A PATHFINDER

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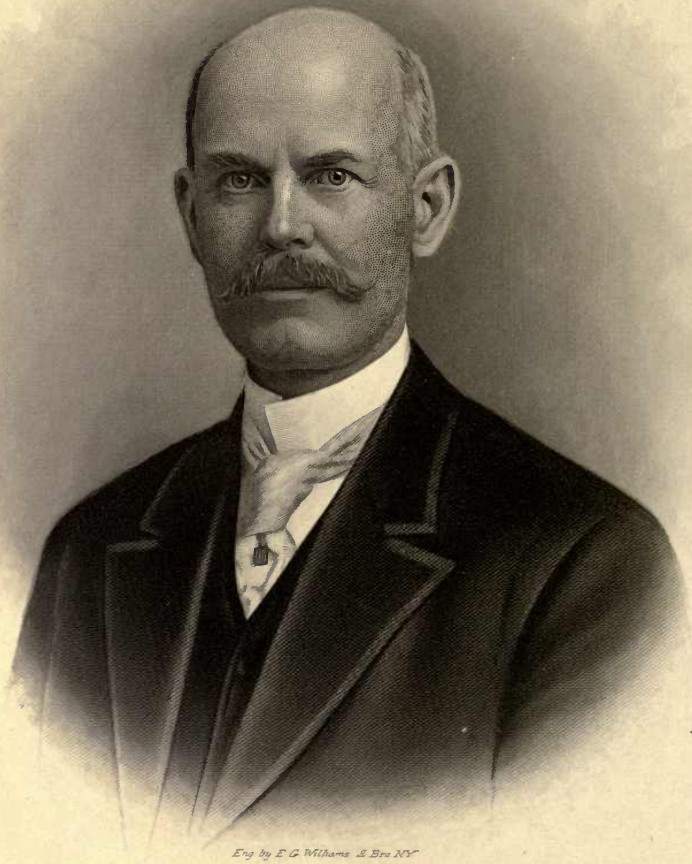

Eng by E.G. Williams & Bro NY

Edward G. Acheson

Acheson, Edward Goodrich

A PATHFINDER

DISCOVERY, INVENTION AND INDUSTRY

HOW THE WORLD CAME TO HAVE AQUADAG AND OILDAG; ALSO, CARBORUNDUM, ARTIFICIAL GRAPHITE AND OTHER VALUABLE PRODUCTS OF THE ELECTRIC FURNACE

THE FIRST OF A SERIES OF EDUCATIONAL BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS

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PREFACE

The subject of this work has for a number of years had in process of preparation a history of his life and work. It has not been his intention to publish it, his sole purpose being to record the events of his life for the benefit of his family and friends. Recently he permitted the publishers to read this autobiographical sketch, and in view of the prominence he has attained, we urged him to give, to the youth and young men of the country, this life-story, and with much hesitation he finally assented to such publication, and we here give it in his own words, with the belief that it may prove of very material benefit to many of the young men of the world, relating, as it does, his boyhood inspirations, struggles as a young man, contentions against many vicissitudes, his persistent dedication of himself to a fixed purpose, his final triumphs, and the acceptance of the results he has attained by the scientific and industrial world.

THE PUBLISHERS

DEDICATION

To Ambitious Youth everywhere, particularly those who need a realization of their own mental and physical ability, as well as a proper conception of the world's appreciation of accomplishment, to inspire them to their greatest efforts to win success, this modest work is dedicated. Should it be the inspiration that arouses one life and awakens it to its own possibilities guiding one to devote his life and efforts as a leader in the world's work, the object of its publication will have been effected.

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CHAPTER I

THE WORLD'S RECOGNITION

There's a divinity that shapes our ends,
rough-hew them how we will.—*Shakespeare.*

IT requires a most thorough knowledge and careful study of the lives of men, who have become eminent in various fields, to realize fully the force and truth of the above quotation. Could we but know the heart-secrets of men who have won renown for great works, we would learn that moving them irresistibly toward higher things was a prompting to which their inspiration responded. There is a wealth of enlightenment and education in reviewing such lives, and the presentation of the Perkin Medal to Dr. Edward Goodrich Acheson on January 21st, 1910, has brought into new prominence an inventor whose life work and achievements make a fascinating story. Twice has his scientific research won for him the John Scott Medal, presented by the Franklin Institute of

Philadelphia. The American Academy of Arts and Sciences has also awarded him the famous Rumford Medals. An additional great honor came to him when the University of Pittsburg recognized his work by conferring upon him the Degree of Doctor of Science. The award and presentation of the Perkin Medal came as a tribute of appreciation from fellow-chemists and electro-chemists of the United States, who thus frankly and generously recognized his position in the field in which he has so successfully labored.

The Perkin Medal was first presented to the noted English scientist, Sir William H. Perkin, in recognition of his services to art and industry in developing the uses of coal tar, for which he was also knighted by King Edward VII. It is a gold decoration given now yearly to the American Scientist who has accomplished the most valuable work in applied chemistry, and its presentation to Dr. Edward Goodrich Acheson by the unanimous vote of committees representing the Society of Chemical Industry, the American Chemical Society and the American

Electro-Chemical Society, showed marked acknowledgment and appreciation of the fact that Dr. Acheson ranks with the eminent of his profession, in the application of his talents and his energy and industry to the betterment of mankind, the advancement of science, and the improvement of the conditions under which we live.

The session of the Society of Chemical Industry, at which the presentation was made, was presided over by Maximilian Toch, Chairman of the New York section of the Society, and Professor C. F. Chandler, of Columbia University, made the presentation in the presence of about one hundred members and guests. Professor Chandler, speaking as a Past President of the Society of Chemical Industry, in reviewing Dr. Acheson's life work, said in part:

"Dr. Acheson possesses the rare merit of combining the inventive, the constructive, and the organizing faculties. He has been most successful in discovering entirely new materials suitable for a great variety of purposes, which have become indispensable to the world. He

has also been able to devise most perfect methods and appliances for producing his new products on a large scale, and to organize and finance great companies to put his inventions into successful operation.

"His efforts have not been directed merely to improving processes and products previously known. He has made entirely new departures and created new industries, supplied previously unknown materials for use in the arts and industries, and he has discovered uses for his new materials and processes for their application. He is a representative electro-chemical engineer, and it is eminently proper that he should have been selected by the great chemical societies of this country to receive the Perkin Medal."

Dr. Acheson, in accepting the Medal, said: "In the last quarter of the nineteenth century, the world was ready for another step forward in the chemical arts. It was ripe for the birth of a new industry until then unknown—industrial electro-chemistry. The field of research and development for the electro-chemist will be practically limitless, and will extend beyond

what the world is now considering—the 'conservation of natural resources'—for they will create valuable products from wastes not now dignified by the title of resources."

With a set of experimental apparatus set up in the room, Dr. Acheson, the discoverer of carborundum and artificial graphite, demonstrated some of his newer investigations and their wonderful results while the learned and distinguished audience looked on with deeply gratified interest. Dr. Acheson's discoveries of Oildag and Aquadag, attracted the closest observation and most earnest expressions of applause as well as surprise.

Dr. L. H. Baekeland, speaking as President of the American Electro-Chemical Society, said in part:

"What is more to the credit of Dr. Acheson than anything else, is the fact that he undertook experiments which probably had been attempted several times before, without success, by people who had more theoretical preparation than he. But his unusual keenness of observation, his logical faculty, and more than

anything, his appreciation of what was of preponderant importance, and of secondary interest, brought him results, where others had failed, and by which he opened a new field of chemical investigation and industrial applications.

"Dr. Acheson stands as a living example to many a chemist, loaded with theoretical knowledge and paper wisdom, and light in judgment or common sense. He entered into a new road with very little knowledge to guide him, but he had an open mind, a fertile brain, a constructive faculty, and the talents of the tireless, intelligent experimenter. Whatever he took up he started from the beginning, and developed to the end.

"His very failures were changed into victories through practical channels. His work on carborundum was initiated by an experiment so simple and so meagre in results, that few people would have found an incentive to further investigation. Later on, when in the manufacture of carborundum, he had to battle with irregularities, due to a partial dissociation of

the silicon carbide, he created a new industry, the manufacture of artificial graphite. In the same way, he gave us Siloxicon, a product which seems to have a considerable future.

"In constructing the great road of industrial progress, very few of us are pathfinders; some are surveyors, other ones constructors, others again are merely switchmen, a brakeman and conductors. Dr. Acheson not only was a pathfinder, but he has been a constructor, conductor, switchman—everything. By his manifold abilities and good judgment, he has been able to develop his discoveries into commercial successes. He has shown us that an inventor or a scientist is not necessarily a theoretical dreamer unfit for executive or practical work."

Dr. Wilder D. Bancroft, of Cornell University, speaking as President of the American Chemical Society, said in the course of an interesting and entertaining address:

"To make carborundum he needed electrodes, so he invented graphite. A suitable refractory was needed to keep the heat in the

furnace, and Mr. Acheson thereupon prepared siloxicon. The furnace had to have brick walls at first, and they were promptly forthcoming in the form of Egyptianized Clay. In order to keep everything running smoothly, including the three automobiles which he had acquired in the meantime, Mr. Acheson prepared the lubricating graphite which he has shown you to-night as Aquadag and Oildag. * * * * You may consider Mr. Acheson's discoveries as scientific inventions or as dividend payers. It makes no difference. They stand all tests, and they mark him as one of the great inventors of the world."

CHAPTER II

DR. ACHESON'S ANCESTORS

The Acheson family is of ancient Scottish origin, and the name is derived from a contraction of the baptismal name of "Archibald," in Scottish abbreviation "Archie." It was spelled in various ways in the early records of Scotland, appearing as Achinson, Akinsonn, Atkinson, etc. The name first occurred in Forfarshire, in the east of Scotland, and can be traced back to about the middle of the fifteenth century. At the close of that century, we find the spelling of the name definitely taking its present form, first as Achesonne, then in the course of two generations, abbreviated to Acheson. We find the Acheson's intermarried, about 1500, with the noble family of Grey, Alexander Achesonne, who married Isobelle Grey, having been direct ancestor of the family to which Dr. Edward Goodrich Acheson belongs. Alexander Achesonne was also progenitor of the noble

family of Gosford, whose genealogy is given in Burke's Peerage. The first baronet of the family was Sir Archibald Acheson, of Haddington, North Britain, son of Captain Patrick Acheson, of Edinburgh, and the sixth baronet, Sir Archibald Acheson, was elevated to the peerage of Ireland, July 20th, 1776, as Baron Acheson, and was made Viscount Gosford, of Market Hill, County Armagh, Ireland, June 20th, 1785. The fourth Earl of Gosford has been Vice-Chamberlain to Her Majesty Queen Alexandra since 1901.

The Goodrich family, from which Dr. Edward Goodrich Acheson is descended on the maternal side, is of English origin, and the exact date of the arrival of the first of the name in America is unknown. The family had already given distinguished names to American annals in the eighteenth century, several of its members achieving lasting fame in literature, theology, and the sciences, including astronomy and mathematics.

Dr. Acheson's grandfather, David Acheson, immigrated to America from Belfast, Ireland, and settled in Washington, Pa., at a time when

that extreme southwestern section of the state still had some of the old frontier associations and surroundings. Grandfather Acheson was gifted with a high degree of intelligence, energy, and enterprise, and was quick to comprehend the resources and grasp the opportunities of the growing state. He prospered in business and gained the esteem of his neighbors, who elected him to the legislature, to which he was three times re-elected. He founded a family which acquired great distinction in Pennsylvania. One of his sons, Marcus W. Acheson was Judge of the United States Circuit Court for the Third Judicial District, which includes the States of Pennsylvania, New Jersey and Delaware; another Alexander Acheson was Judge of Washington County, Pennsylvania, and another son, William Acheson, was the father of the subject of our sketch.

CHAPTER III

DR. ACHESON'S STORY—BIRTH TO SIXTEEN YEARS OF AGE

I was born in the "round corner" at the intersection of Main and Maiden Streets, in the town of Washington, Pennsylvania, on the 9th day of March, 1856, and was the sixth child and second son of William and Sarah Diana (Ruple) Acheson. My father was in the grocery business, his family living over and back of his store, and consisting of himself, my mother, one brother, William—eight years my senior—two sisters, Margaret and Ellen—six and four years my seniors respectively—myself, and two sisters, Jean and Belle, one and three years my juniors.

In 1861 our family moved to Monticello, situated on the Allegheny River, some forty-seven miles above Pittsburgh, and three above Kittanning, the County Seat of Armstrong County, Pa. The property and village of Mon-

ticello and a furnace located there had been purchased by an uncle and other gentlemen of Pittsburgh and my father. My father was made manager, and in view of the fact that his past life had not in any sense prepared him for that of a manufacturer, and more particularly an iron manufacturer, with its multitudinous ramifications, cares and responsibilities, I consider that his selection for so responsible a position was solely due to his sterling qualities of uprightness, energy, and all-around worth. He became successful as a furnaceman, the "Monticello Irons" made under his management attaining quite a reputation for high quality.

My boyhood days at Monticello were, as I remember them, one round of pleasure. I confined myself, however, to the strictly boyish pursuits; my Summer days being spent in fishing, boating, hunting, and spending many hours about the furnace, where I think I was somewhat of a favorite with the workmen. In the Winter I attended the "District School" conducted by one of the neighboring farmers.

I think it was in 1869 I went in company

with R. D. Laughlin, whose uncles lived at and owned Stewardson Furnace, situated some seven miles from my home, to a boarding school at North Sewickley, Beaver County, Pa. I remained there for one school year, and afterward went with young Laughlin to an Academy, sometimes called the "School in the Mountains," at Bellefonte, Centre County, Pa., situated in the midst of the Allegheny Mountains. Here I commenced my first real work at study. I was beginning to form some conception of what my future life might be. I had no taste for the languages, but much fondness for mathematics. I was deeply interested in geometry, trigonometry and surveying, and the following incident which occurred at the time of one of my visits at home during a vacation illustrates my mathematical tendencies.

At Monticello Furnace, there was a ferry crossing the river, the boat being attached by means of a moving wheel to a wire rope stretched across the river. I believe as the results of high water in the river and extra high chimneys, this rope caught upon the smokestacks of a boat and

fell across its deck. The captain of the boat had the rope cut in two with a cold chisel, thus effectually destroying it for further use in ferry work. It was at this time that I came home and the matter of determining the length for a new cable was under discussion. My geometry, trigonometry, and surveying being fresh in my mind, and believing that I had an opportunity for displaying my boyish knowledge, I secured the boards forming the head of a barrel, fastened them together by appropriate cleats to make a complete disc, graduated the edge into three hundred and sixty degrees, mounted on it a cross-bar with sights at each end, the whole being supported by a suitable staff. I laid off a base line on one shore of the river, and from the extremities measured with my crude theodolite the included angles between the line and the supporting point of the cable on the opposite side of the river and determined the distance between the supports of the proposed cable on the opposite sides of the river. You can probably readily imagine that neither my father nor others had much confidence in the result of my

engineering feat, but I remember that after the distance had been determined in some other manner, it was found that my calculations were approximately correct. This I look upon as my first practical engineering, and occurred, I believe, when I was in my sixteenth year.

During the Fall term in 1872, I was suddenly called home, my father having already anticipated the financial catastrophe that overwhelmed the country in 1873-4. This ended my school days. While still in my seventeenth year, and with practically but three years schooling, I found myself brought suddenly face to face with the necessity of making for myself a livelihood.

CHAPTER IV

SIXTEENTH TO TWENTY-SECOND YEAR

My first employment after this recall from school was that of time-keeper at the furnace. This permitted of my devoting considerable time to mechanical and other pursuits. My father took much interest in mechanics, and I can yet remember his suggesting to me that I devote my thoughts to the accomplishment of something of value. He pointed out the need of an improved means of drilling holes in the rocks and slates in the coal mines where blasting was required. He offered to meet any expenses I might incur in my efforts to perfect a boring machine. I set to work at the problem, and before me I now have the papers of a Caveat of the United States Patent Office issued to me under date of March 5th, 1873, for "Improvements in Process of Mining Coal, Ore, Clay, Etc." This notes my first entry into the United States Patent Office at the age of seven-

teen. I also have before me a full itemized bill of William Fisher of Pittsburgh, dated April 25th, 1873, for the labor and material entering into the construction of a Boring Machine I had him make for me. The total cost I find was $154.65; the bill being receipted June, 1873. The machine worked fairly well, but owing to my inexperience, I had designed it too heavy and it was cumbersome to handle. In 1886, I saw this same machine in a machine shop at Kittanning, where it was doing efficient work as a drilling machine.

In the early part of 1873, my father was taken seriously ill with heart disease, from which he had suffered for some years. He was finally relieved by death on the 20th day of June, 1873.

Immediately following my father's death, a great financial panic came down upon the country. The iron business was crushed by the depression. The company in which my father's estate was placed was carried into bankruptcy in 1874. All that was left to my mother and her family was a one-half interest in a coal property that my father and brother

had fortunately bought some years previously. Both my father and brother had transferred their holdings in this property to their wives, and the income from this was all that was left to their families.

I think it was in 1873, when seventeen years old, I made my first practical acquaintance with Electricity. I bought a number of cheap yellow metal watches. Fitting up galvanic batteries, I secured a number of my mother's silver forks and with them as anodes, silver plated the watch cases, and sold them at an increased price. When my mother's effects were divided among her children, my "anodes" were properly deducted from my allotment.

With my old relics, I found a notebook containing entries made in those boyhood days, and amongst them are a number of quotations from Shakespeare and other sources, which I think have had much to do with moulding my character. Here are a few of them:

"Speak sweetly, man, although thy looks be sour."

"There's a divinity that shapes our ends, rough-hew them how we will."

"Life's but a walking shadow."

"The worst is death, and death shall have his day."

"Hope to enjoy is little less in joy, than hope enjoyed."

I am somewhat uncertain of the dates of the various changes that I made during the next succeeding years, but I think the following history is, in the main, correct. In October, 1874, I went to Reynoldsville, Pa., where a brother-in-law, W. H. Smith, husband of my sister Ellen, was Engineer-in-Charge of opening coal mines and laying railroads to them. I was employed for a short period with his civil engineering corps, and then became a clerk in a dry goods and notion store in Reynoldsville. After a short service here, I was called back to Monticello, which had been leased from the assignees by the uncles of my friend, R. D. Laughlin, and they were engaged in converting a very large stock of Lake Superior ore and other supplies into salable iron. My brother, William, was managing the furnace for the Messrs. Laughlin, and I was placed in the general store as clerk.

When the stocks on hand were worked up and the furnace finally and for all time stopped

operations, I went to Emlenton, a station on the Allegheny Valley Railroad, where my brother-in-law, W. H. Smith, was then located as Engineer-in-Charge of the construction of a narrow gauge railroad from Emlenton to Clarion through a newly discovered oil territory. I was employed in various capacities in the corps. While there I met a gentleman by the name of Kendle from Buffalo, N. Y., who was representing parties owning a patented apparatus for regulating the supply of water to steam boilers, and for giving an alarm by whistle in event of the water becoming dangerously low in the boiler. I became much interested and believed the affair a good one. I brought the matter to the attention of a brother-in-law, Dr. T. M. Allison of Kittanning, Pa., husband of my sister Margaret, and induced him to join me in buying the right to the patent for Pittsburgh and the County of Allegheny, Pa. We paid one thousand dollars for this right, the Doctor loaning me the money to pay for my half. I went to Pittsburgh and established myself in a room on the second floor of a bank building at the corner of

Wood and Sixth Streets. The room to the best of my recollection, contained nothing but a washstand, an office table, two chairs and a cot, and served me as office and bedroom. On the glass in the door, I had painted the name of the firm—"Acheson & Allison," and the line of their business. As the results of strenuous efforts over much time, I secured orders for and placed two of the regulators, one in a machine shop and the other in a rolling mill.

Using my office as a bedroom, I took my meals at a restaurant, one of those where you get your meals by the card, each one being recorded by a hole in the pasteboard. Expenses went on without an income, times got gloomy, and I had contracted a debt with the restaurant keeper. Things were so desperate I resolved on a change. I went to the head office of the Allegheny Valley Railroad and inquired for Mr. Thomas M. King, General Superintendent of the Railroad. Mr. King had been entertained at my home and would know me by name. I saw him, told my story, and applied for a position. He told me to return at a certain hour the next

day, and if he were not in to have his Secretary call him by telegraph. I called as told and found him out. His Secretary called him up and found him at Parker Station. Mr. King asked that I call at his office the next day at a certain hour, which I did and learned from him I could have the position of ticket clerk at Parker, at a salary of fifty dollars per month, provided I furnished bonds for one thousand dollars. I thanked him, called upon my uncle, M. W. Acheson, then a prominent lawyer of Pittsburgh, afterwards Judge of the Circuit Court of the Third Judicial District of the United States*, stated my case to him and he went on my bond. I immediately reported to Mr. King and received a pass to Parker. I settled up my business affairs in Pittsburgh, which were largely covered by conveying my office and household effects to the restaurant proprietor for his account against me, and on the following evening I was in Parker, where I was duly installed in my new work.

I think it was early in 1877 that I went to Parker, which was at that time the centre of

* Died of apoplexy June 21st, 1906.

the then stirring petroleum country of America. A narrow gauge railroad ran from the Parker Station out to and through the oil country of Millers Town, Carns City, and adjacent territory. Great crowds of people would come in on this road and take trains on the Allegheny Valley Railroad, making my duties lively and strenuous.

Early in life I developed an acute pride and was quick to resent any accusation of dishonesty or evil intent. This was well illustrated by an incident which occurred here. One day several men came into the gentlemen's room in the station. I recognized them as lumbermen, who had probably come down the River on rafts of timber—a class of men usually rough and uncouth. One of them came up to the ticket window and bought a ticket to a point up on the Clarion River. After having left the window, he presently returned and accused me of having given him short change. I protested against his accusation, when he said, "It is all right for you to claim innocence, but I saw you take the bill from the change," or words to that effect.

The ticket window was fairly large and not protected, as is now the custom, with wire grating. Instantly my arm was outstretched and I struck the man in the face with my fist. A great turmoil ensued. The agent and clerks hurriedly locked all doors, expecting the raftsmen to make a general assault. Much to my gratification and the relief of the office force, the man whom I had struck presently returned and apologized, saying he had been mistaken, having found his change all right.

I think I remained at Parker about six months. I went to Pittsburgh on the last passenger train that passed over the Allegheny Valley Railroad before it was shut down by the great railroad strike of 1877. A general reduction of ten per cent. was made in the wages and salaries of the employes of the railroad; my fifty dollars was thereby reduced to forty-five dollars. The railroad station was on the East bank of the Allegheny River, while the city of Parker was on the West side. There was but one place for me to board—a hotel adjoining the station, and I was required to pay thirty dollars per

month. The balance out of my salary was not large and the end of the year 1877, saw me once more with W. H. Smith as a member of a Civil Engineer Corps in Bradford, McKean County, Pa. Mr. Smith was now Engineer-in-Charge of the construction of a narrow gauge railroad from Bradford, Pa., to Olean, N. Y. I had so far progressed in years and experience that I was made Resident Engineer of a Division from the town of Gilmore to the New York State line.

CHAPTER V

TWENTY-SECOND TO TWENTY-FOURTH YEAR

I look back on my life and experience while on this work with much real pleasure. Being but twenty-one or twenty-two years of age, with a strong, rugged constitution and unbounded enthusiasm, I was ready to meet and enjoy any hardships encountered. The country was wild, rough and heavily timbered. It was in the first acts of development into the most busy and bustling of oil territories. My boarding-house and headquarters were in a rough, frame house, little more than a shanty, in the forest not far from the New York State line. The house accommodated not only our engineering party, but a number of oil well drillers and teamsters. The first floor consisted of a small front room, containing pine benches and a wood stove, the time of year being Winter; back of that was a dining-room, with a long pine table and benches on each side, and still back of that, the kitchen.

My bed consisted of a rough board box filled with straw in a room over the front room downstairs; the stovepipe from the wood stove passed up at the foot of my bunk and out through a large hole in the roof. At night the fire went out and many mornings I have awakened and found a tolerable good coating of snow on my bed coverings, it having entered through the large opening around the stovepipe where it passed through the roof. Along the house, outside of the front door, was a shelf or bench on which were tin basins to be used in washing; the necessary water was obtained from a brook passing the door by breaking the ice covering it.

On the completion of the railroad construction, I secured a position as tank gauger with the United Pipe Lines Company in Bradford. The United Pipe Lines Company was a sub-company of the Standard Oil Company. They had a great network of pipes throughout the oil territory. These pipes were connected to the oil tanks at the wells and conducted the oil to large storage tanks located at convenient shipping points. A tank gauger's duties were to

ride about the country, usually on horseback, and, with a steel tape line, accurately measure the depth of the tank, its circumference at various points between its top and bottom, these varying owing to the tank being smaller at the top than the bottom; note was also made of the thickness of the staves forming the tank, and, if any, how much and where, supports and cross-pieces, known as "dead wood," were placed inside of the tank. These measurements and information were entered in a note book and transcribed in the office in Bradford; and from them, Mr. R. M. Sayer, the Superintendent, and his sister as his assistant, calculated out a skeleton of a table of capacity for the tank measured, which was identified by a number the gauger nailed on it after measuring.

The skeleton for the table of capacity, as prepared by the Superintendent, was handed to one of the gaugers and with it as a basis, he prepared and filled out a complete table, this work being done by him after he returned to the office from his field work, and for it he was paid a certain price per table. I found this work very

much to my liking and quite remunerative, receiving three dollars per day for gauging, and sometimes making as much as six dollars extra by filling out tables. I became quite expert in making the tables, and made a rather good, clear figure. This evidently impressed the Superintendent, for, wishing to have some tables used by him and his sister in calculating the skeleton tables, made in the new, he set me to work copying them. They were very extensive, consisting of a great mass of figures. There was absolutely nothing about them that would inform one how they were made, nevertheless they excited my curiosity and made me envious of the superior knowledge of Mr. Sayer.

Here my restless, inquisitive nature asserted itself and I commenced the calculations for, and construction of, a set of tables from which to rapidly compute the capacities of tanks. To put them in a permanent form, I sent to New York and had a very handsome, strong, leather-covered book made. The book is now before me and on the fly leaf is printed:

Tank Gaugers' Pocket Tables.
Circumference and Diameter of Circles,
Barrels per Inch, Deadwood Tables, Etc.
E. G. ACHESON,
Bradford, Pa., August 1, 1878.

Each page is ruled and appropriate headings printed. It contains about six hundred pages and I had filled about one-third of it with the results of my tedious calculations, when Mr. Sayer learned of my work upon it and discharged me.

Settling up my affairs, I took a train for Monticello where my mother and two younger sisters still lived. On the train I found Mr. Daniel O'Day,* Manager of the United Pipe Lines Company. I related my story to him, and he told me to return to Bradford, and on his return he would investigate my case.

Not long after my return home, I suffered the greatest loss of my life—the counsel and guiding spirit of my mother, who died November 13th, 1878, after having been for several years a patient, uncomplaining invalid. It is to her guiding spirit I owe my fixed purposes in life

*Died September 13th, 1906.

and many, if not all, of my almost miraculous escapes from the snares which beset my way as a young man.

My two sisters, Jean and Belle, wished to go to the Seminary at Washington, Pa. I concluded to go with them to Washington, with the hope of obtaining a position on a Civil Engineering Corps, which was about to take the field for the preliminary survey of a proposed railroad to be called the Pittsburgh Southern, which was to run south from Pittsburgh to Morgantown, West Va. I secured a position on this work, a Mr. McConahey was Chief Engineer of the Survey, and I was appointed his First-Assistant.

I think the surveying party left Washington, Pa., for Morgantown, West Va., on December 31st, 1878. We went by narrow gauge railroad to Waynesboro, and there, being a heavy snow on the ground, by sledges to Morgantown. When on the hill, overlooking the Monongahela River and still some five miles from Morgantown, our sledge broke down. The night was bitter cold, I remember the thermometer stood

at zero. I was taken with severe pains in my stomach. This, I think, was the beginning of the stomach trouble from which I suffered for many years. When our sledge broke down, it was late at night and impossible to obtain a suitable conveyance. Our party of fifteen started to walk. My pains increased and between two of the axmen of the party, I was partly carried to Morgantown, where we arrived at two o'clock in the morning. Shortly after arriving, the pains increased beyond my endurance, and I was given a hypodermic injection of morphia. I remember I slept for something like twenty hours, and remained confined to my room for seven days. I then took the field, and, with the transit at the head of the party, run a line towards Pittsburgh for eighty-five miles, tramping continuously in snow.

After the completion of this survey, I left my sisters in Washington and returned to Bradford and was put back on the force of Tank Gaugers, having agreed to the demands of Mr. Sayer that I give up, while in his employ, the book of tables I was making, cease to work upon

the subject, and work in an outlying territory with the town of Duke Centre as my headquarters. I went to Duke Centre and had as a co-worker, a man by the name of Bates. After being there some weeks, I became restless and could not resist the temptation to occupy my evenings on my old line of calculations. Not long after this, I was called in to Bradford by Mr. Sayer, and there told that Mr. Bates had picked up a piece of paper from the floor of the room we jointly used as an office, had brought the paper to Mr. Sayer, and he recognized my writing and figures, and also that the figures on the paper indicated I was once more calculating out my tables. I acknowledged he was correct, and was removed from Duke Centre to Bradford where I was confined to making out tank capacity tables from the skeletons prepared by Mr. Sayer or his sister. For this work I was paid by the piece, and I noticed there was a gradual falling off of the amount allotted to me. The evident intention of Sayer was to starve me out. At this time Mr. Sayer got married and went on a trip with his bride to Lake Chautau-

qua, leaving in charge of the office a Mr. King, one of the gaugers. Mr. Sayer's sister performed all the calculating relating to the small oil tanks employed at the oil wells, but the field measurements of the large iron storage tanks of the Pipe Lines Company were forwarded to Mr. Sayer, who made the calculations and returned the results to the Bradford Office.

It happened one morning, after I had completed the meagre work that had been allotted to me, I went out on the street and up town, returning about noon to see if there was more work to be had. I found the office in a great uproar. A large iron storage tank had been completed somewhere in the territory the previous day, the field measurements taken and sent forward to Mr. Sayer. Immediately after being measured, the tank was partly filled with oil and the Bradford Office wished to know the amount of oil it contained in order to report it to the head office at Oil City. Mr. Sayer's calculations would not return until the following day. While I was in the office, Mr. Snow, the Superintendent of the United Pipe Lines, came

in and asked me if I could calculate the capacity of the tank. I answered "Yes." He said to proceed; I did. The tank held approximately twenty-five thousand barrels of oil. My figures were used that evening to report to Oil City. The next day Mr. Sayer's figures arrived and were found to differ five barrels from mine. Mr. Sayer was advised of the discrepancy and by return mail acknowledged he had made an error of five barrels in his calculations. He was removed from the superintendency. Had I been older, I probably would have been made Superintendent of Tank Gauging, but, under the circumstances, an experienced man was brought from the Parker field for the position and I was moved into the offices of the United Pipe Lines and made assistant to Mr. Charles R. Huntley, who was in charge of the department known as "Oil Freshening," i. e., the collecting of the storage dues from the operators and issuing certificates that no charges stood against it. Mr. Huntley has remained a friend ever since. He is now identified with many industries in and about Buffalo; the General Manager of the

Buffalo General Electric Company, and a Director of the International Acheson Graphite Company.

While in this position I received seventy-five dollars per month, and during my spare time I became much interested in scientific subjects, particularly electrical ones. I was a constant reader of the "Scientific American," the leading or only publication of the times keeping in close touch with the rapidly expanding electrical field, such as the telephone and Edison's work on lighting. My studies were much stimulated by close association as room-mate with a Mr. Kuno Kuhn, who was the Superintendent of a large oil company, and a man well informed on scientific subjects. I devised plans for a small dynamo and had one built in a local machine shop. It was faulty in design; the bearings were too light and the workmanship on it was not good. The armature struck the field and I could not make it work.

I became so much enraptured with electrical work that I concluded to sever my connection with the United Pipe Lines and seek an opening

in that field. I notified the Pipe Line officers of my intention. They tried to dissuade me by offering to increase my salary to ninety dollars per month. Their efforts, however, were without avail, and I left, I think, late in the Fall of 1879, going down to Monticello, where my brother still lived. He, my sisters and friends, opposed my going to New York to look for electrical work, as was my intention. I was persuaded to join my brother in the business of mining iron ore. My two younger sisters, Jean and Belle, and I started into housekeeping, I spending my time superintending about sixty men mining iron ore at various mines located on the Allegheny River and Red Bank Creek.

While some profit was derived from the ore mined, it was largely expended and lost in searching for deposits that were not remunerative, or failed to exist at the points where openings were made.

By the Fall of 1880, I had concluded there was no promising future in the iron ore business in the Valley of the Allegheny, and once more became restless to go East and cast my lot with

the electrical industry. I wrote to Mr. Edward Weston of Newark, N. J., for a position. Dr. Weston, now the manufacturer of the well-known electrical measuring instruments, was then a large manufacturer of electro-plating dynamos, which was at that time one of the foremost departments of electrical work. He replied that he could not offer me employment. This did not quench my desire and determination.

CHAPTER VI

AT MENLO PARK

My sisters and I broke up housekeeping. They went to Philadelphia to attend school, and I, with a new suit of clothes on my back, which I still distinctly remember, and one hundred dollars in my pocket—my return from ore mining—started for New York, a City I had not up to that time seen.

I stopped off at Newark and called on Mr. Weston. When he came into the office of the Works in answer to my card, which had been taken to him, he exclaimed at once, "I wrote you I could not give you employment." I replied I knew that to be the case, but I came on nevertheless.

I went on to New York City. I called at all of the electrical establishments whose names and addresses I could find,—the medical battery manufacturer's predominating. I came near getting an opening at the Western Electrical

Works, which made telegraph instruments, etc. When I called there, I was told they were in need of a young man to test instruments, that a young man had already applied for the position, and in case he was not on hand the next morning, I could have the place. I returned early next day and to my sorrow was told the young man had reported. I remember this was on Saturday. I was getting desperate. Edison and his laboratory at Menlo Park were then much in the public eye. I had little hope of securing an opening there, but, as a desperate, final resort, took the train out to Menlo Park. I climbed the low hill from the station, entered a small brick building in the corner of a large fenced inclosure. The building contained the office down stairs and Edison's library up stairs. I handed my card to a boy in the office with the request to see Mr. Edison. He took the card and disappeared, presently returning, he opened a small wicket gate and inviting me to enter, conducted me out of a rear entrance of the office, across a vacant lot and into a long two-story frame building. He took me upstairs and into a room cov-

ering the entire second floor containing a number of long pine tables, the walls being lined with shelves holding bottles. At one of the tables sat three men, the centre one in a colored calico shirt, without coat, was introduced as Mr. Edison. The one on his left I knew afterward to be Mr. William J. Hammer, and the one on the right as Mr. Francis R. Upton. Mr. Edison, placing one hand to his ear to indicate I should speak loudly, asked, "What do you wish?"; I replied "Work." He replied, with perhaps impatience, "Go out to the machine shop and see Krussi," and returned to the work absorbing his attention. Mr. Hammer kindly told me to go down stairs, pass back through the laboratory, cross the yard to a one-story brick building and inquire for Mr. Krussi, who was the Superintendent.

I followed Mr. Hammer's directions and entering the machine shop, found myself in a small office, almost completely filled with a large draughting table, over which a man was working. An attendant received my inquiry for Mr. Krussi, and while he was gone I was very

busy preparing myself, loading my gun, so to speak. The draughting table inspired me. I had, had some experience using the tools of a draughtsman in my civil engineering work. Presently a tall, foreign-looking gentleman entered and asked me what I wanted. This was Mr. Krussi. On the spur of the moment, I am afraid I told a white lie. I replied, "Mr. Edison sent me to you for you to put me to work." "What kind of work?" he asked; "Draughting," I said. "All right," he replied. "Mr. Hornig needs an assistant. Can you report for duty Monday morning?" I assured him I could. So it happened that the 12th day of September, 1880, while still in my twenty-fifth year, saw me installed in Mr. Edison's employ at Menlo Park, N. J. Mr. Krussi soon learned of the deception I had played upon him, and held me under suspicion for a long time.

Menlo Park, in the Fall of 1880, was composed almost entirely of Edison's interests. There was the Pennsylvania Railroad station, a hotel, at which I boarded, the homes of Mr. Edison, Charles Batchelor, and Francis Upton

three or four boarding houses, Edison's laboratory, office, machine shop, and a new building to be used as a lamp factory, the first of its kind ever constructed. There were probably two hundred men employed in the Edison works and great activity existed. A few days after I was at work, I took up the subject of perfecting the small dynamo I had made while in Bradford. I found it so faulty that I concluded to build a new one. I had the necessary iron castings made at Newark, and with the help of a co-worker, Martin Force, to set the tools in the lathe, I worked in the machine shop at night, where I was permitted the use of the tools. Mr. Edison several times stopped at the lathe at which I was working and watched me intently. I presume he had forgotten me and had to inquire who I was. Edison was then but thirty-three years of age, although world-renowned by reason of his great telegraph inventions. The World was at that time looking expectantly to Menlo Park for the solution of practical electric incandescent lighting. After I had been at Menlo Park long enough to feel at home, I

showed Edison the small dynamo I had made at Bradford and asked his opinion of the ideas involved. He said it was like the one designed by Siemens, and told me to go over to his library and get from Dr. Moses, the librarian, a certain book in which I would find a machine like mine described. I did so and found, as he had said, Siemens' dynamo almost exactly the same as the one I was working on. I remember the book contained a photograph of the machine, and it was a fair picture of my own machine, design of the frame and all. I then changed the design to that of a rotating transformer.

Shortly after this personal acquaintance was formed with Mr. Edison, I was transferred from the position of Assistant to Mr. Hornig, to the drafting room devoted to making the drawings for Mr. Edison's patent applications and more special work in which Mr. Samuel D. Mott was principal draftsman.

Mr. Edison was at this time working upon an electric meter to be used in connection with central station distribution. I became acquainted with the requirements of the case and

the urgent need of such an instrument. What appeared to be a happy thought occurred to me for the method and design of a meter. I made a drawing of my proposed instrument, and the next time Edison came into the room, I showed it to him. He seated himself on a high stool at the drawing table, put his arms on the board and his head, face down, on them, and seemed lost for some time in thought. After some minutes he raised his head and addressing me said, "I do not pay you to make suggestions to me how do you know but I already had that idea, and now if I use it you will think I took it from you." I assured him I considered anything I could produce while in his employ and pertaining to his interests, belonged to him; that my thinking on those lines was due to my being in his laboratory and cognizant of his needs and lines of work. He made a test of my meter scheme, and, notwithstanding it looked so feasible, it proved a failure. Immediately after this incident, I was taken from the drafting room and placed in the original experimental department. I was now in my glory. I had a large

room under my supervision, equipped with all the conveniences required, balance room, muffle furnaces, air pressure, gas, electricity, steam bath cabinet, etc. I was thrown into association with most agreeable companions. I, at this time, formed a close friendship with Dr. Edward L. Nichols, who had recently returned from Europe where he had followed an extensive course of study in the foremost universities of the Continent. He was at this time doing special scientific work for Edison. The Doctor is now Professor of Physics at Cornell University. I made a number of special investigations for Edison,—especially on the filament for the incandescent lamp. I had every opportunity to use my inventive faculties.

I think it was in the following December that I was one day called by telephone to go down to the new lamp factory and see Mr. Edison. When I arrived at the factory, I found Mr. Edison, Francis R. Upton, Charles Batchelor, and Edward H. Johnson in conference; these three gentlemen were partners of Edison and looked after various departments. I was

ushered into their presence, and Edison informed me that Mr. Batchelor, who was in charge of the construction, development and operation of the lamp factory, was soon to sail for Europe to prepare for the exhibit to be made at the Electrical Exhibition to be held in Paris during the coming Summer, and that he wished me to take charge of the factory. I demurred and said I would much prefer to remain in the laboratory on experimental work. He said that lamp manufacturing was still experimental, and he was kind and frank enough to say he wanted me to take hold of it because I was a thinker. He won the day and under Mr. Batchelor's instructions I began my duties. I think it was the third or fourth day after I had been there, that the following conversation occurred between Batchelor and myself. "Mr. Batchelor, how much am I to get here as salary?" I asked. "How much have you been getting at the laboratory?" he answered. "I was getting seven dollars and fifty cents per week." "Well, I think we can do a little better here," he said. "You will have to pay me one hundred dollars

per month if you wish me to remain. I was getting seventy-five dollars and could have had ninety dollars per month from the Standard Oil interests, but I threw that aside to enter experimental work," I replied. "That is more than we can afford to pay," he said. I told him I was of the same opinion, owing to my inexperience, but he would have to excuse me from continuing. I did not return the next day. Mr. Upton, against his will, was required to take charge and relieve Mr. Batchelor.

I sat around my boarding-house for several days and spent most of the time wondering if I had made a mistake. Finally I brought my courage up to the point of walking up to the laboratory. When I entered I met Edison, and he laughingly joked me about not being able to stand the work at the lamp factory. Then he said, "There in the end of the room is an hydraulic press; have it put in order, and make for me a small graphite loop like this (making a sketch like a horseshoe). I want the loop one inch outside diameter, the filament to be twenty-five thousandths of an inch wide and two thou-

sandths of an inch thick. I will have steel plates made for you to press sheets between and a die made for punching out the filaments. When you make one capable of mounting in a lamp, I will give you a prize of one hundred dollars." All of which was done as he wished, and I received the one hundred dollars. I find I now have in my safe an ordinary visiting card on which is pasted one of these graphite loops, and on the card is written:

"Menlo Park, N. J., Feb. 11, 1881.

Hydraulic pressure one hundred tons. (This referred to total pressure on a sheet of graphite about one and three-quarters inches by four inches from which the loops were punched.) Thickness fifteen ten-thousandths of an inch. This loop won one hundred dollars as a prize; the prize being offered by T. A. Edison to the undersigned,

E. G. ACHESON."

Mr. Edison then entered into an agreement with me to make thirty thousand of these filaments. I engaged a man and a boy to help me, and became so expert at making them that I was earning twelve dollars per day by the time sixteen thousand had been turned out. Edison,

at this time, was occupied in New York, building the first electric lighting station in Pearl Street. The filaments I was making of graphite produced a magnificent light, but they did not last long in use, disintegrating rapidly. I had made sixteen thousand of them and then went to Mr. Upton and told him that I was not happy in making an inefficient article, notwithstanding I was realizing, for me, a great deal of money. I considered it a waste of money and would much prefer to throw up my contract. He wrote to Mr. Edison about the matter, and in a few days I received the following letter:

"New York, April 20, 1881.

Mr. E. Acheson,
Menlo Park, N. J.

Dear Sir:

You had better go into the lamp factory and learn the lamp business in all its details.

Yours truly,
Thos. A. Edison."

I at once knew this meant my preparation for a sojourn in Europe as expert in electric lamp manufacturing. I now returned to the lamp factory, which I had a few weeks before

left, but under very different auspices. I went through all of the departments, learning to do the work with my own hands. The filaments were then made of bamboo. I fashioned the wood fibre, carbonized them, mounted them on their platinum wires, which I had sealed in glass, for the base of the lamp, called "inside part." I sealed the "inside part" into the glass globe, exhausted the air from the lamp, sealed and tested it and prepared it for shipment. I studied the details of the various machinery and apparatus of the factory, and made myself competent to construct and operate one. My relations with Edison at this time may be gathered from the following letter:

"Menlo Park, N. J., May 2nd, 1881.

Mr. E. G. Acheson:

Please come up to the laboratory and bring one of those nickel molds in which they bend the fibre to carbonize it, and press a piece of plumbago the thickness of the mold. It is, I believe, one-eighth of an inch and then hollow it out for the nickel piece to allow the carbon to draw up. After you have got it, have Dr. Haid pass the gas over it. I want to see if we cannot make these little plated molds out of plumbago using

the nickel piece to put straight on the fibre. If we could use these, it would save a great deal of money. Also try some experiments on getting the best mixture of litherage and glycerine, also the right proportions of plaster of Paris for the sockets of the lamps.

We are lame on these points.

Yours,

Edison."

While I was thus preparing myself for the specific work of electric incandescent lamp manufacturing, I was at night diligently at work studying electrical distribution, measurement, and the science generally. At this time the literature devoted to electrical science was limited. I have here before me a book to which I owe much; it is certainly dry reading, but I worked hard over its contents. It is entitled "Reports of the Committee on Electrical Standards, appointed by the British Association for the Advancement of Science," published under date of 1873.

After I had fairly well mastered the lamp business, Edison had me prepare a complete set of instruments for measuring the efficiency of lamps. These consisted of a Rheostat, Con-

denser, Galvanometer, Standard Cell, Resistance Coils, Wheatstone's Bridge, and Photometer. This last mentioned instrument was the only one built under my supervision and according to my design. A description of this Photometer is given in the volume "Dynamo-Electricity" by George B. Prescott, 1884.

CHAPTER VII

IN EUROPE

Everything possible having been done to prepare for a very complete exhibit of Edison's electrical inventions at the coming International Electrical Exposition in Paris, and it having been decided I should go over as First Assistant to Mr. Batchelor, who was Chief Engineer and Edison's representative, I sailed out of New York Harbor on board the French liner "Amerique" on the 20th day of July, 1881,—nine months and eight days from the day I entered Mr. Edison's employ at Menlo Park.

Mr. Batchelor, his wife, and two little daughters were on the vessel. I enjoyed the voyage immensely. This trip is memorable, not only as being my first experience on the ocean, but more especially for the formation of the acquaintance of two gentlemen, who have always since been close friends. One was Mr. John S. Huyler, a confectionery manufacturer of New York, who

was making his first trip to Europe for the purpose of studying the business in its cities, and the other was Mr. Frank L. Freeman,* a patent lawyer of Washington, D. C., who was going to Paris as a United States Commissioner to the International Electrical Exhibition. Mr. Freeman has since procured for me thirty-nine United States Patents.

At the Exposition I was First Assistant, but had charge particularly of the testing apparatus. Edison's exhibit contained the only complete set at the Exposition. An International Committee composed of Mr. William Crookes, now Sir William Crookes, Major R. Y. Armstrong, both of England, and Prof. G. F. Barker of Philadelphia, was appointed to determine the relative efficiencies of the incandescent lamps exhibited. These comprised those of Edison, Maxim, Sawn and Lane-Fox. Mr. H. Crookes, son of Sir William, and I assisted in making the measurements.

Mr. Edison's interests were in charge of Mr. Batchelor, myself and four assistants, amongst whom was a Mr. James C. Hipple, who had come

* Died March 5th, 1907.

over from Menlo Park as a special expert in the glass working of the Edison lamp. He and I became closely associated, and many years afterwards he was employed by me in my Carborundum interests.

At the close of the Exposition, I and the rest of the Edison staff transferred our attention to the construction of machine shops and lamp factories at Ivry-sur-Seine for the Society Edison Continentale of Paris, France, a Company formed to operate the Edison patents in Europe. While devoting the most of my time to the factory building, as occasion would permit, I was sent out to install small lighting plants in other countries. These plants were used as exhibits and formed the basis for the formation of companies to work the Edison patents. My first experience of this kind was the installation of electric lights in the drawing-rooms of the great Scala Theatre of Milan, Italy. Then I installed a plant in a museum in Brussels, Belgium; afterwards started off an installation in the Hotel de Ville, Antwerp, Belgium; then an installation in the Restaurant Kramopolsky, Amsterdam,

Holland. These were the first in these several countries.

It was while building the lamp factory at Ivry that Nicola Tesla first came into my life. Tesla was a Montenegran, had received a fine education and had been employed in Budapest on telephone work. A Mr. Puskus, a Director of the Paris Edison Company, was interested in the Telephone Company of Budapest and brought Tesla to Paris. He was placed with me and it was my business to inform him in the electric lighting business. He progressed rapidly, and, in after years, became world-famous for his schemes and inventions.

After the season closed at the Scala Theatre of Milan, (this Theatre only remained open for two months in the Winter of each year) the installation I had placed in it was to be moved over to the Cafe Biffi in the Galleria Vittoria Emanuele, the engine and dynamo which I had placed in the Royal Entrance to the Theatre were to remain where I placed them. I was at this time in Amsterdam and an engineer by name of Seuble was sent to Milan to make the change.

One day when in Brussels I received a telegram from the Paris office to report there prepared to go to Italy. I immediately took the train for Amsterdam, got together my effects, and returned through Brussels to Paris. Here I learned the lights in the Cafe Biffi had failed; why, no one knew. Having originally put the plant in the Scala, I was well acquainted with its details. I knew the field in the dynamo to be crooked and I suspected Seuble had overloaded the dynamo, which had a capacity of sixty lamps. I reasoned the armature of the machine had been overheated, rubbed the field and stripped the wires off. There was in the Paris factory what was called a boring bar, for boring out the fields of dynamos, and I took this heavy piece of machinery with me in the passenger coach, over the Alps, into Italy. On arriving in Milan, I found the dynamo just as I had expected, Seuble having overloaded it. I bored out the field, re-micaed the commutator, connected up the windings, and, I think, in three days had the lights going in the Cafe Biffi. I

was expected to return to Paris after the Italian interests were put in order.

An Edison Company had been formed in Milan, with Professor Columbo as President. This Company wished me to remain with them and asked me to make them a proposition. If I remember correctly, I was then getting a salary of one hundred and fifty dollars per month from the Paris Company, and I told the Italian Company I would remain as their Engineer at a salary of three hundred dollars per month. They accepted my terms. When the news of my action reached Paris, a Mr. Baily, who was Managing Director of the Paris Company, wrote to me demanding that I sever my connections with the Milan Company, return to them the excess in salary I had received and return to the employ of the Paris Company. He also wrote Professor Columbo to discharge me. When this letter was received, I was installing a plant at Bergamo. I also had a letter from Professor Columbo in which he advised me to pay no attention to the requests of Mr. Baily. However, I wrote Mr. Baily that I would remain with the Italian Com-

pany. Shortly after this Professor Columbo went to Paris and from there to America with Mr. Baily. The following letter was written after Mr. Baily had boarded the steamer and mailed at Queenstown:

"S. S. 'Arizona,' 5th Aug. '82.

My dear Acheson:

I was too busy to write you the last few days I was in Paris. Mr. Columbo is with me, as you know probably. Referring to your letter, you will find your interests advanced by following the counsel I give you,—to not think of treating on your own account. You have experience enough to understand that our Cie Continentale will always have more consideration with the Italian or any other company it may be allied with than you or any other individual can have. Do not try to go too fast, because at the end of six months from now you will not be so far advanced as you would have been by using a little more patience. You must be content to grow with the affairs you are with and as it grows. Your path has widened out somewhat, as I told you it would, and it will continue to widen if you show yourself equal to the situations you are placed in, and do not make it impossible by impatience for those to serve you who would. You ought now to put yourself to instruct with all your might and cordially, the persons put

with you to learn, in making installations and running wires. You are disposed to be constipated on this I think, and don't let yourself out enough. It isn't what is in a man but what gets out that makes an impression on the world. The work I have spoken of above is your work for *now*, but if you act wisely you will have more important work two months hence. Try and make your mark *to-day* without fretting over to-morrow, and I think you will be surprised to find out how to-morrow will take care of itself. I hope you will take *pride* in advancing the interests of our Companies and you will find they will take care of you, and don't get into any side currents or by-ways.

The above is dictated by a desire to advance you. Prof. Columbo and I without doubt shall talk of a good many things before we get back and you will not be forgotten. You can write me for a week out after you get this at 65 Fifth Avenue. ——— ——— Baily."

I consider the criticism contained in this letter as unjust. The "future" Mr. Baily referred to was, I think, my being sent into Germany. I had introduced the light into Holland, Belgium and Italy, and superintended the construction of the lamp factory at Ivry-sur-Seine, France, and the prospects were for the early

introduction of the light into Germany, and the building of a lamp factory at Berlin. I was being made use of, and I was willing to serve the Company's interests, but I did not think I was being justly paid for what I was doing.

The Italian Company bought an old theatre located in the center of the City and converted it into a central electric lighting station, the dynamos and engines and boilers being brought from America. I made frequent trips into neighboring cities and towns to install isolated plants. Among others I placed one in Udine to the northeast of Venice; one in Genoa; one in Pisa, within sight of the celebrated "Leaning Tower"; one in Bergamo; one upon the side of the Alps above Lake Maggiora.

The necessity of getting all our supplies through the Paris Company and the strained relations between me and that office made it very unpleasant for me, and I decided to sever my connections with the Italian Company. I sent in my resignation, and, at the request of the President, remained until an Engineer, Mr. John Lieb, came over from New York to relieve me.

I believe I left the service of the Italian Company about the beginning of the year 1883. I left Milan and returned to Paris, having been in Italy about seven months, and this without having seen Florence, Rome, Naples, or any of the Southern part. I had taken no holidays, following business closely.

I arrived in Paris with some little money in my pocket and a number of ideas in my head to the effect that heat energy could be economically converted into electrical energy. I established myself in a small hotel in Rue d'Auntin near the Avenue de l'Opera. I had two adjoining rooms, one as a bedroom, the other I made into sort of a laboratory and shop. I worked here under tremendous pressure for about five months, without meeting with any success. I ran out of money and cabled to my brother William. He responded with one thousand dollars. My health began to break and I was feeling miserable in every way. I resolved to go over to London; I do not remember that I had any particular object in view. I packed up my effects and crossed the Channel, going to the

Queens Hotel, London. The day after my arrival a most pronounced case of jaundice was developed throughout my system. I certainly was miserable. The hotel people evidently did not care to have me about and recommended to me a boarding house on Rittenhouse Square. I moved my effects to this house, which was conducted by a kindly old lady. I was feeling extremely sick, low spirited, money practically all gone and no doctor to attend me. One bright day I dragged myself out on the pavement in front of the house, in order to get the heat of the sun. I had been there some time when I recognized a familiar face in the passing throng. It was James Holloway, whom I had last seen as a machinist in the machine shops at Menlo Park. He was apparently pleased to see me. In a few minutes he learned my circumstances and very kindly offered to take me to his home. He would not hear of a refusal. He gathered together my effects, I settled up with my landlady, and off we went to Holloway's home on High Holborn. Jim, as I called him, had been sent some time previously to London,

his former home, by Mr. Edison to assist in the introduction of the electric light. He had married, the second time, and was at the time I met him in charge of the electric lighting plant of the Holborn Restaurant, and was living nearby with his wife and his wife's mother.

Holloway procured a doctor for me and he and his family gave me every attention of which their limited means permitted. I was extremely sick, although not actually confined to my bed. I do not know how long I was in this condition, but now think the turning point came with, or as the result of, the following incident. I could with some difficulty get out into the street and sun, and once when out was taken with an intense desire for bananas. I purchased one-half dozen at a nearby stand and smuggled them into my room and ate them all. In a few days I had recovered from all danger, and I learned from my friends that neither they nor the doctor had expected to see me get well. Did the bananas do it?

After I was again well, Holloway became interested in my experiments on the conversion

of heat energy into electricity, and introduced me to Mr. Gordon, who was at the head of the restaurant on High Holborn and the collection of great hotels known as the "Gordon Hotels." Mr. Gordon and a brother-in-law together furnished me with capital for once more taking up my line of experiments, and these were continued without success until well into December, 1883, when I learned that Mr. Samuel Insull, Mr. Edison's private secretary, was in London at a certain hotel. I had known Insull at Menlo Park, and called to see him and related my circumstances. He cabled to Edison in New York and received in reply cabled instructions to furnish me with transportation to America. I returned to America on the S. S. "Arizona," landing in New York on the fourth day of January, 1884. My roving about had given me considerable self-reliance, or what is popularly called "nerve," as is illustrated by this incident: I came over from England as a first-class passenger on a ticket furnished by Mr. Insull. I was completely out of money, and when we fastened to the pier in the North River, New

York, I went down to my state room to have my baggage brought up and found the door locked. This may have been for some other reason, but I thought the steward had locked it up so I could not move out until I had given him a tip. I went up on deck, out on the pier and at a carriage stand engaged a carriage to take me and my baggage to a family hotel on Eleventh Street. I asked the officer in charge of the stand to loan me five dollars in United States money until I arrived at the hotel. He at once handed me the money and I went down, tipped the steward, got my effects, drove to the hotel, went in, registered as coming from London, England, asked the hotel clerk to accommodate me with a few dollars United States money, which he did. I paid my debt and transportation to the cabman, and found myself once more settled in America after two and one-half years of strenuous life in Europe.

CHAPTER VIII

TWENTY-EIGHTH TO THIRTY-FIFTH YEAR

The following day I reported to Mr. Edison's office at No. 65 Fifth Avenue. Mr. Edison was in Florida, but he had left word that I was to take up a line of experiments at his laboratory, which was then in New York City. The Edison Electric Light Company was at this time about to commence the construction of an uptown central station, the Pearl Street Station having proven a success. A few days after I commenced work at the laboratory, I was informed that Mr. Edison had telegraphed from Florida that he wished me to take the position of Engineer of the proposed new central station. I did not consider myself capable for this responsible position. Much progress had been made during the preceding two years, and my work in Europe had not kept me in close touch with the advance. I did not think the position proposed by Edison would be congenial to me, and

I am inclined to think Edison was not accurately estimating my capacity, qualifications and tastes. I declined to take the position and remained for some time in the laboratory until a scheme for controlling electric currents, regulating dynamos, etc., occurred to me and carried me once more into experimental work, which resulted in my again leaving Edison's interests. My experiments proved a failure, and then through the kindness of Mr. Samuel Mott, I was introduced to Captain Gardner of the Consolidated Electric Light Company, a concern owning the Sawyer-Man patents on electric lamps. They had a small lamp and dynamo factory in Brooklyn. From Captain Gardner I obtained an appointment as Superintendent of the lamp department of their factory, a Mr. Edward R. Knowles being General Superintendent.

I now entered upon, perhaps, the most important period of my life. The lamp factory was a very small affair occupying the third floor of a power building. I was paid twenty-five dollars per week at the beginning of my employment, but owing to the economies I introduced

and the increased output, this was soon increased to thirty-five dollars. After I had been there some time, the company of which a Mr. Thayer of Boston was President, undertook a reduction of expenses and re-organization. Mr. Knowles was relieved of his position, and Mr. Thayer wished me to take the General Superintendency, with my salary reduced again to twenty-five dollars per week. I objected to this arrangement and left the employ of the Company.

For some time I had been much in love with a Miss Margaret C. Maher, and I, a world-wanderer, at this critical time when I was out of a position and practically penniless, proposed marriage to her, and she, with evident confidence in my ability to provide for her, accepted me as her partner for life.

Miss Maher, having been raised in the Catholic faith, desired to be married in that church, and we were married by the Rev. W. Keegan in the Church of the Assumption, Brooklyn, N. Y., December 15th, 1884.

While with the Consolidated Electric Light Company, I had met and become acquainted

with Mr. William P. Shinn, who was one of the Directors of the Company. I had also met another Director, Mr. W. C. Andrews, who was also President of the New York Steam Heating Company, Mr. Shinn being Vice-President of that Company. I had a project for the construction of a new style of dynamo, and went to see these two gentlemen about it. At that time I was a great student of Faraday's works, and I took with me to Mr. Shinn's office one of the books of Faraday's, "Experimental Researches in Electricity," and showed to Mr. Shinn why I thought from Faraday's results my plan would prove practical.

Mr. Shinn and Mr. Andrews concluded to go into the project, each of us holding a third interest. Quite a large machine was built in the shops of the Steam Heating Company on Eighteenth Street, New York. My wife and I moved from Brooklyn, where we had been boarding on Jay Street, to a boarding house on Eighteenth Street, New York.

The dynamo we built was a failure, for while it would produce a current of immense amper-

age, the voltage was absurdly low. It was another failure added to my long list.

Just at this critical moment I chanced to meet one day on Broadway, at the corner of Eighteenth Street, John S. Huyler, whom I had not seen since the days of the Exposition in Paris, back in 1881. I think we were both delighted to meet, having formed an attachment on the S. S. "Amerique" in going to France.

We exchanged news hurriedly of what had happened to each since we parted. Huyler conducted me to his confectionery store nearby at No. 863 Broadway, and told me he was interested in a plant over on Hudson Street, in which a Mr. Clark was conducting experiments on the manufacture of insulated wire for electric work. He said he had then expended a great many thousands of dollars, and was slowly forming the opinion that the whole thing was no good. He wanted me to join forces with him, and either carry it to a success or call it off. I told him how I was situated, and could not leave the gentlemen I was with in the lurch. He said he

would buy them out; I told him my venture was a failure. He insisted, and together we went down to Mr. Shinn's office at No. 22 Cortlandt Street.

The sale and purchase was completed, Mr. Huyler paying to Messrs. Andrews and Shinn twelve hundred and some odd dollars and cents, the exact amount expended in building the machine and paying me a salary of twenty-five dollars per week.

Huyler took me over into his employ, paying me twenty-five dollars per week. The dynamo I had built was moved from the shop of the Steam Heating Company and placed in a sub-cellar of a power building on Hudson Street, in which Mr. Clark had his wire insulating plant. I moved my wife from the boarding house on Eighteenth Street to a private flat on One Hundred and Twenty-fourth Street occupied by my friend Mr. Samuel Mott, he and his family going for a trip of some duration into the country.

I set myself earnestly at work upon Mr. Huyler's problem, and ere long convinced my-

self, him and others interested, that their wire insulating project was worthless, and in course of time the plant was shut down.

I now induced Huyler to lend his aid to some experiments I wished to make on the production of an anti-induction telephone wire, using the dynamo in the sub-cellar. He consented, and on a salary of fifteen dollars per week which he paid me, I worked for weeks in this room, two floors underground. My project was to take a rubber-covered wire, coat it with graphite, pass it through a copper solution and plate on it a tube of copper; next braid cotton over the tube; then soak the cotton with asphaltum; then cover the whole with a lead pipe or covering. I made up some in this manner, but they only served as samples. The scheme was good, the central wire and surrounding insulated tube of copper acting as the two conductors for a telephone circuit, their relative positions to each other entirely eliminating cross-talk and induction. I took out patents on the process of making this wire.

While I was engaged on this work, our

daughter Veronica Belle was born, and shortly afterward Mr. Mott returned to town, and I moved my family into a flat on Forty-third Street, between Seventh and Eighth Avenues. I cannot say I then looked upon life as a bed of roses,—with an income of fifteen dollars per week, a rent of thirty dollars per month to pay, and three people to clothe and feed. The sub-cellar was an abominable place in which to work, and I can now remember that I usually left there, after a day's work, cold and almost numb from my feet to the waist. Had I not had a remarkable constitution, I do not think I could have survived this period, and, indeed, it is possible that some of the loss of health I afterwards experienced for some years, may be charged to my struggles at that time.

Things were looking rather desperate when my brother William, who was still living at Monticello, which had been renamed Gosford, came to New York and wished me to go out to Gosford and conduct some experiments on the reduction of iron from its ores by the use of natural gas, which was then quite plentiful in

that vicinity. My work with the wire not being very encouraging, Mr. Huyler assented to my going.

I moved my wife and child to Gosford, and we were provided with accommodations in my brother's house, with his family. Experiments were undertaken, but they were unsuccessful and disappointing. I would mention one little incident that occurred while at work, which had a bearing on my after acts. I passed natural gas into a highly heated furnace in which I had placed some clay articles, and, when cold, I found them thoroughly impregnated with carbon, and I thought they were rendered harder. Things came to a standstill for want of capital, and I again turned my thoughts to my anti-induction telephone wire. I made a trip to Pittsburgh to see Mr. R. S. Waring, President of the Standard Underground Cable Company, with the hope of interesting him. I opened negotiations with him for the sale of my patent. In the meantime, I moved my family to a boarding-house in Kittanning, a town three miles down the Allegheny River from Gosford. It

was about forty-four miles from Kittanning to Pittsburgh.

I was out of money completely, and I saw time would pass in the selling of my patent. I pawned my watch-chain and bought a monthly ticket between Kittanning and Pittsburgh, and made daily trips to the City. I soon learned that Mr. George Westinghouse was negotiating with Mr. Waring to get control of the Cable Company. I went to see Mr. Westinghouse, and proposed to sell him my patent. The negotiations between Westinghouse and Waring came to a finish, the latter selling his interest in the Cable Company to the former.

Mr. Westinghouse bought my patent in the interest of the Cable Company, paying me seven thousand dollars in cash and fifty thousand dollars of the stock of the Standard Underground Cable Company, which was then capitalized at three million dollars, and engaged me for a term of three years as electrician to the Cable Company, at a salary, I think, of two thousand dollars per year. I paid over to Mr. Huyler five thousand dollars to reimburse him

for any expenses incurred on my account, and to my brother I paid two thousand dollars against his expenses. Before my monthly ticket expired, I was settled.

This was late in 1886. I now moved my family to Pittsburgh, and went to housekeeping. I am afraid my new riches made me reckless, but I wished my wife to be as comfortable as possible. I furnished our home as well as I thought we could afford, bought a cow, a horse and carriage, engaged a man to attend the barn and drive, all of which was beyond my means. The capital of the Cable Company was reduced from its three million dollars to one million dollars, thereby reducing my stock to sixteen thousand, six hundred and sixty-six dollars.

I found the work with the Cable Company very agreeable. I made trips to other cities to superintend the laying of cables underground, or investigate troubles that would arise; thus I did work in New York City, Philadelphia, Chicago, Detroit, Washington City and Buffalo. While holding this position, I made my first appearance as the author of a paper before an

audience, and followed it with a number of others.

When the three years expired, I formed a syndicate of gentlemen, among whom was the late Christopher Magee of Pittsburgh, and again took up experiments on the conversion of heat energy into electricity. We rented an abandoned electric railway power house in Allegheny City. Here I worked for several months with indifferent success. In the Fall of 1890, I thought that with a small electric lighting plant in some town, I could make the plant pay its way by night lighting, and use the dynamo for experiments during the day. I looked about for a suitable location, and decided on Monongahela City, thirty miles from Pittsburgh on the Monongahela River.

Mr. Magee and the majority of the members of my syndicate declined to go into the light company. I got together another party of gentlemen, among whom was my friend John S. Huyler, and Joseph W. Marsh, Secretary of the Standard Underground Cable Company.

The Monongahela Electric Light Company

was organized and incorporated for forty thousand dollars, a suitable building purchased, and the necessary engines, dynamos, etc., installed. The Company commenced to furnish light to its customers on the 20th day of November, 1890.

I now arranged to move my family to Monongahela City, it having increased on January 25th, 1887, by the birth of our son, Edward Goodrich; again, on September 8th, 1888, by the birth of our son Raymond Maher; and again, on May 14th, 1890, by the birth of our daughter Sarah Ruth. I bought a small house, paying for it in part with a mortgage, and moved my family from Roupe Street, Pittsburgh, where they then lived. If I remember rightly, the purchase of this house, which I gave to my wife, and settling my family in it, exhausted what was left of the sixteen thousand, six hundred and sixty-six dollars worth of cable stock. I closed out the indebtedness I had incurred in the Second National Bank of Allegheny by selling and assigning the Cable Company's stock owned by me, to Mr. J. N. Davidson, President of the Bank.

After I was located and all the capital I could raise invested, I realized that electric lighting in a small town was no play. Monongahela City had a gas plant, owned by the two local banks. My plant was not meeting expenses, and not being able to get the assistance of the town's local paper, conducted by "Chill" Hazzard, I resolved on a determined effort. The town was entirely in the hands of the Republican Party; I myself was of that persuasion. I had hand bills printed immediately preceding a town election; had boys carry them about the town and push them under the house doors. The election came off, the Town went Democratic, and electric lights were put on the streets.

CHAPTER IX

DISCOVERY AND DEVELOPMENT OF CARBORUNDUM

I did quite a great deal of experimenting during the Winter on various lines. I think it was in February, 1891, I was working on the making of rubber synthetically. I succeeded in producing a small piece, when at this critical moment Mr. John S. Huyler came from New York to see our plant. He was not pleased with the prospects. He looked on it with great disfavor, and said he had just invested considerable money in a rubber tree grove in Mexico, and they intended to produce more rubber than the World would use. He advised me to shut the plant up and "throw it into the Monongahela River." With this, he left me to my own resources. His remarks discouraged me regarding rubber; I dropped the subject and resolved to endeavor to produce an artificial abrasive. Through inexcusable negligence or careless-

ness, I made no record of my experiments on rubber production, and have to-day but a hazy idea of how I produced this small sample.

The value of a good abrasive was brought to my attention by a remark incidentally made in 1880 by Dr. George F. Kunz of Tiffany & Company, New York. I also remembered the observation of clay impregnated with carbon I made at Gosford, and I decided to make experiments on impregnating clay with carbon under the influence of electric heat.

An iron bowl, such as plumbers use for holding their melted solder, was attached to one lead from a dynamo and filled with a mixture of clay and powdered coke, the end of an arc light carbon attached to the other lead was inserted into the mixture. The percentage of coke was high enough to carry a current, and a good strong one was passed through the mixture between the lamp carbon and bowl until the clay in the center was melted and heated to a very high temperature. When cold, the mass was examined. It did not fill my expectations

but I, by sheer chance, happened to notice a few bright specks on the end of the arc carbon that had been in the mixture. I placed one on the end of a lead pencil and drew it across a pane of glass. It cut the glass like a diamond. I repeated the experiment, and collected enough of the material to test its abrasive qualities. I mounted an iron disc in a lathe, and, oiling its surface, applied the material which adhered, and with this revolving disc I cut the polished face off the diamond in a finger ring still owned and worn by me.

I now made a small furnace of bricks, and after much and patient work, had what I considered enough to take to the lapidaries in New York City.

A friend by the name of W. C. McCallister, a druggist of Monongahela, and I started for New York. On the way we coined a name for my new and, as yet, unnamed material. Under the impression, without any chemical analysis, that it was composed of carbon and corundum, I called it Carborundum.

Owing to unforeseen circumstances, I found

it necessary to return to Monongahela City without having presented the subject of Carborundum to anyone who might be interested in it in New York City. A few days later I returned to New York with my new material, which was contained in a little vial. I had a diamond cutter on John Street use some of my product to repolish the diamond I had ground, and the remainder he bought from me at forty cents per carat, or approximately eight hundred dollars per pound, and with the proceeds I purchased a microscope to help me in studying the structure of Carborundum.

A great deal of time and energy were expended in an effort to develop a trade with the Lapidaries, but the consumption of abrasives in this line was small, and mainly covered by the refuse matter from diamond cuttings and chippings.

I gradually increased the size of my furnace and sent samples to various emery wheel manufacturers to be made into small wheels. Without exception, these companies reported that it was not possible to make the material up into

successful wheels. Not discouraged, I undertook experiments on these lines.

I organized The Carborundum Company, and incorporated it for one hundred and fifty thousand dollars on the 21st day of September, 1891. One-third of the capital stock was issued to the stockholders of the Monongahela Electric Light Company in compensation for the services that The Carborundum Company had received from the Light Company.

A new field opened up at this opportune moment for Carborundum. Mr. George Westinghouse had secured the contract for lighting the Columbian Exposition buildings in Chicago, the Exposition was to be held in 1893. The Edison Electric Light interest secured an injunction, restraining Westinghouse from making a lamp of one piece of glass; Westinghouse devised a lamp made of two pieces, fitted together with a ground joint as a stopper fits into a bottle. He found small Carborundum wheels to be the most efficient means for grinding the joint between these two pieces. I made with my own hands some sixty thousand small wheels for this

work, and received from the Westinghouse Electric and Manufacturing Company over seven thousand dollars for them. With this money, The Carborundum Company bought its first dynamo; its electric current up to that time having been furnished from the dynamos of the Monongahela Electric Light Company.

I think it was in January, 1893, I sent out twelve thousand lithographed cards to that number of dentists. In one corner I punched a hole one-half inch in diameter, and in it I placed a Carborundum wheel of that diameter, and one-sixteenth of an inch thick. The cards being made of soft, heavy paper, the wheels were held firmly. On one side of the card were lithographed the words: "The Compliments of the Season and a Carborundum Wheel. Try me wet or dry;" on the reverse side was a price list. By return mail I received sufficient orders and money to pay for the cards, wheels and postage. These wheels I had made myself.

I had two small kilns built, and went earnestly to work to make a high grade vitrified wheel. The success of these wheels caused Mr.

Lee S. Smith of Pittsburgh, who was in the dental supply business, and whom I had endeavored formerly to interest in Carborundum dental goods, to wish the sole agency for the product. He placed an order for five thousand dollars worth of wheels and points, and with this money, the Carborundum Company made an exhibit at the Chicago Exposition, and much attention was attracted to the material. As a result of this exhibit, I sold, before the close of the year 1893, through a Mr. Wissenburger, to an Austrian Bank (known as the Landerbank of Vienna) my patents for Austria-Hungary, receiving for the sale twenty thousand dollars.

I should have stated earlier, that some months after the discovery of Carborundum, I learned from analyses I had made that it was a compound of carbon and silicon, and not alumina, the formula being S i C.

Early in the year 1894, I went over to Europe to work my patents in France, taking with me an engineer by the name of Frederick Bolling, a German who had been in America for some

years. I operated a furnace and made Carborundum in the electric plant at Ivry-sur-Seine, where I had worked twelve years before.

A Mr. Deichmann, to whom I had given the right to handle my German patents, came down to Paris from Berlin, and informed me that he had formed a syndicate of millionaires who were ready to organize a company and buy my German patents. Their headquarters were at Iserlohn, Westphalia.

Mr. Bolling and I went with Mr. Deichmann up to Iserlohn, and I was entertained at the home (called a castle) of Mr. Hebers, a very wealthy man and a member of the Prussian Diet. I think I was there about a week, and I cannot praise too highly the hospitality extended to me. One day I received a telegram asking me to meet a Dr. Rapporport, a representative of the Landerbank of Vienna, in Paris. I answered that I would receive him at eleven o'clock on a certain day, at the Hotel Continental, Paris. This hurried up my German friends, and a meeting was convened in the ballroom of the castle, at which all the members of

the proposed Deutsch Carborundum Werke were present. A corporation lawyer had been brought for the occasion from the City of Dortmund.

Instead of making a contract between the proposed company and myself, as I had expected, the day was spent in forming and executing a power of attorney from me to Mr. Deichmann. Under this power, he was to enter into a contract to sell the patents for sixty thousand dollars, twenty of which should be in cash, and forty in stock of the proposed company.

In drawing up the power of attorney, the German gentlemen wished to have embodied in it an agreement on my part that Mr. Deichmann should contract with the German company that they should not make less than four per cent. on the company's capital. I refused to agree to such a guarantee, as I would not be the manager of the company, and all of the gentlemen were perfectly cognizant of my refusal.

After the day's work was over and the power of attorney duly signed, an elaborate banquet

was served. I was to meet Dr. Rapporport the next morning in Paris. The last train had left Iserlohn, and I was driven twelve miles in Mr. Heber's family coach to Hagen, on the main line to Paris. The next morning at exactly eleven o'clock, Dr. Rapporport called on me and stated that the Landerbank wished to secure more territory, and he was authorized to negotiate for the German patent. He further stated that they would pay me sixty thousand dollars cash for it. I had to tell him that it was too late, as I had sold it the previous day.

Within the next few days, I sold the Landerbank my patent interests in France, Belgium, Switzerland, Italy, and a pending application in Russia, for the sum of sixty thousand dollars cash.

In the Fall of that year, I received at Monongahela City, from Mr. Deichmann, a booklet containing a copy of the contract he had made, as my attorney, with the Deutsch Carborundum Werke, the By-Laws of the Company, etc., and a long letter explaining why, in his judgment, he thought it was wise to sign the contract

with its Fifth Clause agreeing that I guarantee the Company to earn four per cent. on its capital. The Company had already paid me ten thousand dollars, fifteen hundred of which I had paid over to Deichmann as his commission. On receiving his letter and booklet, I cabled over canceling the entire affair, later repaying to the defunct company the ten thousand dollars. I have gone thus fully into this transaction to illustrate how one may, by a narrow margin, miss the opportunity to accept a good offer, i. e., the offer of the Landerbank.

My business having been completed in Europe, I returned home by way of London, where I wished to find my old friend Holloway. After quite a search, I found him living in the outer part of London. He was out of a position, and confined to bed with an attack of lumbago. I had the pleasure of reciprocating, in part, his former great kindness to me.

When in Mr. Holloway's home I noticed an old-fashioned Grandfather's Clock, and on inquiry was told that it had formerly been the property of Michael Faraday. Mrs. Holloway's

mother had known Faraday personally, and knew this clock to have been in his possession. A few months after returning to America, I received by express this same clock, as a present from Mrs. Holloway, and it now stands in my home in Lundy's Lane, Niagara Falls.

On my return home from Europe, I heard much of the electrical development at Niagara Falls, and going there, looked over the prospects for success of the development, prices for power, etc. On returning to Monongahela City, I convened a meeting of my Board of Directors, and laid before them a plan of moving to Niagara Falls, and there build and equip a plant for one thousand horse power. At this time the Monongahela plant used one hundred and thirty-four horse power, and, owing to the high price of the Carborundum produced, but one-half the production was sold. In view of this condition of the plant at Monongahela City, my Niagara Falls scheme was too much for the conservative Directors, and they resigned and left the room. Fortunately for the future of Carborundum, I was in control of its destiny. I organized a new

board; had the Company authorize the issue of seventy-five thousand dollars worth of bonds; placed the money I had brought from Europe (with the exception of twenty-six thousand dollars which I paid to Mr. J. S. Huyler for his interests, he being dissatisfied with my policy) at the service of the Company.

Contracts were entered into with the Niagara Falls Power Company. Substantial brick buildings were erected and provision made for large development. My means began to run low, and it was necessary to raise more. Times were depressed, all business being at a standstill. I made a great struggle to sell the Company's bonds. The Company had no funds to place the necessary machinery in the new buildings. Finally, on the sixth day of July, 1895, I sold to Pittsburgh Bankers, whom I shall hereafter designate "A" and "B", fifty thousand dollars of the bonds, giving them as a bonus twelve thousand, five hundred dollars of the Company's capital stock, which had previously been raised to two hundred thousand dollars.

The Niagara Falls works were started in the

Fall of 1895, it being the second one to take power from the Niagara Falls Power Company, —the Pittsburgh Reduction Company, now the Aluminum Company of America, being the first.

The emery wheel companies would not buy the Carborundum, and it became necessary for me to devise and perfect a method of making wheels; to build a department for that work, and carry a stock of finished wheels. All this required time and much money.

In order to be nearer my work at Niagara Falls, I leased the premises No. 41 Fargo Avenue, Buffalo, N. Y., on the 5th day of August, 1896, and moved my family there from Monongahela City. My family now consisted of my wife and seven children; George Wilson, John Huyler and Margaret Irene having been born March 2nd, 1892, October 31st, 1893, and June 10th, 1896, respectively.

Under the patent laws of Germany, it was necessary for me to work my patents in that country early in 1897. I entered into a contract with "A" and "B" under date of April 13th, 1897, whereby they secured a one-half interest in

the German patent in consideration of fifty-five hundred dollars. They advanced the money to carry out the working and put the business into shape.

I now entered upon the most trying period of my checkered career. I left for Germany, taking with me my old friend, James C. Hipple, to assist me in my work.

I took with me a letter of credit from "A" and "B" for twenty-five thousand dollars, and, with Hipple to assist me, operated furnaces and made Carborundum in the town of Dauben, a few miles from Dresden. The necessary electricity was obtained from the town's electric lighting station.

In Dauben was an emery wheel firm by the name of George Voss & Company, and I closed a contract with them to continue operating the small plant I had built, and to purchase from the American Company about twelve thousand dollars worth of Carborundum goods, as a stock for the German trade.

I left Hipple there and returned home, having been gone about three months and expended

two thousand five hundred dollars of the twenty-five thousand dollars taken over. One half of my expenditures were met by me, the other half by "A" and "B."

The last department of manufacture added to the Niagara Falls plant was made after my return from Europe. It was the manufacture of Carborundum paper and cloth. I had had a number of emery paper manufacturers make some, and I believed it would be a valuable addition to our Works. To raise the required fifty thousand dollars for this department, I gave "A" and "B" forty-six thousand dollars of the capital stock of the Company as a bonus for their loaning the money to the Company. The capital of the company was at that time three hundred thousand dollars, having been raised from its former two hundred thousand dollars for the purpose of buying the Canadian patents from me, I giving to "A" and "B" three-fourths, —or seventy-five thousand dollars of the one hundred thousand dollar purchase price.

"A" and "B" were now in control, I having given them as bonuses for the advancement of

money to the Company forty-six and fifty-eight hundredths per cent. of its total capital stock, to which they added by purchase from other stockholders enough to increase their holdings beyond the half. Their advancements to the Company were all in the form of personal notes at six per cent.

Shortly after they obtained control, they demanded the retirement of the Secretary and the Treasurer, Mr. William H. Arison and Mr. H. H. Williams, and put in their places Mr. F. W. Haskell and Mr. F. H. Manley.

One evening in August, 1898, I left my home on Fargo Avenue to take the eleven o'clock train for Pittsburgh, for one of my frequent interviews with "A" and "B." Within five hundred feet of my house door, I was garotted by three men and knocked insensible by being struck twice on my head. I recovered quickly, and found I had been robbed of my watch and chain, further depredations being prevented by the approach of persons on the street.

Toward the close of the year, I was taken seriously ill, due, I think, to the many trying

circumstances in which I had been placed, and the knowledge that it was the purpose of "A" and "B" to remove me from the Presidency of The Carborundum Company, Mr. Haskell having already been, at their instigation, placed in practical control. I was confined to my bed for five weeks, my mind being so affected that I was for two weeks in an unconscious condition.

On July 1st, 1901, Mr. F. W. Haskell was made President of The Carborundum Company, I having been removed by "A" and "B" from that position. The business of the Company was then on a fine basis, being ready to enter upon a period of great prosperity, but no profits had yet been made. I had created an entirely new industry, worked out and patented the many details of manufacture, created a stock to supply demands from the trade, proved the value of Carborundum as an abrasive and established a demand for the same, and all this while the country was passing through a great financial depression.

On January 1st, 1910, the Company was using ten thousand electrical horse power, and

was producing Carborundum at the rate of ten million pounds per year, the capital of the Company having been increased to six hundred thousand dollars.

CHAPTER X

GRAPHITE

In 1895, I secured a United States Patent for purifying carbon. In 1896, I obtained a United States Patent on the manufacture of graphite. On the 17th day of January, 1899, I secured still another one in this series i. e., on the manufacture of graphite articles.

Realizing that I was completely out of power in The Carborundum Company, and knowing the necessity of accomplishing something for my family, I concluded to form a Graphite Company to operate my patents.

I told "A" and "B" of my purpose, and they immediately demanded forty per cent. of the stock of the proposed company under an old agreement made between them and myself on July 16th, 1896, whereby it was proposed to organize a Carbon Company, they ("A" and "B") furnishing the capital. This was never carried out, and I thought all parties had aban-

doned their claims under it, "A" and "B" not having expended one cent. I objected to their claim for forty per cent. but nevertheless it was clear to me that if I did not pay them tribute under that old contract, I might have difficulty in securing capital for my proposed enterprise. We compromised by my agreeing to present them with twenty-five per cent. of the capital stock of my new company.

I proceeded with my plans and organized the Acheson Graphite Company, with one million dollars capitalization. It was incorporated under the laws of the State of New Jersey on January 26th, 1899. I sold one hundred thousand dollars preferred stock of the Company, and with this money developed the business.

The Company leased suitable ground from the Niagara Falls Power Company, and contracted for one thousand horse power of electricity.

During February and March, 1900, I filed applications for patents on Graphite manufacture in England, France, Belgium, Germany, Austria, Italy, Spain and Russia. I then organized

a company under the title, of International Acheson Graphite Company with a capitalization of three million dollars to operate these patents in Europe. It was incorporated under the laws of the State of New Jersey, March 15th, 1900.

I found it inconvenient to live in Buffalo and spend so much time on the railway, and wished to provide my family with a permanent home, and having an opportunity in 1900 to buy a property of twenty-one acres on Lundy's Lane, Niagara Falls, Ontario, I purchased it. To provide the money to purchase, improve and furnish it, I sold to "A" and "B" thirty-five thousand dollars worth of my Carborundum stock, and with the proceeds, which amounted to thirty-five thousand dollars, I settled my family at Lundy's Lane. The property, home and contents I presented to my wife.

My family had, while living in Buffalo, been further increased by the birth of our daughter, Jean Ellen, on November 16th, 1898, and Howard Archibald on April 1st, 1900. When I moved my family from Buffalo to Lundy's Lane,

we numbered eleven all told,—my wife and I with five sons and four daughters.

The graphite articles, as made by the Acheson Graphite Company, such as electrodes, plates for motor and dynamo brushes, bulk graphite for dry batteries and paint pigment, seemed to fill at once a much needed requirement, and the business of the Company grew accordingly. A plant was built and equipped with one thousand horse power of electricity.

Believing that it would be to the best interests of all concerned to merge the two Graphite Companies under the title and with the capitalization of the International Company, I called the necessary meetings to act on it, and an agreement was executed between them under date of May 1st, 1900.

"A" and "B" opposed the merger and went into the New Jersey Court of Chancery on June 27th, 1900, for an injunction restraining the Companies from merging. I retained Mr. J. B. Dill to defend the Graphite Company's interests, and, after hearing the case, Judge Emery handed down a decision and order under date of July

20th, 1900, granting a preliminary injunction so worded as to indicate that, on final hearing, permission to complete the merger might be granted by the Court.

"A" and "B" thereupon approached me for a compromise. This was arrived at on the following basis. I agreed to have issued to them the amount of stock due them under the merger or one-twelfth plus one-half the difference between the twelfth and their original fourth or one-sixth, they agreeing to convert The Carborundum Company's notes held by them into twenty-year bonds, doubling the capital of the Company to permit of so large an issue, the new stock to be issued to the stockholders pro rata with their holdings; to have The Carborundum Company begin paying dividends; to have The Carborundum Company employ me as Consulting Engineer for five years at a salary of five thousand dollars per year. These conditions being mutually agreed to, the merger was completed.

My health was very bad in 1902. I was worried over the disconnected state of my affairs. I then was possessed of about twenty-

two per cent. of the capital stock of The Carborundum Company, seventy-two per cent. of the International Acheson Graphite Company, and some other scattered interests. I conceived the idea of forming an incorporated company of my family, and dividing its stock amongst my wife and children, and, as a result, I incorporated on January 5th, 1903, under the laws of New Jersey, The Acheson Company, with authorized capital of ten thousand dollars divided into one hundred shares. Of these one hundred shares I gave to my wife thirty-four, retaining the remainder in the interests of my children. To The Acheson Company I transferred all my holdings.

Owing to severe stomach troubles and an operation thereon, I was entirely unfit to attend to business from the early Spring of 1903 to the Fall of 1905, and was absent from home much of this period.

I again assumed the responsibilities of my office, which was that of President, in the late Fall of 1905. I practically reorganized the official staff and management of the Company

and it at once entered upon a period of great prosperity.

By the first of January, 1910, the Company's plant was using five thousand electrical horse power in its furnaces and the amount of graphite being produced was at the rate of more than ten millions of pounds per year.

CHAPTER XI

EGYPTIANIZED CLAY; DIRECT REDUCTION OF ALUMINUM AND SILICON; PRODUCTION OF SILOXICON, LUBRICATING GRAPHITE, AQUADAG AND OILDAG

Having worked out the process of manufacturing practically pure graphite, which I believed to be better than the natural products, I early in 1901 took up experiments having in view the use of my graphite in the making of crucibles. The graphite was not successful as it then existed, but the experiments led me into a study of clays, that had rather an unlooked for result. I discovered that when a clay moderately weak in strength and plasticity was treated with tannin, extract of straw, and other plant extracts, it was increased in those properties. The particles of the clay were reduced so fine that they would pass through a fine filter paper, and would remain permanently suspended in water. I believe this to be an explanation

of why the Egyptians used straw in making brick, and I called clay so treated and dried "Egyptianized Clay."

In 1900 I became interested in experiments having in view the reduction of various metals directly from their oxides, and on December 4th and 20th, 1900, and on January 20th, 1903, I filed applications for patents pertaining to this line of work, all of these applications resulting in the issue of patents. Under the methods therein set forth, I could produce a direct reduction of silicon and also aluminum. All rights pertaining to silicon under these patents, I sold to The Carborundum Company for five thousand dollars, and the process was developed and considerably improved by Mr. F. J. Tone, and has grown to quite a department in The Carborundum Company. The process for the direct reduction of aluminum, as set forth in the patents, avoids the necessity of resorting to the electrolytic methods as practised under the Hall and other processes.

In the late Fall of 1902, I made application for two patents which were issued under date

of March 17th, 1903, one of them being for a method of producing compounds containing silicon, oxygen and carbon, and the other for a refractory material, this latter product having the typical formula of Si_2C_2O, and was called by me Siloxicon, a word coined from the names of the three elements entering into its composition.

I did quite a great deal of work toward the commercial manufacture of Siloxicon, but owing to the poor condition of my health during the following two or three years, my thoughts were carried away from this, and on again taking up a line of experiments, my attention was irresistibly drawn toward the production of lubricating products of graphite.

In 1906 I made a few experiments having in view the possible increasing in value of Carborundum as an abrasive. The experiments were a failure for the purpose I had in mind, but I found in the output of the furnace a small amount of a very soft, unctuous, non-coalescing graphite which I immediately recognized as an ideal lubricating product.

I at once went into experiments to perfect

the manufacture of this graphite, and developed commercial methods of producing what I thought to be a nearly perfect product. Patents were applied for and under date of November 20th, 1906, one was issued to me under the title "Production of Graphite." This I assigned to the International Acheson Graphite Company.

The Graphite Company is now placing this graphite mixed with grease upon the market under the copyrighted name of Gredag, the word being formed from the first three letters of grease, and the initial letters of "disintegrated Acheson-Graphite."

Late in the Fall of 1906, the thought occurred to me to apply to graphite the treatment that I had applied to clay and see if I could not make it remain suspended in water. The treatment proved satisfactory, the graphite being reduced to so fine a state of subdivision that it would readily pass through a fine filter paper and remain permanently suspended in water. I defined the treatment as "deflocculation" and spoke of the graphite as being deflocculated. Experiments showed deflocculated graphite sus-

pended in water formed an excellent lubricant, and it further had the remarkable quality of preventing the rusting of metal which had been immersed in the water carrying the graphite. This new lubricant consisting of deflocculated graphite and water, I called Aquadag, the word being formed from the word "aqua" and the initial letters of "deflocculated Acheson-Graphite." In the following Spring I succeeded in transferring the deflocculated graphite from the water medium to an oil medium, in which it also remained suspended, and this I called Oildag. Various tests of a severe and exhaustive nature showed Oildag to be a very superior lubricant, and some authorities have expressed the opinion that it would extend the possible life of the natural petroleum lubricating oils four times.

Patents were taken out in twenty-three countries, (they including practically the industrial world) on the various processes of manufacture and the products produced as Aquadag and Oildag, and I also trade marked the words "Aquadag" and "Oildag" in those countries.

Wishing the International Acheson Graphite Company to become owners of these new interests I had acquired, I concluded to sell the patents, trade marks, and various interests to it, and the necessary meetings of the directors and stockholders were held to consider and act upon the advisability of an increase in the capitalization for the purchase of these interests. Favorable action was taken and the Company accepted my offer of sale.

Under date of June 3rd, 1907 "A" and "B," by and through counsel, appeared in the Court of Chancery of New Jersey and brought suit to prevent the said purchase by the International Acheson Graphite Company of my interests in Aquadag and Oildag, and as a part of their bill of complaint, they stated as follows:

"And your orators show and charge the fact to be that the said business proposed to be undertaken is not part of the business for which the said corporation (International Acheson Graphite Company) was organized, and that to engage in it is to embark the capital of said Company in a new and distinct enterprise not contemplated

upon the organization of the said Company; that the said processes claimed to be covered by the said letters patent are new and untried and have never been used with commercial success; that they are experimental and undeveloped and at the present stage it is impossible to tell whether or not they can be made commercially successful or whether or not they infringe upon patented processes."

When the papers were served upon me pertaining to this suit, I immediately withdrew my offer of sale of my various interests relating to Aquadag and Oildag to the International Acheson Graphite Company, and under date of May 25th, 1908, I organized and incorporated the Acheson Oildag Company under the laws of the State of New York, and to this Company I assigned all my rights and interests pertaining to Aquadag and Oildag.

In looking back over my life work and results produced, I believe these last two productions, viz., Aquadag and Oildag, will prove to be of more value to the world than any of the preceding products. Much yet remains to do in the

way of perfecting the details of manufacture, company organization and exploitation of the products, but the indications at the present time (1910) are that they will be very quickly appreciated and accepted by the manufacturing and industrial world.

After having solved the problems pertaining to deflocculation of graphite and other insoluble, non-metallic, non-fused, inorganic amorphous bodies, I found that the addition of an electrolyte to the solution, such, for instance, as acids or the solution of ordinary salt, would cause a flocculation of the suspended matter and sedimentation would occur, and I then realized that in Nature we had cases of this kind continuously before us; for example, the suspended matter of the Missouri and Mississippi Rivers, and the effect of salt water or other electrolytes in causing sedimentation furnish a very satisfactory explanation of the formation of the deltas and bars at the mouths of the rivers where they enter salt water, as, for instance, the delta of the Nile and the bars of the Mississippi.

CHAPTER XII

SOCIETIES AND CLUBS

Dr. Acheson is affiliated in the manner stated with the following societies, organizations and clubs:

Charter Member and Past President of the American Electro-Chemical Society; Charter Member and Vice-President of the American Institute of Chemical Engineers; Fellow of the American Association for the Advancement of Science; Member American Institute of Electrical Engineers; Member American Chemical Society; Member American Ceramic Society; Member National Geographic Society; Member Franklin Institute; Member Royal Society of Arts, England; Member Chamber of Commerce, New York State; Member Chamber of Commerce, Buffalo; Member University Club, Washington, D. C.; Member Chemists Club, New York City; Member Buffalo Club, Buffalo, N. Y.;

Member Park Club, Buffalo, N. Y.; Member Niagara Club, Niagara Falls, N. Y.; Member Automobile Club of America, New York City.

CHAPTER XIII

PAPERS WRITTEN AND READ

Dr. Acheson has read the following papers before the various named Societies at the dates given:

Disruptive Discharges and Their Relations to Underground Cables, before the National Electric Light Association, August 29th, 1888.

Lightning Arrestors and the Photographic Study of Self-Induction, before the American Institute of Electrical Engineers, January 8th, 1889.

Carborundum; Its History, Manufacture and Uses, before the Franklin Institute, June 21st, 1893.

Graphite; Its Formation and Manufacture, before the Franklin Institute, March 15th, 1899.

Egyptianized Clay; before the American Ceramic Society, February, 1904.

Discovery and Invention; before the Mining Engineers' Club, Massachusetts Institute of

Technology, March 9th, 1906; Sibley College of Mechanical Engineering, Cornell University, May, 1906; Schenectady Branch of American Institute of Electrical Engineers, October 12th, 1906; Lafayette College, October 18th, 1906.

Seventeen Years of Experimental Research and Development, before the American Academy of Arts and Sciences, April 8th, 1908.

Deflocculation of Graphite, before the American Institute of Electrical Engineers, July 11th, 1908; American Chemical Society, July 12th, 1908; Syracuse Branch of the American Chemical Society, October 16th, 1908; American Electro-Chemical Society, October 17th, 1908; American Mining Congress, November 13th, 1908.

The Electro-Chemist and the Conservation of our Natural Resources, before the American Electro-Chemical Society, May 6th, 1909.

CHAPTER XIV

HONORS CONFERRED

Many honors have been conferred upon Dr. Acheson, prominent among them being the following:

John Scott Medal (Franklin Institute) 1894, for invention of Carborundum.

Gold Medal, Trans-Mississippi and International Exposition, Omaha, Neb., 1898, for Artificial Graphite.

Grand Prix, Exposition Universelle Internationale, Paris, France, 1900, for Carborundum and Artificial Graphite.

John Scott Medal (Franklin Institute) 1901, for Artificial Graphite.

Gold Medal, Pan-American Exposition, Buffalo, N. Y., 1901, for Artificial Graphite.

One of the one hundred "Captains of Industry" who breakfasted with H. R. H. Prince Henry of Prussia in New York on February 26, 1902.

Grand Prize, Louisiana Purchase Exposition, St. Louis, Mo., 1904, for Carborundum and Artificial Graphite.

Count Rumford Premium, American Academy of Arts and Sciences, Boston, Mass., 1908, for new industrial products of the electric furnace.

The degree of Sc. D. was conferred upon Dr. Acheson by the University of Pittsburgh, Pa., February 12th, 1909.

The Perkin Medal awarded by Perkin Medal Committee, January 21st, 1910.

CHAPTER XV

CONCLUSION

In reviewing Dr. Acheson's life as related by himself, one is naturally inclined to attempt an analysis of the qualifications which he evidently possesses and which have enabled him to surmount difficulties and accomplish the results attained. One cannot fail to be impressed with the number of times he converted failures into successes, these almost invariably being the results of observing very small effects that would ordinarily escape the notice of an experimenter. Another characteristic that deserves more than passing note was his desire to tread unknown paths, as shown by the fact of his having entered entirely new fields of research, fields previously unexplored, or if attempts had been made at exploration, the results reported were rather of a kind to have caused one to avoid them. These points were well brought out by a statement recently made by a gentleman holding a very

eminent position in the electro-chemical industries of the United States, and being very concise, we repeat it herewith in his words:

"Dr. Acheson observed the transformation of carborundum at high temperatures into graphite, and drew from this and similar observations, conclusions respecting the effect of impurities upon amorphous carbon, whether normally present therein or derived from external sources, in determining its conversion into graphite. Based upon these conclusions and upon a long experimental study of the transformation of carbon by heat, he founded a new industry, to wit: the manufacture from such cheap forms of carbon as petroleum coke, anthracite coal, etc., of practically uniform grades of electric furnace graphite, of a degree of purity adapted to their intended uses, and by reason of their purity and uniformity, far superior to the crude, impure and variable natural product. He developed also electric furnace methods which have rendered possible the transformation of vast quantities of carbon into graphite, thereby commercializing the industry. He also

developed the present industrial methods for the graphitization of electrodes and other shaped bodies of carbon, and these electrodes, by reason of their homogeneous character and freedom from impurities and extraneous bonding agents have, in many applications, completely supplanted the crude and unsatisfactory baked carbon electrodes upon which the art of electro-chemistry, in its infancy, was forced to rely. It has often been stated that electro-chemistry, supplanting the wasteful chemical and metallurgical methods of the past and present, is destined to become the predominant agent in the conservation of the resources of the world; and it may safely be asserted that electro-chemistry owes its astounding modern growth, first to the development of the dynamo, and second to the production of Acheson-Graphite Electrodes. For the development of the great industry of electrolytic caustic and bleach, for example, their use has been indispensable. Dr. Acheson was pre-eminently and absolutely a pioneer in the graphite art. He was not a mere improver upon an existing art,

but he made a great invention, discovered a new art, never known before and blazed the way as a pathfinder for future generations."

This characteristic of searching out new and untrodden paths is again illustrated in a very forcible manner by his work on the defloccula tion of graphite and other amorphous bodies and the application of deflocculated graphite to the problem of lubrication. Lubrication is one of the most important problems with which man has to contend, entering as it does into every phase of civilized life. The manufacturing and handling of lubricants has been the basis of some of the largest and most powerful organizations of modern times, and it has received the attention of our leaders in scientific thought.

In the judgment of those competent of forming opinions for the world, who have investigated Dr. Acheson's products known as Aquadag and Oildag, he has in these materials, to a large extent, solved the problem of lubrication for future generations. In an address by Dr. Charles F. Mabery delivered by special request before the American Society of Mechanical

Engineers at their January meeting of 1910, he presented the results of very exhaustive and prolonged tests that he had made to determine the efficiency of Aquadag and Oildag for general lubrication, and in this address he stated:

"Deflocculated graphite has peculiar properties; it remains suspended indefinitely in water, but is quickly precipitated by impurities. On account of its extreme subdivision a very small amount suspended in water serves for efficient lubrication. From numerous and long-continued trials it appears that thirty-five one hundredths per cent. serves an adequate purpose and that a larger proportion is superfluous. It is certainly remarkable that such a small quantity of graphite is readily distributed by water between a journal and bearing while sustaining a load of seventy pounds per square inch of bearing surface, and that under high-speed conditions it maintains an extremely low co-efficient of friction."

And in conclusion, he said:

"The results presented in this paper, with reference to the uses of graphite as a solid lub-

ricant, indicate that in the deflocculated form it can readily be applied with great economic efficiency in all forms of mechanical work. One of the most characteristic effects is that of a surface-evener, by forming a veneer, equalizing the metallic depressions and projections on the surfaces of journal and bearing; and being endowed with a certain freedom of motion under pressure, it affords the most perfect lubrication. In automobile lubrication the great efficiency of graphite, in increasing engine power, in controlling temperatures, and in decreasing wear and tear on bearings, has been brought out in a series of tests conducted by the Automobile Club of America. In connection with the reduction in friction of lubricating oils by graphite the extremely small proportion necessary is worthy of note; the proportion used in this work is equivalent to one cubic inch of graphite in three gallons of oil. The curve of temperature for Aquadag, an increase but slightly above that of the surrounding atmosphere, demonstrates an important economic quality of controlling temperatures in factory lubrication, thereby

avoiding the danger of highly heated bearings, which are frequently the cause of fires.

"In the observations described in this paper, and in fact in all the work that has been done in this field, there is not a more impressive example of the efficiency of graphite in lubrication than that presented in the curves of friction and temperature of water and graphite; for water serving merely as a vehicle and completely devoid of lubricating quality, the graphite is permitted to perform its work without aid and with no limiting conditions."