I already knew. Minnesota, like Illinois, had one arrangement which I thought advantageous. Chemical engineering was wholly within the chemistry department and controlled by one faculty. While at Michigan chemical engineering was independent of chemistry and under the engineering faculty.

I visited both places and was cordially received. At Ann Arbor the Apostles Club was still active and I enjoyed dining there though I greatly missed many of my old associates. The chemistry building, constructed while I was formerly there, already was becoming too small, and I realized that on account of its being a completely closed rectangle it would be difficult to add to it. At Minnesota the chemistry building was quite new and so large that some of the rooms on the top story were used as drawing rooms for other engineering students. No director of chemistry had been appointed since the retirement of Professor Frankforter two years before. Professor Bussey of the Mathematics Department had served as acting head. It was evident that a director was needed, and one that could help heal the wounds that had been caused by the failure of anyone within the department to be made director.

Upon my visit to President Coffman of Minnesota he told me he had thought it wiser to bring in a new head. In my interview he saw it would not be easy for me to decide and sensed that I needed a new incentive. This he accomplished in two ways. He pointed out the advantages to be director of a School of Chemistry with an independent faculty (including chemical engineering), rather than to be head of a chemistry department under a faculty of Arts and Science. He also showed his executive ability by raising my offer by $1000—which was no mean percentage raise, as university salaries were then not what they have now become.

I promised President Coffman I would give him my decision soon after consulting my wife. But I believe I was already convinced I should accept Minnesota. This was a relief as at times I had threatened to settle it by flipping a coin. But when my decision was announced some of my friends twitted me that I had decided with Minnesota's superior trout streams clearly in mind. I protested that I had never tried them, as I was never in the state of Minnesota until I went to be interviewed by the University. But I had heard they were good and hoped to find them so, as I later did.

CHAPTER 11

The University of Minnesota

My attraction to this University in 1926 was due to a number of reasons. I regarded it as having a strong and unique organization. Its charter under the state constitution had given it unusual authority of administration without appeal to the Legislature. Its Board of Regents was rendered effective by its small number of nine Minnesota citizens appointed by the Governor under a precedent of careful, non-political selection. The Chairman of the Board is elected by vote of its own members.

The successive presidents of the University, chosen by the Board of Regents, were without exception men of high ability. The first, William Watts Folwell had studied at Hobart College and later in Europe but his academic career was interrupted by the Civil War in which he became an army engineer, advancing from lieutenant to colonel. In 1869 through the influence of friends in Minnesota the Regents were persuaded to appoint him as first president of the University of Minnesota. He had a high conception of what a university should be—"not just an overgrown college." He proceeded to organize it on a basis of high and rigid scholarship. He had many discouragements in finances and students' scholarships, or lack of them. He got great support from Governor John S. Pillsbury, an able financier, so friendly to the University that he was known as its "Father." The Morrill act also helped financially to save the University. But difficulties mounted until in 1882 Folwell thought it best to resign the presidency, but continue as professor of history. He spent the last years of his life writing a monumental four-volume history of Minnesota.

The second president, Cyrus Northrop, was brought from a Yale professorship of English to replace Folwell. He had just the qualifications needed to succeed as peacemaker and bring quiet to the University over which he presided happily for the next twenty-five years. During his administration the student body grew from a few hundred to about six thousand and the professional schools which Folwell had envisioned were brought into being. The benign pacification by Northrop extended to both faculty and students as Minnesota expanded to become a real university.

In its third president Minnesota was again most fortunate. Governor John Lind influenced George E. Vincent to come to Minnesota from the University of Chicago where he was professor of sociology and dean of the faculties of art, science and literature. His dynamic personality at once pervaded and electrified the entire University. This made it easy for him to reorganize and modernize those departments, which under the excessive conservatism of Northrup had gotten somewhat out of date. He reformed the Law School against great professional opposition and brought William Reynolds Vance from Yale to carry out this tough task as head and give the University of Minnesota a law school worthy of the State. Vincent also took a great step in establishing a relation between the University School of Medicine and the Mayo Clinic at Rochester, which through the years has proved of outstanding benefit to both. Vincent not only exerted his talents in stimulating the academic activities but also, with the help of Mrs. Vincent rejuvenated the social life of both students and faculty. He was in constant demand as speaker on all kinds of occasions and universally performed with brilliance. Another of Vincent's highly regarded procedures was his changes in the School of Medicine, not so drastic as that in Law, but equally effective. Dean F. F. Wesbrook accepted a call to the University of British Columbia as president and was replaced by Dr. C. M. Jackson as Dean of Medicine who for many years advanced its professional and scientific status. Vincent brought Guy Stanton Ford from Illinois to be first dean of the new Graduate School. One of Vincent's last acts as president after extricating Education from the Arts College was to persuade Lotus Coffman to come from Illinois to found a School of Education. It was with great regret that the University learned in 1917 of Vincent's approaching resignation. His work was done. He had given Minnesota a great university and a new stimulus for further progress. His imprint on its structure has been a lasting one.

Marion L. Burton became the fourth president of the University of Minnesota. Although a Minnesotan he did not linger long in his native state, but within a year accepted a call to be president of the University of Michigan. His term in Minnesota coincided with our participation in World War I. The War raised some question of divided national loyalty of a few faculty members and one of them was investigated and dismissed. Years later he was exonerated and recompensed for his unjust dismissal. Loss of both students and money, due to the War, extended beyond Burton's short tenure.

Lotus Coffman was in 1920 advanced from Dean of the School of Education to be fifth president of the University. This proved to be an excellent choice. By carrying on the plans of Vincent for expansion he justified and strengthened the "big university" idea by his persistence in appointing only those with outstanding qualifications to major positions in the many schools now comprising the University. Guidance through this critical period of growth by a man with Coffman's ability, perseverance and strength of character was of untold value. When need was, he battled valiantly with the state legislature, with the university regents, faculty or students. And sometimes he faced opposition from several local professions and from the general public. But he usually won and later events proved he had been right. Of all the nine presidents I think Coffman contributed most to the strength and prestige of the modern University of Minnesota. It is very fitting that the Coffman Memorial Union stands as a monument to such a grand man. He was the only one of Minnesota's presidents to die in office.

Following Coffman the University had two successive short-term presidents, both limited by retirement age. Ford was immediately called upon Coffman's sudden death (September 22, 1938) in his stead. He was later made president which he held for a little over three years until he reached retirement age. He was succeeded by Walter C. Coffey, Dean of the School of Agriculture who had come to Minnesota, as had also Coffman and Ford, from the University of Illinois. Coffey's presidency was terminated after only three years. But despite the brevity of both these terms, many important changes took place and the university continued to grow, as it always has, except when disrupted by World Wars I and II. The Graduate School, which under Ford as dean had swelled from 175 to 3300 students, continued to grow under Dean Blegen to around 6000. The University Press was created and immediately became a success, mainly in publishing books by the faculty members. Coffey's term was marked by steady progress. He continued his interest in the School of Agriculture that was made about the best in the country by such men as Clyde Bailey, Elvin Stakman, Herbert Hayes, Henry Schmitz and many others too numerous to mention.

James L. Morrill, eighth president, came from a brief term as president of the University of Wyoming after prolonged administrative experience at Ohio State University as dean, vice-president and acting president. With the able assistance of two men who shall be soon mentioned, he carried on during his term of sixteen years at Minnesota the progressive policies initiated by his predecessors. His suave demeanor generated no antipathies in the Legislature and many fine additions were made to the university, notably the Coffman Memorial Union, the twelve story Mayo Memorial, housing all the medical arts, the Duluth University branch, the Rosemount Research Center, buildings for Journalism and for the School of Business on the main campus.

The most recent president of the University, O. Meredith Wilson, came to Minnesota from the presidency of the University of Washington just when expansion in Minneapolis to the other side of the Mississippi River had begun. This ambitious program stimulated Wilson to support the move and to make large requests of funds. But instead of granting increases the Legislature made drastic cuts which not only embarrassed the administration but caused actual retrenchment in many directions. These periodic and sometimes spasmodic bursts of penuriousness on the part of the Legislature have cropped up occasionally from the very beginning of the University. But always the public reaction has been in favor of education and has practically forced legislative appropriations. It may confidently be expected that this will again happen and come to the rescue of the present administrative programs.

Coffman and all successive presidents had the invaluable aid of two men with unusual talents, Malcolm Willey and William Middlebrook. They came from the East where they had been fellow students at Dartmouth. It was Middlebrook's duty as Comptroller and later Business Vice President to assist the President with internal finances and to appear before the Legislature in the biennial appeals for appropriations. Owing to his many years of experience Middlebrook had acquired good methods of approach, a mixture of tact and insistence. In a state not so abounding in funds as some of the other midwestern states, this appeal was most critical and both the President and Vice-President heaved sighs of relief when it was over—and sometimes only sighs. The growth of the University constantly called for more funds, but during the Depression years severe cuts had to be taken. On the whole the Minnesota Legislature has dealt fairly with the University and at times generously.

Dean Malcolm Willey's assistance was more on the academic side. He had a brilliant mind, wrote well and spoke well, and was constantly called on for various kinds of chores, some of them challenging, others just dull and routine. But always he was willing and efficient. His aid will be greatly missed. He has recently retired after a long term of outstanding service.

Through the years one other man has rendered valiant service to all recent presidents in the central administration of the University. In his several and combined capacities as treasurer, comptroller, business manager and finally vice-president Lawrence Lunden exercised good judgment and nice discernment in carrying out his duties. He succeeded to the office of vice-president upon the retirement of Middlebrook in the summer of 1961.

But I am not writing a history of the University. For that one must see James Gray's recent "The University of Minnesota, 1851-1951." (University Press, 1951, 609 pages). Leaving that excellent text I must get on with chemistry and chemical engineering at Minnesota.

Chemical Engineering was one of the six divisions of the Department of Chemistry and was housed in the new School of Chemistry building when I became director in 1926. Professor Charles A. Mann, the Head of Chemical Engineering, possessed a very dynamic personality and had developed chemical engineering to the extent that the number of its graduates at the Bachelor stage exceeded those in chemistry by several fold. In graduate work, however, the other divisions of chemistry held their own in research and advanced degrees, notably organic chemistry under Professor William Hunter assisted by Dr. Lee Smith, who later became head upon Hunter's death and carried on for many years with the aid of Drs. Walter Lauer and Fred Koelsch. My own research was in physical chemistry, of which Professor Frank MacDougal was head, with a staff of Robert Livingston, Lloyd H. Reyerson and Bryce Crawford, who later became Dean of the Graduate School. In 1927 Professor Izaak Kolthoff was brought to Minnesota from the University of Utrecht to be head of Analytical Chemistry. My choice in selecting him became later more than justified by his outstanding contributions in research and his well known texts and treatises that extended to fields quite outside analytical chemistry, which he has also developed to a high plane of excellence. His graduates have attained high positions in their fields, Ernest B. Sandell at Minnesota, James J. Lingane at Harvard, Herbert A. Laitinen at Illinois. Regrettably, Professor Kolthoff reached the age of retirement in June, 1962.

The division of General Chemistry was presided over by Professor Cannon Sneed with an able staff. Besides the teaching of beginning chemistry for various departments of the University, research in inorganic chemistry was carried on by Professors Sneed, Maynard, Barber, and Heisig who distinguished himself especially in radiation chemistry. L. H. Reyerson has recently retired from the field of physical chemistry in which he has become so well known, but continues to publish recent work. Professor Sneed, now in retirement, is bringing out successive volumes of his Encyclopedia of Chemistry.

Beside my administrative duties in the School of Chemistry I found time to direct the work of assistants and graduate students in the radiation chemistry of gases. The loan of the Bureau of Mines radium had been extended to Minnesota and was used as a source of radon and as radium standards, principally in charge of Professor Robert Livingston.

Among the assistants who worked with me at Minnesota under various grants should be mentioned Dr. George Glockler, later at the University of Iowa and now at Duke University, who observed the effects and products of electrical discharge in a bank of ozonizer tubes in several gaseous systems, notably, butane from which he collected the liquid hydrocarbons condensed by the discharge and studied their forty fractions obtained by distillation. The largest fraction consisted of a mixture of octanes and octylenes produced by doubling the butane molecules by ionization according to the original mechanism of Lind. Dr. Hubert Alyea synthesized phosgene by the action of light and by alpha rays in the reaction mixture ($CO+Cl_2$) and determined the ion yields to be quite high but not nearly so high as in the H_2+Cl_2 reaction. Dr. Robert Livingston measured the photopolymerization of acetylene, and the radiochemical reaction of hydrogen with chlorine (long chain) and with bromine (non-chain). Dr. George Schultze compared the rates of condensation in electrical discharge of the lower members of the paraffin, olefin and acetylene series. Dr. B. E. Cohn observed the color and luminescence produced in zinc borate glass; and Dr. J. C. Jungers of the University of Louvain with Dr. Shiflett and myself determined the ion yield of the radio-polymerization of di-deutero acetylene to be the same as that of ordinary acetylene.

Of the students who took the Ph.D. degree under my direction were Bernard Marks, who worked in electrical discharge in hydrocarbon gases; E. F. Ogg (deceased), who studied the temperature coefficient of the radiochemical synthesis of hydrogen bromide from its elements; E. C. Truesdale, who studied the reactions in the gaseous system hydrogen: sulphur: hydrogen sulphide under the influence of radon; Charles Rosenblum, who studied the kinetics of the $CO+O_2$ reaction induced by radon; C. H. Shiflett, who studied the temperature coefficient of water synthesis from its elements under α-irradiation, the polymerization of C_2D_2 by radon, the combination of deuterium and oxygen induced by radon, the exchange reaction between sodium and ethyl iodides using radioactive indicators, and the oxidation of cuprene by α-rays; C. S. Copeland, who produced neutrons by bombardment of light elements; F. C. Lanning, collaborator in my only venture since Paris into the radiochemistry of aqueous salt solutions, studied by means of dissolved radon the reactions of aqueous solutions of hydrogen iodide, hydrogen bromide, iodine and potassium permanganate. The primary reaction is the decomposition of water (yield about 1) and the secondary reactions are between the transient decomposition products (H_2, H_2O_2, H, OH) and the given solutes, hence both reduction by hydrogen, and oxidation by hydrogen peroxide. Miss Keren Gilmore, later Mrs. K. G. Brattain (deceased) studied the radiolysis of hydrogen iodide.

Midway is my long tenure at the University of Minnesota President Coffman decided to combine the College of Engineering, the School of Chemistry, and the School of Mines and its Experiment Station into one administrative unit with a single representative in his Advisory Committee of Deans. I was made dean of the new Institute of Technology. The Massachusetts Institute of Technology unofficially raised some objection to the use of the term *institute of technology* for a unit within a university and claimed not only priority in this terminology but exclusive right to its use. President Coffman, however, was not deterred in its adoption. The three faculties; (1) Engineering and Architecture, (2) Chemistry and Chemical Engineering, (3) Mining and Metallurgy, maintained their independence and held separate faculty meetings, as in the past at each of which I presided. On account of the approaching retirement of Dean Appleby, the School of Mines was not brought into the Institute until the end of his tenure, two years later.

The Mines Experiment Station had always enjoyed a large degree of independence under its very able director, C. W. Davis, who devoted most of his time to the painstaking development of a process for the treatment of the almost inexhaustible tonnage of low grade iron ore in northern Minnesota. This long-range project became more important as the high grade ores approached exhaustion in many mines. The low grade ores require extensive up-grading to prepare them for iron production in the blast furnace. Mr. Davis' timing was so opportune that his process, after some twenty years of experimental development, reached maturity just when it could be economically utilized. Davis also reached retirement age at the University about this time and immediately took control of the large installation on Lake Superior to apply his process in the beneficiation of the low grade ores by one of the commercial companies. Thus the iron ore indsutry was saved to Minnesota and to the United States for a long time to come. A town named Davis has been created with all modern facilities to house the workers in the enormous plants supervised by Davis on the north shore of Lake Superior. All of this is described in the Engineering and Mining Journal of December, 1956, to which the reader is referred.

How much credit for this development, beyond wise administration, is due to Dean Appleby I do not know. But I am sure I deserve none except in leaving Davis entirely free in the undertaking that I think turned out to be a model of the proper relation between university and essential industry by which the University benefits through a continuing financial support and the state from a large perpetuated industrial undertaking.

The Institute of Technology had occasional faculty meetings attended by those with rank above Assistant Professor. The meetings dealt with matters of common interest to all three units and was careful to avoid infringement on the prerogatives of the three individual faculties.

Dean Appleby, after many years of wise and able service, died soon after his retirement. Dr. Mann unfortunately did not live to achieve two of his most cherished ambitions—a separate building for chemical engineering and a faculty separate from that of chemistry. Both of these deaths came soon after my retirement in 1947, and also after two distinguished professors of chemical engineering had left the University, Drs. George Montillon now at the Gaseous Diffusion Plant at Oak Ridge and Ralph Montonna (deceased).

When we entered World War II many of our students wished deferment from service so as to finish their studies. The petition of each student had to be submitted to his particular Draft Board and had to bear my recommendation—following an interview. Thus to contact every student in the Institute as soon as he reached draft age took most of my time for the duration of the war. Although it interrupted my research I felt repaid in helping the students as well as the armed services.

While I was at the University of Minnesota I was elected President of the American Electrochemical Society in 1927, President of the American Chemical Society in 1940, and received the Nichols Medal of the New York Section of the American Chemical Society in 1926. I was elected to the National Academy of Sciences in 1930, to the American Philosophical Society in 1943, and to the Minnesota Academy of Science in 1940. I was elected member of the International Radium Standards Commission in 1928; the other members were Madame Curie, A. Debierne, A. S. Eve, H. Geiger, Otto Hahn, Stefan Meyer, Ernest Rutherford and E. Schweidler. I was given the honorary Doctor of Science degree at the University of Colorado in 1927, at Washington and Lee University in 1939, at the University of Michigan in 1940.

In 1938 during my tenure at the University of Minnesota I had been appointed one of the delegates of the American Chemical Society to the meeting of the International Union of Pure and Applied Chemistry which was to meet in Rome in June. I secured a leave of absence from the University so that I might attend. Mrs. Lind accompanied me on the Italian liner Count de Savoia (destroyed in World War II). Drs. Charles Parsons, James Norris, Thomas Midgley and many other friends made a pleasant party of American chemists on the boat trip. Mrs. Lind and I landed at Naples with our car when the fine harbor port was just being completed. After visiting Naples briefly, including the beautiful trip around the Amalfi Drive, we made a leisurely journey to Rome where we put up at the Hotel Roma during the week of the convention.

Of course the beauty of Rome entranced us but we did not find the use of a car very convenient in a city designed for horse or foot traffic centuries before the advent of automobiles. Our garage near the hotel was so crowded with closely packed cars that nearly all had to be moved or removed every time any one of them was extricated. So we used our car very little in the city after a mild encounter with a too hurried French bus arriving from Paris. We attended a gay party at the Hotel Excelsior, but owing to the bounteous festivities my ready cash ran out. The hotel declined to extend me credit since we were not staying there. Fortunately my friend Dr. Colin Fink (distinguished Professor of Electrochemistry at Columbia University) came to the rescue until I could draw on my travel funds next day.

I attempted to visit Professor Fermi in his laboratory at the University of Rome but did not succeed in finding him. Professor Hahn, I believe, had the same experience. It appeared later that he had left Rome in anticipation of the reprisals of the Mussolini regime soon to come. So he had disappeared and doubtless was making plans to come to the United States where he later made his home in Chicago until his untimely death in 1954. Besides his many other brilliant contributions Fermi is perhaps best remembered as presiding over and actually constructing piece by piece the first atomic reactor in the world to attain automatic operation. This success, due to his sagacity and patience, at once put uranium reactor on the map the world over. Fermi's untimely death was a great loss to science and it is most fitting that his name should be perpetuated in naming the 100th chemical element, FERMIUM.

Dr. Max Bodenstein, my former thesis director at the University of Leipzig, who had since changed to Hannover, and finally to Berlin, was in attendance as one of the German delegates to the International Union. With his customary hospitality he gave a fine dinner at an elegant restaurant. The number of his guests had to be restricted on account of the limited funds which a traveler could take out of Germany at that time. Present besides Mrs. Lind and myself were Professor Otto Hahn who later discovered the fission of U^{235}, Dr. Herbert Freundlich, author of the adsorption isotherm equation, and A. Mittasch of I. G. Farben Industry. But there was no limit to the bounty of the board and refreshments.

Dr. Hahn was already engaged in his experiments with uranium but had not yet reached the explanation with which he was soon to astound the world and set in motion the events that led to nuclear energy and atomic warfare. The latter was deplored by him later in his book "New Atoms" (p. 34) (Elsevier Publishing Company, 1950). He says: "The energy of nuclear physical reactions has been given into men's hands. Shall it be used for the assistance of free scientific thought, for social improvement and the betterment of the living conditions of mankind? Or will it be misused to destroy what mankind has built up in thousands of years?" The answer (he said) must be given without hestitation . . . but now twelve years later has not yet been given.

On leaving Rome we made Professor Bodenstein our guest in driving up to Florence with some visits to cathedrals and places of historic interest on the way. Arrival at our hotel was attended by an amusing incident. While I was looking after the car Mrs. Lind and Professor Bodenstein were shown into the hotel. On rejoining them I found the hotel manager insisting on lodging them together. I succeeded however in convincing him that I was the husband and that Professor Bodenstein should be segregated—much to his amusement at my expense.

We left Professor Bodenstein in Florence and journeyed to Paris where I visited the new Curie Laboratory and renewed acquaintance of Professor Irene Curie. She took me to one of the afternoon conferences of Professor Perrin. I also visited the laboratory of her husband, Professor Frederic Joliot, already engaged in the experiments that *later* made them both famous and won them a Nobel Pribe in Chemistry in 1935 for the discovery of artificially induced radioactivity.

While in Paris I had occasion to draw on my funds with the American Express Company. Later in England I began to believe I had been overpaid in Paris by the amount of one hundred dollars. But I was unable to confirm this until I returned home and could make a final balance of my expense accounts. On learning that my supposition seemed to be correct, I wrote to the Express Company in Paris, giving the date and inquiring if they had found a shortage—and in what amount. They confirmed a shortage of one hundred dollars on that particular date. I offered restitution on condition that no employee should be discharged but would be retained on receipt of my reimbursement. I received assurance and sent a draft for $100, but with the misgiving that the poor clerk was probably walking the streets already.

Mrs. Lind and I made the usual sight-seeing tours of England, Scotland and Wales, but since they involved no chemistry nor unusual occurrences, they are not recounted here.

In London we were joined by Professor and Mrs. George Burr from the University of Minnesota where he was Professor of Biochemistry. They had left their car in New York and our car was turned over to them and Mrs. Lind for a tour of several weeks on the continent, while I returned by boat to New York and picked up the Burr car for my use until they should return to Minneapolis.

In 1935 cars were not so abundant as now. There was no difficulty in parking on Fifth Avenue or anywhere else in New York City. After making a few purchases I had an uneventful drive back to Minneapolis where I returned to duty in the School of Chemistry of the University.

Looking back over my twenty-two years at the University of Minnesota I am most gratified by the contacts and friends I made there, not only in the School of Chemistry but in all other departments of the University and among chemists and other scientists that I met at scientific meetings.

The first year after my retirement at Minnesota in 1947 I remained in Minneapolis. The University kindly gave me quarters for my office and laboratory work. Dr. Marcel Vanpee, a research fellow from the University of Louvain in Belgium, worked with me in utilizing radon to study some reactions induced by alpha rays. I found him not only an agreeable associate but one utterly fearless of radiation. And if one could judge from his attitude, the opinion in Belgium did not support the extremely low tolerances that are being urged by Health Physics authorities in the United States and adopted by the international committees, to which further reference will be made later.

The state of Minnesota which supports its University is rich in natural resources. Its wide area extending between 43°34′ and 49°23′ north latitude and 89°34′ to 97°12′ west longitude make it an ideal location for agriculture, stock raising, mining, manufacture and industrial arts of all kinds. Its ten thousand lakes, distributed broadly over the state, give it an unexcelled water supply. Its long boundary on Lake Superior from Duluth and Superior (Wisconsin) northeast to the Canadian border provides water transportation for its rich and inexhaustible deposits of iron ore which move down, practically by gravity, from the centers about Hibbing to the highly equipped ports at Duluth and Two Harbors and thence by water to the blast furnaces. Its large grain supplies also move by water through Duluth to the eastern mills now in the vicinity of Buffalo. Modern conditions make it more economical to ship wheat to Buffalo for milling than to make flour on the Mississippi at Minneapolis as was earlier done. This left the great mills on the Mississippi in Minneapolis almost idle.

Unfortunately Minnesota is totally devoid of one most essential natural resource, fuel, either solid, liquid or gaseous. For this reason iron ore cannot be treated in Minnesota but must move down the lakes to meet fuel at the blast furnaces near Chicago and Cleveland. This lack of Minnesota fuel also curtails many other industrial processes. If atomic energy can be made to supply power cheaply enough, it may meet one of Minnesota's greatest industrial needs. The first attempt in this direction is now being made in the Elk River (Minnesota) atomic power reactor. A region without natural fuel is a made-to-order place to try out the potentialities of nuclear power, since the cost of fuel makes it possible to provide high funds for experimenting and later for operating. The answer to this economic question should be found in the near future.

CHAPTER 12

Oak Ridge, Tennessee

In the spring of 1948 I attended a meeting in Oak Ridge and had my first glimpse of the activities that had been kept so successfully under cover since their beginning in 1943. Since I had no clearance my visit was quite limited in scope, but I saw enough to attract me strongly. I therefore applied to the Atomic Energy Commission (A.E.C.) for clearance, which took the usual course of a few months before issue. In July, I was duly cleared and soon after moving to Oak Ridge was appointed consultant to the Union Carbide Company that had the contract under A.E.C. to operate the three plants and laboratories. Due to my being over the age limit of sixty-five years, I could not be appointed as a regular employee but as a consultant, which had both advantages and disadvantages. My contract, which had to be renewed each year, gave me no paid vacations nor annuity insurance. Compensation was for each actual day of work only. Otherwise my contract was liberal in that the number of working days in the year was not limited. I could take vacation any time, travel officially at laboratory expense, and otherwise have all the privileges and duties of regular employment.

My wife and I moved to Oak Ridge and took the only quarters then available, one of the meagerly furnished, so-called Efficiency Apartments near the Guest House (now Alexander Hotel). We remained there for eighteen months and then moved to the Garden Apartments on the day they opened, January 1, 1950, and have lived there comfortably ever since.

My work in Oak Ridge centered first in the area of the Gaseous Diffusion Plant (K-25) which separates U^{235}, the fissionable isotope of uranium, by gaseous diffusion of its hexafluoride. Owing to the low content (less than 7 parts per thousand) of U^{235} in the commonly occurring U^{238}, and the slight difference in their atomic masses (about 1.3%), their separation is a most formidable undertaking. One must admire and marvel at the foresight and courage of those who backed up their calculations by the construction of an enormous plant to carry out, by infinite repetition of a single operation, the stupendous fractionation of two isotopic gases—and all of this construction and expense without any advance assurance of its success. Other processes of separation were considered but only one other, the electromagnetic process at Y-12 was operated on a full scale. Although it confirmed the theoretcial prediction of A. O. Nier (University of Minnesota), by producing enough U^{235} to supply one of the two nuclear weapons used in World War II, its cost was prohibitive and the process, with its many expensive separators, was abandoned except for one or two units reserved for scientific work.

At the time of its construction the successful Gaseous Diffusion Plant in Oak Ridge (K-25) was the largest plant in the world under one roof carrying out only one operation. It has been enlarged by several other larger units since that time. Other diffusion plants have been built at Paducah, Kentucky, and Portsmouth, Ohio. These three plants have continuously produced most of the free world's supply of U^{235}.

In my study of the diffusion process I realized that the fluorides being separated were constantly subjected to bombardment which might disrupt the UF_6 and cause some inefficiency due to precipitation of metallic uranium—or an oxide if any air were accidentally present in small amount. Such solids, actually found in small quantity, represent a slight inefficiency of the process, since the solids will not diffuse through the membrane and would subsequently have to be collected and reconverted to UF_6 to avoid loss of valuable uranium. A previous calculation by one of the staff members had indicated that the radiolytic precipitation of U^{235} by alpha irradiation would be negligible in quantity. I found, however, that this calculation was based on the intensity of radiation effective at initiation of the separation process, before the proportion of U^{235} had been enhanced by passage through the cascade. But the life of U^{235} is much shorter than that of U^{238}, which means that its rate of emission of alpha rays is correspondingly faster. Therefore at the enriched end of the cascade when U^{235} is approaching 100%, and also some U^{233} is arising with a still higher rate of change, the rate of decay and of ionization would be much greater than that previously calculated at the entrance to the cascade. My calculation taking these factors into account indicated that there would be an appreciable precipitation of uranium in the enriched fraction of the upper units of the cascade. This was tested in the laboratory by using radon as a higher source of alpha rays than enriched U^{235}. The result was precipitation. The experiments showed that, after elimination of solid oxides by the exclusion of air, further efforts to reduce the small quantity of solids would be futile, because there is no way to prevent the disruptive action of the alpha rays. The solid precipitates, however, are carefully collected and reconverted to UF_6.

Somewhat later, when changes in the organization at the Oak Ridge National Laboratory (ORNL) caused temporary transfer of Dr. Ellison Taylor, the Director of its Chemistry Division, to other work, I was asked to assume his duties. This brought me into closer contact with all the members of the Chemistry Division, and I was glad to become acquainted with its various problems and researches. I also had contacts with some of the physicists in fields of common interest. Most of my time was now spent at ORNL, but I still retained an office at K-25 where I received all my scientific mail and journals and did a good deal of my reading there, as well as continuing some consultation with the K-25 staff. My continued relation to K-25 also gave me the much appreciated opportunity of occasional visits with Mr. C. E. Center, then in charge for Union Carbide of all four areas, K-25, X-10, Y-12, and Paducah. I should report having seen him (June 13, 1962) after he returned to his office at K-25 following an illness and found him quite well restored.

Besides my earlier administrative duties at the Oak Ridge National Laboratory, I had time to take part in continuing some research in the radiation chemistry of gases. Dr. Philip Rudolph modified the system for radon collection by making the recombination of the undesired large amount of hydrogen and oxygen automatic and continuous. Radon thus purified and collected was used as activating agent in joint study with Rudolph of several reactions. The relative ionization potentials of acetylene (11.41 ev) and of benzene (9.25 ev) permits the prediction that, in a mixture of the two gases, benzene should, by charge transfer, inhibit the polymerization of acetylene, and thus diminish its rate of reaction. Lind and Rudolph proved this to be so—to the extent of about 32% retardation [J. Chem. Phys., *26*, 1768 (1957)]. This retardation in accord with theory is in the opposite direction from the accelerations found by Lind and Bardwell [J. Am. Chem. Soc., *48*, 1575 (1926)] when ionization potentials of inerts are above those of the reactants. Other radiochemical reactions studied with Rudolph were: the polymerization and dissociation of carbon monoxide, the polymerization of acetylene and of mixtures of acetylene with the several noble gases which could, by charge transfer, either accelerate or diminish yields according to the direction of charge transfer to or from reactants as dependent on the relative ionization potentials. Rudolph and Melton supplemented the researches by following these reactions and identifying their products in the *mass spectrometer*, which has the advantage of disclosing and measuring the primary steps, but is usually unable to follow all the intermediate stages leading to final products found by ordinary methods of analysis. A new type of instrumentation is needed to fill this gap.

[In 1949 Lind was elected to the Tennessee Academy of Science. The American Chemical Society awarded him its highest honor, the Priestly Medal, in 1952. In 1963, the University of Notre Dame bestowed on him his fourth honorary Doctor of Science degree.]

Oak Ridge itself is a very unusual community. The site selected early in World War II by a committee in the Army Corps of Engineers had to meet several conflicting requirements; remoteness from large population centers, yet adequate railway facilities to transport promptly all the materials needed for the quick construction of plants and residences; some distance from the seaboard and yet not too far from Washington and the East; sparse rural population without much agriculture which could be displaced without too much disruption or expense; but a location near centers of population that could supply workmen, supervisors, secretaries, etc., without their having to live in Oak Ridge itself. An area of about 90 square miles carved out of two East Tennessee counties, Anderson and Roane, was selected and acquired by the Atomic Energy Commission and administered by the so-called Roane-Anderson Company.

The administration of Oak Ridge (camouflaged as the Manhattan Engineering District) was first under the U. S. Army, with Major General Leslie R. Groves in control. The town of Oak Ridge was laid out by a firm of consulting architects which did an excellent job. Two main roads were constructed, generally East-West in direction—East Outer Drive and West Outer Drive on top of the ridge, at an elevation of 200-300 feet above the "Pike," which was the old highway between the two county seats, Clinton and Kingston. Connecting streets between these two thoroughfares were named for various states of the Union in alphabetical order, east to west. Off the streets, on both sides, lanes or circles were given names in alphabetical succession from the Pike up to Outer Drive with the initial letter the same as the state designation.

The plot was most skillfully and artistically laid out so as to take advantage of all the natural unspoiled beauties of the suroundinrgs. Frequently a home would look out on a valley or ridge with nothing else in sight, as if it were quite alone in a forest, and yet but a few yards below or above, hidden by the trees, another house would be enjoying isolation. The houses themselves were rapidly built and not meant to be permanent. Yet as the life of Oak Ridge has been lengthened, they have held out well and lent themselves to improvement and repair under private ownership that came later.

In the early days the entire area was protected by seven guard-houses, one on each of the entering highways. The three plants were rather widely separated from each other and from the town. The Oak Ridge Gaseous Diffusion Plant (K-25) was located about ten miles due west near the west boundary of the area formed by a branch of the Clinch River. The Oak Ridge National Laboratory (ORNL) was located about ten miles southwest of the town and seven miles southeast of K-25. The third laboratory (Y-12) was located only one or two miles from Oak Ridge off the route to ORNL. Guard-houses were placed about halfway on each of the highways for additional protection, and each plant had a guard-house at each of the several gates of entrance. One had to show his badge in passing into or out of all guarded areas. Guards were on duty day and night.

In 1949 the outer seven gates to the area were thrown open. This was an event of such importance in the history of Oak Ridge that it called for some celebration. Senator Barkley of Kentucky cut the ribbon at the Elza gate on the Pike and Adolphe Menjou and movie actresses assisted in freeing the city from its shackles. The Oak Ridge scientists were not greatly interested and were skeptical of the appropriateness of such ceremonies for a city of the serious character of Oak Ridge. A few years later the midway gates were opened without éclat, and guarding was confined to the immediate entrances of the three plants. In 1958 large areas within ORNL were opened for anyone with general access. Entrance into wilder portions of the area, somewhat reduced from the original 89 square miles, is still prohibited on account of the expense of patrolling.

In 1956 the A.E.C. began selling the residences to private individuals on very inexpensive terms—first choice to the occupant—then to any other resident of the city—and finally to anyone without preference.

Later in 1956 the sale of individual lots for private residence was initiated and some quite modern and elegant residences were constructed both in the eastern and northwestern sections of the city. Also larger sections were sold at auction for housing projects. Many houses and apartments were built for rent or sale and in 1955 a large modern shopping center called "Downtown" was built south of the Pike.

For the past several years the population of Oak Ridge has remained fairly constant, a little below 30,000. Many of the plant workers continue to come from Knoxville and more distant locations. Anyone can now live in Oak Ridge, and private ownership of residences became popular when the Atomic Energy Commission began selling them.

In 1960 the Atomic Energy Commission turned the city over to a city council elected by the residents. Gradually the different facilities have been taken over by the city. The Council, of course, had and still has many problems, not the least of which is taxation. The fact that such a large proportion of the citizens are employed by a Government agency, which itself does not pay taxes, has complicated the question and tended to throw a larger share on the employees of the laboratories of the Atomic Energy Commission. However, the Union Carbide Corporation, as principal contractor, makes generous contributions to charity and to the community. The problem of taxation is likely to become more difficult as the Atomic Energy Commission diminishes its contributions annually over a ten year period with no agreement beyond that term, and will be subject to continuing negotiations. [The A.E.C.'s contributions have been extended and are still in force (1970)].

Besides the facilities provided for study in the different plant areas, another unique system supported by the Atomic Energy Commission is the Oak Ridge Institute of Nuclear Studies (ORINS). [The name was changed to Oak Ridge Associated Universities in 1966]. It provides courses in nuclear science, intended not only for nearby residents, but especially for students from other states and countries. These courses of different length have brought many students from all over the world and from every state of the United States to study special topics, or the more general fields of atomic energy. ORINS also maintains a public Museum of Atomic Energy which attracts many visitors. Its exhibits, besides those of physical and chemical interest, include radiobiology. The Institute also operates traveling exhibits which tour the country with stops of several days in cities and towns where their displays are welcomed and viewed by many visitors. Dr. W. G. Pollard, the Director, and his assistant, Dr. R. T. Overman [now a private consultant], have been most active and successful in building the facilities of ORINS, and in extending them in many directions, particularly to the southern and western states.

As yet, Oak Ridge has no large commercial organizations. Some efforts are being made to stimulate such development. If and when it comes, the general complexion of the city may be expected to undergo alternation. In the meantime, the City Council has enough problems with new and extended residence districts, streets, water, lighting, etc. to keep it busy, as well as the general question of racial segregation and location of business and residence. It is an advantage to have a clean slate, but at the same time, inexperience and lack of precedents may be disadvantageous.

Finally the question of racial integration is faced in Oak Ridge, as elsewhere in Tennessee, in the South, and in fact in the country at large despite the derision which some sections pour out on the others. Oak Ridge was fortunate in having the school question settled by the A.E.C. itself. Integration in the high school has been easy and without problems. Also integration in the lower grades, where it might be expected to be more difficult, has presented no problem. But this may be deceptive, since the lower grades are adequately taught in the school of Gamble Valley [this school was closed in 1967], itself so isolated from Oak Ridge that there is little practical reason for mixing in grade schools or in housing.

One may think then that Oak Ridge schools have set a shining example of integration. How much credit the citizens can claim (or shun) is tempered by the fact that the decision was not their own but one of the A.E.C. administration backed up by a Supreme Court decision. And if Oak Ridge were inclined to vaunt itself, one should look at its inaction in other directions. There is not a moving picture in the city that accepts integration and few restaurants tolerate it. Each operation is free to make this decision. Some of them would not object to integration but fear it would curtail rather than augment their patronage. One outdoor movie made the effort to integrate, but gave up after two weeks—questionably blamed on rowdiness of colored patrons from Knoxville. The entire picture of integration in Oak Ridge is so unsatisfactory that one must ask why in a community of such high percentage of intelligence, with people of broad views from all parts of the country, no stronger effort is being made. One reason, I believe, is that many Oak Ridgers are so engrossed with their own work and intrigued by its disclosures, that they give little thought to integration or other public questions, and that our Council is so occupied with more immediate problems it does not feel able to take on another.

Will Oak Ridge then wake up, seize its unusual opportunity to do something before it is too late? As Oak Ridge grows, the proportion of superior people may diminish. Even integration in the schools may be challenged, as the Atomic Energy Commission gradually reduces its support. This is the picture as I see it, and I am moved to exhort Oak Ridge to bestir itself and take action worthy of a community of intelligent people. But Oak Ridge is surrounded by a state in which prejudice against the Negro runs high in a population of about 80% white. And color has lost ground in the present twentieth century. When I was a boy in McMinnville the so-called "Opera House" had a second gallery for negroes where they saw and heard the occasional plays and minstrel shows that came to town. Today, as in Oak Ridge and in most towns and cities in Tennessee there is not even a picture show where the Negro is admitted [in 1970, only one business in Oak Ridge remained segregated]. And the relations between white and black are less cordial than a generation ago. The Negroes have retired into a shroud of dignity. The young no longer wish to be addressed by their given names, nor the old to be called "Uncle" or "Auntie." They have lost their smiling spontaneous greetings, insist on formal introduction and have replaced their old-time joviality with reserved behavior.

Scientific and technical progress, and the contributions of Oak Ridge scientists to it, seem now to give more reason for satisfaction than ever before. More new and important projects are being invested here by the Atomic Energy Commission. More scientists and engineers are being constantly employed. The all-important subject of experimental power reactors is being centered here. The fact, well realized, that they will not be created by short term research, lends permanence and future to our scientific structure.

It would be unfair to leave Oak Ridge without picturing it as a place to live. Its housing and original street arrangements have already been described. Unfortunately, the system was not followed in areas later added, and it is a problem to find one's way about in some of the newer districts.

The surroundings of Oak Ridge offer many attractions that are easily reached, the "Smokies," the Cumberlands, Knoxville, the various dams and lakes of the Tennessee Valley Authority where fishing abounds the year around—and where else can one try for rainbow trout at all seasons!

The public schools of Oak Ridge, formerly supported by the A.E.C., were developed with fine teachers, courses and buildings, now taken over by the city administration, and by an able School Board. The new High School with a large auditorium, gymnasium, lunch room and more than sixty classrooms is a model for any city, but already needs expansion.

Finally the recreation facilities of Oak Ridge deserve special attention. An unusually large, centrally located, swimming pool, owned by the city is leased for operation to a private concession that charges small fees. An eighteen-hole golf course, a swimming pool [and tennis and squash courts] provide the members of the country club with good facilities, and a large dining hall takes care of special parties and dancing. An active bridge club with the largest number of "Master" players for a town of this size in the United States has regular sessions and an annual tournament.

In closing, I do not fail to see that much in the foregoing chapters has little to do with chemistry but it attempts to picture the conditions under which chemists live and work. I hope that this background, personal and impersonal, will not be too harshly judged, and will add something to the interest, if any, of my subject.