

“A Brief History of the Department of Electrical Engineering University of Michigan” –June 1944
by Ben Bailey

Summary: A thorough firsthand account of the department from 1889-1944, with details from its establishment.

Important Details

- **1853** first Un M Engineering courses (LSA)
- **1895** CoE established, **Chas E. Greene** Dean
- **1888 Henry S. Carhart** offers dynamo electric machinery
- **1889** BS in EE offered
 - Early courses on dynamo-electric machinery, power distribution, photometry, primary/secondary batteries, mathematical electricity
- First laboratory was basement of Physics Building
- **First lab was steam powered!**
- **1898** Steam engine replaced with electric motor
- **1889 George W. Patterson** first instructor in EE (not Physics, though he was soon Assistant Professor in Physics)
- **1904** West Engineering Building begun
- **1905 George W. Patterson** first Professor of EE, Dept. Head
- **1910** West Engineering expanded
- **1915 John C. Parker** Dept. Head
- **1922 Ben Bailey** Dept. Head
- During the war, only “Navy men” remained, since Army men and civilians were overseas
- List of all early faculty, with their titles and sometimes research/accomplishments
- **Almost no electricity on campus until 1897**, **Henry Carhart** organized the first University power house at that time. Replaced in 1913
- **First curriculum (1889):**
 - Mathematics – 22 hours
 - French or German – 20 hours
 - English – 2 hours
 - Physics – 18 hours
 - Chemistry – 8 hours
 - Drawing – 11 hours
 - Mechanical Engineering – 17 hours
 - Electrical Engineering – 11 hours
 - Electives – 16 hours
 - Thesis
- Overview of changes in curriculum
- WWII research projects left the dept. understaffed

- Overview of WWII research
- **WWII coursework changes:**
 - Courses added to officers as civil administrators in occupied countries
 - Two classes of 90 naval officers about electricity on shipboard
 - Requested to teach radar classes, and so many chose them as electives they had to graduate students with missing coursework to fit it in their schedules
 - Had to facilitate 4 different curricula for civilians, Army, Navy, and Marine trainees
 - Navy and Marines ran on 3 16-week terms, Army on 4 12-week terms, which meant 7 schedule changes per year
 - 80-90% of students specialized in high frequency radio because of radar training request

Early Chairs/Heads

Henry Carhart

- Founder without proper title of chair or head, was Physics professor
- Few students even successfully started a motor in his class
- Only one course at first, in dynamo-electric machinery 1888-89

George W. Patterson

John C. Parker

- Responsible for 2-3 advanced theory courses
- Became Vice President of New York Edison Company, later President of American Institute of Electrical Engineers

Benjamin F. Bailey

- Began as instructor in Electrotherapeutics
- Worked at Detroit Edison Company, General Electric, and Fairbanks-Morse Electric Mfg. Co.

A BRIEF HISTORY OF THE
DEPARTMENT OF ELECTRICAL ENGINEERING
UNIVERSITY OF MICHIGAN

By Benj. F. Bailey

June 1944

The Department of Electrical Engineering is now 55 years old. The writer has been associated with the Department for 44 years as a teacher and four years as a student, and has served as Head and Chairman for the last 22 years. On the eve of his retirement it seems appropriate to summarize the development that has taken place.

Courses in Engineering were first offered by the University of Michigan in 1853. At first, the work was under the control of the College of Literature, Science, and the Arts and it was not until 1895 that the College of Engineering became an independent unit with Chas. E. Greene as Dean.

The first important electrical invention was the telegraph which came into use in 1844. Thirty years passed before the next great invention, the telephone, appeared. This was followed in 1880 by the development of electricity as a source of light and power, and people began to realize that a great new force was causing a revolution in the life of the world. Succeeding years have brought X-Rays, radio, television, and electronics. What will come next, no one knows, but it is very evident that the future will bring new wonders. We have come a long way from the magnetic compass and the lightning rod, but we still have a long journey ahead of us.

In the year 1888, Professor Henry S. Carhart, Head of the Department of Physics, first offered a course in dynamo-electric machinery under the title of "Physics 14". One year later, on June 25, 1889,

the Regents, on the recommendation of the faculty of the Department of Literature, Science, and the Arts, established a course in electrical engineering. The degree offered was Bachelor of Science in Electrical Engineering. The course of study included 22 hours of Mathematics, 20 hours of French or German, 2 hours of English, 13 hours of Physics, 8 hours of Chemistry, 11 hours of Drawing, 2 hours of Civil Engineering, 17 hours of Mechanical Engineering, and at least 8 hours of Electrical Engineering. In September of the same year, George W. Patterson was appointed Instructor in Electrical Engineering.

The electrical courses offered included dynamo-electric machinery, distribution and transmission of power, photometry, primary and secondary batteries and an elective course in mathematical electricity.

The laboratory was established on the basement floor at the east end of the old Physics Building. Power was supplied by a steam engine which drove a countershaft and to this could be belted various electric generators. These consisted of an Edison bi-polar dynamo of 5 kilowatts capacity, a 10 arc Brush dynamo with arc lamps, a 5 horsepower direct current motor and a cradle dynamometer. There was a small photometric room adjacent to the laboratory and a battery room containing a storage battery of 31 cells. A few electrical measuring instruments and accessories were also available.

The Engineering Department, independent of the Literary Department was established in 1895. The department grew rapidly both in the number of students and the physical equipment. In 1898 the steam engine had been replaced by an electric motor, current being then available from the University power house. A 30 kilowatt alternator, a number of transformers, and a home-made polyphase alternator had been added. In

this same year the first induction motor on the campus was designed and built under the supervision of Professor Carhart. It was a two-phase machine operating on 120 cycles. Mr. Carroll Jones, who had had considerable practical experience in electrical engineering, was added as an instructor. Unfortunately, Mr. Jones died shortly afterward and his place was taken at the beginning of the school year in 1900 by Benjamin F. Bailey as Instructor in Electrical Engineering.

In 1904 a portion of the present West Engineering Building was built and the electrical engineering laboratory occupied the basement floor of the south end of this building. This gave the department much needed space, and equipment was rapidly added. In May 1905, George W. Patterson became the first Professor of Electrical Engineering and was placed in charge of the department. He held this position until 1915. During this period the department expanded greatly in its scope, offering a wide variety of courses, practically equivalent to those offered today except in the departments of electronics and radio, which were just beginning to assume commercial importance.

In 1910 the West Engineering Building was enlarged to take care of the rapid growth of the department and most of the electrical engineering laboratories were transferred to the north end of this building, where they have since remained.

In 1915 Professor Patterson became Head of the Department of Engineering Mechanics and John C. Parker was appointed Head of the Department of Electrical Engineering, a post which he held until 1922. During this period the number of students of electrical engineering remained relatively constant and opportunity was offered to revise and refine the course of study. The number of staff members increased to 14 and the department began offering a number of specialized courses

such as radio, advanced theory of circuits, advanced courses in design, etc. A number of the more practical courses were necessarily eliminated and the work as a whole placed on a more advanced plane. Considerable additions were made to the physical equipment of the department.

In 1922 Professor Parker resigned and was succeeded by Benj. F. Bailey, who has since been Head of the Department. During this period, likewise, the number of undergraduate students has remained relatively constant although there has been a very decided increase in the number of graduate students. Candidates for the Master's degree have become quite numerous and there are usually one or two candidates each year for the doctorate. The physical equipment has been increased moderately although the depression years have prevented any great outlay for new equipment.

During the past two years, we have been in the war and this has naturally had a profound effect upon our work. We have dropped entirely the old plan of two semesters plus a summer school and are now operating with three terms of 16 weeks each and practically no vacations. For the first war year we taught both Army and Navy men and a considerable number of civilians. Now in the summer term the Army men and the civilians are practically all gone and we have only Navy men. The actual content of the courses taught remains, however, practically unchanged.

The Staff in Electrical Engineering

Someone once said that a log with a student on one end and Mark Hopkins on the other constituted a University. All three elements are essential and we will devote some time to each of them.

To give a complete history of all staff members during the past 55 years would require too much space. In the following, I will attempt to outline the more important changes which have taken place, and give some impressions of a few of the faculty.

Until the present (June 1944) there have been four heads of the department, although Prof. Carhart never held that title, in fact, Prof. Patterson was the first Professor of Electrical Engineering. The list is as follows:

H. S. Carhart	1889-1905	Served 16 years
Geo. W. Patterson	1905-1915	" 10 "
John C. Parker	1915-1922	" 7 "
Benj. F. Bailey	1922-1944	" 22 "

H. S. Carhart

The founder of the Electrical Engineering Department was Prof. H. S. Carhart. He never held the title of Head or Chairman of the department but remained Professor of Physics as long as he was here. I remember that he once told me that no one was ever authorized to start such a department, but like Topsy, it "just grew". At first the courses were all listed under Physics and it was not until 1895-96 that they were grouped separately as Electrical Engineering.

At first only one course (in Dynamo Electric Machinery) was offered. This was in 1888-89 and was taught personally by Prof. Carhart.

I think it is safe to say that no one who studied under Carhart will ever forget him. He was a small, nervous man, full of energy and "pep". He was a good lecturer, but not very profound. It was rumored

among the students that he had stomach trouble and that was why he was so sour. His pet aversion was blown fuses and each case called for a thorough investigation. The poor culprit did not hear the last of it for many a long day. In his laboratory classes, we lined up outside the door. Promptly at one o'clock, the doors opened and we filed in. Everything was "hooked up" and we were each assigned to read an instrument. When we were "all set", "H²S" as he was called (for obvious reasons), started the motor and the experiment proceeded. It is a fact that I was the only student in my class who ever even started a motor and that was because I sneaked in at night to see if I could do it.

John O. Reed

We learned most from John O. Reed, Professor of Physics. He was an excellent lecturer and quiz master. When we were called upon to recite, we knew the lesson "or else". His sarcasm would blister the hide of a mule. As a graduate student I took a course in sound from him and it was then that I first saw the utility of differential equations and acquired some facility in their use.

Carl Guthe

Dr. Carl Guthe, a young German, was so in love with his subject that he inspired some of us with enthusiasm to become scientists also. Some of his early work in radio was of importance and his untimely death was a blow to Michigan.

Geo. W. Patterson

The name of Geo. W. Patterson, who was destined to play a very important part in the development of Electrical Engineering, first appeared in 1889-90 as Instructor in Electrical Engineering. One year later his title was Instructor in Physics, but in 1891-92 it was

Assistant Professor of Physics. A little later he became a Junior Professor and in May 1905, Professor of Electrical Engineering and Head of the Department. He held this position until 1915 when he was appointed Head of the Department of Engineering Mechanics and Assistant Dean of the College.

He was undoubtedly the best loved of our teachers and is still thought of by his old students as "Pat". He was by no means a "practical" engineer but he was a thorough mathematician and had a wide grasp of electrical theory. As a teacher he was very poor except for the better students as he never could realize that the students were not as brilliant as he was. If he ever "flunked" any one I never heard of it. He never wrote much or carried on much research but was nevertheless one of the strong men of the faculty. For those who could "take it", he was a real inspiration.

John C. Parker

John C. Parker was appointed head of the department in the summer of 1915 to replace Prof. Patterson. He had had wide practical experience in power plant work and was a profound student of electrical engineering. During the seven years he served, he did much to build up the department and was responsible for the introduction of two or three advanced theoretical courses. While he was here, several strong men were added to the staff. Only two of these (Prof. Jos. H. Cannon and A. D. Moore) are still with us. Prof. Parker left us in 1922 and made a quick rise in industry. He is now Vice-President of the New York Edison Company and has served a term as President of the American Institute of Electrical Engineers.

Benj. F. Bailey

My name first appears in University lists in 1897-98 as Dispensing Clerk in Electro-Therapeutics. I graduated in '98, spent a year with the Detroit Edison Company and the General Electric Company and returned in 1899-1900 as Instructor in Electro-Therapeutics. In 1900-01 I took Carroll Jones' place as Instructor in Electrical Engineering and a year later became a regular instructor. I have been here ever since, except for several leaves of absence. During one of these I was Chief Engineer for the Fairbanks-Morse Elec. Mfg. Co., of Indianapolis. I passed through the usual grades, becoming a full professor in 1912 and Head of the Department in 1922. I shall be officially retired in the summer of 1945 but expect to spend from July 1944 to then on a leave of absence.

L. F. Morehouse, after some other teaching experience joined the staff in 1903 and was with us three years. He left to go into telephone work and is now one of the important men of the telephone industry.

Geo. P. Rowe was an instructor for a year in 1892-93, and Carroll D. Jones likewise served about two years, but died in 1900. Earnest Steck and A. D. Spencer, now Vice-President of the Detroit Edison Company, also served for short periods.

Fredrick DeLay and R. D. Parker (not John C.) joined us in 1907 and both were with us for several years. DeLay taught the machinery courses while Parker (who soon rose to Assistant Professor) specialized in communication, which then meant Telephone and Telegraph. He left us in 1916 to go into telegraph work with the A. T. and T. and has risen high in this work. L. D. McOmber and B. L. Barnes joined us in 1909

but did not stay long.

In 1908 C. L. DeMuralt was chosen to "strengthen" the staff by Dean Cooley and was appointed a full professor. He was supposed to have a great reputation in Germany (he did but not the kind we thought) and was to give the staff a strong practical flavor while Patterson supplied the theory. Many pages could be written about what happened while he was here but no good could come of it. The inevitable "blow up" occurred when it was discovered that he was meeting his class in alternating currents only once a week instead of three times. His explanation was that he could teach them all they needed to know in 15 lessons. The correct explanation will be obvious. He left by request in 1914 and at last accounts was a portrait painter in Dresden, Germany.

H. H. Higbie, who is still with us, was an assistant in Mechanical Engineering (although his training had been electrical) for about two years, and changed to Electrical Engineering in 1905. He has been one of our key men ever since. I could write much in praise of him but being so closely associated it might be embarrassing.

A. H. Lovell is another who has been with us for many years. He joined us in 1910 as instructor. He distinguished himself in the first World War and came out a Colonel of Engineers. On his return to the University he was advanced to a Professorship and from 1930 to 1944 was Assistant Dean. His specialty for many years has been Electric Power Plants.

Harry S. Tanner was with us as instructor from 1911 to 1913. He was one of our valued instructors, but left to accept a position with the Sperry Gyroscope Company. Here he rose rapidly to a position of importance, but was unfortunately killed in an automobile accident a

few years ago.

John Fay Wilson was an instructor from 1911 to 1916. Mr. L. W. McOmber also served as instructor during 1909-10, and Mr. H. D. Wines was with us from 1913 to 1916.

Mr. Harry S. Sheppard was appointed as an instructor in 1913, became an Assistant Professor in 1915, and remained with us until 1917. He was one of our important men and has risen high in the Bell Telephone System. Messrs. Porter Evans, G. A. Pomeroy, F. R. Zumbro, H. L. Ballard, H. W. Collins and L. W. Brunson were others who served for a year or so during the period 1915 to 1920.

In the year 1915, T. J. MacKavanagh came in as Assistant Professor. He remained with us until 1918 when he resigned to accept a position with the Catholic University of Washington, D.C. He is still with them, but in addition has studied law and is a patent attorney. "Mac" was a real character; very strong for his religion, and many were the good natured arguments we used to have. He had spent some of his early years on a cable ship and could (and did) spin yarns by the hour. We were sorry to lose him.

In 1915 John C. Parker was brought in as Head of the Department. He soon added several strong men to the staff, two of whom are still with us. A. D. Moore became an instructor in 1916 and Joseph H. Cannon an Assistant Professor in 1917. Both are still with us and have had an important part in shaping our policies and setting our standards. We hope they will be with us for many years in the future.

Two other strong men of this period were Ward F. Davidson (1916) and James F. Fairman. When Prof. Parker left in 1922 he took both of these men with him. Another notable addition was E. B. Stason (1919)

as part-time Assistant Professor of Electrical Engineering. His work as a teacher was outstanding. He spent part of his time studying law. He was with us a couple of years and then joined his father in the practice of law. A few years later he wrote me saying he had decided to devote his life to teaching, and that he didn't care whether he taught Law or Electrical Engineering. We had no suitable opening but they were glad to have him in Law. He had a spectacular rise and is now Dean of the Law School and Provost of the University. We are proud to have had him on our staff.

Another outstanding personality was Erwin E. Dreese. He entered the Engineering College with advanced credit from the Literary College, dropped out for two years to serve in the Navy during World War I, and graduated in 1920 with an all A record. He was appointed instructor in 1921. He was a brilliant teacher in addition to being one of the best students we ever had. Sometime in the spring of 1925, Mr. James Lincoln of the Lincoln Electric Company of Cleveland, Ohio, called me on the phone to see if they could pick up a young engineer, good enough to qualify as Chief Engineer inside of a year. Without hesitation I recommended Dreese. He and Mr. Lincoln quickly reached an understanding and he did become Chief Engineer within a year. A few years later he became Head of the Electrical Engineering Department of Ohio State University, and he still holds that position. He is one of the men we should not have lost but it was impossible to pay him enough to keep him.

Mr. W. L. Everett became an instructor in 1925 but remained with us only two years. He is now a Professor at Ohio State University and is making a name for himself.

From 1920 to 1926 we added six men to the staff all of whom are still with us, S. S. Attwood (1920), M. B. Stout (1922), H. S. Bull (1922), J. S. Gault (1922), L. N. Holland (1924), and W.G. Dow (1926). I could write much of these men and would if they were not still with us. Suffice it to say that we obviously liked them or we would not have retained them 20 years and similarly they apparently liked us. Practically all of them have had offers of better paying positions but they preferred to stay with us. Incidentally, at least three of these men accepted positions with us before a word was said about salary. Attwood and Dow are away on essential war work, but we hope they will be back soon.

Mr. A. R. Helwarth joined us in 1931 as instructor and was advanced to Assistant Professor the next year. The year 1933 was perhaps the worst year of the depression for us. All salaries were reduced and we were forced to let one man go. Helwarth being our youngest member was the "victim". He is now with the Detroit Edison Company and we have never been able to get him back.

To take care of the added teaching load and fill the places of those working on war projects, we have added as instructors, H. J. Gomberg, J. F. Cline, J. S. Needle and K. R. Moehl. They have not yet had time to establish themselves but are showing promise. Gomberg is absent on war work and we may lose others any time. Mr. Alten Gilleo and Mr. Robert Miller were appointed instructors in February 1944, but never got a chance to serve. Mr. Gene Antonette was a Special Assistant Professor for two years, loaned to us by the Detroit Edison Co., but we had to let him go when all our soldier students were withdrawn.

The University Power House

Until the year 1897 very little electricity was used on the campus. A local company generated power at 2200 volts and 124 cycles but little, if any, was used in residences or on the campus. One small transformer was installed in the old medical building, which stood where the Randall Laboratory of Physics now is. The supply was at 2200 volts single phase, 124 cycles and was stepped down to 52 volts. The current was used for experimental work in Electro-Therapeutics. A few small motors around town were operated by 500 volt, direct current.

A few years later a water power plant was built at Geddes, three miles down the river. It was a two-phase plant operating at 60 cycles. We used some of this power in our laboratories. Power for all the laboratories in the early days came from steam engines. One quite large Corliss engine drove all the machinery of the shops, transmission being by long counter-shafts and belts. A 70 hp Russel horizontal engine with counter-shaft, clutch and belts provided power for the electrical engineering department. The steam for these engines came from the boiler house, located just west of the present West Engineering Building. Steam for heating the campus buildings was also furnished from this boiler house. (All the University buildings, except the hospitals, were then located on the original 40 acres, bounded by State, North, South and East University.)

In June 1897 the Regents approved the purchase of two generators and engines and they were put into service in December 1897. Being only a student at the time, I of course had no part in the discussion of the type of electric power to be generated. I have been told that the decision to generate direct current at 220 volts, was due to Prof.

Carhart. Most city systems at that time operated on the 3-wire system, generating both 110 and 220 volt direct current. For incandescent lamps, the 110 volt pressure was much the better. Two hundred and twenty volt lamps were manufactured but they cost more, were less efficient and less sturdy than 110 volt lamps. However, we had seen the early 55 volt lamps superseded by 110 volt lamps and it seemed quite possible that in a few years the 220 volt lamp might be improved so as to be substantially equal to the 110 volt lights. However, this has not taken place and the campus has been handicapped for nearly 50 years by its 220 volt system. Prof. Carhart decided against the 3-wire system (which would have been much better) because the University would have been forced to pay royalties to the General Electric Co. who owned the patents. An alternating current system could have been used but suitable motors were lacking. It would also have been possible to use a 2-wire, 110 volt system but that would have required four times as much copper. In all the newer buildings 110 volt lighting is now used, but all the older buildings are still on 220 volts, although the supply is now alternating current.

The system finally installed was, I believe, unique. Two Thompson-Ryan generators of 75 kw each operating at 250 rpm were used, each driven by a single cylinder non-condensing engine exhausting into heating mains. The two generators were compound wound and with full compensating windings. The generators were adjacent to one another with the engines on the outside. A complicated system of quill shafts and clutches was used, so that if desirable either engine could drive its own generator, or the other one or both at the same time. As far as I know no occasion ever arose when it was necessary to make use of

these possibilities. Current for the hospitals was furnished through a line about a mile long and a series booster was used to force the current through this line. In addition a 25 kw generator was installed at the hospitals. In 1904 more power was needed and a third unit of 200 kw was installed. The prime mover of this unit was a non-condensing, compound engine.

This plant gave excellent service for many years but was dismantled in 1913-14, when the present power house was built. This is a 3-phase system but some 220 volt direct current is still furnished by motor-generator sets. The installed capacity in 1914 was 625 kw., the power being furnished by a Corliss engine. In 1939, the capacity had increased to 8400 kw in turboalternator units.

As soon as electric power was available, the steam engine in the Electrical Engineering Laboratory was removed and a 40 horsepower direct current Excelsior motor was substituted for it. The first motor was differentially compound wound to give constant speed. Apparently it gave some trouble and was replaced by a shunt wound machine. This motor is still in our laboratory, but is not in active use.

The Curriculum in Electrical Engineering

To report all the changes in the curriculum in Electrical Engineering during the 55 years of our history would be tiresome and would serve no good purpose. An Attempt will therefore be made to indicate the broad outline of what has happened.

In 1889 the requirements for a degree were as follows:

Mathematics	22	hours
French or German	20	"
English	2	"
Physics	18	"
Chemistry	8	"
Drawing	11	"
Mechanical Engineering	17	"
Electrical Engineering	11	"
Elective	16	"
Thesis (no credit)		
Total	125	hours

The required mathematics differs but little from our present requirement except that about 4 hours of what we now call Engineering Mechanics was included under Mathematics. In fact the work in Mathematics is today practically identical with that given 55 years ago.

French and German (or for that matter any foreign language) are no longer required. For many years there was a profound difference of opinion regarding the desirability of including foreign languages in an engineering course. Former Dean Cooley was very much opposed to dropping the requirement but was ultimately outvoted. He would have been glad to substitute Spanish, on account of its practical value in South America. No one seems to have considered Portuguese, although more people in

South America use this language than use Spanish.

The principal argument in favor of language study was that the engineer needed a knowledge of French and German to keep abreast of the developments abroad. For a few research men (particularly Chemical Engineers) this was probably true. However, the bald fact was that not over one percent ever mastered enough French or German so that they were of any practical value. A check of the books in the library shows that most of the foreign language books have not been taken out for many years. As a practical matter, it is a fact that more scientific material is now published in Russian than in any language except English.

The other argument was that the study of languages had great cultural value. No one doubts this but the consensus of opinion seems to be that the limited time available might better be spent on such subjects as English, Economics, Political Science, etc. However, we still require some language work as a pre-requisite for entrance.

The requirement in English has shown the greatest change. "Paragraph Writing", (two hours credit), was for a long time all that was included. By 1913, the requirement had increased to Theme Writing (4 hours) and Supplementary Reading (1 hour). At the present time (1944) we require 10 hours. It is difficult to explain why so little English was specified in the early days. I have the impression, however, that our students used to come to us better prepared in English. In addition, there has been a growing recognition of the fact that English is one of the fundamental tools of the engineer. To impart his ideas to others, the engineer is limited to English, Drawing and Mathematics. In spite of the increased time given to English, the results are very disappoint-

ing. Part of the blame lies in the home, perhaps part in the methods of instruction. It should also be noted that what is labeled "English" involves a good deal of discussion of Philosophy, Religion and related subjects. This is probably a good thing but does not help the student in spelling, grammar or composition. Incidentally, plenty of poor English is used by many faculty members and this is by no means confined to the Engineering Department.

In Physics, there has been little change, and the same thing is true of Chemistry. Drawing is much the same, but we formerly required a course in Shades, Shadows and Perspective. This was dropped many years ago.

In Mechanical Engineering 17 hours were required but this is very misleading. It included four courses in Shop Work: Pattern Making, Forging, Foundry and Machine Shop, a total of 10 hours. There was also included a course in Mechanism, three hours, and one in Dynamics of Machinery, 2 hours, both now given under Engineering Mechanics. The only course that we would now list under Mechanical Engineering was a course in Prime Movers, two hours. We now require a four hour course in Heat Engines, plus a one hour course in the laboratory and a three hour course in Elements of Machine Design. In the early days a similar course was included under Design of Shop Machinery but was supervised by the Department of Mechanical Engineering.

Prior to about 1900 the engineering student was exposed to practical engineering by being required to take 10 hours of Shop Work, listed however under Mechanical Engineering. This was actually manual training and at least showed the students how things were done and how to do them, (which is quite a different matter). As engineering

developed, we were forced more and more to limit the time spent in this way until now only two hours are required in the working, treating and welding of steel. We have the same requirement in all the branches of engineering except Mechanical which requires 10 hours and Metallurgical Engineering which requires four hours. The emphasis today is upon how things are done, not on how to do them.

Engineering Mechanics has been kicked around like a football. Of course some of the elements have always been taught as part of Physics, but in the early days, Mathematics assumed much of the burden. Later all this work was handled by the Civil Engineering Department. In 1895, Theoretical Mechanics was a part of Mathematics, but Graphical Analysis of Structures, Strength and Resistance of Materials and Hydraulics were under Civil Engineering. All the "old timers" will remember "S. and R." as taught first by Dean Greene and later by Gardiner Williams. It was for many years our "Pons Assinorum". Under Gardiner Williams (then Head of Civil Engineering) the examinations lasted two or three days. Perhaps largely to correct this condition, Engineering Mechanics was finally made an independent department.

For a good many years, we have required one course in Civil Engineering and one in Chemical Engineering. There has been little change in these. Economics (6 hours) was added to the requirements about ten years ago, largely to take the place of Language.

There has been constant pressure through the years to increase the non-technical content of the engineering curriculum. Everyone agrees that the engineer should be a broadly educated man and many of us wish that we had five or six years in which to do the job. Many attempts have been made to lengthen the course to correspond with the

Medical, Dental and Law courses but all have been failures. Among the Universities who tried to require five or six years were Columbia, Yale, Minnesota and others. The trouble was that the students went elsewhere, and the experiments gradually died out.

In 1908 Michigan tried its hand at a six year curriculum. The regular four year program was continued but the student could if he wished take the longer course. All the regular studies were still required but in addition he took more work in English, Mathematics, Mechanical Engineering, History, Philosophy, Geology, Law and much more elective work, mostly of a non-technical nature. The technical content in Electrical Engineering was slightly increased. In all, 210 hours were required for graduation. After completing 140 hours the degree of Bachelor of Science in preparation for Engineering was granted. The second degree, Bachelor of Engineering, required 175 hours and finally after 210 hours he was supposed to become Master of Electrical Engineering (or Mechanical, Civil, etc.). This course looked good on paper; actually few, if any, ever completed it. Of course, it is a simple matter of arithmetic to see that in six years a young man could take his Bachelors degree in the usual manner, then a Masters degree and have largely completed the work for the Doctorate, and naturally many did this.

The phenomenal advance in the Science and Art of Electrical Engineering explains much of the change that has taken place in the content of the technical requirements in electrical engineering. In 1889 the telephone was about 14 years old, commercial electric lighting about 9 years old, the electric trolley car about 3 years old. Long distance electric transmission was hardly contemplated; the X-Ray had not been

discovered nor had radio. Electronics was far in the future and even the incandescent lamp and the electric motor were still to go through a long period of development. To cover quite thoroughly what was then known of electrical engineering was a simple matter; today it is an impossibility. The best we can do is to give the student a smattering of the fundamentals and expect his employer to finish the process on the job.

The first requirement for graduation in Electrical Engineering is contained in the calendar for 1889-90. Twenty five "full courses" (125 credit hours) plus a thesis were required. No courses in Electrical Engineering were listed under that name but courses 1, 2, 3a, 4, 5a, 8a, and 9 in Physics were specified. Of these the first three were elementary Physics. Course 4 was Primary and Secondary Batteries (2 hours), Course 5a was Electrical Units and Measurements, (5 hours), 8a was Dynamo Electric Machinery (4 hours), and 9 was Distribution of Electricity and Photometry of Electric Lamps (4 hours). Courses 8a and 9 totaling 8 hours, were the only ones we would now list under Electrical Engineering. Today the requirement has grown to 35 hours and in the case of those studying Ultra-High-Frequency Radio, 15 additional hours are needed. However some substitutions are allowed so that the actual number of hours in Electrical Engineering is about 45 for students specializing in Radar.

Ten years later (1899-1900) the Engineering Department had obtained its divorce from the Literary Department and the requirements for graduation had grown to 130 hours but no thesis was required. The Electrical Engineering courses were no longer listed under Physics and the required courses were E.E. 1, Primary and Secondary Batteries;

E. E. 2 and 3, Electrical Measurements; E.E. 4a, Dynamo Electric Machinery; E.E. 5, Alternating Current Apparatus; E.E. 6, Photometry; E.E. 7, Design of Electrical Machinery; and E.E. 8, Distribution of Electricity. Of these, courses 1, 2, and 3 were really Physics, leaving a requirement of 14 hours in actual electrical engineering. The principal change was the requirement of courses in Alternating Currents and a course in Design. Two elective courses were offered. Even two years later when I took my Masters degree, very little elective work was available and I had to take Physics as my "Major" and Electrical Engineering and Mathematics as "Minors".

Going ahead another 10 years to 1909-10 the required Electrical Engineering work had jumped to 25 hours. The course in Primary and Secondary Batteries has been dropped entirely but an elective course in Storage Batteries was offered. The work in Dynamo Electric Machinery had been expanded to include more work in alternating current motors and converters. A new course in Electric Generating Stations and Sub-Stations was required and two courses (totaling 4 hours) in Telephone, Telegraph and Related Apparatus were included. Another new required course, Electric Railways was added as well as several elective courses. Credit could also be obtained for research work although this was intended primarily for graduate students. The total number of hours for graduation had been increased to 140.

Another decade brings us to 1919-20. At this time Prof. John C. Parker had been in charge of the department for five years. He came with a broad practical experience and had instituted many changes. The total requirement remained at 140 hours and the Electrical Engineering requirement was 31 hours. Two of the required courses (1 and 14),

however, were mechanical design and were really courses in Mechanical Engineering. They had been transferred to our department, since Prof. Parker felt that we could do a better job with our own students. After a few years they were returned to their own home. Since these two courses carried 5 hours credit the actual Electrical Engineering content was 26 hours. The course in Electric Railways and those in Telephone and Telegraph were now elective. The course in Power Plants had been expanded to 5 hours and included work in the economics of power generation. An entirely new advanced course, E.E. 17, Electro-Mechanics, had been added to the requirements. We were rapidly getting away from the practical and applied courses and were stressing theory more than before. This tendency still continues.

The course contained 14 hours of Group Options. These were to be elected from one of six groups: Communication, Machine Design, Power, Railways, Illumination and a General Science Group. These groups included "Cultural" as well as technical subjects. Radio Telegraphy and Telephony makes its appearance as an elective subject. Until this time, no course in Radio had been offered.

In 1929-30 the staff consisted of 11 men, all of whom are still with us. They were Bailey, Higbie, Lovell, Cannon, Moore, Attwood, Stout, Bull, Gault, Holland, and Dow. The most notable addition to the requirements was E.E. 1, Principles of Electricity and Magnetism. This was and is a theoretical course in which electric and magnetic fields are studied. It is now regarded as a very important part of our course of study. The work in electric circuits and a-c and d-c machinery remained much the same. E.E. 5, Electrical Design, however, was well on its way to becoming a highly scientific study of the

principles underlying design. Much attention was being given to such subjects as flux mapping and heat transfer. In the early days design methods were very crude, and design was an art, rather than a science. We believe our work along this line has kept pace with commercial developments. The total requirement in electrical engineering courses had now grown to 31 hours, due to the inclusion of E.E. 1.

In the year 1929-30, for the first time, we offered a course in Electronics. This was the entering wedge which threatens to split the curriculum into two parts, Power and Communication. More about this later.

Another ten years passed and we now come to 1939-40. As just noted Electronics was an elective course when first offered but was made a required course in 1931-32. We are proud of the fact that Michigan was, as far as we know, the first engineering school to take this step. This increased the required work to 35 hours where it still stands.

Throughout the years there was a steady growth in the number of advanced elective and graduate courses. As a rule these were offered at the request of staff members who were specializing along certain lines and wished to pass along the results of their work to their students. For example, Course 10, Advanced Theory of Electrical Circuits, was a natural outgrowth of E.E. 17, Electromechanics, and this in turn was based on E.E. 3, Alternating Current Circuits. Course 6, Advanced Theory of the Induction Motor, naturally follows E.E. 4. Out of E.E. 7, Illumination, grew such courses as E.E. 7a, Building Illumination, E.E. 15, Advanced Lighting, E.E. 70, Electrical Control for Lighting, E.E. 71, Interior Illumination, and E.E. 74, Lighting

Equipment. From E.E. 11, Power Plants, came E.E. 19, Study of Design-Power Plants, E.E. 20, Electric Transmission and Distribution, and E.E. 36, Electric Rates and Cost Analysis. The work in Electrical Design was expanded to include E.E. 52, Heat Problems in Electrical Design, E.E. 1 naturally led to E.E. 25 and 25a, Electromagnetic Field Theory, E.E. 27, Electrical and Magnetic Properties of Materials and E.E. 28, Technical Electrical Measurements. Other courses in advanced theory were E.E. 26, Heaviside Operators, E.E. 31, Symmetrical Components, and E.E. 16, Electrical Rectification. The work in Electronics was expanded to include E.E. 21, Theory of High-Vacuum Electronic Devices, and E.E. 82, Theory of Gaseous-Conducting Electronic Apparatus. We also offered elective courses in Radio, Elements of Electrical Communication, Telephone Communication, and Electric Control. This increase in the number of advanced elective courses coincided with the increase in the number of students wishing to take advanced work.

Throughout this decade it was becoming increasingly clear that it is impossible in four years to cover the material that is necessary for a well rounded engineering education. As a result, it was becoming more or less common for the average student to stop at the end of four years, the superior student usually wanted at least one year more of technical work and a fair number took three years of graduate work to secure the Doctorate.

1939-40 to July 1944

In 1939 when the Germans started their attempt to dominate the world, it quickly became apparent that we would be involved and that this would have a profound effect upon engineering education. In the early days, engineers were divided into Civil and Military Engineers.

It soon became apparent that we were all to become Military Engineers. Of course, the old distinction has largely disappeared, just as the distinction between soldiers and civilians is becoming very vague.

It is too early (July 1944) to attempt a complete report of the effect of the war upon our activities but a few of the outstanding points may be mentioned. It has been difficult to retain a proper staff in view of the requirements of the armed forces. For example, Prof. Holland has been teaching only part time for three years, the remainder of his time being devoted to an important and confidential research project. Prof. Bull and Mr. Cline have also worked on this project.

For more than a year, Prof. Dow has been absent on leave, doing research work in Electronics in the Craft Laboratory of Harvard University. Prof. Attwood has been away for nearly a year doing important work on the transmission of ultra high frequency radio waves. He was flown to England, spent several weeks there and is now located in New York. Prof. Bull spent nearly a year in Monmouth, New Jersey, with the Signal Corps. He returned at our urgent request, when Prof. Dow left, to help carry the work in Electronics. Half of his time, however, is spent on the research project previously mentioned.

During the past two years an important research project in powder metallurgy has been under way. The method of heating has been to induce currents in the mass of powder by means of high frequency currents. Frequencies ranging from 300,000 to 9,000,000 cycles have been used. The electrical part of the work has been under the direction of the writer. Mr. Henry Gomberg and later Mr. Kenneth Moehl have done most of the actual experimental work.

During 1932 Prof. M. B. Stout had charge of the Signal Corps Under-Engineer-Trainee-Radio Program. The course was an extensive one lasting 24 weeks and was taken by 60 students.

During the same year a course under the direction of Prof. W. C. Trow was given to prepare officers as civil administrators in occupied countries. The men devoted much of their time to language study. Those with engineering experience, took up advanced work in engineering. The writer was in charge of the electrical work.

Two classes of about 90 naval officers have been given special courses of lectures in the use of electricity on shipboard. This work also has been under my direction.

During the past two years we have been asked to teach courses in Ultra-high frequency technique (Radar). These courses have been offered as electives and approximately 90% of our seniors have elected them. In order to make this possible, it was necessary to allow a great many substitutions, and consequently a good many students have been graduated lacking such subjects as Economics 54, lab work in Mechanical Engineering and Engineering Mechanics, Physics 147 and Electric Measurements. To a certain extent the material missed has been included, however, in these special courses.

The development of these courses has been due largely to the efforts of Prof. L. N. Holland, who has done a magnificent job. He has taught this work to our own men and has also conducted a 12 weeks course in the subject for Signal Corps officers. This particular course was sponsored by the United States Office of Education for Officers of the U.S. Army and Navy. During this course Profs. S. S. Attwood and W. G. Dow gave approximately 30 lectures each. Mr. J. F. Cline and T. W.

Hildebrandt assisted in the laboratory.

Much credit is due Prof. Attwood for his work in developing these courses in Ultra-high frequency. He has delivered most of the lectures on propagation of these high frequency waves and has written an extensive mathematical treatment of the subject. This has been mimeographed and was used in the work.

Intensive Education.

About two years ago the University abandoned the traditional two semester plan and instead adopted three terms of 16 weeks each. This has presented many problems, especially in regard to the pay for the summer term. These matters have, however, been adjusted to the reasonable satisfaction of every one.

Army, Navy and Marine Instruction.

The past year has been the most trying in our history, due to the fact that we have had to furnish instruction to four different classes of students at the same time, civilians, Army, Navy and Marine trainees. The Naval and Marine students were easily taken care of since, in general, their courses were nearly identical with ours and the length of their term (16 weeks) was the same. We are in the process of changing to Naval courses only and are now giving the first of the V-12 courses, E.E. 1n, to two sections. In general, the Navy men were carefully selected. With very few exceptions they have been doing good work, perhaps a little better than the civilians. We have had a few Marines and the above remarks apply equally well to them.

To handle the Army students was much more difficult. The Army insisted on four terms of 12 weeks each per year, while the Naval students and the civilians took three terms of 16 weeks each. This

meant that the schedule of studies had to be changed seven times per year, frequently with corresponding changes in the number of instructors.

During the Summer Term of 1943 we gave only one Army course, A.S.T. 414, but we loaned Prof. Attwood to the Mathematics Department to teach A.S.T. 403, Engineering Mathematics. We had on the staff 6 Professors, 2 Associate Professors, 2 Assistant Professors, 2 Instructors and 3 Assistants. These assistants were outstanding senior students, but were actually in full charge of laboratory sections. We were forced to do this, much against our will, as it was impossible to get more experienced men.

During the regular Fall Term, Army students in large numbers were sent here and we taught as many as 13 courses to them. The staff was increased to 20 men. Several entirely new courses were taught, of which A.S.T. 424 (Servo-mechanisms) required the greatest amount of preparation and new equipment. The staff was heavily overloaded and it became necessary to drop practically all our advanced elective and graduate courses. The Army students as a rule were less well prepared than the Navy men and obviously took less interest in their studies. The work was given much too fast and little time was available for study. The result was poor work and there is more than a suspicion that in many cases it was necessary to "temper the wind to the shorn lamb".

I am sorry to say that there was much evidence that the honor system largely broke down. This does not necessarily reflect upon the Army. The partial failure was probably due to the fact that the system was new to most of the men and since there were no civilians in the Army classes, they lacked the example of others who had been trained in the honor system.

The Future

What has preceded this is, as far as the writer can determine, factual. I now, however, venture to make a few suggestions and predictions regarding the future.

The number of required hours in electrical engineering subjects has grown from about 10 to 35 and in the case of those specializing in ultra high frequency radio (and this includes 80 to 90 percent of our students) to about 45. This is, of course, a temporary condition, due to the need of men trained in radar by the armed forces. Moreover, the content is much more technical and consequently difficult. For example, we formerly had a course in Primary and Secondary batteries. Obviously such a course was purely descriptive and required only a smattering of Physics and Chemistry as a prerequisite. Of course, no Mathematics was involved. In fact, as a student, I often wondered why we spent so much time on Mathematics, since we almost never used it, except in a very elementary way. As a contrast, consider such courses as Electric and Magnetic Fields, Alternating Currents, Electrical Design and Radio, to mention only a few. To master these requires real study and the ability to think along mathematical lines. At first glance it might seem that the students today are a race of supermen compared with those of my generation, but the fact of the matter is the students do not "learn" this mass of material, they merely skim over the top. They have a vague idea of a great many things, but no basic understanding of anything. It has been shown many times that any simple examination on fundamentals gives appalling results. I am firmly convinced that we should cover less material and cover it better. Much of the work we now give to undergraduates should be reserved for the Master's degree.

Electives

It has become almost a tradition that the electrical curriculum should consist of 132 hours of required work plus 8 hours of free electives. Probably, if we could require all students to take a year of graduate study this would be ideal. In the extra year he could specialize in those subjects in which he was most interested. Assuming however, that we continue to require 8 terms of 16 weeks each (and this seems inevitable) I believe the time has come to allow the student to take the line of work in which his interest lies. Actually, we do this now to a considerable extent, by the use of substitutions, but this is a complicated and unsatisfactory solution of the problem.

Other branches of engineering have met the situation by offering several options, in some cases ultimately forming new departments. Thus Aeronautical Engineering was once part of Mechanical Engineering, Metallurgical Engineering part of Chemical Engineering, and Transportation is a branch of Civil Engineering. Civil Engineering has adopted the procedure more than any other branch, Electrical Engineering, not at all. In Civil Engineering there are six options and six more listed under Transportation.

I venture to suggest tentatively the following groups in the Electrical Engineering curriculum: Power, Electronics, Communication and General Science. Further consideration might suggest a better selection. We have been greatly disturbed during the past few years by the number of students deserting us for Engineering Physics. A more liberal curriculum as outlined above, would do much to correct this situation. This matter would have been presented to the staff a couple of years ago, but due to the needs of war work, it seemed inadvisable, since practically all our students were studying Radio.