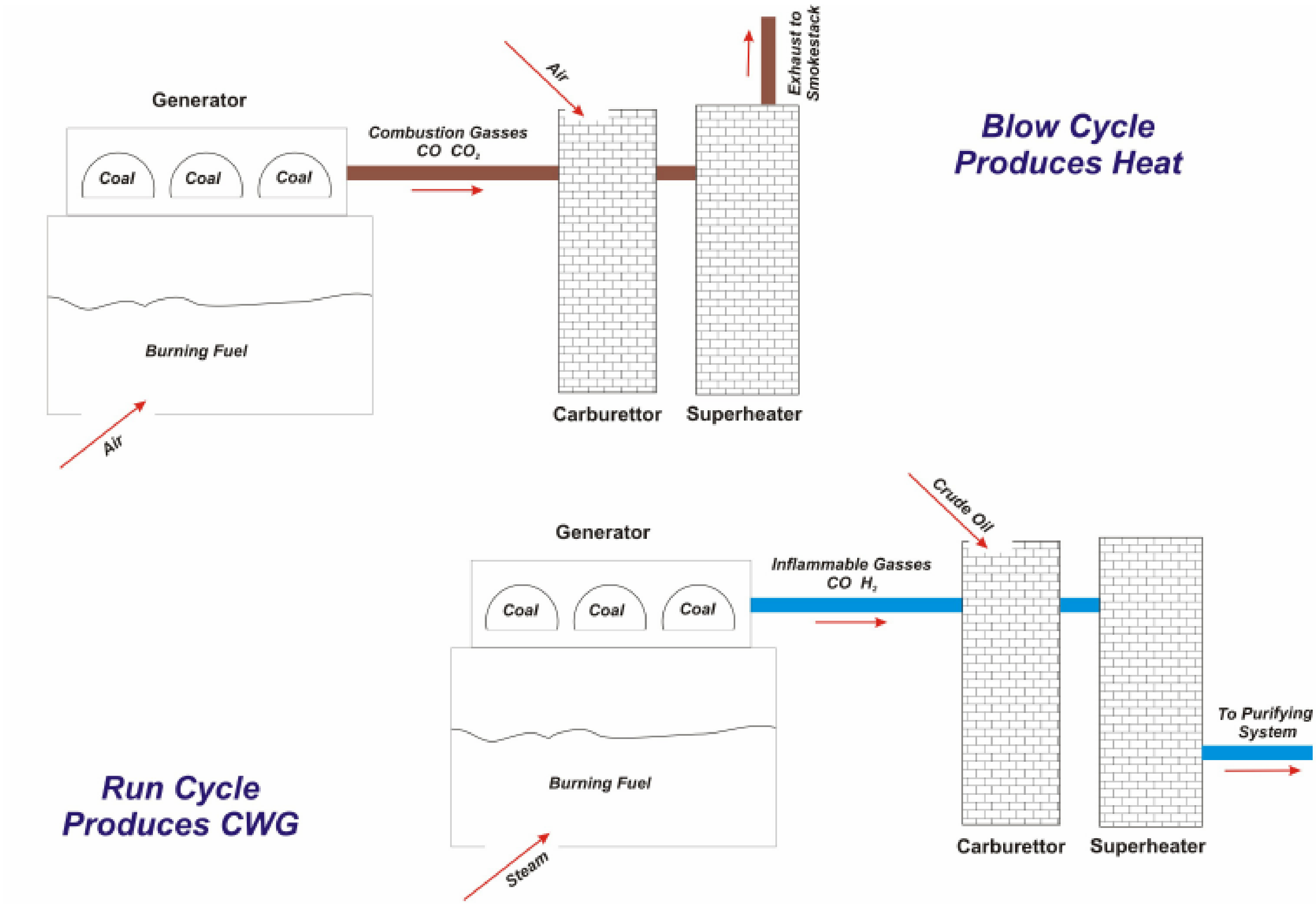
The process had two states, a blow cycle and a run cycle. In the blow cycle, air would be forced through the burning fuel in order to produce large amounts of heat. When the hot fumes passed into the carburettor, more air was blown in to complete combustion and produce more heat. The waste gasses passed through the superheater and were directed out of the smokestack and into the atmosphere.

Once the system was sufficiently hot, the run cycle would begin. The engineer would direct steam, rather than air, into the generator, and it would react with the burning fuel and hot coal in the retorts to make what was known as "blue gas" or "water gas." This gas burned hot and well, but it didn't have enough hydrocarbon compounds suspended in it to make a good light.

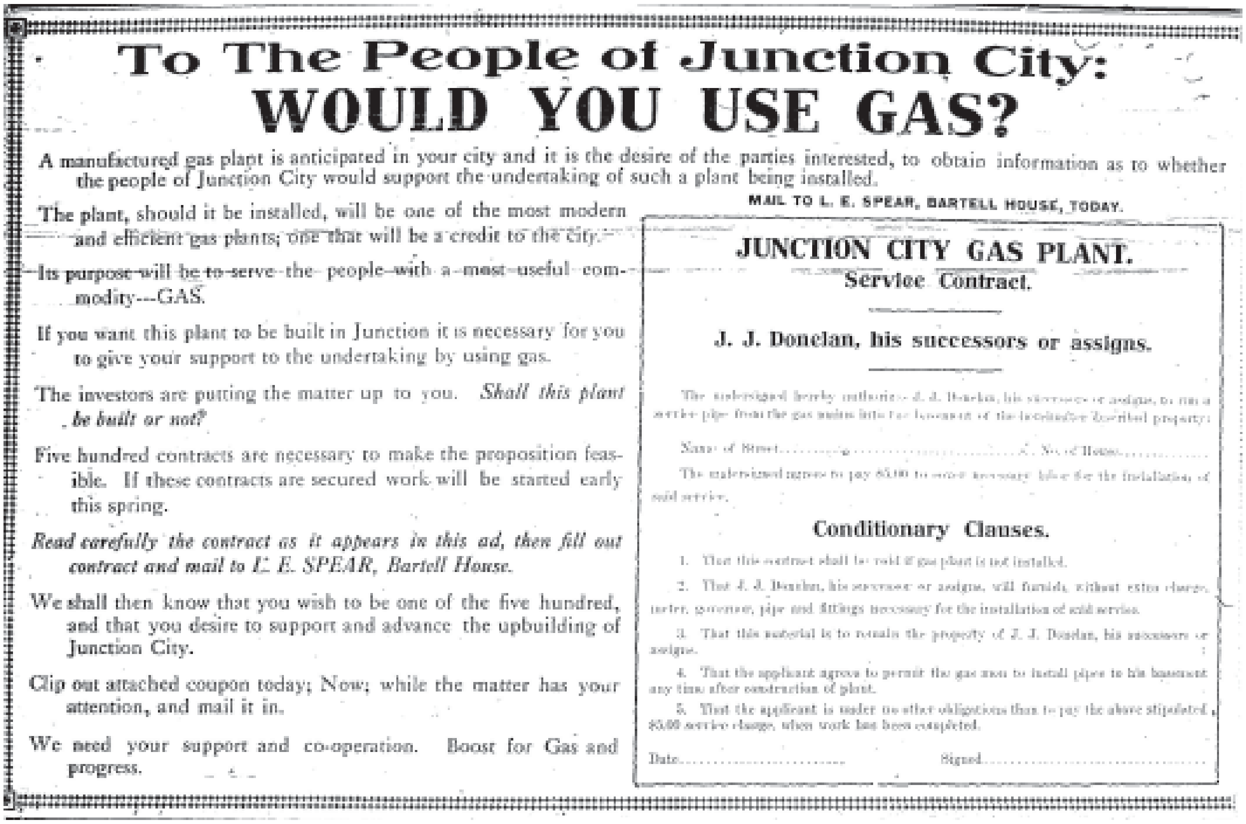
Hydrocarbons were added by spraying crude oil, or lighter "gas oil," onto the hot bricks in the carburettor. This thermocracked the oil into smaller compounds, which would be permanently fixed in a gaseous state by exposure to the high temperature in the superheater.

Once made, the CWG would be sent through the same purification and delivery process as coal gas.

Water gas, without carburetion, continued to be produced even after natural gas became available nationwide. Because water gas is chemically similar to natural gas, it was possible to make gas during times when natural gas supplies were limited, or there was high demand, and it could be used in the same appliances as natural gas.



The Carburetted Water Gas Manufacturing Process: Blow and Run Cycles



To The People of Junction City:

WOULD YOU USE GAS?

A manufactured gas plant is anticipated in your city and it is the desire of the parties interested, to obtain information as to whether the people of Junction City would support the undertaking of such a plant being installed.

The plant, should it be installed, will be one of the most modern and efficient gas plants; one that will be a credit to the city.

Its purpose will be to serve the people with a most useful commodity—GAS.

If you want this plant to be built in Junction it is necessary for you to give your support to the undertaking by using gas.

The investors are putting the matter up to you. *Shall this plant be built or not?*

Five hundred contracts are necessary to make the proposition feasible. If these contracts are secured work will be started early this spring.

Read carefully the contract as it appears in this ad, then fill out contract and mail to L. E. SPEAR, Bartell House.

We shall then know that you wish to be one of the five hundred, and that you desire to support and advance the upbuilding of Junction City.

Clip out attached coupon today; Now; while the matter has your attention, and mail it in.

We need your support and co-operation. Boost for Gas and progress.

MAIL TO L. E. SPEAR, BARTELL HOUSE, TODAY.

JUNCTION CITY GAS PLANT.

Service Contract.

J. J. Donelan, his successors or assigns.

[illegible]

Name of Street........................ No. of House..............

[illegible]

Conditionary Clauses.

1. That this contract shall be void if gas plant is not installed.
2. That J. J. Donelan, his successors or assigns, will furnish, without extra charge, [illegible], governor, pipe and fittings necessary for the installation of said service.
3. That this material is to remain the property of J. J. Donelan, his successors or assigns.
4. That the applicant agrees to permit the gas men to install pipe to his basement any time after construction of plant.
5. That the applicant is under no other obligations than to pay the above stipulated $5.00 service charge, when work has been completed.

Date........................ Signed..............................

Junction City awarded its manufactured gas enterprise to J. J. Donelson, who promised to build a plant if enough citizens pledged to use gas. Advertisements like this were placed in the Junction City Union. Construction began in May 1913 and customers were using gas stoves by August.

Gas Distribution

The gas was delivered to consumers through a series of pipes laid underneath the city streets. Usually the gas works was located at a low elevation relative to the rest of the city because gas is naturally lighter than air and would rise through the mains.

One of the problems encountered was that of condensation in the pipes. The gas would pick up humidity from the purification process, and on very cold days this water would condense or freeze in the pipes, blocking or perhaps breaking them. Other substances also condensed; napthalene, the chemical used in mothballs and a primary component of coal tar, would often precipitate into crystals in the pipes. Napthalene is associated with anemia, liver damage, and cataracts, and may be a carcinogen. Its unpleasant odor made it an unwelcome addition to the gas.

In order to control condensate, the distribution lines included drip pots in low spots. These pots acted as sumps, collecting water and tars from the gas. Workers would regularly maintain the pots by pumping them out.

Manufactured Gas in Daily Life

Before gas could be used for light, heating, and cooking, the building had to have gas pipes installed. Fitters would install pipes from a meter on the distribution line to each room in which gas would be used. The pipe required a corrosion resistant coating that prevented it from reacting with compounds in the gas.

Lighting fixtures could be installed on the walls or ceiling, and were often elaborately decorated. Many of our modern electrical lamps and chandeliers are based on the designs for gas lamps.

A kitchen stove had burners and an oven heated by gas. In order to use any of these, the owner would simply turn a valve and light the gas with a match. Gas cooking stoves were particularly appreciated in the summer, because when the cook was finished preparing a meal, she could just turn the stove off. Wood or coal stoves, by contrast, would continue heating the kitchen until the fire burned out. Heating stoves were often small enough to fit on a shelf or a table, and were connected to the pipes by special valves that could be connected and disconnected easily, allowing the heater to be moved from room to room.

One of the primary uses of gas was to fuel street lights. Lighting the streets improved safety, reduced crime, and encouraged people to socialize in the evening. Shops could stay open later, and the city's downtown could become an entertainment district, with theaters and fine restaurants, as well as a business center. The street lights were maintained by lamplighters, who would light and extinguish the gas and polish the soot off the glass.

Gas lighting wasn't perfect. The pipes would make noise, and burning gas left soot on the walls and ceilings. The gas itself had a distinctive unpleasant odor. The burners had to be properly adjusted and provide the correct mixture of gas and air, otherwise the gas wouldn't burn cleanly and compounds like carbon monoxide could poison the residents. If a gas pipe leaked, or a valve was left open, enough gas could build up in a room to cause an explosion. Several contaminants found in gas, such as hydrogen sulphide, cyanide, and napthalene, could make residents seriously ill after inhaling them.

In the 1890s, gas mantles became available. These were thumb-shaped mesh bags impregnated with thorium, which incandesces at high temperatures. The burning gas would heat the bag, which would glow brightly. The gas mantle, now often made with non-radioactive yttrium, is still used in propane-powered camp lanterns.

The End of Gas Manufacturing

Pittsburg, Kansas, had abundant coal with which to power its industries; Lawrence had its Kaw River dam and water mills. Iola, in Allen County, discovered it had rich and accessible reserves of natural gas, and began successfully promoting itself as the next industrial center in Kansas. Natural gas was so abundant in Iola that every citizen was initially given as much gas as they wanted for $1 per month. Allen County aggressively recruited fuel hungry industries such as zinc smelting, portland cement manufacturing, and glass making to locate in Iola and the neighboring cities of La Harpe and Gas. Gas field entrepreneurs quickly learned how to store and transport natural gas to locations away from the gas fields, and by 1908, eleven manufactured gas plants statewide had been abandoned.

Electric power was being developed in Kansas about the same time as manufactured gas. Photographs of downtown Topeka from the early 1870s show electric street cars, and in many cases, the manufactured gas plant also began to generate electricity for domestic and industrial use. With the development of a successful incandescent light bulb by Thomas Edison in 1879, gas lighting now had a competitor, and many gas consumers retrofitted their gas lighting fixtures to use the new power source. Electricity didn't produce soot or odors like gas would, and proved to be very popular. Electricity, provided by a gasoline-powered generator, was particularly advantageous on farms and households which were too far from town to be connected to the gas mains.

By 1930, the last manufactured gas plant in the state closed its doors. Gas was still manufactured in other parts of the United States until a nationwide system of natural gas pipes was completed in the 1960s. Europe, without ready access to natural gas, continued to manufacture gas into the 1980s, when an exploitable reserve of natural gas was discovered in the North Sea. The buildings housing the gas holders have been considered cultural and historical landmarks, and many have been converted into living, retail, or office space.

These gasometers in Vienna were used until 1984, and have since been converted to retail, office, and living space.

Manufactured Gas and its Environmental Legacy

Although it was relatively clean-burning at the consumer's end, gas was anything but clean to make. In recent years, there has been a lot of interest in locating and assessing the environmental impact of former manufactured gas plants in the United States. The process of making gas left behind substances such as coal ash, clinkers, coal and oil tars, lampblack, ammonia, cyanide compounds, and emulsions of oil or tar in water.

Some of these materials had commercial value and could be resold or used. Coal tar, lampblack, sulfur, and ammonia could be used as feedstock for the chemical industry. Coal tar could also be used as fuel in the furnaces. Coal ash and cinders were often used as inexpensive construction fill or to treat icy roads in the winter.

Residual material that could not be sold was often stored or disposed of on site. These materials might include water contaminated with ammonia and tar, which might be dumped into the nearest creek or river. Coal tar could be stored in a tar well—a pit often lined with brick or concrete. Even if the tar was later recovered and sold, it might have leaked through cracks in the lining into the soil. Coal tar would also collect in the gas holder tank, and could leak from there into the soil. Spent lime and iron shavings used in the purification process, along with the wood chips or ground corn cobs used to increase the surface area of the purifier material, would be spread or buried on-site.

Once the plant was decommissioned, it was usually torn down. Leftover equipment, residual materials, and construction debris would be used to fill in the gas holder tank. The city of Wellington decided to turn their former manufactured gas plant into a park and community center. In order to fill the gas holder tank, the entire city cleaned out their closets, basements, and yards, and used the trash as fill.

In her history of Sellers Park, Marie Seelers Van Denenter wrote:

"On the property was also a deep pit 54 feet in diameter and 20 feet deep, originally known as the "gasometer" or "holding tank" which was inadequately covered. It was filled with stagnant water and debris and gave off a foul odor. Filling this pit was a primary concern of the Cary Circle women because of the possible danger to children playing in the area. The problem was how to get it filled.

It was decided there wasn't anything Wellington needed more than a citywide cleanup and no better place for the trash than this deep hole. Therefore, with the approval of the City Commission for a cleanup, every club and organization was asked to help, and a week was set aside in March (1914) for all property owners and all renters to cleanup their premises, and on March 21st, all discarded trash would be hauled away free. Publicity, donated by the two daily and one weekly newspapers, urged citizens to contribute anything they wanted to get rid of, and produced an overwhelming response. Many men with teams and wagons gave their time and equipment free of charge to help with the hauling. There were old stoves, broken household furniture, iron beds and bedsprings, cupboards, broken china, and trash of every kind and description, and a great many loads went into the hole. Everyone seemed to catch the spirit, with one city ward vying with another to see which would contribute the most trash to fill the old gas tank. It is doubtful if Wellington ever presented a more shining appearance than in the week following this scouring.

The first cleanup and dumping of rubbish which took several hundred loads to fill was a great success, but the trash soon sank and more was needed. The following year another cleanup was proclaimed and with the support of the citizens the level of the pit was again achieved."

The gas generation building was turned into a clubhouse, and used for many years for parties, banquets, and community gatherings. After World War II, the Park House was turned into a recreation center managed by the local school district. Park House is now the Panhandle Railroad Museum.

Park House in Wellington was used as a community center and now houses the Panhandle Railroad Museum.

Removing the contents of the gas holder tank at the former manufactured gas plant in Manhattan. The contents are primarily water, woody debris, soil, and hard-parts refuse.

Excavated material from the site placed in the gas holder tank to soak up water contaminated with coal tar. The contaminated material was removed and properly disposed of at a hazardous waste disposal facility.

Excavation revealed underground foundations and structures. These were left in place when clean fill was installed.

The outside wall of the coal tar well. This kind of brick construction was typical of underground structures at a manufactured gas plant.

Filling the gas holder with clean fill. The bottom of the gas holder tank was broken to prevent water from continuing to collect in it.

The site after remediation was completed. It can now be redeveloped and put back into use.

The Remediation of a Former Manufactured Gas Plant

The substances usually associated with a former manufactured gas plant are hazardous, consisting of coal tars containing polynuclear aromatic hydrocarbons (PAHs) and volatile organic chemicals (VOCs), purifier residues that may contain sulfur and cyanides, and coal ashes that may contain heavy metals such as arsenic. However, these substances are typically immobile when buried in the subsurface and do not migrate appreciable distances by, for example, contaminating very large amounts of ground water. Some of these contaminants would have, over the time since the former manufactured gas plant was closed, have evaporated or been subject to natural biodegradation in the environment. Remedial efforts usually involve contaminant source removal and/or containment, and a long term commitment to assessing and monitoring ground water quality.

There are many strategies that can be applied to remediation, ranging from simple excavation of impacted soil and residual tars for disposal in an approved landfill, to on-site treatment options, to placing Environmental Use Controls on the property to limit current and future land use. These remedial strategies can be applied to soil, sediments, and ground water.

Selection of the best remedial alternative is only made after careful and thorough characterization of the nature and scope of contamination, and only after consideration of stringent screening criteria, including the overall protection of human health and the environment; compliance with applicable or relevant and appropriate requirements (ARARs); long-term effectiveness and permanence, reductions of contaminant toxicity, mobility, and volume through treatment; short-term effectiveness; cost; state acceptance; implementability; and, perhaps most importantly, community acceptance. In a few cases, after thorough site assessment, no remedial action at all is required.

The cleanup costs at former manufactured gas plants are highly variable, depending on the amount of impacted material, how deep below the ground surface it is buried, and the availability of an appropriate disposal facility.

Locating and cleaning out the gas holder tank and coal tar well, if it exists, are a high priority. Experience has shown that these are the locations in which contamination is most likely to be concentrated. Remediation often consists of digging out and removing the contents of these underground structures, assessing the removed material for its hazardous characteristics, and disposing of it offsite in an approved waste disposal facility. The gas holder and tar well may then have the brick or concrete linings broken in order that water does not collect in the structure, and then are filled with clean gravel and soil. Soil, debris, and other materials which are judged to be non-hazardous can be consolidated onto one section of the site and covered with an engineered cap which is designed to protect the subsurface soil and prevent rain water from percolating into the subsurface. The cap can be paved and used a building foundation or a parking lot, or planted with grass.

In most cases, these activities successfully remediate the site to below Kansas Risk-Based Standards for non-residential properties. If low levels of contamination remain in the subsurface, the remediation process can be completed by placing an Environmental Use Control on the property, adding language to the deed which restricts certain future activities on the site such as digging or excavation, and prevents the installation and use of wells.

Manufactured Gas in our Future

America is currently seeking new forms of energy, and manufactured gas, now known as "syngas", may make a comeback. The gasification process for coal; oil; or the biomass from wood, vegetable oil, or garbage is a well-understood method of making hydrogen. Hydrogen is a fuel that burns without releasing pollutants or greenhouse gasses into the atmosphere, and is being considered as a fuel for cars. Some companies are developing new technologies that may make manufacturing syngas both economical and clean by improving the efficiency of the gasification process and developing more effective methods of capturing and removing contaminants. If biomass, rather than natural gas or coal, is used as the primary feedstock, gasification can even be made carbon-neutral. Whether manufactured gas is once again used as a practical source for fuel remains to be seen.