

**A HISTORY OF
UNION CARBIDE
CORPORATION**

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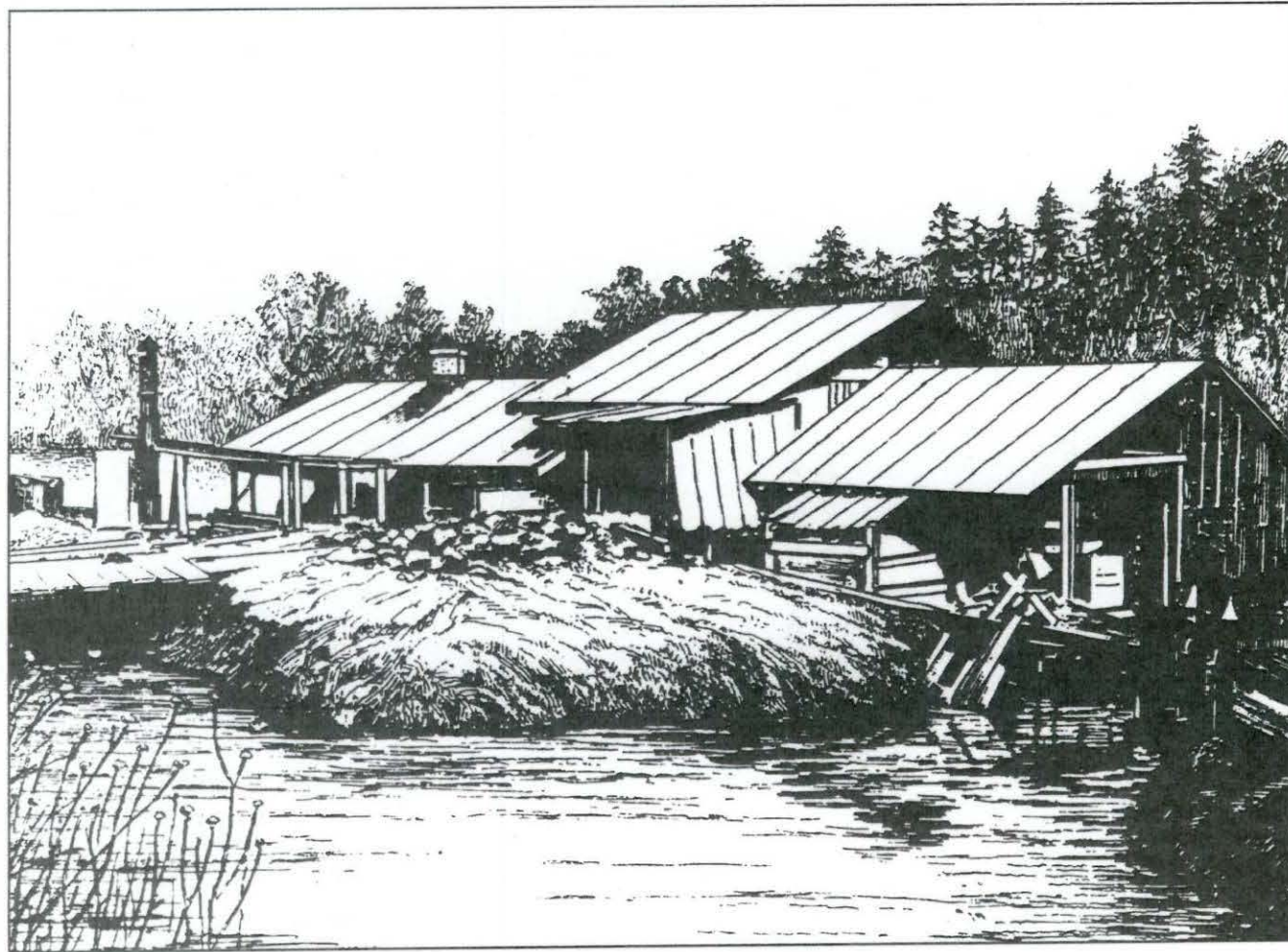
From the 1890s to the 1990s

Robert D. Stief
1998

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Calcium Carbide Plant at Spray, NC, in 1896

Illustration Courtesy of Herbert T. Pratt

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A HISTORY OF UNION CARBIDE CORPORATION

Chapter One

GENESIS (1890-1920)

Ethyl alcohol has been made by fermentation since time immemorial in the making of beer and wine, and the roots of synthetic organic chemistry go back to 1828 when the German chemist Friedrich Woehler synthesized urea from ammonium cyanate. The organic chemical industry, however, began in the mid-1800s in Europe, largely in Germany, based on coal and coal-tar chemicals. Coal-tar chemicals are aromatic in nature, that is they have a makeup that incorporates the benzene ring in their structure. The driving force for much of the early development in organic chemicals was the need for synthetic dyes for the growing textile industry. The demand for explosives also was an important factor. Whole industries grew out of these developments. Germany was a particularly fertile ground for the development of organic chemicals because of its unique working relationships between industry and the universities. Up to that time much if not most industrial development was empirical. A scientific approach, afforded by German universities, provided the means for development of the organic chemical industry that would not have been possible otherwise.

Petroleum refining and petrochemicals, however, are more recent and are largely American developments. Petrochemicals are chemicals derived from petroleum and are different from coal-tar chemicals. They are more properly termed synthetic aliphatic chemicals and generally have a linear or branched structure rather than a ring structure. There is of course no absolute dividing line between the two areas, indeed there is considerable overlap in practice.

Growth of petrochemicals in the United States was based on the ready availability of inexpensive gas and oil and on the growing but largely undefined needs of the automobile industry. Growth was facilitated by the newly emerging discipline of chemical engineering, with its emphasis on definable and continuous processing methods, which were needed to build large plants with economies of scale. Interestingly, many new petrochemical products found their own applications rather than the other way around. Early applications were as solvents for paint and other

things, anti-freeze, intermediates for making low-temperature dynamite, dyes, pharmaceuticals, and so on. Ultimately, whole industries derived from petrochemicals: plastics, packaging, paints, fibers, fertilizers, solvents, synthetic rubber, agricultural chemicals, and a host of others. However, most petrochemicals, with the exception of plastics, are intermediates that the general public never sees and doesn't recognize.

The principal building block in the petrochemical industry is ethylene, an unsaturated aliphatic hydrocarbon molecule that consists of two atoms of carbon and four atoms of hydrogen. It is a member of a family of unsaturated aliphatic chemicals called olefins. Propylene is also a member of this family having three carbon atoms and six hydrogen atoms. Ethylene, which is a gas at atmospheric temperatures and pressure, has been known since 1795. Until the 1920s, what little was manufactured was made by chemically dehydrating ethyl alcohol that had been produced by fermentation. Ethylene was first produced in quantity in the early 1920s by Union Carbide and Carbon Corporation by cracking natural gas liquids. From that time Union Carbide has led the industry in the development and manufacture of ethylene and its derivatives. The next major producer of ethylene was Dow Chemical in 1941. By that time, Union Carbide had built four ethylene (olefins) plants (three in Charleston, West Virginia, and one in Whiting, Indiana) and was in the process of completing a fifth in Texas City, Texas.

Willson Aluminum Company

Union Carbide Corporation owes its existence to a Canadian inventor named Thomas Leopold Willson. Willson, who was born in 1860 to a well-to-do family in Princeton, Ontario, had a consuming interest in electric power, especially in electric arcs and dynamos. He had invented neither, but held numerous patents on their uses and improvements. In the 1880s, electric power was in its infancy, and Willson had promoted the use of electric arcs for street lighting in Hamilton, Ontario. Willson, however, was unsuccessful in his venture, and he set off to try his luck in the United States. He initially worked as an electrical inspector but experimented on the side with an electric arc furnace provided to him by the Eimer and Amend Company, chemical distributors in New York City, the forerunner of Fisher Scientific. Willson was particularly interested in reducing refractory ores—that is, hard to smelt ores—to their base metals in an electric arc furnace, and had secured a patent in



Figure I
Thomas Leopold Willson 1860 - 1915

in 1890 to the rights to the use of the electric arc for ore smelting. He especially thought that he could make aluminum by smelting bauxite, an aluminum ore, mixed in pitch—a source of carbon—to reduce the ore to the metal. Aluminum held great promise as a new metal. Charles Hall, while still at Oberlin College in Ohio, had developed in 1886 a successful process for electrolytically reducing bauxite to aluminum. Hall's success had set off a craze to find other ways to produce it. Whereas, Hall used electrolysis, Willson proposed and tried to reduce aluminum ore thermally, that is, by high heat, in an electric arc furnace. However, Willson's work in the laboratory was not particularly successful. Small bits of aluminum were produced but there was no flux to permit them to agglomerate. He thought that a larger scale of operation might turn the trick, but for that he needed capital and a source of power.

Spray Plant

Willson was acquainted with George F. Seward, president of the New York Fidelity and Casualty Company, and approached him for help. Seward was interested and brought in Major James Turner Morehead, a North Carolina entrepreneur, who owned a water-powered cotton mill in Spray (now Eden) North Carolina. Morehead had surplus water power available and was looking for ways to put it to good use. He was also interested in making aluminum. As a result, Seward and several others—including Eimer of Eimer and Amend—put up \$30,000, and with Willson and Morehead, formed the Willson Aluminum Company. Morehead was president, Seward was vice-president, and Willson was secretary.

Major Morehead's role in the venture was primarily that of fund raiser and entrepreneur. He also, of course, owned the plant site. Morehead was a member of a prominent North Carolina family—his father had been governor of the state—and he was a wounded veteran of the Confederate Army. He also had made a fortune after the Civil War in textiles and flour milling. However, he had gotten overextended building the Cape Fear and Yadkin Valley Railroad and had lost his money in the financial panic of 1888. He was holding on by the skin of his teeth at Spray and hoping to recoup.

Willson and Major Morehead went to work in 1891 at Spray to put together a facility to make aluminum. They hired John Motley Morehead, the son of Major Morehead and a recent graduate of the University of North Carolina, as the plant



Figure II
Major James Turner Morehead 1840 - 1908

chemist. They also hired a couple of local farm boys, Jesse King and Edgar Price, as operators, plus two laborers. Willson bought a 300-HP water wheel and designed and built a 35-volt, 2000-ampere water-powered alternating current electric generator. He also designed and built an electric arc furnace with a carbon crucible that was 20 inches in diameter and about a foot deep. It had a hollow pencil electrode that was one-and-one-quarter inches in diameter, and which could be moved up or down in the crucible on a screw to follow the mass that was being smelted. The other electrode was the crucible itself. The process was carried on in a batchwise manner.

Operations, or rather experimentation, started in 1892. To make a run, finely ground alumina was mixed with coal tar, the mixture was heated to drive off the volatile matter, and the resultant mass cooled and crushed to form a black powder. An arc would be struck in the furnace and the mixture slowly shoveled in. The pencil electrode would be raised as the mass liquified. When the furnace was full—about 35 to 40 pounds of mixture—the resultant mass would be held in a liquified state for about two hours. The mass was then cooled and removed.

The scaled-up process didn't work any better than it had in the laboratory. Without an effective flux, the small amount of aluminum that was produced remained dispersed in small globules in the furnace charge. Many tests were run without success. To defray expenses, Willson fell back on making aluminum bronze, which consists of about twenty percent aluminum and eighty percent copper. This was done by adding granulated copper to the furnace charge. Willson had earlier patented this process, but the market for aluminum bronze was small at that time and it could not support the operation.

Willson then came up with an idea that it might be possible to reduce alumina in an electric arc with an active metal like calcium. But first they had to make some calcium. So, on May 2, 1892, they set about in an impromptu fashion to make calcium in the electric arc furnace. First, they mixed sixty pounds of slaked lime—calcium hydroxide—which had been purchased to whitewash the walls of the building—with five gallons of coal tar. The mixture was then heated to drive off the volatiles, crushed to powder, and fed to the arc furnace. After two hours, the furnace was tapped and some of the melt ladled into a bucket of water to cool it. Gas and steam erupted immediately and exploded into flame, ignited by the red hot melt. Knowing that calcium reacts with water to produce flammable hydrogen, their initial reaction was that they had made calcium. Willson, who was in Asheville during the experiment, notified his patent lawyer in New York to that effect.



Figure III
John Motley Morehead 1870 - 1965.

The remainder of the melt was allowed to cool and was taken out of the furnace as a brittle, crystalline mass. Again, some of the cooled mass was dumped into water and again it erupted in gaseous bubbles. John Motley Morehead tied an oily rag to the end of a fishing pole, lit it, and swung it over the bubbles. Again the gas ignited, but it burned with a dense black smoke. Morehead was suspicious. He knew that calcium reacting with water would produce hydrogen which burns with a colorless flame. The black smoke was indicative of the presence of carbon in the gas. He took the crystalline material to his laboratory and analyzed it. In several days he had determined that it was, as he called it, the carbide of calcium, or as we know it today, calcium carbide. However, he could not identify what the gas was that was being given off when the calcium carbide was immersed in water. In any event, Willson applied for a patent in August of 1892 for the process for making crystalline calcium carbide. The wonder of it all was that, by chance and on the first try, they had hit upon the necessary conditions and proportions of lime and coal tar to make calcium carbide. (Later, coke was used in place of coal tar.)

Dr. Francis Venable, a chemistry professor at the University of North Carolina—and later president of the University—served as a consultant on the work at Spray. He took some calcium carbide back with him to Chapel Hill for further study. In the fall of 1892, a student assistant, William Rand Kenan, identified the gas given off by the reaction of calcium carbide and water as acetylene. He also observed that acetylene burned with a brilliant white flame, brighter than any other gas flame known, when properly mixed with air.

Calcium carbide and acetylene had been prepared and identified in 1862 by the German chemist, Friedrich Woehler, who had made it in the laboratory by heating a zinc-calcium alloy and charcoal. However, he had not produced crystalline calcium carbide and nothing further had been done since that time. Henri Moissan, a French chemist, had also independently made calcium carbide from lime and charcoal in an electric arc furnace at about the same time that Willson did. Willson was first, however, as corroborated by Professor Venable's work at Chapel Hill and by the dates of Professor Venable's correspondence about the invention with Lord Kelvin in England. It was also confirmed by the German Patent Office, which annulled Moissan's patent claims. Willson's United States Patent No. 541,138 for the manufacture of a new product, crystalline calcium carbide, was issued on June 18, 1895.

The discovery of processes to make calcium carbide and acetylene were momentous, but not a call for rejoicing. There was no immediate market for either with which to pay the bills. In the summer of 1892, John Motley Morehead, Edgar Price, and one of the laborers were laid off. The operation continued with Willson, Jesse King, and a laborer. Mostly they made aluminum bronzes and calcium carbide. John Motley Morehead was paid in Willson Aluminum Company stock in lieu of salary (apparently, he had continued to live with his father in Spray and thus had his room and board.) Morehead got a job first with a bank in New York, then with Westinghouse in Pittsburgh, and then served as a consultant. Price got a job with a railroad in West Virginia. Both would be gone for several years, but both would be back.

In the spring of 1893 the country had another financial crisis, and the Willson Aluminum Company was faced with failure. Major Morehead was sold out by his creditors and was left owing \$200,000. However, he was allowed to continue the smelting operation at Spray. He sought to sell the calcium carbide process and its patents in the United States, in England, and in Germany, but had no takers—not even for as little as \$5000. Willson went to New York and tried to sell calcium carbide. Finally, in January of 1894, Willson sold a ton of calcium carbide to Eimer and Amend, the chemical supply house that had provided some of the original backing for the venture at Spray. Eimer and Amend also provided support and facilities for Willson to develop chemical uses for acetylene, such as the manufacture of chloroform, aldehydes, and calcium cyanide. Unaware, however, of the explosive nature of compressed acetylene, they suffered an explosion and fire that destroyed their laboratory, which ended their experiments. Nonetheless, Willson applied for a patent in 1894 for the production of acetylene derivatives and for the use of acetylene as an illuminating gas.

In spite of his financial difficulties, Major Morehead was able to borrow more money and keep the Spray facilities going. He had a talent for being able to borrow money without collateral. He hired a Dutch chemist, Dr. Guillaume de Chalmot, in 1894 to improve the calcium carbide process and operations. Whereas most of the earlier work had been done on an empirical basis, Dr. de Chalmot brought a scientific approach to the process. He successfully improved the calcium carbide process and operations and also developed processes to make ferroalloys—ferrochrome and ferrosilicon—and silicon in the arc furnace. Indeed, de Chalmot, who died in 1899 at the age of 29, set the stage for commercial

entry into the manufacture of both calcium carbide and ferroalloys. His untimely death cut short a promising and significant career.

The Spray plant was rebuilt and enlarged in 1894. It had two arc furnaces, and had become the first commercial calcium carbide plant. Major Morehead and Willson continued to promote their product. Through Edward N. Dickerson, a patent lawyer, they met George O. Knapp of the Peoples Gas Light and Coke Company of Chicago, and they interested him in using acetylene to enhance the luminosity of town gas (water gas), which was a primary source of home lighting at the time. As a result, in late 1894, Knapp and Charles F. Dieterich—also of Peoples Gas Light and Coke Company—bought the Willson Aluminum Company's United States rights for manufacturing calcium carbide for illuminating purposes. They formed the Electro Gas Company to exploit the opportunity, which they did by selling franchises for district rights for manufacturing calcium carbide. One of the franchises was acquired by Major Morehead. All of the other rights relating to calcium carbide and the electric arc furnace, including chemical derivatives and metallurgical processes, were retained by Willson Aluminum. Willson personally retained all the rights for Canada.

The use of acetylene for lighting began to take off in 1895. The catalyst for the increased usage was the development by Dickerson, the lawyer, of a safe and effective means of compressing and storing acetylene and of practical burners for lighting purposes. The demand was great and acetylene lights were soon to be found on farms, on city streets, on bicycles, on railroads, and in mines.

Holcomb Rock and Glen Ferris Plants

The Spray plant burned in 1896 and was not rebuilt. Instead, Major Morehead built a new, 12-tons-per-day calcium carbide plant at Holcomb Rock on the James River near Lynchburg in Virginia. It was powered by a hydroelectric system that utilized an old dam that had been built as part of the Kanawha and James River Canal, which was now defunct. Guillaume de Chalmot was the plant manager, and under de Chalmot the plant thrived. He optimized a dozen or so variables in the process ranging from the type of lime used to appropriate voltages and amperages for the arc furnaces to the best size for calcium carbide ingots. He also continued to make and experiment with ferroalloys.

In 1897, Major Morehead built a second hydroelectric smelting plant at the head of navigation at the falls at Glen Ferris on the Kanawha River in West Virginia. However, this plant was dedicated solely to the manufacture of ferroalloys. The plant started up just in time to provide large amounts of ferrochrome to the U.S. Navy for armor plating ships during the Spanish-American War. The first superintendent of this plant was Thomas R. Ragland, Sr., who also had hired in at Spray.

Calcium Carbide Franchises

Electro Gas Company sold eight franchises for the manufacture of calcium carbide—five in the United States and three in Europe. Most of the franchisees failed, and the franchising business got a bad name. The only successful franchisees were Major Morehead with his plant at Holcomb Rock, the Lake Superior Carbide Company (formed by George O. Knapp of the Peoples Gas Light and Coke Company) which had a plant at Sault Sainte Marie in Michigan, and the Acetylene Light Heat and Power Company of Philadelphia, which had a plant at Niagara Falls in New York. The plant at Niagara Falls was viable, in part, because they had hired Edgar F. Price, who had been at Spray, as Superintendent. They also had hired Jesse King and William Rand Kenan, and John Motley Morehead was retained as a consultant.

A major breakthrough in calcium carbide manufacturing was made at the Sault Sainte Marie plant. William S. Horry, an engineer, invented a rotary furnace that produced calcium carbide on a continuous basis and reduced the cost of manufacture considerably. The new furnace needed less manpower to operate, but more importantly, it reduced the cost of electric power. Now power could be contracted for at a level needed to operate continuously, rather than at the higher level needed to support the old on-off batch process. A facsimile copy of a letter from Horry to George O. Knapp dated January 26, 1897 regarding work on a furnace is shown in Figure VI. This is the first known Research and Development report in Union Carbide's history.

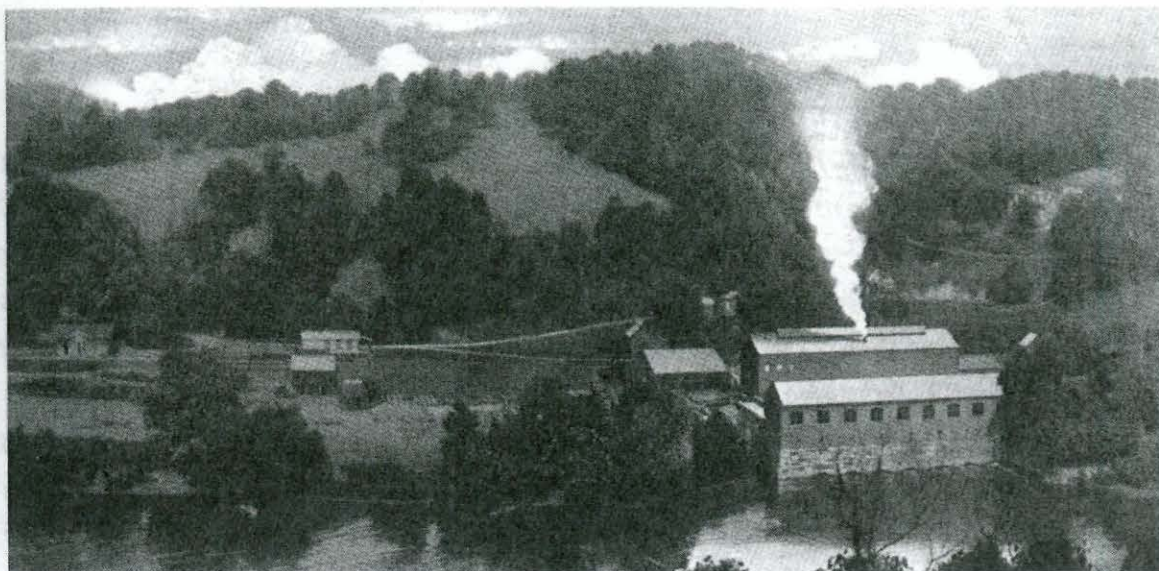


Figure IV
Former Willson Aluminum Company Plant
at Holcomb Rock, Virginia in 1929



Figure V
Electro Metallurgical Plant
at Glen Ferris, West Virginia in 1929

Union Carbide Company

Peoples Gas Light and Coke believed that there was more opportunity here than they had previously recognized. Therefore, they formed a new company in 1898 to take over the Electro Gas Company and buy out the surviving franchisees—the Lake Superior Carbide Company with its plant at Sault Sainte Marie, the Acetylene Light Heat and Power Company with its plant at Niagara Falls, and the Willson Aluminum Company, with its plant at Holcomb Rock.

They called the new company Union Carbide Company. The incorporators included George O. Knapp and Cornelius Kingsley Garrison Billings, also of Peoples Gas Light and Coke Company. Knapp later would be the first president of Union Carbide and Carbon Corporation. Billings, who was one of the richest men in America, later would be a chairman of Union Carbide and Carbon Corporation.

Electro Metallurgical Company

The capacities of the plants at Sault Sainte Marie and Niagara Falls were both expanded. Edgar F. Price, the superintendent of the Niagara Falls plant, had excess capacity and experimented with ferrosmelting, as de Chalmot had done at Spray and Holcomb Rock. He developed some patents and some facility in dealing with ferrosilicon operations and then sold an initially reluctant board at Union Carbide Company on getting into the metallurgical business. The first thing that they did, in 1906, was to form a subsidiary, the Electro Metallurgical Company, and buy out Major Morehead and the remainder of the Willson Aluminum Company. The facility that was involved was the plant at Glen Ferris, West Virginia. From that time forward, Union Carbide was in the ferroalloy business. In the process, Major Morehead got well financially. John Motley Morehead also benefitted substantially. He had received Willson Aluminum Stock in lieu of salary and had a large stake in Union Carbide Company. Union Carbide also bought out Thomas Willson's carbide interests in Canada in 1914. The Willson Aluminum Company, which never made any aluminum, was eventually dissolved (in 1916).

In order to secure the services of Dr. Frederick M. Becket, The Electro Metallurgical Company purchased the Niagara Research Laboratories. Dr. Becket had developed low-carbon ferrosilicon as an agent to replace carbon as the reducing agent in the manufacture of modern alloy steels. Dr. Becket became the

Jan'y 26 7

Geo O Knapp Esq

Dear Sir

The carbons arrived and the furnaces are running again— Yesterday (Monday) we made two runs with Charcoal, the runs extending over three hours. I think that the evidence is conclusive that we cannot use charcoal here. To begin with it is next to impossible to keep the building from catching fire when charcoal is used & on this account we had to stop running it. We have made very little carbide on these runs, less than one quarter the amount we would have made with coke. Then the sparks came out to a great distance (6 feet) when we opened the furnace door & this made stoking difficult. The Carbide is full of blow holes & looks very much like inferior coke Carbide.

We are running coke & lime now and will not try the charcoal again just at present.

The Pratt & Whitney Co's man is now here setting up the scales it is likely we may have to stop running for a day or so as we have to empty the bins.

I have ordered a shaper for two hundred dollars to plane up the carbons with as we cannot any longer depend on the Canadian machine shop for this work. Ordered from Pratt & Whitney a tool 30 days ago, second hand.

Yours,

Horry

Figure VI - Facsimile of first known R&D report, dated January 26, 1897, from William S. Horry at Lake Superior Carbide Company in Sault Sainte Marie, Michigan, to George O. Knapp in Chicago



Figure VII - Union Carbide Company Founders and Management Group at Niagara Falls Gorge in 1911

Front row (standing): 1) Unknown, 2) John Williamson, Chief Engineer of the Peoples Gas Company, 3) George O. Knapp, President of Union Carbide Company, 4) George O. Cox, Niagara Falls Plant Superintendent. Back row (seated): 1) Unknown, 2) Anthony N. Brady, Financier, 3) Edgar F. Price, Vice President of Union Carbide Company, 4) Cornelius Kingsley Garrison Billings, Founder, 5) Isaac R. Edmunds, Chief Engineer of Electro Metallurgical Company, 6) Chester T. Ayres, Works Manager.

chief metallurgist of the new company. Besides low-carbon ferrosilicon, the Electro Metallurgical Company also made ferrochrome and ferronickel for the manufacture of stainless steel and silicon for alloying with aluminum for use in the aircraft industry.

Union Carbide Company and the Electro Metallurgical Company both required large quantities of carbon electrodes for use in their smelting operations. These were obtained from the National Carbon Company. National Carbon had been organized in 1886 in Cleveland, Ohio, by Myron Herrick and W. H. Lawrence, among others, to make carbon electrodes for street lighting. Lawrence had earlier been associated with Charles F. Brush, who was a pioneer in the electric arc lighting business and had successfully demonstrated the first commercial electric arc light in Cleveland in 1876. The electrodes were made from petroleum coke, which at the time was a worthless byproduct of the Standard Oil refinery in Cleveland. Despite company lore, Brush's association with Union Carbide was not through National Carbon. Brush was involved later in the formation of the Linde Air Products Company, and his connection with Union Carbide and Carbon Corporation was through that route. (The carbon "brushes" in electric motors are named after him.)

National Carbon Company had gotten into the dry cell battery business in 1890. They made and marketed EVEREADY batteries first in the United States and eventually throughout the world. Dry cell batteries have a carbon rod at their core and that was the connection that took them into the battery business. In addition to being used in flashlights, dry cell batteries were widely used to power early telephones and then early radios. In fact, radio batteries became the driving force in the battery business. As an interesting sidelight, starting with radio station CKNC in Toronto, Union Carbide in Canada established a chain of radio stations in the 1920s and 1930s to stimulate the sale of radio batteries. At the outset of World War II, in 1939, the stations were being operated for Union Carbide by an American citizen. The Canadian government was not comfortable with that situation; therefore, they bought out the stations. This action provided Canada with the nucleus from which they formed the Canadian Broadcasting Company. It should also be noted that National Carbon's worldwide manufacture and marketing of EVEREADY batteries in the 1930s provided Union Carbide with a ready entry into overseas markets for other businesses.

National Carbon had been successful from the outset in the carbon electrode lighting business because they had produced a superior product (it was stronger and had a longer life). Now, to make a superior product for furnace electrodes, they acquired the Acheson Graphite Company. Dr. Edward G. Acheson had developed a process for converting carbon into graphite by baking it at high temperature. Graphite made a better electrode than carbon because it had better electrical conductivity and because it was thermally more stable.

Linde Air Products Company

In 1895, Henri le Chetalier, a Frenchman, determined that acetylene and oxygen burned with a very hot flame, hot enough to melt steel. In 1901, Edmond Fouche also a Frenchman, developed a practical blowpipe—or torch—for use in oxyacetylene cutting and welding. As a result of those developments, the demand by the metal trades industries for oxygen and acetylene increased dramatically. Oxygen, however, was not readily available in large quantities. It had previously been generated mostly by the electrolysis of water or by the decomposition of potassium chlorate.

In 1895, Professor Carl von Linde, a German physicist from Munich, developed a successful system to produce oxygen by the low-temperature liquefaction and rectification of air. Professor von Linde had been a pioneer in refrigeration and in 1873 had developed the first ammonia refrigeration machine, which was used to make ice. His cryogenic air liquefaction and separation invention exploited the use of the Joule-Thomson effect, in which a compressed gas cools itself when the pressure is released and it expands. He also used the technique of fractional (stagewise) distillation to separate the liquefied components of air.

Myron Herrick of the National Carbon Company was a personal friend of Professor von Linde. On a visit by von Linde to Cleveland in 1906, Herrick arranged for von Linde to have breakfast with a number of “captains of industry” and to tell them about what he was doing, about what was happening in Europe, and about the conditions under which he would be willing to transfer his rights. Afterwards, Charles F. Brush passed around a sheet of paper asking for signatures of those who would subscribe to buying the American rights to von Linde’s process. Thirteen of the fifteen present signed. The next day incorporation papers for the Linde Air Products Company were drawn up and the company was officially