

## Physics: Its Development in Indiana

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As is all too painfully apparent to the physicist, his subject concerns a wide variety of topics, and many of them have such a tremendous practical importance that they become the routine province of the engineer, the maintenance mechanic, or even other scientists, with the original contribution of physics and the physicist becoming lost in the shuffle. For example, Wabash, Indiana, is reputedly the first town in the country to have installed electric street lighting, and Indiana was an early center of automobile development and manufacture. Yet, there was apparently little recognition of the physics with which these two major industries were vitally concerned.

This continuing anonymity of the physicist or, perhaps, the non-recognition of the importance of the subject to various activities, is indicated even today by the major industrial and research-oriented Indiana company which, in its analytical work, regularly uses an electron microscope, does various types of spectroscopy from the ultra-violet to the infra-red, makes X-Ray diffraction studies, obtains nuclear magnetic resonance and electron-spin resonance data, and is currently investigating possible applications of lasers. Yet, it does not believe it employs a single full-fledged physicist!

Thus, it is not surprising that the principal history of physics as a recognized subject in Indiana (as in the United States and the rest of the world generally) lies in its educational institutions. This aspect of the history of physics in the state presents three rather distinct eras with the dates of about 1890 and 1930 being major "break" points.

The first students attending Indiana's colleges had a clear choice of subjects to take—they took the prescribed curriculum or they didn't attend school, and the various college catalogs show that even the first curricula gave Natural Philosophy an important place. DePauw's catalog of 1842 detailed what was included under this topic as Mechanics, Hydrostatics, Hydraulics, Pneumatics, Acoustics, Optics, Electricity, Magnetism, and Electromagnetism; very obviously, this was physics. Natural Philosophy courses were specifically listed in the catalogs of Hanover "from the first", Indiana University in 1831, Wabash College in 1834, and DePauw (Indiana Asbury until 1884) in 1839. The term "Physics" was itself apparently first used in DePauw's catalog of 1854 with Wabash using the term in 1865, Hanover in 1870, and Purdue from its founding in 1874. In these early catalog descriptions, the topics treated were frequently specified by reference to a specific text or texts, as "Deschanel's text" at Purdue.

Natural Philosophy was itself generally considered a branch of the more general subject of Natural Science, and the topics now considered as physics were grouped under one or more of these titles and that of the newcomer, Physics. Early professors were rather widely accomplished men who normally taught many topics. Thus, Natural Philosophy was taught by half of DePauw's first faculty, Rev. (later

Bishop) Matthew Simpson, who was not only professor of Mathematics and Natural Science in 1838-1839 but was also president in his spare time. The 1843 catalog was the first one listing a separate professor of Natural Science, Charles G. Downey.

By about 1880, departmental designations using physics as at least a part of the title began to appear, as was initially the case at Purdue. However, a physics department as such was first established at Wabash in 1879, at DePauw in 1881, Hanover in 1885, Indiana State in 1887, and Butler in the 1890's. Such emergence of physics departments as separate entities apparently has depended upon the development of the school in size, curricular emphasis, and probably what can only be called politics. As two examples, Notre Dame, founded in 1842, did not establish a separate physics department until 1920, and Indiana State, in reducing the number of its departments in 1923, included physics under a Science Department from which it emerged in a subsequent reorganization.

The establishment of physics as an undergraduate major at any school apparently depended upon a general curricular reorganization, a practice not completely unknown today. Such a change introducing disciplinary majors (and minors), with physics as one of the subjects concerned, took place at DePauw in 1890 when it was the largest school in the state. However, it was some 20 years later, in 1910, before 6 students graduating therefrom were among the first baccalaureate physics majors in the state, Earlham awarding a similar degree in a program established in 1960.

It was not until 1915 that Wabash established an undergraduate major with the first graduates in 1919, and Hanover did not establish such a majors program until 1925. On the other hand, physics as an undergraduate major was first mentioned at Butler University in 1914 with the first major graduating in the early 1920s. Indiana Central College (founded in 1902) established a physics department in 1922, provided an undergraduate major in 1925, and graduated the first physics major in 1928. Notre Dame did not set up an undergraduate major until 1937, and awarded its first baccalaureate physics major in 1941; these later dates are subsequent to the establishment of graduate courses at the school and the award of a master's degree in physics in 1936.

The first program for earned (*pro merito*) doctorates was established at DePauw in 1886, but none were apparently given in physics, unless the 1887 degree of John B. DeMotte, physics professor during 1882-1891, was in this subject. At this time and earlier, the Ph.D. was also frequently given as an honorary degree (without the *pro merito* designation) by the various schools. By faculty vote, DePauw gave such an honorary degree to Prof. Joseph Tingley in 1871 as a "surprise." The earned Ph.D. program was itself withdrawn in 1895, and it was in 1936 that records first show the award of a master's degree in physics at that institution.

The first program offering an earned graduate degree in physics at I.U. was apparently established prior to 1883, a master's degree being awarded that year to J. P. Naylor who subsequently became the long-time physics department head at DePauw. However, it was not until 1915 that I.U.'s first physics doctorate was awarded. Both the recipient

thereof and the recipient of a degree the next year had not only done their undergraduate and master's work at Indiana University but also stayed on to teach at their Alma Mater.

Purdue's graduate program was established in 1908 with the first doctorate in physics awarded in 1934 on the topic of electron diffraction. Notre Dame established its master's program in 1934 (with a degree awarded in 1939) and its doctoral program in 1939 (with 5 candidates receiving degrees in 1942). Ball State lists the establishment of a graduate program in education with physics major in 1941 with a degree first awarded that year; Rose Polytechnic Institute authorized a graduate program in physics in 1958, the same year an undergraduate major was established, and awarded its first master's degree in 1964, the same year Indiana State University awarded a master's degree in the graduate program established the preceding year.

At the other end of the physics instruction spectrum was that of the secondary schools. In many public school systems, the earliest records indicate physics as a part of the curriculum for most of the city systems since about 1900; the earliest date established was that of 1882 for Shortridge High School in Indianapolis. The topic was introduced in the Goshen schools in the early 1880s as a part of what would be now called a science survey course. It became a full semester course in 1895, and the report of the Goshen Public Schools for 1898-1899 states that "Physics is studied throughout the junior year in the English course, and throughout the senior year in the Latin course." The remainder of the description names texts and the topics studied, which are certainly what we now call physics. Although data are not available, it would appear that few high schools in the state today do not include some introduction to physics as a part of their curricula, some providing two years of the subject.

During the rapid ferment of development of the subject of physics at the turn of the century, the college professors recognized the desirability of professional association, and the College Physics Teachers' Association of Indiana was organized, apparently in 1902. Although there is some indication that the date was 1906, a meeting announcement and program dated January, 1906, did not indicate that this meeting was an organizational one. That particular announcement, signed by Professor Kent of Wabash, the host school, named nine colleagues as having indicated their intention to attend. By 1922, the mailing list had grown to 22 individuals, including 2 from out-of-state and 2 high school teachers, plus the general address of "Professor of Physics" at 6 schools, including Notre Dame. Only at Purdue was more than one name listed (4 were listed there). The meeting at Purdue in April of that year, however, attracted 18 people, 5 from Indiana University, 3 from Valparaiso, 2 from each of DePauw, Rose Polytechnic, and Indiana State, and single representatives from Franklin, Wabash, Indiana Central, and West Lafayette High School.

This organization thus antedated by more than a quarter century the formation of the American Association of Physics Teachers in 1930. Its name fluctuated somewhat with the records showing such appellations as the College Physics Teachers' Club of Indiana, the Physics Teachers

of Indiana Colleges and Normal Schools, and the Association of Indiana College Physics Teachers being bestowed thereon. In fairness, it appears that the organization, which held one or two meetings each year among the schools having major physics programs, received its various titles at the whim of the one calling the meeting each year and survived despite such name-calling. By about 1940, Hoosiers had apparently accepted the national organization, voting to apply for a charter in 1938, and the records for the next 10 years begin to reflect joint meetings of the "two" groups and the frequent use of the term Indiana Chapter of the American Physics Teachers. By about 1950, the current appellation of the Indiana Section of the American Association of Physics Teachers had been rather generally adopted and high school physics teachers had taken a more active part.

In addition to organization of their own group, Indiana physicists have also been active in the Indiana Academy of Science, which was founded in 1885. At this organization meeting, J. P. Naylor, then at Indiana University but due to come to DePauw in 1891, gave a talk on "The Progress of Physics in Indiana."

The fact that at least one of the problems of the physics teacher has not changed in 60 years is shown by one of the topics proposed for discussion at the 1906 meeting, which was "What are the fundamentals upon which emphasis should be placed in an elementary course for students or in other words what should be the subject matter presented to students in elementary work?" Another topic was listed as "The propadeutics (*sic*) of moment of inertia." Another one of particular interest in view of the then recently-announced explanation of the photoelectric effect was given as "Sound, light, etc., exhibit various interference phenomena. We conclude that sound, light, etc., are examples of wave motion. Could someone put into precise form the missing premise required to render the above conclusion valid?"

At succeeding meetings of the group, the topics discussed included not only those concerning the development of the phenomenological part of physics but also the problems and successes of physics teaching. It may be recalled that, for the professors in most of the schools, travel funds were not too generally available for meeting attendance and these annual, or semi-annual (between 1934 and 1944), meetings thus provided the main opportunity for many of the participants to rub elbows with their colleagues (no 1945 meeting was held because of war conditions). The meetings were also somewhat social in nature, a description of the 1921 meeting held at I.U. including the notation that "The visitors were met at Indianapolis by the Indiana Staff with eight cars, and taken for a drive to Bloomington by way of Brown County." Some 30 members attended this meeting, and 13 of them were accompanied by their wives.

An ever-present problem (and one receiving considerable attention and discussion at professional meetings today) was that of preparing physics teachers for the secondary schools. What would now be called a task force, if not originated by this group certainly heartily endorsed thereby, was headed by Prof. Lark-Horowitz of Purdue in 1941. Continuing for at least 3 years, it attempted to persuade the state de-

partment of education that among other things, high school teachers should have 20 semester hours of work in the subject. The efforts of this group, and similar ones in other subjects, were apparently successful in influencing the state licensing requirements listed in 1946.

The organization continues to sponsor annual meetings in the spring, the location being at the invitation of one of the colleges and the program consisting of contributed and invited papers.

In addition to the attraction of reasonably competent students with scientific abilities and interests, the development of physics as a scholarly enterprise depends upon faculty, finances, and facilities, primarily the faculty, which itself depends on finances and, to a somewhat less extent, on facilities.

Prior to about 1890, Indiana schools apparently provided adequate instruction in the subject, and little of what is now called research took place; essentially the same was true throughout the country. Probably the outstanding physicist of this period was Joseph Tingley, an 1846 DePauw graduate who stayed on as tutor until 1849 when he became Professor of Natural Science, a position he held until 1879. He also held the title and duties of Vice-President after 1860 and was an accomplished musician, portrait painter, and photographer. He traveled widely through the state, giving demonstration lectures, principally in electricity, which included the telegraph as early as 1859 and amplified telephony connecting Greencastle and Indianapolis in 1878. President Simpson, while feeling that the chair of natural science in many schools was the "source of skeptical speculation," rejoiced that this position at DePauw was held by such a devout Christian as Tingley who, in one of his lectures, is reported to have "demolished the theory of the Evolutionists, Darwin, and the rest"; in fact "Prof. Tingley's Scriptural and Scientific entertainments" were self-confessedly suitable for "all lovers of THE GOOD, THE BEAUTIFUL and THE TRUE." However, his lecturing activities, which would today be thought to bring credit to the university, did cause absences and thus drew unfavorable attention from the trustees who, by 1878, were also apparently dissatisfied with the faculty in general, though not on theological or sectarian bases. Hence, in 1879, Prof. Tingley was among the half of the university faculty which was summarily dismissed. In 1883, the trustees voted that Science Hall, a classroom in the present East College, be henceforth identified as Joseph Tingley Hall; in current usage, this is the ladies powder room.

The financial poverty of physics in the state at this time is indicated by the fact that an early (about 1860) DePauw student publication complained (or bragged) that DePauw equalled any midwestern school in successful teaching of the natural sciences, including experimental demonstrations, despite the fact that the entire outlay for natural science equipment had been only \$1,500 for 27 years, while similar schools elsewhere were spending as much as \$100,000; the mechanical and construction skill of Tingley and his predecessors, William C. Larrabee and Charles G. Downey, must have been much in evidence.

A notable professional contemporary of Tingley was John L. Campbell who graduated from Wabash in 1848 and then taught natural science there during the half century, 1853-1903. His 1863 suggestion

to Joseph Henry of the Smithsonian Institute that the 300th anniversary of Galileo's birth be commemorated, brought an invitation to give such an address on Feb. 15, 1864; this he could do because "a friend here has generously offered to make up the deficit in my expenses above your usual appropriation without which I would have been compelled at present to decline." Similarly, his 1868 suggestion to Philadelphia's mayor that the 100th anniversary of the Declaration of Independence be celebrated was probably not unrelated to the Philadelphia Exposition of 1876. He spent the years 1875-1877 in Philadelphia on leave of absence and was secretary of the U.S. Centennial Commission. He was also president of the Indiana Commission to the Chicago World's Fair of 1893.

Parenthetically, it should be mentioned that a Notre Dame symposium in 1964 was one of the few taking place in the world, and almost the only one in the United States, where the 400th anniversary of Galileo's birth was celebrated.

Physics apparently went to sleep in Indiana between about 1890 and 1930; perhaps it only seemed that way as the status quo, presumably of classical physics at the undergraduate level, was maintained while the subject itself put on Seven League Boots with the development of many of the topics generally called Modern Physics. Thus, while X-rays, radioactivity, relativity, quantum mechanics, wave-particle duality, and the identification of atomic and nuclear particles were exciting the scientific world, there is little indication that Indiana did much more than recognize the fact; certainly, no major research activities were underway. At DePauw, the state's largest school which had authorized a Ph.D. program in 1886, the 1893 panic eventually destroyed President John P. D. John's first effort (in 1890) to enlarge expenditures for physics by authorizing a \$600 budget (with \$1000 for each of biology and chemistry) instead of the preceding budgets of some \$50-\$100; President John himself resigned in 1895. At about the same time, President David Starr Jordan of Indiana University left for Stanford (in 1891) and science, particularly biological sciences, no longer received his vigorous and effective support. The departure of these two able administrators affected the entire state, particularly in the apparent decline of graduate work.

During this period, two individuals may be noted. One was Joseph P. Naylor, who left the headship of the physics department at Indiana University in 1891 to accept the same position at DePauw, telling someone "he thought that DePauw had a greater future, —, and also had a better (base)ball team." A watchmaker by trade, he was an accomplished machinist and, prior to retirement in 1925, he not only made much of the experimental apparatus used by his students but also constructed precision tools and other devices, many of which may still be seen. He also had close ties with the U. S. Coast and Geodetic Survey.

At Indiana University at the same time was Arthur L. Foley, who received his first physics appointment at that school in 1890 and was department head from 1897 until 1937, followed by his retirement in 1938. His principal research field was acoustics, and he and his students apparently published some 90 papers, about 75 appearing in the

*Proceedings* of the Indiana Academy alone. His introductory textbook, *College Physics*, was among the most popular of the time, going through several editions. During his tenure, the department's four principal professors were I. U. baccalaureate graduates, and two of them also received their Ph.D. degrees there.

Rose Polytechnic Institute had an important place in Indiana's physics development at about the turn of the century. Thus, E. S. Johannott, an RPI alumnus distinguished by starring in American Men of Science, served during 1899-1925, following C. L. Mees who came to RPI as a physicist in 1887 and then served as president during the quarter century, 1895-1920. Another starred physicist, T. C. Mendenhall, also served as RPI president during 1886-1889. A contemporary of these men and an engineer of international reputation, Thomas Gray, a Scotsman, certainly was not unrelated to physics as he had worked with Lord Kelvin for a number of years, and during his tenure at RPI (1888-1908) prepared the *Smithsonian Tables* published in 1896.

At about this same time the name of Zahm had a double meaning as far as physics at Notre Dame was concerned; Father John Zahm served as professor of physics (and chemistry) from about 1873 to 1896 and Albert Zahm, with a particular interest in aerodynamics, served on the faculty during 1885-1892. As a student in 1882, he built the state's first wind tunnel; in the late '80s he built and flew a man-carrying glider, and then presented a paper on the "Stability of Aeroplanes and Flying Machines" at the first International Aeronautics Congress in 1893.

Physics did not entirely neglect the distaff side either. What was probably the first wireless message sent in Indiana was the mile-long transmission from Notre Dame by Professor Jerome Green, and his physics class, to Sister M. Augustine Farmer of Saint Mary's College, and her physics class, in April, 1899. The receptor employed the induction coil used to supply high voltage for the X-Ray "machine" obtained for Saint Mary's by Father John Zahm on a trip to Europe in 1896.

During this period, physics at Purdue provided primarily a service function, and its resultant state is epitomized by the 1928 staff which consisted of five professors, only one with a Ph.D., and five graduate assistants. The library "consisted of one corner of a very small room that had a few shelves of textbooks for general physics. People were told that if they wanted to do research work they would have to do it at their own expense and on their own time." The equipment and supply budget for that year was \$14,000 with which the undergraduate program was to be developed and research initiated in the revitalized (perhaps only vitalized) graduate program to which emphasis had been given in 1924.

What might be called an awakening period for Indiana physics as a graduate subject began with the arrival of Vienna-born Professor Lark-Horowitz at Purdue in 1928. A theoretician, he apparently possessed keen insight into the basics of any problem confronting him and had the rare quality of encouraging his students and colleagues in their own efforts. Such encouragement was apparently not always gentle nor of the type by which we are advised to win friends and influence people—but they produced results and loyal colleagues. The

1938 construction of a cyclotron and the development of such important research as the growing of germanium crystals and their use as solid state devices, activities where Purdue was a major factor during World War II, while perhaps not directly the work of his own hands were certainly not completely unrelated to Dr. Lark-Horowitz's efforts. His interest in science teaching at both the college and the public school levels brought him a Distinguished Service Citation from the A.A.P.T. in 1935, he also having been appointed to the A.A.A.S. Committee on the Teaching of Science and Mathematics about this same time (he was committee chairman 1945-1950). His training of graduate students did not neglect the preparation and presentation of papers at professional societies; in the early days, many of these were given at the Indiana Academy meeting, as many as five being presented at that of 1934 alone.

It is of interest that Purdue's pre-World War II research budgets, as was the case elsewhere, were extremely limited, and much sweat and ingenuity went into the graduate program. Thus, for example, the 250 kV Van de Graaf generator, completed in 1937, cost "\$825.62 plus the hard labor of two graduate students." Similarly, the total cost of the 1938 cyclotron was \$9,030.90, which "was just the cost of the materials and the machining of the pole tips—. All the labor was discounted; it was mostly graduate student labor anyhow." Inland Steel's first bid for the magnet steel alone was \$2,762, but assistance from a metallurgy professor and a hitch-hiking trip to Gary by a graduate student brought the price down to the \$1,598 of actual labor and shipping costs. Incidentally, by 1958, Purdue's equipment budget had apparently climbed to some \$280,000.

A. E. Haas, a renowned German theoretician, spent his last years, 1936-1941, in residence at Notre Dame, coming there at the time the school, in recognizing the importance of physics in a major institution, was initiating a major graduate program under the leadership of Rev. H. J. Bolger, C.S.C., who served as department head during 1937-1963 and saw the specialization of Notre Dame in nuclear work with the construction of both open and pressurized van de Graaf machines.

The arrival of Dr. A. C. G. Mitchell, son of the famous University of Virginia astronomer, to accept the position of physics department head in 1938 signalled the beginning of interest at Indiana University in the so-called Modern Physics, and this interest has continued despite his untimely death in 1963. He served on the council of the American Physical Society, 1943-1947, and was Associate Editor of the *Physical Review*, 1941-1947. He had served similarly for the *Journal of Chemical Physics*, 1932-1934. At the time of his death, he had completed his third term as president of the Midwestern Universities Research Association.

World War II, the scientific accomplishments of which were so intimately bound up with physics, almost completely passed Indiana by as far as development of physics in the state was concerned. True, a major part of the growing of germanium crystals and their development as what are now known as solid state devices took place at Purdue, and some work on the properties of rubber was done at Notre Dame. Otherwise Indiana professors ended up at M.I.T., Chicago, Oak Ridge, Los Alamos, and other places where major research was underway. After

the war, many of them returned to the state, and, although they retained their knowledge, the "hardware" with which they had worked did not come with them.

At the undergraduate level, Indiana physics did not fare so badly, principally because of dedicated and effective professors. Of perhaps greatest national recognition was Professor O. H. Smith who served DePauw during 1925-1952 when he retired, only to return in 1956 to serve as emeritus professor until 1964. He was one of that small group of excellent physics teachers in the Midwest and elsewhere who, working frequently as one-man departments in liberal-arts colleges, so inspired their students as they taught them that, prior to World War II certainly, their products formed a disproportionately large fraction of those who subsequently earned the Ph.D. in physics. Professor Smith was awarded the Oersted Medal by the A.A.P.T. in 1950 and was selected to receive the Gold Key award in 1959 by President L. A. DuBridge of California Institute of Technology as the professor having had the greatest effect upon his own subsequent distinguished career. (Actually, Professor Smith always had assistance, DePauw having doubled its department size in 1919 with the employment of Margery Simpson.)

Another prominent physicist who has served Indiana was Duane Roller, physics professor at Wabash from 1944 to 1948. He edited the *American Journal of Physics*, the official publication of the A.A.P.T., from 1933-1949, and received the Oersted Medal in 1946 during his Wabash career. More recently, Lewis Salter, a Wabash faculty member, 1953-1967, was one of nine recipients of the Danforth Foundation-presented Harbison Award in 1966.

Other colleges have also had their dedicated physicists, many of whom provided service over and beyond the call of duty. Thus, at Hanover, Professor Earl Martin (1928-1957) not only taught some 18 hours per semester but was also building and grounds supervisor during the 1930-1940 period which saw tremendous advances for the school in physical equipment and college environment. His carefully kept notes as secretary of the Indiana Section of the American Association of Physics Teachers provides the flavor of those early days.

Olaf Hovda greeted the first students entering Evansville in 1919 and continued as head of the Physics Department until his death in 1942. His work in what would now be called undergraduate research resulted in the construction of a miniature planetarium and a wind tunnel for model planes.

Charles S. Morris, first professor of physics at Manchester, served from 1926 to 1961 and was responsible for several students continuing to physics graduate study. Similarly, physics at Butler University during 1924-1956 was the province of S. E. Elliott whose heavy teaching load was characteristic of many of the teachers in liberal arts colleges of this, and earlier, times.

Primarily an educator, J. F. Mackell came to Indiana State as Assistant Professor of Physics in 1921 and 2 years later succeeded Prof. Robert Gillum who had served as department head for 37 years. At this time, physics and other sciences were merged in a Science Depart-

ment of which Prof. Mackell became chairman in 1936, serving in that capacity until 1954. He published several papers on the general topic of science education, and in 1943, suggested an exchange of 1000 teacher-training students of the United States with a similar number from South America; this effort was a forerunner of UNESCO and similar post-war exchange programs.

A Valparaiso University graduate of 1922 who remained as head of the physics department for the next 5 years, J. B. Hershman obtained his physics Ph.D. in 1932 at I.U. and 12 years later founded Valparaiso Technical Institute to train specialists in electronics and communications, thus putting his physics education to a very practical use. In the succeeding 12 years until his death in an automobile accident in 1956, he had developed a physical plant capable of handling some 500 students, had secured the cooperation of several industrial firms in Indiana and elsewhere in promoting the need for the training his institute provided, and had become president of the National Council of Technical Schools.

Among notable Indiana-born physicists have been H. C. Urey, Nobel laureate in 1934, who attended Earlham but did not graduate therefrom (actually Urey considered himself a chemist) and L. A. DuBridg, current president of California Institute of Technology.

E. M. Purcell, a Nobel laureate of 1952, graduated from Purdue in 1933 and attributed his interest in physics to Prof. Lark-Horowitz who permitted him to do what is now considered undergraduate research in electron diffraction. Purdue also points with considerable pride to the fact that Dr. Julian S. Schwinger, Nobel laureate in 1965 and also winner of the Albert Einstein prize that year while at Harvard University, served on the Purdue faculty in the years 1941-1946.

Some 7 Indianans were starred in *American Men of Science* for physics research prior to 1943, the last year for this starring. Three of these and 8 other similarly starred physicists received their college education in the state, 4 at DePauw, three at Indiana University, and two each at Purdue and Rose Polytechnic.

At the beginning of the educational process as far as formal physics is concerned are the secondary schools, and it is only recently, essentially since the debut of Sputnik in 1957 and even later, that much recognition of excellence in teaching or student accomplishment has been given. However, several Indiana high school students have been recognized for competence in physics by National Science Fair and Atomic Energy Awards, Westinghouse Talent Search awards, and major competitive scholarship awards at various colleges and universities. South Side High School of Fort Wayne and Bosse High School of Evansville received awards from the A.A.P.T. in 1966 for demonstrated excellence in physics teaching. Robert Bussard and Robert White of South Side were recognized by the A.A.P.T. Recognition Program in 1963. Woodrow Pemberton of Bosse High School in Evansville received similar recognition by the A.A.P.T. in 1965 as did Robert J. Sum of West Lafayette High School. E. W. Gross, a teacher at Indiana University High School, produced four Westinghouse award winners between 1952 and 1958, was coauthor of three junior science textbooks, and was physics editor of *School Science and Mathematics* at the time of his untimely death.

Faculty members of various Indiana high schools have been honored by various scholarships and awards for continuing service, such as those sponsored by the N.S.F. and the N.D.E.A. Also, longevity in teaching physics has not been solely the province of the colleges nor has been the accomplishments of the teacher. For example, Louis Hall did such extensive work with cloud chambers during his 28 years at South Side High of Fort Wayne that the *Scientific American* accepted an article thereon. Similarly, Eiffel Plasterer, of "Bubbles Concerto" fame, taught at Huntington High for 25 years, David Wells taught Crawfordsville youngsters the subject for 36 years, and F. J. Jones, known as "Doc" to his students and "professor" to the entire community, served Greencastle High for 26 years prior to his retirement in 1952; in fact, his service almost exactly matched that of O. H. Smith at DePauw during the same period.

In addition to other financial problems, it seems that physics has been traditionally crowded for space, relieved periodically by "new" facilities which, themselves, go through the same cycle of crowding. Purdue's experience is illustrative of this trend. Its first curriculum in 1874 included physics, and the importance of laboratory work was emphasized in the president's report of 1876; however, the only provision made therefor was sufficient space on the second floor of the laboratory building for 15 students during a two-hour period each day. Within the next couple of years, laboratory work practically ceased, then apparently gradually increased until the establishment of a more detailed electrical measurements laboratory in 1885 and the movement of mechanical engineering to a new building in 1886 with a consequent expansion of physics laboratory space in the basement of its building. By 1889, Electrical Engineering occupied its new building and physics received second-floor quarters in that building. Over-crowding continued with laboratory work expanding into the halls, the attic, and the basement of the new building. Then a structure identified as the PHYSICS building was completed in 1905, was enlarged in 1934 and 1937 to almost twice its floor space, and by 1958, had become a Biology Annex. The present physics building was completed in 1941, and although its space was about three times that formerly available, it too has become rather crowded even though special facilities have served to take care of some of the research overflow, especially that related to engineering which operates the reactor.

At another institution, completion of Minshall Laboratory at DePauw in 1902 (with a restriction against the teaching of evolution therein) brought a very welcome expansion of facilities for the physicists as they left their few rooms in the basement of Middle College (now demolished) to take over half of the lower two floors of the new building from which they have since gradually expanded to the third floor also. However, these same facilities still in use in 1966 pending completion of the science building now on the drawing boards, are somewhat crowded.

On the other hand, at Hanover, the first laboratories were in the basement of Classic Hall; they expanded into several lecture rooms and classes in a science building which was destroyed by fire in 1919 to be replaced promptly by a new building which was in use until construction

of Goodrich Hall immediately after World War II provided facilities which are still generally adequate.

If the regional branches of Purdue and of Indiana University be considered integral parts of their parents, there are currently some 42 institutions of higher learning in the state of Indiana, this including theological seminaries, art schools, etc. Of these institutions, 22 provide programs leading to an undergraduate physics major. Doctorate programs are available at Notre Dame, Purdue, and Indiana Universities while Ball State, DePauw, Indiana State, and Rose Polytechnic Institute offer graduate programs leading to the master's degree.

Today, physics research in a large number of topics is generally available at the three Ph.D. granting universities, both at their own sites and in cooperation with other universities and national laboratories, principally Argonne National Laboratory. In addition to the cyclotrons at Purdue and Indiana University and the van de Graaf generators at Purdue and Notre Dame as described, these schools have active programs in analyzing bubble chamber photographs taken elsewhere for elementary particle study, and there are the usual spectrometers and equipment items for electronic and solid state experimentation. Indiana's only research reactor, dedicated in 1961, is available at Purdue, and Valparaiso is one of the two undergraduate schools in the United States having a pulsed subcritical reactor which permits offering experimental reactor studies to its seniors. All of the 7 graduate-degree granting schools, as well as many of the colleges, including Wabash and Valparaiso, have computers which are generally used in conjunction with the mathematics departments.

The three Ph.D. granting schools list 112 physics staff members having ranks of instructor or above, with another 32 faculty members at the regional campuses. Another 29 physicists are at the four schools with master's programs. There are 53 physics teachers at the 15 other schools giving baccalaureate majors, and 42 others teach physics at the other institutions. Of this 236 total, 30 teach on a part time basis, principally at schools which do not offer a major. In the five years 1960-1964, Indiana University, Notre Dame and Purdue awarded 30, 38, and 44 Ph.D. degrees in physics respectively, and, in 1965, there were 336 full-time physics graduate students at Indiana schools; this figure includes 69 at Indiana University, 79 at Notre Dame, 162 at Purdue, and 26 at the other schools having graduate programs.

However, the production of physics majors among undergraduates in the state apparently remains the forte of the schools emphasizing undergraduate instruction and these are several times as productive as the others. Thus, there are some 155 junior-senior majors among the approximately 65,000 undergraduates at the schools having graduate programs and about 125 in the some 20,000 students at the other colleges offering a physics major (about 10,000 students attend schools where such a major is not available). Similarly, some 90 majors are enrolled in the state-supported institutions which have undergraduate enrolments of about 55,000 and about 190 in the 30,000 undergraduates of the private schools. The enrolment figures are those of full-time students for fall, 1965, while the figures for majors refer to the year 1966-67.

In 1964, Wabash was one of the five undergraduate schools of the nation selected by the A.A.P.T. Committee on Physics Faculties in Colleges to feature as "detailed case studies of institutions where the quality of physics teaching is outstanding."

A rather sketchy study of industry has, even at this late date, shown a rather disappointing lack of recognition of the capabilities of physicists and their specialties with a consequent lack of employment opportunities. Thus, P. R. Mallory Co., an Indiana firm which is a major factor in electronic component manufacture, does much of its manufacturing and product development in the state, employing some four or five physicists in its Indianapolis operations; yet its principal basic research operation is located in another state. There are some bright spots, however, as exemplified by Allison Division of General Motors Corporation which first specifically hired a physicist in 1950 and currently employs 23 physicists, 2 at the doctorate level, 2 at the masters, and 19 with the baccalaureate. Similarly, Sarkes Tarzian, Inc., a comparatively small but widely known specialty company, has employed one or more physicists for some 15 years. At the other end of the recognition scale is the major industrial and research-oriented company noted in the first paragraph. Maybe there are physicists masquerading under other names or others taking over the accomplishments of the physicists. Certainly, at this date, physics should be better appreciated in Indiana than in the days of World War II when the physicists so important to the war effort all too frequently had to gulp as they were deferred as "other scientists," or even, the crowning blow of all, as "chemists."

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