History of the Physics Department

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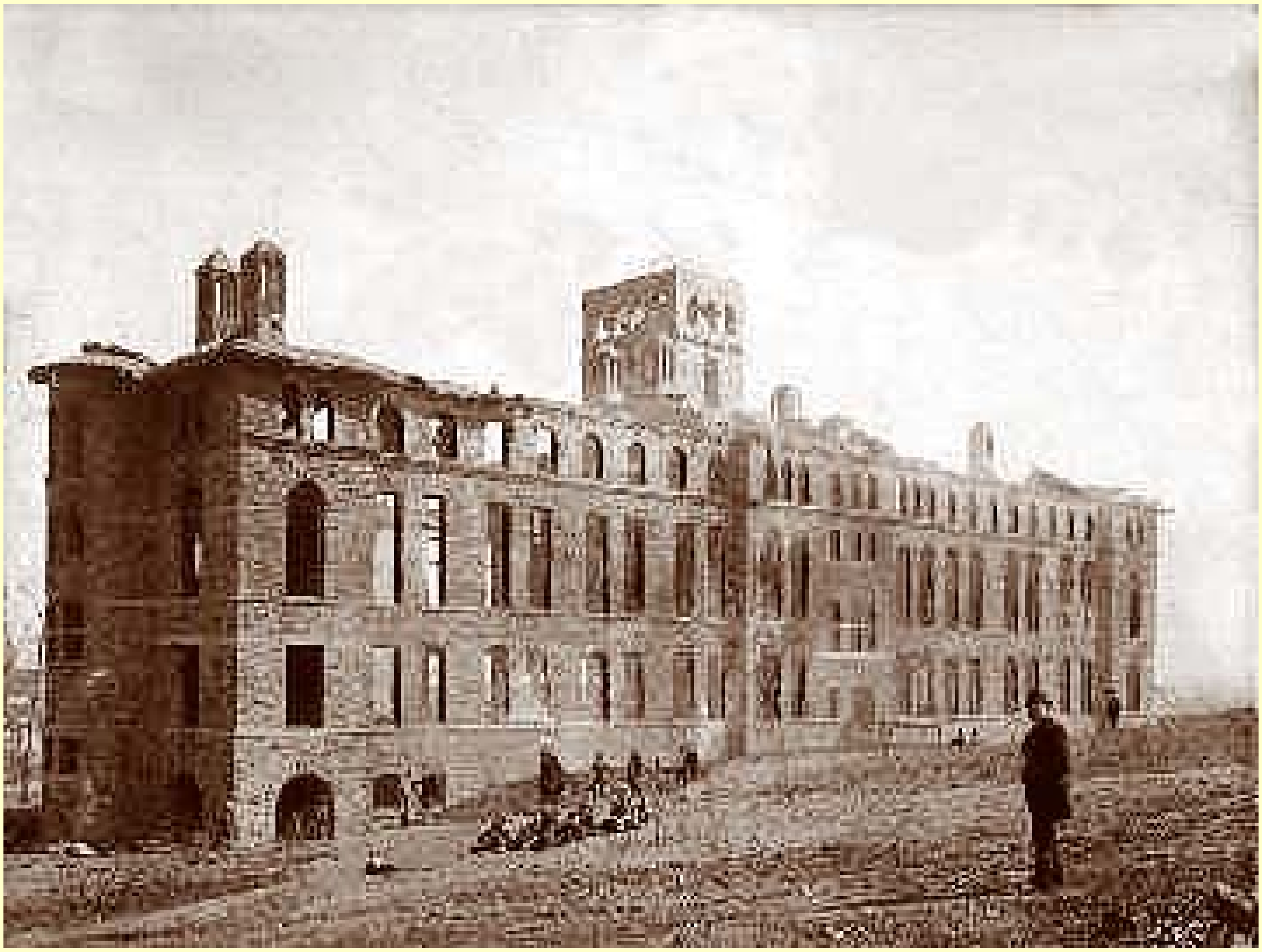
History of the Physics Department



The physics building after the fire of 1900 (read the news story).

(The Web page is still under construction)

After reading about the fire, click on "NEXT" below.

Introduction

Lehigh University was founded by Asa Packer in 1865. Packer and his advisors developed a mission for Lehigh which is summarized in the motto, taken from Francis Bacon, "Homo Minister et Interpres Naturae", or "Man, the minister and interpreter of nature". The mission emphasized engineering and science, but included a strong liberal, or classical, component; a liberal dose of the classics was required in all curricula, and students who so desired could pursue a liberal education for their full four years.

The first institution of higher education in what is now the United States was Harvard College, founded as a theological seminary in 1636. The scientific revolution, particularly that in astronomy and mechanics with which the names of Kepler and Galileo are associated, was in its infancy. The method of adding to human knowledge by first observing nature had an ancient history but, excepting the followers of Hippocrates in medicine, few practitioners. Most instruction and texts were in Latin, which the student knew on arrival at college. The curriculum was completely prescribed, and included Greek, Hebrew, Rhetoric, Religion, and a course in arithmetic, geometry and astronomy. Freshmen had one term of logic and physics.[1] But contrary to the main lesson of Aristotle, who learned by studying nature, "physics" meant the study of Aristotle. The classical education was really, really classical.

During the seventeenth and early eighteenth centuries the ranks of the scientific revolutionaries were added to by such as Boyle, Torricelli, Gassendi, Hooke, Huygens, Descartes, and most notably Isaac Newton. The colonies made contributions to science which were significant but not in the first rank worldwide. Nevertheless there was wide awareness and appreciation of the new science, and natural philosophy began its entrance into the curriculum toward the end of the seventeenth century.[2] In 1727, the year in which Newton died, Thomas Hollis, a London merchant, endowed a professorship in Mathematics and Natural Philosophy at Harvard and supported it with a gift of scientific equipment.

Benjamin Franklin was born in Boston in 1706 and, after visits to Philadelphia and London, settled in Philadelphia in 1726. The fortune he earned as a printer, publisher and journalist gave him the leisure to follow his scientific curiosity. His discoveries attracted attention in England and Europe, and added to the fame which gave him access to the highest levels when his career turned to diplomacy. In Newton's death year Franklin formed a club, called the Junto, which in 1743 became the American Philosophical Society (of which Thomas Jefferson was the third president). He was instrumental in the founding of The Academy and Charitable School of the Province of Pennsylvania which later became the University of Pennsylvania.

Benjamin Thompson will be mentioned here because of his American birth and education. Born in Woburn, Massachusetts in 1753, he enrolled at Harvard and studied under John Winthrop, the second Hollis Professor of Mathematics and Natural Philosophy. Not favoring American independence, he went to England and later obtained high rank in the Austrian and Bavarian armies. In 1792 he was made a Count of the Holy Roman Empire, and chose the name Rumford from the American township where his wife's family lived. Count Rumford made many scientific contributions, the most notable being his paper of 1798 "Enquiry concerning the Source of Heat which is excited by Friction", in which he proposed that heat is a form of motion.

There was an immigration in the opposite direction when Joseph Priestley, under attack for his sympathy with the American and French revolutions, moved from England to America in 1794 and settled in Northumberland, Pennsylvania, on the Susquehanna river north of Harrisburg, where he died in 1804. This leads to an interesting story with Lehigh connections. Two brothers, Charles F. and William H. Chandler, the former at Columbia and the latter at Lehigh, were founding editors of the journal American Chemist. The issue of April, 1874 contained a communication from H.C. Bolton suggesting that a meeting be held "at some pleasant watering place" as a centennial celebration of Priestley's discovery of oxygen and "the foundation of chemistry on its present basis". A meeting was held on July 31 and August 1 of the same year at the Priestley home with Charles F. presiding over a large group of notable chemists. A memorial was delivered at Priestley's grave by Henry Coppée, Lehigh's first president. The American Chemical Society traces its origin to this meeting.[3]

Joseph Henry was born in Albany, NY, in 1799, three years after Franklin's death. He attended the Albany Academy (whose alumni include Herman Melville); while a student he tutored the van Rennselaer children as well as Henry James, father of the psychologist William James and the novelist Henry James. Later he became Professor of Mathematics and Natural Philosophy at the Albany Academy, where his work on electricity and magnetism gave him a reputation which led to his appointment in 1832 as Professor of Natural Philosophy at Princeton. In 1846 he left Princeton to become the first Secretary to the Smithsonian Institution. Henry was self-taught, and lived far from the European centers of science. Nevertheless he gained international prominence, ranking with the best of the European scientists, and his name was attached to the unit of inductance in 1893, fifteen years after his death.

The period identified with Franklin and Henry saw accelerating growth across a wide range of science and technology. Increasing industrialization depended on a stronger scientific base, and made available the needed time and materials. Geology was stimulated by the search for minerals and chemistry by its use in industrial processes and in agriculture. There were expeditions, and geological and botanical collections were amassed. Paper- making was introduced to America, in Philadelphia and essential to Franklin's journalism, by William Bradford and William Rittenhouse in 1690. The cotton gin was invented by Eli Whitney in 1793. Robert Fulton's steamboat Clermont started passenger service between New York and Albany in 1807. The telegraph was patented by Samuel F.B. Morse in 1837 (Henry had constructed an early telegraph to communicate from his lab to his wife at home but did not proceed with patent and commercial development). Crawford W. Long used ether anesthesia in 1842. John Gorrie, a physician, invented the ice-making machine to cool his patients in 1851 and Linus Yale invented the cylinder lock in the same year. Alexander Graham Bell received early encouragement from Henry and gave a public demonstration of his telephone in 1876.

The late eighteenth and nineteenth centuries saw the foundation of many scientific societies and journals. The founding of the American Philosophical Society by Franklin has been noted. The American Academy of Arts and Sciences was incorporated in 1780 at the instigation of John Adams. Benjamin Silliman at Yale founded the American Journal of Science in 1818 and it quickly became a major outlet for American scientists. The Association of American Geologists was formed in 1840 and in 1848 broadened into the American Association for the Advancement of Science. The National Academy of Sciences held its first meeting in 1863 with Henry as president. Many other scientific societies and journals were founded, some local and some temporary.

A revolution in higher education was needed to accommodate the scientific and industrial revolutions. The colonial colleges offered a single, prescribed, classical course of study. This course had steadily adapted to external developments; for example at Harvard in 1825 out of 56 one-term courses (three terms per year) 15 were devoted to mathematics or science.[4] The introduction of scientific content had generally been done with enthusiasm but with limits inherent in the classical model. A different model was needed for students with primary interests in science and related technical subjects, and its development occupied most of the nineteenth century, saw many failed experiments and had some of the aspects of a holy war.[5] On one side it was argued that the classical education was necessary to develop mental discipline and to provide the proper foundation for other studies. A view from the other side was given in 1826 when the charter of Lafayette College was under discussion in the Pennsylvania House and a member said "The knowledge of all the dead languages would not furnish a single idea that could not be communicated in English ... and added no more to scientific knowledge than the croaking of frogs." [6] A resolution presented to the President and Fellows of Yale College in 1828 asked that a study be made of the "expediency of leaving out the study of the dead languages", but the Yale faculty responded that the ancient languages should be retained, and that "the details of mercantile, mechanical, and agricultural education, might be taught at the college, to resident graduates." [7]

The monopoly of the classicists was broken by new programs which came with the colleges and universities founded in profusion during the nineteenth century. By 1700 there were two colleges in the colonies, Harvard, and William and Mary. The number increased to 14 by the time of the American revolution, to 29 by 1800, to 283 by the year of Lehigh's founding, and to 670 by 1900.[8] As the century progressed an increasing number of new institutions, and some old, introduced curricula whose main purpose was to educate in science and its applications.

From its founding in 1802 the Military Academy at West Point taught military engineering and the associated science; many West Point graduates helped to implement technical curricula at other institutions. Under the presidency of Eliphalet Nott, a Congregational minister and inventor, Union College pioneered in the introduction of scientific courses, and in 1815 awarded the B.A. degree upon completion of a course of study, parallel to the classical course, which emphasized science. (At a few other institutions parallel scientific courses were introduced but branded as inferior by culmination in a certificate rather than a degree.) In 1819 Thomas Jefferson founded the University of Virginia with a novel breadth, including schools of mathematics and natural philosophy. The Rensselaer Polytechnic Institute was founded in 1824 with a strong orientation toward science and engineering, and granted the first engineering degrees, in civil engineering, in 1835. At Dartmouth the Chandler Scientific School, intended to be a school of "the industrial vocations", was established in 1851. The University of Michigan introduced engineering courses in 1853. Popular support for technical education was reflected in the Morrill act of 1862 which provided land grants for the establishment of colleges to teach "such branches of learning as are related to agriculture and the mechanic arts". During the next ten years the number of schools with engineering curricula increased from six to seventy.[9]

Iron was first produced in Pennsylvania in the late seventeenth century; at the

Durham furnace near Bethlehem in 1727 (again, the year Newton died). In 1812 Josiah White and Erskine Hazard used anthracite coal successfully in an iron furnace. An anthracite market also developed for heating; Eliphalet Nott obtained the first patent for an anthracite-burning stove. In order to produce and transport anthracite, White and Hazard formed the Lehigh Coal and Navigation Company in 1821. Coal was brought to market first down the Lehigh river, then along a system of canals. The Lehigh Canal carried passengers and other goods in addition to coal, and connected with the Delaware Canal to Philadelphia and the Morris Canal across New Jersey to New York City. Within 20 years Lehigh Coal and Navigation became the largest company in America. Coal and cheap transportation reduced the price of iron and stimulated its demand, and many furnaces were built along the Lehigh river. Other industries developed to take advantage of the region's resources and transportation.

Asa Packer made canal boats for Lehigh Coal and Navigation, then concluded that a railroad would provide cheaper and more reliable transport. He obtained a controlling interest in the Delaware, Lehigh, Schuylkill and Susquehanna Railroad Company, which had not yet completed its first section of track, and in 1853 reorganized it into the Lehigh Valley Railroad. Traffic began two years later when a trainload of coal went from Mauch Chunk (now Jim Thorpe) to Easton and across the Delaware river to Phillipsburg, the route passing along the southern bank of the Lehigh River a short walk from what is now the Asa Packer Campus of Lehigh University. The route eventually extended east to New York City, and northwest to Buffalo. Packer put Robert H. Sayre in charge of his railroad, and Sayre established headquarters in South Bethlehem. In 1860, with the help of John Fritz and others, Sayre founded the Bethlehem Iron Company (forerunner of Bethlehem Steel) to provide a nearby source of rails, which had previously been shipped from England.

Beginning with the canal era and extending through the nineteenth century, industrial growth was so rapid and substantial in the Lehigh Valley that it has been called the birthplace of the industrial revolution in America.[10] Lehigh University was born from the wealth generated by, and the need for educational opportunities adapted to, the industrial revolution

It seems unlikely that Packer could have taken advantage of the Morrill Act since the state had already allocated its land grant to Penn State (then called The Farmer's High School). In any case it appears from President Williams' foreword to the history by Cornelius that Packer would have preferred to provide the initial, and later, funding (which ultimately amounted to more than $2,000,000) entirely from his own resources. He had been a member of Congress during debate of an early version of the Morrill Act, which was vetoed by President Buchanan on the grounds that it was "extravagant, impolitic, and unconstitutional". Williams goes on to say: "Mr. Packer, an intimate friend of President Buchanan and fellow strict- constructionist, with a strong sense of Yankee frugality and an abhorrence of political control of education, doubtless shared the President's views".

Some events later in the nineteenth century will be noted to add further context to Lehigh's founding. Following Henry as the second giant of nineteenth-century American physics was Josiah Willard Gibbs, appointed Professor of Mathematical Physics at Yale in 1871, the same year that James Clerk Maxwell was appointed the first Cavendish Professor at Cambridge. In the year of Lehigh's birth, Ezra Cornell founded a university "where any person can find instruction in any study"; "any person" included women and blacks, and "any study" meant a significant expansion of the previously-meager elective principle. (Asa Packer may have had mixed emotions when his railroad passed his university carrying students on their way from New York City to Ithaca.) In 1869 Charles William Eliot became president of Harvard; among the many reforms and innovations during his forty-year presidency were the opening of the curriculum to electives, the formation of a graduate school, and the development of the habit of research in a faculty which was reluctant to take time from class work for that purpose. Johns Hopkins University opened in 1876 with an emphasis on graduate education and research; Henry A. Rowland from Rennselaer was hired as the Professor of Physics.

The Physical Review appeared in 1893 under the auspices of Cornell University; Volume 1 contains three articles and three reviews by William S. Franklin, whom we will meet again. The American Physical Society was formed in 1899 with Rowland as president; in 1913 the APS took over publication of the Physical Review.

Next

This material was compiled and written by J. A. McLennan.
Last modified: 4/23/2002

History of the Physics Department

From the Allentown Morning Call of April 7, 1900

All that remains of that magnificent grey stone structure known as the physical laboratory building of the Lehigh University, in south Bethlehem, are four walls, and just how intact these are is a matter of conjecture and cannot be determined for some time to come.

The fire is as great a calamity to the university as the destruction of Pardee Hall was to Lafayette college, only in this instance it was not the work of an incendiary. The fire started at 8:30 o'clock yesterday morning in the dark room of the photographing and developing room, situated in the east wing of the building, on the first floor alongside the elevator, and it is no doubt to the latter that the destruction is due.

At the hour mentioned above Prof. Franklin was engaged in the photographic room in a series of experiments trying to photograph an electric spark. In his experiment he used flash powder and for some reason or other there was an explosion.

The sparks from the explosion set fire to a curtain and other drapery and in a minute the room was in a blaze. The elevator shaft acted as a chimney for the flames and so rapid was the spread of the fire that some of the students got out barely in time.

There was a class in the lecture room on the third floor and the first they knew of the fire was when one of their numbers, who heard the crackling of the flames, opened the door. When in rolled a big volume of smoke, an instant stampede followed. The doors on the south side of the room were locked. These were burst open by the students and a rush was made for downstairs.

The flames spread with a rapidity which was remarkable. Within twenty minutes flames were bursting from the greater part of the windows of the four stories and their interior was like a seething furnace.

The university does not seem to be well equipped with fire fighting apparatus. The halls in the building were equipped with plugs and hose and these the students manned, but the rapid spread of the flames soon drove them from their positions.

The employees of the Bethlehem Steel Works were among the first to respond, and they came with two hose carriages and worked like Trojans removing machinery and fighting the fire. The fire department of South Bethlehem consisting of two hose carriages and the Bethlehem steamer, hook and ladder and hose carriage, also responded, but by ten o'clock all that remained of the building were the walls.

The physical laboratory was one of the best-equipped buildings on the ground and filled with costly machinery from top to bottom. Its dimensions are 235x44 feet. It is four stories high and was erected in 1892 by the late J. S. Allam, the well- known contractor, at a contract price of $74,000. The loss on the building and its equipment for scientific study and research amounts to $150,000.

This material was compiled and written by J. A. McLennan.
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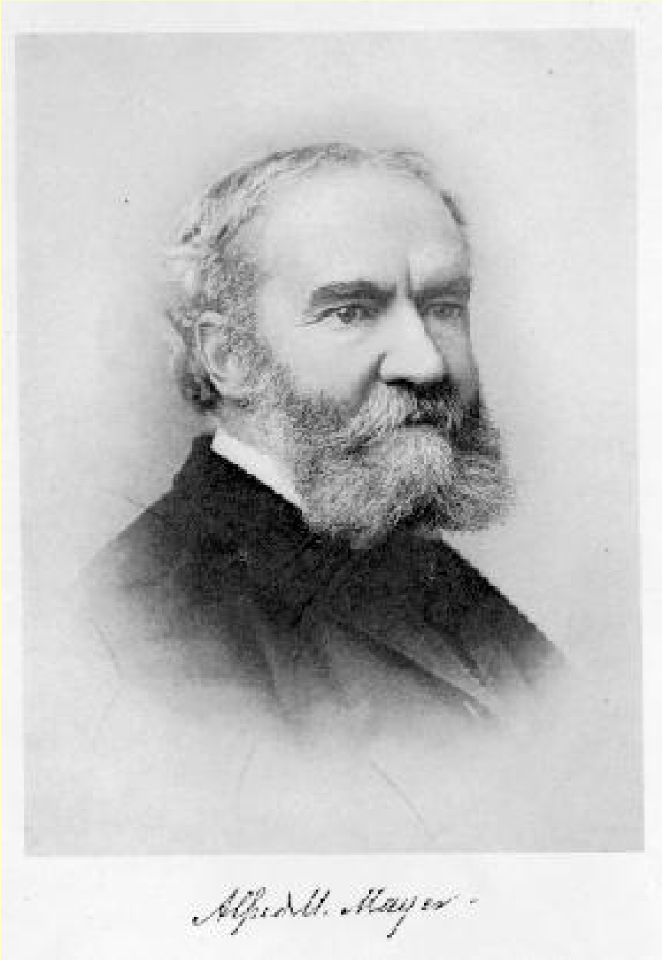
Click here to return to the picture of the burned out building.

History of the Physics Department

Department of Physics

Center for History of Physics



Alfred Marshall Mayer

From Biographical Memoirs of the National Academy of Sciences

Chapter 2

Lehigh's first class entered in the fall of 1866. The Register (as the catalog was then called) for this class lists Henry Coppée, LL. D., as President and Professor of History and English Literature. In addition, there are listed as Professors:

Reverend Eliphalet Nott Potter, M. A., Professor of Moral and Mental Philosophy and of Christian Evidences

Charles Mayer Wetherill, Ph. D., M. D., Professor of Chemistry

Edwin Wright Morgan, LL. D., Professor of Mathematics and Mechanics

Alfred Marshall Mayer, Ph. D., Professor elect of Physics and Astronomy

William Theodore Roepper, Esq, Professor of Mineralogy and Geology and Curator of the Museum

The Register also lists George Thomas Graham, A.B., Instructor in Latin and Greek, and Secretary to the Faculty. Two slots for Instructor in French and Instructor in German are mentioned but not filled.

The eighth and final member of the staff was Mr. George Washington Smith, Janitor.

The first Register lists 39 students in the First Class. In addition there was one, Miles Rock, in the Second Class.

Mayer is listed as Professor elect because he did not begin duty at Lehigh until the fall of 1867.

The course of study was common for all students during their first two years, and included English composition and literature, foreign languages, mathematics, chemistry, physics, history, and drawing. The languages were Latin, Greek and German in the first year, and Latin, German and French in the second.

For junior and senior students, there were available five schools: General

Literature, Civil Engineering, Mechanical Engineering, Mining and Metallurgy, and Analytical Chemistry. In today's terminology the schools would be called curricula. Graduates from the School of General Literature received a B.A. degree; other degrees were C.E. for Civil Engineering, M.E. for Mechanical Engineering, A.C. for Analytical Chemist, and E.M. for Engineer of Mines.

A correspondence between professors and schools is not spelled out, but clearly Coppée and Potter (assisted by Graham) had primary responsibility for students in General Literature, Wetherill for those in Analytical Chemistry, and Roepper for the E.M.'s. The M.E.'s and C.E.'s were evidently handled by Morgan with help from Mayer.

The five schools had their individual course requirements, but there was much in common. All juniors took moral philosophy, physics, French and German. Juniors also took drawing, but students in General Literature learned drawing as art, while those in other schools were taught descriptive geometry and drawing of structures and machines. All seniors took courses in Christian Evidences, French, German and Astronomy.

The Register provides a roster showing the teaching schedules of each professor, and the classes taken by various students. The hours of classes were 9, 10, 11, 2, and 3, Monday through Friday, and 9 on Saturday. Two class hours of physics were taken weekly by all students during their first three years, and seniors took two hours per week of astronomy. The Register for 1869-70 provides Professor Mayer's schedule as: freshmen at 2 on Monday and 10 on Tuesday, sophomores at 9 on Monday and Friday, juniors at 10 on Monday and 11 on Friday, and seniors at 9 on Tuesday and 11 on Wednesday. There was a laboratory for juniors in Analytical Chemistry, but the Register gives no mention of a physics lab.

The physics course was based on Ganot's Treatise on Physics, and Professor Mayer's lecture notes. The text for astronomy was Loomis' Treatise on Descriptive and Practical Astronomy; the instruction extended into the instruments and methods of surveying.

Graduating seniors were required to submit a thesis, and thesis titles are given in the early Registers.

There were no graduate courses or programs (and few existed elsewhere) but graduates could remain as "resident graduates", who were "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 Register for 1873-74 lists three resident graduates; the first graduate degree, an M.A., was awarded in 1882. The undergraduate program was open only to men; women were first admitted to the graduate school in 1918, and to the undergraduate program in 1971.

The first Register lists yearly expenses as $90 for tuition, $190 for board, $20 for books, and $25 for washing, for a total of $325.

Initially the University was housed in Christmas Hall, which was obtained by Packer from the Moravian Church. The Register describes this building as "a large and commodius brick edifice, containing a chapel, lecture-rooms, and students' dormitories." The much larger building, Packer Hall, now the University Center, opened in September, 1868. The Register then describes Christmas Hall as "a large and commodius brick edifice, containing students' dormitories and a mess hall."

The Sayre Observatory opened in 1868, and fell under Professor Mayer's responsibility; in fact he supervised its design and equipping. According to the Register:

> By the liberality of Robert H. Sayre, Esq., one of the trustees of the university, an Astronomical Observatory has been erected on the University grounds and placed under the care of the Professor of Physics and Astronomy, for instruction of students in Practical Astronomy.
>
> The Observatory contains an Equatorial, by Alvan Clark, of six inches clear aperture, and of eight feet focus; a Zenith Sector by Blunt; a superior Astronomical Clock by Wm. Bond and Sons; a Meridian Circle, and a Prismatic Sextant by Pistor and Martins.

The observatory was primarily a teaching facility, although it did enable Mayer to write one paper as described below. Today it is no longer in existence as an observatory. George McCluskey, the current Professor of Astronomy, recalls being told by his predecessor, Ralph van Arnum, that during the 1960's it had fallen into disuse and the space was desired for other purposes. The instruments were transferred to storage, but a later check found them to be missing, evidently stolen. The observatory building now houses a center for graduate students.

The early faculty was well-chosen and distinguished, and provided a coverage of science, engineering and the liberal arts which was unusual for the times.[1] Coppée had attended and taught at West Point, had strong engineering credentials, and had been a professor of English Literature for ten years at the University of Pennsylvania when appointed to the Lehigh presidency. Potter[2] was a grandson of Eliphalet Nott, the president of Union College mentioned in the previous chapter, and Potter later occupied the same presidency as well as the presidency of Hobart College; he was in addition a brother of the noted architect Edward T. Potter, designer of Packer Hall, the president's house and the nearby Episcopal Church of the Nativity. Wetherill had been the first chemist in the U.S. Department of Agriculture (indeed the first person in the federal government to hold the title of chemist), then the first chemist in the Smithsonian institution, and was a prominent chemist on arrival at Lehigh; he was also a first cousin and classmate (at the University of Pennsylvania) of Samuel Wetherill, an inventor and businessman active in the local zinc industry. A letter from Coppée to Wetherill[3] shows the level of professorial salaries at the time: "The salary of the Professor for the first year is fixed at $2400. As soon as practical a house will be erected for you, which will be free of rent." In 1871 Wetherill accepted the offer of a professorship at the University of Pennsylvania but prior to moving suffered a fatal heart attack. Morgan was educated at West Point and resigned his commision two years after graduation to pursue a career in civil engineering; he was fifty years of age when appointed to the Lehigh faculty. Roepper, appointed at the age of 56 and the oldest of the faculty, was born in Europe and educated at Moravian schools; in 1840 the church asked him to go to Bethlehem where he taught at Moravian Seminary and also became auditor for the Bethlehem Iron Company; he had a strong interest in geology, explored and published on local geology, and was the discoverer of zinc ore in the area which he encouraged Samuel Wetherill to exploit.

Mayer was born in Baltimore in 1836. His father Charles F., a graduate and trustee of Dickinson College, was a lawyer and planned a similar career for his son. However at an early age Alfred showed a strong interest in science, and his rooms became filled with collections and equipment of his own making. His biographers[4] say: "..but the engineering sciences in which this boy delighted held but a poor place in the respect of the aristocratic South. Self-absorbed, eccentric, and disapproved of as seeking a career in which even success meant failure, he early learned the strength of his own unaided personality and with the knowledge he acquired self-reliance.." Joseph Henry visited the Mayer home, was introduced to Alfred and his equipment, and the two formed a friendship which lasted until Henry's death.

Mayer dropped out of school and at the age of sixteen went to work as a machinist in a local engineering firm. After two years he became an analytical chemist working for manufacturing and mining corporations; he found that the red lead used in glazing pottery was poisonous. At the age of nineteen he published his first paper, and his second two years later. In 1857 he became Professor at the University of Maryland, lecturing on physics and chemistry, and in 1858 was appointed to the Charles Professorship of Natural Sciences at Westminster College, Missouri. In 1863 he enrolled in the University of Paris where he studied under Henri Regnault. In 1865 he became Professor of Physics and Chemistry at Gettysburg College, which a year later awarded him an honorary Ph.D.

In 1871 Mayer accepted a professorship at the newly-opened Stevens Institute of Technology and this was where he spent most of his career. Nevertheless his tenure at Lehigh was productive and significant; "for the first time in his life, he became master of a well-equipped laboratory, and under the stimulus of favorable surroundings he plunged enthusiastically into experimental researches, especially in the fields of electro- magnetism and astronomy."[4] During this four-year period he published twelve papers and a book, and evidently established a substantial reputation as the year after moving to Stevens he was elected to the National Academy of Sciences. His obituary in the Physical Review begins with: "Among American physicists devoted to pure science few have become so distinguished as the one whose death we are called upon now to record."[5]

Some of Mayer's publications while at Lehigh will be briefly described below; a full list of publications is given in his biography.

Mayer's first publication at Lehigh, and so the first publication from the physics department, reported on experiments with vibrating rods[6]. The frequency was determined from a tracing on a rotating drum.

Mayer's "Lecture-Notes on Physics", preparation of which probably began at Gettysburg, first appeared as a series in the Journal of the Franklin Institute then as a book.[7] The first four of six sections deal with the scientific method and instrumentation, and includes a brief discussion of mechanics and Newton's laws (brief no doubt because this subject was covered by Morgan). The fifth and longest section in the book is devoted to the properties of matter, including energy, thermodynamics, and the molecular hypothesis, and the last section covers capillarity. The book is labeled Part I so a continuation was evidently planned to cover other subjects such as elasticity, sound, and electricity and magnetism. No subsequent parts appeared, although Mayer did later write books on sound and light.

Mayer was chief of the photographic section of an expedition, sponsored by the Superintendent of the Nautical Almanac, to Iowa for observation of the solar eclipse of August 7, 1869. An early example of undergraduate participation in research is given by the inclusion in the party of the aforementioned Miles Rock.[8] The telescope was a refractor with an aperture of 6.24" borrowed from the Central High School of Philadelphia. Mr. Zentmayer of the Longacre Co. constructed a shutter consisting of a spring-driven plate containing a slit, which gave an exposure of 0.002 second. The time of each exposure was accurately determined with a chronograph. Forty-one pictures were taken, including four during the eighty-three seconds of totality, and this was considered to be remarkable in the days of wet-plate collodion photography when each plate had to be prepared shortly before exposure. Mayer returned home, measured the plates to extract data on solar spots, prominences and other features, prepared two manuscripts, the major report being 28 printed pages, and the two papers[9] appeared in print in October, two months after the eclipse.

During observations of Jupiter from the Sayre Observatory Mayer noticed the feature now called the Great Red Spot. The resulting publication[10] provides details of the GRS and includes a plate of a water-color sketch he made of the planet. According to modern history the GRS was noted by a few observers earlier in the nineteenth century and may even have been seen in the seventeenth century, so Mayer's observation was not, as he thought, the first. However his paper had sufficient interest to be reprinted in a British journal and it is cited, with a quotation, in a recent list of early observations.[11]

In 1870 Mayer made observations of an aurora which reached as far south as Bethlehem, finding correlations of activity in the aurora with the declination of a magnetic needle on the ground[12]. This was a period of considerable solar activity and he also made measurements of the size of sunspots. There were other aurora in the same month and apparently at least one prior to the reported observations; he commenced measurements of magnetic declination five minutes after sighting the aurora, indicating that he had prepared for it.

An unusual set of measurements[13] were made at Niagara Falls and Trenton Falls of the temperature at top and bottom, with the purpose of comparing an expected rise in temperature with that obtained from the conversion of kinetic energy when the falls hit bottom. Some fifteen years earlier Joseph Henry had reported, at a meeting of the AAAS, on a similar experiment at Niagara Falls, with no effect detected, due, Mayer says, to insufficient accuracy of the thermometer. Mayer's results were inconclusive; at Niagara Falls the temperature fell (but rose on misty days), a result attributed to evaporation, while at Trenton Falls the rise in temperature was greater than expected. These experiments were no doubt partially motivated by Mayer's strong interest in the outdoors; he was an avid hunter and fisherman and among his later publications were such as "On the Invention of the Fishing Reel."

History of the Physics Department

H. Wilson Harding

Chapter 3

The first five years saw a complete turnover of the faculty, with the exception of President Coppée. Potter and Roeper left in 1869 and Morgan died the same year; in 1871 Wetherill died and Mayer moved to Stevens. Major Lorenzo Lorain of the U. S. Army then became Professor of Physics and Mechanics. Hiero B. Herr had arrived in 1869 to replace Morgan as Professor of Mathematics and Mechanics, but with Lorain's arrival he became Professor of Mathematics and Astronomy; this began the organizational association of astronomy with mathematics.

Lorain was born in Philipsburg, Pennsylvania, in 1831.[1] He entered West Point in 1852, was commissioned in 1856 and assigned to duty in the northwest territories. He had been interested in photography and obtained a camera which, his biographer suggests, may have been of his own construction. His photographic record of his surroundings, including the wilderness, small frontier towns, Indians and soldiers, are an important contribution to the history of the northwest. Lorain was transferred east upon the start of the Civil War, and after receiving a disabling wound in an early battle became a professor at West Point. A leave of absence, no doubt initiated by Coppée through his West Point connections, made it possible for Lorain to spend one year as Lehigh's physics professor.

After the expiration of Lorain's leave, Hugh Wilson Harding was appointed Professor of Physics and Mechanics. Biographical information on Harding is accessible through his sister Rebecca Harding Davis and her sons Richard Harding and Charles Belmont who attended Lehigh and lived with their uncle. Rebecca Harding Davis was a distinguished writer of short stories and novels; her first major work, "Life in the Iron Mills", published in the Atlantic Monthly in 1861, brought quick recognition and she is considered to be a pioneer in the introduction of realism into American literature.[2] Richard Harding Davis was a noted journalist, war correspondent, writer, and more; as a student his grades were never satisfactory and he had an unsuccessful year at Swarthmore; he was accepted for admission to Lehigh after a year of tutoring by Uncle Wilson and at Ulrich's Preparatory School (which specialized in preparing students for Lehigh); after three years the faculty prevented him from returning because of low grades, for which his extensive extracurricular activities no doubt bore the blame; he then transferred to Johns Hopkins for another year of college but again avoided a degree.[3] The biographies of Rebecca and Richard are scattered with information about Professor Harding.

The Wilson-Harding families lived in Washington, Pennsylvania, where Rebecca was born in 1831. The Harding family moved to Big Spring, Alabama, and Hugh Wilson was born there in 1835. The next year the family settled in Wheeling, (not yet West) Virginia. Rebecca married Clarke Davis, then on the editorial staff and later Managing Editor of the Philadelphia Inquirer; the couple initially settled in Wheeling but moved to Philadelphia where their children were born.[2]

Harding attended Washington College (which later joined with Jefferson College to form Washington and Jefferson) and obtained his A.B. degree in 1854. He taught at the Classical Academy in Wheeling until 1866, then became a professor at Bethany College (in West Virginia) until his appointment at Lehigh.[4] He obtained his A.M. degree from Bethany College in 1872.

Harding was a large man with such a resemblance to Napoleon III that he was once mistaken for him while visiting Paris. Although a bachelor, he maintained a house and entertained a wide circle of friends; there Richard met and formed friendships with iron company presidents and congressmen.[5]

Harding was an effective and popular teacher. It was said in the campus newspaper *The Burr* for February, 1883 that he could "with an old tin can, a piece of wire and three inches of rope, explain everything in the course and make it so plain that the dullest man in the class could not fail to understand it."[6] The Epitome for 1889 contained a poem:[7]

> And do not pass without regarding
> The lectures of Professor Harding,
> So lucid, fresh and admir*able*
> And entertaining as a fable, -
> But then his lectures have that zest
> Which springs from his own inter*est*
> In things of which he has to treat,
> Light, electricity, and heat.

In 1877 the School of General Literature was split into the Classical Course leading to a B.A. degree, and the Scientific Course with a B.Sc. degree. A further split is described in the Register for 1882-83. In addition to the Classical Course there is the Latin Scientific Course, leading to the Ph.B. (changing the next year to the B.S.) degree, and the Course in Science and Letters, leading to the B.S. degree. Students in the Classical Course spent about 30% of their time on mathematics, physics, chemistry, geology and astronomy, but the "scientific" courses presented a case of false advertising. The Latin Scientific Course differed from the Classical Course only in the replacement of Greek by German, while students in Science and Letters could avoid the "dead" languages altogether by taking French and German. Thus neither scientific course provided anything which might qualify as a major in physics, or in any science.

It was also in 1877 that a group of alumni went to Asa Packer with a request that the university be converted to a school of engineering. The Founder declined, and the Register has an announcement: "A classical professorship has recently been established by the Hon. Asa Packer."

Descriptions of physics in the Register for 1877-78 include the phrase "With Laboratory Practice." This signaled the beginning of instructional lab work in physics, although earlier Registers mention Meteorology, and Barometric Levelling and Measurement of Heights. The first physics labs were located in Packer Hall.

In 1881 a School of Technology was announced, which contained courses in Civil Engineering, Mechanical Engineering, Mining and Metallurgy, and Chemistry, that is, the technical programs which had previously been called schools.

In 1883 Harding introduced a course on Advanced Electricity, which within a few years developed into the Electrical Engineering curriculum.[8] In the same year his title changed from Professor of Physics and Mechanics to Professor of Physics. According to Catherine Drinker Bowen[9] Harding "held this chair [of Physics and Mechanics] until '83 when he relinquished the charge of the Mechanical Department to Joseph F. Klein and devoted himself to Physics and Electrical Engineering." However it seems very likely that responsibility for the mechanical engineering students on the part of the professor of mechanics had declined since the appointment in 1871 of Charles McMillan as Professor of Civil and Mechanical Engineering.[10] The change in Harding's title may have corresponded with the transfer of a course on mechanics from physics to mechanical engineering. In any case, a Professor of Mechanics was not seen again for many years.

Advanced Electricity was a one-year course and ended with a certificate rather than a degree. There were few entrance requirements "excepting a general knowledge of Algebra, Geometry and Plane Trigonometry and some familiarity with the leading principles of Chemistry." Nevertheless there was extensive coverage of physics including laboratory practice. Subjects included mechanics, heat, light, magnetism, static and dynamic electricity, machines, telegraphy, and electric lighting. The one-year course was not intended for regular Lehigh students, but for "Those persons ... who desire to take up any of the leading industrial applications of Electricity; or those, who having already been engaged in such work, are familiar with the practice, but wish to gain a knowledge of the theory and scientific principles involved..." Evidently the course was taken by industrial employees who had the interest and means to learn about this rapidly- developing field. A list of those who completed the course is given in Registers for the period, following the list of regular alumni.

The 1886 Register contains an announcement of a "New Four Years Course in Physics ... involving a full development of the branches of Physics and Electrical Engineering. This course will begin in September, 1888, and will replace the present one year's Advanced Course in Electricity. A degree will be given with it." The 1888 Register describes "The Course in Physics and Electrical Engineering" but the inclusion of physics was half-hearted and the description ends with "The degree of Electrical Engineer (E.E.) will be given to the graduates of this course."

The course in Advanced Electricity attracted 13 students its first year. The enrollment then dropped to 8, then up to 12, then 23, and jumped to 41 in 1888 when the four-year E.E. course opened. In 1889 enrollment was 75, exceeded only by civil engineering, and in 1894 E.E. was the largest with 136 students. (The figures count freshmen through seniors.)

The increased enrollment required more staff, and in 1884 Harvey S. Houskeeper was appointed Instructor in Physics. Mr. Houskeeper was a member of the class of 1872 and received his B.A. degree with a thesis entitled "On the Science of Language". He served for several years as Superintendent of the High School in South Bethlehem before joining the physics faculty. He left the faculty in 1895 and for a period was Burgess of South Bethlehem.[11]

New space was needed. Saucon Hall (the fourth academic building on campus after Christmas, Packer and Sayre) had been built in 1872 just east of Christmas Hall, and initially provided space for a student dormitory and mess hall. In 1886 physics moved into Saucon, and the next year occupied two rooms of Christmas Hall and its tower for purposes of meteorology.

In 1889 the faculty expanded to three with the addition of Richard O. Heinrich as Instructor in Physics, and the next year to four with the appointment of Dwight F. Carroll, A.M., Instructor in Physics.

In 1891 Harding's title changed to Professor of Physics and Electrical Engineering. This year saw the first graduates in E.E., eight in all, listed below with their thesis titles:

- Murray Blatcheley Augur, *Experiments to Determine the Efficiency of a Novel Motor*
- Jacob Burr Buckley, *Construction and Tests of a Standard Tangent Galvanometer*
- Walton Forstall, *The Thomson-Houston System*
- Paul Depue Honeyman, *Tests of a Thomson-Houston Dynamo*
- Joseph Simonson Lockwood, *A Series of Tests for the Edison Dynamo*
- Frank Anderson Merrick, *Design for an Electric Light Plant for Lambertville, N.J.*
- John Zollinger Miller, *An Original Form of Magneto-Electric Telephone*
- George Edward Wendle, *Investigation of the Westinghouse System*

At some point discontent developed among the students, to the point that they sent a letter of protest to the trustees. Perhaps the rapid increase in enrollment, even with additions to the staff, caused a decline in quality of the program, and it was said that Harding failed to keep up with the latest developments in the new field of electrical engineering. In response the faculty recommended that a separate department be formed, that is, that a Professor of Electrical Engineering be appointed in addition to the Professor of Physics. This the trustees were unwilling to do at the time (but relented a few years later). As a temporary solution, in 1895 Alexander MacFarlane, a well- known English mathematician, was appointed as Lecturer, In charge of the Department of Electrical Engineering.[12] In 1894 all faculty (Harding plus three instructors) had appointments in "Physics and Electrical Engineering", but in 1895 some titles showed a separation of responsibilities; J. Henry Klinck and Henry Storrs Webb were Instructors in Electrical Engineering, and Schuler Stevens Clark was Assistant in Physics. The split into separate departments of physics and of electrical engineering became complete in 1903.

Without a curriculum of its own, physics had been limited mostly to introductory courses. Mayer had taught freshman through seniors, but by 1877-78 the physics offerings consisted of a course for first-term freshmen described as "Deschanel's Mechanics and Lectures. With laboratory practice. (2)" and one for first-term sophomores covering "Heat; Meteorology; Barometrical Levelling and measurement of Heights; Magnetism and Statical Electricity. Lectures, with Laboratory Practice. (3)" Implementation of the E.E. curriculum required advanced courses, with coverage of a range of subjects, and these were developed by Harding with later help from MacFarlane. By 1896 about 40 semester- hours of courses at the junior-senior level were offered, covering advanced E&M, electrical measurements, electrical machinery, alternating currents, telegraphs and telephones, and electric power and lighting. There was a one-credit course on units which no doubt spent a good bit of time dealing with the confusion inherent in the Gaussian system of esu and emu units. Freshman physics had been dropped some years previously but a one-year course for sophomores covered heat, magnetism, electricity and light.

There was an episode of interest to physicists in 1880 for which the responsibility lay not with Harding but with Mansfield Merriman, Professor of Civil and Mechanical Engineering (the next year, Professor of Civil Engineering). Merriman caused to be published in the Bethlehem Daily Times for February 10, 1880, a report of a meeting of the Monocacy Scientific Club, at which Mr. H.E. Licks described his invention called the diaphote. Presiding over the meeting was Prof. L.M. Niscate, and among the dignitaries attending were Prof. M.E. Kannich and Col. A.D.A. Biatic[sic]. The diaphote enabled one to transmit an image over a distance. Receiver and transmitter were arrays of elements, in the first case an amalgam of selenium and silver iodide and in the second a compound of selenium and chromium. There were 72 wires running between receiver and transmitter, and each element was also connected to a battery so a closed circuit could be formed. The transmitting array was placed at the focal plane of a camera. In the demonstration a committee of three carried the transmitter, trailing the bundle of wires, to a lower floor. Various objects, brightly illuminated, were held before the camera and seen by the audience above; these included a kitten, a watch on which motion of the minute hand could be followed and a coin whose date could be read. It is known that Merriman used H.E. Licks for a pseudonym and clearly he was a prankster. But he did have an early vision (not the earliest) of the transmission of pictures over wires, and his hoax had the plausibility to attract considerable attention at the time. He is given credit in a recent history of television.[13]

Harding had begun planning for a new building, for which construction began in 1892. In 1894 physics left Christmas-Saucon for its new quarters, originally called the Laboratory of Physics and Electrical Engineering, then called the Physics Building after E.E. moved into Packard Lab in 1929. Now part of the Fairchild complex, on its centennial the building was named the Lewis Laboratory after W. Deming Lewis, Lehigh's tenth president and a physicist.

Harding retired in 1897, as the university's first professor emeritus, and the trustees provided him with a retirement salary of $1200 per year. Although he left little as a legacy in research, his tenure is notable for the development of the curriculum in electrical engineering, for the construction and equipping of the physics building, and for the expansion of the faculty from a single professor to a staff of five.

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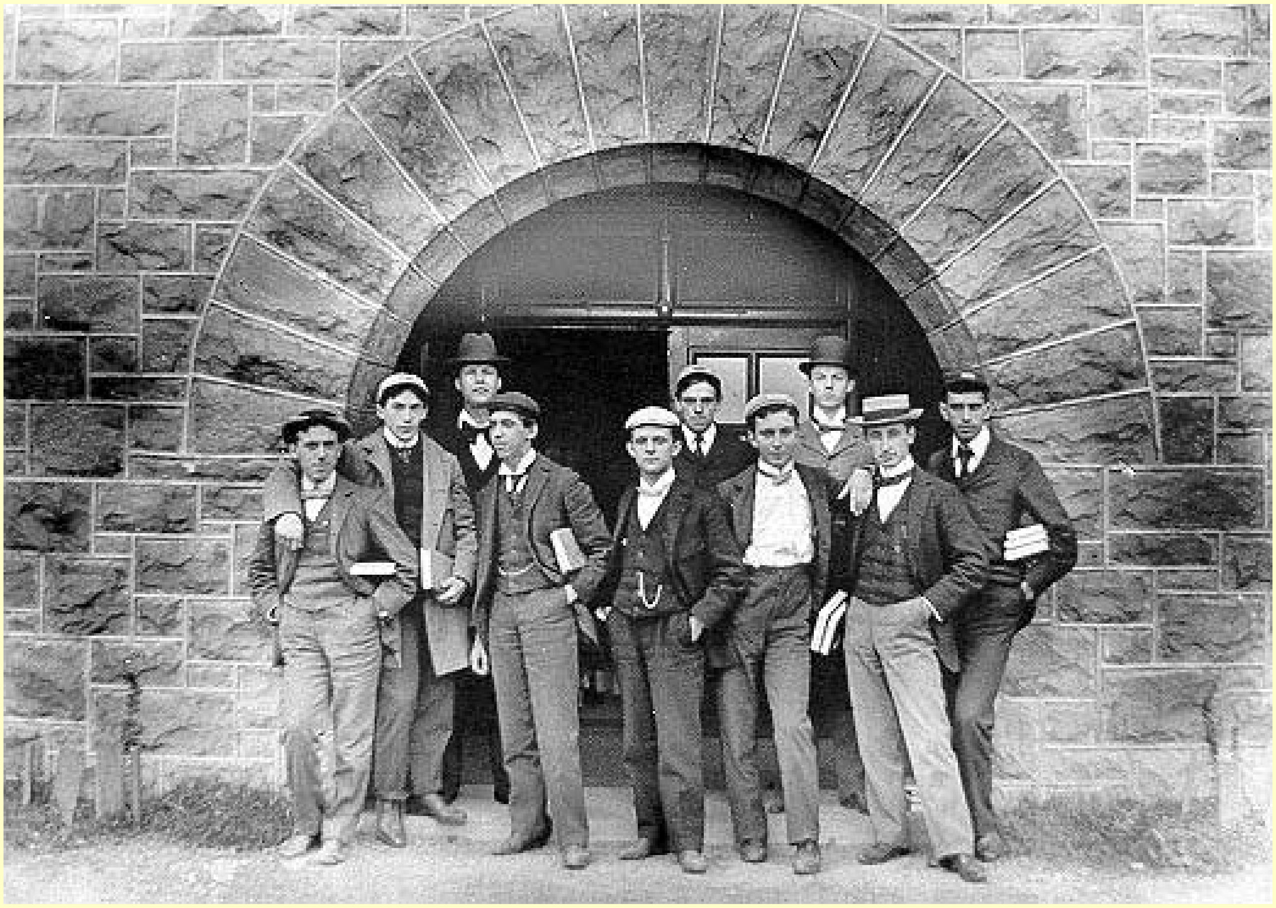
History of the Physics Department



Class of 1899

Left to right: Louis T. Rainey, James C. Holderness, Professor William S. Franklin, Leon W. Bailey, Arthur K. Birch, Eugene Gifford Grace, Abram P. Steckel, (unknown), John S. Viehe, John Wesley Grace

Chapter 4

In 1897 William Suddards Franklin was appointed as Professor of Physics and Electrical Engineering, replacing Harding on his retirement. In the same year MacFarlane's title changed to Lecturer on Mathematical Physics, and he is so listed in the Register through 1907. However after 1898 his address is given as Chatham, Ont., and according to Catherine Drinker Bowen his "illustrious name was erased from the active Faculty list in 1897, through his resignation." Evidently after 1897-98 any duties MacFarlane had were less than full-time.

Franklin was born in Geary City, Kansas in 1863. In 1883 he enrolled at the University of Kansas, with entrance exams so impressive that he was essentially given the standing of a graduate student; his first year he enrolled in mathematics classes at the sophomore, junior and senior levels, and led them all. Before the end of his third year he was acting as an instructor in physics. He received his B.S. degree in 1887 and was appointed Assistant Professor of Physics for a term of three years; his M.S. degree was awarded in 1888, also from the University of Kansas. He then went to Berlin and studied under Max Planck for one year, and held a Morgan Fellowship at Harvard for a year. He was a professor of physics at Iowa State College for five years before coming to Lehigh. In 1901 he received the D.Sc. degree from Cornell.[2]

Soon after his arrival on campus, Franklin began a reorganization and expansion of the catalog of physics and E.E. courses. In 1896-97 (that is, in Harding's last year) a one-year course for sophomores, covering heat, magnetism, electricity and light, was the only course at the introductory level, freshman physics having been dropped some years earlier. The teaching of physics had not developed a coherent and stable form. The stage at which a student might be introduced to subjects such as mechanics, electricity and magnetism, and thermodynamics was variable, and the introduction might be given by a department of engineering or mathematics. Franklin introduced a freshman- sophomore sequence of three lecture-recitation courses, with labs, described in 1899-1900 as: Mechanics; Heat, Electricity, and Magnetism begun; and Electricity and Magnetism, Light and Sound. Except for the omission of quantum mechanics and relativity, which had not yet been invented, the structure and descriptions are close to what is familiar today. The advanced courses for junior and senior E.E. majors were also rearranged and expanded to cover more topics. The subjects of interest at the time included dynamos and motors, power generation and distribution, electric railways, the telegraph and telephone, and the theory of alternating currents. At the graduate level Franklin introduced courses entitled "Theoretical Physics" and "Physical Research" for students seeking an M.S. in Physics, and "Alternating Currents" and "Electrical Testing" for the M.S. in E.E.

Franklin spoke and wrote widely on issues involved in the teaching of physics. The clientele for physics consisted almost entirely of students in engineering, and it is evident that Franklin, aided by MacNutt, gave much thought to the coverage and organization of material and the pedagogy associated with the teaching of physics to engineers. He was active in the Society for the Promotion of Engineering Education and regularly delivered papers to meetings of that society. His early and significant influence on the teaching of introductory physics, and especially on the course of physics for engineers, has been recognized in a recent history of the physics textbook.[4] His interest in physics teaching was not limited to the college level, and he contributed papers to the journal School Science and Mathematics.

The point was reached rather quickly that the E.E. tail was wagging the physics dog. The birth of a separate department began with the appointment of William Esty as Assistant Professor of Electrical Engineering in 1901. At the trustee meeting of June 17, 1903 the department was divided. Franklin's title changed to Professor of Physics while Esty became Professor of Electrical Engineering. Other members of the faculty had titles which included either "Physics" or "Electrical Engineering", but not both as had previously been the case. The two departments thus formed continued to occupy the same building until Electrical Engineering moved to Packard Lab when that building opened in 1929.

Electrical Engineering took with it most of the advanced courses, which had been designed for the purposes of that curriculum. A few, particularly the sequence in alternating currents, were retained by physics and taken by the E.E. students. Franklin added an introductory course for students in the School of General Literature and an additional introductory lab. New advanced courses were introduced to provide sufficient coverage for a major in physics.

In 1902 the School of Technology added a degree program in physics (in addition to that in electrical engineering), graduates of which would receive the degree of B.S. in Physics. However there is evidence for only one student in physics, who switched in his sophomore year to electrical engineering, and at the faculty meeting of December 11, 1905 "On motion of Prof. Franklin the present course [degree program] in physics as printed in the 1905 Register was abolished." At about the same time the Arts and Science program liberalized its requirements. Electives were increased in the B.A. curriculum to the point that a student could take up to 30 credit hours of physics, or other major field. In 1909 under Arts and Science four courses were introduced leading to the degree of Bachelor of Science, described as

1. A course in which the Biological and Chemical Sciences predominate
2. A course in which the Geological Sciences predominate
3. A course in which the Mathematical and Physical Sciences predominate
4. A course in Business Administration

Students completing the third course received a B.S. in Mathematics and Physics; a specialization in either mathematics or physics could be obtained by choice of electives. Of the four courses only Business Administration maintained sufficient enrollment to justify itself, and the Arts and Science B.S. programs were dropped in 1918 when the Colleges of Arts and Science, of Business Administration and of Engineering were formed. The B.A. was then the only avenue for a student of physics, until the introduction of Engineering Physics in 1924.

The first degrees in physics were awarded during Franklin's tenure. In 1898 M.S.'s were given to Barry MacNutt and Henry Storrs Webb, whose theses were titled respectively *A Study of Galvanic Polarization* and *Hysteresis Loss in Soft Iron for Small Ranges of Induction.* Apparently the first degree at the bachelor's level was the B.S. given in 1915 to William Stauffer More, whose thesis was entitled *Viscosity of Oils*. A B.A. with major in physics was given in 1917 (when Franklin had been succeeded by MacNutt) to Thomas G. Ralph, whose thesis had the title *The Recovery of a Bidwell Selenium Cell*. The first degree in Engineering Physics was awarded in 1925 to George J. Leshefka.

Franklin had broad interests, and subjects covered by his research papers extended across elasticity, vibrations and sound, E&M, magnetism, diffraction, optics, acoustics, thermodynamics and fluid dynamics. His publications are mostly theoretical but a few reported on experimental work. He was a prolific writer of books, some as sole author but most with one or more co-authors. His first, co-authored with Edward L. Nichols[3], was *The Elements of Physics; A College Text-Book* which appeared in 1896-1897 and went through three editions and six reprintings until 1913. Subsequently texts and manuals on physics and on electrical engineering, at introductory and advanced levels, came at a rate of nearly one per year. A number of these were written with Barry MacNutt, who joined the faculty in 1899 and became Franklin's successor.

Some of Franklin's publications have shown impressive durability. For example his 1903 Physical Review article on acoustics was cited as recently as 1988.[5]

In an 1898 review of a book by Pierre Duhem[6], Franklin made some remarks which would be familiar in the context of today's theory of chaos but are remarkable for their early date. He says that "A state of unstable equilibrium is produced by the heating of the lower strata of the atmosphere." and "..an infinitesimal cause may produce a finite effect." He then goes on to say "Long range weather prediction is therefore impossible, and the only detailed prediction which is possible is the inference of the ultimate trend and character of a storm from observations of its early stages; and the accuracy of this prediction is subject to the condition that the flight of a grasshopper in Montana may turn a storm aside from Philadelphia to New York!" The butterfly effect was introduced by Edward Lorenz in the 1970's to illustrate the sensitive dependence on initial conditions which is at the heart of chaos[7]; the grasshopper effect is the same except for the insect and geography, and of course, perhaps because of its early date, it had much less influence on the progress of science.

For the popular market, Franklin collected a few essays into *Bill's School and Mine*. One of the essays had been published as "A Tramp Trip in the Rockies" and describes a month- long hike in Colorado taken by Franklin with one of his students; "Bill's School" is the great outdoors. Youth and nature were abiding interests of Franklin's.

Franklin's warm interest in young people is illustrated by Bowen's comments:[8]

> "Professor Franklin has appeared to the writer, since her childhood days, as a man of marvels, a miracle worker. When she was about nine years old he took her one day into that house of magic, the Physics Laboratory. Leading her upstairs to a long room, full of strange and awful machines and devices, the Professor walked over and touched a match to a gas jet, from which there sprang immediately a tall, hissing flame.
> 'Now you stand over there', he directed; 'and go smack, smack with your lips, and watch this flame,- and it'll just up and answer you!'
> The writer complied, and thus was early introduced to the mysteries of the sensitive flame. After this, by hanging around the door at auspicious times, she was allowed to witness more magic; the magician, by drawing the edge of a violin bow across the edge of a steel plate on which sand was sprinkled, could make the sand form pleasing patterns, and,- Oh crowning delight! The Professor one day let her blow some glass and take home the result."

Franklin was a member of the Parks Commission and worked for the establishment of playgrounds. Wishing to use Sand Island in the Lehigh river as a park, he started a movement to purchase at least part of the island for that purpose. In this endeavor he encountered an obstacle in the person of General William E. Doster[9], a prominent attorney and owner of Sand Island. The price asked, of $20,000 for three acres, Franklin felt to be exorbitant; he also took issue with Doster over actions which threatened the ecology of the Monocacy creek and Sand Island. His indignation was expressed in a letter to the President of Bethlehem Town Council and in a pamphlet which he had printed and circulated. He was severely chastised by President Drinker for "publicly and virulently attacking General Doster, a gentleman of high standing and a good friend of our University." Furthermore his statements "injure our University by holding out to the world that we have in our Faculty as one of its senior members, a man of unbalanced and erratic judgement."[10] The attack on Doster by Franklin was not nearly so virulent as that on Franklin by Drinker. Franklin prevailed, as a portion of Sand Island was obtained by the city and a park installed there, which was named Franklin Park in 1916.[11]

During Franklin's tenure a toy cannon using carbide gas, eventually called the Big-Bang Cannon, was invented and brought to market. This development was primarily due to James Hunter Wily who joined the physics faculty in 1906, but in 1907 Franklin obtained a patent for a "new and useful Improvement in Gas-Guns." Wily made significant improvements in the design and kept a cannon of his design and construction on his desk. On seeing the toy, Vice President Natt Emery encouraged Wily to take it to market, emphasizing Wily's duty to provide a safe substitute for the fireworks which were responsible for so many injuries during Fourth-of-July celebrations. In 1912 Wily formed the Gas Cannon Company, which in 1924 became the **Conestoga Company** and still manufactures the Big-Bang Cannon. Wily left the faculty in 1920 and remained in charge of the company until 1955.[12]

At some point ill-feeling developed between Franklin and Esty, which grew into a major feud.[13] One issue is well-documented: Esty attempted to have the junior course in electricity, taken by both mechanical and electrical engineers, transferred from physics to electrical engineering on the grounds that Franklin had dropped coverage of the magnetism of iron; this Franklin claimed had been done because an exhaustive treatment of the subject was not needed by the mechanicals; furthermore, according to Franklin, it had been done with Esty's knowledge, approval, and understanding that the subject would be taught to the E.E.'s by Esty. What may have been a deeper problem is revealed in a letter from Franklin to President Drinker: "I have hesitated up to this time to go into this matter of the magnetism of Iron for the mechanical engineers because it may necessitate my entering with you and with the Board of Trustees a formal charge of serious incompetency against our Professor of Electrical Engineering." Subsequently Franklin drew up a list of charges against Esty and the matter was taken to the trustees. A committee of trustees was formed and chaired by E.G. Grace, Franklin's former student and future Chairman of the Board of Trustees (and future Chairman of Bethlehem Steel). The committee held a meeting on July 19, 1915, lasting from 8 p.m. until midnight, to which all trustees and faculty were invited. The support Franklin sought was not given, and within a week he resigned and took a professorship at M.I.T. The Board, in consideration of his "long, continued, faithful, and able services to the University", awarded Franklin an honorarium of one year's salary.

The Franklin-Esty controversy aroused much interest and strong feeling among the alumni, particularly those who had graduated from the E.E. program. There were meetings and conferences on and off campus, and many letters written to the president. A few letters supported Esty, or supported the president and trustees in their handling of the matter, but the dominant reaction was dismay at the loss of Franklin: Lehigh had lost an outstanding teacher and researcher; it was primarily Franklin who had constructed the E.E. curriculum as it then existed and he was the main asset of the E.E. department; his reputation attracted students and assured that they would be well-received on graduation. A letter from President Drinker replying to one alumnus upheld Esty on the grounds that the E.E. graduates did well and "the proof of the pudding is in the eating", to which the rejoinder was: "If the pudding is any good, Prof. Franklin is the man who has made it so." Another alumnus said "I feel terribly, terribly grieved. Grieved far more for Lehigh than for Franklin."

Franklin retired from M.I.T. in 1929 and took a position as visiting professor at Rollins College. While returning from Florida after the end of the academic year, he was killed in an automobile accident.

Franklin was the first recipient, posthumously, of what is now called the Oersted Medal, given for excellence in teaching by the American Association of Physics Teachers.[2] A plaque[14] commemorating the award hangs on a wall near the physics department office, and a duplicate plaque is located at M.I.T.

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History of the Physics Department

Barry MacNutt

Chapter 5

Barry MacNutt joined the faculty in 1899 as Instructor in Electrical Engineering. He became Instructor in Physics in 1903, then Assistant Professor in 1906 and Associate Professor in 1909, and was appointed Professor of Physics on Franklin's departure in 1915. MacNutt had obtained his E.E. degree in 1897, then an M.S. in 1898, both from Lehigh.

MacNutt has appeared briefly in the previous chapter as Franklin's co-author of a number of texts, and he is due some credit for the development of an introductory sequence of modern form. In addition he was responsible for the creation of the curriculum in Engineering Physics, following the failed attempts by Franklin to establish a viable physics program.

A program in physics could provide background for graduate work, but only a few students would be attracted for that purpose alone. The viability of a new program would depend strongly on the employability in industry of its graduates. In 1922 and 1923 MacNutt wrote to directors of a number of industrial and government research labs. Outlining his ideas for a program in physics, he asked for suggestions for improvement, and asked the critical question: "Would you hire a graduate of a physics program?."

The response to MacNutt's proposal was uniformly favorable. A typical example is the comment from the Bureau of Standards (now NIST) that "there is a growing demand in industry for young men who are well grounded in physics." A variety of suggestions was made regarding the details of MacNutt's proposed curriculum, some wanting more of engineering and applied subjects and others emphasizing the importance of fundamentals.

The "growing demand in industry" was unquestionably responsible for the success of Engineering Physics, just as its lack (perceived if not real) was responsible for the failure of earlier physics programs.

MacNutt submitted his proposed curriculum in June of 1923, under the title Physics for Engineering Development. The Committee on Educational Policy carried the proposal forward with a change of title to Engineering Physics, and in September the faculty approved the curriculum. In a letter to MacNutt of the same date as the recommendation from the Committee on Educational Policy, John Mills of Western Electric had said "I think the course is an excellent basis for what we might call engineering physics." Evidently the term "engineering physics" surfaced and caught on during the summer of 1923.

The Register for 1923-24 (published in the spring of 1924) lists the curriculum and two students, a junior George J. Leshefka and a sophomore Malcolm K. Gordon. Leshefka became the first recipient of the B.S. in E.P. degree at the June commencement of 1925.

Curricula in Engineering Physics were introduced elsewhere in the same year as at Lehigh, and a number came later.[1] In some cases there are separate departments of engineering physics. The most common feature is a close association with a college of engineering which provides a source of students and induces an appreciation of the applications of physics.

The Register contains an introduction to the curriculum which describes its purpose:

> The recent growth and expansion of industrial research laboratories, in which methods and apparatus are investigated and developed for engineering application, has caused a large demand for young men capable of attacking the problems arising in these laboratories. The aim of the Curriculum in Engineering Physics is to provide the training necessary for this kind of work; it also provides a training which will prepare young men eventually to follow a career of pure science.

The history and philosophy of the curriculum, and its relation to engineering, is covered in a talk given by MacNutt's successor, Charles C. Bidwell, to the Society for the Promotion of Engineering Education. The Engineers' Council for Professional Development had just begun to accredite programs in engineering, and Bidwell makes a case for the accreditation of Engineering Physics as an engineering curriculum. Ultimately the ECPD (now ABET) added Engineering Physics to its list of accreditable curricula.

Enrollment in the E.P. curriculum grew steadily. Within a few years it passed chemistry; beginning in the thirties and continuing to 1941 and the beginning of World War II, from six to twelve degrees were awarded annually. During the post-war period the senior class grew past twenty and briefly exceeded thirty. The E.P. degree, at Lehigh and elsewhere, was no doubt responsible for attracting a significant number of students into physics who might otherwise have gone into a field of engineering.

Lehigh's E.P. curriculum evolved into an (unmodified) physics curriculum, with some exposure to what it is that engineers do, but without the courses in practice and design which came to be required by the accrediting body. It differs only in minor respects from the major in physics offered to students in the College of Arts and Science, but the E.P. enrollment has usually been substantially greater than that in the physics major.

MacNutt's strengths were in teaching and curricular development. He did little in research nor did the rest of the department during his tenure as Head. Bidwell was brought in by President Richards to build up research, and MacNutt left on Bidwell's arrival.

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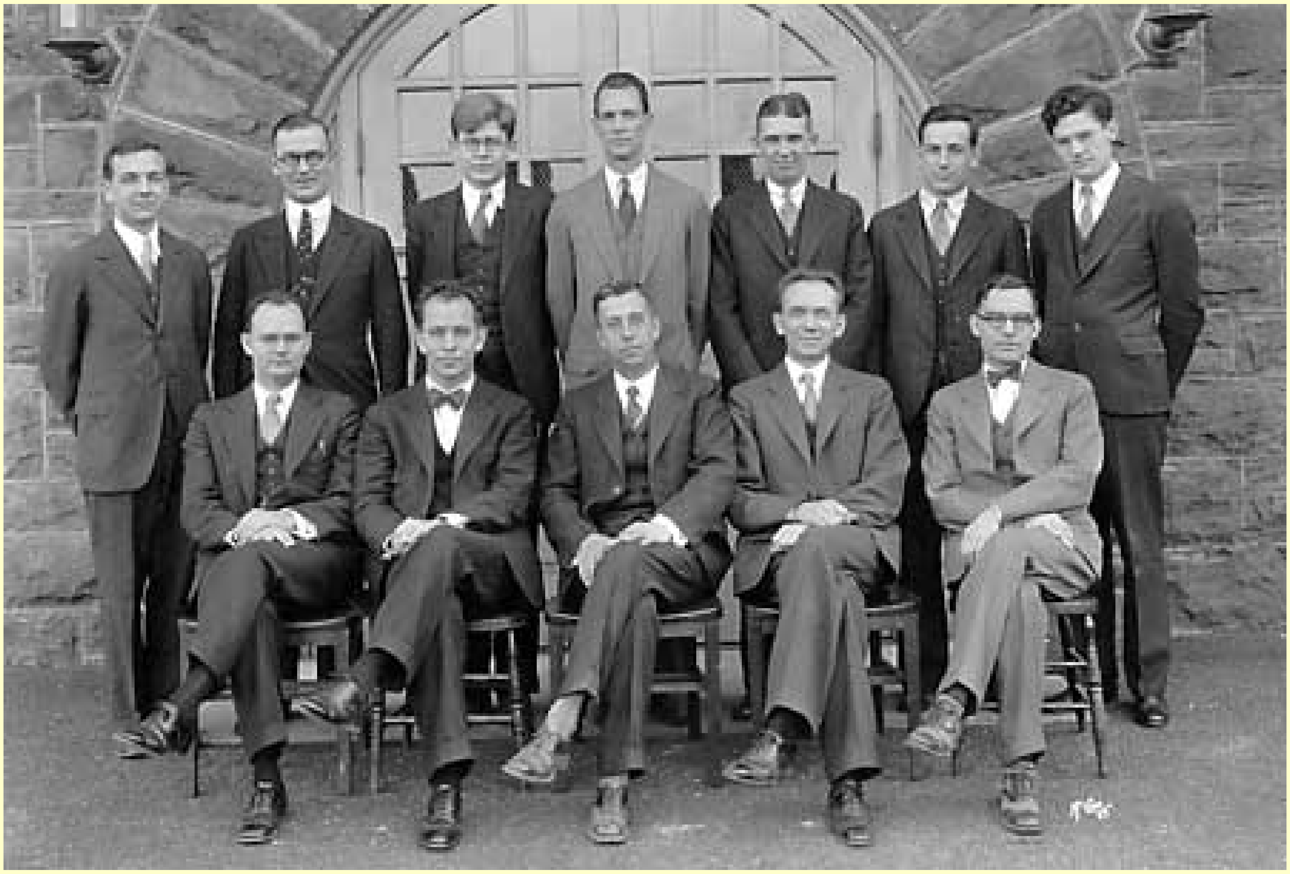

The Faculty, 1933

Left to right, back row: Snavely, Berger, Ewing, Frey, Scott, Crary, Kelly
Front row: Carwile, Bayley, Bidwell, Petersen, Larkin

Bibliography

Notes for Chapter 6

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Chapter 6

Charles Clarence Bidwell came to Lehigh from Cornell in 1927, with a charge from President Richards to rebuild the department.[1] Evidently ample resources and support were supplied by Richards as major changes were made in the staff. Paul Leverne Bayley and Robert Lewis Hanson came with Bidwell from Cornell as associate and assistant professors respectively, and in addition Bidwell hired Preston Banks Carwile and Max Heinrich Petersen as assistant professors, plus William Bender, John Charles Clark and Louis Arthur Pardue as instructors. Four graduate assistants were also appointed. Two years later three assistant professors were added plus as many instructors. Overall the instructional staff expanded to 16, *vs.* 11 in MacNutt's last years.

Leaving in the year of Bidwell's arrival were MacNutt and four other members of the faculty at the rank of instructor and above. By 1930 the turnover was complete with the staff consisting entirely of Bidwell and his appointees.

At the time of Bidwell's arrival, an undergraduate interested in physics had two paths available, leading to the B.A. with major in physics or the B.S. in Engineering Physics. Neither program had a significant enrollment at the time, and Bidwell took steps to increase interest in physics. He was particularly impressed by the potential of the E.P. curriculum, which had been started by MacNutt only three years earlier (see his talk on the subject). A description of the E.P curriculum was distributed to "the technical high schools and preparatory schools of the country so as to better acquaint the graduates thereof with its possibilities," and was also sent to the major industrial and research labs "so as to secure their cooperation in ... placing our men after their graduation." Bidwell also prepared a booklet entitled "Physics as a Career" to be distributed to freshmen and high-school students. A physics club (later associated with the national Society of Physics Students) was formed and held its first meeting on December 17, 1928 when the audience was addressed by Prof. Floyd K. Richtmyer of Cornell. A meeting of the club later that academic year had as speaker Dr. Nicholas Hunter Heck of the US Coast and Geodetic survey, and in 1931 it was decided to assist the club in arranging programs for five meetings during the year. Measures such as these paid off and significant increases in enrollment were seen, particularly in the E.P. curriculum.

An indication of areas of interest at the time is given by the schedule for the Freshman Engineering Conference in the spring semester, 1928. In addition to several research projects, tours included demonstrations on:

Tesla coil and electric waves- Bidwell
Barkhausen effect- Scott
Short wave set- Bender
Crookes tube, cathode rays, fluorescence, etc.- Carwile
Cathode ray oscillograph, magnetostriction effect- Webb
Alpha ray tracks- Petersen
Brownian movement- Bayley

Amplifier effect- Bender
Photo-electric cell, music over a beam of light- Hanson
X-ray tube- Martin

New research programs in several areas started up soon after Bidwell's arrival. Publication was even stimulated from some long-time members of the faculty for whom there is little evidence of previous research productivity. Bidwell himself established a program on thermal conductivity of solids, mostly metals, which lasted well past his retirement. Bayley's work included the Raman effect in various liquids, and the generation by X-rays and properties of color centers in insulating solids. Bayley and Bidwell also published a text, *An Advanced Course in General College Physics*. Other members of the staff published on electronics and instrumentation (Bender, Martin, Carwile, Scott, Larkin, Frey), electronic discharges in gases (Pardue, Webb, Frey), crystallography (Davidson), and various properties of solids (Osteen, Crary, Petersen) including anthracite (Myer). The most significant research story is that of Maurice Ewing and geophysics, which will be told separately.

Appointments with the title "Graduate Assistant" were made for the first time by Bidwell. This corresponds with a greater emphasis on graduate work and formalization of the graduate program along lines which are familiar today. Earlier there had been the position of "Assistant," dating back to Harding's tenure, but it was not designed particularly for students seeking a graduate degree. Some early recipients of the M.S. degree did their graduate work while holding the rank of Instructor, and some of these had previously held the rank of Assistant. Other graduate students evidently came with their own support. The graduate assistantships carried a yearly stipend of $1000 plus remission of tuition. A flyer announcing their availability, plus that of the New Jersey Zinc Company Research Fellowship, was printed and circulated. (The early graduate assistants would today be referred to as teaching assistants, while the term graduate assistant now includes both teaching and research assistants.)

Since its beginning the university had accomodated resident graduates, and graduate degrees were announced in the Register for 1877-78. The first graduate degree awarded was the M.A. given in 1882 to Thomas Hughlett Hardcastle. In 1895 the first Ph.D. was given to Joseph W. Richards in metallurgy and a second Ph.D. was awarded the next year to Herman E. Kiefer in chemistry. The first graduate degrees in physics were M.S.'s awarded in 1898 to Barry MacNutt and Henry Storrs Webb. Financial problems brought on by the depression of the early 1890's forced a severe cutback in the graduate program; the Ph.D. was dropped and production at the master's level was slight. By 1930 graduate enrollment increased to the point that the question of offering the Ph.D. was raised again. Within the physics department the general opinion seemed to be that the department should not push the matter but should not hold back the other departments should they desire it. An increase of at least one member in the staff and funds for the purchase of research equipment were considered necessary for the carrying out of such a program. In 1936 the department became more enthusiastic and agreed upon requirements for the Ph.D. in physics. In 1938 the first Ph.D.'s given by the university since Richards and Kiefer were granted to four students, two in chemistry and two in metallurgy. The first Ph.D. in physics was given in January of 1943 to John Brackett Hersey, and the second in October of the same year to Robert August Buerschaper.

In November of 1929 the librarian agreed to the establishment of a reading room in the physics building to contain current periodical literature.

A remodeling of the building took place during the summer of 1930. This involved installlation of permanent benches or tables, and sinks and fixtures in various labs; gas and air lines were also installed. Minutes of the faculty meeting of April 5, 1929 contain the statement "The meeting was called to make a survey of the teaching conditions following the recent fire." However evidently the fire was not extensive and any damage was repaired during the remodeling, which had been planned prior to the fire.

Lehigh was of course adversely affected by the Great Depression.[2] Enrollment declined from 1569 in September 1929 to 1327 four years later and there were reductions in alumni giving and endowment income. From 1929 to 1934 the number of teaching positions dropped from 144 to 125. The Office of Admission was formed in 1934, and by virtue of its recruitment efforts enrollment recovered to the point that in the fall of 1936 it stood at 1634. However there were few raises or promotions, and stringent restrictions were imposed at budget-making time.

The expense budget for the department fell from $10,000 in 1930-31 to $3500 in 1934-35. The salary budget declined from $42,500 in 1928-29 to $36,550 in 1933-34, and the teaching staff declined from 17 in 1929-30 to 10 in the fall of 1933. There had been five graduate assistants just prior to the depression but the number gradually declined and none were appointed for the 1935-36 academic year. In a letter of January 10, 1936 to President Williams, Bidwell says " The most serious effect of the constriction of our staff and the elimination of assistants has been the immediate cessation of graduate work."

In December, 1933 Arnold (Al) Leeming was appointed as Mechanician at a salary of $1500/year. The budget was helped since he replaced George R. Gilbert who had resigned at a salary of $2000. Al remained as director of the physics shops, with responsibility for student instruction as well as equipment construction, until his death in 1967.

During the late 1930's economic times began to improve. Two graduate assistants, Allyn C. Vine and Norman H. Webster, were appointed in the fall of 1936. For 1937-38 there were four graduate assistants and 14 total on the teaching staff, and the next year the teaching staff regained its 1929 level of 17. The graduate and research programs appeared to be on their way to a recovery, but then were interrupted again by World War II.

One response to the war by the university was an accelerated program announced in the Register for 1941-42. Three sixteen-week semesters were scheduled, enabling a student to complete work for a bachelor's degree in 32 months.

Some students obtained deferments to the end of a semester or school year, but eventually the campus at Lehigh, as elsewhere, was nearly emptied of civilian male students. Civilian enrollment dropped from 1770 just prior to the war to 472 in the fall of 1943, then to 362 the next spring. There was partial compensation when a unit of the Army Specialized Training Program was assigned to Lehigh. Instruction began in July 1943 and continued until the next summer. About 1500 student/soldiers were assigned to Lehigh during the 1943-44 school year, but the number attending at any one time was considerably smaller.[3]

The ASTP program was divided into three curricula: Basic Engineering, Advanced Engineering, and Foreign Area and Language. It was broken into twelve-week quarters, and the courses covered material at the freshman and sophomore levels. The requirements could not be met by the regular courses already in existence, so new courses had to be developed on short notice. In addition to its regular courses, the physics department offered three ASTP courses:

AST 304 Mechanics
AST 305 Heat, Sound, and Light
AST 306 Electricity and Magnetism

The scheduling of teaching assignments was complicated by the need to handle both regular courses with sixteen-week semesters, and ASTP courses with twelve-week quarters. Much of the teaching staff left to join the military or to take war-related jobs. Teaching loads were high, with contact hours per week even reaching into the low 30's. The university was short-handed but the physics department apparently more so than most as people from other departments were called upon to teach physics. Some examples are Alfred C. Callen (Dean of the College of Engineering), Robert Gallagher and Eric Sinkinson from Mining Engineering, Harry G. Payrow (father of the Bethlehem mayor H. Gordon Payrow), Arthur Ippen and Eugene Uhler from Civil Engineering, Cornelius Brennecke, Jacob Beaver and Howard Gruber from E.E., and Clarence Shook from Mathematics.[4] In addition, undergraduates were used as "Graduate Assistants": Robert Maiden and Albert Thalhamer taught Physics 23 in the spring of 1942 and received B.S.'s at the end of that semester while Maynard Arsove, who also taught in the spring, 1942 semester, did not receive his B.S. until 1943. There are additional names which appear on the teaching sheets for only one semester but cannot be identified from other records.

In 1942 Elliott Cheney joined the faculty as Associate Professor, and Peter Bergmann as Assistant Professor. After two years Bergmann left for a war-related job. By 1944 the teaching staff was down to two professors, Bidwell and Cheney, with help from Buerschaper as sole graduate assistant.

Bergmann was an assistant to Albert Einstein and wrote an important and popular text on relativity theory. His son Ernest, now at Lucent, was born during his tenure at Lehigh and later was a member of the physics department for about twenty years. Peter Bergmann's most famous student was no doubt Lee Iacocca, who in his autobiography[5] devotes nearly a full page to Bergmann and little else to his other professors. Iacocca had trouble with physics but developed a strong feeling of friendship for the physics professor: "We would walk around the campus, and he would describe the latest developments in physics." There is a story about Bergmann which was part of departmental folk lore in the late 1940's. It has been denied by Bergmann but not emphatically, and its wide circulation indicates a kernel of truth. Lecturing to a class on the fourth floor, Bergmann sat gently rocking on the wide ledge next to an open window when suddenly he rocked too far and disappeared from view. As the class sat stunned in horror, a hand reached in still holding the piece of chalk, Bergmann crawled back and calmly continued with the lecture. According to the story, workmen had erected a scaffold which provided an ample platform just outside the window.

Previous

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Geophysics

William Maurice Ewing arrived in 1930 as Instructor in physics and initiated a program in geophysics which grew to major proportions.

Charles Bidwell, head of the department, wished to include coverage of geophysics in the physics program and had introduced some topics of geophysics into his advanced laboratory in the spring of 1930. The mining and geology departments were enthusiastic about the appearance of a geophysicist on campus. There is some earlier background which is relevant to the story. In 1895 William Bowie graduated from Lehigh with a degree in Civil Engineering. He became Chief of the Division of Geodesy of the U.S. Coast and Geodetic Survey and was one of the founders of the American Geophysical Union. The highest honor given by the AGU is the William Bowie Medal and Bowie himself was the first recipient. Nicholas Hunter Heck received a B.A. from Lehigh in 1903, a C.E. in 1904, and also joined the Survey where he became Chief of the Division of Geomagnetism and Seismology; he visited campus regularly and had addressed the student physics club in 1929. (Heck is listed in the Register as Lecturer on Geophysics for 1938-39 through 1945-46, but no description of his duties in this position has been found in the records.) Heck and Ewing ultimately became recipients of the Bowie medal, and the Maurice Ewing medal was established by the AGU in 1974.

Ewing was born to a Texas farming family, and became the eldest of seven children after the death of the oldest three. In spite of the family's limited circumstances, all children but the oldest daughter, who married young, attended college and had successful professional or academic careers. At the age of sixteen Maurice entered Rice Institute (now University) and was awarded a scholarship. He majored in electrical engineering for two years but enjoyed contact with the physics professors and switched to the physics major. He received his bachelor's, masters and doctoral degrees from Rice, the last in 1931. He spent a year at the University of Pittsburgh before moving to Lehigh.

Although he took no courses in geophysics, Ewing had become interested in the subject while at Rice. The title of his Ph.D. thesis was *Calculation of Ray Paths from Seismic Travel-Time Curves*. He spent some summers working with an oil-prospecting crew in shallow lakes along the Gulf Coastal Plain, exploring the underwater geology by the technique of seismic measurements following a controlled explosion. Explosion seismology had been developed by the oil companies not many years earlier and Ewing was among the first investigators to apply it underwater.

Ewing quickly made a strong impression at Lehigh, as indeed it seems he did everywhere. In a letter regarding the budget to President Richards dated January 30, 1931, only a semester after Ewing had joined the department, Bidwell referred to "... the case of Maurice Ewing who has turned out to be an unusually valuable man and one whom we should make an effort to retain permanently... Ewing has a thorough grasp of modern theoretical physics, is an excellent teacher and is thoroughly well liked by students and staff associates. He received an offer last summer of $3500 from one of the Texas oil companies and just recently showed me a letter from a Geophysics Exploration Company, of Beaumont, Texas, urging him to come with them and set his own salary. His inclination, however, is for university work... In addition to his interest in geophysics, Ewing has some interesting work on 'electrets' under way... I am hoping that we may be able to make him an assistant professor at an early date." Bidwell requested a raise from Ewing's starting salary of $2000 to $2500 per year but times were tough and advancement slow; 1932 saw a salary increase to $2200 and 1936 brought promotion to Assistant Professor at a salary of $2500.

Initially Ewing taught introductory courses, including recitations and in some semesters the large introductory lectures, and advanced lab. By modern standards his teaching load was high, initially 13 contact hours per week and once reaching as high as 21, but about the same as that of other young faculty members who, according to the custom of the times, were expected to work longer hours than their seniors. A sequence on geophysics, Physics 150 and 151, was introduced in 1933-34 with the description "The application of physical measurements to the study of geologic structures. Special emphasis is placed upon the seismic method. The course is designed for advanced students in geology, mining, and physics." This sequence was made part of the mining curriculum. The program of instruction and research in geophysics as it existed in 1937 was described by Ewing in the Lehigh Alumni Bulletin.[1]

Ewing's first two papers with a Lehigh address were written with L. Don Leet of the Harvard Seismograph Station. They cover theory and analysis of data from the Gulf Coastal Plain[2] and seismic experiments done in Massachusetts and Rhode Island[3] during the summer of 1931. Ewing then turned his attention to the resources and opportunities in the local area. In 1934 there were two papers[4] with A.P. Crary (M.S., 1933), the first also with A.M. Thorne (B.S., 1932), on elastic waves in ice, the measurements being done on laboratory ice and on lake ice at Saylor's lake; continuation of this work was described in a 1935 paper[5] with Crary and E.B. Douglas (B.S. 1932, M.S. 1933). In 1934 Ewing and Crary reported on results of explosion seismology in the area around Green Pond.[6] Advantage was taken of quarry blasting in the cement belt north of Bethlehem and Allentown for "a seismological investigation which may be considered as intermediate between seismic prospecting and the study of earthquakes;" this work was reported in a 1934 paper[7] with Crary and J.M. Lohse (B.S., 1933) and a continuation[8] in 1935 by Ewing and Crary. A paper[9] in 1936 with Crary (now at the Independent Exploration Company in Houston), Joe Webb Peoples (previously Instructor in the Department of Geology) and James Alexander Peoples (a brother-in-law of Ewing's and Instructor in the Department of Physics for 1938-1940) dealt with prospecting for anthracite by measuring the resistivity of the earth. A 1936 paper[10] with H.H. Pentz (B.S. in Mining, 1933; M.S., 1939) reported on "a large magnetic anomaly" found in the Hanoverville area north of Bethlehem, and another paper[11] that year by Ewing described seismic studies done in the same area to determine the velocity of elastic waves in limestone. A 1938 paper[12] by Ewing described work done "several years ago" with Crary and J.W. Peoples using magnetic measurements to locate a power shovel which had been buried by a landslide in an anthracite strip mine.

In the papers just cited thanks are given to the National Research Council for a grant-in-aid, the Geophysical Research Corporation for providing seismic instruments, the Trojan Powder Company for explosives, and "practically all of the cement and crushed-stone manufacturers in this region" for their generous cooperation.

Development of theory was necessary for interpretation of the seismic data. The theoretical problem is that of wave propagation in an inhomogeneous material, frequently simplified to a layered medium. Ewing was a strong theoretician, indeed his Ph.D. thesis was theoretical and theory was included in the early papers just mentioned. Lake ice was an early object of Ewing's attention and was no doubt chosen because uniformity of the ice layer and accessibility of the parameters make it an ideal model for study of seismic waves, whether from controlled explosions or from earthquakes. Ewing was a leading contributor to the theory of wave propagation in layered media, which has applications extending beyond geophysics.[13]

The work outlined above added to the knowledge of geology in the local area and of the properties of some materials of geological interest. It also enabled Ewing to develop his geophysical skills and techniques, including the theory of the propagation of seismic waves.

A problem and opportunity of great significance lay waiting at the bottom of the sea. At the time knowledge of the ocean floor and its geology was limited. Depth to the bottom could be determined by dropping a line or with sonic methods. The Coast and Geodetic Survey had found some deep gorges off the Atlantic coast, east of Virginia, which showed that the ocean bottom was not totally featureless and stimulated the curiosity of geologists. Little was known about the deep ocean bottom or the structure of the ocean floor.

In November, 1934, Ewing was visited by Richard Field and William Bowie. Field was a professor of geology at Princeton with an interest in the oceans (and a later recipient of the Bowie medal). Recognizing that submarine geology presented a rich opportunity for research, Field initiated the formation of and chaired a committee of the AGU on the Geophysical and Geological Study of Oceanic Basins. Bowie and Heck were members of the committee, and Heck wrote an appendix to its report.[14] The committee suggested several geophysical techniques as being of primary importance in their adaptation and perfection for work at sea. One of these was "Artificial seismic methods," of which the committee said "Too great stress can not be laid upon immediate research as to the application of this method to the study of (1) the thickness of coral reefs on continental margins and oceanic islands, and (2) the study of the drowned continental margins and the floors and substructures of oceanic basins."

Someone was needed to implement the proposal. Ewing had the necessary background and talent but he was young and not widely known. He was however known to Field, Bowie and Heck, perhaps best known to Heck who visited campus regularly. In a budget letter of January 29, 1935 Bidwell cited the visit from Field and Bowie as evidence of Ewing's increasing recognition and said "... a proposal originated in ... a committee of which Professor Field of Princeton is chairman and was carried to Drs. Bowie and Heck of the Coast Survey and thence led to the selection of Ewing as the best man to do the work."

Field and Bowie asked if explosion seismology could be used at sea.[15] Ewing said yes, if he had the equipment and ships. The Survey owned a steamer *Oceanographer* (formerly J.P. Morgan's yacht *Corsair*) which was in use off the Atlantic coast. It was arranged that Ewing spend two weeks, beginning June 17, 1935, on *Oceanographer*. The party on board included Crary, Heck ("whose broad experience in scientific work at sea enabled him to give much valuable advice and assistance") and H.M. Rutherford from the University of Pittsburgh. Financial help was provided by the Geological Society of America and equipment was donated by the Geophysical Research Corporation.

While they were on route to port, the captain of *Oceanographer* and an assistant who had been expected to help Ewing had an automobile accident which injured the captain and killed the assistant. The ship was put under command of the Executive Officer who continued its regular survey schedule, and Ewing's work was limited to night-time while at anchor.

The procedure was to lower an explosive charge to the bottom some 500 feet from the ship, and detonate the charge by means of a cable connected to the ship. Waves were reflected from bedrock, which supported a bed of sediment, and detected by geophones on the bottom underneath the ship. In spite of the limited schedule, useful results were obtained regarding the depth to the rock and the value of explosion seismology for study of the ocean bed was established.[16]

In a different approach, called the refraction method, waves are detected which have been refracted and travel more-or-less horizontally through one or more layers of sediment or rock. This gives more complete information than the reflection method, but requires that the charge be placed as much as several miles from the detector.

The voyage on *Oceanographer* made the need apparent for a vessel more adaptable to Ewing's requirements. Accordingly Field convinced the director of the Woods Hole Oceanographic Institution to put their vessel *Atlantis* at Ewing's disposal for a two- week period in October, 1935. The scientific crew consisted of Ewing, Crary and Rutherford. Refraction surveys were made along a line extending south 90 miles from Woods Hole and one extending out 150 miles from Virginia. During the interim between the *Oceanographer* and *Atlantis* voyages Ewing made land measurements in Virginia so the structures under land and under water could be tied together. Consequently a section was obtained of the Coastal Plain extending from Camp Lee, near Richmond, to the edge of the Continental Shelf.[17] This work was supported by the Geological Society, the Coast and Geodetic Survey and Woods Hole.

At the easternmost point the water depth reached 100 fathoms (600 feet). The sedimentary bed, in which several layers of differing compositions could be distinguished, was found to reach below water to a depth of 12,000 feet at its outer limit. It then dropped off abruptly, at the edge of the Continental Shelf. Information on the nature of the rock supporting the sediment was also developed.

Submarine beds of sediment such as that first studied by Ewing can hold deposits of oil, which nowadays are accessed from off-shore platforms. Ewing recognized the practical implications of his discovery and approached an oil company for support, but was told that there was plenty of oil and no need to look for it at sea.

Ewing's undersea exploration required novel instrumentation and equipment. Explosion seismology depended on control of the timing of an explosion deep under water, and then detection of the resultant waves, usually again at depth. Protection of the instrumentation from the high pressure presented a challenge. Some equipment could be used off the shelf, but much was designed by Ewing and constructed by him and his students. (The professional part of the physics shops was generally off-limits to faculty and students, but an exception was made in the case of Ewing whose expertise as a machinist was recognized by the mechanician Al Leeming.)

Ewing's next cruise after that on *Atlantis* was in the submarine *USS Barracuda*, measuring the acceleration of gravity in the Puerto Rico trench by means of the Vening Meinesz pendulum. The submarine cruise started in the Canal Zone on November 30, 1936, and ended in Philadelphia on January 14, 1937. The acceleration of gravity was measured at 51 sea stations and in nine harbors.[18] In addition to the Navy, institutions providing support were the American Philosophical Society, the Coast and Geodetic Survey and the AGU, while Bell Telephone Laboratories designed and constructed a crystal chronometer used in timing the pendulum.

Ewing took a leave of absence for the fall semester, 1936, to enable his submarine cruise. Two graduate assistants, Allyn C. Vine (M.S., 1940) and Norman H. Webster, both from Hiram College, were hired as partial replacement for Ewing. Increasing enrollment justified their continued support, and they subsequently became students of Ewing's.

In the spring of 1937, Ewing obtained a grant of $3000 (which was continued for four years) from the AGS to carry out refraction measurements across New

Jersey from Princeton to Barnegat Bay, similar to the work he had done in 1935 in Virginia. In this work he had the assistance of Vine, George P. Woollard, Meredith Johnson and J. Lamar Worzel (B.S., 1940).[19]

Bullard[20] quotes Woollard on life with the hard-working Ewing: "It was a tight little group, and although we worked most nights on instruments or data analysis, and spent most weekends in the field, one night a week was devoted to relaxation. We'd start with spareribs and beer in a cheap little German restaurant, migrate up to the University rifle range for a couple of hours' shooting, and then end up at either Ewing's house or my apartment for more beer, music, and discussions...followed by scrambled eggs and coffee in the wee hours before calling it a night." Life was also strenuous financially; to cope with his shortage of funds, Vine lived one semester in his lab, taking showers in the gym.[21] (He was not the last graduate student to make quarters in the physics building.)

During the summer of 1937 equipment was built for deep-water exploration, past the Continental Shelf. A test was carried out in September when Ewing, with Vine and Webster, sailed again on *Atlantis*.[22] Recording apparatus was enclosed in a piece of six-inch gun barrel obtained from Bethlehem Steel. This was connected by a cable to four seismographs[23] and three bombs, the assembly being stretched out on the sea bottom over a distance of about a mile, at depths reaching 2,600 fathoms. There was financial support from the GSA, watches for timing were provided by the Hamilton Watch Company, Alnico magnets for the seismographs were provided by the Taylor-Wharton Iron and Steel Company and the DuPont Company donated explosives and assistance in handling them at depth.

A number of technical problems were encountered.[24] The most serious were associated with the cable and the difficulty in laying the assembly out in something resembling a straight line. Results of the test showed that "the line of instruments did not extend to nearly its full length" and in one test a twenty-pound bomb was determined to be less than 600 feet from the recording apparatus. To maintain a straight line the cable should be kept taut while it was being laid but this meant some dragging over the bottom which would damage the equipment; furthermore a taut cable would carry unwanted signals to the seismographs. To overcome these problems Ewing and Vine suggested a method "without wires or cables" with floats and ballast used for lowering and raising the equipment.[25] Equipment could be lowered to the bottom, then brought up after a set period of time or by a signal from the surface. The float system was developed in 1939-1940 but further deep-sea exploration was interrupted by the war.

Trips to deep water involved several days going out and coming back. Not being one to waste time, Ewing developed a camera for deep-sea photography so time not otherwise occupied could be spent taking pictures of the bottom. He found little enthusiasm for this venture as it was the general opinion of oceanographers that the ocean bottom had no features of interest, but nevertheless support was obtained from the National Geographic Society. The first camera, designed to go to a depth of 3000 fathoms, was constructed by Ewing, Vine and Worzel in the Lehigh shops in 1939 and tested during a cruise on *Atlantis* in March, 1940.[26] This camera was lost in May, after providing one useful sequence of pictures of the bottom. Funds were not provided for construction of a second camera, so one was built "from parts which could be found around the laboratory or purchased for a total of less than fifty dollars." (Scrounging was not limited to the laboratory; for example a flash-bulb socket was fashioned from an automobile carburetor bowl.) This second camera was used successfully on five cruises, but in July, 1940 it was lost at 1500 fathoms. Undersea photography revealed a wealth of interesting features on these and later cruises.

In 1938 Ewing obtained a Guggenheim Fellowship, which was extended for another year. He took a leave from Lehigh, splitting his time between Woods Hole and Lehigh. It became clear that he could be useful to the Navy during the looming war and Woods Hole would be his natural location. After a cruise on *Atlantis* in September, 1940 to make additional seismic refraction measurements, he moved to Woods Hole with Vine and Worzel. He had been promoted to Associate Professor of Geophysics in April effective for the fall semester but never actively held the title. The Director of Woods Hole, Columbus Iselin, said of Ewing "He had a profound effect on the success of this laboratory. He arrived here first as a very young professor...He brought with him several Lehigh students and the place has never been the same since. They literally worked night and day, and seven days a week."[27] After the war Ewing joined the geology department at Columbia University and in 1949 he established the Lamont (now Lamont- Doherty) Geological Observatory. For his many later accomplishments the reader is referred to his biographies.

In 1943 Ewing and Worzel showed that sound could be transmitted over long distances through a layer they called the SOFAR (sound fixing and ranging) channel and this was quickly applied to anti-submarine warfare.[28] Following the war Worzel went to Columbia where he obtained his Ph.D. and became Associate Director of Lamont-Doherty. The first research contract awarded by the Office of Naval Research was to Ewing and Worzel in 1946 for continuation of work on SOFAR. Worzel made other important contributions to underwater sound, underwater photography, and gravity meaurements at sea.

Vine stayed at Woods Hole. He was influential in the Navy's decision to build a vessel for deep-water exploration, and the result was named Alvin[29] in his honor. Alvin was commissioned in 1964 and has had many notable accomplishments, among which are the recovery in 1966 of an H- bomb which fell off the coast of Spain following the crash of a B-52, and the exploration (through Jason, tethered to Alvin) in 1986 of the wreckage of Titanic.

Crary did oil exploration during the 1930's then went to Woods Hole in 1941. After the war he became interested in the polar regions, and was the first person to set foot on both the North and South Poles. He was Chief Scientist for Antarctica during the International Geophysical Year and the Science and Engineering Laboratory in Antarctica, as well as a range of mountains, are named for him. He became Director of the Division of Environmental Sciences at the National Science Foundation, retiring in 1976.[30]

The first Ph.D. awarded by the physics department was to John Brackett Hersey. He came to Lehigh in 1939 to work with Ewing after receiving his B.S. and M.S. at Princeton. There was little contact between student and professor because Hersey arrived the year Ewing went on leave, but nevertheless Hersey received his Ph.D. in 1943 with a thesis titled *Gravity Investigation of Central Eastern Pennsylvania*. (The thesis is signed by Bidwell, no doubt because Ewing was not available at the time the thesis was presented.) Hersey went to Woods Hole in 1946 and in 1966 joined the Office of Naval Research where he became Director of Ocean Science. In this position he oversaw ONR grants for research on the oceans.

William B. Agocs received his B.S. and M.S. in Mining and then transferred to physics to work with Ewing. He received his Ph.D., the third given by the department, in 1946 with a thesis titled *A Method of Determining the Time Break on Deep Sea Seismic Records, and the Slope of the Sea Bottom and its Direction from Water Sound Arrivals*. (As in Hersey's case, the thesis is signed by Bidwell although Ewing was in fact the advisor.) Agocs joined Kutztown University where he became head of the department and established a seismic observatory.[31]

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History of the Physics Department

PHYSICAL AND ELECTRICAL LABORATORY.

circa 1896

The Physics Building

That a research lab was available to Professor Mayer by 1870 or earlier can be inferred from his publication that year of two papers reporting on experimental work. (A third paper in 1870 described observations of Jupiter from the Sayre Observatory.) This lab was located in Packer Hall, as were all academic operations after Packer opened in 1868. Instructional lab space was made available in Packer by 1877.

Significantly more space was obtained when Saucon Hall was renovated for physics and occupied in September of 1886. The Register for 1886-87 contains the following description:

> **THE PHYSICAL LABORATORY**
> consists of three stories. A large lecture room with a seating capacity of 150, occupies a portion of the second and third floors. It is well lighted and admirably adapted to its purposes. On the remainder of these floors are two rooms, each 40 feet long, for Heat and Light laboratories, a dark room for photographic work, spectroscopic and apparatus rooms and the private laboratories of the instructors.
>
> The lower floor is devoted to the use of the students in the Advanced Electrical Course. A large room nearly 40 feet square is used as the Electrical Laboratory. There are similar rooms for photometric and spectroscopic work, also reading, balance, apparatus and engine rooms. On the floor a twelve-horsepower high speed engine and a dynamo supply two systems of electric lights, one of 25 incandescent lamps, the other of four arc lights, for practical tests in the Electrical Laboratory and for experimental purposes in the lecture room above. In the cellar are battery, store rooms, etc.

The Register for 1887-88 has an additional closing paragraph:

> The tower and two rooms in the east end of Christmas Hall have been given to the Department of Physics and will be equipped as a Meteorological Observatory.

The "tower" had been the bell tower in Christmas Hall's design as a church. Christmas and Saucon were joined by a central building in 1926.

More and better space was provided when construction was completed of a new building. In some sources it is said that the building was constructed during the 1892-1893 academic year, and in others that it was occupied in 1894. In any case, the Register for 1895-96 describes the Physics Building, now called the Lewis Lab:

THE PHYSICAL LABORATORY

This building is of stone, 235 feet in length, and 4 stories in height. The first or ground floor is devoted to electrical work, and forms the Senior Electrical Laboratory. It contains a large dynamo room, with the engine, dynamos, and motors, with all their appliances; battery, balance, calorimetric rooms and workshops. The eastern part of this story has been carefully arranged for delicate work. The use of iron has been avoided; the gas and steam mains and pipes, radiators, etc., are all of brass. In this section are seven special rooms for investigations of the magnetic properties of iron and for original research. A hall over 200 feet in length can be darkened and utilized for long range work in testing lamps. Under this floor is the "cave" or even-temperature room, completely enclosed with solid stone masonry. On this and the other three floors are private laboratories, store and apparatus rooms, and offices for instructors.

The second story contains the Junior Electrical Laboratory, 56 by 44 feet; the Mechanical Laboratory, 60 by 44 feet, with tables for 80 students, the Library, a time room and two balance rooms, with floors resting on solid stone arches.

On the third floor is a public hall, 70 by 44 feet, for examinations; also the professor's lecture room, 40 by 44 feet, with private laboratories, etc.

On the fourth floor in the west wing are two recitation rooms for the instructors, 40 by 18 feet, and the Heat Laboratory, 44 feet square, with tables for 72 persons. On the east side is the Light Laboratory. This contains one room with tables for 40 persons, and 8 smaller dark rooms, each of which can be divided into two parts. Besides these are four photographic dark rooms, 8 by 28 feet, each with all the necessary equipments.

The tower, which is devoted to meteorological purposes, has two stories of one room each, 16 by 21 feet, with a vane room above. Besides these there are several small rooms for special purposes scattered among the four floors.

The tendency in the latest and best Physical Laboratories is towards a larger number of small rooms, rather than to a few large rooms. It will be seen from this description that the advantages of this plan have been gained by the many smaller rooms that exist, while for general work the larger halls are provided.

Three staircases, at the middle and the two ends of the building, afford ample means of entrance and egress.

During the first year of occupancy more equipment was obtained and there was some rearrangement of the space. The description in 1896-97 reads:

THE PHYSICAL LABORATORY

The Physical Laboratory, erected in 1893, is a stone building 235 long, mostly 44 feet wide, and four stories in height. The general plan of the floors is to devote each wing to a large room, while the central part provides offices and store rooms, and the extreme ends provide auxiliary rooms and stairways.

FIRST FLOOR.- In the west wing is the dynamo laboratory, comprising dynamo room, battery room, workshop, calculating room, etc. The dynamo room is 70 feet long and 20 feet wide. A fifty-horsepower Straight-line steam-engine drives a line shaft, to which the several dynamos are connected by belting and friction clutches. The electrical plant consists of two Westinghouse rotary transformers, two Edison dynamos, one Thomson-Houston arc dynamo, one Richter arc dynamo, one Wenstrom incandescent dynamo, one Westinghouse alternator, two Tesla induction motors, several small motors, ten alternating current transformers, etc. The laboratory is well equipped with ammeters, voltmeters, wattmeters, and other measuring instruments. In the battery room an 80-cell chloride accumulator supplies current for testing purposes when the engine is not working. In the east wing is the thesis laboratory, consisting of eight small rooms, each of which is furnished with three stone tables resting on foundation piers. One of these rooms is specially fitted up for arc-light photometry.

SECOND FLOOR.- In the west wing is the designing room, 56 feet long by 44 feet wide, and adjacent to it is a small room which has been fitted up for blueprinting. In the east wing is the electrical laboratory, 60 feet long by 44 feet wide. It has been furnished and equipped for the several kinds of electrical measurement. A small room adjoining has been fitted up for the measurement of the magnetic qualities of iron. In the central part is the departmental library and reading room; on the table will be found the current numbers of the principal electrical journals.

THIRD FLOOR.- The principal apartments are the Lecture Hall in the west wing, and the Lecture Room in the east wing. The former is used for examinations, University lectures, and the meetings of several of the Engineering Societies; the latter is equipped with all the appliances for experimental lectures on physics and electricity.

FOURTH FLOOR.- The west wing contains two recitation rooms, and the laboratory of general physics; while the east wing contains the light laboratory. The latter, in addition to desk accomodation for forty students, contains twelve dark rooms fitted up for photometry and photography.

The building was destroyed by fire in 1900, and immediately rebuilt. In the reconstruction the meteorological tower was omitted, but the massive walls which provided its support are still in evidence at various points in the building. The slender spires shown in early pictures were also omitted; these sat atop shafts reaching down to the ground floor to provide ventilation. Another change, shown in plans for the reconstruction, was the elimination of the stairways at the east and west ends; the space so retrieved was used for labs. To partially compensate for the loss of stairways, a small elevator, or dumbwaiter, was installed in what had been, and now is, the east stairwell, extending between the second and fourth floors.

This material was compiled and written by J. A. McLennan.
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The Faculty

The faculty list has been compiled from the Registers (or Catalogs) and departmental teaching records. The latter are probably more accurate but do not cover the period prior to 1929.
An asterisk indicates that the individual was on leave.
The early title "Graduate Assistant" has been replaced by "Teaching Assistant" to conform with modern usage.

1867-1871: Alfred Marshall Mayer; Ph.D. (Hon.), Gettysburg, 1866; Professor of Physics and Astronomy

1871-72: Lorenzo Lorain; Commissioned as Second Lieutenant, West Point, 1852; Professor of Physics and Mechanics

1872-1883: H. Wilson Harding; A.B., Washington College, 1854; A.M., Bethany College, 1872; Professor of Physics and Mechanics

1883-1884: Harding, Professor of Physics
Harvey S. Houskeeper; B.S., Lehigh, 1872; Instructor in Physics

1885-1889: Harding, Professor of Physics and Electrical Engineering
Houskeeper

1889-90: Harding, Houskeeper
Richard O. Heinrich, Instructor in Physics

1890-91: Harding, Houskeeper, Heinrich
Dwight F. Carroll, A.M., Instructor in Physics

1891-92: Harding, Houskeeper, Heinrich, Carroll
Burton E. Moore, A.M., Instructor in Physics

1892-93: Harding, Houskeeper, Moore
George Edward Wendle; E.E., Lehigh, 1891; Instructor in Physics

1893-94: Harding, Houskeeper, Moore
Wendle, Instructor in Physics and Electrical Engineering
Harry J. Atticks, E.E., Instructor in Physics

1894-95: Harding
Houskeeper, Instructor in Physics and Electrical Engineering
William Henry Powell, M.E., Instructor in Physics and Electrical Engineering
Edwin Eugene Fisher, M.E., Instructor in Physics and Electrical Engineering

1895-96: Harding
Alexander MacFarlane; M.A., D.Sc., LL.D.; Lecturer, in charge of the Department of Electrical Engineering
J. Henry Klinck, M.E., Instructor in Electrical Engineering
Henry Storrs Webb; B.S., MIT, 1892; Instructor in Electrical Engineering
Schuyler Stevens Clark; S.B., MIT, 1895; Assistant in Physics

1896-97: Harding, MacFarlane, Klinck, Webb
Clark, Instructor in Physics

1897-98: William S. Franklin; B.S., U. Kansas, 1887; M.S., 1888; D.Sc., Cornell, 1902; Professor of Physics and Electrical Engineering
MacFarlane, Lecturer on Mathematical Physics
Klinck, Webb, Clark
Robert B. Williamson, M.E., Instructor in Electrical Engineering

1898-99: Franklin, MacFarlane, Klinck, Webb, Clark, Williamson

1899-1900: Franklin, MacFarlane
Robert M. Wilson, M.E., Instructor in Electrical Engineering
Barry MacNutt; E.E., Lehigh, 1897, M.S., 1898; Instructor in Electrical Engineering
John S. Viehe; E.E., Lehigh 1899; Instructor in Electrical Engineering

1900-01: Franklin, MacFarlane, Wilson, MacNutt
Harold Warner Brown, B.S., Instructor in Electrical Engineering
Howard Logan Bronson, A.B., Instructor in Physics
Chauncey M. Crawford; B.A., Yale, 1900; Assistant in Physics

1901-02: Franklin, MacFarlane, MacNutt, Brown
Crawford*, Instructor in Physics
William Esty, M.S., Assistant Professor of Electrical Engineering
Charles C. Schenck, Ph.D., Instructor in Physics
Ernest A. Regestein, S.B., Instructor in Electrical Engineering
Lewis A. Freudenberger, E.E., Instructor in Physics and Electrical Engineering

1902-03: Franklin, MacFarlane, Esty, MacNutt, Crawford, Regestein

1903-04: Franklin, Professor of Physics
Esty, Professor of Electrical Engineering
MacFarlane
MacNutt, Crawford, Instructors in Physics
Regestein, Instructor in Electrical Engineering
William R. Whitehorn; A.M., Ph.D.; Instructor in Physics

By 1903 the separation into two departments was complete, so faculty in Electrical Engineering will not be included below.

1904-05: Franklin, MacFarlane, MacNutt, Crawford, Whitehorne

1905-06: Franklin, MacFarlane, MacNutt, Crawford, Whitehorne
William W. Crawford, Assistant in Physics

1906-07: Franklin, MacFarlane
MacNutt, Assistant Professor
Chauncey M. Crawford, Instructor
Charles C. Schenck, Ph.D., Instructor
James Hunter Wily; E.E., Lehigh, 1905; Instructor

1907-08: Franklin, MacFarlane, MacNutt, Wily
John A. Veazey; A.B., Westminster, 1902; M.A., 1905; A.B., Cornell, 1906; Instructor
George A. Stebbins; A.B., Ph.D.; Instructor
Rollin L. Charles, B.A., Instructor

1908-09: Franklin, MacNutt, Wily, Veazey, Charles
Frank Thurman Leilich; E.E., Lehigh, 1908; Instructor

1909-1910: Franklin, Charles
MacNutt, Associate Professor [the only and apparently the first holder of the title]
Wily, Assistant Professor
Clinton Maury Kilby, Ph.D., Instructor
S. Leroy Brown, Ph.D., Instructor
Alfred C. Callen; E.M., Lehigh, 1909; Instructor
John L. Dynan; E.M., 1909; Assistant

1910-11: Franklin, MacNutt, Wily, Charles, Brown
Rogers H. Galt, Jr.; A.B., Ph.D.; Instructor
Howard M. Fry; E.E., Lehigh, 1910; M.S. in Physics, 1915; Instructor
Otto B. Niesen; M.E., Lehigh, 1910; Instructor
Frank Glen Perley; E.M., Lehigh, 1908; M.S. in Physics, 1913; Instructor

1911-12: Franklin, MacNutt, Wily, Charles, Fry, Perley
Robert Clyde Gowdy; B.A., M.A., Ph.D.; Instructor

1912-13: Franklin, MacNutt, Wily, Charles, Fry, Perley
Parke B. Fraim; E.M., Lehigh, 1909; M.S., 1919; Instructor
Edward Joseph Lorentz, M.A., Instructor

1913-14: Franklin, MacNutt, Wily, Fry, Perley, Fraim
Charles, Assistant Professor
George Jantzen Buckner; B.S., CCNY, 1914; M.S., Lehigh, 1916; Instructor

1914-15: Franklin, MacNutt, Wily, Charles, Fry, Fraim, Buckner
G.E.M. Jauncey; B.S.; M.S., Lehigh, 1916; Instructor

1915-1916: MacNutt, Professor
Wily, Charles, Fry, Fraim, Buckner, Jauncey

1916-1917: MacNutt, Wily, Charles, Fry, Fraim, Buckner
Whitmell P. Tunstall, C.E., Instructor

1917-1918: MacNutt, Wily, Charles, Fraim, Buckner, Tunstall
Fry, Assistant Professor
Vivian E. Ayre, B.S., E.E., Instructor

Leslie Hart, A.B., Instructor

1918-1919: MacNutt, Wily, Charles, Fry, Fraim, Tunstall
Robert E. Martin, B.A., Instructor
John C. Pomeroy; B.A., M.A.; Instructor
Leroy P. Ramenstein; B.A., M.A.; Instructor
Harvey C. Zinszer; B.A., Lehigh, 1922; M.A., 1924; Ph.D., Indiana U., 1926; Assistant

1919-1920: MacNutt, Wily, Fry, Martin, Zinszer
Charles, Associate Professor
Fraim, Assistant Professor
Robert N. Taylor; Ph.B., B.S.; Instructor

1920-1921: MacNutt, Charles, Fry, Fraim, Martin, Taylor, Zinszer
August Concilio; E.E., Lehigh, 1918; M.S., 1922; Instructor
Andrew J. Nicholas, M.E., Instructor

1921-1922: MacNutt, Charles, Fry, Fraim, Concilio, Zinszer
Martin, Assistant Professor
Kenneth V. Glentzer; A.B., Indiana University, 1921; M.S., Lehigh, 1923; Instructor
George M. Carleton, B.S., Instructor

1922-1923: MacNutt, Fraim, Martin, Concilio, Glentzer, Carleton
Fry, Associate Professor
Zinszer, Instructor
Elias Klein; A.B., A.M., Ph.D.; Assistant Professor

1923-1924: MacNutt, Fry, Fraim, Martin, Klein, Concilio, Zinszer
Arthur Gibbs Crafts, A.B., Instructor
Israel Maizlich; B.S., MIT, 1919; Ph.D.; Instructor
James Shepard Webb, B.S., Instructor

1924-1925: MacNutt, Fry, Martin, Klein, Concilio, Zinszer, Crafts, Webb
William Polk Jesse; M.E., U. Missouri, 1913; Ph.D., Yale, 1924; Assistant Professor
Maurice John Brevoort, M.A., Instructor
Louis Ernest James; A.B., A.M.; Instructor
Theodore Albertus Smits; B.A., E.E.; Instructor

1925-1926: MacNutt, Martin, Jesse, Crafts, Webb

Klein, Associate Professor
David Gordon Bourgin; B.S., M.A.; Instructor
Scott Preston Ewing; B.S., Ph.D.; Instructor
John Philip Karbler; B.Sc., M.A.; Instructor
Harris Cary Palmer, M.A., Instructor
Glen Francis Rouse; B.A., M.A., Ph.D.; Instructor

1926-1927: MacNutt, Klein, Martin, Jesse, Crafts, Webb, Bourgin, Karbler, Palmer, Rouse
Walter Robert Couch; C.E., Akron, 1923; M.S. in Educ., 1926; M.S. in Physics, Lehigh, 1929; Assistant

1927-1928: Charles Clarence Bidwell; A.B., Rochester, 1904; Ph.D., Cornell, 1914; Professor and Head
Martin, Crafts, Webb, Karbler, Palmer, Couch
Paul Leverne Bayley; B.A., Arkansas, 1913; M.A., Illinois, 1914; Ph.D., Cornell, 1923; Associate Professor
Preston Banks Carwile; A.B., Davidson, 1920; M.A., Virginia, 1924; Ph.D., 1927; Assistant Professor
Robert Lewis Hanson; A.B., Ph.D.; Assistant Professor
Max Heinrich Petersen; B.S., Northwestern, 1913; M.A., Wisconsin, 1914; Ph.D., 1924; Assistant Professor
William Bender; B.A., M.S.; Instructor
John Charles Clark; A.B., M.S.; Instructor
Louis Arthur Pardue; A.B., M.S.; Instructor
Teaching Assistants:
Halton Hobson Friend; B.S., Northwestern, 1926; M.S., Lehigh, 1929
Frederic Allen Scott; B.S., New York State College for Teachers, 1924; M.S., Lehigh, 1929; Ph.D., Rice, 1935
William Joseph Sette; B.S., Yale, 1927; M.S., Lehigh, 1929
Wayne Treber Sproull; B.S., U. Akron; M.S., Lehigh, 1929; Ph.D., U. Wisconsin

1928-1929: Bidwell, Bayley, Martin, Carwile, Hanson, Petersen, Crafts, Karbler, Clark
Couch, Instructor
Otto Frederick Ritzmann; B.S., M.S.; Instructor
Teaching Assistants:
Friend, Scott, Sette, Sproull
Herbert Hersh Reichard, B.S.

1929-1930: Bidwell, Bayley, Carwile, Petersen
Scott, Instructor

Charles Edward Berger; B.S., Penn State, 1916; Ph.D., Cornell, 1920; Assistant Professor
Austin Rogers Frey; S.B., MIT, 1920; M.A., Harvard, 1924; Ph.D., 1929; Assistant Professor
Charles Rozier Larkin; B.A., Virginia, 1923; M.A., 1925; Ph.D., 1929; Assistant Professor
Daniel Bailey; B.S., M.S.; Instructor
Clement Long Henshaw; B.S., M.A.; Instructor
Frederick Taylor Holmes, B.A., Instructor
John Allen Osteen; B.S.; M.S., Lehigh, 1932; Instructor
Teaching Assistants:
Elmer Raymond Binkley; B.S.; M.S., Lehigh, 1931
Edwin Enos Leidich, B.S.
Robert Kready Mowrer; B.S.; M.S., Lehigh, 1931
Lehman Charles Shugart; A.B., M.S., Lehigh, 1931

1930-1931: Bidwell, Bayley, Carwile, Petersen, Berger, Frey, Larkin, Scott, Henshaw, Holmes, Osteen
William Maurice Ewing; B.A., Rice, 1926; M.A., 1927; Ph.D., 1931; D.Sc. (Hon.), Lehigh, 1957; Instructor
Teaching Assistants:
Binkley, Mowrer, Shugart
J. Leland Myer; B.S. in E.P., Lehigh, 1930; M.S., 1931

1931-1932: Bidwell, Bayley, Carwile, Petersen, Berger, Frey, Larkin, Ewing, Holmes, Osteen, Scott
Benjamin Lichty Snavely; B.S. in E.P., Lehigh, 1928; Ph.D., Princeton, 1935; Instructor
Teaching Assistants:
Albert Paddock Crary; B.S., St. Lawrence U., 1931; M.S., Lehigh, 1933
Harry Charles Kelly, B.S. in E.P., 1931; M.S., 1933; Ph.D. MIT, 1935

1932-1933: Bidwell, Bayley, Berger, Frey, Larkin, Scott, Ewing, Snavely
Petersen, Associate Professor
Carwile, Associate Professor
Teaching Assistants:
Crary, Kelly

1933-1935: Bidwell, Bayley, Petersen, Carwile, Berger, Frey, Larkin, Ewing, Snavely, Crary

1935-1936: Bidwell, Bayley, Petersen, Carwile, Berger, Frey, Larkin, Ewing, Snavely, Scott

1936-1937: Bidwell, Bayley, Petersen, Carwile, Berger, Frey, Larkin, Snavely, Scott
Ewing, Assistant Professor
Teaching Assistants:
Allyn Collins Vine; B.A., Hiram College, 1936; M.S., Lehigh, 1940
Norman Harvey Webster; A.B., Hiram College, 1936

1937-1938: Bidwell, Petersen, Carwile, Berger, Frey, Ewing, Snavely, Scott
Bayley, Professor
Larkin, Associate Professor
Teaching Assistants:
Vine, Webster
William Stanley Lanterman; B.S. Lafayette, 1935; M.S., 1937
William Reagle Transue, B.S.

1938-1939: Bidwell, Bayley, Petersen, Carwile, Larkin, Berger, Frey, Ewing*, Snavely, Scott
James Alexander Peoples; B.A., Vanderbilt, 1933; M.S., 1934; Ph.D., Ohio State, 1938; Instructor
Teaching Assistants:
Lanterman, Vine, Webster
Robert August Buerschaper; B.S. in E.P., Lehigh, 1937; M.S., 1940; Ph.D., 1943
Kenneth Berlin Shiffert; B.S., Muhlenberg, 1934; M.S., Lehigh, 1938
Rollaston George Stiles; B.S., U. Vermont, 1936; M.S., 1939

1939-1940: Bidwell, Bayley, Petersen, Carwile, Larkin, Berger, Frey, Ewing*, Scott, Snavely, Peoples
Teaching Assistants:
Buerschaper, Lanterman, Shiffert, Stiles
Carl Daniel Bauman; B.S., Albright, 1938; M.S., Lehigh, 1941

1940-1941: Bidwell, Bayley, Carwile, Larkin, Berger, Frey, Scott, Snavely, Peoples
Petersen, Professor
Ewing*, Associate Professor of Geophysics
Teaching Assistants:
Bauman, Buerschaper, Lanterman, Shiffert, Stiles
Bernard Altshuler; B.S. in E.P., 1940; Ph.D., NYU, 1953

1941-1942: Bidwell, Bayley, Petersen, Carwile, Larkin, Berger, Frey, Ewing*, Snavely
Scott, Assistant Professor
Teaching Assistants:
Buerschaper
William Bailey Agocs; B.S. in E.M., Lehigh, 1934; M.S., 1944; Ph.D., 1946
Arthur Woodward Warner; B.A., U. Delaware, 1940
Robert Mercer Maiden, B.S. in E.P., 1942
Maynard Goodwin Arsove; B.S. in E.P., 1943; Ph.D., Brown, 1950
Albert Leo Thalhamer; B.S. in E.P., 1942; M.S., Cornell, 1954

1942-1943: Bidwell, Bayley, Petersen, Carwile, Ewing*, Frey*, Larkin*, Snavely*, Scott*
Elliott Ward Cheney; A.B., Dartmouth, 1920; Ph.D. Princeton, 1926; Associate Professor
Eric Spencer Sinkinson; B.Sc. Sheffield, 1909; D.I.C., Imperial College, 1918; Associate Professor
Peter Gabriel Bergmann; Sc.D., U. Prague, 1936; Assistant Professor
Teaching Assistants:
Agocs, Buerschaper
Kurt Weber; B.S., Lehigh, 1942; M.S., 1944
William Connor Brower, B.S. in E.P., 1943
George Harvey Brower, B.S. in E.P., 1944

1943-1944: Bidwell, Bayley, Petersen, Carwile, Cheney, Ewing*, Frey*, Larkin*, Snavely*, Scott*, Bergmann, Weber
Buerschaper, Instructor
Jonathan Karas; B.S. in E.P., Lehigh, 1943; M.S., 1947; Instructor

1944-1945: Bidwell, Bayley*, Carwile*, Cheney, Frey*, Larkin*, Bergmann*, Scott*, Snavely*, Buerschaper

1945-1946: Bidwell, Bayley*, Carwile*, Cheney, Larkin*, Bergmann*, Snavely*
Scott, Associate Professor
Charles Olavi Ahonen; B.S. Wayne, 1939; M.S., U. Michigan, 1940; Ph.D., 1945; Assistant Professor
Paul Franklin Bartunek; B.S., U. Nebraska, 1930; M.S., 1932; Ph.D., U. Michigan, 1935; Assistant Professor
Peter Havas; Graduate Technische Hochschule, Vienna, 1938; Ph.D., Columbia, 1944; Assistant Professor

Dean Waldo Stebbins; B.S. in E.P., Montana State, 1935; Ph.D., Iowa State, 1938; Assistant Professor
Teaching Assistants:
Buerschaper*
Richard Frank Greene; B.S. in E.P., Lehigh, 1946; M.S., 1947; Ph.D., U. Pennsylvania, 1951

1946-1947: Bidwell, Bayley, Cheney, Havas, Ahonen, Bartunek, Stebbins, Greene
Scott, Professor
Agocs, Assistant Professor
Karas, Instructor
Frank Evans Myers; B.A., Reed, 1927; M.S., NYU, 1930; Ph.D., 1934; Professor
Cassius Wild Curtis; A.B., Williams, 1928; Ph.D., Princeton, 1936; Associate Professor
James Mead Hyatt; A.B., Cornell, 1918; Ph.D., 1922; Associate Professor
Raymond Burkert Sawyer; Ph.B., Ripon, 1921; M.S., Wisconsin, 1925; Ph.D., 1930; Associate Professor
Raymond Jay Emrich; B.S., Princeton, 1938; Ph.D., 1946; Assistant Professor
Wilbur DeVilla Bernhart Spatz; B.S., Lafayette, 1930; M.S., Purdue, 1934; Ph.D., NYU, 1943; Assistant Professor
Teaching Assistants:
Carl Maxmillan Adams; B.S., Juilliard School of Music, 1940
Michael Fintz Amsterdam; B.S. in Ch.E., U. Pennsylvania, 1941; M.S., Lehigh, 1947
Jacob Lester Barber; Sc.B., Dickinson, 1946; M.A., Lehigh, 1948
William Vincent Feller; B.S., Muhlenberg, 1942
Robert Charles Good, Jr.; B.S. in E.P., Lehigh, 1940; Ph.D., 1951
Leonard Robert Greene; B.S. in E.P., Lehigh, 1943; M.S., 1947
Clarence Lester Hogan; B.S., Montana State, 1942; M.S., Lehigh, 1947; Ph.D., 1950
Morton Fischel Kaplon; B.S. in E.P., Lehigh, 1941; M.S., 1947; Ph.D., U. Rochester, 1951
Alfred Baer Laponsky; B.S. in E.P., Lehigh, 1943; M.S., 1947; Ph.D., 1951
Richard Wells Rusk; B.S. in Chemistry, Lehigh, 1938; M.S. in Physics, 1949
James Robert Schooley; A.B., Duke, 1942

1947-1948: Myers, Head of Department
Bayley, Cheney, Bartunek, Havas, Curtis, Hyatt, Sawyer, Emrich, Spatz,

Karas,
Donald Bingham Wheeler, Jr.; B.S. in E.P., Lehigh, 1938; Ph.D., Cal Tech, 1947; Assistant Professor
Good, Instructor
Hogan, Instructor
Laponsky, Instructor
Teaching Assistants:
Adams, Feller, Rusk
Robert Michel Belmonte; B.S. in E.P., Lehigh, 1947; M.S., 1949
William James Crowe; B.S. in E.P., Lehigh, 1947; M.S., 1949
Nathaniel Ellmaker Hager, Jr.; B.S., F&M, 1943; M.S., Lehigh, 1948; Ph.D., 1953
Paul William Huffman; A.B., West Virginia Wesleyan, 1941
Ward Townsend Langstroth; B.S. in E.P., Lehigh, 1947
John William Marini; B.S. in E.P., Lehigh, 1947; M.S., 1948
Frank Lewis McCrackin; B.S., Montana State, 1947; M.S., Lehigh, 1949; Ph.D., 1957
James Downs Shreve, Jr.; B.S., F&M, 1947; M.S., Lehigh, 1949; Ph.D., 1951
John Arol Simpson; B.S. in E.P., Lehigh, 1946; M.S., 1948; Ph.D., 1953
Lewis H. Strauss; A.B., Harvard, 1947; M.S., Lehigh, 1949
William Moss Strouse; B.S. in E.P, Lehigh, 1943; M.S., 1949
Renn Zaphiropoulos; B.S. in E.P, Lehigh, 1947; M.S., 1949

This material was compiled and written by J. A. McLennan.
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History of the Physics Department

Bibliography

The Bayer Galleria of Linderman library has many documents related to Lehigh's history, including catalogs (called the Register in the early years), minutes of early faculty meetings, photographs, the Lehigh Presidential Papers collection, and other departmental histories. I am indebted to Marie Boltz for frequent and knowledgable help in accessing material in this collection, including many trips into parts unknown to retrieve documents and photographs.

Files in the physics department contain material dating back to the late 1920's.

Some histories of Lehigh are:

Edmund M. Hyde, *The Lehigh University, A Historical Sketch* (South Bethlehem, 1896)

Catherine Drinker Bowen, *History of Lehigh University* (The Lehigh Alumni Bulletin, 1924). Bowen moved to the Lehigh campus at the age of eight when her father, Henry S. Drinker '71, became president. Her book *Family Portrait* (Little-Brown, Boston, 1970), is primarily a portrait of the Drinker family but includes descriptions of the university and its neighborhood during the early twentieth century.

William A. Cornelius, *Seventy-Five Years of Lehigh University* (Lehigh University, 1942). This is a short pamphlet, with brief summaries of each of the seventy-five years and a statistical supplement. The foreward by President Clement C. Williams describes the circumstances of the

founding.

A concise summary of significant events can be found in a loose-leaf binder titled *History of Lehigh*, which is maintained by library staff and located in the Bayer Galleria.

Frank Whelan and Lance Metz, *The Diaries of Robert Heysham Sayre* (Lehigh University, 1990).

W. Ross Yates, *Lehigh University: A History of Education in Engineering, Business, and the Human Condition* (Lehigh University Press, 1992). The Yates manuscript, held in the Bayer Galleria, contains many interesting details not included in the printed version. This is the most complete Lehigh history, and is depended on here at a number of points without specific attribution.

Additional Lehigh history can be obtained from the **Lehigh home page**; do a search on History of Lehigh.

For local industrial history, see for example Craig L. Bartholomew and Lance E. Metz, Ann Bartholomew ed., *The Anthracite Iron Industry of the Lehigh Valley*; Randolph L. Kulp ed., *Railroads in the Lehigh River Valley*; and Ronald E. Shaw, *Canals for a Nation*. These books are available from the **National Canal Museum**.

General references used are:

Samuel Eliot Morison, *Three Centuries of Harvard* (Harvard University Press, Cambridge, 1936).

J. G. Crowther, *Famous American Men of Science* (W. W. Norton and Company, New York, 1937).

Thomas Coulson, *Joseph Henry, His Life and Work* (Princeton University Press, 1950); Alfred E. Moyer, *Joseph Henry, the Rise of an American Scientist* (Smithsonian Institution Press, Washington, 1997).

Frederick Rudolph, *The American College and University* (Alfred A. Knopf, New York, 1962).

Saul Sack, *History of Higher Education in Pennsylvania* (The

Pennsylvania Historical and Museum Commision, Harrisburg, 1963).

Ralph S. Bates, *Scientific Societies in the United States* (The MIT Press, Cambridge, 1965).

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Notes for Chapter 1

[1] Samuel Eliot Morison, *Harvard College in the Seventeenth Century* (Harvard University Press, Cambridge, 1936), vol. 1, p. 141.

[2] "Natural philosophy" was used to distinguish the new science from the ancient, and this terminology lasted until about the middle of the nineteenth century. However the breakdown into categories like those used today, with "physics" taking its modern meaning, started at least by the early nineteenth century. The first issue of Silliman's American Journal of Science, appearing in 1818, provides such a categorization and has a broad view of science, including military and civil engineering; the leading article is an "Essay on Musical Temperament".

[3] American Chemist **4**, 362 (1874), **6**, 401 (1876) and Journal of the American Chemical Society **48**, 36 (1926).

[4] Samuel Eliot Morison, *Three Centuries of Harvard* (Harvard University Press, Cambridge, 1936), p. 235.

[5] This development as it took place in Pennsylvania is described in detail in Saul Sack, *History of Higher Education in Pennsylvania* (The Pennsylvania Historical and Museum Commission, Harrisburg, 1963), particularly Chapters XX and XXIV.

[6] David Bishop Skillman, *The Biography of a College, being the History of the First Century of the Life of Lafayette College* (Lafayette College, Easton, 1932), p 35.

[7] American Journal of Science **15**, 297 (1829).

[8] Numbers taken from the World Almanac, which counts institutions still in existence with an enrollment of at least 1000.

[9] W.E. Wickenden, Director of the Investigation, *Report of the Investigation of Engineering Education, 1923- 1929* (American Society for Engineering Education, Pittsburgh, 1930-34), p. 815.

[10] Craig L. Bartholomew and Lance E. Metz, Ann Bartholomew ed., *The Anthracite Iron Industry of the Lehigh Valley* (Center for Canal History and Technology, Easton, 1988).

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Notes for Chapter 2

[1] An early view of Lehigh is indicated in Morris Bishop, *A History of Cornell* (Cornell University Press, Ithaca, 1962), p 52. Speaking of Ezra Cornell's thoughts regarding his university, the author says "Where, indeed, could the eager youth learn the theoretical background of the mechanic trades?... Harvard, Yale, and Lehigh had their scientific schools, but all these were beyond the reach of a poor boy."

[2] Information on the Nott-Potter family is given in Sarah Bradford Landau, *Edward T. and William A. Potter, American Victorian Architects* (Garland Publishing, Inc., New York, 1979).

[3] The letter is given on p. 2163 of Wetherill's biography by Edgar Fahs Smith, Journal of Chemical Education **6**, 1076, 1215, 1461, 1668, 1916, and 2160 (1929). A picture of the gathering at the Priestley home is reproduced at p 1463.

[4] Alfred G. Mayer and Robert S. Woodward, *Biographical Memoir of Alfred Marshall Mayer* (National Academy of Sciences, 1916).

[5] The Physical Review **5**, 118 (1897). Other obituaries are given in Science **6**, 261 (1897); American Journal of Science **IV**, 161 (1897).

[6] Alfred M. Mayer, "Apparatus for registering and exhibiting the vibrations of rods, for obtaining the number of their vibrations in one second, and for determining their laws of vibration", Journal of the Franklin Institute **84**, 343 (1867).

[7] Alfred M. Mayer, *Lecture notes on physics Part I* (Journal of the Franklin Institute, 1868). The individual items from which the book was formed are: Journal of the Franklin Institute **84**, 321 (1867); **85**, 35, 113, 183, 249, 328, 400 (1868); **86**, 45, 109, 177, 253, 336 (1868).

[8] Mr. Rock obtained the C.E. degree in 1869 as a member of Lehigh's first graduating class (of three), later became an astronomer at the United States Naval Observatory, served as chairman of a commission to establish the boundary between Mexico and Guatemala, and was elected by the Lehigh alumni as a trustee.

[9] Alfred M. Mayer, "Solar Eclipse of August 7, 1869", J. Franklin Institute **88**, 249 (1869). The preceeding paper by Henry Morton, J. Franklin Institute **88**, 200 (1869), is a letter from Prof. Morton as organizer of the expedition to Prof. J.H.C. Coffin, Superintendent of the Nautical Almanac and sponsor, reporting on the expedition as a whole. Mayer also wrote "An Abstract of some of the Results of Measurements and Examinations of the Photographs of the Total Solar Eclipse of August 7, 1869", Proceedings of the American Philosophical Society **11**, 204 (1869), which, although it is called an abstract, is five pages long.

[10] Alfred M. Mayer, "Observations on the planet Jupiter", Journal of the Franklin Institute **89**, 136 (1870).

[11] John H. Rogers, *The Giant Planet Jupiter* (Cambridge University Press, New York, 1995), p 189.

[12] Alfred M. Mayer, "Observations on the Variation of the Magnetic Declination in connection with the Aurora of October 14, 1870. With remarks on the physical connection between changes in area of disturbed solar surfaces and magnetic perturbations", American Journal of Science ser. 3 **1**, 77 (1871).

[13] Alfred M. Mayer, "On the thermo-dynamics of water-falls", Proceedings AAAS **18**, 64 (1869).

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Notes for Chapter 3

[1] For a biography of Lorain, see Alan Clark Miller, "Lorenzo Lorain, Pioneer Photographer of the Northwest", American West **9**, March 1972, p 20; also see Terry Todtemeier, "Oregon Photography: The First Fifty Years", Oregon Historical Quarterly, spring 1993, p 37.

[2] Sharon M. Harris, *Rebecca Harding Davis and American Realism* (University of Pennsylvania Press, 1991), and Helen Woodward Sheaffer, *Rebecca Harding Davis: American Realist* (University of Pennsylvania, dissertation, 1947).

[3] Charles Belmont Davis, *Adventures and Letters of Richard Harding Davis* (Charles Scribner's Sons, New York, 1917), and Fairfax Downey, *Richard Harding Davis, His Day* (Charles Scribner's Sons, New York, 1933).

[4] Information obtained courtesy of Betsy Toulouse of the Washington and Jefferson Alumni Office.

[5] Downey, loc. cit., p 18.

[6] Yates manuscript, p 201.

[7] Quoted in Catherine Drinker Bowen, *History of Lehigh University*, p 33; also partially quoted in Downey, loc. cit., p 18.

[8] The country's first course in Electrical Engineering was announced at Cornell in 1881 at the instigation of William A. Anthony, Professor of

Physics, and came into operation as a four- year course in 1885. See Morris Bishop, *A History of Cornell* (Cornell University Press, Ithaca, 1962), p 162, 244.

[9] Bowen, loc. cit., p 33.

[10] The history of the Professor of Mechanics is: Position first occupied by Morgan as Professor of Mathematics and Mechanics, succeeded by Herr, then Lorain followed by Harding as Professor of Physics and Mechanics. The first engineering professor was Charles McMillan, appointed as Professor of Civil and Mechanical Engineering in 1871, succeeded by Augustus J. DuBois in 1875, by S.R. Crumbaugh in 1877, then in 1878 by Mansfield Merriman. In 1881 Merriman's position was split and Joseph F. Klein took over the mechanical half. In 1883 the professorship of mechanics was dropped, to reappear much later.

[11] Yates manuscript p. 369.

[12] Yates manuscript p. 348.

[13] See André Lange, ***Histoire de la Television***. I am indebted to Professor Lange for bringing this episode to my attention. His history contains some interesting material regarding Merriman, in addition to that concerning the diaphote. As H.E. Licks, Merriman wrote *Recreations in Mathematics* (D. Van Nostrand, New York, 1917), in which the story of the diaphote is retold. This was brought to the attention of modern readers by **Col. G.L. Sicherman** who deduced that Licks was Merriman.

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Class of 1899

Clearly there are ten figures but only nine names are given on the back of the photograph. Franklin and the Grace brothers can be identified from other photographs. It is surmised that the person with a high hat like Franklin's is another member of the faculty (no doubt one of the instructors as he appears too young to be MacFarlane) and if so his name is the one omitted. The names of the other individuals are given in the same order as on the photograph. Holderness is listed as a sophomore in the 1897 Register but not in later Registers so evidently he left during the 1898-1899 academic year after the picture was taken.

The full list of the 1899 graduates in E.E. with their thesis titles is:

- Leon Whetstone Bailey (with A.K. Birch): *Investigation of Glass Jacketed Incandescent Lamp Filaments*
- Arthur Knode Birch (with L.W. Bailey): *Investigation of Glass Jacketed Incandescent Lamp Filaments*
- Eugene Gifford Grace (with J.W. Grace, jr.): *Efficiency Tests of Gravity Cells.*
- John Wesley Grace, jr. (with E.G. Grace): *Efficiency Tests of Gravity Cells.*
- Owen Gray MacKnight: *Critical Study of the Operating Conditions of the Allentown-Bethlehem Electric Railway.*
- J. Foster Morgan (with A.P. Steckel): *Investigation of Martiensseen's Method for Measuring Inductance.*
- John Thomas Morrow: *On the Influence of Arsenic upon the Electrical Conductivity of Copper.*
- Louis Thomas Rainey: *Design and Construction of a*

Magnetic Plunger.

- Abram Peters Steckel (with J.F. Morgan): *Investigation of Martiensseen's Method for Measuring Inductance.*
- John Sage Viehe: *A New Method for Multiplex Telegraphy*.

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Notes for Chapter 4

[1] Catherine Drinker Bowen, *History of Lehigh University*, p 37.

[2] Biographical information on Franklin is given in American Journal of Physics **5**, 31 (1937). This article contains addresses by President D.L. Webster and Professor Frederic Palmer on the occasion of Franklin's posthumous reception of the first Award for Notable Contributions to the Teaching of Physics (now called the Oersted Medal) by the American Association of Physics Teachers. Additional information on Franklin and the Oersted Medal can be found in the **History of the Association** at the web site of the **AAPT**.

[3] Nichols was a professor at Cornell University. For many years The Physical Review carried under its title the line: *A journal of experimental and theoretical physics established by E.L. Nichols in 1893*. The collaboration between Nichols and Franklin dates back at least to 1893 when the two co-authored a paper in the first volume of Physical Review.

[4] Charles H. Holbrow, "Archeology of a Bookstack: Some Major Introductory Physics Texts of the Last 150 Years", Physics Today, March 1999, p 50.

[5] See E.N. Gilbert, Acustica **66**, 275 (1988), and J. Acoust. Soc. Am. **83**, 1804 (1988).

[6] W.S. Franklin, Review of *Traité Élémentaire de Méchanique Chimique fondée sur la Thermodynamique* by P. Duhem, vols. I and II, Phys. Rev. **6**, 170 (1898).

[7] Cf. Robert C. Hilborn, *Chaos and nonlinear dynamics: an introduction for scientists and engineers* (Oxford University Press, New York, 1994).

[8] Bowen, *History of Lehigh University*, p 37. Similar comments about Franklin are made in *Family Portrait*, p 40.

[9] Doster was a Civil War veteran, and defended two of the conspirators in the assassination of President Lincoln. See Edward Steers Jr., *Blood on the Moon* (University of Kentucky Press, Lexington, 2001) and his article in the Allentown Morning Call, January 6, 2002.

[10] Letter from Drinker to Franklin, April 31, 1912, in the Presidential Papers.

[11] The park was at one time identified by a sign, but the sign could not be located during a recent search.

[12] See Raymond V. Brandes, *Big-Bang Cannons: The Carbide Cannon, A Unique American Toy* (Ray-Vin Publishing Co., New Brunswick, N.J.) This book and an abbreviated history are available from the **web site** of the Conestoga Company. I am indebted to Ned Heindel for bringing this episode to my attention.

[13] The Presidential Papers contain an extensive set of documents dealing with the Franklin-Esty feud.

[14] The original plaque was stolen and a duplicate now hangs on the wall. I am indebted to Raymond J. Emrich for recalling this event which took place in the late 1960's or early 1970's.

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Early Degrees in Physics

A few early degrees in physics, with thesis titles, are listed below. Early records are ambiguous on a student's "major," except for engineering degrees such as the C.E. or M.E. The thesis, if it can be found, might identify the advisor or otherwise reveal the student's main interest, but today's format with departmental affiliation, acknowledgements and vita was not then standard.

> Barry MacNutt, M.S., 1898, "A Study of Galvanic Polarization"
> Henry Storrs Webb, M.S., 1898, "Hysteresis loss in soft iron for small ranges of induction"
> Frank G. Perley, M.S., 1913, "On the Motion of a Sphere in a Viscous Fluid"
> Paul Cloke, M.S., 1913, "Recent Developments in High Frequency Electric Oscillations"
> William Stauffer More, B.S. in Mathematics and Physics, 1915, "Viscosity of Oils"
> Howard Massey Fry, M.S., 1915, "Test of Ulbricht Sphere and Mathews Integrating Photometer"
> G.E.M. Jauncey, M.S., 1916, "The Effect of a Magnetic Field on the Initial Recombination of the Ions Produced by X-Rays in Air"
> George C. Buchner, M.S., 1916, "A New Type of Highly-Sensitive Electrometer"
> Walter C. King, B.S. in Physics and Mathematics, 1917, "History and Theory of Gyro-Compass"
> Thomas G. Ralph, B.A., 1917, "The Recovery of a Bidwell

Selenium Cell"
August Concilio, M.S., 1922, "Noises in Stressed Metals"
Kenneth V. Glentzer, M.S., "The Variations of the Initial Current in the Electrolysis of Copper"
Harvey Alfred Zinszer, M.A., 1924, "A Study of the Effect of an Equal Energy Spectrum upon Metallic Selenium"

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Publications of William S. Franklin

This is a partial list of Franklin's publications. Journal citations are taken from the Physical Review (dating from 1893) and Science Abstracts (dating from 1898). In addition Franklin made a number of contributions on the teaching of physics, at school and college level, and he also wrote for the popular market.

JOURNAL ARTICLES

Review of *The Theory and Practice of Absolute Measurements in Electricity and Magnetism* by Andrew Gray, Phys. Rev. **1**, 66 (1893).

"Method for Determining Focal Lengths of Microscope Lenses", Phys. Rev. **1**, 142 (1893).

Review of *A Treatise on the Mathematical Theory of Elasticity* by A.E.H. Love, and *Leçons sur la Theorie de l'Élasticité* by H. Poincaré, Phys. Rev. **1**, 310 (1893).

Review of *An Elementary Treatise on Fourier's Series, and Spherical, Cylindrical, and Ellipsoidal Harmonics, with Applications to Problems in Mathematical Physics* by W.E. Byers, Phys. Rev. **1**, 397 (1893)

"On the Condition of the Ether Surrounding a Moving Body", Phys. Rev. **1**, 426 (1893). With E.L. Nichols.

"Three Problems in Forced Vibrations", Phys. Rev. **1**, 442 (1893).

"A New Method for Testing the Magnetic Properties of Iron", Phys. Rev. **2**, 466 (1895).

"Note on a Phenomenon in the Diffraction of Sound", Phys. Rev. **2**, 469 (1895).

"A New Electrolytic Generator for Oxygen and Hydrogen", Phys. Rev. **4**, 61 (1897).

Review of *Physikalische Krystallographie und Einleitung in die krystallographische Kenntnis der wichtigeren Substanzen* by P. Groth, Phys. Rev **4**, 71 (1897).

"On the Mechanical Conceptions of Electricity and Magnetism", Phys. Rev. **4**, 388 (1897)

"Some Determinations of the Slide Modulus of Glass, and the Shortening of Glass Fibers with Age", Phys. Rev. **4**, 498 (1897). With L.B. Spinney.

Review of *Traité Élémentaire de Méchanique Chimique fondée sur la Thermodynamique* by P. Duhem, vols. I and II, Phys. Rev. **6**, 170 (1898); vol. III, Phys. Rev. **8**, 253 (1899); vol. IV, Phys. Rev. **10**, 191, (1900).

Review of *A Treatise on Magnetism and Electricity* by Andrew Gray, Phys. Rev. **7**, 307 (1898).

"A Normal Curve of Magnetization of Iron", Phys. Rev. **8**, 304 (1899). With S.S. Clark.

"Commercial Electrolytic Generation of Oxygen and Hydrogen", American Electrician **11**, 526 (1899).

"Some Lecture Room Methods in the Elementary Theory of Elasticity", Phys. Rev. **11**, 75 (1900).

"The Problem of the Stresses and Strains in a Long Elastic Hollow Cylinder Subjected to Internal and External Pressure and to Tension", Phys. Rev. **11**, 176 (1900).

"Poynting's Theorem and the Distribution of Electric Field Inside and Outside of a Conductor Carrying Electric Current", Phys. Rev. **13**, 165 (1901).

"Some Diffraction Photographs", Phys. Rev. **14**, 61 (1902).

"Lecture Room Demonstrations of Astigmatism and of Distortion", Phys. Rev. **15**, 119 (1902).

Review of *Light, a Consideration of the More Familiar Phenomena of Optics* by Charles S. Hastings, Phys. Rev. **16**, 127 (1903).

"Derivation of Equation of Decaying Sound in a Room and Definition of Open Window Equivalent of Absorbing Power", Phys. Rev. **16**, 372 (1903).

"The Misuse of Physics by Biologists and Engineers", Science **18**, 641 (1903).

"Electric Waves and the Behavior of Long-Distance Transmission in Lines", J. Franklin Inst. **160**, 51 (1905).

"A Lecture Experiment in Hydraulics", Science **22**, 793 (1905).

"Reversible and Irreversible Electrolytic Polarization," Trans. Amer. Electrochem. Soc **7**, 34 (1905); **8**, 227 (1905). With L.A. Freudenberger.

"The Precipitation of Colloidal Solutions by Centrifugal Force", Trans. Amer. Electrochem. Soc. **8**, 29 (1905). With L.A. Freudenberger.

"Alternating Current d'Arsonval Galvanometer", Electrical World **48**, 569 (1906). With L.A. Freudenberger.

"Alternating Current Kelvin Galvanometer", Electrical World **48**, 718 (1906). With L.A. Freudenberger.

"A New Type of Alternating Current Galvanometer of High Sensibility", Phys. Rev. **24**, 37 (1907). With L.A. Freudenberger.

"Measurement of Electrolytic Resistance", Phys. Rev. **25**, 294 (1907). With L.A. Freudenberger.

"Note on Spherical Aberration", Phys. Rev. **28**, 221(A) (1908).

"On Entropy", Phys. Rev. **30**, 766 (1910).

"Dielectric Stresses from the Mechanical Point of View", J. Franklin Inst. **171**, 245 (1911).

"The Principle of Relativity", J. Franklin Inst. **172**, 1 (1911).

"An Important Practical Problem in Gyrostatic Action", Phys. Rev. **34**, 48 (1912).

"Poynting's Theorem and the Equations of Electromagnetic Action", J. Franklin Inst. **173**, 49 (1912).

"Some Phenomena of Fluid Motion- The Curved Flight of a Baseball", J. Franklin Inst. **177**, 23 (1914).

"A Method for Calculating that Part of the Recoil Momentum of a Gun which is Due to the Action of the Gases after the Projectile Leaves the Muzzle", J. Franklin Inst. **179**, 559 (1915).

"Some Mechanical Analogies in Electricity and Magnetism", General Electric Rev. **19**, 264 (1916).

"Electric Waves", J. Western Soc. Eng. **22**, 589 (1917). With B. MacNutt.

TEXTBOOKS

The Elements of Physics; a College Text-Book, vol. 1 Mechanics and Heat, vol. 2 Electricity and Magnetism, vol. 3 Light and Sound. Macmillan, New York (1896). With Edward L. Nichols.

The Sophomore Physical Laboratory Course: Lehigh University, Part 1, Mechanics and Heat, and Part 2, Electricity and Magnetism, Light and Sound. South Bethlehem, (1898-1899). With Schuyler Stevens Clark.

The Elements of Alternating Currents. Macmillan, New York (1899). With Robert B. Williamson.

Dynamo Laboratory Manual: For Colleges and Technical Schools.

Franklin and Esty, South Bethlehem (1906). With William Esty, and with the cooperation of Stanley S. Seyfert and Clarence E. Clewell.

The Elements of Electrical Engineering; A Text Book for Technical Schools and Colleges, vol. I Direct Current Machines, Electric Distribution and Lighting, vol II Alternating Currents. Macmillan, New York (1906). With William Esty.

The Elements of Mechanics; A Text-book for Colleges and Technical Schools. Macmillan, New York (1907). With Barry NacNutt.

Practical Physics; A Laboratory Manual for Colleges and Technical Schools. Macmillan, New York (1908). With Barry MacNutt and Chauncey Crawford.

The Elements of Electricity and Magnetism; a Text-book for Colleges and Technical Schools. Macmillan, New York (1908). With Barry MacNutt.

Electric Waves; An Advanced Treatise on Alternating-Current Theory. Macmillan, New York (1909).

Dynamos and Motors; A Text book for Colleges and Technical Schools. Macmillan, New York (1909). With Wlliam Esty.

Light and Sound; A Text-book for Colleges and Technical Schools. Macmillan, New York (1909). With Barry MacNutt.

An Elementary Treatise on Calculus; A Text Book for Colleges and Technical Schools. Franklin, MacNutt and Charles, South Bethlehem (1913). With Rollin. L. Charles and Barry MacNutt.

Elementary Electricity and Magnetism; A Text-Book for Colleges and Technical Schools. Macmillan, New York (1914). With Barry MacNutt.

General Physics; An Elementary Treatise on Natural Philosophy. McGraw-Hill, New York (1916). With Barry MacNutt.

A Calendar of Leading Experiments. Franklin, MacNutt and Charles, South Bethlehem (1918). With Barry MacNutt.

Lessons in Electricity and Magnetism; A Text Book for Colleges and Technical Schools. Franklin and Charles, Bethlehem (1919). With Barry

MacNutt.

Lessons in Heat; A Text-book for Colleges and Technical Schools. Franklin and Charles, Bethlehem (1920). With Barry MacNutt.

Notes for Chapter 5

1. Homer Dodge at the University of Oklahoma was one of the leaders in the development of engineering physics, and Oklahoma introduced its E.P. curriculum in the same year as Lehigh. A history of the curriculum at Cornell has been given by Paul L. Hartman, *Applied and Engineering Physics at Cornell* (College of Engineering, Cornell University, 1994); I am indebted to Gil Stengle for this reference.

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Talk given by Bidwell to the Society for the Promotion of Engineering Education in 1937 or 1938

Upon my coming to Lehigh in 1927 I found a so- called curriculum in Engineering Physics-- a new curriculum offered for the first time in 1924. We had been offering a four year curriculum in physics at Cornell. The curriculum was in the Arts College and had very few takers in the eight or ten years it has been in the catalog. I was very skeptical therefore of the prospects for success of such a curriculum at Lehigh but I could do nothing but play along with it. I found however a difference-- the curriculum at Lehigh was offered in the Engineering College as an engineering curriculum. Students with an aptitude for physics are far more certain to be found in the engineering college than in the arts college. The truth of this was evident in the number of freshmen electing the curriculum at the end of their freshman year when they are required to make their choice. These men were interested in physics. We have more in one year electing physics at Lehigh than in the ten years of the arts physics curriculum at Cornell. We have averaged about ten freshmen per year. This gives a physics group of about 35 or 40. The number is increasing although with fluctuations. Last year twelve came into physics and this year twelve freshmen have tentatively indicated physics.

In 1924 and '25 curricula in Engineering Physics were organized at Ohio State, Montana, Oklahoma, and Lehigh. There have since been organized similar curricula at Michigan, University of Denver. Rennselaer has had for several years a curriculum in physics as one of its twelve engineering courses. M.I.T., Cal. Tech. and Carnegie have four year physics curricula in their schools of science. This particular training is thus acquiring a wide recognition.

Many of our physics men are original physics men. By this I mean they have not been diverted into physics after arriving at Lehigh. Twelve men of the present freshman class indicated on their registration cards that they were coming for engineering physics. This is gratifying because when men are diverted into physics from electrical or mechanical engineering through some conversation with me or other members of the staff one is not always sure that he is doing the man a good turn. There is a responsibility there--the student would make a good electrical engineer and he might have better opportunities in the electrical field. You cannot be sure. But when he picks out Lehigh because he can get engineering physics--that is another thing.

Our curriculum is a curriculum in physics and engineering. The physics is the same as found in any four-year course--such as that at Cornell. However the student carries, throughout, one or more engineering subjects and thus acquires and develops the engineering point of view. Such subjects are Dynamos and Motors; A.C. Machinery; Heat Engines; Machine Design; Properties of Materials; Surveying; etc. We have a common freshman year in all engineering and math. Physics, chemistry, and economics are common in the sophomore year. Our men take two years of German or French. In the upper two years the course has 24 hours of free electives. The curriculum is with minor changes and shifts the same as the "Ideal Curriculum in Engineering Physics" proposed by Prof. H.T. Dodge in the symposium on "Training of Physicists for Industry" held in October a year ago in New York under the auspices of the American Institute of Physics.

In considering this curriculum the question immediately arises as to the attitude of industry towards its graduates. Will these men meet a need of industry? Does industry recognize this need? Letters were sent to scores of industrial concerns back in '22 and '23 by Prof. Barry MacNutt and there was live interest expressed in the proposed training. In the early years after my coming to Lehigh I was much concerned as to whether I could sell such men. I found that the industries were and are after first class men and these are the only kind we have. The mediocre men do not come into physics and if they enter through poor judgement or advice, they rather quickly shift out again. We are finding that the industries are again bidding for our men and to a much greater extent than before the depression. We like to flatter ourselves that it is because of their particular training. Many of our men go into straight engineering jobs along with mechanicals and electricals. I have inquired if these men felt handicapped but they have in every case said "No!" They thought they had the edge on the other fellows in their more thorough grounding in fundamentals.

Of our 46 graduates in Engineering Physics, 31 have gone directly into engineering jobs. Eleven have secured fellowships or assistantships for graduate study and of these nine already have their Ph.D. Thus three-fourths of our men go directly into industry and one-half of these seem to have stayed in research jobs, the others going into engineering, development, testing, sales, etc. Four of these latter are in geophysical prospecting jobs.

We do not of course pretend that undergraduate engineering physics takes the place of Ph.D. training. We advise however only the very outstanding man to continue for the Ph.D. Industry is not always willing to pay the price for a Ph.D. and often the Ph.D. is no guarantee of genius. Our men develop on the job just as the engineering graduate must and for many men that sort of development is more valuable than graduate training. The placing of Ph.D. men seems to be something of a problem. There is no problem in the placing of Engineering Physics men.

My particular interest in the accrediting of Engineering Physics curricula as engineering was aroused by the action and views of the Committee of the E.C.P.D. [Engineers' Council for Professional Development] who recently were invited to make a survey of the engineering curricula at Lehigh with a view to their accrediting by the E.C.P.D. With regard to Engineering Physics--a curriculum in the Engineering College--they were uninstructed and expressed uncertainty as to whether Engineering Physics was to be considered engineering.

We have been going on the assumption at Lehigh that a curriculum with all the common basic engineering courses but with broad specialization in physics, definitely meeting a need and demand in industry, is a type of engineering and entitled to be called such. We would maintain that the same might be true of geology. We do not have a curriculum in this subject at present although it has been proposed. The question which arises is whether a curriculum in the Engineering College with all the common basic engineering courses but with a new field of specialization arising from the needs and demands of industry should be denied recognition as engineering. Electrical engineering, metallurgical engineering, chemical engineering have been new fields in their time and have had to acquire recognition.

In my concern I wrote to Dr. Karl Compton, Chairman of the Committee on Engineering Schools of the E.C.P.D., asking how his committee was going to view these curricula. I would like to read Dr. Compton's reply as it places squarely before us the attitude of the engineers.

[The text of Compton's letter is unavailable.]

You will note the requirement that "basic and professional courses converge upon some field of applied science in which there is a recognized body of theory and more or less standard practice." They speak of the required proficiency of the engineer in "Design" and courses in "Structure" as requisite to all fields of engineering. Such courses at present are optional in our Engineering Physics. They are also optional in the curricula of metallurgical and chemical engineering.

A curriculum in Engineering Physics differs from a curriculum in applied physics in that the former is given in the Engineering School and supposedly contains all the common basic engineering courses. The engineering background and setting is retained throughout the four years but the specialization is applied physics. A curriculum in Applied Physics is usually an Arts Curriculum and as such lacks the engineering background and training. It can hardly lay claim to the title of engineering.

As a "recognized body of theory and more-or-less standard body of practice," the "physical engineer" (which term I believe we are entitled to and should seriously adopt) has to himself the field of optics, thermometry, electronics (being rapidly appropriated by the electrical engineer although practically all of the fundamental developments are due to the physicist), sound and acoustics, X-rays, nuclear physics, etc. Engineering Physics certainly has "a background body of theory and more-or-less standard practice."

What Engineering Physics lacks is a champion. It has no representation on the E.C.P.D., which is "a conference of engineering bodies." It is necessary for someone to show that this is engineering. If the physics group of the S.P.E.E. takes this view and goes on record as doing so, then we have an entering wedge for we here are part of the combined engineering groups. This body might petition the American Institute of Physics to present the case to the E.C.P.D.

One possibly may question, as does Dr. Compton, the necessity or desirability of a recognition of Engineering Physics as engineering, of this "taking refuge under the way of engineering." I answer to that that the industries are taking our men and are taking them as engineers. They are taking them primarily for research jobs but many go into development, testing, manufacture and sales as do other engineers. With the recognition of these men as engineers we have a wide and growing field open to our physicists. Without this recognition industry will not be so ready to accept these men. I have heard the question propounded at Physical Society meetings, "What are we going to do with our Ph.D.'s?" Apparently more are being trained than industry or education can absorb. This is not true of engineering physics at present. Industry apparently uses engineers with a specialization in physics. I think this recognition is worth going after.

This material was compiled and written by J. A. McLennan.
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Notes for Chapter 6

[1] Yates, *Lehigh University*, p 141, and Yates manuscript, p 92.

[2] Yates, *Lehigh University*, p 163.

[3] Yates, ibid p 176.

[4] The identifications of people from other departments are not certain as the hand-written sheets listing teaching assignments do not include first names or initials. Sinkinson is listed in the Register as a member of the physics department for 1942-43 but had previously been Associate Professor of Ore Dressing and Fuel Technology in the department of Mining Engineering.

[5] Lee Iacocca with William Novak, *Iacocca, an autobiography*, Bantam Books, New York (1984).

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Department of Physics

Center for History of Physics

Chapter 1

Chapter 2

Chapter 3

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Chapter 5

Chapter 6

Geophysics

The Physics Building

The Faculty

Notes for Geophysics

Thanks are due to Wesley J. Van Sciver for a number of discussions. Van Sciver is a condensed-matter physicist and also a sailor with skill to sail, with his wife, his boat across the Atlantic several times, and has a strong interest in oceanography. A number of years ago Van Sciver made me first aware of Lehigh's history in geophysics/oceanography. I am also indebted to William B. Agocs (Ph.D. 1946) and J. Lamar Worzel (B.S. 1940) for several discussions and communications.

A useful resource is the interview with Worzel by Ron Doel, *The Reminiscences of J. Lamar Worzel*, Lamont-Doherty Earth Observatory Oral History Project, Oral History Research Office, Columbia University (1998), also available from the Center for History of Physics of the American Institute of Physics. This interview has many interesting comments on the physics department as seen by an undergraduate who worked closely with Maurice Ewing. See also J. Lamar Worzel, "Tracing the Origins of the Lamont Geological Observatory," EOS **81**, no. 46, p. 549 (November 14, 2000).

The two main biographies of Maurice Ewing are William Wertenbaker, *The Floor of the Sea: Maurice Ewing and the Search to Understand the Earth*, Little, Brown and Company, Boston (1974), and Edward C. Bullard, "Maurice Ewing," in *Biographical Memoirs of the National Academy of Sciences* **51**, 119 (1980). The first of these was preceeded by Wertenbaker's series in The New Yorker: **50** no. 7, Nov. 4, p. 54; no. 8, Nov. 11, p. 52; and no. 9, Nov. 18, p. 60 (1974). Bullard also wrote "William Maurice Ewing" in *Biographical Memoirs of Fellows of the Royal Society of London* **21**, 269 (1975). Bullard includes a complete list of Ewing's publications.

[1] Maurice Ewing, "Research at 2,600 Fathoms," Lehigh Alumni Bulletin **25**, no. 3, p. 12 (1937).

[2] Maurice Ewing and L. Don Leet, "Comparison of Two Methods for Interpretation of Seismic Time-distance Graphs which are Smooth Curves," Transactions of the American Institute of Mining and Metallurgical Engineers **97**, 263 (1932).

[3] L. Don Leet and Maurice Ewing, "Velocity of Elastic Waves in Granite," Physics **2**, 160 (1932).

[4] Maurice Ewing, A.P. Crary and A.M. Thorne, Jr., "Propagation of Elastic Waves in Ice. Part I," Physics **5**, 165 (1934); Maurice Ewing and A.P. Crary, "Propagation of Elastic Waves in Ice. Part II," Physics **5**, 181 (1934).

[5] Maurice Ewing, A.P. Crary and E.B. Douglas, "Dispersion of Flexural Waves in Lake Ice," Phys. Rev. **47**, 797(A) (1935).

[6] Maurice Ewing and A.P. Crary, "Study of Emergence Angle and Propagation Paths of Seismic Waves," Physics **5**, 317 (1934).

[7] Maurice Ewing, A.P. Crary and J.M. Lohse, "Seismological observations on quarry blasting," Trans. AGU, **15**, 91 (1934).

[8] Maurice Ewing and A.P. Crary, "Propagation of elastic waves in limestone," Trans. AGU **16**, 100 (1935).

[9] Maurice Ewing, A.P. Crary, J.W. Peoples and J.A. Peoples, "Prospecting for Anthracite by the Earth-Resistivity Method," Trans. AIMME **119**, 443 (1936).

[10] Maurice Ewing and H.H. Pentz, "Magnetic Survey in the Lehigh Valley," Trans. AGU **17**, 186 (1936)

[11] Maurice Ewing, "Seismic Study of Lehigh Valley Limestones," Proc. Pa. Acad. Sci. **10**, 72 (1936).

[12] Maurice Ewing, "Locating a Buried Power Shovel by Magnetic Measurements," Proc. Pa. Acad. Sci. **12**, 31 (1938).

[13] A standard treatise is W. Maurice Ewing, Wenceslas S. Jardetzky and Frank Press, *Elastic Waves in Layered Media*, McGraw-Hill Book Company, New York (1957).

[14] The report of the committee is given in Trans. AGU **14**, 9 (1933).

[15] The use of explosion seismology at sea had been proposed by E. DeGolyer, "The Applications of Seismic Methods to Submarine Geology," Trans. AGU **12**, 37 (1932).

[16] For an account of the *Oceanographer* voyage, see N.H. Heck, "Lehigh Men Explore the Ocean Floor," *Lehigh Alumni Bulletin* **23**, no. 2, p. 9 (1935). Bullard says of this voyage that "no identifiable reflections were received from the basement" but Heck says "a large part of the fifty odd records obtained were useful and one of them was a more perfect reflection record than ever obtained on land."

[17] Maurice Ewing, A.P. Crary, and H.M. Rutherford, "Geophysical Investigations in the Emerged and Submerged Atlantic Coastal Plain. Part I: Methods and Results," Bull. GSA **48**, 753 (1937).

[18] See Maurice Ewing, "Gravity Measurements on the USS Barracuda," Trans. AGU **18**, 66 (1937); Maurice Ewing, "Marine Gravimetric Methods and Surveys," Proceedings of the American Philosophical Society **79**, 47 (1938) and M. Ewing and H.H. Pentz, "A proposed investigation of Vening Meinesz anomalies," Trans. AGU, **19**, 90 (1938). The Lehigh Alumni Bulletin 24, no. 4, p. 16, Jan 1937 has a news item: "Dr. Maurice Ewing, assistant professor of physics, who is working with the Naval Geographic research expedition, has left the Canal Zone and is now in Bridgeton, Barbados, where additional submarine gravity studies will be conducted during the coming month."

[19] This work is reported in G.P. Woollard, M. Ewing, and M. Johnson, "Geophysical investigations of the geological structures of the coastal plain," Trans. AGU **19**, 98 (1938); Maurice Ewing, George P. Woollard, and A.C. Vine, "Geophysical Investigations in the Emerged and Submerged Atlantic Coastal Plain. Part III: Barnegat Bay, New Jersey, Section," Bull. GSA **50**, 257 (1939); Maurice Ewing, George P. Woollard, and A.C. Vine, "Geophysical Investigations in the Emerged and Submerged Atlantic Coastal Plain. Part IV: Cape May, New Jersey, Section," Bull. GSA **51**, 1821 (1940); and Maurice Ewing, "Present

Position of the Former Topographic Surface of Appalachia (from Seismic Evidence)," Trans. AGU **21**, 796 (1940). Woollard was a graduate student in geology at Princeton, and Johnson was the New Jersey State Geologist. Woollard and J. Tuzo Wilson, also a graduate student at Princeton, were sent to Lehigh by Richard Field to be tutored in geophysics.

[20] Bullard, op. cit., p. 134.

[21] Wertenbaker, op. cit., p. 30.

[22] See Ewing, "Research at 2,600 Fathoms", op. cit.; G.P. Woollard and Maurice Ewing, "Structural Geology of the Bermuda Islands," Nature **142**, 898 (1939); and Maurice Ewing, G.P. Woollard, A.C. Vine and J.L. Worzel, "Recent Results in Submarine Geophysics," Bull. GSA **57**, 909 (1946).

[23] An on-line description of a **seismograph** constructed by Ewing, Vine and Worzel has been provided by the Society of Exploration Geophysicists.

[24] Worzel, in his interview cited above, gives many details of the equipment and the technical problems encountered.

[25] M. Ewing and A.C. Vine, "Deep sea measurements without wires or cables," Trans. AGU **19**, 98 (1938).

[26] Maurice Ewing, Allyn Vine and J.L. Worzel, "Photography of the Ocean Bottom," J. Opt. Soc. Am. **36**, 307 (1946); Maurice Ewing, J. Lamar Worzel and Allyn C. Vine, "Early development of ocean-bottom photography at Woods Hole Oceanographic Institution and Lamont Geological Observatory," in *Deep-Sea Photography*, edited by John Brackett Hersey, the Johns Hopkins Press, Baltimore (1967).

[27] Bullard, op. cit., p. 135.

[28] See for example **this site.**

[29] The history of Alvin is given in Victoria A. Kaharl, *Water Baby, The Story of Alvin*, Oxford University Press, New York (1990). An **online history** is available from Woods Hole.

[30] See for example this NSF site. The dedication plaque, containing a brief biography, is pictured in a virtual tour of McMurdo Station.

[31] Some of Agocs' activities in geophysics are described in the Lehigh Alumni Bulletin **87**, winter issue, p. 31 (1977).

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