Ninety Seven Years of Metallurgy at Lehigh University

by

Allison Butts

Professor of Metallurgy Emeritus

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In 1865, Judge Asa Packer, resident of Mauch Chunk, Congressman, industrialist, and builder of the Lehigh Valley Railroad, announced his intention to appropriate $500,000 to found a university in South Bethlehem to be called "The Lehigh University." As stated in the first Lehigh University Register (1867), "The purpose of the founder was to provide the means of imparting to young men....a complete professional education, which should not only supply their general wants, but also fit them to take an immediate and active part in the practical and professional duties of the time.... The founder proposes to introduce those important branches of education which have been heretofore more or less neglected in what purports to be a liberal education, and especially those industrial pursuits which tend to develop the resources of the country -- such as Engineering, Civil, Mechanical, and Mining, Chemistry, Metallurgy, Architecture, and Construction."

A description of the general plan of instruction in the first Register informs us that the first two years were to be devoted to "the study of those elementary branches in which every young man should be instructed, for whatever profession or business in life he may be intended, viz.: Mathematics, Languages, Chemistry, Drawing, Elementary Physics, Physiology, History, Rhetoric, Logic, Declamation, and Composition." At the end of two years the student was to select one of five "schools" in which to pursue "some special professional course, to which all his studies and efforts will be directed" for an additional two years, receiving at the end "a special degree." The five schools were listed as (1) General Literature, (2) Civil Engineering, (3) Mechanical Engineering, (4) Mining and Metallurgy, and (5) Analytical Chemistry.

A brief description of the "nature" of each of the schools followed. It was stated that in the studies of the School of Mining and Metallurgy "are included Mineralogy and Geology; Metallurgy, with the modes of extracting all metals from ores; the methods of mining for various ores with special instructions as to iron, coal, zinc, lead, copper, gold and silver. The aim will be to fit the student for immediate service in the rapidly developing mines of these metals in many parts of our country. The students in this school will be taken to the mines for ocular instruction. The graduate in this school will receive the degree of E.M. (Engineer of Mines)."

Under the description of the School of Analytical Chemistry, it was stated that "this school will comprise all the operations of chemical analysis; of inorganic and organic chemistry; the spectroscope; the blow-pipe; assays of every kind; practical problems; the analysis of minerals; mineralogy, geology, metallurgy."

Lehigh University was formally opened Sept. 1, 1866. The five "Special Schools"began instruction Sept. 1, 1867.

The "programme of instruction" for each special school lists the subjects studied by "Junior Schoolmen" and "Senior Schoolmen." Juniors in the School of Mining and Metallurgy took "mathematics, mechanics, physics, machines, geology, mineralogy, and drawing." Seniors took "metallurgy, mining, chemistry applied to the arts, astronomy, Christian evidences, industrial jurisprudence, and drawing." Metallurgy included these topics: "Methods of reducing all ores. Qualitative and quantitative analysis of minerals. The spectroscope. The blow-pipe. Assays wet and dry. Alloys of gold, silver, and copper for monetary and other purposes. Fluxes, slags. Access to the Metallurgical Cabinet, with illustrative lectures." It is evident that instruction leaned heavily toward practice, as no doubt was natural, if not necessary, in those times; but the need for a liberal education for engineers was recognized even then in the studies of the first two years.

College catalogs have never been noted for minimizing the advantages of their parti-

cular institutions. Thus, we read in the early Lehigh Registers: "The health of Bethlehem is proverbial. The air is pure and extremely invigorating. The water in the University grounds and buildings is excellent, and free from limestone. The swiftly flowing Lehigh does not produce those ailments which are found on the banks of larger and more sluggish streams." Ah well, that was before the advent of heavy industry, which the University was to aid and abet. Problems of air and water pollution lay far in the future, and Bethlehem was actually a summer resort for Philadelphians and others.

The general plan of instruction in the five special schools as set forth in the first Register continued unchanged for the next seven years. The outline for the School of Mining and Metallurgy was then altered by insertion of the following:

"On account of the great number and scope of the studies necessary to the completion of the full course, it is four years and a half in length. The graduate in this school who has taken the full course will receive the degree of E.M. (Engineer of Mines). A partial course may be taken in this school by those who wish to pursue the study of Metallurgy. The course of Metallurgy includes the studies of the full course except those of Mining and Surveying. More time is devoted to Chemical Analysis and Machines than in the full course. The length of the course is four years. The graduate of this school in the Metallurgical course will receive the degree of Metallurgist (Metallt.)"

No students were listed as candidates for this degree until 1879-80, when the name of one appeared as a sophomore; however, he remained in the University only one year and there were no additional candidates for this degree. The degree was never awarded.

The above description applying to the degree of Metallt. was dropped from the 1881-82 Register, and under the heading "The Course in Mining and Metallurgy" we read: "....On account of the great number and scope of the studies necessary to the completion of this course, it is five years in length. The graduate in this course will receive the degree of Engineer of Mines (E. M.). At the completion of the fourth year of this course, the student will receive the degree of Bachelor of Metallurgy (B. M.)"

That the study of metallurgy at Lehigh was thus subsidiary to that of mining was typical of the early technical institutions, although the five-year: four-year plan does not appear to have been used elsewhere.

Thomas T. Read[9] records that Yale appointed a Professor of Metallurgy in 1855, but no students wished to take the course. He goes on to say: "Yale, which in 1857 was in a position to become the outstanding institution in the United States at which to study metallurgy, had to make a fresh start 50 years later." Metallurgy was a required course in the mining engineering curriculum of the Polytechnic College of the State of Pennsylvania, the first institution in the United States to grant degrees in mining engineering. (This college was chartered in Philadelphia in 1853, but went out of existence about 1890). In the eighteen-sixties several colleges started curricula in mining, with a course in metallurgy contained in most, if not all of these. They included Columbia School of Mines, M.I.T., University of Michigan, Lafayette, Lehigh, Washington College (now Washington and Lee), Rensselaer, and possibly also University of Pennsylvania, Harvard, and Yale. Five others began in the seventies, and six in the eighties.

Thomas M. Drown (M. D., University of Pennsylvania, 1862), later to become President of Lehigh, had been appointed instructor in metallurgy at Harvard in 1869. Like Bradley Stoughton later, Dr. Drown had been Secretary of the American Institute of Mining Engineers (1873-1883). He was President of A.I.M.E. in 1897-98.

Though subsidiary to mining, metallurgy at Lehigh was accorded special prominence. Be-

ginning in 1876-1877 the Register contained this statement:

"The location of the University in the vicinity of the iron works of the Lehigh Valley, and especially of the extensive establishment of the Bethlehem Iron Company, affords unusual facilities for the practical study of iron metallurgy. The processes for the manufacture of spelter and oxide of zinc may be studied at the Bethlehem Zinc Works." These words were carried in the Register for the next 22 years, except that in 1896-97 "Bethlehem Zinc Works" became "Lehigh Zinc and Iron Company" (forerunner of the New Jersey Zinc Company).

The early importance of metallurgy at Lehigh is also evident in the titles of theses presented by the graduates of the School of Mining and Metallurgy. Until 1917 the Registers gave the titles of all theses, which were required for graduation in all departments of the University until that year. For example, the two E.M. graduates of the class of 1877 presented these theses:

1. Review of Blast Furnace Plant at Stanhope, N.J., by Henry Richards.
2. Review of Copper Smelting Works at Phoenixville, Pa., and of the Hunt and Douglass Wet Process for the Extraction of Copper as Applied at the Works of the Chemical Copper Company at Phoenixville, Pa., by Charles L. Taylor.

Taylor later became a partner of Andrew Carnegie in business. Carnegie gave Lehigh Taylor House, completed in 1907, naming it after Charles L. Taylor. Taylor himself became the donor of Taylor Gymnasium and Taylor Field.

In 1870-71 there were in all 12 juniors and 10 seniors in the University. There were no juniors in the School of Mining and Metallurgy, and the sole senior was Henry S. Drinker, who became Lehigh's fifth president in 1905. Volume I of the Transactions of the A.I.M.E. contains a paper by Drinker describing both the mining and metallurgical operations of the Lehigh Zinc Company.

The degree of Bachelor of Metallurgy (B.M.) was awarded to 19 graduates between 1884 and 1890. In the Register for 1886-87 the stipulation of the degree to be awarded was changed to Bachelor of Science in Mining and Metallurgy (B.S.). This degree was received by 10 men in the next three years.

Presidents of Lehigh University

1. 1866-1875. Henry Coppée.
2. 1875-1880. Rev. John M. Leavitt.
3. 1880-1893. Robert A. Lamberton. (Died Sept. 1, 1893).
   1893-1895. (Henry Coppée, Professor of English Literature, International Law, and Philosophy of History, was Acting President).
4. 1895-1904. Thomas M. Drown. (Died Nov. 16, 1904).
   1904-1905. (William H. Chandler, Professor of Chemistry, was Acting President).
5. 1905-1920. Henry S. Drinker.
   1921-1922. (Natt M. Emery, Vice President, was in executive charge).
6. 1922-1935. Charles R. Richards.
7. 1935-1944. Clement C. Williams.
   1944-1945. (An Administrative Committee (Philip M. Palmer, Dean of the College of Arts and Science; Neil Carothers, Dean of the College of Business Administration; and A. Copeland Callen, Dean of the College of Engineering, was in executive charge).
   1945-1946. (E. Kenneth Smiley, Vice President and Director of Admissions, was in executive charge).
8. 1946-1960. Martin D. Whitaker. (Died Aug. 31, 1960).

Presidents of Lehigh University (Cont.)

1960-1961. (Harvey A. Neville, Vice President and Provost, was in executive charge).
9. 1961- Harvey A. Neville.

In 1890-91 there appears for the first time in the Register a heading "The Course in Metallurgy," with the degree of Bachelor of Science in Metallurgy (B.S.) to be received after four years. The following year there were separate sections for "The Course in Mining" and "The Course in Metallurgy." Mining could be either a four-year course for the degree of Bachelor of Science in Mining (B.S.) or a five-year course for the degree of Engineer of Mines (E.M.); there was never a five-year course for a metallurgical degree until the coming of the Arts-Engineering curriculum in 1949-50. Mining Engineering reverted to a four-year curriculum in 1896-97.

The year 1890-91 may be regarded as the year of birth of the Lehigh Department of Metallurgy.

Lehigh was among the very first schools to adopt this cleavage between mining and metallurgy. Others began to follow, but it was a slow development, especially in the West. At M.I.T., Mining and Metallurgy did not become separate departments until 1937-38.

The degree of Bachelor of Science in Metallurgy was given to approximately 53 men during the ten years following 1890-91. Among those to receive it in 1895 was Howard Eckfeldt, who later became Head of the Department of Mining Engineering. He received the E.M. degree in 1896.

Beginning with the class of 1901 the degree of Bachelor of Science in Metallurgy was changed to the degree of Metallurgical Engineer (Met. E.). This degree endured until 1930; during the 29-year period it was awarded to approximately 96 men.

Heads of the Department of Metallurgy

1. 1890-1903. Benjamin W. Frazier.
2. 1903-1921. Joseph W. Richards (died Oct. 12, 1921).
   1921-1923. (G. A. Roush was in executive charge).
3. 1923-1939. Bradley Stoughton.
4. 1939-1952. Gilbert E. Doan.
5. 1952-1956. Allison Butts.
6. 1956-1960. Robert D. Stout.
7. 1960- Joseph F. Libsch.

In the fall of 1901 there was established in the Department of Metallurgy a "Course in Electrometallurgy." According to the Register of that year, "This course is designed to prepare the student to enter the rapidly developing fields of electrometallurgy and electrochemistry. For the first two years the course is identical with that in Metallurgical Engineering." From its inception this curriculum surpassed in popularity the regular curriculum in metallurgical engineering, a development which we may surmise resulted from Professor Richards' prominence in this field and his enthusiasm for it. Enrollment in electrometallurgy was greater than that in metallurgical engineering in all but one of the 14 years in which students were enrolled in both curricula in the four undergraduate years. The cumulative enrollment in electrometallurgy in the 14 years was 259 compared to 186 in metallurgical engineering.

The degree awarded on completion of this curriculum was Electrometallurgist (El. Met.). After 1921 this degree was discontinued, although enrollment in the curriculum during its last years was close to the peak. It was felt to be undesirable to continue granting a degree that was out of line with those being given at other engineering schools. In all, 66 gradu-

ates received the degree of El. Met., as against only 24 receiving the degree of Met. E. during the same period. The greater disparity between enrollment and degrees awarded in the two curricula is probably due to students changing to El. Met. after starting out as candidates for the Met. E. degree. In later times, and perhaps at this time also, the metallurgical enrollment was to benefit in a similar manner by transfer of students from other engineering curricula to metallurgy.

The year 1925-26 is an important one in the history of engineering education at Lehigh. During this year, under the leadership of President Charles R. Richards, the faculty of the College of Engineering made an intensive study of all the engineering curricula. An extensive revision of all the curricula was initiated for students entering in September, 1926, due to graduate in the class of 1930. At the same time a uniform freshman year was adopted, with only small differences in the sophomore year. A comprehensive examination, or "engineering aptitude test," at the end of sophomore year was instituted as a requirement for entering the junior year. (This regulation was abolished in 1950). Further, the engineering degrees, such as Met. E., were replaced by the degree of Bachelor of Science in the specified branch. The professional engineering degree, such as Met. E., would now be awarded after "not less than five years of acceptable practical experience in responsible charge of work after graduation," and submission of a suitable thesis.

The award of professional engineering degrees was discontinued at the end of 1959-60, no applications for the degree having been accepted after January 1, 1957. During the thirty years of their existence the degrees had been granted to 53 engineering post-graduates, of whom 10 had received the degree of Met. E.

Members of the Metallurgical Staff

There is given below a chronological roster of all past and present members of the faculty of the metallurgical department, together with their titles at appointment and their final titles. The University Registers also list the names of research assistants, scholars, and research fellows. No account of these is taken in this listing since they were not members of the instructional staff. Some of the instructors were research assistants or fellows prior to their appointments as instructors.

Richard P. Rothwell.	1869-73	Demonstrator of Mining and Metallurgy.
Benjamin W. Frazier	1871-1905	Professor of Mining and Metallurgy. Professor of Mineralogy and Metallurgy. Head of Department. (Died Jan. 4, 1905).
Enos K. Bachman.	1884-87	Instructor in Mining and Metallurgy. Instructor in Metallurgy.
Fayette B. Petersen.	1886-88	Instructor in Metallurgy.
Joseph W. Richards	1887-1921.	Assistant Instructor to Instructor in Metallurgy and Blow-piping. Instructor to Assistant Professor of Metallurgy, Mineralogy, and Blow-piping. Professor of Metallurgy. Head of Department. (Died Oct. 12, 1921).
Joseph Barrell.	1893-96.	Instructor in Mining and Metallurgy.
John Boyt.	1897-99.	Assistant in Metallurgy to Instructor in Metallurgy.
E. Williamson Miller.	1900-02.	Instructor in Mining and Metallurgical Desig
Lucien N Sullivan.	1902-06.	Instructor in Mining and Metallurgical Desig
Walter S. Landis.	1902-12	Assistant to Instructor in Mineralogy and Metallurgy. Assistant Professor of Metallurgy and Mineralogy. Assistant Professor to Associate Professor of Metallurgy.

Otto C. Burkhart.	1905-08.	Instructor in Mineralogy and Metallurgy.
Newton W. Buch.	1907-09.	Instructor in Metallurgy and Mineralogy.
Gar A Roush.	1912-23.	Assistant Professor to Associate Professor of Metallurgy. In executive charge of Department 1921-23.
Siegfried Fischer.	1912-15.	Instructor in Metallurgy.
Arthur S. Callen.	1914-16.	Assistant in Metallurgy.
Allison Butts.	1916-57.	Assistant in Metallurgy to Associate Professor of Metallurgy. Professor of Electrometallurgy. Professor of Metallurgy. Head of Department. Professor Emeritus, 1957- .
Harry B. Pulsifer.	1920-24.	Assistant Professor of Metallurgy.
Bradley Stoughton.	1923-44.	Professor of Metallurgy. Head of Department. Professor Emeritus, 1944-59. Also Dean of Engineering 1936-39.
Frank J. G Duck.	1924-26.	Instructor in Metallurgy.
Maurice B. Leidy.	1926-28.	Instructor in Metallurgy.
Gilbert E. Doan.	1926-52.	Assistant Professor to Professor of Metallurgy. Head of Department.
Wilber E. Harvey.	1928-34.	Graduate Assistant to Assistant Professor of Metallurgy.
John H. Frye, Jr.	1935-37, 1940-44.	Instructor to Associate Professor of Metallurgy.
George L. Kehl.	1937-39.	Instructor in Metallurgy.
Gerald R. Van Duzee.	1938-40.	Instructor in Metallurgical Engineering.
Robert D Stout.	1939- .	Instructor to Professor of Metallurgical Engineering. Head of Department. Dean of the Graduate School, 1960- .
Joseph F. Libsch.	1946- .	Instructor to Professor of Metallurgical Engineering. Head of Department.
John H. Gross.	1946-59.	Graduate Assistant to Assistant Professor of Metallurgy. Associate Professor of Metallurgical Engineering.
James G. Kerr.	1946-49.	Graduate Assistant to Instructor in Metallurgy.
Walter Beck.	1947-50.	Associate Professor of Metallurgy.
Francis H. Laxar.	1949-57.	Instructor to Assistant Professor of Metallurgy.
Edward P Rowady.	1950-52.	Instructor in Metallurgy.
George P. Conard II.	1952- .	Assistant Professor to Professor of Metallurgy.
Joseph C. Danko.	1952-56.	Instructor in Metallurgical Engineering.
William J. Murphy.	1952-57.	Instructor to Assistant Professor of Metallurgy.
Richard A. Proebstle.	1956-58.	Instructor in Metallurgical Engineering.
Harry Suprinick.	1956-62.	Instructor in Metallurgy.
Herbert H. Johnson, Jr.	1957-60.	Assistant Professor of Metallurgical Engineering.
Edward H. Kottcamp.	1957-62.	Instructor to Assistant Professor of Metallurgical Engineering.

Richard D. Morrison.	1957-60.	Instructor in Metallurgical Engineering.
Karl E. Dorschu.	1957-59.	Instructor in Metallurgical Engineering.
Stanley A. Agnew.	1958-60.	Instructor in Metallurgical Engineering.
Dominic A. Canonico.	1958-62.	Instructor in Metallurgical Engineering.
George C. Horak.	1958-63.	Instructor to Assistant Professor of Mining Engineering. Assistant Professor of Metallurgical Engineering.
Alan W. Pense.	1960- .	Instructor to Assistant Professor of Metallurgical Engineering.
Ralph J. Jaccodine.	1960- .	Lecturer in Metallurgical Engineering
Robert E. Caffrey.	1960- .	Lecturer in Metallurgical Engineering
S. Kenneth Tarby.	1961- .	Assistant Professor of Metallurgical Engineering.
Robert A. DePaul .	1961- .	Instructor in Metallurgical Engineering.
Paul J. Horvath, Jr.	1961-63.	Instructor in Metallurgical Engineering.
Edward J. Jablonowski.	1961-63.	Instructor in Metallurgical Engineering.
John R. Thompson, Jr.	1961- .	Instructor in Metallurgical Engineering.

In addition to the 52 faculty members named above, all of whom were on the staff for tw years or more, the following held positions during one year only: H. H. Stock, Warren Worth ington, Foster Hewett, W . H. Hendricks, J. R. Dawson, Henry Eagle, J. L. Burns, C. H. Samans J. J. Buczynski, M. C. Lee, J. B Kushner. The following, appointed in 1962 or 1963, are continuing in 1963-64: R. Wayne Kraft, John D. Wood, D. L. Albright, R. A. Moll, T. E. Torok, W. C. Hahn, George Krauss, Jr.

Of the faculty members above whose terms were completed, two (Professors Frazier and Richards) died in service; only two (Professors Stoughton and Butts) received the designatio Emeritus.

Although not a member of the teaching staff, Martin Sheska should receive special mention. First appointed in 1937 as a machinist, now Laboratory Foreman, his services through the years have been invaluable.

Professor J. W. Richards was the embodiment of the expression "a gentleman of the old school." He was a colorful figure as he crossed the campus, slight of build, but immaculat ly attired in frock coat, striped trousers, and wing collar, accompanied by a huge Newfound land dog, which often slept beside the rostrum as he lectured. He believed thoroughly that the student should rise or fall through his own efforts. No coddler he. We can imagine with what impatience he would have viewed some of the present-day "services" existing in mos colleges. He took no record of class attendance, but the privilege of absenting oneself seems not to have been regarded as a privilege; at least it was not abused.

The obituary of Professor Richards published in the Lehigh Alumni Bulletin at the time of his death in 1921 contained the following sentences: "None of Lehigh's sons has done mo for his Alma Mater...With him passes the last except one of the old guard who first placed Lehigh on the high pedestal she has occupied as an engineering college for three decades." These sentences taken from a Faculty minute adopted at the time of his passing may be added: "Nor, while giving diligent attention to technical subjects in various phases of applied science, did he neglect personal advancement in matters of general culture; developing and extending all the talents with which he was gifted, with a sympathetic interest in all that is best in music, in art, in literature and in language. He was endeared to all his colleagues and associates through an unfailing courtesy and unselfishness, a calm and gentlemanly demeanor, the fair and judicious way in which he conducted any matter at the time in controversy among educational or commercial experts; and whether in private argument or general debate, under the stress of keen cross-examination in legal cases, where his learnin

and judgment were valued and welcomed, or in the ordinary clash of opinions in private conversation -- there was always the same dignified courtesy and consideration for others which were perhaps his most marked characteristics."

Like Richards, Bradley Stoughton was outspoken for what he thought was right, in educational matters and all else. Few men possessed so much energy, enthusiasm, and capacity for work as did Stoughton. His extraordinary activity endured almost undiminished until the last year or two of his life. He died in 1959 at the age of 86. A memorable characteristic of Stoughton was his desire to help others in all walks of life. His liking for people was evident in numerous ways, and one of the joys of his later life was keeping in touch with former students as well as others of his legion of friends. A portrait, painted by Mrs. Daphne Parke after his death, hangs in the metallurgy departmental office. This was made possible by contributions from many alumni of the department who graduated during the years he was department head.

These brief appreciations of Richards and Stoughton have been entered here as significant of the heritage of the Department of Metallurgy.

Buildings

At its opening in 1866 all of Lehigh University was housed in Christmas Hall. This building, together with land around it, was purchased from the Moravian Congregation so that the University might begin operating at the earliest possible date. It had been named Christmas Hall to commemorate the organization of the South Side Moravian Congregation December 25, 1862. When purchased by the Lehigh trustees in March, 1866, it was being built for the Moravians' church edifice and was not yet finished.

Construction of Packer Hall, named in honor of the founder, was begun by the Lehigh trustees that same fall, but the building was not completed and opened for use until September, 1868. At the same time there were being built the President's home and just north of it two large brick dwellings called the Professors' houses. One of these later became the residence of Professor J. W. Richards.

Richards, an ardent member of the Bach Choir, established the custom of inviting devotees of the Bach Festival to his home for tea between the Saturday afternoon sessions of the Festival, a custom which was later continued by presidents of the University at the President's house.

The two Professors' houses were torn down in 1920 to make way for the Alumni Memorial Building, and Richards had to move across the river to East Market Street. The Alumni Building was completed in the fall of 1924.

Besides lecture rooms Christmas Hall contained a chapel, dormitory, and mess hall. It was used for all of these purposes until 1885. Saucon Hall was erected in 1876-77, and the two were joined to form the present Christmas-Saucon Hall in 1926. Packer Hall was completely remodeled and extended to become the present University Center in 1958-59.

Professor Richards had an office in the basement of Christmas Hall, as did also others of the metallurgy staff who came later, including Landis, Roush, and the writer. Here were located also the national headquarters of the American Electrochemical Society from its founding in 1902 until after Professor Richards' death in 1921.*

There were, of course, no separate rooms in either Christmas or Packer Hall for Professor Frazier's classes in metallurgy. Separate quarters for Metallurgy were first established in

* See page 27.

1884-85, when rooms comprising most of the south wing of the present Chemistry Building, completed in 1884, were assigned to Metallurgy. These included a large lecture room, two large laboratory rooms, offices, and a department library and museum. The catalog of that year stated with reference to the chemical-metallurgical building that "in completeness and conveniences it is unsurpassed by any similar establishment in the country."

All of the metallurgy staff offices were moved from Christmas Hall to the Chemistry Building about 1919. The Department continued to have these quarters until 1929, when completion of the James Ward Packard Laboratory of Electrical and Mechanical Engineering enable the Department of Mechanical Engineering to move from Williams Hall, thus making its space available for Metallurgy. This building was the gift of Dr. E. H. Williams, Jr., a Lehigh alumnus, for many years Professor of Mining and Geology, and founder of Tau Beta Pi.

After some exchange of rooms with the departments of Biology and Geology, which were already in Williams Hall, Metallurgy was now to occupy most of the east end of the building, besides a large lecture room and museum at the west end of the third floor. In the basement were furnace rooms, a welding laboratory, and a machine shop. Laboratories for physical metallurgy and metallography and for electrochemistry were on the first floor, the departmental office and department library on the second floor; the large lecture room, a classroom, a drawing room which later became a research laboratory, and a room for graduate students were on the third floor. Offices were scattered on the three floors above the basement.

Some time before daylight on the morning of Saturday, January 7, 1956, a disastrous fire broke out in Williams Hall. It started on the third floor at the east end of the building. Although holes in the flooring after the fire indicated that it may have originated in a small room assigned to another department, there is no certainty of this and the cause of the fire remains unknown. Flames and heat swept through the third floor nearly to the center of the building, while everything on the lower floors and basement in the east half was drenched with water. Outside the temperature was cold but not freezing, and the wind was not strong. Firemen did excellent work in saving the building, and the fire was under control before 8 a.m.

Students and staff members assisted in removing things from the building. Portable apparatus was taken to the Chemistry Building for cleaning and repairing; books, largely ruined by water, were taken to the Main Library; all motors and generators were sent out for renovation.

Rooms for metallurgy classes were quickly found by Registrar J. H. Wagner, in such unlikely places as the Gymnasium and the Library as well as other buildings. No classes were missed except those of Saturday morning, but the work of laboratory sections requiring apparatus was disrupted. Some graduate students suffered greatly when their apparatus was destroyed and their programs set back. Dr. Conard, whose office was on the third floor in the southeast corner, was hardest hit of the faculty members.

The building was fully covered by insurance and the equipment was insured by two types of policy - the blanket insurance and the Fine Arts policy for scientific and laboratory apparatus. Probably the greatest ultimate loss to the University was the loss of books of the Metallurgical Department Library.

Since the Department had been so short of space before the fire, and the Geology and Biology departments also needed more space, it was decided that renovation of Williams Hall would include addition of a fourth floor. This permitted a redistribution of space, and the Metallurgy Department was allotted nearly all of the basement and first floors. Biology has the entire second floor and a little space on the third floor, while Geology has most of the third floor and the new fourth floor. This gave the Metallurgy Department much additional room for laboratory instruction and research. Nevertheless a severe lack of space has again developed. Some of the recent additions to the Department's equipment have been installed

in Coxe Laboratory.

The need for larger and more modern quarters for metallurgy had been recognized by the Administration for several years, and a new metallurgy building was given priority after the addition to the Fritz Engineering Laboratory, new dormitory buildings, the Health Center, and the University Center. While the Fritz Laboratory extension was being planned in 1953, some consideration was given to incorporation of metallurgy quarters there. This was found to be unsuitable and the plans that had been drawn were abandoned. Plans for a building to be occupied jointly by the metallurgical and the chemical engineering departments were begun immediately and the first draft was completed that same year. New plans, involving among other things a change of location, are now in progress. Erection of the building on the north side of Packer Avenue, between Adams and Webster Streets, is expected to begin early in 1964, utilizing funds obtained in Lehigh's Centennial Campaign, as well as a large grant from the Longwood Foundation which was made for this purpose in the fall of 1962.

The new building and its environs will be on property partly occupied by the present First Moravian Church. Their edifice was purchased by the Lehigh trustees December 13, 1962, just twelve days before the one-hundredth anniversary of the founding of South Side Moravian Congregation on Christmas Day, 1862. Thus is history repeated.

Equipment

The equipment of the Department for instruction and research has grown more or less steadily, especially in recent years, although acquisition has been somewhat retarded because of lack of space. Additions through purchase by regular University funds and by special University Alumni Fund appropriations have been supplemented by important gifts from industrial companies, especially numerous in the last few years.* In addition to equipment owned by the University, the Department has a considerable amount of apparatus on loan from industrial companies or Government agencies for use in specific research projects. The value of equipment in both these categories is shown separately below. It should be noted, however, that not all of the rapid rise in value in recent years represents increase in amount of equipment. Since these are replacement values, they are inflated by the rise in prices.

Inventory Replacement Value of Metallurgical Department Equipment

Year	Property of Lehigh University	On Loan
1952	$48,580	$21,074
1953	57,533	35,167
1954	83,076	38,302
1955	86,028	30,291
1956	115,412	28,047
1957	144,909	36,041
1958	156,746	32,323
1959	184,189	34,560
1960	198,406	52,541
1961	267,185	59,271
1962	308,779	43,656
1963	360,503	43,352

* It is of interest to note that all early issues of the Lehigh Register through 1893 contained detailed lists of gifts to the University during the past year, down to such minor items as samples of ores and metals for museum purposes, single books, and even pamphlets.

The following list gives the principal items of equipment as of 1963. Both apparatus used mainly for instruction and apparatus used only in research are included.

Property of Lehigh University

Instron universal testing machine
Baldwin-Southwark 120,000-lb. testing machine and accessories
Tinius Olsen 60,000-lb. testing machine
Baldwin-Lima-Hamilton hot-tensile tester and furnace
Baldwin-Lima-Hamilton testing machine recorder
Baldwin-Lima-Hamilton deflectometer
2 Krause fatigue testing machines
Cam fatigue machine
High-temperature fatigue-testing equipment, instrumented
Stress-rupture apparatus and accessories, 5 stations
3 Tinius Olsen impact testers
Baldwin impact tester
12 Hardness testers, various types
Leitz dilatometer and accessories
General Electric box furnace, 20 kw., with transformer and accessories
Hevi-duty box furnace, 14 kw., and accessories
4 Hayes Certain-curtain furnaces
Hayes globar furnace
Hayes brazing furnace, 15 kw.
Hy-temp furnace, with vacuum capsule and accessories
Cooley circulating furnace
Vacuum induction furnace, 30 kw.
Lepel high-frequency converter, 15 kw.
Lindberg atmosphere furnace, 8 kw.
3 Lindberg crucible pot furnaces
3 Driver-Harris salt-pot furnaces
3-unit lead-pot furnace
RCA electron microscope
2 Metallographs, Bausch and Lomb, and accessories, ILS
Metallograph, Bausch and Lomb, research
15 Bench metallographic microscopes
Buehler polishing wheel assembly
AB electropolisher and accessories
Crystal slicing machine
RCA-Siemens direct-recording X-ray diffractometer and accessories
General Electric R.D. 4 X-ray diffractometer and accessories
Jarrell-Ash high-temperature X-ray camera
Westinghouse X-ray radiographic unit
X-ray control unit
General Electric transmission photometer
Rubicon Sanford Bennett permeameter and accessories
Czochralski crystal grower and associated control cabinet, 10 kw.
Mosely Autograf recorder
Speedomax recorder
Beckman pH meter
Linde Heliarc welding equipment with wire feeder
Westinghouse Rectarc welding generator
Westinghouse welding feed head
Una welding head and transformer
2 Linde sigma welding units
Federal butt-welder and accessories
Oxweld oxy-acetylene welding and cutting apparatus
Linde manual welding outfit

Blake and Johnson 2-high laboratory rolling mill with motors
General Electric AC-DC motor-generator, 30 kw.
Chambersburg tool dressing hammer
Fenn rotary swaging machine and accessories
Hydraulic draw bench, 8,000-lb., instrumented, and bull block
Kinney evaporator
Ingersoll-Rand air compressor, 10 hp.
Jolt-squeeze molding machine and match plates
Clearfield sand mixer
Sand muller and sand-testing equipment
Sieburg Tensilkut machine and accessories
2 Abrasive cut-off machines
U. S milling machine
Universal Kempsmith milling machine
Kearney and Trecker universal milling machine
DoAll contour machine
DoAll surface grinder
Blanchard surface grinder and accessories
Carney Marvel band saw
6 Chemical balances, various types
Monroe electric calculator

On Loan

Lepel high-frequency converter, 30 kw.
Lepel high-frequency induction unit, 10 kw.
Plasma torch fixture
Floating zone fixture and accessories
Ray-o-tube and thermocouple temperature controllers
Magnetostriction measuring apparatus
Dynamic hysteresis loop tracer
Leeds and Northrup program controller
Dumont oscillograph record camera
General Electric sintering furnace for metal powders

Nearly all of the items of equipment listed above have been acquired by the Department during the last 15 years. The list does not include the many items of lesser value.

The will of Professor J. W. Richards bequeathed his technical books to Lehigh, and the Register until 1950 carried a statement that "the Joseph W. Richards Library of Metallurgy and Chemistry, consisting of about 3,000 volumes, is located in the Department of Metallurgy." New books were purchased annually for the Richards library to keep it up to date. Professor Stoughton, after his retirement, added many of his books to it. In 1958, however, the department library was discontinued; all the metallurgical books and most of the bound periodicals were removed to the Main Library and distributed among the books there. The completeness of the collection of metallurgical reference books and bound periodicals has suffered.

Enrollment

The University at first grew slowly. After 10 years the total registration in the "special schools" reached 44 juniors and seniors, declining to 32 the next year. The number in the School of Mining and Metallurgy in this period varied from 0 to 5.

In 1877-78 the University enrollment including sophomores, but not freshmen, was 41, of whom 10 were in mining and metallurgy. The next year a steady growth began. The total enrollment, not counting freshmen, was 216 in 1887-88, of whom 31 were taking mining and metallurgy; nearly all of the latter were studying for the mining degree, and the number enrolled in metallurgy was not shown separately in the Register until 1899-1900.

Enrollment in the Department of Metallurgy from that year on is given in the following data. The figures are for seniors, juniors, and sophomores only, since during much of the time, as at present, freshmen were not definitely assigned to a department. In order to save space, the figures are given for the average annual enrollment during five-year periods rathe than for each individual year. The number of degrees awarded in metallurgy (including electrometallurgy) is also shown. The enrollment figures are for the fall semester. The data for degrees conferred include those awarded in February and on Founder's Day as well as in June.

Five-year Period Ending in June	Average Annual Undergraduate Enrollment ex-Freshmen	Average Annual Number of Bachelor's Degrees Awarded
1900-1904	5	4
1903-1907	12	3
1908-1912	28	4
1913-1917	33	4
1918-1922	54	9
1923-1927	25	8
1928-1932	38	8
1933-1937	43	11
1938-1942	78	20
1943-1947	32	14
1948-1952	76	25
1953-1957	98	32
1958-1962	80	26

During the five-year periods when sophomore, junior, and senior students were registered for the El. Met. degree, the enrollment was divided as follows between Metallurgical Engineering and Electrometallurgy:

Period	Met. E.	El. Met.	Total
1904-1908	4	9	13
1909-1913	8	14	22
1914-1918	9	16	25

The largest enrollment in metallurgy for any one year was reached in 1955-56 and again in 1956-57, with 102 sophomores, juniors, and seniors in the fall semester of each of these years. In the spring semester of 1956 the total including freshmen was 130, the largest enrollment in any year to date; of these, 24 were freshmen. The largest graduating class to date is the class of 1956, with 37 receiving the B.S. degree in that year.

A survey made by the American Society for Metals in 1954-55 showed Lehigh's metallurgica department tied for first place in undergraduate enrollment among the 47 colleges in the United States and Canada awarding degrees in metallurgy. The 27 B.S. degrees in metallurgy given at Lehigh in that year were 6.2 per cent of the total such degrees given in the United States and Canada. In 1962-63 Lehigh was fourth in upper-class undergraduate enrollment in metallurgy among American colleges, according to figures compiled by J. P. Nielsen and published by the American Institute of Mining, Metallurgical, and Petroleum Engineers. The metallurgical departments leading in enrollment in the fall of that year were as follows:

		Seniors	Juniors
1.	Missouri School of Mines and Metallurgy	79	93
2.	Colorado School of Mines	54	66
3.	Michigan College of Mines and Technology	38	59
4.	Lehigh University	38	33
5.	Drexel Institute of Technology	28	14
6.	Rensselaer Polytechnic Institute	27	22
7.	Case Institute of Technology	26	35
8.	Purdue University	26	22
9.	Lafayette College	24	24
10.	Massachusetts Institute of Technology	23	24
11.	Illinois Institute of Technology	23	17
12.	Carnegie Institute of Technology	22	23
13.	University of Pittsburgh	21	31
14.	Pennsylvania State University	20	22
15.	University of British Columbia	19	24
16.	University of Alabama	19	9
17.	University of Illinois	18	24

Research

Representing a growing science, the Metallurgy Department fittingly was research-minded from the beginning, but early accomplishment in this area was handicapped by lack of facilities and personnel. Richards and Landis were interested especially in determination of fundamental constants. Some of their work is found in published papers, but it cannot be said that their work in research was notable.*

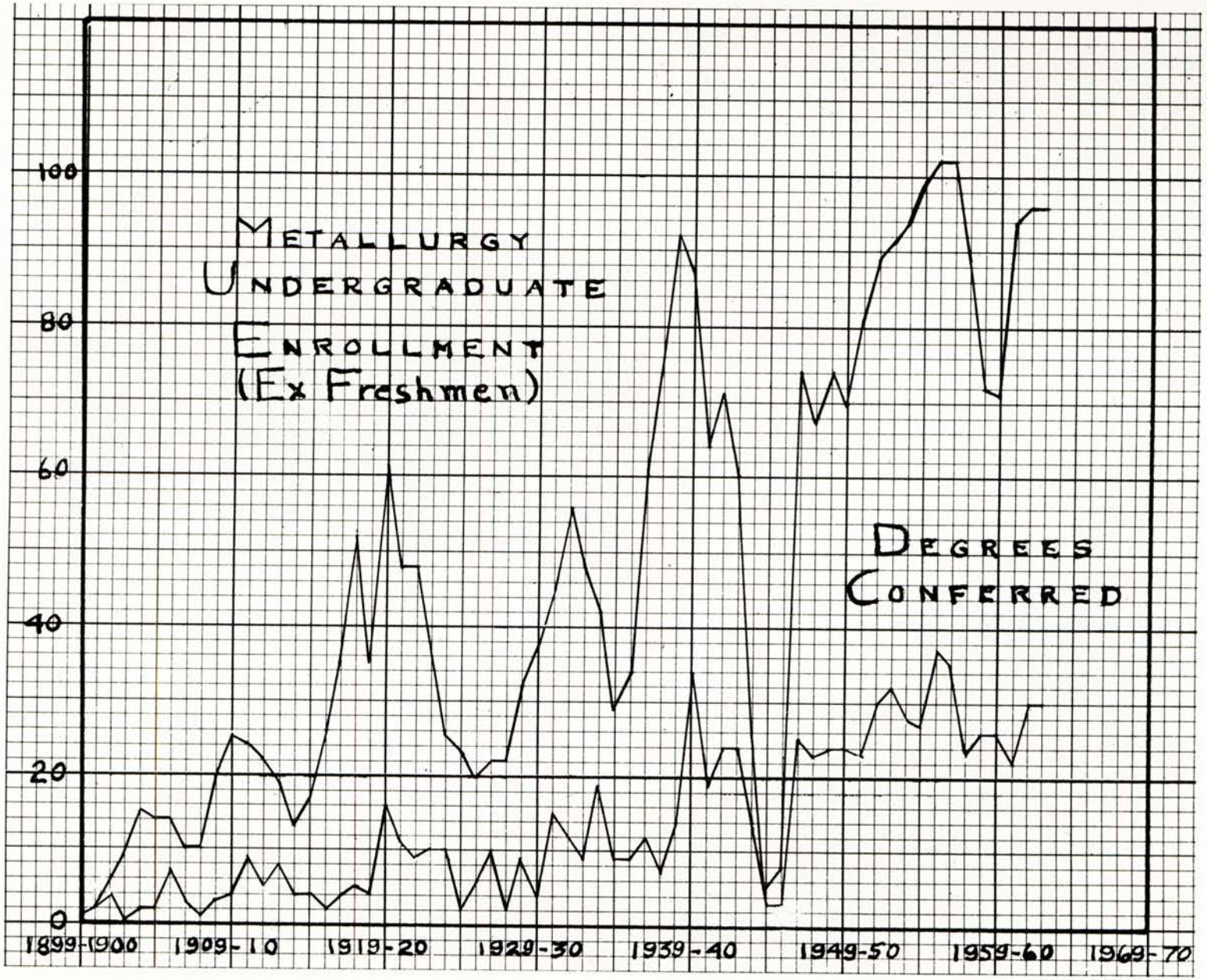
At that time little research was being carried out at Lehigh, and all of it was a personal matter for those who wanted to do it and could find the time, with or without the assistance of students or graduate students. Research grants and contracts were unheard of.

The coming of President C. R. Richards in 1922 was a milestone in the history of Lehigh research, and another was the establishment of the Institute of Research in 1924. It was a primary aim of President Richards to promote research at Lehigh, and his insistence that good teaching and research go hand-in-hand is well remembered by his contemporaries.

In the Metallurgy Department four areas of research stand out. These are gamma-ray radiography under Doan and co-workers; welding metallurgy, begun by Doan and continued by Stout and their co-workers; magnetics, begun by Libsch and continued by Conard and their co-workers; and induction heating, especially surface hardening, by Libsch and co-workers. ("Co-workers" refers to graduate students and younger staff members; most of the published papers bear the names both of the professor-directors and the co-workers.)

The work in welding has been most prolific. It was begun in 1930 under sponsorship of the Engineering Foundation. This has concerned not the welding process but its effect on properties of the welded metal and in later years the relation to fracture, including the effect of fatigue...in general, the metallurgy of welding. The "Lehigh restraint specimen" as developed by Stout is a term well known among workers in metallurgical welding research. Dr. Stout has long been active in the American Welding Society, a member of the Welding Research Council, and has made several visits to summer welding conventions in various countries of Europe as a delegate to the International Institute of Welding.

* For notation of Landis' later achievements in the field of research, see page 31.


METALLURGY
UNDERGRADUATE
ENROLLMENT
(Ex Freshmen)
DEGREES
CONFERRED
100
80
60
40
20
0
1899-1900
1909-10
1919-20
1929-30
1939-40
1949-50
1959-60
1969-70

Magnetics research at Lehigh grew out of a 1950 contract with the U. S. Signal Corps, bearing the title "Development of Improved Magnetic Materials." This was in charge of Dr. Libsch, who became the Metallurgy Department's Director of Magnetic Projects. In this capacity he was later succeeded by Conard, who has continued the work with financial support fro both Government and industry.

The Department has received numerous Government and industrial research contracts over the years. Annual reports from the Metallurgy Department Head to the President show total contract budgets for the Department (all carried on under the Institute of Research) as follows for recent years:

1953-54	$104,640	1958-59	$101,000
1954-55	99,640	1959-60	103,000
1955-56	70,607	1960-61	91,600
1956-57	83,349	1961-62	139,385
1957-58	86,500	1962-63	179,685

Publication of many research papers, especially in the Transactions of various engineering societies, has resulted from Lehigh's metallurgical research. Doan, Stout and Libsch ha been responsible for the largest numbers of these; Stout, usually with co-workers, has published about seventy research papers to date.

One of the earlier industrial contracts was that directed by Butts for the American Silver Producers' Research Committee. Results of this work, carried out in 1939-41, appear in the book "Silver in Industry," edited by Lawrence Addicks.

A wartime contract directed by Butts and Frye was one entitled "Investigation of the Effect of Impurities on the Ferromagnetism of Nonferrous Alloys." This work was done in 1944-46 and is described in the Proceedings of the American Society for Testing Materials.

Current contracts (1962-63), in addition to those in the areas of welding and magnetics are concerned with embrittlement in alloy steels, high-temperature fatigue, fatigue properties and effects of accelerated cooling in pressure-vessel steels, high-temperature deformation in sintered carbide, structures in the iron-silicon system, optimum composition of ship steels, reduction of oxides under vacuum in liquid steel, solid-state properties of catalyst surface hardening, and eutectic alloys unidirectionally solidified.

The Materials Research Center

An important new direction in emphasis took place among metallurgical departments acros the country about 1959, arising from the need for new materials having properties superior for certain applications to those possessed by available materials. Attention was directed to the principles governing the properties of all materials, metals and non-metallic substances alike.

Metals have always been in competition with various non-metallic materials, and it has been recognized that similarities or differences in behavior could be explainable through knowledge stemming from metal physics and physical metallurgy. But the growth of plastics, ceramics, semiconductors, high-temperature, thermoelectric, and cryogenic materials, to name some of the more important classes, has lent new impetus both to theoretical and practical study in this field.

At some engineering schools metallurgical departments have been renamed departments of materials science or materials engineering, or metallurgy and materials science or engineering. At Lehigh a committee composed of representatives from several engineering departments including also mathematics, mechanics, physics, and chemistry, was appointed by Dean L. V. Bewley in 1960 to study the implications for Lehigh and the steps which should be taken here Dr. Libsch, Head of the Metallurgical Department, was appropriately named chairman of this committee.

The recommendations of the committee in 1961 led to the establishment of a Materials Research Center and to setting up of research programs in materials science in which several departments would cooperate. A portion of the space in Coxe Laboratory vacated by the Department of Mining Engineering was given over to facilities for materials science research and additional equipment was installed in the laboratories of the departments of metallurgy, physics, chemistry, electrical engineering, and mechanical engineering. Dr. Libsch was appointed Director of the Materials Research Center.

No changes in undergraduate curricula have been made, but some graduate study programs were directed to materials science. The establishment of the Materials Research Center will further increase research and graduate study in the Department of Metallurgy. Moreover, research projects on materials, previously scattered through ten departments, will be brought together under a central staff which will expand and diversify materials research throughout the University. Some current projects in this area include preparation of sapphire crystals using a plasma source, photochemistry and radiation-induced luminescence, properties of resins and surface polymers, surface properties of germanium, and rheology of disperse systems. A major program of investigation of a new class of metallic alloys, to be carried out under a two-year grant of $53,400 from the National Science Foundation, has recently been announced. This is entitled "Structure and Properties of Unidirectionally Solidified Eutectic Alloys", to be directed by R. W. Kraft, associate professor of Metallurgical Engineering.

About 125 persons, including faculty and graduate students, are now engaged in research relating to materials science, and financial support exceeding $500,000 annually has been received from foundations, industry, government, and technical societies. The Materials Research Center will work in close cooperation with the Institute of Research, of which Professor G. R. Jenkins is Director.

Curricula, Old and New

The schedule of courses and credits, which we here call the curriculum, undergoes alterations every few years. Usually the changes are minor, but sometimes major changes are made. In the course of time the curriculum becomes much altered, though perhaps the change is not so rapid as one might expect. There is a certain stability due to the fact that the basic elements of a sound program endure.

To trace all the changes in the curriculum would take much space and would make dull reading. Yet some of the highlights should be of interest. We may begin by setting down the very first curriculum, which appeared in the Register for 1873-74 and was headed the "Programme of Studies" for the "Course in Metallurgy," and then for comparison the latest curriculum as given in the Register for 1962-63.

The First Published Metallurgy Curriculum, 1873-74

First Term		Second Term	
		First Class	
Geometry and Mensuration	5	Algebra and Trigonometry	5
History	3	Rhetoric and Logic	2
Essays	1	Essays	1
German	4	German	2
Chemical Physics	2	French	2
Elementary Drawing	3	Chemistry	3
		Drawing	2

The First Published Metallurgy Curriculum, 1873-74 (Cont.)

First Term		Second Term	
		Second Class	
Descriptive Geometry	4	Analytical Geometry	4
English Literature	2	Physics	3
Farm Surveying	2	German	2
German	2	French	3
French	2	Blow-pipe	1
Chemistry	4	Laboratory Work	2
Chemical Laboratory	2	Drawing	1
		Junior Class	
Differential and Integral Calculus	4	Mechanics	4
Physics	5	Physics	1
French and German	2	German	1
Crystallography	2	Mineralogy	3
Laboratory Work	3	Blow-pipe	1
Machine Drawing	1	Metallurgy	3
		Laboratory Work	3
		Senior Class	
Applied Mechanics	5	Geology	2
Geology	3	Economic Geology	1
Moral Philosophy	1	Steam Engine	2
Metallurgy	4	Machines	2
Laboratory Work	3	Laboratory Work	3
Theory of Machines	1	Drawing	2
Drawing	1	Thesis	

Note the large amount of foreign language and drawing and the small amount of metallurgy in the above curriculum. No description of courses is given in the Register, and one wonders of what the large amount of "laboratory work" consisted.

The terms "freshman" and "sophomore" first superseded "first class" and "second class" in 1875.

The Latest Curriculum, 1962-63

First Semester		Second Semester	
		Uniform Freshman Year	
General Chemistry	4	General Chemistry	4
English Composition and Literature	3	English Composition and Literature	3
Development of Western Civilization	3	Development of Western Civilization	3
Analytical Geometry and Calculus I	4	Analytical Geometry and Calculus II	4
Mechanics of Mass Points	3	Economics	3
or		or	
Economics	3	Mechanics of Mass Points	3
Physical Education	-	Physical Education	-

The Latest Curriculum, 1962-63 (Cont.)

First Semester		Second Semester	
Sophomore Year			
Analytical Chemistry	3	Economics	3
Engineering Graphics	2	Unit Operations	3
Analytical Geometry and Calculus III	4	Mechanics of Materials	3
Statics	3	Introduction to Metallurgy	3
Heat and Electricity	4	Electricity, Light, and Atomic Physics	4
Junior Year			
Physical Metallurgy I	4	Physical Metallurgy II	4
Nonferrous Metallurgy	4	Ferrous Metallurgy I	3
Physical Chemistry	3	Physical Chemistry	3
Procedures of Mechanical Design	2	Dynamics	3
Probability and Numerical Analysis	3	Elective	3
General Study	3	General Study	3
Senior Year			
Metallurgical Thermodynamics	3	Metallurgical Reports	3
Mechanical Metallurgy	3	Industrial Metallurgy	3
Ferrous Metallurgy II	3	Electrical Circuits and Apparatus	3
Technical Elective	3	Electrical Problems	1
General Study	3	Dynamo Laboratory	1
Professional Development	1	Technical Elective	3
		General Study	3
Senior Year Research Option			
Metallurgical Thermodynamics	3	Metallurgical Colloquium	2
Mechanical Metallurgy	3	Industrial Metallurgy	3
Ferrous Metallurgy II	3	Experimental Metallurgy	3
Theoretical Physical Metallurgy	3	Electrical Circuits and Apparatus	3
Research Techniques	2	Electrical Problems	1
General Study	3	Dynamo Laboratory	1
Professional Development	1	General Study	3
Senior Year Industrial Metallurgy Option			
Metallurgical Thermodynamics	3	Metallurgical Colloquium	2
Mechanical Metallurgy	3	Industrial Metallurgy	3
Ferrous Metallurgy II	3	General Study	3
Electrical Circuits and Apparatus	3	Metallurgical Practice (cooperative with Bethlehem Steel Co.)	8
Electrical Problems	1		
Dynamo Laboratory	1		
Professional Development	1		
General Study	3		

The curriculum must provide for instruction in all of the various divisions of study - all that are deemed necessary as a foundation for development of a metallurgical engineer, or for ensuing graduate work. The following table shows the percentage division of the curriculum among the different fields for the two curricula detailed above, and for some other years when important revisions were made. This table partially traces evolution of the curriculum from 1873 to 1962. The fields of study listed in the first column are essentially those delimited by the Engineers' Council for Professional Development in examination of engineering curricula for accreditation. The Council's program of accreditation was begun in 1936; the Lehigh Metallurgical Department was inspected in 1938 and again in 1950, 1955, and 1960, receiving full accreditation each time. These elaborate and thorough inspections include not only curricula, but also faculty, buildings and equipment, and all other pertinent factors.

	1873	1906	1919	1926	1930	1940	1955	1962
Basic Science	37	30	30	30	29	28	33	36
Metallurgy	11	13	18	17	22	20	23	24
Allied Engineering, Applied Science	30	44	42	32	29	24	11	12
Humanities, Non-technical	22	13	10	16	14	16	21	22
Free electives	0	0	0	0	6	6	6	6
Military Science	0	0	5	6	6	6	6	0
Total Credit Hours Required for Graduation	138	148	164	152	152	148	143	137

Required summer courses are included in the above tabulation. The first of these were introduced in 1899. They consisted of a four weeks' course in Constructive Elements of Machinery and Electrical Apparatus at the end of freshman year and four weeks in Mechanical Technology at the end of sophomore year. In 1918 the latter course was changed to Assaying, and in 1926 the course in the summer following freshman year was changed to Surveying. At the end of junior year eight weeks of industrial employment became a requirement, which has remained ever since; Reserve Officers' Training Camp might be substituted by those taking Advanced R.O.T.C. The summer course in Surveying was dropped in 1938 and Assaying in 1942.

The gradual increase in Metallurgy is noteworthy. This would be expected as the field of metallurgy expanded, and particularly after physical metallurgy began to be an important subject. Metallography first appeared in the curriculum in 1908. Physical metallurgy listed as such did not appear until 1927; it was then introduced as a 2-hour junior course optional with Sanitary Bacteriology! It was followed by 2 hours of Metallography. This option lasted until 1930; then Physical Metallurgy became a 3-hour requirement followed by 3 hours of Metallography. In 1955 the course in metallography was re-named Physical Metallurgy II, both I and II becoming 4-hour courses, and a third course in physical metallurgy was offered as an elective.

Along with the increase in metallurgy has gone a progressive decline in the content of other engineering and applied science courses. This has dropped from 44 per cent in 1906 to only 12 per cent at present. Only by a very liberal interpretation of some metallurgy courses as "engineering" or "design" can the "metallurgical engineering" curriculum meet the recommendations of E.C.P.D. for accreditation as an engineering curriculum. This is true at many other colleges as well.

French and German were required in the curriculum until 1926. Of 30 credit hours of Humanities and Non-technical studies in 1873, no less than 20 were French and German.

A choice or option between one course and another (often among several courses) first appeared in the curriculum in 1926; no free electives were permitted, however, until 1930. In 1938 the trend toward elective courses was advanced by the introduction of 6 hours of General Study electives in junior year, followed by 9 hours of Professional Subjects (essentially technical or business electives) and 5 hours of free electives in senior year.

By 1945 the General Studies had been adopted by all the Engineering College curricula, the number of credit hours ranging from 6 to 12. The metallurgical curriculum now had 9. In this year the Uniform Freshman Year was altered by initiation of the two-semester course in Development of Western Civilization (6 credit hours).

A thesis was required for graduation in all the engineering departments through the class of 1917. It then became optional with the department and was dropped by most of them. The Metallurgy Department continued to require it through 1926, when it became elective for a few of the better students. In 1956 "Thesis" became "Experimental Metallurgy," a required course in the Research Option. Theses were, of course, always required for graduate degrees.

One feature of the comprehensive 1926-27 revision of engineering curricula was a large reduction in the number of credit hours required for graduation. In metallurgy the reduction was from the peak of 164 down to 152. By 1955 this had reached 143, or 137 without Military Science. This is where it stands in 1963, back where it started in 1873.

In 1951 several changes were made in the metallurgical curriculum, including the introduction of a one-credit-hour course in Professional Development in each semester of senior year. A course in Industrial Metallurgy was also begun. A course in Mechanical Metallurgy was included in the revision of 1955.

The trend away from extractive metallurgy was followed further in the changes made in 1957, which included dropping the course in Electrochemistry and Electrometallurgy and dropping the Metallurgical Problem courses as such. This entailed relinquishment of leadership in two fields of metallurgy in which Lehigh was pre-eminent, having established a reputation therein dating back to the time of J. W. Richards. Some of the problems work remains, being incorporated in other courses, such as Metallurgical Thermodynamics. There appears in the curriculum also a trend away from operation and toward preparation for research, even apart from the Research Option.*

In addition to certain courses mentioned above as having been dropped from the curriculum, many others have succumbed to changing times, or to the necessity of making room for newly important areas of study. Some which were taken for a period of years but have since disappeared include the following: metallurgical construction and design, certain drawing courses, mineralogy, crystallography, ore dressing, geology, economic geology, hydraulics, corporation finance, types of world literature, heat engines, engineering laboratory. Small portions of some of these subjects are now included in

* To this writer it would appear that dropping of the course in Electrochemistry and Electrometallurgy leaves a gap in the basic science of metallurgy. There is little study ofelectrochemical principles, so important in production, refining, and treatment of metals, as well as to an understanding of corrosion and surface properties. At other colleges this is provided either by a course in electrochemistry or by an adequate content of electrochemistry in the courses in physical chemistry.

other courses.

Ferrous and nonferrous metallurgy are no longer separated at a number of colleges, since the distinction is a somewhat artificial one from the standpoint of theory. The common principles underlying both ferrous and nonferrous metallurgy may be given in a single course in theoretical extractive metallurgy. The Lehigh curriculum will follow this system beginning in 1964-65.

The curricular changes delineated in the foregoing paragraphs do not begin to tell the whole story of progress in instruction. Change in the division of the curriculum between the different fields has been far surpassed by change within the courses. Especially in a rapidly developing field such as metallurgy, both the identity of the courses grouped under Metallurgy and the content of the courses themselves undergo continual change. It is not possible to show this here.

Options

It has been noted earlier in this history that during the period 1906 to 1921 a student in the Department could pursue either a curriculum leading to the degree of Met. E. or one leading to the degree of El. Met. This is an instance of two separate curricula and degrees offered in the same department. By "option", on the other hand, is meant an established variation from the regular curriculum but leading to the same degree. Options are very common in engineering education.

As pointed out previously, the study of metallurgy at Lehigh was at first an option in the curriculum in mining engineering, as indeed it was at many other engineering institutions. The first option offered here after the establishment of the separate curriculum in metallurgy (in 1890-91) was the Electrometallurgy Option instituted in 1933-34, twelve years after the cessation of the award of the degree of El. Met. In the main it differed from the regular curriculum in senior year, where courses in electronics, electrical engineering, and electrometallurgy were substituted for certain other courses. The Electrometallurgy Option was discontinued in 1941.

In 1950 there was established a new graduate option called the School of Metallurgical Engineering Practice, leading to the degree of M. S. Carried out cooperatively with the Bethlehem Steel Company, it was at first offered only to graduate students, but in 1953-54 it was made available as an undergraduate option under the head Metallurgical Practice Option, now called the Industrial Metallurgy Option. It is now taken mainly by selected seniors who apply for it. It requires spending three days per week in the second semester carrying out plant investigations in the Steel Company plant at Bethlehem. The work is laid out jointly by a representative of the company and of the Department and is supervised by two of the Department staff members.

The curriculum revision made in 1955 included establishment of a Research Option. This option requires taking senior courses in Theoretical Physical Metallurgy, Research Techniques, and Experimental Metallurgy in place of certain courses in the regular curriculum.

Election of the Industrial Option or the Research Option is made toward the end of junior year, and is open only to students selected on the basis of superior academic ability.

The Arts-Engineering Curriculum

For a number of years prior to 1949 the College of Arts and Science permitted candidates for the B.A. degree to major in metallurgy. An average of one or two students a year took this program, mainly those who wished to omit some of the more advanced courses in mathematics and physics and some of the engineering courses required for the

B.S. in Met. E. degree.

This was a four-year program. In 1949-50 there was initiated a five-year program, in which the student takes the first four years in the College of Arts and Science, receiving the B.A. degree, and the fifth year in the College of Engineering meeting the remaining requirements to receive the appropriate B.S. degree in engineering. The program has become a very popular one. In the fall of 1962 the enrollment included 62 freshmen, 42 sophomores, 34 juniors, and 27 seniors. A number of these men were taking or planning to take the fifth year in metallurgical engineering.

The success of this program is a logical result of the widespread conviction that professional engineers should have a broad education. The idea is by no means new. In the 1902-03 Lehigh Register appears an announcement of a six-year "Combination of Literary and Technical Studies" leading to the B.A. and an engineering degree. This statement was continued in the Register until 1913-14, but few candidates elected the program. In 1938 Professor Butts discussed four types of five-year curricula, including the one now in operation, in a paper presented before the Faculty Educational Club. This club, incidentally, was a valuable forum for discussion of ideas in education, teaching methods, etc. It was in existence from the early twenties to 1949.

Lehigh's metallurgical department has consistently advocated more general education for engineers. Professor Doan wrote and published several articles on the subject. On Doan's initiative a course in Professional Development was introduced in the metallurgy curriculum in 1951-52.

Graduate Study

There was no program of post-graduate study in the original plan of the University, but a provision was made under the head of "Resident Graduates" that "a limited number of graduates, who desire to pursue their studies under the general direction of the Faculty, may be allowed the use of the Library, and may attend lectures in any of the departments, during a term of three years, free of expense." The Resident Graduates were to have their names placed in the Annual Register.

In the Register for 1876-77 appear the names of the first graduate students in Mining and Metallurgy. These were Henry Richards; Charles W. MacFarlane, in whose honor there is now a Professorship of Theoretical Economics; and Charles L. Taylor, whose benefactions to Lehigh are noted on another page.

The provision for Resident Graduates disappears from the Register for 1877-78, and in its place is a section headed "Post-graduate Degrees." These were M.A., for which a Bachelor of Arts might qualify in two years; D. Sc., for which a Bachelor of Science might qualify in two years; and Ph.D., for which a Civil, Mechanical, or Mining Engineer or Analytical Chemist might qualify in two years. No graduate students are listed in this Register.

In 1882-83 there was inserted in the Register the following statement: "The Faculty will recommend for the Degree of Doctor of Philosophy candidates, otherwise properly qualified, who after taking at this University either of the degrees of Civil, Mechanical, or Mining Engineer, or Analytical Chemist, shall pursue, for two years, at the University, a course of advanced Scientific study in the line of their profession, pass a thorough examination in the same, and present a satisfactory thesis." The following year this somewhat indefinite provision was made more in line with modern practice: "The Faculty will recommend for the degree of Doctor of Philosophy candidates, otherwise properly qualified, who after taking at this University the degree of Master of Arts or Master of Science shall pursue, for at least one year in this University, or two years elsewhere, a course of advanced study prescribed by the Faculty, pass a thorough examination in the presence of the Faculty in the same, and present a satisfactory thesis

giving evidence of original investigation. Candidates shall have a good knowledge of Latin and either French or German."

Offering of the Ph.D. degree was discontinued in the middle nineties. In the meantime there had been 10 registrants for the program, but only two Ph.D. degrees had been awarded. One of these was to Professor J. W. Richards, who received it in 1893, the other to H. D. Kiefer, a Chemistry graduate who received it in 1896.

Graduate work in its present form dates from 1936. After a study made at that time the Graduate School was established. The Ph.D. degree was again offered and requirements for the M.A., M.S., and Ph. D. were set up essentially as they are at present. Granting of the Ph.D. was limited to nine departments, one of which was Metallurgy. This number has since been increased to fifteen, while twenty departments offer the Master's degree.

Between 1879-80 and 1899-1900 there was a cumulative enrollment of 98 graduate students in Mining and Metallurgy. Most of these were E.M. graduates. Beginning in 1900-01 there is a separate listing of graduate students in Metallurgy. Through 1936 these totaled 84. Following are the data for the period since 1936"

	Enrollment in Fall Semester			Degrees Granted	
Year	M.S.	Ph.D.	Total	M.S.	Ph.D.
1936-37	1	0	1	1	0
1937-38	3	3	6	1	2
1938-39	9	2	11	6	0
1939-40	10	1	11	3	0
1940-41	10	2	12	4	1
1941-42	5	2	7	2	0
1942-43	2	2	4	2	0
1943-44	3	4	7	0	3
1944-45	3	2	5	0	2
1945-46	4	1	5	1	1
1946-47	4	2	6	3	0
1947-48	10	5	15	1	3
1948-49	7	3	10	0	0
1949-50	8	6	14	2	3
1950-51	7	7	14	5	1
1951-52	6	8	14	8	3
1952-53	5	8	13	3	6
1953-54	10	8	18	4	1
1954-55	15	10	25	3	7
1955-56	16	2	18	5	2
1956-57	10	6	16	3	1
1957-58			20	5	4
1958-59			24	7	0
1959-60	22	8	30	7	4
1960-61	21	6	27	4	3
1961-62	22	10	32	6	3
1962-63	37*	16	53*	11	2

*Not including the 15 graduate students engaged in off-campus study in the Lehigh-Western Electric Program; see page 24.

As in other universities, graduate students in science and engineering are now financed largely by contract research, scholarships, fellowships, or grants. Those engaged in contract research, and some others, do not carry a full fifteen-credit-hour roster of graduate work, and consequently take correspondingly extended time to complete the requirements for the degree.

Beginning in 1953 arrangements were made whereby qualified industrial employees in Bethlehem and vicinity might take three to six credit hours per semester of graduate work in metallurgy at Lehigh. These are included in the figures for enrollment.

In 1961, in line with the great increase in graduate study throughout the country, it was decided approximately to double the output of Lehigh's graduate school over a period of the next few years, metallurgy, of course, to share in the increase. Graduate work in metallurgy will receive impetus both from the building of the new Homer Research Laboratories of the Bethlehem Steel Company at the top of South Mountain and from the establishment of the Materials Research Center at Lehigh.

Dr. R. D. Stout, formerly Head of the Metallurgy Department, is now Dean of the Graduate School.

Special Programs of Instruction

The special wartime instruction programs given at Lehigh are noted in the section on the Department in Two World Wars.

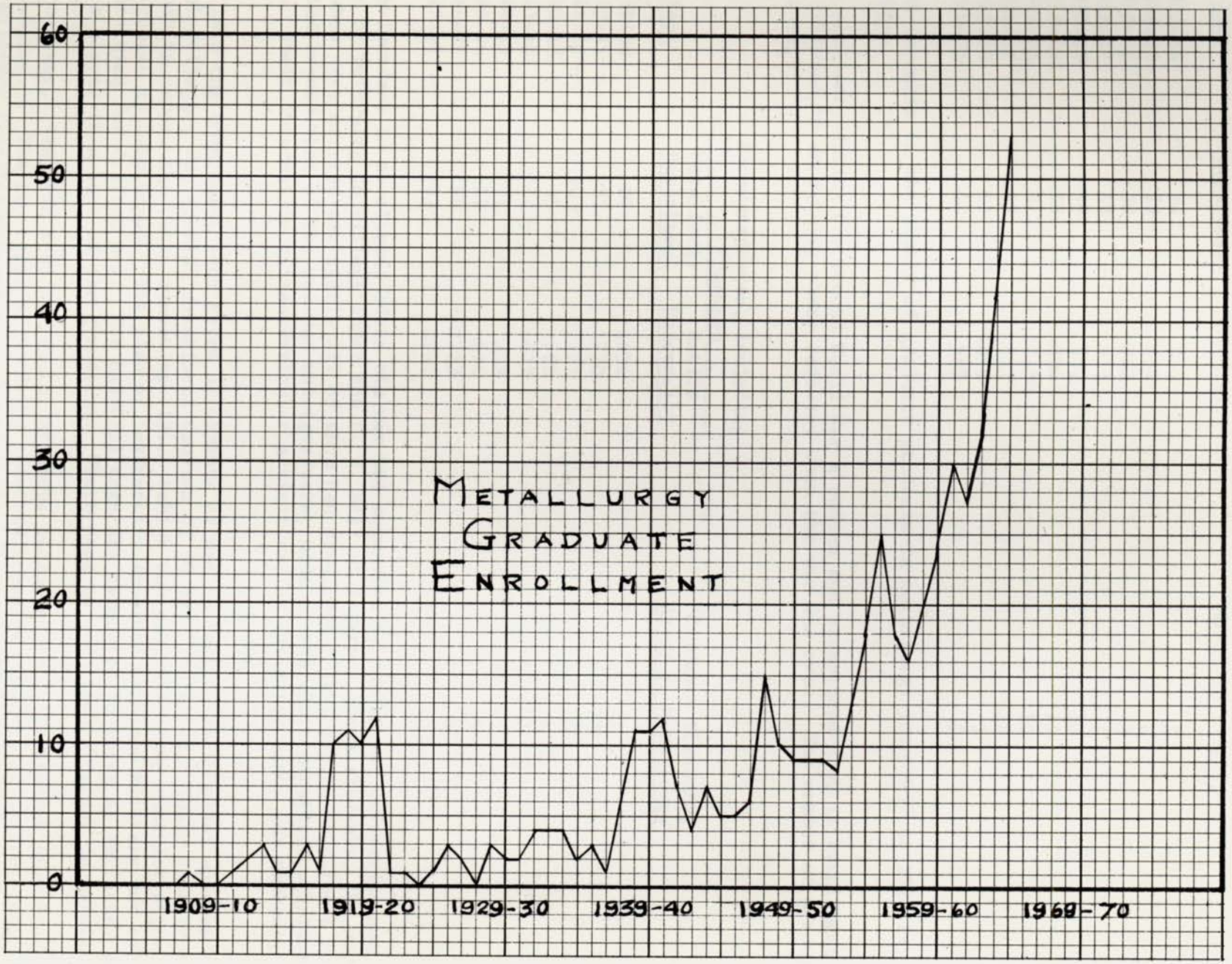
In 1957-58 Lehigh was chosen as one of five engineering schools by arrangement with the Government of India to give instruction to a group of 40 Indian students to prepare them for work in the Indian iron and steel industry. The program, sponsored by the Ford Foundation under the auspices of the State Department, was a cooperative program with certain steel plants, the students at Lehigh being instructed simultaneously at the Bethlehem Steel plant. In addition to metallurgy (both process and physical metallurgy), courses were taken in economics, sociology, and history. The program, entitled the Indian Steel Training and Education Program (INSTEP), was repeated in 1958-59, 1959-60, and 1960-61. About 100 men attended the classes at Lehigh in the four years.

In 1962-63 the Western Electric Company began an advanced study program in cooperation with Lehigh's Graduate School. Two curricula are provided, one in the areas of solid-state physics, chemistry, and engineering materials, the other in the field of operations research. Each is of two years' duration and leads to the degree of Master of Science. The program is administered by Lehigh under the direction of Dr. Stout, with Dr. Conard as program coordinator, but the work is carried out at Western Electric's Engineering Research Center near Princeton, N. J. Thirty Western Electric engineers constitute the first class, with thirty more to enter next year. Half are assigned to the Department of Metallurgy and half to the Department of Industrial Engineering. The program is divided between classroom work and research. Each student carries out a specific research project as the basis for his Master's thesis. The instructional staff is selected from Lehigh's departments of Metallurgy, Mathematics, Physics, and Industrial Engineering.

The Department in Two World Wars

From April 6, 1917, to Nov. 11, 1918, and again from Dec. 7, 1941, to Aug. 15, 1945, the United States was engaged in a World War. Both wars had a profound effect on the operations of the University and of the Department.

Enrollment in metallurgy was affected oppositely by the two wars. In the first war, and especially immediately after the war, enrollment was stimulated, as shown by the following data:


60
50
40
30
20
10
0
METALLURGY
GRADUATE
ENROLLMENT
1909-10
1919-20
1929-30
1939-40
1949-50
1959-60
1969-70

Year	Undergraduates, Including Freshmen: Metallurgy Department	Undergraduates, Including Freshmen: Entire University	Graduate Students, Major in Metallurgy
1913-14	24	652	1
1914-15	28	684	1
1915-16	36	712	3
1916-17	53	813	1
1917-18	59	654	10
1918-19	53	834	11
1919-20	81	1019	10
1920-21	63	1012	12
1921-22	57	1056	1
1922-23	40	999	1

The increase in the number of graduate students in metallurgy from 1917 to 1921 is noteworthy.

In contrast, during the second World War a sudden and pronounced drop in enrollment took place, followed by an equally sharp recovery when the war was over. The number of graduate students fell:

Year	Undergraduates, Including Freshmen: Metallurgy Department	Undergraduates, Including Freshmen: Entire University	Graduate Students, Major in Metallurgy
1939-40	87	1834	11
1940-41	92	1770	12
1941-42	103	1781	7
1942-43	93	1780	4
1943-44	14	472	7
1944-45	11	339	5
1945-46	17	674	5
1946-47	87	2723	6
1947-48	82	2961	15

The increase in enrollment after the war was augmented by numbers of ex-service men entering or returning to college under the G. I. Bill of Rights. These students, the majority of whom were married and nearly all of whom had developed a seriousness of purpose and motivation beyond that of the pre-war undergraduate, made on the whole excellent scholastic records. Their interest in extra-curricular activities, on the other hand, was markedly lower.

In 1918 the Government sent three allotments of men to Lehigh, as to other approved technical colleges, for special vocational courses of 60 days' duration. These came from Army training camps, the total numbering 1151. Lehigh was put under Army administration and was designated as Camp Coppée. The plan of instruction involved combined military and scholastic training for drafted men. The baseball cage was remodeled to serve as barracks, and beds were placed in a part of the gymnasium. There were no vocational courses in metallurgy.

In October, 1918, the body of regular students became part of the Student Army Training Corps (S.A.T.C.). The two types of students received separate programs of instruction. Compulsory military training was begun, destined to last in some form until 1961, when it became elective. Faculty members in 1917 met in the gymnasium to learn the rudiments of military drill, and several joined Bethlehem's Home Guard.

Commencement in 1918 was advanced two months, to April 13, so as to permit seniors to graduate before entering the armed forces. Classes were then continued through the summer and the Faculty made plans for an accelerated three-semester year. Regular four-year programs were resumed in January, 1919.

In October, 1918, the nationwide epidemic of Spanish influenza struck the campus. All students, even those whose homes were in Bethlehem, were ordered not to leave the grounds. All were fed in the Commons (now Lamberton Hall). Faculty members could go home but could re-enter the campus only with a pass. Drown Hall was taken over as a hospital; here 150 sick were cared for and seven deaths occurred. Classes continued as usual, and there was little excitement or disturbance of routine.

In the spring of 1917 the Metallurgy Department staff consisted of Richards, Roush, and Butts. From 1915 until after the close of the war Richards was a member of the U. S. Naval Consulting Board. Through 1917 and 1918 he spent three days of each week in Washington on this work. Roush was appointed Supervisor of Training in the Inspection Division, U. S. Army Ordnance Department, receiving a Captain's commission, later becoming Major. He was away from Lehigh for a year. In view of the high enrollment these engagements created severe instruction problems, but no classes were abandoned or curtailed.

Having had the experience of World War I, the colleges made a somewhat more deliberate and orderly transition to wartime operation in World War II, but inevitable complications arose later. Under the Selective Service and Training Act of 1940, students who were reservists in any of the branches of the armed forces (which included R.O.T.C. men) were exempt from draft. In the early part of the war, Lehigh participated in the Engineering Defense Training program set up by the U. S. Office of Education. Selected groups of students were assigned to Lehigh for courses in the chemistry of explosives, Diesel engines (for U. S. Navy officers), ultra-high-frequency currents, air-raid protection, and others. The greater part of the regular student body again went on a three-semester accelerated program, with instruction continued through the summer, making it possible to graduate in two and two-thirds years. However, the four-year curriculum remained as an option, and instruction was provided for the two programs side by side, in addition to the special courses. The University was not put under military command as it had been in the first World War. Under the accelerated program there was no abbreviation of requirements for graduation, no reduction in hours, and no courses were omitted.

During 1942 a course in metallurgy, one of eleven special courses in the University, was given under the auspices of the U. S. Office of Education. The Civil Aeronautics Authority sponsored a course in flight training, which was taken by 262 aviation trainees. Basic ground work was taught on the campus and pilot training at the Airport.

After the military reverses of 1942 and with the need for more and more men in the armed forces, all this was changed. In February, 1943, the War Manpower Commission announced that Lehigh had been selected by the Army as one of the colleges to be used as a training base for engineers. The Army Specialist Training Program (ASTP) was accordingly set up, and a contract was made between the Army and the University for instruction, housing, and subsistence.

The first contingents of an ultimate 1400 army trainees to come to Lehigh arrived in July, 1943. Soon all the campus dormitories and fraternity houses were being used as barracks. All civilian students - about 450 - lived in town. Drown Hall was used as an auxiliary cafeteria for soldiers for whom there was no space in Lamberton.

Late in 1943 the draft age was reduced from 21 to 18, and enlisted reserves of both Army and Navy and students in the R.O.T.C. were called to the colors. The University enrollment, which in the summer of 1943 had been nearly 2000, the largest in history up to that time, fell suddenly below 500. In February, 1944, the ASTP at Lehigh was reduced by several hundred, and by April all had been withdrawn. The Army contract expired June 30, 1944, and that fall the University enrollment fell to its low point of 291.

As enrollment went down, financial concern of the Administration and Trustees went up. Although 69 per cent of the faculty had gone, the University continued to offer all but two minor courses in its regular program. Many faculty members went into military service, many were engaged for research in other universities, and many of those remaining at Lehigh were employed full time or part time on classified research.

In the spring of 1945 veterans began to return to college, and the financial difficulties began to subside. By July 1 the normal system of faculty schedules and salaries was restored, and faculty members, most of whom had been teaching continuously since August 1942, were required to take at least two months' vacation during the ensuing year. The three-semester calendar of operation lasted from May, 1942, to June, 1947. "Mid-year commencements" were held from 1943 to 1947. To provide for vacations during 1947 to 1949, "double half-semesters" were scheduled during those three summers.

The Metallurgy Department was able to take up the slack due to reduced instructional requirements through additional research. The metallurgy staff in 1941-42 consisted of Stoughton, Doan, Butts, Frye, and Stout. All except Frye, who went to the Bethlehem Steel Company and later became Director of Metallurgy at the Government's Atomic Energy Research Laboratory at Oak Ridge, remained through the war. The Department carried on research contracts with the U. S. Navy Department, Army Ordnance, and Signal Corps, most of the work being done on the campus and some at other places.

Professor Stoughton was chief of the heat-treating unit, Tools Section, War Production Board, from 1941 to 1945, and acting head of the Foundry Equipment Section in 1944-45. At the close of the war he became a member of the U. S. Technical Industrial Intelligence Commission, Foreign Economic Association, and was stationed in London throughout the summer of 1945. Doan and Butts were Investigators, Office of Scientific Research and Development, and Butts was a Technical Representative, National Defense Research Committee, 1944-46.

The first Lehigh man to die in the war with Japan was metallurgical graduate G. O. Ellstrom, '38. An Air Force pilot in the Philippines, he was killed in action in the Japanese attack the day following Pearl Harbor. In 1944 Lehigh students formed the George Oliver Ellstrom Veterans Society, a main purpose of which was to help orient veterans entering or reentering college and in readjusting to civilian life.

Participation in the Work of Engineering Societies

Following the lead of Dr. J. W. Richards, the Department has always been active in the work of engineering societies. Important lectures given by staff members and awards made to staff members are noted on other pages.

Richards was one of a group of six men who first issued a call for a meeting in Philadelphia which resulted in the founding of The Electrochemical Society in 1902. This society, now grown to a membership of 3550 (in 1962), has contributed greatly to progress in electrochemistry and metallurgy. Richards was chosen its first president, and on expiration of his term became secretary, an office which he held until his death in 1921. He was also editor of the Transactions, and the national offices of the society were in the basement of Christmas Hall throughout this period.

W. S. Landis was elected president of The Electrochemical Society in 1920. Bradley Stoughton was president of this society in 1931, chairman of its Electrothermic Division in 1922.

Richards was also one of the founders of the Engineers' Club of the Lehigh Valley. He was chairman of the temporary officers at the organization meeting in 1921 and was chairman of the committee which drafted its constitution. Stoughton was president of this organization in 1928-29.

Richards was also prominent in the affairs of the American Institute of Mining and Metallurgical Engineers. He was chairman of its Iron and Steel Committee in 1914-16. Bradley Stoughton was national secretary of this society from 1913 to 1921. He was chairman of its Iron and Steel Committee in 1922-23, just prior to his coming to Lehigh. Butts was chairman of its Education Division and a Director in 1950-52. He was chairman of the Lehigh Valley Section of A.I.M.E. in 1932.

The American Society for Metals elected Bradley Stoughton as its national treasurer for 1938-39. He became president of the society in 1941. Stoughton, Harvey, Stout, and Libsch served terms as chairman of the Lehigh Valley Chapter of A.S.M., and Conard has been chosen for this position for 1962-63. In 1951 Doan was chairman of the education group of conferees at the World Metallurgical Congress sponsored by A.S.M. in Detroit.

Stoughton was chairman of the Mineral Technology Division of the American Society for Engineering Education in 1939. Butts served terms as vice chairman and secretary of this division. Conard will be chairman of the Middle Atlantic Section of A.S.E.E. in 1962-63.

Stout is a Director of the American Welding Society and was chairman of the Lehigh Valley Chapter of A.W.S. in 1952-53. Doan was chairman of this Chapter in 1946-48.

Space does not permit mention of the many committee chairmanships and memberships which staff members have held in various technical and engineering societies.

Books

Certainly one of the most useful contributions by Lehigh's Department of Metallurgy, both to the teaching of metallurgy and to the development of the industry, has been authorship of books by members of its staff.

For many years instruction in metallurgy was greatly handicapped by complete absence of textbooks in the field. As late as 1920 only two or three metallurgical books adaptable as college texts had been published in English. It should be noted that an excellent book written for the industry may be wholly unsuitable for college use except for reference. On the other hand, a good textbook will do much for industry and the whole metallurgical profession as well as for the college student.

The relatively small size of the field of metallurgical education acts as a deterrent both to authors and publishers. Prospective sales of a few thousand copies are not a source of encouragement. Yet it must not be thought that there has been anything altruistic about writing books such as has been done at Lehigh, or is now being done at M.I.T. A successful book does bring at least some financial remuneration as well as enhancement of the reputation of the author and of the University.

A large number of metallurgical books have been published in the last thirty years, but other than those from Lehigh and more recently M.I.T. they have not been written in numbers at any one school.

Few works have had so great an impact on the metallurgical industry as Richards' two books, "Aluminium" and "Metallurgical Calculations." The first was published in 1887, only a year after Richards received his first degree at Lehigh. Its preface contains an acknowledgment of "permission to use the author's thesis as the basis for this book." The third and last edition of this work, which appeared in 1896, was more than twice as large as the first. It is a tribute to its excellence that this remained the only comprehensive book on aluminum for 29 years. One may contrast this with the numbers of books on metals written now, an indication of the growth in stature of the field of metallurgy since that time.

"Metallurgical Calculations" appeared first in serial form in the magazine Electrochemical and Metallurgical Industry (now Chemical Engineering). Part I was published in book form

first in 1906, Part II in 1907, and Part III in 1908. These were combined in the one-volume edition in 1918. Like "Aluminium" a pioneer work in its field, this book also had a long life, and being of broader application than "Aluminium" it did much more for the advancement of metallurgy.

Richards also translated five metallurgical books from German and Italian into English, and his "Metallurgical Calculations" was translated into German, Italian, and Russian.

One of the first books admirably adapted to teaching in metallurgy was Stoughton's "Metallurgy of Iron and Steel." Written while the author was teaching at Columbia, the first edition was published in 1908. The fourth and last edition was prepared while Stoughton was at Lehigh and was published in 1934. For forty years this book dominated its field for both college and industrial use.

Both Richards and Stoughton were leaders in extending the teaching of metallurgy to other branches of engineering. Away back in 1908 Lehigh introduced a "short course" in metallurgy for civil and mechanical engineering students, and when Stoughton came to Lehigh in 1923 this course was required of chemical, civil, electrical, industrial, and mining engineers. Stoughton was impressed with the need for a textbook in these classes. To meet the need Stoughton and Butts' "Engineering Metallurgy" was published in 1926. This, too, was a pioneer book in its class, a class which has since become the largest for metallurgical textbook publication, about twenty-five books in this category having appeared in English to date. The fourth edition of "Engineering Metallurgy" was published in 1953, with A. M. Bounds, Chief Metallurgist of the Superior Tube Company, a bachelor's and master's graduate of Lehigh, added as a co-author.

In 1932 there was published the first edition of Butts' "Textbook of Metallurgical Problems." As Richards' book was written primarily for the industry, this later book was written with the needs of students in mind. It has had worldwide acceptance and remains the only book of its kind down to the present. A second edition came out in 1943.

The largest area of publication in metallurgy is now physical metallurgy. One of the earliest books in this field was Doan's "Principles of Physical Metallurgy," published in 1935. The second edition had E. M. Mahla, a du Pont metallurgist, a bachelor's and doctoral graduate of Lehigh, as co-author. The third edition of Doan's work was published in 1953.

Another outstanding book to be credited to Lehigh is "Principles of Metallographic Laboratory Practice," by G. L. Kehl. One of the most successful metallurgical textbooks, the first edition was written in 1939 while Kehl was an instructor at Lehigh.

Pulsifer wrote his "Structural Metallography" while at Lehigh, and after leaving here published his well-known "Inspection of Metals" (1941).

Roush was Editor of McGraw-Hill's annual book "The Mineral Industry" all during his stay at Lehigh and thereafter until its final issue in 1941, when this authoritative series, dating from 1892, became a casualty of the second World War. Butts was Assistant Editor and then Associate Editor of this volume from 1916 to 1927. Roush published a book on "Strategic Mineral Supplies" after leaving Lehigh.

"Principles of Metallurgy," by Liddell and Doan, was published in 1933. Doan's textbook on physical metallurgy, mentioned above, grew out of his portion of this earlier book.

Stoughton was co-author with E. S. Greiner and J. S. Marsh of "The Alloys of Iron and Silicon," one of the Alloys of Iron Research Monographs, published in 1933.

Butts wrote or was responsible for all of the metallurgical definitions in the Second Edition of the Merriam-Webster Dictionary, published in 1934.

In 1954, published as one of the American Chemical Society's Chemical Monograph Series, the treatise on copper entitled "Copper: the Science and Technology of the Metal, Its Alloys and Compounds" had Butts as its Editor.

Stout was co-author with W. D. Doty of the book "Weldability of Steels," published in 1953.

Stoughton, Roush, Butts, Libsch, and Conard wrote sections of other well-known books, handbooks, and encyclopedias, including among others Kent's "Mechanical Engineers' Handbook" (Stoughton), "Standard Handbook for Electrical Engineers" (Roush), Eshbach's "Handbook of Engineering Fundamentals" (Stoughton), Mantell's "Handbook of Materials of Engineering" (Conard), "Metals Handbook, 1955 Supplement" (Libsch), "Encyclopedia Britannica" (Butts), "Encyclopedia Americana" (Roush), "World Book Encyclopedia"(Butts), "Americana Annual" (Roush and Butts), "American Year Book" (Roush and Butts), Clark's "Encyclopedia of Chemistry" (Butts), the McGraw-Hill "Encyclopedia of Science and Engineering" (Butts), and Hampel's "Encyclopedia of Electrochemistry" (Butts) (in preparation).

Stoughton was for many years Chairman of the Metallurgical Texts Committee for the McGraw-Hill Book Company.

Lectures

Lectureships have been established by numerous scientific and engineering societies in honor of noted men in their fields. One of these is the Joseph W. Richards Memorial Lecture of The Electrochemical Society, established in 1930. The third lecture in this series was given by W. S. Landis. His lecture, delivered at Philadelphia in 1934, was entitled "Joseph W. Richards, the Teacher - the Industry." The sixth of these lectures was by Bradley Stoughton, delivered at the New York World's Fair in 1939. His subject was "Modern Marvels of Electrometallurgy."

One of the most famous lectureships is the Henry M. Howe Memorial Lecture of the A.I.M.E. The fourth of these annual lectures was given by Professor Stoughton in New York in 1927. His topic was "Alloy Steels."

Another notable lecture was given by Professor Doan in the Franklin Institute guest lecture series in Philadelphia in 1932. This was entitled "Gamma Ray Radiographic Testing."

Almost every year members of the Department staff, and often graduate students, have presented papers at meetings and conventions, later to be published in the Transactions of the societies. In addition, staff members have been active as speakers before local sections of societies. Professors Libsch and Stout have given many of these talks in localities from coast to coast in the United States and in Canada. Professors Stoughton, Butts, and Frye each gave several invitational lectures at various times and places.

Awards

In 1944 the Lehigh Valley Chapter of the American Society for Metals established the annual Bradley Stoughton Award for Outstanding Contributions to Metallurgy. Professor Stoughton was the first recipient of this award, which was later received by Professors Doan (1949), Butts (1955), Stout (1957), and Libsch (1959).

A.S.M. also made annually an award of $2000 to one or more teachers of metallurgy under 40 years of age. Stout was chosen as one of the first three recipients of this award in 1952, and Libsch was one of three to receive it in 1954. In 1960 this became "The Bradley Stoughton Award for Young Teachers of Metallurgy."

In 1959 the American Institute of Mining, Metallurgical, and Petroleum Engineers gave its Mineral Industry Education Award to Professor Butts. In 1961 Professor Butts was selected as the second recipient of the Albert Easton White Distinguished Teacher Award of the American Society for Metals.

Professor Stoughton in 1929 was awarded the Grasselli Medal of the Society of Chemical Industry (London).

Professors Doan, Frye, and Stout received jointly the Lincoln Gold Medal of the American Welding Society in 1943. This award was made for their research and subsequent paper on "Preserving Ductility in Weldments." Stout in 1956 received the newly established Meritorius Service Award of the American Welding Society.

Doan received the U. S. Navy Certificate of Appreciation in 1947.

The eighth recipient of The Electrochemical Society's annual prize to young authors (under 27) was William A. Johnson, senior in metallurgy at Lehigh, for the paper "Studies of Overvoltage: The Effect of Fusion of the Cathode and the Effect of Temperature on Gas Polarization," of which Professor Butts was co-author. This award was in 1936. M. A. Streicher, graduate student in metallurgy, won this prize in 1948 for his paper "The Dissolution of Aluminum in Sodium Hydroxide Solutions." In 1939 the Weston Scholarship of The Electrochemical Society was awarded to Vittorio de Nora, graduate student in metallurgy at Lehigh, as a result of his paper "Structure and Grain Size of Electrodeposited Copper," of which Professor Butts was co-author.

Dr. Stout received Lehigh's Hillman Award in 1962.

After leaving the Lehigh metallurgical staff to become Chief Technologist and later Vice President of the American Cyanamid Company, W. S. Landis was recipient of three awards: the Chemical Industry Medal (1936), the Perkin Gold Medal of the Society of Chemical Industry (1939), and the Medal of the American Institute of Chemists (1943). These awards resulted from the many important research discoveries and developments which he made for his company, and which caused him to be described as "a man of extraordinary achievements." These included design and building of the first American plant for production of ammonia from cyanamid and its oxidation to nitric acid, first commerical production of argon, and processes for manufacture of cyanamid, of cyanide from cyanamid, and of urea. Landis received more than fifty patents. A graduate of Lehigh (Met. E. 1902), he became a Trustee and was awarded the honorary degree of Doctor of Science.

Professor Stoughton received the honorary degree of Doctor of Engineering from Lehigh in 1943.

Welding Symposia

The Department of Metallurgy sponsored a Welding Symposium in 1926 and annually thereafter until 1930. Other engineering departments also took part, and papers were presented by prominent metallurgists and engineers. Demonstrations were held in the Metallurgical Laboratory in Williams Hall, the Physics Department, and Packer Laboratory. Tests of welds were made in the Fritz Engineering Laboratory and a demonstration of cutting metal under water was given in the swimming pool.

"Open House"

In 1933 the undergraduate enrollment of the University had fallen from 1558 (in 1930-31) to 1337, as a result of the depression. As a means of creating desirable publicity and stimulating enrollment, the Faculty decided to institute an annual "Open House." All the buildings of the University were thrown open to visitors during a Friday afternoon and evening, and every department staged exhibits. Many lectures and special events were also held. Thousands thronged the campus; probably more than half were school children from Bethlehem and nearby cities and towns. After three years the event was discontinued.

The share of the Metallurgy Department in the undertaking is shown in the following extract from the printed program for the "Third Annual Open House." This affords an interest-

ing listing of some of the leading topics in the metallurgy of thirty years ago, particularly those adaptable to a popular demonstration.

DEPARTMENT OF METALLURGICAL ENGINEERING

Electrometallurgy

Chromium Plating. (Visitors may make souvenir platings).
An Electrolytic Snow-storm: Manufacture of White Lead by Electrolysis.
Demonstration of Ajax-Northrup High-frequency Induction Furnace.
Conductors of Metallic Sodium.

Heat Treatment

Electric Heat-treating Furnaces in Operation.
Automatic Controlling and Recording of Temperature in a Heat-treating Operation.
Hardening of Steel by Quenching.
Hardness-testing Machines.

Nonferrous Metallurgy

"Tempered" Copper: Cutting Steel with a Copper Chisel.
The Tungsten Filament: Working Demonstration of How Metallurgy Has Improved Illumination in the Home.
The Alloy Which Looks Most Like Gold. Melting and Casting Aluminum Bronze.
Melting and Casting Pure Silver.
Working Demonstration of Pyrophoric Alloys.
New Exhibit of Brasses: Illustration of Manufacture of Seamless Brass Tubes.
Strong Metals Extremely Light in Weight.
Melting an Alloy in Hot Water (Wood's Metal).

Physical Metallurgy

Demonstration of High-strength Metals: Suspension of Heavy Loads by Wires So Small as to Be Almost Invisible.
Detecting Season Cracking in Brass.
Light and Heavy Metals Compared.
The Metals Necessary for a High-speed Stream-lined Train.
Relative Magnetism of Different Metals.
An Alloy So Sensitive as to Be Magnetized by the Earth's Field.
A Metal Bar One End of Which Has Been Magnetized Whereas the Other End Cannot Be Magnetized.
Magnetic Bar Suspended in Air, Overcoming Gravity.
Looking at Alloys under the Microscope.
Gamma-ray Testing for Hidden Defects in Metals.
Spectrograms from X-ray Analyses.

Pyrometry

High-temperature Measuring Devices. (Visitors may take the temperatures of hot furnaces).
The Jumping Disc: Bi-metallic Thermostat Controller, for Flat Irons, Refrigerators, Air Conditioning, etc.

Welding and Flame-cutting
(Visitors may make welds and keep them as souvenirs)

Demonstrations of the Following: Oxy-acetylene Welding; Cutting Steel Plate with the Oxy-acetylene Flame; Electric Arc Welding; Butt Welding; Spot Welding; Thermit Welding.

Employment of Metallurgy Graduates

Obtaining a job following graduation has in the past been far from automatic, especially during times of economic recession. During the industrial boom after World War II, however, there developed a shortage of engineers which has continued in greater or lesser degree ever since. Job placement has been facilitated and well organized by Lehigh's Placement and Counselling Office, established in 1932, which has become highly efficient under Director E. A. Teal. Graduating seniors have been in large demand, most of them having several offers of employment. Initial salaries have grown steadily to what seem like fantastic levels, as shown by the following figures for the average monthly salaries obtained by graduating senior in metallurgy at Lehigh:

1954 - $362	1958 - $485	1962 - $554
1955 - 373	1959 - 490	1963 - 586
1956 - 421	1960 - 524	
1957 - 460	1961 - 548	

Some of the increase represents inflation, but most of it is due to a seller's market for the services of engineering and science personnel.

The Student Metallurgical Society

Information is lacking as to the history of this organization. However, it is known that the Metallurgical Society was first formed some time between 1902 and 1905. After a few years it went out of existence, but was reactivated in 1917.

A student Mining and Geological Society had been formed some years prior to 1917. In the early twenties a merger took place, forming the Mining and Metallurgical Society. About 1934 the Lehigh Metallurgical Society, at the instigation of Professor W. E. Harvey and with the support of the local chapter of the American Society for Metals, was established as a separate organization. This has continued down to the present without further interruption.

The activities of the Lehigh Metallurgical Society have varied, but have usually consisted of about four evening meetings a year with a guest speaker and refreshments, together with a Christmas banquet and a picnic in May featured by a softball game. The activities are carried on solely by the student members, with a minimum of assistance from the staff.

References

In addition to the author's files and recollections, and records of the Metallurgy Department, the following were sources of information:

1. Lehigh University Registers and Catalogs, 1867 to 1962.

2. Lehigh Alumni Bulletin, bound volumes.

3. Miscellaneous papers of the Lehigh collection, Lehigh University Library.

4. "Who's Who in America."

5. Bethlehem Globe-Times.

6. Transactions of the A.I.M.E.

7. Transactions of the Electrochemical Society.

8. Publications of the American Society for Metals.

9. Read, Thomas T.: "The Development of Mineral Industry Education in the United States," A.I.M.E., 1941.

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