Chapter 3

Growth and the War: The Bray-Shreve Years (1934-1951)

To the casual reader of the history of the evolution of chemical engineering, major changes and achievements in this field occurred slowly, progressively and with a certain methodology, often by university adaptations to the needs of a particular era. However, upon digging deeper in historical documents it is evident that major directions in chemical engineering education and research, important changes in philosophy and practice, and exhibition of far-reaching insight into the future needs of the chemical engineering profession are usually traced, programmed, and controlled by a strong person, a gifted leader with characteristic attributes and (often) with an unusual background. Warren K. Lewis at MIT, George G. Brown at Michigan, Olaf A. Hougen at Wisconsin, Neal R. Amundson at Minnesota and Allan P. Colburn at Delaware were some of these gifted leaders who changed the course of chemical engineering. For Purdue, this leading researcher, this important leader, who shaped the directions of research and education from 1930 until approximately 1960, was R. Norris Shreve, the mature consultant and industrial chemist that Professors Moore and Peffer had tried to attract to Purdue so eagerly in 1929.

Shreve was Head at Purdue for a relatively short a period of time (1947-51). He was, however, the most active researcher, externally the most recognized faculty member of the School, and the most successful promoter of the graduate program. His directions were "accepted" and his ideas soon became the credo of almost the entire ChE faculty at Purdue University. His zenith was achieved during the years of headship of John L. Bray (1935-47). After 1943 when Bray was weakened by continuous illness, Shreve was effectively the captain of the ship, the leader of the School.

When Peffer died in July 1934 it was rather late to start a search for a new Head, and frankly Dean Potter did not see any pressing reason to invite someone from another University or industry to take charge of Chemical Engineering. The faculty was relatively young (the oldest faculty member was Shreve, then 49 years old) and there were enough faculty members to teach the courses. For one year the affairs of the School were directed by an Executive Committee headed by Dean Potter and consisting of Bray, Serviss and Shreve[1].

Finally on July 1, 1935 John Leighton Bray, the faculty member with the longest tenure, was appointed to succeed Peffer as the second Head of the School. Bray had joined the School in 1923 with only a B.S. from MIT (1912) but with significant industrial experience.

Left: John L. Bray, the second faculty member and second Head of the School, circa 1940.
Right: R. Norris Shreve in 1937.

John Leighton Bray
(1890-1952)

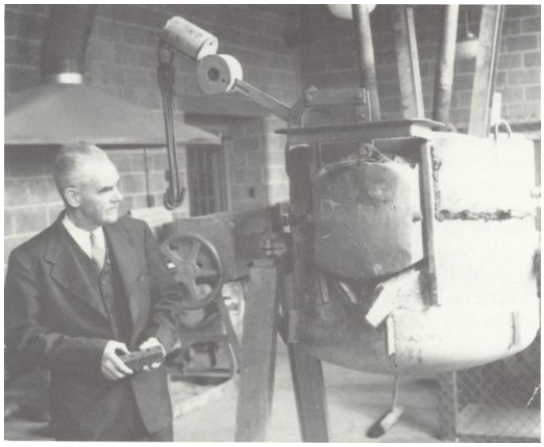
John Leighton Bray, the second faculty member and second Head of the School, was born in Milbridge, Maine on August 11, 1890. He was educated at MIT where he received his B.S. in 1912 and his Sc.D. in 1930 working with Prof. R.C. Williams in the Metallurgical Engineering (now Materials Science) Department. Upon graduation with the B.S. degree he spent five years as a mining engineer in British Columbia, Canada and in Oregon and New York[2]. From 1917 to 1918 he was a major of ordnance in the Army Corps of Engineers. In 1918 he went to Tegucigalpa, Honduras where he was superintendent of construction and operations for Rosario Mining Co., and then served a year as professor of metallurgy at the Nova Scotia Technical College in Halifax, Canada. From 1921 to 1923 he was metallurgist for the U.S. Tariff Commission at Washington and in 1923 he joined Purdue. He took a leave of absence in 1929 to complete his Ph.D., and returned to Purdue in 1930. He became Head in 1935 and stayed in this position for twelve years.

Bray was active in various societies including AIChE, AIME, Society for Metals, ACS, Electrochemical Society, Institute of Metals and ASEE. He was also a member of Sigma Xi, Tau Beta Pi and Omega Chi Epsilon. An active researcher and prolific writer he wrote more than 90 publications and several books. Early in his career he contributed the *Textbook of Ore Dressing* (1925), *Principles of Metallurgy* (1929) and *German Grammar for Chemists* (1938). His most impressive textbook output came in the 1940's when he wrote the classic *Non-Ferrous Production Metallurgy* (1941) and *Ferrous Production Metallurgy* (1948). These two books were used for many years as standard textbooks. He supervised the Ph.D. theses of 13 students, the M.S. of 27, and 9 professional Ch.E. theses in the areas of Chemical and Metallurgical Engineering.

Bray was an excellent teacher, respected by the students and his colleagues. Shreve wrote to him[3] on the occasion of a teaching award voted by the members of the Sigma Delta Chi fraternity in 1952. "In the twenty two years that I have been connected with this School, you have been the teacher that all the rest of us have tried to emulate, first, in your splendid relationship with the students, second, in your patience and understanding in handling backward students, and third, in your skill in the presentation of your subjects." By example he encouraged thoroughness, perseverance, straight-forwardness, inquisitiveness and the creative spirit.

About his administrative skills, J.M. Smith wrote[4]: "Dr. Bray was a man of decision. Whenever a staff member came to him with a problem he did not try to lay it aside but took action as soon as possible. I can remember many times when I wished to obtain some equipment for research work and asked him about the possibility of getting it. Without further discussion, he would pick up the telephone and the matter would be attended to immediately." And at his death, Shreve wrote to the faculty of the School[5]. "John Bray was not addicted to speaking along lines of contemplation, but to those who knew him, he had a basic philosophy of service... The ideal of service as a motivation in human contacts, made John Bray the outstanding teacher... he was."

His contributions to the School were recognized by the establishment of the John L. Bray Memorial Award given since 1956 to an outstanding senior student of the School of Metallurgical (now Materials) Engineering, and by a distinguished professorship named in his honor. Professor Byron Pipes is the first recipient of this professorship.



John L. Bray inspecting a furnace in the fall of 1951.

An Easterner by birth and in spirit, Bray returned often to New York, Boston or Maine for vacations, research meetings or consulting. Yet he soon became a most loyal Purdue supporter and gave long hours every day to the improvement of the curriculum and research in the School. He was assisted in

that by a loyal Administrative Assistant who started as his secretary and developed into a strong caretaker of the School for more than 30 years, Helen C. Wilson Giese (1910-1999) who retired in 1970 from the School of Materials Science and Metallurgical Engineering.

Bray's early research was on metallurgical processes, the subject that would occupy him throughout his career at Purdue. The fourth M.S. awarded to a chemical engineer (Raymond H. Hobrock. MS '27) was supervised by Bray. This was an indication that Bray believed in research, which he started as soon as he arrived at Purdue, even with the meager means that he had at Purdue Hall. Bray started writing his Ph.D. thesis at Purdue and in 1929 took a leave of absence and returned to M.I.T. where he completed his Ph.D. working under the direction of Prof. R. Williams in Metallurgical Engineering.

Bray returned to Lafayette in August 1930 in time to welcome a new faculty member who was about to join Purdue a month later, R. Norris Shreve. When Shreve accepted Purdue's offer (in April 1930 as far as can be established from letters in Prof. Shreve's private correspondence) Bray took a week-end off from his work at M.I.T. and visited him in New York. "My dear Mr. Shreve," he was writing shortly thereafter[6], "I enjoyed very much our discussions at the Chemists' Club of New York last Saturday ... I believe that you will enjoy Purdue's unspoiled land and that you will appreciate the advances made in Chemical Engineering there ... I agree with you that we should promote Organic Chemical Technology in the School." Thus in September 1930 with Bray returning to Purdue with a fresh doctorate from the leading technological institution in the United States and Shreve relocating after his studies at Harvard and his over twenty years experience in plant-wide consulting, a bright future was opening for the School of Chemical Engineering. The future of the School was in the hands of two Boston-educated chemical engineers who seemed to have very similar ideas about chemical engineering. To be sure, they had similar ideas about research and the future greatness of Purdue, but this does not mean that they did not have differences of opinion. As long as Bray was the Head, excluding perhaps the period from 1943-47 when he was ill, he was the decision-maker! Shreve could do what he wanted with his research group, but the rest was up to Bray.

The first four years of Shreve's presence at Purdue were years of great activity. Bray and Shreve concentrated on the development of the graduate program and by 1934 several Ph.D. students had enrolled. Laboratory equipment was brought in with various funds, most of which were coming from the industrial contacts of Shreve.

Randolph Norris Shreve
(1885-1975)

The life of Randolph Norris Shreve has been well documented. Shreve was such an influential figure for Purdue University, and chemical engineering in general, that many scientists and historians have written about him. His impact on chemical engineering and the School which he served continuously from 1930 until his death was monumental. An excellent source about his life is the transcription of a five-part interview[7] given by Shreve to Prof. Robert E. Eckles of the Purdue History Department between July 23 and 31, 1969.

R. Norris Shreve was born in St. Louis, Missouri on March 9, 1885. He attended a private grade school and the Ferguson High School, from which he graduated in 1902. He got a job (salary of $20 per month) at the Mallinckrodt Chemical Works Company[7] "washing dishes" and being taught chemistry by Dr. Charles Luedeking and William Lamar. He learned how to manipulate laboratory equipment and make laboratory analyses; Luedeking was so impressed that he asked the company to approve a petition and lend him money to study chemistry.

Shreve arrived in Cambridge, Massachusetts in September 1904, having been admitted to Harvard University after special examinations he had taken at St. Louis. At Harvard he had a brilliant scholastic career, graduating with an A.B. summa cum laude in only three years (1907), a record that remained for more than 40 years. While at Harvard, Shreve was a member of the Sigma Alpha Epsilon fraternity and a high jumper for the track and field team. He became a Phi Beta Kappa member as a junior and started the Boylston Industrial Chemical Club in 1906.

While at Harvard, Shreve became very interested in research. He was fortunate enough to work in the laboratories of Theodore W. Richards, under his supervision and that of Latham Clarke, a young instructor. Theodore William Richards (1868-1928), a great chemist and Professor at Harvard from 1894 until 1924, was educated there (A.B. '86, Ph.D. '88) under Josiah Cooke. He contributed numerous papers on the atomic weights of some 60 elements, reaffirmed the existence of isotopes, and investigated the compressibility of gases. He also worked on thermodynamics, thermochemistry and electrochemistry. In 1914 Richards was the first American chemist to become Nobel Laureate in Chemistry.

At the end of his undergraduate studies, Shreve was offered a fellowship for graduate work with Theodore Richards, but Edward Mallinckrodt, Jr. (1878-1967), then President of Mallinckrodt Chemical Works, persuaded him to return to St. Louis. He became an assistant chemist in the alkaloidal department, with W. Lamar in charge, and he was involved in the development and study of the properties of alkaloids, and later photographic chemicals. In 1911 he followed Lamar to Newark, New Jersey, where he worked for Lamar's newly established company, Lamar Chemical Works, in competition with Mallinckrodt. This company did not do well financially and was soon abandoned by Lamar. Shreve decided to take over the company because "... as the younger and `less expensive' man, (I) should stick to the ship and see if I could save it." Suddenly a brilliant industrial career had started. By 1913 at the age of 28 Shreve had made the company again profitable. In 1914, while at Lamar, he also started the Shreve Chemical Company. In 1915 he abandoned Lamar Chemical Works, and as president of his own company (at the age of 30) he became associated

with Marden, Orth and Hastings of New York. He designed, built and operated a two million dollar plant for production of ammonium nitrate in Newark, New Jersey, along the Passaic River. This dye plant was very profitable, but it was absorbed in 1918 by Calco Chemical Company. That same year, Shreve produced his first book, *Dyes Classified by Intermediates* and started his long correspondence with A.E. Chichibabin, a famous Russian chemist of the Moscow Institute of Chemistry, who had already published many articles on the chemistry on nitrogen-containing heterocyclic compounds, including pyridine and its derivatives.

Shreve stayed with Calco from 1918 to 1919 (the company was eventually bought by American Cyanamid). Though these continuous changes of his company, he had become a very important stockholder and already lived a very comfortable life. In 1919 Shreve made the major decision to abandon industry and start working as an independent consultant. At age 34 he opened a technical office in the same building with the Chemists' Club of New York, on 52 East 41st Street. The Chemists' Club (still in existence today) was then a very exclusive Society with very high standards of admission, where one could meet the leaders of the chemical industry. He became an active member in 1919 and a life member in 1932 paying the sum of $500 for this membership (equivalent to approximately $8000 today). However, his decision was most appropriate. Through his association with the Chemists' Club he was able to find many serious clients and embark on a most successful career as a consultant. A cosmopolitan and a bon vivant he lived at 43 Fifth Avenue traveling often, including trips to France, Italy, Germany and one, much later in 1928, to Russia.

From 1919 to 1930 his consulting work included the production of potash from the greensand beds of Texas, which was done for Eastern Potash Corp., soda ash from the alkali lake deposits for Inyo Chemical Co., medicinal dyes for Roosevelt Chemical Co., and antiseptics and dyes for Mallinckrodt. The breadth of his activities in those years is immense and can be found in his correspondence in the Archives of our School. During that period he wrote his second book, a 690-page *Greensand Bibliography* published in 1930 by the U.S. Bureau of Mines. It is an interesting coincidence that his contact with the Bureau and publisher of the book was Alden H. Emery, the father of the former Purdue faculty member.

In 1923 he embarked on another industrial adventure (one that strangely enough he avoided discussing[8] in the later years of his life) by forming the Ammonite Co., Inc. and becoming its President and chief stockholder (54.5%). Ammonite had been formed to utilize the results of his research as well as the research of Chichibabin in Russia to produce various types of nitrogen-based explosives. Unfortunately, a major explosion in that company led to its dissolution in 1926. In 1928, while consulting for Mallinckrodt he was asked to go to Europe, where, among others, he finally visited Professor Chichibabin. During that trip he started collecting the famous Faberge gems that became part of his gold and gems collection given to the Purdue Library thirty five years later.

The interview with Eckles[8] shows how cosmopolitan Professor Shreve was and depicts the wide range of important people he knew. In the interview Shreve talks about his discussions with Lord Melchett, his visits at the Plaza Hotel, his trips to Germany, etc. Financially, he was already quite independent. Indicative of his success is the fact that from one company alone he had a retainer of $1,800 per year (approximately $28,000 now).

The Chemists' Club of New York had at that time a small employment agency directed by Dr. A. Moody. In July 1928, Harry Peffer wrote a letter to Moody asking him if he could recommend someone in "organic technology." Moody approached Shreve and said[8]: "There is a nice University out in the Midwest that wants a man who has your experience, and why don't you go to see them?" Indeed, along with a trip to Detroit he came to Lafayette, met Peffer, Richard Moore of Chemistry and David Ross and "was sold on Purdue University." He came to Purdue in the summer of 1930, keeping some of his industrial consulting "to help augment the small salary that Purdue was then paying." His first payroll card has been kept[9]. It shows a starting date of September 1, 1930 with a salary of $4,000 per year, approximately $52,500 in December 2010, if my extrapolation is correct. This was a pay-cut for him! He was appointed an Associate Professor, although he wanted a full professorship, because Dean Potter was away in the summer of 1930 and Peffer did not have the authority to give such an appointment. Needless to say in September 1931 he became a Full Professor.

When he arrived at Purdue one of his first tasks was to start the graduate program in ChE. However, equipment was scarce and he needed funds. He approached his former clients. Mallinckrodt first[10] and many other companies after them started supporting his students in exchange for the rights to the patents produced – a procedure that would no longer be allowed at research universities.

Shreve was a dedicated researcher and educator. As a researcher he spent long hours with his students or writing letters to secure funds for his work. In a period of a year (1935) he may have written more than 1,000 letters, properly typed by his personal secretary and his "right hand," Rosie H. Roush (1932-40). Later, A. Taylor (1940-43) and especially his trusted assistant Elizabeth Prentiss (1943-75) continued to handle his exponentially increasing output. In his administrative years (1947-51) he loved to leave all the administration to Helen Giese and Elizabeth Prentiss and to concentrate only on his research and books. A most gracious colleague, he liked to write long letters about items that others would consider "small," often (after 1946) with carbon copies to Dean Potter and President Hovde (a chemical engineer from the University of Minnesota). For example, on the occasion of the announcement of a teaching award to Bray he wrote a long two page letter to him[3] praising his teaching skills.

Shreve had very specific ideas about chemical engineering. In 1931 this research field was defined by him, but not by most chemical engineers, as organic chemical technology[11]. In 1969, he stated[8] "my job was to develop the applications of chemistry to industry and that's what we call chemical engineering." He believed in industrial experience and had a very high respect for professors who had a balanced background. To Henry J. Ramey, Jr. (B.S. '49, Ph.D. '52), who was contemplating accepting an offer from Texas A&M University he wrote[12]: "It always pleases me when any of our boys go into teaching particularly after they have had industrial experience. There are too many teachers of engineering who think all they need to do is sit in a corner and push a slide rule or run a computer. Both of these instruments are necessary and more so every day, but the work of a chemical engineering professor is to teach students how to run the chemical industry of the United States and they need industrial experience."

Shreve loved to teach both undergraduate and graduate students. Teaching freshmen did not offend him. In fact for years he was displeased with an outstanding researcher and colleague in the School who avoided freshmen or sophomore courses. The students absolutely loved Shreve and in 1985 Prof. Peppas received at least 150 letters from his former B.S., M.S. or Ph.D. students describing various anecdotes from his (and their) life, too many to present here. It is a common secret that he was known as "`Benny" to the students. When asked by Eckles[7] to explain why so, Shreve gave the explanation that the students felt that in some slides he had shown from a scientific excursion to the saline deposits of California, he looked like the hero of "Benny rides again," a popular song in those days. However, the most probable explanation, as related by many former students, is that Shreve loved to add to his lectures stories from his various trips abroad starting with the expression I have been there. In the *Razz-Banquet* of 1938, an amateur writer wrote a monologue about Shreve, and in Shreve's absence, presented the skit *Mr. Shreve Goes to Town* (very much *ala* Frank Capra). "I have been there" became Benny and passed into history. Shreve had a strong sense of loyalty towards the University and its rules and regulations. Most students recall his famous golden chain worn across his vest (it can be seen now in the exhibits of the Purdue library) with the insignia of Tau Beta Pi, Omega Chi Epsilon, Sigma Xi, Phi Lambda Upsilon, Phi Beta Kappa, AIChE, ACS and the Catalyst Club. The day after disciplinary action had been taken against the Catalyst Club for a childish action of its members, his golden chain was prominently missing the insignia of the Club!

Before World War II Shreve believed that thorough knowledge of the German language should be a requirement for all students. He used to cite Beilstein, Ullman and other classic references, and in the Archives we find a rich correspondence concerning this subject.

His research was the subject that kept him busy from 1930 until 1955. He had an unusually large number of students who worked on methods of production of dyes, drugs, explosives, acids, alkalis, and later various salts and polymers. However, his love remained the study on N-containing heterocyclic compounds. Each of his students was supported by a different company, and each company wanted an extensive report every month or quarter. One is amazed at the work that must have been produced by Shreve. For example, just in a two-year project (1934-36) for his research on fur bleaching supported by Crofut-Knapp Corp. of S. Norwalk, Connecticut he wrote 21 monthly reports, each one between 15 and 20 pages.

Shreve was the author of several books, most prominent among which is the classic *Chemical Process Industries*, first published in 1945. Presently in its fifth edition published in 1984 with George T. Austin, this book had sold more than 180,000 copies in 1986. He wrote more than 250 articles (125 of them in scientific journals) and obtained eight patents. He supervised an impressive number of 106 students with 44 Ph.D., three Ch.E., and 59 M.S. theses in a period of 25 years (in reality 20, since before 1935 he was mostly constructing his laboratories). This is the record for the School which only Lyle F. Albright (122 theses at Purdue for over 100 graduate students), Nicholas Peppas (~51 Ph.D. and 39 M.S. at Purdue), and George Tsao (52 Ph.D. and 40 M.S.) have been close to matching. Shreve's students became very successful, as a simple listing of some of them shows: Miller W. Swaney (Ph.D. '35), formerly Esso Chemicals; Robert B. Bennett M.S. '33, Ph.D. '36), former Professor Emeritus at the University of Florida; Richard K. Toner (M.S. '36, Ph.D. '39), former Professor Emeritus at Princeton University; Herbert F. Wiegandt (B.S. '38, M.S. '39, Ph.D. '41),

former Professor Emeritus at Cornell University; Lloyd Berg (Ph.D. '42), Professor Emeritus at Montana State University; John H. Lux (B.S. '39, Ph.D. '42), former Chairman of the Board of Ametek, Inc.; Charles J. Marsel (Ph.D. '45), former Professor at New York University; Brage Golding (B.S. '41, Ph.D. '48), distinguished educator, Head of the School, and former President of three Universities; George A. Kruder (B.S. '42, Ph.D. '48), former Vice-President of R & D of HPM Corporation, Fredrick R. Lloyd (B.S. '44, Ph.D. '49), former Vice-President of Eli Lilly & Company; J. Clarence Lottes (B.S. '35, Ph.D. '49), former Professor at Purdue University; Harold E. Marsh Jr. (B.S. '46, Ph.D. '50) formerly at Jet Propulsion Laboratory; Sarah M.C. Willoughby (Ph.D. '50), first woman to earn a Ph.D. in all of Engineering at Purdue and former Professor at the University of Texas-Arlington; Albert A. Gunkler (B.S. '48, Ph.D. '51), former President of Gunkler Consultants; George S. Bankoff (Ph.D. '52), former Walter Murphy Professor at Northwestern University; C. Robert Hiles (B.S. '42, Ph.D. '52), former President of Lilly Industrial Coatings; and Joseph A. Brink, Jr. (Ph.D. '53), former Professor and Head at Washington State University.

Shreve kept up with the alumni throughout his life. An impressive number of letters to graduates from 1911 until 1940 was kept in a special file. He followed their progress, and kept clips and photocopies from newspapers, announcements, and the Who's Who. He had a special relationship with his former students.

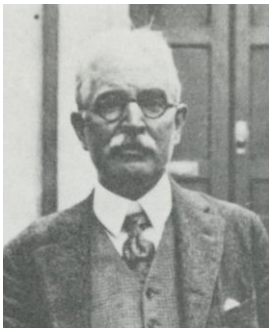
Professor Shreve's wife, Eleanor Burns Mitchell (they were married on December 16, 1935), was a gracious lady and great benefactress of the University. She accompanied him on all his trips and joined him in a series of donations and the establishment of the Shreve Distinguished Professorship in Chemical Engineering (see Chapter 4). She passed away in November 1967. In June 1968 Shreve married the former Irene Mary Stieby who, with great affection, collected, classified and analyzed most of his post 1940 correspondence and continued donating to the University.

R. Norris Shreve died on February 17, 1975. Of all the letters and comments received, probably the one that best expresses the feelings of his many associates was written[13] by Prof. Donald F. Othmer of the Polytechnic Institute of New York, the coeditor of the *Kirk-Othmer Encyclopedia*: "For all these many years, I have looked up to him as the `dean' of our profession; a tower of all the virtues of competence, integrity, and diligence to be presented as an example to my own students."

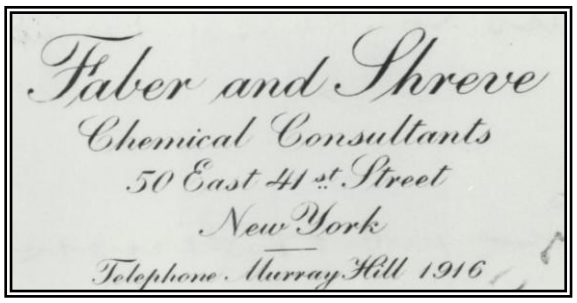
In the fall of 1934 Clifton Lee Lovell (1901-1948, B.A. '23 University of Mississippi, M.S. '25 Louisiana State University, Ph.D. '31 University of Iowa) was appointed Assistant Professor. He inherited the Chemical Engineering course originally taught by Peffer which he soon changed and developed into a course in Unit Operations. He was instrumental in promoting the "acceptance" and teaching of the "MIT system" at Purdue. He used modern textbooks, and was liked by the students. In 1935 he became professor in charge of the Summer Session of Chemical Engineering. He was always much involved with student activities and served as faculty advisor of the Catalyst Club for several years. He became ill in 1946 and was obliged to take a leave of absence in 1947. He passed away in 1948. His research was in the forefront of chemical engineering of those days as he worked on distillation, evaporation and heat transfer. He supervised five Ph.D., including George T. Austin who much later revised the fifth edition of

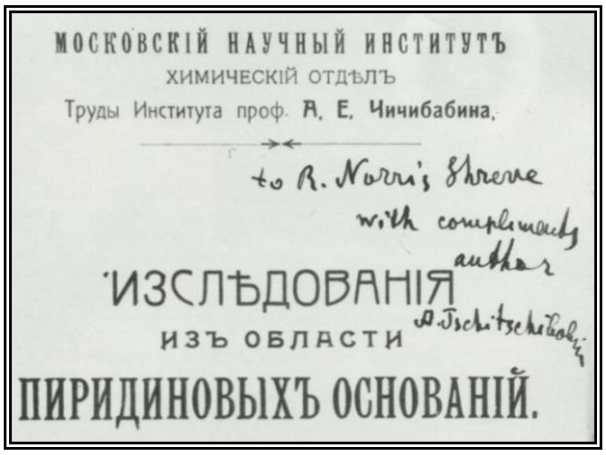
Shreve's book, and 32 M.S. students, more than any other faculty member of those times, except for Shreve. Clifton Lovell was a great pioneer of the School, a man with far-reaching insight into the future of the School and chemical engineering in general. Lovell was a student of George H. Coleman (a distinguished industrial chemist at the University of Iowa), and almost a contemporary of H. Frazer Johnstone who moved to the University of Illinois, where he created a great ChE Department. Lovell was a pioneer in research. He supervised the first ever Purdue ChE Ph.D. theses in fluid mechanics, distillation and biochemical engineering (see Chapter 8). His numerous contributions to education are discussed in Chapter 7. Lovell is honored by a distinguished professor position, currently held by Professor Phil Wankat.

Left: Theodore W. Richards (1868-1928), a Harvard professor of chemistry and 1914 Nobel laureate, was the mentor of R.N. Shreve.
Right: The legendary Prof. R.N. Shreve, great builder of the School and benefactor of the University, in 1955.

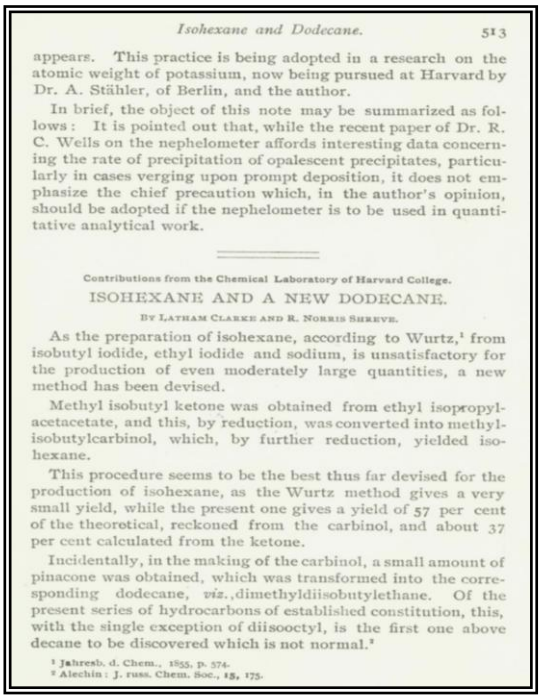


In 1934, Prof. William Burton Sanders (1893-1966, B.S. '19, M.S. '22, both from Purdue in Mechanical Engineering) was "borrowed" and appointed part-time Associate Professor to teach the classes of Plant Design. He stayed on the faculty until 1939.





Left: Shreve's letterhead when he was a consultant in New York, circa 1920.
Right: Autographed copy of Prof.A.E. Chichibabin's works on Pyridine Bases sent to R.N. Shreve in 1919.



Isohexane and Dodecane. 513

appears. This practice is being adopted in a research on the atomic weight of potassium, now being pursued at Harvard by Dr. A. Stähler, of Berlin, and the author.

In brief, the object of this note may be summarized as follows: It is pointed out that, while the recent paper of Dr. R. C. Wells on the nephelometer affords interesting data concerning the rate of precipitation of opalescent precipitates, particularly in cases verging upon prompt deposition, it does not emphasize the chief precaution which, in the author's opinion, should be adopted if the nephelometer is to be used in quantitative analytical work.

Contributions from the Chemical Laboratory of Harvard College.

ISOHEXANE AND A NEW DODECANE.

By Latham Clarke and R. Norris Shreve.

As the preparation of isohexane, according to Wurtz,[1] from isobutyl iodide, ethyl iodide and sodium, is unsatisfactory for the production of even moderately large quantities, a new method has been devised.

Methyl isobutyl ketone was obtained from ethyl isopropylacetacetate, and this, by reduction, was converted into methylisobutylcarbinol, which, by further reduction, yielded isohexane.

This procedure seems to be the best thus far devised for the production of isohexane, as the Wurtz method gives a very small yield, while the present one gives a yield of 57 per cent of the theoretical, reckoned from the carbinol, and about 37 per cent calculated from the ketone.

Incidentally, in the making of the carbinol, a small amount of pinacone was obtained, which was transformed into the corresponding dodecane, *viz.*, dimethyldiisobutylethane. Of the present series of hydrocarbons of established constitution, this, with the single exception of diisooctyl, is the first one above decane to be discovered which is not normal.[2]

[1] Jahresb. d. Chem., 1855, p. 574.
[2] Alechin: J. russ. Chem. Soc., 15, 175.

Professor Shreve's first publication was from his studies at Harvard and was published in the American Chemical Journal, 35, 513 (1906).

Meanwhile, Shreve's research program was maturing and in May 1935 he offered for the approval of the faculty the first two Ph.D. candidates of the School. The two men who had this honor were William N. Pritchard, Jr., who graduated on May 21, 1935 and Miller W. Swaney, who graduated on May 24, 1935.

A comment must be made here about research in Chemical Engineering. With the lack of significant facilities in the School of Chemical Engineering, at least while at the Education building and Purdue Hall, it was extremely difficult to perform serious research. Until 1923 the School was essentially an undergraduate School, although, to his credit, Peffer made every effort to do research; in fact the second M.S. student of the School was his, Ralph H. Williams (M.S. '23).

Left: Clifton L. Lovell in 1941.
Center: Helen W. Giese, the loyal administrative assistant of the School, served the School from 1935 to 1959, and continued in Materials Engineering until 1970. This picture is from Heavilon Hall in 1936.
Right: The Dean of Engineering, Andrey A. Potter, in 1939.

Artist's conception of the CMET building.

With the move to Heavilon Hall, research laboratories were formed and industrial funds started coming to the School, some from the industrial contacts of Bray and Shreve, others from contributions of alumni. In 1930, the Ph.D. program was also established. The lack of a Ph.D. program until then was not totally unacceptable in a "good" Chemical Engineering Department. Reid states[14] thatthe first Ph.D. degrees in chemical engineering were awarded to C.H. Herty and J.L. Keats of MIT in 1924. Soon thereafter the Universities of Michigan and Wisconsin, Columbia and the University of Pennsylvania gave their first Ph.D. degrees in the same area*. Thus, Purdue was not far behind other leading Schools. What was probably different at Purdue was that Ph.D. degrees were awarded almost exclusively for research in industrial chemistry or metallurgy, two areas that faculty members from other Schools considered somewhat off the main track of chemical engineering in the 1930's.[38]

Olaf A. Hougen[15] of the University of Wisconsin, for example, notes that "from 1888 to 1923 that industrial chemistry was the chief offering of all chemical engineering departments ...," and he continues "in these courses, the sequences of steps in chemical manufacture were described. The approach did not allow much time for discussion in depth of the scientific principles involved." Hougen remarks also that the introduction of unit operations to the curriculum by Walker, Lewis and McAdams of MIT during the 1920's "marked the beginning of the distinctive American system of chemical engineering education." This was the approach strongly supported by Lovell at Purdue. Hougen concludes that the next three decades (1920-50) in the development of the science of chemical engineering "came with the application of physical chemistry to material and energy balances, to thermodynamics, and to rates of chemical reactions in industrial processes."

Robert L. Pigford of the University of Delaware, a deep thinker and analyst of the progress of chemical engineering in the 20th century, who in the 1980's was one of the major supporters of an increase in chemistry courses for undergraduate chemical engineers, noted[17] that "an equally important contribution to the role

* James O. Maloney, claims[16] about 10 Ph.D. theses in chemical engineering in the pre-1924 years. Unfortunately, he accepted the claims of schools that a thesis was in chemical engineering, and his research is not totally substantiated.

of applied physical chemistry in chemical engineering occurred in 1936 with the book *Industrial Chemical Calculations* by Hougen and Watson. Their textbooks had a profound effect upon students in the forties and fifties and thus upon many practicing engineers today."

The site of construction of the CMET building in 1938 **(left)** and 1939 **(right)**.

Surprisingly enough "industrial chemistry" was also attacked by engineers working in industry such as Albert B. Newman (1948 president of AIChE) who in 1938 wrote[18].

> The forward-looking administrator of a chemical engineering course is thoroughly convinced that major emphasis should be given to elementary and advanced fundamentals and that the teaching of descriptive and factual material should be only illustrative of these fundamentals. He knows the absurdity of trying to teach student the minute details of a wide variety of industrial processes, knowing very well that such details can be learned more quickly, accurately and effectively in the industry itself. The teaching of descriptive and factual material should be only illustrative of fundamentals. *The modern employer does not engage a graduating student because the student can describe for his employer how his product is made* (author's italics).

To counterbalance these views one may use a large number of letters written by leaders in industry to various faculty members during the period 1934-40 and kept in the Archives of the School of Chemical Engineering at Purdue University. It seems that major industries were very supportive of Purdue's educational and research philosophy, their leaders often taking a polemic, aggressive attitude, fighting a crusade-like war. Just one such letter[19] will show the tone of discussions about chemical engineering during the 1930's.

> While I am on the subject may I suggest that each year you try turning out a few good industrial chemists. I don't mean (the) so called chemical engineers who have spent most of their time on strains and stresses of steel and other rot that they don't need, I mean men who can look at a formula and give it a name, who know the principal reactions for the replacement of groups in the organic molecule... We are greatly disturbed over the variety (of) guinea pig chemists, that call themselves engineers as well, that we have to employ.

Amidst these criticisms and praises, Bray, Shreve and most of the faculty (probably excluding Lovell) remained quite serene, continuing their work with the conviction that what they were offering in terms of "finished product" (i.e., graduate students) was needed by industry. In fact, in the early days (1930-38) rarely did Shreve even use the word "chemical engineering." For him[19] "this field of *Organic Technology* (author's italics) is a wide and varied one, which employs many chemical engineers, and is based upon much research. Its object is the making of products of ever increasing importance in our economic life." Later, he was writing[20] to an official of Dow Chemical Co. "Here at this University we quite regularly cooperate with industry in carrying out researches in conjunction with the staff and with our students ... Such work is done in a very modest way or extensively, depending upon the value of the project ... Arrangements can be made to patent results... ."

When John L. Bray became Head of the School on July 1, 1935, several major changes were made either in the School or University-wide. Bray recognized that metallurgy was an important component of the School and with the approval of the administration he changed the name of the School to "School of Chemical and Metallurgical Engineering." Then, a summer session was instituted for juniors to work in a unit operations laboratory with Clifton Lovell in charge. Required summer sessions were for a period quite popular in US ChE departments, although they were not popular with the students. Currently, required summer sessions are retained by very few schools, such as the University of Wisconsin.

The original departmental seal. Designed by R.N. Shreve it was cast in cement and placed over the southwest door of the CMET building.

The graduation of the first two Ph.D. students in May 1935 was an event worthy of celebration. Perhaps an even more important event was the graduation of the first woman chemical engineer, Elizabeth Henius, in June 1935.

Early Women Graduates

Elizabeth Henius, the first woman graduate of the School of Chemical Engineering, was born in Chicago on December 23, 1912. She first enrolled at Northwestern University in 1930. In September 1931 she transferred to Purdue University. While at Purdue she was a member of Kappa Kappa Gamma. She graduated in June 1935 and worked in Chicago for more than 20 years. In 1936 she married R.C. Morgan. Her activities after 1961, according to the Alumni Association records, are unknown. Charlotte Jane (Spears) Bennett (1914-1992), the second woman graduate of the School, was born in Clinton, Indiana, on December 8, 1914. She started Chemical Engineering in September 1932 with a scholarship and was a member of the Pi Beta Phi Sorority, the Purdue Exponent staff and the YWCA. In 1935 she married Robert B. Bennett (1909-1994), then a graduate student, and the third Ph.D. in the School's history. Mrs. Bennett graduated in 1936. They moved to the University of Florida where her husband became a professor of Chemical Engineering, and she studied and earned a Master's degree in Education in 1960 at the same Institution. After her graduation from the University of Florida she taught in the Alachua County Florida School system. She died on August 25, 1992.

The ChE truck. Senior parade before the first football game of the season against Michigan State on October 21, 1939. The seniors wear the typical derbies of those days and their signs read: *Here Come the Organics-Skunk, I Under-wear Lovell's,* and *Lottes Deodorize with Moore Chemicals*.

Left: Undergraduate students in the Unit operations laboratory in 1941.
Right: Elizabeth Henius (B.S. '35), the first woman ChE graduate of the School, circa 1934.

William Nelson Pritchard, Jr. (1893-1955) and Miller Woodson Swaney (1912-2000)

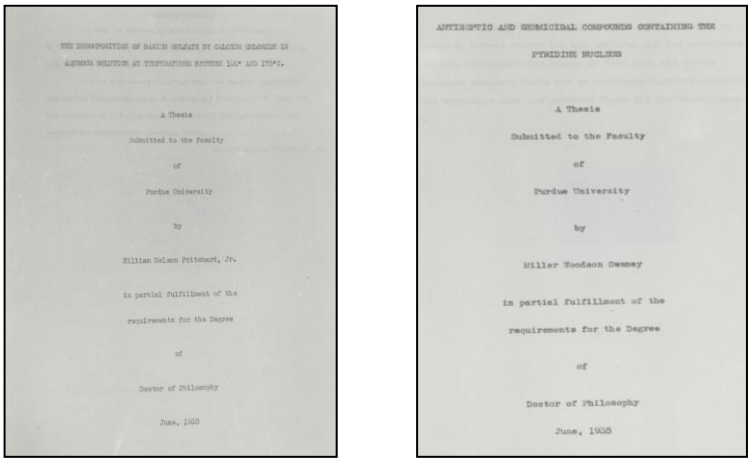
With the arrival of Shreve at Purdue and the increase in the number of faculty members that occurred in the 1930's, it was possible for the School to provide the appropriate educational environment for the introduction of a Ph.D. program. The first Ph.D. students were enrolled in 1932 and graduated in 1935, by sheer coincidence three days apart: first Pritchard on May 21, 1935, then Swaney on May 24, 1935. A look at their plan of study and some correspondence found in the Archives is most instructive in forming a good picture of how graduate student research was carried in those days.

William Nelson Pritchard, Jr. was born in Anniston, Alabama, on November 30, 1893. He received his B.S. degree from the University of North Carolina (his Purdue transcript states in Chemical Engineering, but that University never had a ChE program) and the M.S. degree in Chemical Engineering from the University of Alabama in 1932. His Ph.D. thesis was on *The Decomposition of Barium Sulfate with Calcium Chloride in Aqueous Solutions*. See also http://openlibrary.org/books/OL6400562M/Decomposition_of_barium_sulfate_by_calcium_chloride_in_aqueous_solution. He had to pass a preliminary (June 1934) and a final exam; there were no qualifying examinations. His thesis committee included Shreve, Bray, Peffer, Sherman, Newton and Read. He was required to take two foreign languages (German, French) and his plan of study Included 16 (!) courses (10 in ChE, four in Chemistry, two in Physics) in addition to another five courses he had transferred from the University of Alabama. At that time two "minors" were required, which he took in physical chemistry and physics. Shreve presented results from his thesis work at the New York ACS meeting in April 1935. Pritchard, Shreve's first student, worked on a project related to Shreve's consulting with Mallinckrodt Chemical Works of St. Louis. Upon his graduation Pritchard was employed by Glidden Varnish Co. in Collinsville, Illinois, until his death on September 6, 1955.

Let us examine how graduate students were "recruited" in those days. Shreve knew Pritchard personally and asked him to come to Purdue and work with him (no School recruiting in those times). Then he wrote[23] to Mallinckrodt: "As I wrote you, Mr. Pritchard is coming here to work on his Doctorate under my direction, and it seemed to me that it would be of interest to the firm to have a much closer study made of the barium and strontium sulfate reactions." The company accepted this three-paragraph proposal and Pritchard became a Ph.D. student paid by a "grant" from Mallinckrodt.

He sent reports to the company often[24], describing his results in detail. Later the possibility of a patent appeared and Shreve wrote[25]: "We believe it is most urgent for us to get a patent application in and I shall start working on that tomorrow and elaborate the form of the drafts,... so that you can take it up with the attorneys in St. Louis." Present day administrators of the Purdue Research Foundation would be stricken by the direct patent arrangements and lack of a share for the university in those days.

Miller Woodson Swaney, the second Ph.D. student, was born in Gallatin, Tennessee on February 29, 1912. He received his B.E. (1931) and M.S. (1932) in Engineering from Vanderbilt University and joined Purdue that same year. His Ph.D. was on *Antiseptic Azo Dyes Derived from 2,6-Diaminopyridine*, another favorite subject of Shreve's. Mallinckrodt supported this work which led to the commercialization of a drug called *Matlophene*. Swaney had 20 courses in his plan of study including French and German and he transferred in two courses from Vanderbilt. His thesis committee consisted of Shreve, Lovell, Campbell, Degering, Newton and Nelson. Upon graduation Swaney became a research chemist for Ellis laboratories (1935-39). Robert Edward Swaney, his son, wrote "My father, Miller Woodson Swaney became the first [sic] person to graduate with a Ph.D. in Chemical Engineering from Purdue University, and he went on to write the first book in the US on soilless growth, then worked for the Esso Research and Engineering Company as the Elastomers Engineer in top management. He also started 'Enjay Laboratories' which is now the entire chemical arm of EXXON" In 1993 Miller Swaney received the School's Outstanding Chemical Engineer Award. He died on October 18, 2000, in Lake Barrington, Illinois.



A Thesis

Submitted to the Faculty

of

Purdue University

by

William Nolan Pritchard, Jr.

In partial Fulfillment of the

requirements for the Degree

of

Doctor of Philosophy

June, 1935

ANTISEPTIC AND GERMICIDAL COMPOUNDS CONTAINING THE PYRIDINE NUCLEUS

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The first pages of the Ph.D. theses of William N. Pritchard, Jr., **(left)** and Miller W. Swanev **(riaht)**.

In the 1930's the ChE student chapters and organizations were flourishing again. On May 3, 1936, a rather memorable event took place, a banquet for the senior students and staff sponsored by the Catalyst Club, "a last get-together and gridiron banquet at which the quirks of the professors were unreservedly broiled."[22] This senior dinner is the *Razz-Banquet* which remains a tradition for the School. In 1952, students started sporadically awarding the *Worst Professor Award*, which eventually was named after a specific former faculty member, until 1982 when it was dropped

as tasteless. In 1975, the faculty members started taking their revenge by presenting an appropriate skit about the senior students, expertly written by Alden Emery, and with the professors acting the roles. In recent years David Corti has ably taken over the task of writing and "directing" the professors. [Directing professors is probably more difficult than herding cats.] Most of the time both skits are presented with a sense of good fun.

Left: Frederick L. Serviss in 1940.
Right: R. Norris Shreve in 1940.

Bray had to face three major problems early in his Headship. First, the enrollment in Chemical Engineering was reaching explosive proportions. [This is a problem that has reoccurred periodically since then.] In March 1936 there were 450 undergraduates (156 freshmen, 99 sophomores, 95 juniors and 74 seniors) and 27 graduate students, seven of them Ph.D. candidates, with only four professors (Bray, Serviss, Shreve and Lovell) although several instructors and professors from other Schools were helping. An announcement made by Potter in April 1936 that a new program, General Engineering (which eventually became Freshman Engineering and then the First Year Engineering program within the School of Engineering Education), was to be formed starting the next fall (where all the freshmen engineers would be educated) would not change the situation much, since in the fall of 1936 the School had 356 sophomores, juniors and seniors.

Left: John F. Eckel, who contributed to the area of metallurgy, in 1941.
Right: Edward C. Miller, who contributed to metallurgy, in 1941.

A number of long memoranda were exchanged between Bray and Dean Potter between June 1936 and January 1937. Bray wrote[26]:

> Judging from the lengthy debate in the session of the Executive Committee it appears to be the opinion of the engineering as well as administrative staff that enrollment in engineering ought to be limited. If that is true it is obvious that the situation in one School may be very different or more critical than in another. Such is the case in Chemical Engineering. I am sure that Professor Harding (author's note: C. Francis Harding, the legendary Head of Electrical Engineering from 1908 to 1942, a Purdue record) would hesitate to face the prospect of even 50 seniors with one motor, one transformer, and one generator. We deem it unwise to allow 120 seniors to come up for instruction with one evaporator, one still, and one diffusion tower.

He continued by mentioning many other reasons for the curtailment of enrollments including the lack of staff and facilities and the difficulty in AIChE accreditation (which had been obtained in 1933) due to the lack of laboratory instruction. Finally, Bray asked the sophomores to meet with the Dean on January 22, 1937 (a bold move indeed) to express their opinion, and requested a maximum of 75 sophomores for the next year. Surely forty years later Lowell B. Koppel must have faced the same problem and had similar conversations with Dean Hancock and seventy years later Arvind Varma had a similar discussion with Dean Jamieson when the number of sophomores again swelled to more than 200!

Dean Potter disregarded[27] Bray's request offering to him a letter written by "an outstanding member of the Purdue engineering staff" where comments were made that the anonymous writer did not "believe that either equipment or personnel is employed at maximum efficiency," and advice was given to reduce the "individual instruction which is little more than tutoring." Bray* continued pressing the Dean, now with the assistance of Norris Shreve, who by now had become a very respected professor, and - most importantly - a friend of President Elliott.

By June 1937 a monumental decision had been made. The sophomore admission standards from General (Freshman) to Chemical Engineering would be raised to achieve a certain screening of students and hopefully a decreased enrollment. This measure gave some initial results (reduction of the 1941 senior class by 32%) until the World War II years and the GI bill led to the biggest enrollment the School has ever seen.

Bray's second problem, a lack of sufficient faculty, was solved by funds made available to him, but often with strings attached, which did not allow him to do serious national searches for new faculty members.

* It is interesting that Knoll[22] claims that Bray was the favorite Head in Potter's list, although differences of opinion about administrative matters always existed.

The third problem was the construction of a new building. Already in 1935 it was evident to Bray, Shreve and Lovell that with its growing graduate program, the School would be unable to satisfy the demand for graduate research space in Heavilon Hall by 1936. Solutions such as temporary use of other buildings were not satisfactory. President Elliott, to his credit, recognized the need for a new building, which became a reality in 1940. The old equipment from Heavilon Hall was transferred to CMET building by Helen Giese and the students, and an inventory was taken. New equipment was being purchased continuously, because after 1937 the research programs of Bray, Lovell and especially of Shreve were increasing almost exponentially. The younger faculty members were also active in research. In 1939 the School had more than 60 enrolled full-time graduate students (30 of them for the Ph.D. program), 52 of them supported as "fellows" or "research assistants" and eight as "teaching assistants."

In 1939 the graduate plan of study included 18 courses and two foreign languages. However, there were neither qualifying examinations for admission to the Ph.D. program, nor preliminary examinations, only a Ph.D. thesis defense for which a faculty committee of six or more was required. It was only in 1949 that the number of faculty members of a thesis committee was reduced to three, and only in 1953 (according to the estimation of Alden Emery) that C.O. Bennett, J.M. Smith and H.C. Van Ness demanded the institution of qualifying examinations as a method of screening the students who wished to perform a Ph.D. thesis.

Another interesting attitude of the 1930's was the conviction of the faculty that technical German should be a required course for chemical engineers. These were the pre-World War II years, when Ullman, Beilstein, Gmelin and the Zentralblatt were the main sources of chemical engineering education and research, or, if you wish, chemistry research. Professor Mellon of the Chemistry Department taught the course on Technical Literature for chemical engineers from 1921 until about 1960. Bray and Shreve got together with Prof. John Fotos of the German Department, and wrote three textbooks on the subject, including a German grammar textbook.

The first mimeographed and privately printed edition of Shreve's German textbook in the mid-1930s received accolades from industry. Edgar C. Britten of Dow Chemical Co. wrote[28] to Shreve: "The student who is able to read German, at least chemical German, is much better equipped than the one who cannot. As you well know, any person who cannot read German is completely at a loss to find out all there is to know about an organic compound. Our Beilstein is in German and at least the literature up to 20 years ago is largely in German." There are another fifty-three letters written in the same spirit in the Archives of the School. Again, organic chemical technology was dictating the course of chemical engineering at Purdue.

In the mid to late 1930's several new faculty members joined the School as a result of the successful pleas of Bray to Dean Potter. Edward Calvin Miller (1905-1970, B.S. '28, Missouri School of Mines, M.S. '29 University of Idaho) joined the School as

an Instructor in 1935 to teach Metallurgical Engineering. He became an Assistant Professor in 1941. Among other courses, he was in charge of the summer session in Metallurgical Engineering. During World War II he was in the Navy. He left in 1947 to teach at Wayne State University. In 1948 he moved to Union Carbide from which he retired in 1970. Edwin Jacob Kohl (1893-1975, B.S. '15 Albright College, M.S. '19 Purdue University, Ph.D. '30 University of Wisconsin) was an Associate Professor of Botany when he joined the school in 1937 to develop courses in Industrial Photography (ChE 142 and 150). During World War II, because of a shortage of staff members and supplies, the courses were cancelled. Professor Kohl left Purdue in 1941 to become a botanist at Lakeside Biological Products Inc. in Ripon, Wisconsin. With the departure of Joseph W. Campbell in 1935 it was necessary to hire other faculty members to assist Bray in the areas of physical metallurgy and metallography. D.A. Ackerman* was hired in September 1935 and Arnold Peter Hoelscher in January 1936. Hoelscher (1901-1987, B.S. '23, Ph.D. '30, both from Iowa State University) was an Instructor in chemistry at Iowa State University (1923-36) until January 1936 when he joined Purdue. He was a well regarded metallurgist with numerous publications who taught metallography until May 1937 when he joined Carnegie-Illinois Steel Corp. He was replaced by John F. Eckel (see below).

The fifth faculty member to join Chemical Engineering in 1937 would stay here 23 years until his retirement in 1960, when he became the first Professor of Chemical Engineering to receive the title Professor Emeritus. George William Sherman, Jr. (1890-1970, B.S. '12 Rhode Island State University, M.S. '14 Purdue University, both in Electrical Engineering) was an electrical engineer who joined Purdue in 1912, thus having the distinction of the faculty member with the longest continuous service to Purdue University, an impressive 48 years. From 1912 to 1937 he was Instructor (1912-18), Assistant (1918-24) and Associate Professor (1924-37) in the Department of Physics, where at the instigation of Peffer he developed a course in pyrometry, namely the study of the techniques of measurement of high and low temperatures. He transferred his course to ChE, and an article by Bray[29] in 1940 shows a picture of Sherman's laboratory in room 210. Sherman initially had a half-time appointment in ChE and after 1942 a full-time appointment. He became Full Professor in 1948. His course was modernized in 1942 and changed to Instrumentation (ChE 155) with the addition of other techniques of measurement such as pH, "height of liquids," velocity and pressure.

* Despite our efforts and research on the Internet and in the Purdue libraries and payroll records we have been unable to find more information about Ackerman. Only Bray mentions in his History that Ackerman was hired for a short time. The Purdue Bulletins do not mention anything about him, but in Bray's personal copy of the 1936 Bulletin of Purdue, Ackerman's name has been added with pencil.

Sherman became a legendary figure in the School and throughout the University, not only because of his very long tenure here and his soft-spoken style, but also because (at a time that computers did not exist in the University) he was the perennial chairman of the Scheduling Committee. As Knoll notes[22] "(Sherman was) so happy with the complexities of the registration process that he looked forward to the registration periods as if they were holidays". His course may be considered obscure by today's chemical engineers, but it was obviously highly respected then, as a memorandum of Shreve shows[30], written in 1961 on the occasion of the 50th Anniversary of the School. "Don't forget to lay stress on the pioneering work of George Sherman in his instrumentation ... becoming more important and more scientific each year".

Up to now we have stressed the significant contributions of regular faculty members to the development of the educational and research programs of the School. However, in the 1930's it became a practice at Purdue to use instructors to teach some of the required courses. Two of the many instructors of the 1930's and 1940's require special mention here. Robert Byron Moore (1913-2004, B.Ch.E. '35, M.S. '36 University of Minnesota) came to Purdue in the fall of 1936 and stayed in the School for seven years. He became a legendary figure, as the assistant of Clifton L. Lovell in all the unit operations courses, and was much liked by the students. In the late 1930's he started teaching courses on industrial electrochemistry (ChE 141) and engineering materials (ChE 30) as well as the graduate course on filtration and separations (ChE 226d). He had worked on his Ph.D. thesis on Heat Transfer in concentric Pipe Heat Exchangers under the direction of Clifton Lovell but for personal reasons he left Purdue in the summer of 1943. He was subsequently employed by Standard Oil Co. of Louisiana (now Exxon) in Baton Rouge (1943-62) and in Houston (1962-78). He retired in 1978 and enjoyed his hobby of birding. He returned to Purdue for the 75th anniversary of the School and proved to be a great story teller of his days at Purdue.

Robert John Raudebaugh (1910-1999, B.S. '32 Carnegie Institute of Technology, Ph.D. '45 Purdue University) was an employee of the American Rolling Mill Co. (1933-38) when, at the instigation of Robert H. Heyer, he joined Purdue. He taught courses in metallography, corrosion and the properties of cast iron, and did his Ph.D. under the direction of John F. Eckel. While at Purdue Raudebaugh wrote *Nonferrous Physical Metallurgy* (1945) reprinted by Pittman in 1952 and currently available from Amazon. He left Purdue in 1945 to become Associate Professor at the University of Rochester (until 1948), and then Professor of Metallurgical Engineering at Georgia Institute of Technology (1948-54). He was subsequently employed by International Nickel Co. (1954-66), Merica Research Labs (1964-72) and as an independent consultant (1972-75). In 1963 he was president of ASM. In 1964 he was the first DEA from the School of Materials Engineering. In 1975 he became the Executive Director of the U.S. National Committee at the World Energy Conference in Geneva, Switzerland. He then retired and did consulting.

Two more faculty members were added in 1939. John Friend Eckel (1903-2002), A.B. '25, University of Kansas, M.S. '28, Carnegie, D.Sc. '32 Carnegie) was hired from the University of Iowa to improve the courses and research in Metallurgy, especially because of Bray's health problems. He stayed until 1945 when he joined General Electric Company. Later he became Professor of Metallurgical Engineering at Virginia Polytechnic Institute from which he retired in 1968. He died at the age of 99 on September 27, 2002, in Blacksburg, Virginia.

John Clarence Lottes (B.S. '35, Ph.D. '49 Purdue University) joined Purdue as an instructor in 1939 to assist Shreve in teaching his courses on Chemical Process Industries, while working towards his Ph.D. degree. Lottes was nurtured by all the senior faculty members as the "hope" of the School, the person who could clearly become the leader of the next generation of Purdue's chemical engineers. Unfortunately, his brilliant career was interrupted on November 10, 1951 when at the age of 38 he passed away, suffering from terminal cancer. His son James graduated from Purdue with a BSChE in 1966 and earned his Ph.D. in chemical engineering from Purdue in 1971.

A historical picture from the January 1947 visit of Professor W.H. McAdams of M.I.T. to Purdue. From left to right:
First row: W.H. McAdams, Dean A.A. Potter, the legendary M. Jakob (Illinois Institute of Technology), and H.L. Solberg, Head of Mechanical Engineering.
Second row: J.L. Bray, J.M. Smith, Dean G. Hawkins and Y.S. Touloukian, later Director of CINDAS.

Since the mid 1930's, Bray had bombarded Dean Potter with memoranda stating the need for a new building to house the School of Chemical and Metallurgical Engineering. Potter was very supportive of these ideas which he had relayed to President Elliott on several occasions. It soon became obvious that the lack of laboratory facilities and space would severely curtail the research activities of the School, which in the late 1930's were at a high level. Especially concerned about this problem were Shreve, Bray and Lovell, the three most active researchers of

the School. For example, in September 1938 the enrollment was 274 sophomores and juniors, 108 seniors, 16 MS and 20 Ph.D. students and it was necessary to limit the graduate enrollment to 35 students.

Finally in 1938, as both Bray[1] and Knoll[22] describe it, "Santa Claus came to ChE," in the form of significant state appropriations. [Much later when ChE again needed a new building, Santa Claus, in the form of the Forney's, would come again – see Chapter 6.] For the new building, the CMET building, four sites had originally been considered, including the sites of the present Physics, Pharmacy, and Schlemann Hall Buildings. At that time, only the Electrical and Mechanical Engineering Buildings and the Executive Building (now Hovde Hall) existed. During 1938 and 1939 Bray taught very little, concentrating on the design of the building and the allocation of space. Finally, construction was completed in 1940 and the staff moved to the CMET building in August 1940. At that time Purdue ChE had the most modern building in the country with ample space for all types of operations. This pleasant circumstance repeated in October 2004 when the new Forney addition was completed.

The CMET Building

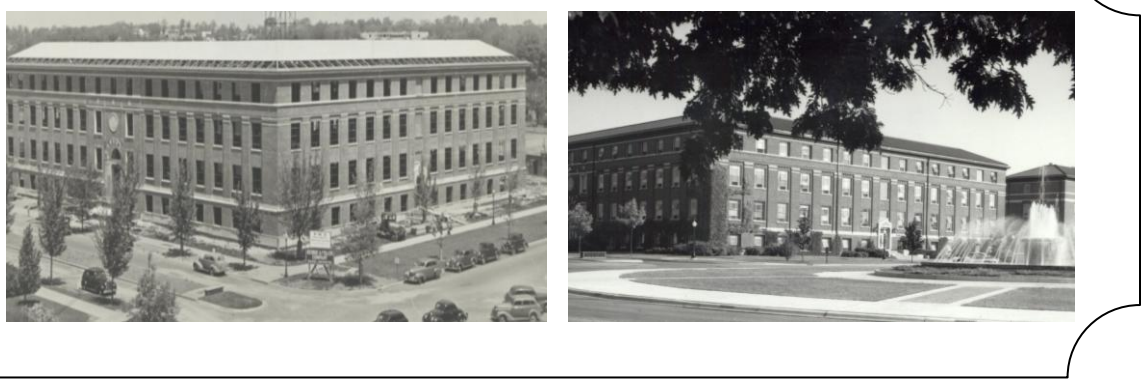
Since about 1935 Professors Bray and Shreve had expressed the feelings of the faculty of the need for a new building to house the expanding research activities of the School and the increasing number of undergraduate and graduate students. Construction of the building started in 1938 and the cornerstone was laid at 1:30 P.M. on Friday, March 31, 1939 with the students of the AIChE and AIME Chapters in charge[31]. The Chemical and Metallurgical Engineering (CMET) building was completed in August 1940 and occupied soon thereafter. It had[29] a total floor area of 78,952 square feet. The front and short wing have four stories and an attic, and the long wing has a basement. The prophetic statement of Bray that "the building will eventually take the form of a quadrangle, of which only a little more than one L has now been completed" came close to becoming true when the Forney addition was completed. The CMET building was made possible with a PWA grant of $271,584 and the total cost was $580,000. As of December 2010 this is roughly equal to $9,150,000.

The ornamentation on the southwest entrance of the building was designed by Professor Shreve. A series of chemical symbols representing the processes of solution, fermentation, filtration, fixation, putrefaction, separation and sublimation are crowned by the words *Service Through Chemical Change*.

In the first decade of its history, the Unit Processes laboratory of Shreve and his associates occupied the third floor. The second floor housed the research on thermodynamics (e.g. the research of J.M. Smith), the instrumentation laboratory of Sherman, the metallography laboratory and the X-ray diffraction unit. Offices, a general instruction area for production metallurgy, and a part of the unit operations laboratory were on the first floor. The ground floor housed the Unit Operations laboratory and the Geology section of Professor Serviss. A machine shop and supporting services were in the basement[32].

Major renovations were done to CMET after 1967, after Metallurigical Engineering moved to the new MSEE building in 1988, and again after 2004 when the Forney addition was completed and the building was renamed in honor of the Forneys.

The events of 1939 in Europe with the *Anschluss* of Austria and the attack of Poland by Germany were followed cautiously on the American continent. The further escalation of the war in 1940 with the German attack of France, the Low Lands, Scandinavia and the Balkan countries should have left no doubts that US entry into the war was not far away, but pacifism was very strong. The Pearl Harbor attack on December 7, 1941, led to the immediate entrance of the USA in World War II and changed entirely the educational process throughout the country and of course at Purdue University. Many Purdue students and faculty members were called to service and many were lost in this war.



The CMET building in May 1940 **(left)** and in 1985 **(right).**

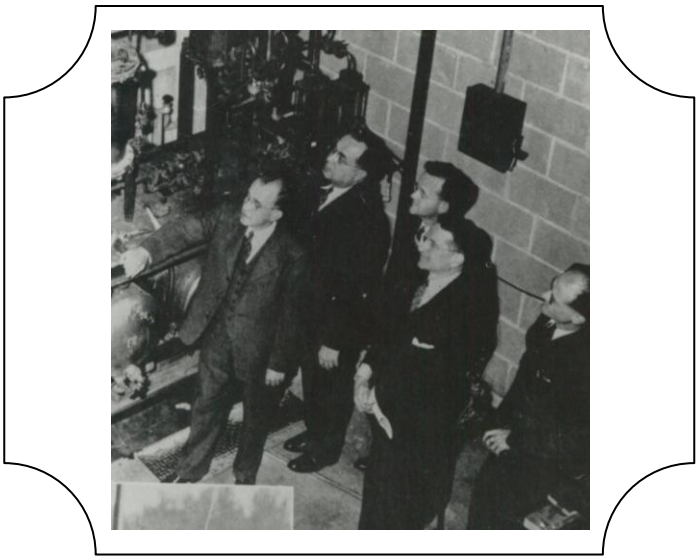
The various research contributions of the School during the War years are described by Knoll[33] and they will be discussed more extensively in Chapter 8. One of the early decisions made was the establishment of an accelerated educational program with three "terms" per year (Purdue has always been on a "semester" system) which was given from 1941 to 1945. The number of graduates during the war years fluctuated significantly and is difficult to follow (see Appendix M), but by 1943 there were 510 sophomores, juniors and seniors in all Divisions of the School.

Left: From the cornerstone celebration of March 31, 1939. In the front one sees Dean Potter, President Elliott and J.L. Bray with students.
Right: The cornerstone of the CMET building.

Several faculty members, notably Bray, Shreve, and Lovell, engaged in projects for the Federal Government. In 1942-45, Shreve and George T. Austin (1914-1996), a 1943 Ph.D. of the School under Clifton Lovell, and later a professor and head for 22 years at Washington State University, established in the School an accelerated training program (including laboratory) in the manufacture of munitions, which was attended by 200 men who eventually worked in US munitions factories.

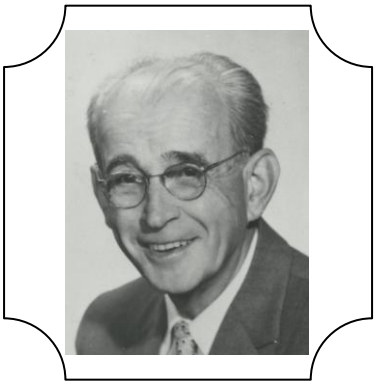
ChE laboratory circa 1944

During the World War II years, there was no question of staff expansion. Everyone was trying to contribute in the best possible way to the needs of the country, although it is interesting that the graduate program was not interrupted. In fact, more than 15 Ph.D. students graduated during these years. During 1942 a decision was made to award a Ph.D. degree in Metallurgical Engineering, which until then was designated as a Chemical Engineering degree. The first such degree was awarded in 1944 to a student of J.L. Bray, David J. Mack, for his thesis on *Corrosion Fatigue Preparation of Some Hard Lead Alloys*. Mack eventually became a professor at the University of Wisconsin.



The faculty of the School of Chemical Engineering in the Unit Operations Laboratory in 1944. **From left to right:** George W. Sherman, Jr., Clifton L. Lovell, John F. Eckel, R. Norris Shreve and Frederick L. Serviss.

Roy Erwin Swift (1911-1995, B.A. '34 Massachusetts School of Mines, M.S. '40 University of Washington, M.S. '45 University of Utah, D.Eng. '49 Yale University) joined Purdue in 1945 fresh out of School to improve research in the areas of engineering geology and mining engineering and to help Professor Serviss. He stayed here only one year. He eventually retired as a Professor of Metallurgical Engineering at the University of Kentucky. Thomas Josiah Hughel (1920-2005, B.S. Met. E. '42, Ph.D. '51 Purdue University) became first an Instructor, and then Assistant Professor in 1951. He worked in Metallurgy and was considered a faculty member of the Metallurgical Engineering Division, as was John Thomas McCormack (B.S. '23 University of Chicago, M.S. '48 Purdue University, Ph.D. '50 Purdue University) who joined the faculty as an Instructor in 1946 and became an Assistant Professor in 1950. Samuel Charles Hite (1922-2002, B.S. '43, Ph.D. '51 Purdue University) originally became an instructor while working on his Ph.D. with J.L. Bray. During the trying years of high enrollments after the war he made significant contributions to the educational program of the School. He became an Assistant Professor in 1951 and after a promotion to Associate Professor in 1957 he left for the University of Kentucky where he started the Department of Chemical Engineering. In 1970 he moved to Rose-Hulman Institute of Technology where he became the Chairman of the Department. J.C. Lottes, about whom we talked before, was the fourth Purdue graduate who became an Assistant Professor in 1949.



George W. Sherman, Jr. was a pioneer in the development of instrumentation and control laboratories. He is shown in a 1955 photograph.

A dangerous precedent was developing at Purdue in these first post-war years. A large number of the faculty members believed that the School could be best staffed by outstanding graduate students who could stay as instructors while they finished their Ph.D. degrees, eventually becoming Assistant Professors. This system, known as "inbreeding," is considered undesirable by today's educational and research standards, because it perpetuates the same research and educational ideas in a Department and can lead to stagnation. Such inbreeding is, according to many, the reason for the significant "fall" in the graduate programs of the University of Michigan and MIT in the 1950's and 60's. The process of inbreeding is no longer practiced by the School.

With the departure of Eckel, George Magee Enos (1899-1952, B.S. Met. E. '21 South Dakota School of Mines, M.Sc. '22 Carnegie, Ph.D. '25 University of Cincinnati) joined the School in 1946. Enos, a researcher with significant industrial and research experience at the Bureau of Mines (1923-39) and the University of Cincinnati (1939-46) seemed certain to make a major impact on research in the next 20 years (he was only 47 years old when he came to Purdue). Unfortunately, he died in 1952.

In the last two years of Bray's Headship, two professors with similar research interests were hired to start and develop a new (for Purdue) research field, that of thermodynamics. In the 1930's theoretical and applied thermodynamics became an important research and educational area in ChE, probably triggered by the 1935 publication of the revolutionary textbook on *Thermodynamics for Chemical Engineers* by Harold C. Weber of MIT, later revised by Herman P. Meissner. At the same time the University of Wisconsin contributed three major textbooks that included thermodynamics, chemical kinetics and some reaction engineering, those of Olaf A. Hougen, Kenneth Watson and Ronald A. Ragatz under the general title *Chemical Process Principles, with subtitles Material and Energy Balances, Thermodynamics, and Kinetics and Catalysis.*

These textbooks were quickly accepted by all the major Departments of Chemical Engineering. Soon thereafter, industrial recruiters started asking for graduates who had a good knowledge of these "new subjects." At Purdue, the strong areas of research and education were unit operations, unit processes (or industrial chemistry) and metallurgy. It is to the credit of Bray that he recognized the need for a change

One of the two men hired to develop these new areas was Dysart Edgar Holcomb (1917-2010, B.S. '37 Texas Technological Institute, M.S. '38 and Ph.D. '41, University of Michigan) who had worked with G.G. Brown and was interested in thermodynamics and, in a more general sense, in unit operations. He had worked with Universal Oil Products (now UOP) in Chicago before coming to Purdue. Holcomb's contributions to the School were immense despite staying at Purdue only two and one-half years. A dedicated researcher, he graduated two Ph.D. students during that period. Unfortunately, in August 1948 when he arrived at Purdue as an Associate Professor, Clifton Lovell had a heart attack. Thus, Dysart was asked to teach the unit operations courses and to be in charge of the Summer Session, in addition to his regular research and educational interests. An ambitious person, Holcomb was not satisfied by these assignments. He resigned in 1948 to return to the petroleum industry (Sinclair Refining Co.), and in 1950 he became Dean of Engineering of the Texas Technological Institute in Lubbock. In 1955 he became President of Texas Western College and in 1958 Director of Research at El Paso Natural Gas Co. In 1965 he accepted a position as Vice President for Research and Development of Pennzoil United Inc. from where he retired in 1982. He died at the age of 92 on February 26, 2010. All things considered, the School

benefited significantly from the immense contributions of two "mavericks," Clifton L. Lovell and Dysart E. Holcomb, two researchers who had great ambitions and hopes for the research program, hopes that did not always materialize.

The selection of the second man who was hired for his interest in thermodynamics, turned out to be one of the happiest and best decisions of John Bray and the faculty. In his name the School would find the first internationally recognized, "modern" chemical engineer, whose contributions to research, education and the philosophical direction of the School would be many and significant. Joe Mauk Smith (1916-2009, B.S. '37 Cal Tech, Sc.D. '43 MIT) was educated during the best days of MIT under the direction of the legendary Warren K. "Doc" Lewis, the "father of chemical engineering."

Left: John L. Bray (left) and Dean Andrey A. Potter in the Unit Operations laboratory in 1941.
Right: Dean Andrey A. Potter and students during the laying of the cornerstone of the CMET building.

Joe Mauk Smith
(1916 - 2009)

Prof. Joe Mauk Smith, was interested in modernizing the School of Chemical Engineering at Purdue, and in giving new, more fundamental directions to graduate research. In his first six years at Purdue he worked to establish thermodynamics and heat transfer as research fields, and to create a research program of national reputation. In the next six years, he promoted his philosophy of education and research to the other faculty members. With Carroll O. Bennett and John E. Myers, he formed a triumvirate that became the spirit of the School's revitalization in the 1950's.

Smith was born in Sterling, Colorado, on February 14, 1916. The family soon moved to California where he attended primary, junior high and high school in Long Beach. His undergraduate education was at Cal Tech, where he graduated in 1937 with a B.S. degree in Applied Chemistry. "I was first introduced to chemical engineering in a most fortunate way with William N. Lacey teaching a course to two students using the classical book authored by Walker, Lewis and McAdams... I was fortunate enough to be able to take, while employed by Chevron Research, a graduate course in thermodynamics with Bruce Sage. These professors taught me some of the elegance and precision involved in thermodynamic thinking," he said in a 1983 interview[34]. From 1937 to 1939, he worked for the Texas Company in New York as a design chemical engineer. From 1939 to 1941, he was employed by the Standard Oil Company of California (now Chevron) in development work in the thermodynamics of underground petroleum reservoirs.

He returned to MIT in 1941 and received his Sc.D. in Chemical Engineering in 1943, while working with Warren K. "Doc" Lewis on a classified war project. He was fortunate enough to take thermodynamics with Harold C. Weber. The influence of Lewis on Smith's thinking is well known. "Thesis work with W.K. Lewis was an inspiration," he said[34]. "One of the most lasting benefits of this association was learning the importance of being able to generate new ideas about chemical engineering problems. Dr. Lewis was an inspiring innovator and his students could not help but see the beauty and advantages of innovative approaches to difficult problems. Dr. Lewis had no patience with inferior work."

In January 1943 he became an instructor at MIT, and in July he joined the University of Maryland as an Assistant Professor. In July 1944 he went to Publicker Commercial Alcohol Co. in Philadelphia, where he was "discovered" by John Bray who, at the suggestion of Clifton Lovell, had written to "Doc" at MIT asking him for a good candidate for a faculty position. Smith was not totally unknown to Bray, since in 1943 he had visited the School for a different reason.

Thus, Smith arrived at Purdue in July 1945 as an Assistant Professor. Characteristic of Purdue's hierarchal and inflexible system in those days is the letter Bray sent to Smith, in which he offered the position to him[35]. "We shall assign you to half-time teaching and half-time research to start. The teaching would be in Unit Operations. The research would be on the hydrogenation of coal for the Indiana Gas Association or the U.S. Bureau of Mines, although other research projects more pressing may come along." Even the research that one was supposed to do was controlled by the administration in those days.

Smith ignored these directions, quickly established his laboratories, and started significant research in thermodynamics, heat transfer and applied reaction kinetics. He was promoted to Associate Professor in 1949 and Full Professor in 1951.

Smith became the most recognized faculty member of the School. The students loved him, and his educational system, an extrapolation of the now famous dialectic-Socratic approach of W.K. Lewis, became well known and appreciated. "Joe really turned me on; he was the first teacher who gave me problems I couldn't solve... *I had never met a professor who wanted to know you as an individual* (the italics are mine). If I were working in the lab late at night, he'd stop in, put his feet up on the desk, and talk with me, not necessarily about my thesis, but about almost anything," says Robert C. Reid[36] of MIT who did his M.S. degree with Smith at Purdue. And a graduate of the University of California at Davis, where Smith moved in 1966, adds[34]: "he calls on students in class to answer questions, insuring that the class is following the development of his presentation." What Professor Smith probably does not know is that *his educational system* influenced Reid, and through him three generations of educators, so that forty years later one author (NAP) applied it at Purdue exactly as Smith was applying it in 1946.

Raymond W. Fahien, who was a Professor of Chemical Engineering at the University of Florida and got his Ph.D. under Smith in 1954 pointed out[34] that "he is also a warm, sensitive person who thoroughly enjoys the company of others - as well as a charismatic leader who knows how to motivate people. He does this by imparting a sense of purpose or mission to every activity in which he is engaged. For example, in his lectures Joe would begin by asking the question: `Why are we, as chemical engineers, interested in this topic?' His books also first make clear the relevance of each chapter or section before going into the theory."

Indeed, Smith was not only interested in research. He had enough enthusiasm and dedication in chemical engineering to get involved in book writing and administration. He started writing his now famous *Introduction to Chemical Engineering Thermodynamics* in 1947 and published the first edition in 1949. The 2nd edition was co-authored with Hendrick C. Van Ness (an Assistant Professor at Purdue from 1952 to 1956), and the book is now in its 7th edition (with M. M. Abbott added as an additional co-author). This book is the all time best selling title in chemical engineering and had a tremendous impact on chemical engineering education. He wrote his book on *Chemical Engineering Kinetics* in 1955 and published it as he was leaving Purdue.

Early in his career he also spent some time in administration. In the last few years of Dean Potter's administration, he became Assistant to the Dean of the Graduate School (1949-53) and in 1954 he became Assistant Director of the Engineering Experimental Station. In 1953-54 he was a Visiting Professor (as a Fulbright and Guggenheim Fellow) at the Technische Hoogeschool of Delft. Finally, in February 1957 he made the big decision to move to the University of New Hampshire as Dean of Engineering. In September 1957 he moved to Northwestern University as the Chairman of the Department. One of his graduate students at that time was Lowell B. Koppel, who came to Purdue in 1961 and was Head of the School from 1973 to 1981. In 1966 Smith moved to the University of California at Davis where he died at the age of 93 on June 7, 2009 after 43 active years in teaching and research at Davis.

His research impact at Purdue was of monumental significance. In a period of eleven years he supervised 23 Ph.D. and 38 M.S. students, an incredible academic production indeed. Some of his many successful Ph.D. students include Robert E. Hall (B.S. '40, Ph.D. '48); James B. Henderson (B.S. '46, Ph.D. '49), former Executive Vice-President

of Shell Oil Co.; Ganesh S. Laddha (Ph.D. '49), former President of the AC College; Robert C. Forney (B.S. '47, M.S.I.E. '48, Ph.D. '50), former Senior Vice-President of E.I. duPont de Nemours and extraordinary donor to the School; Henry J. Ramey, Jr. (B.S. '49, Ph.D. '52), former Chairman of Petroleum Engineering at Stanford University; Raymond P. Fahien (Ph.D. '54), former Professor and Head at the University of Florida and founder of *Chemical Engineering Education*; Robert P. Bringer (B.S. '52, Ph.D. '56), former Technical Director of 3M Co.; and Phillip G. McCracken (Ph.D. '56), former Technical Director of Ciba Geigy Co. His impact in ChE research and education was recognized by election to the National Academy of Engineering in 1975, and by the William H. Walker (1960), Warren K. Lewis (1983) and R.H. Wilhelm (1977) Awards of AIChE. As a small recognition of his impact at Purdue he was selected by the faculty unanimously to be one of the two plenary lecturers for the 1986 Gala Weekend Celebration for the 75th Anniversary of the School. Joe attended and enjoyed very much the whole event. His wife was particularly excited to discover the original of the photograph shown below, which she proclaimed to be the best photograph of this beloved Purdue professor.

Left: Joseph M. Smith, here shown in 1945, was the first ChE faculty member to teach thermodynamics. **Right:** Frederick L. Hovde, who became President of the University in 1946, at age 37.

At the end of the 1946-47 academic year, John Bray stepped down because of his deteriorating health. Of course, there was no question as to who would be the new Head of the School. Indeed on September 1, 1947, the man who up to that time had produced the largest number of graduate students in the history of the School, the researcher who had established an epoch for the School and for chemical engineering in general, R. Norris Shreve, finally became the Head. He stayed in this position only until 1951, since at that time there was a mandatory retirement of Purdue administrators at the age of 65. Shreve continued as a "regular" (if this word can be used for him) faculty member until 1955 when he retired.

Shreve's ascent to the Headship of the School almost coincided with another major event in the history of Purdue, the undertaking of the Presidency by a chemical engineer, Frederick L. Hovde (1908-1983). When President Elliott retired in 1948, the Board of Trustees and the faculty searched hard for a new President. Andrey A. Potter, the Dean of Engineering, was the favorite and immediate choice of many, but he refused to abandon Engineering.

The final selection of the Search Committee was Frederick Lawson Hovde, a chemical engineer by training, who would become the youngest President in the history of Purdue (at age 37) and the third consecutive chemistry-educated President of the University; from 1900 until 1971 the Presidency of Purdue was in the hands of chemists or chemical engineers. Hovde was born in Erie, Pennsylvania, on February 7, 1908, and was raised in North Dakota. He attended the University of Minnesota, where he quarterbacked the football team, and graduated with a B.S. in Chemical Engineering in 1929. He earned a B.A and M.A. in chemistry from Oxford University as a Rhodes Scholar. From 1932 to 1936 he was Assistant Director of the General College of the University of Minnesota, and from 1938 to 1941 Assistant to the President and Lecturer in Chemistry at the University of Rochester. After government service during the war, he accepted the Trustees' offer and arrived at Purdue on January 7, 1946.

Hovde's presidency (1946-71) was very beneficial to the School. He soon developed a deep friendship with Shreve which lasted for 30 years. Their correspondence[9] is long and very revealing of the respect that the President had for Shreve and the School; their letters are kept in a special volume in the office of the Dean of Engineering. From them comes a very clear picture that, at least between 1947 and 1966, Shreve had become the advisor and "senior spokesman" of the School, although his Headship lasted only four years.

Shreve's short period of administration is highlighted by his successful recruitment of three important faculty members and an unprecedented number of graduate students. These graduates of the School (1947-55) became leading executives of major companies around the world. During Shreve's administration the School had a large number of students, both undergraduate and graduate. Indeed, in the post-war period enrollment climbed rapidly, due to the "G.I. Bill" which allowed returning veterans to enroll and obtain a university education. Thus, enrollment reached its maximum in September 1948 with 635 undergraduate students in Chemical Engineering, 212 in Metallurgical Engineering and 103 graduate students in both divisions.

Administratively, Shreve divided the School into three divisions, Chemical Engineering, Metallurgical Engineering and Engineering Geology. These would not become officially recognized entities until 1953. In a 1950 leaflet, probably prepared by Shreve, one finds that in Chemical Engineering, Shreve was in charge, with himself, Lottes and Brink working in unit processes; Doody and Myers in unit operations; Smith and Bennett in Thermodynamics; Sherman in instrumentation, and Hite in gas research. In the Division of Metallurgical Engineering George M. Enos was in charge, with himself, Evers, Hughel and Hoefs (at Fort Wayne) working in physical metallurgy and Bray and McCormack in process

metallurgy. In the Division of Engineering Geology Serviss was in charge, with Johnstone in physical geology and Guttorsmen in paleontology.

Shreve's executive memoranda and publications during the 1947-55 period reveal a major change in his research and his views about chemical engineering. When Shreve arrived at Purdue, and roughly between 1930 and 1937, he worked on what could broadly be described as applied organic chemistry. His many interactions with colleagues from other universities, especially through ACS meetings and the Chemists' Club of New York, led to his realization that unit operations were an important part of chemical engineering.

Thus, around 1937 he started promoting the idea that industrial chemistry could be taught and researched in a similar way, by dividing each industrial process into distinct *unit processes* such as oxidation, nitration, sulfonation and alkylation. This idea was further catalyzed by the publication in 1935 of the very successful book *Unit Processes in Organic Synthesis*, edited by P.H. Groggins, to which Shreve contributed the chapter on alkylation. Consequently, in the 1940's Shreve promoted the idea of unit processes and started writing the monumental textbook *Chemical Process Industries*, which was finally published in 1945 by McGraw-Hill. He worked on his book almost continuously from 1942 to 1944. The research for various subjects was done by his graduate students and by his trusted secretary Elizabeth Prentiss who worked with him from 1943 until 1975 and typed the manuscript of over 800 printed pages. This book became a best-seller beyond any expectations, selling more than 180,000 copies by 1986, and it is currently available as a paperback through McGraw-Hill Europe. Alkylation research continued at Purdue under Prof. Lyle Albright until Albright's death in 2010.

John Clarence Lottes
(1913-1951)

John Clarence Lottes received his B.S. from Purdue in 1935. After four years of industrial employment he returned to Purdue as an Instructor working with Professor Shreve in the courses on Chemical Process Industries and Unit Processes. At the same time he started working on his Ph.D. with Shreve. His stay here was interrupted by his enlistment in the Navy, where he engaged on research in high explosives. He returned to Purdue in 1946 and completed his Ph.D. in 1949 working on the Alkylation of 2-Methyl Naphthalene. That same year he became Assistant Professor and in 1951 he was promoted to Associate Professor. Lottes was very much liked by the students and the other professors. He was an excellent teacher and did significant research attempting to merge unit processes with novel ideas from chemical reaction engineering and

catalysis. The more senior faculty members, especially Shreve and Bray, considered him the person best suited to become Head of the School in the future. Unfortunately, his career was interrupted abruptly on November 19, 1951 when he died at the age of 38. The School remembered his contributions by establishing the Outstanding Senior Award in his memory. This award is given to the best senior student on the basis of scholastic ability. Appropriately enough, the co-winner of the 1966 Lottes Award was James F. Lottes, his son, who received all his degrees at Purdue (B.S. '66, Ph.D. '72) and is retired from Mobil Chemical Research and Development Co.

Table 3-1. Lottes Award Recipients

1953	Robert W. Scher
1954	John W. Klar
1955	Alfred L. Paschen
1956	Maurice G. Lorenz
1957	Robert V. Mrazek
1958	J. Gordon Eversole
1959	Leonard G. Rossa
1960	Leoniel C. Baldwin
1961	Charles R. Kline
1962	Bennie J. Lipps, Jr.
1963	Loren J. Western
1964	Richard A. Hazleton
1965	John A. Krochta
1966	James F. Lottes Phillip C. Wankat
1967	David T. Clay
1968	Joseph M. Sroka
1969	Olagoke Olabisi
1970	David V. Addington
1971	Joseph C. Winner
1972	David F. Strahorn
1973	David A. Sirotti
1974	David J. Adler
1975	Raymond Comingore
1976	R. Janet Whitmore
1977	Robert M. Stanfield
1978	Robert E. Benner, Jr.
1979	Diane J. Graziano M. Susan Ogg
1980	James A. Might
1981	Dean B. Nelson, Jr.
1982	Gibson L. Batch
1983	Richard S. Masselnik
1984	Nicholas G. Valkanas
1985	M. Rajesh Ramaswamy
1986	Nikola M. Juhasz James M. Yang
1987	Tamara Daugherty
1988	Curt M. Walker
1989	Jo Ann Campbell
1990	Robert C. Adams Jeffrey M. Kobe
1991	Adrian Brown David Burkett
1992	Kristi Anseth
1993	Brad Berkowicz
1994	Michael Hoffman

1995	Jeffrey Ladner
1996	Karleen King
1997	Patrick McGough Yuniarto Widjajaj
1998	Kevin L. Rabinovitch
1999	Scott D. Phillips
2000	Irina Elkin
2001	Christopher Calderon Adam Meadows
2002	Theis F. Clarke
2003	Patrick Stenger
2004	Kristianto Tjiptowidjojo
2005	Amanda R. Braun Paul C. Jorjorian
2006	Dan J. Eckerle Samantha Sanders Mark H. Tucker
2007	Daniel Robbins
2008	Jeremy Jones
2009	Ashley Wenger David Hanna
2010	John Kindler
2011	Kimberly Ohn William Borror

J. Clarence Lottes and Helen W. Giese in the main office of the School (room 104) in 1948.

However, after about 1949 and as he was approaching retirement, Shreve tried to merge his ideas with modern chemical engineering ideas. Thus, many of his Ph.D. theses of 1952-54 were on more fundamental research subjects such as gas absorption towers, the engineering aspects of polymerization reactors, and fluidization processes.

Thomas Clare Doody (1901-1992, B.S. '24 and M.S. '25 both in Chemical Engineering, Ph.D. '38 in Chemistry, all three from the University of California at Berkeley) arrived at Purdue in September 1947 from the North Carolina State College where he had been since 1940. His appointment was as an Associate Professor and he was promoted to Full Professor in 1965. At Berkeley he studied under Merle Randall of Lewis and Randall fame. At Purdue he developed a research program in mass and heat transfer with interests in absorption, vapor-liquid equilibrium, and related areas. He supervised the theses of 6 Ph.D. and 18 M.S. students. He retired in 1970. The other two professors were Carroll O. Bennett, who was hired in 1949, and John "Jack" E. Myers, who came in 1950. Their biographies and achievements will be presented in the next Chapter.

In 1948 a chemical engineer was hired to contribute to Metallurgical Engineering. Dillon Evers (1908-1963) had obtained all his degrees from the University of Iowa (B.S. '31, M.S. '32, Ph.D. '36). He became involved in physical metallurgy and contributed significantly to the School. He stayed at Purdue until 1956 when he left for Mallory-Sharon Titanium Corp. Around 1950 the Division of Metallurgical Engineering became quite independent, awarding degrees in this area independently of Chemical Engineering. Consequently, after 1950 we will follow only what was going on in Chemical Engineering. For the record, the Schools were completely separated in 1959 (see box).

Another highpoint in the School's history was the graduation of the first woman student* with a Ph.D. degree, S. Margaret Willoughby, who was also the first woman to receive a Ph.D. in any engineering program at Purdue.

Sarah Margaret Claypool Willoughby
(1917-2008)

Born in 1917, Sarah Margaret (Claypool) Willoughby received her B.S. in Chemistry from the Western Kentucky State Teachers' College in 1938. She worked as a teacher for the Bullitt County Ky. Schools (1941-42), and then as a paint chemist for Devoe-Reynolds Co. (1942-43) and Curtiss-Wright Corp. (1943-44). After her first husband died in an airplane accident and after being told by the professor that she could not attend his lectures at the University of Louisville (despite being supported by the Curtiss-Wright Corp.), she did a search and determined that Purdue would accept women into the ChE graduate program. She came to Purdue in 1944 where she worked with R.N. Shreve, receiving her Ph.D. in 1950. While at Purdue she had minors in forestry and agricultural biochemistry and was a member of ACS and Sigma Xi. In June 1948 she married Glenn Willoughby. Upon graduation she worked for Monsanto Co. in Everett, Massachusetts. Later she became a Professor of Chemistry at the University of Texas at Arlington (then Arlington State College) and did research in the field of polymers. A native of Kentucky she was named a Kentucky Colonel. Dr Willoughby was invited to Purdue in the late 1980s and was named an Outstanding Chemical Engineer. On this occasion, she gave a seminar about her work at Purdue and her interaction with R. N. Shreve. It was a magical visit, much appreciated by faculty and students. This remarkable person retired in 1984 and died December 27, 2008.

Sarah Margaret Claypool Willoughby
first woman to receive a Ph.D. in any engineering program at Purdue

* The first woman graduate student in Chemical Engineering was Helen Florence Ginsberg who registered in the fall of 1943 but left in 1944.

The School of Materials Engineering (MSE)

The Schools of Chemical Engineering and Metallurgical Engineering (METE) totally separated in the summer of 1959. Faculty members in the Division of Metallurgical Engineering between 1951 and 1959 included, in addition to those mentioned in the main text, Paul B. Eaton (served 1951-84, B.S.M.E. '48 University of Notre Dame, M.S.I.E. '51 Purdue University), Albert G. Guy (served 1952-60, B.S. '38 University of Chicago, M.S. '41 Ohio State University, D.Sc. '44 Carnegie), Pekka Rautala (served 1955-60, Dipl. Eng. '46 Finland Institute of Technology, Sc.D. '51 MIT), Reinhardt Schuhmann, Jr. (served 1953-83, B.S.M.E. '33 Missouri School of Mines, M.S. '35 Montana School of Mines, Sc.D. '38 MIT), Richard E. Grace (served 1954 -2000, retired as Vice President of Purdue, B.S.M.E. '51 Purdue University, Ph.D. '54 Carnegie), Clarence T. Marek (served 1951-72, B.S.M.E. '42, M.S.M.E. '44, both from Purdue University), Norman A. Parlee (served 1953-62, B.S. '35 and M.S. '37, both from Dalhousie University, Ph.D. '39 McGill University), and Peter G. Winchell (served 1958-81, A.B. '48 University of Chicago, B.S. '53, Ph.D. '58, both from MIT). Readers interested in Metallurgical and Materials Engineering are referred to Dayananda's history[37]. Note: years served are years active at Purdue in METE and MSE.

Reinhardt Schuhmann, Jr. who was in charge of the Metallurgical Engineering division of ChE became the first Head of the School of Metallurgical Engineering in 1959 and served for six years. During his administration, faculty members hired were Gerald L. Liedl (served 1960-1999, former Head of the School, B.S.M.E. '55, Ph.D. '60 both from Purdue University), and Samuel J. Hruska (served 1964-1999, B.S.M.E. '59 Purdue, M.S.M.E. '62, Ph.D. '63 both from Carnegie). Due to the changing nature of research and education and the significant increase of interest in materials in general, the name of the School was changed to the School of Materials Science and Metallurgical Engineering in 1965 and Richard E. Grace was appointed its Head. The formal association of Chemical Engineering with Materials Engineering was completed in June 1988 when Materials Engineering moved to the new MSEE building, and Chemical Engineering inherited all of the CMET building except for a small suite of offices used by the Division of Interdisciplinary Engineering for a number of years.

In his last days, Bray was occupied with some research (Samuel C. Hite, his last Ph.D. student, graduated in 1951) and the writing of his second major book on *Ferrous Production Metallurgy*, which became a classic in the area. One of his last interests was the preparation of *The History of the School of Chemical and Metallurgical Engineering*[1] which was printed in September 1951. In it, the reader finds a methodical presentation of the events that led to the School's glory in the 1940's. Bray avoided making critical comments about his former and contemporary colleagues, since he was part of that history and had met all the faculty members of the School and 85% of its graduates. His history will remain a valuable document for future generations of historians and friends of the School. Knoll's history[22] published in 1963 is to a large extent a rewritten narration of what Bray wrote. In 1968 Shreve wrote a five-page Chronology which shed no new light on the events of the early days of the School. Both Helen Giese and Elizabeth Prentiss recalled that Professor Shreve had collected a great deal of material for the writing of a history, and that he

had actually written some portions of it. Unfortunately, these were not found during Prof. Peppas' five years of research, and no one in the School knows where they might be.

One year after the publication of his History, John L. Bray, who came to Purdue in 1923 to join Harry C. Peffer as the second faculty member and became the second Head of the School, passed away on December 6, 1952 at the age of 62. With him, the School lost a feisty fighter for its causes, a brilliant teacher and an excellent researcher and author.

The Division of Engineering Geology

The "option" of Geology within Chemical Engineering was established in 1929 with the arrival of Prof. Frederick L. Serviss. Over the years, this option developed into a strong component of the program. This was not unexpected, since in many universities around the world Geology and Mining Engineering have been traditionally associated with Chemical Engineering. After 1947, with the Divisions established by Shreve, Professor Serviss was given more freedom to hire new faculty members including James George Johnstone (G.E. '48 Colorado School of Mines) in physical and forestry geology, Paul Andrew Guttorsmen, Jr. (A.B. '43, Hannover College) in paleontology and Wilton Newton Melhorn (B.S. '42 and M.S. '51 Michigan State University, Ph.D. '55 University of Michigan). Soon after the death of Serviss, this Division was absorbed within Civil Engineering and Geosciences.

The giant of the 1934-51 period, R. Norris Shreve, was asked to step down as Head in August 1951 because Purdue regulations delineated a 65 retirement age for administrators. He stayed in the School as a Professor until 1955, and as we will see in the next Chapter, he continued influencing the School of Chemical Engineering for another fifteen years. With his retirement one could sense that the end of an era had come. But the man who had educated 44 Ph.D. and 59 M.S. students, the person who had started and was responsible for the Ph.D. program in the School would continue to promote the cause of Chemical Engineering at Purdue for many more years.

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