U. of Iowa 80-19

Annals of a University of Iowa Department

FROM NATURAL PHILOSOPHY
TO PHYSICS AND ASTRONOMY

by

James P. Wells

Department of Physics and Astronomy
The University of Iowa
Iowa City, Iowa 52242

June 1980

PREFATORY OVERVIEW

As well as tracing some of the legacies to the present from the past, these annals seek to identify and delineate the work experience of the scientist-educators who involved themselves in the structures and dynamics of matter and energy at the University of Iowa. Thus the following pages chronicle the faculty in the changing circumstances of their times, giving some account of the nature of their teaching and investigation and revealing some of the professional and public impact of their efforts.

Much of what has happened here is similar to the experience of other continuous organizations engaged in the acquisition and dissemination of knowledge of the physical universe. For instance, the magnitude of expansion and the increasing complexity over the years is typical as well as remarkable. Since 1856 the organization now known as the Department of Physics and Astronomy of the University of Iowa has grown from part of the offerings of a single man to an aggregate of the general and specialized programs of a teaching and research faculty of more than twenty persons.

Besides the many similarities with other departments, much of which can be assumed rather than recounted, this history brings out much that is singular, even extraordinary perhaps, in more than a century of happenings on a few acres of Midwestern America. In the sense of pioneering, taking the lead in a progression of events, the annals of this department reveal:

(1) Natural Philosophy was the first, the bellwether, science to be taught at the University of Iowa, with instruction beginning in September 1856. This inauguration was the major first step in the school's fledgling efforts toward acceptance as a higher institution of learning. Before then, instruction was limited to mathematics and languages, largely in the areas of college preparatory skills. Significantly the University awarded its first baccalaureate degree in 1858 to Dexter Edson Smith, whose major studies were in the subject matter of Natural Philosophy.

(2) During the late 1860's Physical Science moved into a vanguard position. It was the first department of its kind to the west of the Appalachians to provide student-use laboratories and detailed programs for students learning from conducting their own experiments. With other innovative efforts in the advancement of science, the department became much the most prominent among those of the University during the 1870's. The spirited leadership of Gustavus Hinrichs brought Physical Science at Iowa commendations from points as distant as Central Europe.

(3) Again, in the years following the opening of a new Physics Building in 1912, G. W. Stewart and his young staff secured widespread recognition for the Department of Physics. Their work in their modern facilities became a center of attentive approval, much as with Hinrich's laboratory around 1870. Then the wartime research contributions of Stewart, L. P. Sieg, and F. C. Brown in acoustics and ballistics resulted in further commendations for the department in 1919 and 1920.

(4) Beginning in 1936 and continuing through 1959, the annual Colloquium of College Physicists brought teachers and research specialists together for mid-June sessions at the University. Colloquium rosters of invited speakers included many distinguished persons in the forefront of modern physics. Annual attendances averaged 105 persons representing 19 states and 65 institutions.

(5) World War II brought special assignments and special recognition. Alexander Ellett and James A. Jacobs, in particular, led University of Iowa science and engineering personnel into a contributing role in the development of certain kinds of proximity fuses, weapon accessories incorporating some of the physical principles of radar.

(6) In the late 1950's the department moved into the forefront in space physics and technology. America's first earth satellite--Explorer 1 (1958)--carried cosmic ray apparatus as its major experiment. Shortly afterward James Van Allen and his associates were credited with a discovery of a major phenomenon of Earth's environment--the Van Allen radiation belts. Since early 1958 more than forty spacecraft have carried U of I instruments for explorations around the planets and in intermediate regions of our solar system. The present Physics Building, new in 1965, has become a prominent center for the study of data from space, particularly that from Iowa instruments which have traversed the magnetospheres of Earth and Jupiter.

Such are some of the highlights which differentiate and distinguish the annals of this department. Much else, of course, has occurred in these 120 years of teaching and research. The scarcity of surviving records for much of the time and the writer's use of non-technical language make these chapters much less than all inclusive. Physicists and astronomers increasingly communicate with mathematical equations and with highly specialized language. Compare if you will the use of mathematics in Gustavus Hinrichs' Atomechanics of 1867--and there is much of it there--with the arrays of symbols pervading the work of present-day William Klink in his theoretical studies of multiple-particle collisions at high energies.

TABLE OF CONTENTS

Chapter One

The Beginnings in Natural Philosophy

In March 1855 the University of Iowa opened in a small rented building. For three years and four months a few teachers and their supporters struggled to keep the little school alive. Despite their efforts the University closed in July 1858 to await the growth of sufficient resources for a continuity of operation. Although he must have been sadly disappointed, the 1856-1858 chairman of the pioneering faculty, the Rev. Jared M. Stone, concluded his last report to the Board of Trustees in language of hope and prophecy:

> Allow me to say, also, that we regard it as no small honor to have been the first laborers, the first working faculty organized in an institution which we believe is destined, at no distant day, to take a high and noble stand among similar institutions in our land, and to shed a genial influence, not only over this great commonwealth, but also in some measure over all our national domain.[1]

The historians of the University's early years have given scant attention to Professor Stone and his work.[2] Their disregard may have stemmed partly from their perception of him as an unimportant and ineffectual figure during a terminal period, partly because of the scarcity of surviving records of the educational work then of the University. Yet he served as the resident administrator for most of that period of trial. He was the first to prepare and recommend a U of I student for a baccalaureate degree. He was the first to teach a science at the University.

What has now become the modern teaching and research aggregation known as the Department of Physics and Astronomy had its local origins as part of the work of this clergyman-educator.

Instruction in science at the University of Iowa began in September 1856 when Natural Philosophy[3] joined the departments then in operation: Mathematics, Ancient Languages, Modern Languages, Normal, and Preparatory. To the hard-pressed supporters of the impoverished little school, the coming of physical science was a major step toward public acceptance as "a higher institution of learning." The inherent prestige of the new department would help to erase the growth-inhibiting image of "local preparatory school." Utilitarian applications of studies of matter and energy would broaden the appeal of the University around the state.

Virtually unnoticed outside its home county, the University had opened its doors to its first few students on March 5, 1855, eight years after its founding by Act of Legislature. The campus was a small, rented building known as Mechanics Academy. The faculty comprised a teacher of mathematics, a teacher of languages, and a third man to work with those not yet ready for the instructional levels of the two "professors."[4]

With the addition of a fourth man as a Normal Principal, this division of labor continued through the academic year of 1855-1856. Most of the students were of secondary school age, a few preparing for college entry, others for teaching in the rapidly growing number of elementary schools in the state. Between 1850 and 1860 the population of Iowa rose from 192 to 675 thousand, an increase of 250 percent. Total U.S. growth during these years at the floodtide of western migration was 36 percent.

The scene of these academic beginnings was a two-story brick structure of less than thirty by sixty feet in its base dimensions. It had been built in 1842 by Iowa City craftsmen to serve as a business, social, and educational center. Located at the northeastern fringe of downtown, at Iowa Avenue and Linn Street, Mechanics Academy came to house a variety of community enterprises. It was the only building used during the University's first three years of operation.

Following its modest opening, another eighteen months passed before the infant University was able to expand its offerings to include instruction in science. The Board of Trustees had planned in 1855 to add two science departments but they lacked personnel and funding resources to realize their hopes. On April 2 of that year the Board elected two Eastern scientists into the faculty -- James Hall of Albany, New York as Professor of Geology, Zoology, and Natural History; and Josiah D. Whitney of Northampton, Massachusetts as Professor of Minerology, Meteorology, and Chemistry.[5] These men were listed as faculty in the first and second "Circulars" issued in September 1855 and in July 1856, and in the first "Catalogue" printed in July 1857. Although both Hall and Whitney appeared at times in Iowa City in connection with geological surveys for the State of Iowa, neither of them conducted classwork in Mechanics Academy. Each man was involved in a number of enterprises across the nation. Each became prominent for work in several state and regional surveys of geographical contours and of water, oil, and mineral resources.[6]

Respecting the non-appearing professors of science, Thomas H. Benton, Jr., a long-time member of the Board of Trustees, referred briefly to them in his lengthy and detailed address on the history of the University at the Commencement Exercises of June 21, 1867. Benton summed up the academic year of 1855-1856 in this fashion:

> Under this organization (meaning that of the spring of 1855) it appears that the University was again partially opened in Sept. 1855 and continued in operation until June 1856 under Professors Welton (languages), Johnston (mathematics), Van Valkenburg (normal principal) and Guffin (preparatory principal), the Chancellor and other Professors being only nominally connected with it.[7]

At their meeting of June 30, 1856 the Board elected "the Rev. J. M. Stone of Indiana," relating to him no other identification or credentials, to the Chair of Natural Philosophy. They also resolved then "that no salaries be paid to the President or any Professor of the University except for the time they are in the actual service of the University."[8] This resolution was probably unnecessary, for Amos Dean, the president-in-absentia, was compensated only for his travel expenses incurred in three trips to Iowa City plus a $500 fee for working up plans for organization. There appear to be no records of any payments to Hall and Whitney for services to the University. The resolution expressed the Board's frustration after signing up professors who did not appear on the scene to teach.

The Rev. J. M. Stone did come to occupy the Chair of Natural Philosophy, and studies pertaining to the structure and dynamics of matter and energy began at the University with the opening of the fall term of 1856-1857 on September 17, 1856.[9]

No account survives of Professor Stone's background and qualifications for the post in records of the meetings of the Board of Trustees, who employed him, nor in the work of the historians of the University's early years. The secretary of the Board had identified him simply as "the Rev. J. M. Stone of Indiana."

Presented with the problem of supplying him with a past and a future, librarians of the Indiana State Library and of the Indiana Historical Society, both in Indianapolis, searched county, church, and school records of their state.[10] They discovered a biographical paragraph in the General Catalog of Hanover College of 1890. In that issue the college gave an account of faculty and alumni since the 1833 beginnings of the institution.

Before coming to Iowa, Jared M. Stone had served as professor of natural science at Hanover between 1851 and 1856. Born in Milford, Connecticut October 4, 1808, he had earned his A.B. and A.M. degrees at Miami University (Ohio) in 1834 and 1837. He had held Presbyterian pastorships in Connersville, Indiana, 1837-1841 and in Springdale, Ohio, 1842-1850.

The Hanover Catalog listed him as "prof. and acting pres. Iowa State Univ., 1856-58." After the dismissal of the collegiate faculty of the University, Stone became pastor of the Presbyterian Church in Princeville, Illinois and the principal of the church's academy there. He died October 10, 1876 in DuQuoin, Illinois where he had served as Presbyterian pastor 1871-1876.

At the University of Iowa only a few of the more than one hundred enrollees in the fall of 1856 were ready for classwork at the college freshman level. The first University Catalog, which was printed in the summer of 1857 and covered the events of the preceding academic year, listed 105 students in the Normal and Preparatory Departments and 19 in the various collegiate departments. Almost all of them were from the city and rural outskirts of Iowa City, and some of them had not advanced beyond the rudimentary "3 R's."[11]

Coursework as we understand it today, with centrally scheduled hours continuing throughout the term on a specific subject of study, did not take hold at the U of I until the middle 1860's. J. M. Stone and others of his time would bring together a group of students for a series of lectures and demonstrations. The students would then study several pages of whatever text was within their comprehension. Only a few were ready to work their way through Introduction of Natural Philosophy, the two-volume text of Denison Olmsted of Yale College. Following their initiation into a topic, like some phase of acoustics or optics, and their study of their text, the students would take turns reciting and answering questions.

Very few records and descriptive accounts of the University's academic program prior to the Civil War have survived to this day. Record keeping tended to be brief and casual, with very little information reaching printed form. On rare occasions short items about the openings of fall terms and longer ones about University commencement exercises would appear in the Iowa City newspapers of the 1850's and 1860's, the weekly Press and the weekly Republican. Many issues of these papers are missing in the files of the library of the State Historical Society of Iowa.

Perhaps the best clues as to the first offerings of the Department of Natural Philosophy appeared in the first University Catalog, which simultaneously reported the academic program of 1856-1857 and presented that for the coming year.

The subjects to be taught in this department are

1. Mechanics, including Statics, Dynamics, Hydrostatics, and Pneumatics. Analysis of Machinery: its elements, uses, conditions, and applications
2. Electricity, Magnetism, and Electro Magnetism
3. Acoustics
4. Optics
5. Meteorology

A somewhat different version of the content and objectives of Natural Philosophy was provided in a communication by Professor Stone to the Iowa State Teachers Association in the fall of 1856:

> The course of instruction here will embrace a wide range of topics--and will be elementary and popular for such as may require this mode, and more rigidly analytical and demonstrative for such students as are sufficiently grounded in mathematics. The history of inventions and the relations of mechanical philosophy to civilization and human progress will be brought prominently into view.[12]

Teaching and learning conditions in Mechanics Academy were primitive and frequently uncomfortable, a situation common to many educational buildings of the time. In 1856-1857 an estimated daily average of ninety students--with four professors, the preparatory principal, and the normal principal--worked in four makeshift rooms, these crudely partitioned with many crevices among the separating panels of boards. The library of some 200 books was a stairway closet four feet deep and four feet wide. Room stoves were supplied from wood piles in the basement. The building was often to be reached only by wading through deep mud or snow.

Stone expanded upon the deficiencies of Mechanics Academy as a University building in his report of December 27, 1856 to the Board of Trustees:

> ... with a daily attendance of from 80 to 100 students our room accommodations are sadly deficient. The work of two different Departments--for instance--has to be carried out in a single room.

And in the same report on the critical shortage of books and apparatus:

> We are aware that in the present condition of the University it might be deemed a questionable policy to make any heavy expenditure for books and instruments. But you are well aware that without some facilities of this kind it is utterly impossible to work the Institution with any satisfaction or success.

The library grew from fewer than 100 volumes, many of them "very old, very large, very musty" in the fall of 1855, to a count of 479 in the spring of 1857.[13] The apparatus resources for two departments--Natural Philosophy and Mathematics--improved considerably during the year 1856-1857. That July Stone assured the Board of Trustees that:

> The apparatus procured is of the finest quality (with one or two exceptions--the magic lantern, for instance) and is sufficient for the successful working of Mathematical and Natural Philosophy Departments.[14]

Apparatus purchased during the year and its costs were listed in the University Catalog issued in the summer of 1857:

> Air pump, $80; electrical machine, $70; microscope, $65; set of mechanical powers and Atwood's machine, $75.

With the whole University operation confined to the space afforded by Mechanics Hall, the teaching and learning environment did not improve over the year. Stone concluded his year-end report with the plea:

> More room--more room--Gentlemen, as soon as it can possibly be furnished. We are all willing to work. Only give us a fair opportunity.

As an academic study at the U of I, astronomy was listed for 1856-1857 as part of the third-year program offered in the Department of Mathematics. It was algebra, geometry, trigonometry, and surveying for the first two years; then calculus and astronomy for the third and last year. The Professor of Mathematics, 1856-1858, Frederick Humphrey, A.M., was also the University's first librarian.

There is some surviving evidence of a few mathematics students working in the calculations of the field of astronomy during the latter part of 1857-1858. In his role as faculty chairman, or acting president, J. M. Stone gave an account in June 1858 of "studies pursued by the more advanced students:" In mathematics, among other things, they were

> measuring heights and distances, and calculating latitude, time, and the altitude of the heavenly bodies. They have learned to construct all the trigonometrical tables of Bowditch's Navigator and nearly all the astronomical tables of the same work. At the close of the term they were engaged upon the most abstruse parts of Peirce's Spherical Astronomy.[15]

In the Department of Natural Philosophy at this time, Professor Stone detailed a longer list of "studies pursued:"

> Mechanical philosophy, geometrically and analytically pursued, including the mechanics of solids; the doctrine of force and motion; gravitation; the mechanical powers in all their varieties and applications; the subject of central force and equilibrium; the pendulum in its principles and applications; strength of materials, etc. with experiments; the mechanics of fluids, including hydrostatics, hydraulics, pneumatics, and acoustics, studied after the method of senior class recitation in Yale College, with experiments.
>
> Lectures on animal mechanics, illustrated from the human skeleton.
>
> General physics, including the imponderable agents, light, heat, and electricity in their numerous sub-sections.
>
> Cosmical arrangements, as exhibited in the structure of the globe, in meteorology, etc.[16]

In such reports Stone was evidently trying to show that the struggling little University was indeed more than a local preparatory school, that it bore some resemblance to a college, to "a higher institution of learning." He was painfully aware that many Iowans were reluctant to support an institution whose teaching was elementary and which appeared to be serving only a small part of the state. With a blend of pulpit rhetoric and some of the language of physics, he had warned the Trustees that

> if ... the Public Mind shall settle down upon the conviction that it is a local school sustained at great expense of public funds what earthly power would suffice to uphold it and commend it to public favour? All the levers of Archimedes would not under such malign influences suffice to lift it one inch out of the mud! All the batteries that were ever put in action could not galvanize it into even temporary vitality!

He had concluded his December 27, 1856 report to the Board with a benediction:

> May the wisdom which cometh down from the Father of Lights--through the person of Jesus Christ--be your guide in all these high and arduous responsibilities.

Even with the University facing suspension of its activities because of lack of support, Stone continued his efforts to provide the beleagured program with some of the investitures of a college. In July 1858 the University's first baccalaureate degree, that of Bachelor of Science, was awarded to Dexter Edson Smith, 19, of Iowa City. As Professor Stone's letter of recommendation shows, Smith earned his degree largely for his studies in Natural Philosophy. The letter also reveals the length and general nature of the candidate's work for the degree.

> June 29, 1858
>
> I do hereby certify that Mr. D. Edson Smith has pursued under my direction during two terms of five months each in the State University of Iowa a daily recitation in Natural Philosophy. The course of study thus indicated

> has embraced the subjects of Mechanical Philosophy, the Statics and Dynamics of Fluids, Pyronomics, Acoustics, Optics, and Electricity in its several subdivisions. In addition to this he has attended a pretty full course of lectures on the subject of Animal Mechanics. This Course of Study has been prosecuted by the said D. E. Smith with much zeal and success: and his attainments in this direction--conjoined with general proficiency in the several branches prescribed in other departments--are deemed amply sufficient to entitle him to the Degree of Bachelor of Science, and for which he is hereby recommended to the Board of Trustees.
>
> Signed,
>
> J. M. Stone

A lengthy account of the following Commencement Exercises, in the course of which Smith received his degree, appeared in the Iowa Weekly Republican of July 7, 1858. In those days the public was invited to a series of final recitations and oral examinations, and the audience was impressed by the amount of knowledge displayed. The writer for the Republican, James Remley, expressed high praise for the recitations in the three departments of Mathematics, Ancient Languages, and Modern Languages. Then he was more moderate in his commendations of the fourth department:

> In the department of Natural Philosophy and Chemistry, although, as the professor stated, the classes were fragmentary and irregular, and destitute of suitable textbooks, and in Chemistry particularly, of anything like adequate apparatus, yet they acquitted themselves in a very satisfactory manner, and exhibited a good degree of proficiency in the elements of those noble sciences.

Remley did not name any of the professors. He did indicate that Stone, the acting president and Professor of Natural Philosophy, was in charge of the Commencement Exercises.

> I could not possibly understand Prof. Stone when he announced the names of the different speakers.

Apparently Remley's account met with some disagreement, for he wrote a follow-up letter for the Republican of July 14 to explain further his coverage of the event.

> Messrs Editors--
> It has been suggested by a very intelligent friend, that my remarks in the last *Republican* on the recent examinations, etc. so far as they relate to the Department of Natural Philosophy, are calculated to make a false impression since they apply to only one of the Elementary Classes and entirely ignore the more advanced classes. Yet at the moment of writing, I had in view only the more numerous class whose examination I had attended. In justice, then to Professor Stone and the advanced class, I beg leave on the authority of the friend above mentioned, to state that the latter class, consisting of Messrs. J. Porter, G. S. Hampton and D. E. Smith was not "fragmentary" and *did* have a textbook--Prof. Olmsted's larger work on Nat. Philosophy, that during the year, they went through said textbook in the most rigid and careful manner, uniformly applying the mathematical demonstrations; and at the examination acquitted themselves in a highly satisfactory manner.

In regard to the University the *Republican* also printed some vehement protests against the suspension of its academic activities. A new Board of Trustees had decided during the spring of 1858 not to open the collegiate departments for the coming school year. Amos Dean, the president-in-absentia, had been persuasive about the need for a period to replenish financial resources and to develop statewide interest and support. Time and money would enable the Board to refurbish the State Capitol into an instructional building, to increase the size of the library, to augment teaching apparatus, and to recruit faculty for a more extensive program. Trying to pay the bills of moving the capital to Des Moines during the autumn of 1857, with Iowa's economy aggravated by the national panic of that year, the State Legislature was reluctant to fund enough for operation of an institution which appeared to be serving only its local vicinity.[17]

The faculty of 1856-1858 had perhaps contributed to the suspension and to their own dismissal by pointing up the poverty of the U of I and stressing the immediate need for an appropriation of $30,000. A document presented to the Board of Trustees in January 1858, and to the House of Representatives the following month, the "Memorial of the Faculty of the State University to the General Assembly of the State of Iowa" urged the beginnings of what must have seemed to many to be an overly expensive program.

Among other things, the faculty pointed out that the University Library numbered only 479 volumes. In contrast, they listed the sizes of many U.S. and European libraries. For instance, Yale College had 65,000 volumes, and Indiana University counted 5,000.

> To meet the demands of science and supply the rapidly growing wants of the State, would require, in the course of a few years, $20,000 for the purchase of apparatus.

Although they were soon to have a building of their own, with the transferred State Capitol more than quadrupling the space within the rented Mechanics Academy, they stressed the deficiencies of their future home and the urgent need for an additional building.

> It is hardly necessary for us to state that the University building, formerly the Capitol, needs thorough and extensive repairs, since many of your Honorable Body are intimately acquainted with its time-worn and weather-beaten condition. In addition to repairs, its rooms must be changed, adapted to the wants and fitted up for the uses of the University. In brief, it needs a complete overhauling from base to dome. It is estimated that several thousand dollars, probably from six to eight thousand will be required for this work.
>
> The present edifice, even when repaired, will not furnish the requisite number of rooms for recitation, for public exercises, for literary societies, for library, and other cabinets ... A suitable building will probably cost from $20,000 to $25,000.

They concluded with

> Having exhibited the deficiencies, stated the necessities and indicated what the State University of Iowa ought to be, it devolves upon the General Assembly to decide what it shall be.
>
> With confidence that enlarged views and comprehensive statesmanship, uninfluenced by private interest or local prejudice, will inaugurate a new era in the history of

> science in Iowa, and thus promote the highest interests of the citizens and welfare of the State, your memorialists do earnestly pray the General Assembly of Iowa to grant, at this critical period the desired and needed appropriations in behalf of your own State University.
>
> J. M. Stone, Professor of Natural Philosophy
> H. S. Welton, Professor of Ancient Languages
> Frederick Humphrey, Prof. of Mathematics
> E. Bondalie, Professor of Modern Languages
> D. Franklin Wells, Prof. of Normal Department
> E. M. Guffin, Prof. of the Preparatory Department

In response to the petition signed by all resident and active members of the faculty, the General Assembly appropriated in March 1858 $3,000 for "repairing and modifying the building" and $10,000 for "the erection of a suitable building for boarding hall, etc." Nevertheless, the Board of Trustees voted in July to dismiss the faculty and suspend the operations of the University.[18]

Except for the Normal Department under D. F. Wells, reopened in the Fall to increase the supply of schoolteachers, the University closed down between 1858 and 1860. During the interim the pedagogical program moved to the rent-free Capitol Building, working in the southwest corner of the ground floor while the building was being remodeled into a collegiate structure. In October 1859 the Rev. Silas Totten, who had come to Iowa City to serve as pastor of the Protestant Episcopal Church, was recruited as the University's first president in residence. He had taught at William and Mary College in Virginia and had served as president of Trinity College in Connecticut.[19]

Instructed to deliver an Inaugural Address before the state legislature in Des Moines, February 6, 1860, President Totten emphasized the role of a state university in providing scientific progress and enlightenment. Illustrating particularly from the work of early nineteenth century physical scientists--Hans Oersted, Michael Faraday, Joseph Henry--Totten envisioned a future brightened by further discovery:

> And let no one suppose that the discoveries of the nineteenth century have exhausted the domains of nature, leaving nothing further to be explored. We have only begun to penetrate into her secret mysteries; and new wonders meet us on every side as we advance; and the farther we advance, the wider appears the region to be explored. Of that mysterious substance, the effects of which science has lately opened our eyes to behold in the lightning, in the telegraph, and in the magnetic engine, and a hundred other forms, we as yet know comparatively little. There are indications of its agency in light and heat, and in vegetable and animal life; and who can tell what benefits may not accrue to mankind, from a further investigation of its properties and its laws.[20]

Totten clearly saw that the best hope for stronger and wider support for the beleagured little university lay in the attractions of science and its applications. Early in 1856 the first railroad had crossed the Mississippi and reached Iowa City. The telegraph, labor-saving machinery, analysis of mineral resources and agricultural chemistry--all these were influentially making their way westward during the late 1850's. During the turbulent and agitated years prior to the American Civil War, the advancements of science and invention seemed to many the most positive and hopeful movements in the country.

The prospects of the University reopening with more science in its curricula appealed to thoughtful citizens who looked forward to a time when Iowa youth might have instruction approaching levels like those at Yale and Harvard. Then the nation's leading institutions in the teaching of science, Yale had such men as Benjamin Silliman and Denison Olmsted in Natural Philosophy; Harvard enjoyed the presence of Asa Gray, America's foremost botanist; and of Louis Agassiz, the celebrated natural historian. Iowa readers of eastern periodicals like the <u>American Journal of Science and the Arts</u>, founded at Yale and popularly known as "Silliman's Journal", were intrigued by discoveries in the laboratories and study rooms of Europe. Charles Darwin had published <u>Origin of Species</u> in 1859, to be supported in the United

States by Gray and attacked by Agassiz. In Scotland Lord Kelvin was notably advancing the understanding of thermodynamics. In Germany Robert Bunsen and Gustav Kirchhoff were developing spectroscopic techniques for the analysis of chemical elements and of heavenly bodies by means of prism-refracted color spectra.

During the early months of 1860 President Totten worked with the Board of Trustees to organize and prepare the University for its reopening. He found it difficult to attract educators with backgrounds of recognized accomplishment to an unstable and frugal situation. But he and the Board did the best they could. When the University reopened in September 1860, with all its departmental chairs filled, the new and second Professor of Natural Philosophy, like Stone, was also a member of the clergy. The Rev. Oliver M. Spencer had been in charge of a young ladies' seminary in Indianapolis before his call to Iowa as Professor of Ancient and Modern Languages. After arriving in Iowa City, Spencer exchanged chairs with the Rev. James Lillie for Chemistry and Natural Philosophy, as the department was renamed in 1860.

Born in Cincinnati in 1829, the son of the prominent Ohio clergyman, Oliver O. Spencer, he had graduated from Ohio Wesleyan University and had become a minister in the Methodist Episcopal Church. He had been placed in charge of a young ladies' seminary in Worthington, Ohio, and later transferred to a similar position in Indianapolis.[21]

In addition to the departments of 1856-1858, the new faculty roster included a Chair of Natural History, to inaugurate the teaching of the life and earth sciences at the University of Iowa. Named as Curator and Librarian and Acting Professor of Natural History was Theodore S. Parvin, a southeastern Iowa attorney, a longtime supporter and lobbyist for the University, and a former member of the Board of Trustees. Active in Iowa politics and in the Masonic Lodge, and given a variety of other duties in the University, Parvin did not begin to teach natural science until 1861-1862.[22]

Like Parvin, Spencer was a man of broad education and interests, quiet and courteous in manner, exceptionally articulate in speech and writing. Appointed to teach languages, he taught physical science during the first two years at Iowa. He served as Secretary of the Faculty during 1860-1862, and his handwriting of the minutes set standards of neatness and legibility rarely achieved by his successors in that post. After his appointment to the University Presidency in August 1862, followed shortly afterward by the arrival of Gustavus Hinrichs to teach physical science, Spencer taught Moral and Intellectual Philosophy and Belles Lettres until his departure in June 1866 to become U.S. Consul in Genoa, Italy. While holding this diplomatic post he wrote articles on Italian life and literature for such American periodicals as Atlantic Monthly and Harper's. In 1878 he was appointed Consul General in Melbourne, Australia, where he lived until his death in 1895.[23]

Judging from Iowa City newspapers of the early 1860's, Spencer was highly regarded as a public speaker, both for his lectures on European culture and for his guest sermons at local churches. Following a public ceremony in tribute to Stephen Douglas shortly after the untimely death of the Illinois Senator in 1861, the Weekly Iowa State Reporter, Iowa City, observed: "The funeral oration was delivered by Prof. Spencer of the State University. It was a well considered, eloquent, appropriate, polished address."[24]

Spencer also contributed articles on practical science to the local press. For instance, he detailed his own experiments for the improvement of the color and flavor of sorghum syrup. He called attention to optimum temperatures, crystallization, and specific gravity in his extraction processes.[25]

As indicated by the title of the department, Chemistry and Natural Philosophy, starting in 1860 the sciences were beginning to separate, although they were still under one man in the same department. But Chemistry, which received little attention from J. M. Stone (and that little during the last term he taught), was to be emphasized in the new program. There was a growing demand for services in this field as Spencer pointed out in an early report to the Board of Trustees. He referred to "frequent applications made by parties desiring an analysis of soils, minerals, mineral waters, ores, articles of commerce, and other compounds, which applications, from our geographical position, are likely to increase for many years to come. Moreover, this department of the University, in successful operation, may become a most useful and important auxiliary in developing the resources of the state."[26]

The listing of subjects to be taught in the University Catalog of 1861-1862 reveals an effort to achieve an equal balance between Physics and Chemistry in the offerings of the department headed by Spencer:

I Natural Philosophy, including Mechanics, Hydrostatics, Hydrodynamics. Pneumatics, Acoustics, Pyronomics, Optics, Magnetism, Statical and Voltaic Electricity.

II Mechanical Philosophy, with its application to the higher Mathematics.

III Chemistry, including the imponderable agents, Chemical Philosophy, Inorganic Chemistry, and Organic Chemistry.

IV Analytical Chemistry, embracing a systematic course of quantitative and qualitative analysis, under the direction and supervision of the professor of the department--together with the applications of Chemistry to Agriculture and the Arts.

The progression in time of the Course of Study was: Junior Class: First Term--Natural Philosophy; Second Term--Chemistry. Senior Class: First Term--Analytical and Agricultural Chemistry; Second Term--Mechanical Philosophy in its application to the higher Mathematics.

In those days Junior Class meant the first year at a college level; Senior Class, the second year. The University was not yet a four-year college as we understand it today. A B.A. degree could be earned in two years, and an A.M. could be the reward for a third year of study.

In respect to Oliver Spencer's teaching of chemistry and natural philosophy there appears to be less surviving record than of the teaching of J. M. Stone. For one thing, during President Totten's regime, Commencement Exercises became much more formal, with student orations and music replacing the final recitations before a public audience.

Some account of Spencer's science teaching appeared half a century later in Clarence R. Aurner's History of Education in Iowa:

> Professor Oliver M. Spencer so demonstrated his work that his department became the most popular in the institution. One of his associates has said that as professor of physics and chemistry (1860-1863) Spencer was scantily provided with apparatus, but by using what he had a course of illustrated lectures was prepared which early in the second year of his service made his the most attractive classes in the University.[27]

The associate to whom Aurner referred was Nathan Leonard, professor of mathematics at the U of I, 1860-1887. While this informant did not add Spencer's attractive appearance and his eloquent and polished speech as contributing factors to the popularity of his lectures, enough is known of Spencer's possession of these qualities.

The site for Spencer's lectures and demonstrations in chemistry and natural philosophy was Old Capitol. Through 1860-1862, before the completion of the adjacent South Hall, it was the scene of all the University's instructional activities, with the exception of the Normal Department which moved back to Mechanics Academy for a while. At the time of the 1860 reopening, the University had more than quadrupled its floor space, for the former Capitol Building had more than twice the length, more than twice the breadth, and much more usable ground-basement floor.

Except for the second floor, assignment and use of the rooms tended to be fluid and casual among the departments. The former House and Senate chambers on the second floor came to house chapel, assembly, and the larger lecture groups; also, the library and the locked cabinets for apparatus, supplies, and the beginnings of the natural history museum.

The Faculty Minutes of the 1860's rarely indicate the location of an academic activity in Old Capitol. The whole University was such a small organization that students and visitors could soon find their way to professorial desks and learning areas. During the Civil War enrollment grew and activities expanded into South Hall, and an item dated December 24, 1863 cited the faculty agreeing to requisition labels for the rooms assigned as follows:

President-- cabinet
Dr. Robert-- S of NW Division
Prof. Parvin-- NE Division
Prof. Wells-- S of SE Division
Prof. Leonard-- N of NW Division
Mr. Hinrichs-- SW Division
Mr. Borland-- N of SW Division
Miss Davis-- Large room of new bldg.
Miss Brainard-- NE room of new bldg.
Miss Bowen-- NW room of new bldg.

As the brief outline in the handwriting of Professor Nathan Leonard, the then faculty secretary, shows, President Spencer had the privilege of inhabiting the relatively austere and sequestered Senate Chamber upstairs. The Collegiate professors, along with D. Franklin Wells, Professor and Principal of the Normal Department, held forth on the first floor. Among other things, the ground floor housed the Model School, a practice teaching organization, on its south end. The janitor (the entire Physical Plant and Campus Security personnel of the time) lived with his family in the north end.[28]

In the early 1860's faculty members and students were pleased to inhabit the former Capitol, a much more commodious and comfortable building than Mechanics Academy. The description of the developing campus in the University Catalog of 1862-1863 was brief and glowing:

> The University is located at Iowa City and occupies the spacious building erected for a State House. Another large building, designed for public halls and lecture rooms, is nearly completed. The site is a beautiful and commanding one, embracing an extensive campus highly ornamented with groves of native forest trees.

But more buildings were soon to be needed. Increasing enrollments, expansion in academic offerings, and the growth of student services and clubs were to create demands for more square footage by the close of the Civil War. The Department of Physical Science was particularly expansionist at that time. Primarily responsible for its growth was a young Danish-German immigrant whose work will be the subject of the next two chapters of this history.

Notes and Sources

Newspapers cited are in the Library of the State Historical Society of Iowa located in Iowa City. Most of the other source materials are in the University of Iowa Archives in the Special Collections area of the University Library and in the stacks of bound volumes of periodicals. Primary source volumes in the Archives are Minutes of the Board of Trustees, Book A 1847-1876 and Minutes of the Faculty, Book A 1860-1881. The University Catalogues of the time are valuable sources but these tend to offer considerably more than was actually given. For instance, the Catalog of 1856-1857 listed nine departments, five "philosophical" and four "scientific." Then it presented only four active collegiate departments for the previous year and the one to follow.

DEPARTMENTS IN OPERATION

> Besides the Preparatory and Normal Departments, the Trustees have opened the following Departments in the University proper, viz:--those of the ANCIENT LANGUAGES; of the MODERN LANGUAGES; of the MATHEMATICS; and of NATURAL PHILOSOPHY. They have deemed it proper first to organize the Departments, and then to open gradually and successively, for the admission of students, such, and so many only, as the exigencies of the time require. They have organized the University for the FUTURE as well as for the PRESENT; and in that organization have been more solicitous of bestowing upon it the elements of FUTURE GROWTH than of PRESENT PERFECTION.

[1] J. M. Stone's report to the Board of Trustees, July 6, 1858.

[2] Vernon Carstensen, The State University of Iowa: the Collegiate Department From the Beginning to 1878, Doctoral Dissertation, SUI Department of History, June 1936.

Thomas H. Benton, Jr., Historical Sketch of the State University of Iowa (Commencement Address, June 21, 1867). Later revised and expanded into book form, 1879.

Josiah L. Pickard, Historical Sketch of the State University of Iowa, 1899.

Clarence Ray Aurner, History of Education in Iowa, Vol. IV, published at Iowa City in 1916 by the State Historical Society of Iowa. For this volume Aurner drew from material on the development of the sciences in his unpublished "Manuscript Relating to the Teaching of Science," the original typescript of which is at the State Historical Society of Iowa, Iowa City.

Carstensen wrote a massive and authoritative history of the early years, a work substantially enriched by his interpretation of events and by appended copies of significant documents. He provided accounts of the political, economic, and educational aspects of the University's founding and early development. But the reader of Carstensen can find relatively little in the book concerning the teachers and their classes in the 1850's and the early 1860's. Surviving records were few and often difficult to locate, and there was so much for him to relate outside the faculty-student activities. He was writing for these years a history of the University as a whole, with its early policies and problems; its aspirations, frustrations, and controversies. Other historians were expected to follow with accounts of the development of individual departments and colleges.

Carstensen apparently wrote most of what he could find about J. M. Stone, who seemed to have disappeared without a trace after the suspension of the University in 1858. Others among the earliest faculties remained in eastern Iowa for some time afterward.

The name of J. M. Stone appeared but once, and on only one page, in Aurner's uncompleted manuscript on the teaching of science, a work which is relatively rich in information on the physical sciences at the University for much of the fifty-year period of 1860-1910.

[3] The common assumption that Natural Philosophy is merely an old-fashioned term for Physics is unsustained in the history of science. From the days of ancient Greece, the word philosophy has served as a broad and prestigious heading for man's search for understanding of himself and his environment. Over the years various qualifying adjectives--intellectual, moral, natural--developed and were employed to divide the areas of study and the modes of investigation.

Natural Philosophy is rarely used now outside the universities of Scotland, but for many centuries the term embraced all studies of man's environment, particularly of what was perceivable by the senses. Then, as the work of Galileo, Kepler, and Newton developed a content of mathematical laws for the motions of large bodies, Natural Philosophy applied primarily to what was measurable and constant in the physical and earth sciences. Plant and animal organisms and the processes of growth became the province of Natural History.

By the early nineteenth century Chemistry and Geology has grown rapidly and began to diverge as separate fields of study. With these departures Natural Philosophy and Physics became virtually synonymous as department and textbook titles. In the 1860's, for instance, a text widely used in the United States bore the title: Introductory Course of Natural Philosophy Edited from Ganot's Popular Physics, by William G. Peck.

[4] Summaries of the earliest operations are based on information in Carstensen, op. cit. and in Benton, op. cit. along with verifications from primary source materials in the University of Iowa Archives.

[5] This is a history of the beginnings of science teaching at the U of I, so, although no evidence has appeared showing any significant connection between the early activities of the University and the work of James Hall and Josiah D. Whitney in Iowa, it seemed appropriate to give some account of the roles of these prominent and influential scientists when they were in the vicinity.

[6] In his biography, Life and Letters of Josiah Dwight Whitney (Houghton Mifflin, 1909) Edwin T. Brewster called attention to the appointments in 1855 of both James Hall and Whitney to the faculty of the University of Iowa. Brewster then observed that "as the University of Iowa existed in large part only on paper, the chief duties of the professor of chemistry were understood to be in connection with the state geological survey." Noting Hall's commitments to other survey projects, Brewster pointed out that "Hall was able to give at most but a quarter of his time to Iowa; so that Whitney, nominally only chemist to the survey, became practically its working head."

Among the excerpts from Whitney's letters which Brewster included in his book, one to the scientist's wife, from Muscatine, Iowa, dated April 21, 1856 told of difficulties of travel from Burlington to Muscatine toward Iowa City. The succeeding letters in May and June of that year are from Schenectady, New York. Then in a letter from Northampton, Massachusetts dated December 20, 1856, Whitney related ... "to Iowa again, where I spent a couple of months only, as the weather was so unfavorable that the field work had to be closed up very early."

From such evidence it seems that Whitney appeared briefly in Iowa City in the spring of 1856 and spent approximately two months in Iowa during the fall of 1856, preoccupied primarily with his field work outside Iowa City. He might have visited Mechanics Academy, only three blocks away from the geological survey's headquarters in the State Capitol, and perhaps he might have met the science teacher J. M. Stone and other members of the early faculty.

[7] Benton, op. cit.

[8] Minutes of the Board of Trustees, 1847-1876.

[9] University Catalogue, 1856-1857, corroborated by Carstensen and Benton and by J. M. Stone's reports to the Board of Trustees.

[10] Librarians in Indianapolis also found a brief item in The History of Fayette County, Indiana to the effect that Rev. J. M. Stone was the first pastor of the newly built Presbyterian Church in Connorsville. The information from Indiana librarians Leona T. Alig and Frances B. Macdonald is now in the J. M. Stone file in the University of Iowa Archives.

[11] On his way to Grinnell in September 1856, Leonard F. Parker visited the State University where at that time he found that "algebra was the highest study, and there were sixty pupils scattered all the way down to the three R's"--from Jacob A. Swisher's Leonard Fletcher Parker, p. 47. Parker was to become Professor of Greek Language and Literature, 1870-1887, at the State University of Iowa.

[12] Printed in Voice of Iowa, the early journal of the Iowa State Teachers Association, in January 1857.

[13] Professor Henry S. Welton, Ancient Languages, 1855-1858, described the unattractive condition of about fifty of the books in 1855. The following year Frederick Humphrey, the first librarian, said he found some 160 books "thickly covered with dust and lying on the floor," as recorded in History of the University of Iowa Library by Mildred Thorne (University Archives). In the late spring of 1857 Humphrey organized the library into five classes, as follows:

I	Theology	14	volumes
II	Jurisprudence and Politics	43	"
III	Science and Arts	135	"
IV	Belles Lettres	100	"
V	History	187	"
		479	"

[14] J. M. Stone, "Report to the Board of Trustees," July 6, 1857.

[15] Iowa City Republican, June 20, 1858.

[16] Ibid.

[17] The circumstances and controversies relative to the University's interregnum of 1858-1860 are given full treatment in Carstensen, op. cit.

[18] Carstensen, op. cit.

[19] Theodore Wanerus, a 1910 graduate of the University, wrote a series of short biographical sketches of the early presidents for the Iowa Alumnus. His account of Silas Totten appeared in January 1912, Vol. IX, pp. 105-108.

[20] From "Inaugural Address," President Silas Totten, in the University of Iowa Archives. Totten demonstrated a considerable knowledge of the history of science as he repeatedly emphasized the role of the university in providing the basic principles for the advancement of science and its applications.

> There is a common belief that practical men, with little learning or cultivation, have been the great discoverers and inventors: and that to them alone we owe, all the improvements in the practical arts. But this is a great error. The learned must investigate the principles of science, before the ingenious artizan can apply them to the purpose of life.
>
> Watt, and Whitney, and Arkwright did nothing more than apply principles, which had been investigated long before by learned men, either belonging to the Universities, or trained in them; and without these principles, they never could have proceded one step in their inventions. Watt could never have perfected the steam engine, had not Dr. Black, of the University of Glasgow, first investigated the laws of steam.

[21] Theodore Wanerus, "Oliver M. Spencer" in Iowa Alumnus, February 1912, IX, 136-140. Wanerus summed up:

> Oliver M. Spencer's period of service at the State University of Iowa was characterized by a more thorough centralization in organization, and by a steady growth in attendance.
>
> The old system of giving credit by means of certificates of proficiency was abandoned and the work of a school year made the basis of granting degrees. Work completed in the first three years of the scientific course; and for four years' work, the degree of Bachelor of Philosophy. Those completing the four year classical course were granted the degree Bachelor of Arts.

[22] J. W. Rich, "Natural History at Iowa State University--What It Was and What It Is" in Iowa Alumnus, April 1906, III, 187-194. Rich, a former University of Iowa librarian, observed that:

... the name of Theodore S. Parvin appears in the catalogue as "Curator and Librarian, and Acting Professor of Natural History," but no class was organized in the subject that year (1860-1861). In 1861-2 actual work in natural history began in a tentative way--with a small unclassified geological cabinet, no apparatus, and no library worth mentioning.

[23]Wanerus on Spencer, op. cit.

[24]Weekly Iowa State Reporter, June 12, 1861.

[25]O. M. Spencer, "Chinese Sugar Cane," Iowa City Republican, October 8, 1862.

[26]O. M. Spencer, "Report to the Board of Trustees," undated MSS cited by Carstensen, op. cit.

[27]Clarence R. Aurner, History of Education in Iowa, pp. 174-175.

[28]Along with discussions and decisions on student infractions of the rules (like those for chapel attendance and behavior) considerations of the janitor's work performance appear frequently in the Faculty Minutes of the 1860's. The janitor was instructed, for instance, to relocate the woodpile to a less conspicuous place, to set up screens at the entrances to the outhouses, and to be more vigilant in keeping the town boys from playing on the campus.

Chapter Two

Rapid Rise and Support of Physical Science

As the Civil War drew toward its close, interest in the physical sciences began to sweep across the small campus. The interest was bolstered by the opening of a new laboratory and chapel-library building (North Hall) in the fall of 1867. At the crest of the upsurge, during 1870-71, four out of every five of SUI's 350 students[1] at the time did some work in the new laboratories whose director called "temples of science." Eloquent, energetic, and evangelical in scientific causes, Gustavus Hinrichs found Iowa students receptive.

He had migrated to the United States in the summer of 1861 after studying for eight years in the polytechnical school founded by Hans Oersted at the University of Copenhagen. Then 24, he was the author of a small book on the electromagnetic principles of telegraphy and of a pamphlet on terrestrial magnetism.[2] Unable to find a college post because of the shrinking enrollments during the Civil War, he secured his first employment to teach foreign languages in the Davenport, Iowa school system. In September 1862 he was appointed to teach French and German at the State University of Iowa.

Soon after his arrival in Iowa City, he began to assist with the instruction of chemistry and natural philosophy. Oliver Spencer had just become the University's third president and had inherited the teaching of moral and intellectual philosophy from departing President Silas Totten. So, from 1862 through 1864, Spencer and Hinrichs shared the physical science teaching load, with more and more going to the younger man with the more specialized training. Hinrichs still had the modern languages to teach.

The record at that time of University administrative actions and deliberations was the Faculty Minutes. During the autumn of 1862, only three brief notations appear regarding the new man: September 13, 1862—"G. Hinrichs elected teacher of modern languages" ... "salary $450." October 8—"Hinrichs appointed recorder for weekly reports of student scholarship." November 19—"Prof. Hinrichs to take charge of instrumental music on all occasions at Chapel."

The increase in physical science offerings is best shown in the University catalogs, which were printed during the summer, giving specifics on courses and enrollments for the previous academic year and, in more general and promotional language, looking forward, for instance, to additional chemical and philosophical apparatus and new building facilities under construction. At that time the school year consisted of three terms of three months each—fall, winter, and spring terms.

For the year 1862-63 the department had given a full-year course (three terms) of Natural Philosophy and two terms of Chemistry. In 1863-64 Chemistry became a full-year course with the addition of a spring term in agricultural chemistry. In 1864-65 departmental offerings were shown as a three-year course of study, with four term courses of Natural Philosophy and five terms of Chemistry. In 1865-66 it was four term courses of Natural Philosophy and eight of Chemistry.

The 1865-66 Catalog also lists the hourly schedules for President Spencer and the five other members of the collegiate faculty. The "Programme" for Professor Hinrichs shows that he was confronting students without a break from 8 a.m. until 1 p.m., Mondays through Fridays.

Fall Term: 8—Mechanics, 9—Laboratory Practice, 10—Physics, 11—Laboratory Practice, 12—Analytical Chemistry.

Winter Term: 8—Electricity, 9—Laboratory Practice, 10—Inorganic Chemistry, 11—Laboratory Practice, 12—Minerology.

Spring Term: 8—Optics, 9—Laboratory Practice, 10—Organic Chemistry, 11—Laboratory Practice, 12—Agricultural Chemistry.

President Spencer taught two classes each morning, and Professor Nathan Leonard of Mathematics and Astronomy, three. The Professor of Ancient Languages had four daily classes.

Afternoons, evenings, and weekends were also periods of intensive work for Gustavus Hinrichs. He was conducting research and reporting his findings in a variety of professional and popular periodicals. He was giving public lectures on a wide range of topics. He was writing his own textbooks for both Physics and Chemistry. He was planning and securing equipment for 3,500 ft^2 of laboratories for the new North Hall, constructed between 1865 and 1867.

And throughout all this much of his time and energy was consumed by the major crusade of his early professional life, his studies of the mechanics of atoms. As a student in Copenhagen in the 1850's, he had begun to sense the nature of his destiny. He would bring to the atoms of the fifty-odd chemical elements the kind of unity and order that Kepler and Newton had formed for the motions of the planets. He would become a major benefactor to students of chemistry and physics and would ensure for himself a principal role in the history of scientific discovery.

After thirteen years of labor on his passionate quest, he offered to the world in the summer of 1867 "A Programme of Atomechanics: or Chemistry as a Mechanics of the Panatoms." He mailed his work to some sixty locations of physical science activity in Europe and to at least ten in the United States.[3] He wrote accompanying and follow-up letters in several languages to many scientists, including such eminent personages as John Tyndall and Charles Darwin in England, August von Hofmann and Justus von Liebig in Germany, and Dmitri Mendeleev in Russia. Hinrichs had convinced himself that he was laying the groundwork for a system of mathematical principles governing the common structure of the different elements.

Drawing analogies from the celestial mechanics of Kepler and Laplace in particular, Hinrichs urged:

> Let us have the boldness to pronounce a similar hypothesis in regard to the chemical atoms. Let us suppose that the atoms of the different elements only differ in regard to quantity; that is, in regard to the number and relative position of the atoms of some one primary matter ... [4]

In August 1868 he read three papers detailing the ramifications of his "Programme" before the annual meeting of the American Association for the Advancement of Science in Chicago. Again in August 1869 he read three more papers at the AAAS meeting in Salem, Massachusetts. On each occasion two of the three papers were published in the Proceedings of the AAAS.

It should be noted that other speculative scientists had developed theories on the unity of matter, but none appear to have promoted their programs with more zeal and persistency. Nor did they more exhaustively detail the presumed structural relationships of their basic essence. Hinrichs' hypothesis was advanced some forty years before the proton-electron model of the atom as supported by the experimental studies of J. J. Thomsen and Ernest Lord Rutherford and by the theoretical work of Niels Bohr and others.

Hinrichs encountered considerable skepticism and criticism as he detailed his structuring of the "panatom." Some senior members of the AAAS viewed his presentations as presumptuous and premature. With one eminent scientific figure, attacks and counter attacks continued for several years and resulted in exchanges of mutual animosity. James Dwight Dana, Yale geologist and editor of the American Journal of Science, called the Atomechanics "fanciful and unintelligible" and charged the younger man with plagiarism from Dana's Minerology and from the works of others. Hinrichs spiritedly counterattacked Dana on grounds of misquotation and inaccuracy and accused the senior scientist of "deliberate appropriations" from the work of Rene Hauy, the eighteenth century French minerologist.[5] Since Dana, along with Louis Agassiz of Harvard, was one of the major American scientists opposing Darwin's work on evolution and natural selection, Hinrichs wrote to the British biologist in hope of support. Charles Darwin's reply could be described as carefully noncommital but sympathetic.

Aug. 13, 1868

My Dear Sir:

I have received your letter with its enclosure in reference to Professor Dana, but I have not received some other publication to which you allude. As it is many years since I have attended to chemistry, I should not be able to form any sound judgment on your theory; but I can clearly see, if you can establish your case, that you will have made a magnificent discovery ...

Pray believe me, dear Sir, with every good wish, yours faithfully.

Ch. Darwin

On several occasions earlier, Hinrichs had corresponded with Joseph Henry, the most renowned physical scientist of mid-nineteenth century America. Henry served as science advisor to several U. S. Presidents and as administrator of the Smithsonian Institution since its beginnings in 1848. In 1867 he helped Hinrichs in disseminating copies of Atomechanics abroad. Henry's letter to Hinrichs at that time could be described as benignly understanding and encouraging but circumspect:

Smithsonian Institution,
Washington, July 12th, 1867

Professor G. Hinrichs
Iowa City, Iowa

Dear Sir:

Your copy of Atomechanik has been received and I write to say that it will give us pleasure to transmit as many copies as you may desire to send to German Physicists and, also, copies of the work on Chemistry and its French resume to Chemists in England and France.

A large amount of thought and labor is, at this time, devoted to molecular physics and indeed it is the branch of Science to which we may look for more extended views of nature, and from the investigation of which we may hope to obtain further control over the physical forces which underlie the phenomena of the material Universe.

I need not, however, say to you that the test of the value of an antecedent hypothesis, in regard to the subject, is not only its capability of explanation of known phenomena, but, also, its power to suggest and develop those which are new.

Yours, Very respectfully,
Joseph Henry

Hinrichs also hoped for approval and support for his panatom hypotheses from John Tyndall who, following Michael Faraday's death in 1867, had succeeded to the directorship of the natural philosophy laboratory of the Royal Institution. Tyndall's measurements of the absorption of radiant heat by gases and his studies of beams of light through water and solutions, Hinrichs asserted, all served to prove the open geometrics of his structuring of the common elements of the atoms. As the following letter shows, Tyndall gently admonished the impetuous younger man:

8th January 1868

I spent some time today in looking over the resume of your work. I wholly agree with you that the problem of chemistry is one of molecular mechanics, and the last eight years of my life have been occupied in endeavoring to get some experimental hold on the atoms and molecules themselves.

Whether the time has come to found a definite system such as you propose is an open question. For my own part, I fear opening the petals of that flower before it is mature.

Yours very truly,
John Tyndall

But Hinrichs was not to be restrained by any lack of acceptance of his program. He continued, for instance, to cite Tyndall's work as supportive of his theories: in 1868 in "How a Snowflake is Built," an article in the Scientific American, and in "Atom-Mechanics Proved by Tyndall's Experiments," in the American Journal of Mining. He also crusaded from the public lecture platform in Iowa City, Muscatine, Davenport, etc. He seldom ranged far from his base. Travel for speaking engagements consumed considerably more time then, and he was much too busy to expend very many of his days in that fashion.

In Iowa at least his presentation of "The Unity of Matter" appears to have been well received. After noting the largest audience of any recent lecture, the Muscatine Daily Journal delivered this opinion:

> We have heard some of the most noted savants of science in our country and can truly say that Prof. Hinrichs is equal to the best of them as a public lecturer. [6]

He has been described as willing to talk on almost any scientific subject as well as on some other educational topics. He spoke on "The Coal Fields of Iowa" in Council Bluffs and on "What the Stars are Made Of" in Davenport. He was "one of the most versatile men in American Science," according to one admirer.[7] Another pulled out all the stops in his organ of praise.

> G. Hinrichs, the peer of Agassiz, the countryman of Humboldt, the pioneer of scientific investigation in this era, whose name is as familiar as a household word in schools of Berlin, Vienna, St. Petersburg, Paris, and Stockholm. [8]

The author of the extravagant language above, Editor John P. Irish of the Iowa City Press, chose for his Christmas Day paper, 1867, to print in full verbatim Hinrich's hour-long Sunday Lecture on "Faith and Science." Rarely did a newspaper of the time report much of the content of a speech, except for Inaugural and State of the Union addresses by U. S. Presidents and sometimes a major speech by a state governor. Generally a nineteenth century editor thought it sufficient to name the speaker and his subject, then offer some praise or censure in a brief paragraph.

With the publication of Darwin's Origin of the Species in 1859, Hinrichs was speaking in a time of considerable controversy between votaries of the new science and supporters of the Old Testament version of creation.

He distinguished between the territories of science and faith in this fashion:

> Now science is the substance of things known, the evidence of things seen (heard, or otherwise perceived). ... faith is the evidence of things not seen, like the stars of the noonday sky ...

With examples from the histories of science and religion, he pointed out that science begins in a diversity of individual approaches, then moves toward unity and harmony in the discovery of the natural laws underlying and governing animal and plant life and the structure and motions of matter. On the other hand, he explained, faith starts with a universally unifying awe and love of a creative and immortal being of supernatural power; then partisans tend to divide into numerous differing and often conflicting sects.

> Thus we see, that history proves science to be convergent, centralized, centripetal; while faith has been centrifugal, decentralized, and divergent.

The passionate eloquence of Hinrichs in the cause of science reached a peak in the rhetoric of this passage:

> They who would put shackles to science, those who would hinder her in her onward march are undertaking to stop the effulgence of the noonday sun, are trying to prevent the solar ray from reaching every part of the universe; and fortunate it is that every attempt of this kind is vain, for as in nature the light of the sun fills our rivers, sends rain to our fields, weaves air into grain, with one word, supports and feeds all changes on the globe from the deposition and vaporization of the dew drops to the brightening of the eye of man; so science is the only and sufficient basis of the wealth of humanity.

Hinrichs sent Darwin a copy of "Faith and Science" and received the following response:

> I have read your Sunday lecture on Faith and Science with very great interest: it appears to me excellently written and contains many ideas quite new to me. [9]

Such excerpts from Hinrich's wide repertory of speech and publication, and responses to his presentations, reveal, among other things, his versatility and intensity. He was unquestionably committed to the advancement of science, seeking personal recognition--there was considerable vanity in this Messiah--and also sharing his knowledge with a genuine concern for the enlightenment and welfare of others. The altruistic side of his nature is well attested by student and newspaper support.[10]

In 1864 he began his campaign for a physical science laboratory that he was determined to make the best in the country. His model was the laboratory for general student use that Justus von Liebig established in the 1830's at the University of Giessen in Germany.

The state legislature appropriated funds for a new building, the first floor of which was to house physical science and the second floor a chapel-assembly-library room. And in the summer of 1865 Hinrichs was provided with $100 in travel funds to visit Eastern university laboratories to gain ideas for the design and equipping. He chose to spend nearly a week each at the laboratories at Harvard, Yale, Columbia, and Michigan. He reported that they were all modeled after von Liebig's laboratory, thus reinforcing his intention to emulate, if not surpass, the one at Giessen.[11]

Opened for use in the fall of 1867, the laboratory was proudly described as "second to none in the United States" year after year through 1871 by the University Catalogue. Its proportions and arrangements were reported as follows:

> Exclusive of ample halls and the basement rooms already partly used for chemical purposes, the laboratory proper has an area of nearly 3,500 square feet with a height of fifteen feet. It is divided into four large rooms, of which the 'Students Laboratory' is thirty by sixty feet. The laboratory is already well provided with cases (in two stories, the lower eight feet high, the upper seven, accessible from a gallery) filled with apparatus, chemicals, minerals, rocks, etc. etc. It is provided with the most necessary furnaces, distilling apparatus, gas and water fixtures, balances, spectroscope, etc.

In the fall of 1869 the editors of the University Reporter, precursor to the Daily Iowan, visited the laboratory and wrote:

> "Neatness and most perfect order was observed. We saw much new apparatus purchased by Prof. H. when east last summer: a new analytical balance, a series of models of crystals of glass, and a collection of finely crystalized minerals. We were shown an Arsenic apparatus, invented by the professor himself, which in regard to accuracy is far superior to any heretofore constructed. A hundredth part of a grain can be detected by it, even if diffused in a large quantity of liquid ... when we took our departure from this review, we did it feeling prouder of the department, of the University and of the State.[12]

Shortly after the visit of the Reporter editors, the laboratory acquired some additional apparatus: a goniometer for measuring the angles of crystals, a Ruhmkorff induction coil, Hofmann's apparatus for the decomposition of water, and a Holtz electrical machine capable of producing electricity without friction.[13]

Hinrichs welcomed visitors to view his array of apparatus imported from France and Germany. There were only a few such laboratories in the United States in the late 1860's, and SUI's was becoming the major one to the west of Ann Arbor, Michigan. The visitors were bound to be impressed to find so near the frontier so many instruments of such awesome precision, seemingly portentous of miraculous performance. High priest of this "temple of science," the small and intense professor presided over the rituals of laboratory method, pointing out his framed pictures of, and testimonial letters from, scientists of central Europe mounted around his posted LABORATORY RULES:[14]

> 1. BE QUIET.—Talk not to your fellow students, and only in low whisper to your teacher. Walk to and from the balance so that your steps are not heard. Early learn thus to show reverence for truth and its investigation; the laboratory should be a temple of science.
>
> 2. BE CAREFUL.—Handle every apparatus precisely as directed, and as if it would require a fortune to replace it. See that everything is in good order when you receive it, and take an honest pride in returning it in excellent order to your teacher. If you injure anything, frankly take it to your teacher, and pay enough to repair the injury and the loss.
>
> 3. BE CERTAIN.—Do everything so that no doubt can arise. Measure, weigh, and record as directed, then you will be sure. Do not trust to your memory. Do not assert anything of which you are not sure. Never guess--at most, estimate.

Devoutly, evangelically the apostle of Science, Hinrichs sought to invest every laboratory action with a charismatic aura of deep significance and nobility of purpose. "Students with their own young hands dip the water of truth from the pure fountain of nature," he said in urging other instructors to use the methods advanced in his text, The Elements of Physics, Demonstrated by the Student's Own Experiments. Clumsiness and fumbling were not to be permitted with the instruments of progress toward knowledge. The instructor should initiate the student into the use of the laboratory with meticulous care. Thus the novitiate should begin with measuring and weighing, not only because magnitude and weight are major properties of matter, but also to "acquire some degree of culture in his fingers, so very necessary in experimentation."[15] So the first forty pages of The Elements present a list of exercises, with procedures and precautions painstakingly spelled out, in measuring and weighing and in sketching and drawing objects and equipment.

To the readers of these annals who have had experience in modern physics laboratories, Hinrichs' methodology may well appear excessively elementary as well as perfectionist, even pompous. But there was very little science taught in the public schools at that time, and many students were seeing their first meter sticks and gram-weight balances. Some perhaps had collected and classified rocks, plants, and insects, but few had even entered a physical science laboratory. Thus for these inexperienced newcomers, many of them at the college preparatory level, Hinrichs stressed care and caution in handling the tools of his sciences. Apparatus and supplies had not come easily into the laboratory. Annual funding from the Board of Trustees for these items totaled \$142 in 1865, \$150 in 1866, and \$270 in 1867.[16]

With the new North Hall laboratories in operation and the growing prestige of their director, the funding increased substantially. In 1868, in addition to nearly doubling the annual amount--from \$270 to \$500--Hinrichs was given an assistant to help him with the large enrollment in the physical sciences: Rush Emery, the University's first assistant professor and the first faculty member to hold a Ph.D. degree.

One of Hinrichs' first students, Emery had earned an A.B. at SUI in 1863 and his A.M. in 1864. He continued his study in Germany, receiving his doctorate at the University of Goettingen in 1868.[17]

In 1869 the Board of Trustees voted $1,000 for the laboratory; in 1870, another $1,000 and a second assistant, Francis Nipher, to help with the mounting program.

The academic year of 1870-71 proved to be the summit time of Hinrichs' influence and of support and enrollment in the physical sciences. In addition to directing a total of 292 students in their laboratory practice, he was complimented by newspaper editors and other visitors.

Earlier, in the winter of 1870, his self-esteem and local reputation had been considerably enhanced by an event in Austria. On January 20, 1870, Wilhelm von Haidinger, Director of the Geological Institute of Vienna, read and praised Hinrichs' paper on the structure of quartz before the Imperial Academy of Sciences. The University Reporter of March 1870 made much of this:

> Haidinger referred to the complete harmony between his own observations and the graphic constructions given by Prof. Hinrichs relating to the motion of the solid particles of pseudomorphs, and to the molecular motions which attend the slow formation of crystals. He also called attention to the progressive labors of Professor Hinrichs in the study of artificial crystals, and placed before the Academy a view of the buildings of the State University of Iowa ...
>
> "Von Haidinger is one of the oldest and ablest of living mineralogists, and it gives us pleasures to observe from time to time that the man whom some of us are proud to recognize as our teacher, is also appreciated by the ablest workers in the great field of science.

Hinrichs was also trying to generate more interest and activity in physical science in the public schools. In his department's pages in the University Catalog of 1869-70, he noted that "for the next year will be added a course of three lectures on The Physical Laboratory of our Common Schools." On the same catalog's page describing THE LABORATORY, he concluded with an exhortation which must have irritated some of his fellow scholars:

> School teachers, desirous of introducing physical sciences into their schools, will at any time, by spending a few weeks at the University, receive that special information concerning physical practice in schools, which is essential to success in this work. They will, by seeing classes work at the experimenting tables, learn more in one day in the laboratory than they could learn in weeks from books.

A few months later, in March 1871, he set up on the title page of The School Laboratory, a publication of his department, the following:

> Let us hasten the day when an experimentative table, with physical apparatus and specimens, shall be as indispensable an appurtenance of the smallest school house as a blackboard is now, and when every town of a thousand inhabitants shall possess a good SCHOOL LABORATORY wherein twenty-five pupils can experiment at the same time.

In the University, as revealed by the Catalog of 1870-71, all students were required to take some physical science courses and to do some work in the laboratory. The degree program comprised five years, including the sub-freshman class for those who had not completed high school. Admission was by examination over the English and Latin languages, arithmetic and elementary algebra, and U. S. history and geography.

Hinrichs and his two assistants provided a full-year course in physical science for both the sub-freshmen and for the freshmen. For the sub-freshmen it was Elements of Physics in the fall term, Elements of Chemistry in the winter term, and Elements of Cosmical Physics in the spring term. For the freshman class it was Principles of Physics in the fall term, Principles of Chemistry in the winter term, and Applications of Physical Science in the spring term.

The sophomores were free of requirements in Hinrichs' department, taking work instead in the natural sciences. For their junior and senior years, students chose either the Literary or the Scientific course of study.

Term-length courses in Physical Science for the Junior Class included Descriptive Minerology; Physical Minerology; Molecular Science, Agricultural Chemistry I, II, and II; and Qualitative Analysis I, II, and III. The offerings for the Senior Class included Higher Physics I, II, and III and Quantitative Analysis I, II, and III. (Higher Physics was largely theoretical induction and deduction.)

The catalog assured its readers that "the degree of BACHELOR OF ARTS will be conferred on every student who completes the Literary course; that of BACHELOR OF PHILOSOPHY on every one completing the Scientific course."

During the three University commencements of 1869, 1870, and 1871, the literary degrees totaled 14, the scientific degrees 18, as compiled from the catalogs of those years.

A feature of the University Commencement exercises of June 27, 1871 was the inaugural address of a new President, the Reverend George Thacher. The address turned out to be the beginning of the end of Hinrichs' hopes for the continued expansion of his programs.

<u>Notes and Sources</u>

In addition to those surviving records preserved in the Archives of the University of Iowa Library, in the University Registrar's Office, and in the Library of the State Historical Society of Iowa, other collections have been useful in the preparation of Chapter Two.

One such collection is the Theodore Parvin legacy of books and papers to the Iowa Masonic Library which he founded in Cedar Rapids. From 1860 to 1870 Parvin was Professor of Natural History and Librarian at SUI.

Another is the gift of Hans Hinrichs of St. Louis of his grandfather's works and records to the Archives of the University of Illinois, Champaign-Urbana, Illinois. In 26 manuscript-boxes the GUSTAVUS DETLEF HINRICHS collection ranges from his high school texts and notebooks through the numerous articles, pamphlets, and college textbooks he wrote and published. Much of his personal and professional memorabilia—copies of correspondence, newspaper clippings, lecture notes, etc.—can be found there.

[1] University Catalog, 1870-71.

[2] "Contributions to Knowledge by Gustavus Hinrichs," a bibliography in the Journal of the Iowa Academy of Sciences, XXXI, 80, 1924. Hinrichs was a principal founder of the Iowa Academy.

[3] From his papers in the Archives of the University of Illinois. He marked the locations on maps of Europe and the United States.

[4] "A Programme of Atomechanics," pamphlet of August 1867.

[5] "Remarks on a Recent Editorial in the American Journal of Science," pamphlet of May 1868, responding to J. D. Dana's editorial of January 1868.

[6] Muscatine Daily Journal, Dec. 5, 1867. Similar praise appeared in Davenport Gazette issues of April 3, 1867 and February 15, 1868.

[7] "Gustavus Hinrichs," a biographical article by C. C. Wylie in The Palimpsest, XI, 193-, May 1930.

[8] Editor John P. Irish in the Iowa City Press, Aug. 9, 1871.

[9] From the previously quoted letter from Charles Darwin, dated August 13, 1868.

[10] For one of many examples: "Petition for More Science at the University," MSS Archives, by Frank Springer et al. (five other students).

[11] Report of Hinrichs to the Board of Trustees, June 25, 1866.

[12] University Reporter, Nov. 1869.

[13] From Report of the State University to the General Assembly, 16, Jan. 18, 1870. President James Black also reported that the General Library had reached 2,000 volumes and that the new Law Library "already numbered near 1,000 volumes."

[14] As printed in Hinrichs' textbook, Elements of Physics, 1870.

[15] Addendum to above book, "Guide to the Proper Study of the Elements of Physics," p. 156.

[16] Minutes of the Board of Trustees, June 25, 1865; June 28, 1866; June 25, 1867.

[17] "Rush Emery," biographical article in the University Reporter, June 1869.

Chapter Three

Dissension and Decline from Prominence

The years 1870-72 proved to be the peak period of the rise and influence of the physical sciences at the University. From then on the efforts of Hinrichs and his supporters failed to halt the cutting and weakening of the laboratory-based program. Despite some impressive plaudits in British and American journals, the share of financial support and number of course offerings diminished. The path was to be downward and dim of prospects for more than forty years.

Foreshadowing the coming dimunition was the resignation of science-supportive President James Black in December 1870. After an interval with Nathan Leonard, Professor of Mathematics and Astronomy, as acting president, the Reverend George Thacher was formally inaugurated as Black's successor on June 27, 1871.

On that occasion the new President urged a renewal of more of the classical and philosophical education prevailing in the venerable universities of the Eastern seaboard. He particularly stressed the values of Latin and Greek in the development of intellectual and moral discipline.[1]

> And the time is fast coming when the recent loud outcry against the required study of Latin and Greek in our colleges will seem too absurd and even ludicrous ever to have been sincere; for it is one of the surest means of elegant and finished culture. The languages themselves are more nearly perfect than any other ever used by men. The literatures embodied in them comprise the purest models of written composition extant. Their remains are among the most precious of all the legacies of olden times to the present. They are called the <u>dead</u> languages. Never was a word more abusively misapplied.

Such language warmed the hearts of Amos Currier and Leonard Parker, the teachers then of classical languages and of ancient history and literature. For the past several years the Board of Trustees, the legislature, and the public had grown more responsive to the "practical education" of the physical sciences than to the cultural disciplines of the traditional departments.[2]

President Thacher went on to pay homage to other fields of study as contributing a proportional balance for both earthly and immortal life:[3]

> But exactly, what is to be this academical course? Chiefly study--of the ancient classics; of the modern languages; of mathematics; of natural, physical, and political science; of philosophy and English literature; each to be adjusted to the others in such proportion that the effect of the whole curriculum shall be, as nearly as possible, not a one-sided but a symmetrical and well-balanced education.

It was a foreboding disclosure to Gustavus Hinrichs as he listened in the chapel-assembly room above the laboratories which he had toiled to obtain, to equip, and to celebrate. But the new President was to receive effective support for his views from faculty members who felt too little recognized and Hinrichs overly lionized. At times the little scientist's strutting and preening manner galled his associates. And he could expect little favor from those he considered to be less competent, less dedicated, and less vigorous.

But it was not until the spring of 1873 that the new courses of study were to take effect and cast the physical sciences into relatively minor roles. In shaping their programs, Thacher, Leonard, Currier, and their supporters had to move slowly and carefully to gain approval. They did succeed, however, in reducing the physical science funding for supplies and apparatus from the $1,000 of the previous year to $500 for 1871-72. Meeting with Thacher and Leonard at the time of the June commencement and presidential inaugural ceremonies, the Board of Trustees voted $800 for Leonard's department of mathematics and astronomy. It was the first time in the history of the institution that another department received a larger appropriation than that of physical science.[4]

Three months after the inaugural and fiscal activity of the last week of June, an event in London created an upturn in Hinrichs' fortunes, delaying further reduction of his influence and share of support. The prestigious science journal, Nature, devoted three full columns (about 3,000 words) to a laudatory review of The Elements of Physical Science and to the work of its author in the laboratories of the State University of Iowa.[5] This evaluation provided a timely defense for Hinrichs as he struggled to hold what he had won.

Portions of Nature's review were soon quoted in American journals and newspapers. Among the endorsements cited from the British publication:

> We trust that these important reforms in science teaching will prove contagious, and spread rapidly from the plateau of Iowa City to a region of even greater extent than the American continent.

and

> It is deplorable to think how few school laboratories there are in England which could in any way vie with that in Iowa State University, where 'more than two hundred students have experimented within six months;' and we fear that this state of things will continue for the most part unaltered until the public examiners require a practical knowledge of the sciences taught in schools.

and, after discussing the work, chapter by chapter, and considering the amount of space allotted to each subject:

> Still, if Prof. Hinrichs has not discovered every gem, he had nevertheless succeeded in pointing out the right path of discovery, along which he has acted on the whole as a faithful and thoroughly painstaking guide.

and, concluding with the following paragraph:

> We trust that the efforts of this able reformer of science teaching will be amply seconded; and we believe that these Elements will be found of great service to every conscientious teacher, who will be able to glean from them many valuable suggestions both as to method and treatment; and we recommend them especially, because a widely spread knowledge of a work of this kind will tend very much towards the introduction of experimental science into the curriculum of our schools.

Such international recognition, following other accounts supportive of his work, spurred Hinrichs to increase his requests for more facilities and apparatus. Pointing out that his program had outgrown the space in North Hall in 1869, just two years after its occupancy, he asked for a new laboratory building at a cost he estimated at $20,000. In addition, he requested an apparatus appropriation of $4,000 for 1872-73, saying:[6]

> The above wants of the laboratory must be satisfied, or it will become unable to give that practical instruction which is demanded by the students who throng its rooms.

He accentuated his pitch with a ten-page tribute to the power of physical science in its industrial and military applications:

> The possession of the knowledge of physical science enables Great Britain to exert a mechanical power equal to a nation almost twenty times as numerous, but not possessed of that knowledge ...
>
> This same knowledge gave the North a great advantage over the South in the late Civil War; for the burning of 200,000 tons of coal per annum under the boilers of northern factories performed as much mechanical labor as 1,400,000 able-bodied, full-grown slaves could annually perform for their masters ...

and in its contributions toward the enlightenment of mankind:

> If much of superstition yet remains, it is due to the fact that the proper study of physical science has not yet become an essential part of the work of every common school.

But the University leadership and the Board of Trustees were not sufficiently persuaded, for the appropriations for 1872-73 provided only $700 for the physical sciences, whereas Leonard's department was voted $1,000. The following year, 1873-74, Hinrichs' funding was further reduced—to $550—and mathematics and astronomy was granted $2,250. (This princely sum was to pay for a telescope ordered from Joseph Grubb of Dublin and to erect an observatory to house the instrument.)[7]

Hinrichs continued undaunted to campaign for the support of his sciences and his ways of teaching them. In the spring of 1873 when the new academic program was about to amputate some of his classes from the courses of study, he welcomed editors and other persons of influence in visits of his "temple of science." He was particularly gratified when Rossiter W. Raymond, U. S. Commissioner of Mining, came, examined the work of the students, and reported:[8]

> Prof. Hinrichs was not the first, though one of the first, to insist that physics as well as chemistry, should be studied in the laboratory, and that every law, principle, and mathematical relation should be verified by the actual observation of the pupils. But he is the first to show how this can be done conveniently and efficiently, with simple and inexpensive apparatus, and for large numbers of students ...
>
> I have examined a large number of the laboratory journals of the students, and I am satisfied that this system is practically efficient.

During the summer of 1873 Hinrichs traveled in Europe to visit science centers in England, France, and Germany, and to exhibit at the International Exposition at Vienna more than one hundred of the laboratory journals of his students.

The University Reporter had this to say soon after his return:[9]

> On the morning of the 6th, while waiting in chapel for the usual exercises, we were agreeably surprised by the entrance of Professor Hinrichs ... The first notice of his entrance was from an unusual excitement among the students next to the door, which, as he passed up to the

> platform, increased to an enthusiastic clapping of hands. Professor Hinrichs is a general favorite, and all were glad to see him back ...
>
> The Haidinger Club are anticipating a rare treat from Professor Hinrichs' promised lectures on his European tour. We are glad to inform our readers that he has promised us several articles on the same subject ...

Upon his return from this summer abroad, he reported to the Board of Regents:[10]

> I have during the past summer visited the principal laboratories of Europe at a considerable expense to myself. In regard to facilities to advanced students, those laboratories are far ahead of any on this side of the Atlantic; but I am sincere in the conviction that many of our American laboratories already now do more good to a greater number of students than is done by similarly endowed laboratories in Europe.

In the above report he pointed out that he had taught and given laboratory practice to nearly 300 students in each of the school years of 1871-72 and 1872-73. He requested that "at least five thousand dollars should be expended at once" to obtain "a collection of accurate working instruments for exact studies in Physics and Chemistry." But he did not press this time for a new science building:

> The necessity of a new Laboratory building, referred to in my preceding biennial report, has been removed by the great change in the course of study, carried into effect at the recommendation of a majority of the Collegiate Faculty.

The reshaped courses of study had truncated much of the program that Hinrichs had described for 1870-72. In the fall of 1873 there were now three Collegiate Courses--Classical or Philosophical or Scientific--in place of the two--Literary or Scientific--that had been in effect between 1865 and 1872. In all the new programs of study Physics (Fall Term) and Chemistry (Winter and Spring Terms) had been moved to the sophomore year. Even in the Scientific Course of Study no further physical science course was required, but Physiology and Zoology were obligatory in the junior year and Geology and Astronomy were requisites in the senior year for those pursuing a primarily scientific education. Juniors and seniors could choose only one elective course each term in Physics and Chemistry.[11]

In short, Hinrichs could now reach and teach fewer students in fewer classes in his efforts to develop interest and methodology for the advancement of science. Thus the courses of study adopted in 1873 blocked his hitherto onrushing campaign. Frustration and dismay, after so much arduous work accepted elsewhere but rejected at home, escalated his reactions from appeal to protest to resentment and rancor.

The "ravishing of studies from his chair" drastically affected the numbers of students choosing to be identified with the scientific course of study. The proportion of science "majors" dropped from around half in 1868 through 1871 to their lowest levels from 1874 through 1878, with only 2.5 percent of the regular students listed as "scientific" in academic year 1875-76.

For a period of twenty years beginning with its issue covering 1874-75, the University Catalog listed the names of the students by class and by their chosen course of study (Classical, Philosophical, or Scientific). The Scientific proportion over this period follows:

1874-75	4.8%	1879-80	10.8%
1875-76	2.5%	1880-81	17.0%
1876-77	5.2%	1881-82	21.3%
1877-78	4.1%	1882-83	19.6%
1878-79	7.4%	1883-84	23.1%

There were no catalog figures comparable to the above for the late 1860's and early 1870's, but the proportions of degrees in science to those in arts and letters at that time indicate that around half of the students had programs that were heavy in science courses.

After the slump in curricular science activity during the cultural elitism period of the middle 1870's, Thacher was eased out of the presidency, asked to resign in 1877.[12] He was succeeded by University leaders more sympathetic to the sciences and to law and to engineering. The proportion of science majors then began to rise steadily and substantially in the early 1880's in the Collegiate Department (the precursor of the modern College of Liberal Arts). But this rise in science study was largely influenced by a growing interest in the natural sciences. Under the tutelage of Samuel Calvin, in geology, and Thomas Macbride, in botany, the quarries, fields, and riverbanks became the popular laboratories. The field trip and the natural history museum were displacing the work sessions at the apparatus bench.

His support and course offerings cut, his assistants taken from him, Hinrichs diverted much of his time and effort into the Iowa weather reporting service which he began to organize in 1875. The state was districted, and hundreds of volunteer observers reported to the central station in Hinrichs' home. Located one block north of the SUI campus at 9 East Market Street, the house was a three-story structure with the top bristling with weather instruments. He often remarked that he built his home more to serve Science and the State than for the comfort of his family.

The quantities of logbooks, charts, maps, observer communications, and other meteorological data in the Hinrichs Collection at the University of Illinois attest the zeal and industry of this first meteorologist to be appointed by any state in the United States. The University of Illinois collection preserves eighteen volumes of such logbooks and reports over the years 1876-1888, with some of the weather summaries beginning as early as 1871 when his weather study was primarily in conjunction with his teaching of meteorology in his North Hall laboratories.

There are also numerous reprint articles in the Illinois archives with such titles as "The Great Iowa Meteor," 1875; "Description of the Storm of Easter Sunday, April 21, 1878 in Iowa," 1879; "The Climate of Southern Russia and Iowa Compared," 1888; "Tornadoes and Derechos," 1888; and "Rainfall Laws Deduced from Twenty Years of Observation," 1893.

To give much attention to Hinrichs' work in the beginnings of Iowa weather reporting is outside the intent and scope of these annals, which primarily depict the work and workers in physics and astronomy emerging from natural philosophy and growing into the modern programs of an aggregate of specialized groups. Yet, since Hinrichs was perhaps the most versatile--and the most controversial--scientist in the history of the University, the wide range of his work should be recognized before examining the developments which led to his dismissal and to the verbal donneybrooks of charges, countercharges, and investigations which followed.

During his first years at SUI, Hinrichs appears to have worked quietly as well as diligently at his assigned tasks. A poor young immigrant grateful for the opportunity, he labored to build a physical science program under the helpful leadership of President Oliver Spencer. One can speculate how different the 1870's and the 1880's might have been at the University if the urbane and progressive Spencer had remained at the helm instead of leaving for the U. S. foreign service. Succeeding presidents lacked the qualities to maintain harmony in the faculty and to mediate effectively with the University's governing board.

Historians of the University's first fifty years devote considerable space and prolixity of language to Hinrichs' career and to the problems raised by his aggressive campaigns for a major role for physical science. Carstensen,[13] who takes SUI up through 1878, is largely laudatory of the scientist, while noting his abrasive manner toward some of his associates. William C. Lang,[14] who carries on through 1900, deals extensively with his dismissal and the following repercussions and investigations. Carl B. Cone,[15] in his history of the College of Medicine, where Hinrichs taught part-time from 1873 through 1886, strongly condemns his actions which in 1888 brought lengthy state investigations of the University and of medical personnel and practices in particular.

While there was some friction within the faculty during the late 1860's, Carstensen points to 1872 as the year when "the break occurred." As recorded in the Faculty Minutes of June 25, 1872, Hinrichs was confronted with his frequent charges that other professors "do not respect the work which he attempts to do in the Laboratory." The faculty voted to refer the matter to the Board of Regents for consideration and urged "a reproof to the erring party, whoever he may be."

The Board admonished "Professor Hinrichs to extend to the President of the University the honor and courtesy due to his station," and, among other things, requested Hinrichs "to refrain from teaching astronomy except to such extent as may be approved by the professor of astronomy."[16]

Given the differing backgrounds and temperaments of the two men, it was almost inevitable that Leonard and Hinrichs would clash in jurisdictional disputes over the teaching of astronomy. In most institutions of the time astronomy was linked with mathematics. Calculations in celestial navigation, using sextants and star transits, went along with engineering calculations employing earth-measurement transits. Astronomy was clearly an extension of the mathematics of earth, Leonard maintained.

But Hinrichs was also deeply interested, as well as knowledgeable, in areas of astronomy. He had published papers on planetary motions and their effects. He liked to lecture on large-body, or cosmic, physics and point to likenesses within his structural concepts of the physics and chemistry of the atoms and molecules. Also, the composition of meteorites was obviously within the province of the minerologist and the inorganic chemist, Hinrichs declared.

Following the admonishment by the Board, rumors circulated that President Thacher had requested Hinrichs' dismissal. A group of students, with the support of many townspeople, set up a meeting to honor the little scientist, presenting him with a gold watch as a demonstration of their affection. Newspapers took sides,[17] with the Clinton Herald, the Des Moines Register, the Iowa City Press, and the Ottumwa Courier warmly supportive. The Burlington Hawkeye and the Iowa City Republican (the latter generally at odds with the Democratic Press) came out partly approving but mostly disapproving: recognizing Hinrichs' achievements but decrying his egotism, his capacity for creating dissension, and his lack of tact in openly espousing Darwinism before audiences including religious fundamentalists.

Hinrichs continued to be an epicentral figure in newspaper disputations. In the spring of 1874 an Iowa graduate then at Yale for advanced study precipitated a flurry of conflict in a lengthy and severely critical letter to the Press.[18] J. P. Sanxay contended, among other charges, that Iowa was not a real university in the sense of providing significant research in the sciences and the humanities. He asserted that only one man in the faculty merited a place among the nation's scholars.

> ... if Gustavus Hinrichs' name were erased from its catalogue, the University would decline to an ordinary dispensary of other men's thoughts and its ambitious title become a huge sarcasm.

Leonard accepted the task of responding in support of the University. He avoided discussions of personalities and charges of political corruption, admitting that the University was lagging in research. He said that it was not quite fair to compare a young institution with establishments like Harvard and Yale.[19]

The meteorite fall near Amana of February 12, 1875 brought both Leonard and Hinrichs to the scene, each collecting and quarreling over some of the fragments. Aggravated by their previous differences, the animosity of the two men reached the point that the Board appointed a committee of three Regents to examine the matter. Upon the report of the committee, the Board reprimanded both professors for carrying their personal quarrels to the newspapers. Hinrichs asked the Board to investigate the "systematic opposition" of Leonard to his work, also to examine the assignment of Physical Science to an inferior position among the departments following the adoption of the 1873 course of study. The board expressed their intent to treat all departments as of equal importance and entitled to equal consideration, then referred the matter to the faculty to study and report.[20]

At this time Hinrichs received a substantial vote of confidence from nine prominent Iowa Citians, who presented some financial support to Physical Science as evidence of their esteem. The group, headed by M. L. Close, requested the Board for permission for them to give $200 annually, half for Hinrichs to use for apparatus and publication costs, and half as prizes for student performances in quantitative analysis. The petitioning offer, which the Board accepted, concluded with this testimonial:[21]

> We ask the endorsement by you of this offer for the reason that we regard the practical results of physical science and chemistry as of more immediate financial benefit to the state than anything else taught in the university. You must be aware that the manufacturing industries of the East have been developed and are maintained by application of the chemical knowledge. And we regard the fostering of original research in the same direction as of the highest value to every manufacturing interest in the Northwest and as one of the first duties of Iowa University. We also intend this as a token of our profound respect for your present Professor of Science.

The establishment of the Close Prize and the accompanying favorable publicity made only a slight upturn in the fortunes of Hinrichs' programs. The classicists held the reins, and the faculty continued to diminish the relative support and influence of the physical sciences. In 1876 the Board was persuaded to assign Hinrichs' one remaining assistant, William C. Preston, to serve under Professor Leonard in the more flourishing department of Mathematics and Astronomy, which was now offering more coursework and boasted a telescope observatory.[22]

This transfer of his hard-working assistant to his arch rival was a shattering blow to Hinrichs. Preston had been one of his ablest and favorite students between 1866 and 1869, at which time he had graduated, to succeed Rush Emery as an assistant, then as assistant professor.

Following Thacher's departure in the summer of 1877, a member of the State Board of Regents, Christian Slagle accepted the presidency pro tempore for a period of one year. Slagle, a Fairfield businessman and conciliatory by nature, healed some of the wounds created during the rigid Thacher regime, and there followed a brief period of relative peace on the campus.

Slagle worked with faculty and the Board for a reorganization into two sub-faculties: a School of Letters, including the Classical and Philosophical courses of study; and a School of Science, with common curricula for the freshman and sophomore years and three optional programs for the next two years: Physical Science or Natural Science or Engineering. Hinrichs was somewhat placated by his appointment as chairman of the sub-faculty of science.

Perceiving a need for a seasoned educational administrator, the Board elected in 1878 as the new president Josiah Pickard, who had been City Superintendent of Schools in Chicago for thirteen years. But Pickard soon came to view Hinrichs as a troublemaker and as an obstacle in the way of his administrative plans. Consequently the new President supported the more compliant members of the faculty. In the sciences he bolstered the programs of Leonard, Calvin, and

Macbride. A new Science Hall was projected, planned, and built (completed in 1884) to house geology, botany, zoology, mathematics, and astronomy, and the growing Museum of Natural History. After the rejections on his requests since 1871 for apparatus and laboratory expansions, Hinrichs felt affronted and deeply hurt as he watched the rise of spacious new quarters for men he considered to be superficial popularity seekers, collectors rather than scientific investigators.[23]

During the early 1880's Hinrichs spent relatively little time with Physics, only one spring term then required in the sophomore year. He also taught two term courses of Chemistry for sophomores in the Collegiate Department and a full-year course of Chemistry and Toxicology in the Medical Department, which he had been serving as an adjunct, or part-time professor since 1872. His Iowa Weather Station was beginning to consume the larger part of his time and interest. For instance, all 25 of his publications for the year 1880 were reports, remarks, or results pertaining to conditions or events of Iowa weather, for instance "Rainfall and Timber of Iowa," "Droughts in Iowa," and "relations between Cloudiness and Solar Radiation in Iowa City."[24]

He assuaged some of his feelings of rejection and bitterness in this busy schedule of teaching, of meteorological activity, and in conducting biochemical tests for poisons and other foreign substances in blood, urine, and in foodstuffs. He spent much less of his time than in previous years with students outside formal classes. He avoided faculty meetings as much as he could. He virtually stopped giving voluntary special lectures.

By the late 1870's and early 1880's the temple of science had faded in lustre and lost much of its aura of exalted ritual. Instead, it had become more of a parish workroom for a faithful few, seldom the lodestar it had been for admiring visitors and University Reporter editors. For both students and visitors the botanical, geological, and zoological collections had become the attractive scientific scene. In addition, the natural science professors were affable and genial, whereas the Professor of Physical Science often projected an image of brusqueness, irritability, and persecution-obsession.

On the campus Hinrichs appeared to many a strange and harried little man—to some even a ludicrously comic figure—as he shuttled back and forth on the path west of Old Capitol, carrying his racks of glassware, chemicals, and balances. With no assistant since 1876 and with less funding for his work, he often lacked enough materials and apparatus for separate demonstration set-ups in both North Hall and the Medical Building.

After the arrival of President Pickard in 1878, Hinrichs spent increasingly more of his hours in the relative isolation of his home office-laboratory. Aside from his classes and his work with Iowa weather observers, he communicated vocationally for the most part in French and German to chemists in Paris, Vienna, and Berlin, where he felt his views and studies to be accepted and appreciated. He was still advancing and promoting his Atomechanics hypothesis of a structuring essence comprising all the elements of the atomic table.

Often emotionally upset by what he later termed the political tyranny and pious hypocrisy in "The University of Darkest America,"[25] he encouraged former students and supportive newspaper editors to continue his battles for his physical science programs. For himself during much of this time, he preferred the role of the silent martyr,[26] reserving his revelations for his scientific peers, those secure and honored professionals of the enlightened Continent. Disdaining the Iowa natural history collections, he presented choice specimens of his Amana meteorite fragments to several European museums.[27]

Under such circumstances, the atmosphere of suspicion and mistrust between Hinrichs and others of the faculty was bound to thicken. In June 1884 a series of letters to the Board of Regents, each signed by most of the faculty, charged Hinrichs with obstructing educational progress through his disparaging attitudes toward his associates and through neglect of duty by absenting himself from faculty meetings.[28] The Board requested more information but did not initiate any official action.

In June 1885 President Pickard filed a series of further charges against Hinrichs to the Board.[29] Pickard enlarged upon the faculty complaints of the previous year and cited instances of lack of cooperation and insulting behavior toward the President and the Dean (Leonard) of the University.

This time the Regents came to Iowa City, investigated and supported Pickard's charges. The Board then dismissed Hinrichs from the Collegiate Faculty but kept him on at half-salary in the Medical and Pharmaceutical Faculties. On receiving more charges against him, the Board peremptorily discharged him from further service in the University on March 2, 1886.[30]

With some income then from a belatedly bestowed salary as director of the Iowa Central Weather Station, he managed to remain in Iowa City until the summer of 1889. Separated then from his meteorological post, he left Iowa to become Professor of Chemistry in the St. Louis College of Pharmacy.

In 1886 Hinrichs began to broadside the U of I management with many charges of corruption and malpractice. He demanded legislative investigations of University and Medical Department personnel and financing. He made numerous allegations of unprofessional and unethical conduct before the joint House and Senate committee which held open hearings in Iowa City in June and July of 1888. Because of the often indiscriminate nature and excesses of his charges, Hinrichs discredited himself in the eyes of most observers. Yet he continued his attacks, with privately printed pamphlets and with letters to editors and legislators, as late as 1898 from his new home in St. Louis.[31]

In retrospect it appears that Hinrichs remained in Iowa City much too long after the Thacher *et al.* courses of study drastically reduced the physical science program in 1873. But he stayed to fight for what he had built and for his concepts of personal and academic freedom. Growing increasingly bitter, he corroded the brightness of his earlier image with his hostile and sometimes irrational assaults. During those 1874-89 years, the work of this extraordinarily gifted and energetic man would better have served to advance scientific education and research elsewhere. In a less adversary situation he might have achieved the lasting recognition to which he aspired.

As it is, GUSTAVUS DETLEF HINRICHS persists to this time most perceptibly as a black-lettered name on 26 manuscript boxes, otherwise unidentified, preserved within the University of Illinois Archives.[32] No mention of his work is evident in the more accessible histories of physics and chemistry.[33]

Some other legacies survive: numerous reports on the Iowa climate of a century ago, scattered articles in nineteenth-century volumes of some scientific journals, a highly laudatory obituary in the 1923 Proceedings of the Iowa Academy of Science,[34] of which he was one of the founders. Perhaps there has also been some transmission through the generations of the interest in science which he aroused and nurtured.

Notes and Sources

[1]President George Thacher, *Inaugural Address, 1871*, p. 19, MSS in University of Iowa Library Archives.

[2]Vernon Carstensen, *The State University of Iowa: The Collegiate Department from the Beginning of 1878*, pp. 240-251.

[3]Thacher, *op. cit.*, p. 19.

[4]*Minutes of the Board of Regents*, June 26, 1871, p. 389; June 26, 1872, pp. 420-421; June 20, 1873, pp. 440-441.

[5] *Nature*, Sept. 28, 1871, pp. 421-422. The reviewer also gave some account of the content and organization of the work:

> In the first volume of this work, the student is taken in about 150 pages, through a course of simple and easy experiments relating to Magnitude, Weight, Machines, Properties of Matter, Light, Electricity and Magnetism. Each operation is so clearly described that the book might almost be employed by a solitary student, and many of the experiments, we are convinced, not only could but ought to be performed by children at the very commencement of their school career.

The British writer applauded the amount of emphasis given to measurements of length, area, and weight (41 pages), thought there was too little on mechanics (16 pages), and:

> We think also that too much attention (relatively, at least) has been paid to Electricity and Magnetism (27 pages).

[6] *Report of the President of the State University of Iowa to the Board of Regents*, Dec. 20, 1871, pp. 110-119.

[7] *Minutes of the Board of Regents*, June 20, 1873, pp. 440-441.

[8] *Engineering and Mining Journal*, Aug. 1873.

[9] *University Reporter*, SUI, Oct. 1873.

[10] *Report of the President of the State University of Iowa to the Board of Regents*, Sept. 15, 1873, pp. 46-49.

[11] *University Catalogue*, SUI, 1873-74.

[12] Carstensen, *op. cit.*, p. 291.

[13] *Ibid.*

[14] William C. Lang, *History of the State University of Iowa: The Collegiate Department from 1879 to 1900*.

[15] Carl B. Cone, *History of the State University of Iowa: The College of Medicine* (1941).

[16] Carstensen, *op. cit.*, p. 269.

[17] While the *Iowa City Republican* of July 17, 1872 raises questions of Hinrichs "atheistic attitudes" and "egoism", the *Iowa City Press* on the same date is concerned that "we may lose him and turn the State University into a Johnson County High School."

[18] *Iowa City Press*, April 13, 1874 and following issues.

[19] *Iowa City Republican*, April 27, 1874.

[20] Carstensen, *op. cit.*, p. 286.

[21] Minutes of the Board of Regents, June 29, 1875, pp. 505-507.

[22] Report of Hinrichs to the Board of Regents, June 15, 1877.

[23] Hinrichs discounts the scientific merit of the work of his former associates in a pamphlet printed in 1892, with the title "False Statements Made by the Regents of the Iowa State University to the 24th General Assembly to Secure More Money."

[24] Charles Rollin Keyes, "Contributions to Knowledge by Gustavus Detlef Hinrichs," in Proceedings of the Iowa Academy of Science, XXXI (1924), pp. 85-86.

[25] In, for instance, "Corruption in the University of Darkest America," pamphlet he printed in 1896. Also in his 1894 text, The True Atomic Weights of the Chemical Elements and the Unity of Matter, wherein he reminisces on his forty years of work on his Atomechanics hypothesis.

[26] In July 1885, when area newspapers carried considerable pro and con evaluations of him in editorial commentaries, his reaction to his dismissal was primarily to have printed a chronological list of scientific books and papers, from No. 1, "Die Electromagnetische Telegraphie" (1856) through No. 159, "The Tornado Seasons in Iowa" (1885). At the end of which he observed:

> In the school year of 1871-72 I instructed 340 of the 515 students in attendance at SUI, and 272 of these did work in the Laboratory, from two to ten hours a week each. This immense work was done by myself, aided by only two assistants, namely Professors W. C. Preston and Francis E. Nipher. This method of work was well received, leading scientific men and journals highly commending the same abroad, and many teachers of science visiting the Laboratory to study the minutiae of the method of work. By an administrative change, which need not be dwelt upon at this place, this work was abolished at the home institution.

[27] In Hinrichs, Introduction to General Chemistry, published in St. Louis in 1897, he encloses a page of plates of his Amana meteorite collection, indicating which museums received specimens.

[28] Lang, op. cit., Appendix F, pp. 502-524, "Documents Relating to the Dismissal of Dr. Gustavus Hinrichs."

[29] Ibid., pp. 511-515.

[30] Ibid., pp. 515-516.

[31] Ibid., pp. 521-522. Also in Cone, op. cit., pp. 104-105.

[32] Icko Iben of the University of Illinois Archives received the Gustavus Hinrichs collection from grandson Hans Hinrichs from 1959 through 1964. Also an immigrant from Northern Germany and

holder of a doctorate in biological science, the late Dr. Iben took a special interest in the material and prepared a thirty-page inventory search-guide, upon the completion of which in 1967 he added the following memorandum:

> The manuscripts described in this inventory appeared to be of sufficient interest to serious students of the History of Science to warrant a detailed inventory. There are records here, all centered around a very successful physical scientist, to illustrate an entire career, beginning with his schooling in Europe, showing his development in the United States of America and his impact upon the evolution of certain basic phases of physics and chemistry. His long years of connection with many learned organizations, especially with the French Academy in Paris, are documented by correspondence with important members; a substantial list of books and articles, all of which are in the collection, testifies to his solid and comprehensive learning.
>
> Beyond this there are records documenting Professor Hinrichs' years as the first meteorologist appointed by any state in the United States (Iowa), also his association with the University of Iowa at Iowa City, his vigorous championship of academic freedom in Iowa and finally records of a number of important opinions on chemical problems he was called on to render in his capacity as a professional chemist in St. Louis, Missouri and as a witness in cases adjudicated in United States courts.

[33] An exception would be a passing mention on p. 466 of <u>The Story of Nineteenth Century Science</u>, by Henry S. Williams, 1900, Harper Bros. Williams noted that Hinrichs' investigations helped to confirm the "law of octaves", the intervals of eight elements which Dmitri Mendeleev charted in his periodic table of 1869.

[34] Writing an <u>In Memoriam</u> obituary for the Iowa Academy of Science, Iowa geologist Charles Rollin Keyes related Hinrichs ancestry, his childhood feats in science, and his three years as a boy soldier in a liberation movement for the border province of Ditmarsia. Keyes then showered his subject with lavish praise. Among the encomiums:

> Little as some of us duller Iowans might have suspected it ... he was without question a genuine genius. He was the brainiest personage that perhaps ever trod our prairie soil.
>
> ... he was received with loud applaudits everywhere throughout intellectual Europe ... No countryman of ours was ever in such frequent and friendly communication with the world's savants of his day.

Chapter Four

Separating from Chemistry and Regrouping

Fewer than five hundred students registered for the opening of the fall classes of 1885-86. In the prevailing climate of well-aired faculty quarrels and general unrest over the condition of the State University of Iowa, the enrollment had dropped to its lowest level in fifteen years. The final attendance count was 52 below that of the previous year and 115 under that of 1882-83.[1] With Iowa's population steadily increasing, a larger proportion of students were attending other colleges.

For the University, the 1880's were a time of beyond-normal doubt and distrust in the minds of Iowa citizens. The unrest was embroiled into heated controversies by charges from supporters of Gustavus Hinrichs and by the attacks of various political and quasi-religious factions. Populist, taxpayer, and prohibition groups questioned the financial and personnel practices of President Pickard and the Board of Regents. Critics assailed the increasing expense of University operation.[2]

A substantial part of the enrollment decline was related to the growing anti-saloon crusade in the state. Numbers of parents were reluctant to expose their sons and daughters to the temptations of a city bruited to be lax in moral fibre and notoriously lacking in alcoholic temperance. In discussing the situation in his history of SUI covering the years between 1879 and 1900, Lang relates:

> In 1884 it was reported that there were at least thirty saloons and three breweries in Iowa City and more than two-thirds were within six hundred feet of the campus.[3]

In such an atmosphere of controversy and brewing investigations that would force in 1887 the departures of three long-term faculty members in addition to Hinrichs,[4] the University opened its doors in September 1885.

A new occupant held the chair of Physical Science and Chemistry. Launcelot W. Andrews came from the faculty of Iowa State College of Agriculture, where he had also served as a chemist for the Iowa Board of Health. A native of London, Ontario, he was a graduate of Yale University with his doctorate of philosophy from the University of Goettingen.[5]

A well-traveled and articulate young man of broad interests, Andrews often ranged beyond the physical sciences into aspects of the political and social sciences, sometimes during after-school sessions with older students. Professionally, however, he preferred to continue his work in chemistry, the field of his training and of his publications. In the fall of 1886 he also succeeded Hinrichs as Professor of Chemistry and Toxicology in the Medical and Pharmaceutical Departments. Consequently he had little time and inclination to do much for the physics program, which had received relatively little attention since the Thacher et al. courses of study diminished the program in 1873.

To rejuvenate the instructional vitality of the science of matter and energy in 1886-87, President Pickard gave Andrews some assistance, increased the facilities for physics, and moved toward making the science an independent department.

For 1886-87 Andrew Veblen's title was changed from Assistant Professor of Mathematics in Nathan Leonard's department to Assistant Professor of Physics to support Launcelot Andrews.[6] A brother of Thorstein Veblen of The Theory of the Leisure Class, Veblen had come to SUI in 1884 as a mathematics instructor. A native of southern Minnesota, he was a graduate of Carleton College and had taught mainly English and Latin languages at Luther College from 1877 to 1881. He then earned his A.M. degree in mathematics at Carleton and followed with two years of graduate studies at Johns Hopkins University.[7]

Persuaded to switch departments for the good of the University, Veblen had little background in physics. But he soon became very much interested in the contemporary developments in electromagnetic theory and in working with such apparatus as induction coils and dynamo armatures. A soft-spoken and fastidiously neat young man,[8] he enjoyed applying his mathematics and working with his hands in the precision measurements of the laboratory.

During his first year as a physics instructor, Veblen's performance was evaluated by a visitor from the Board of Regents. Because of the controversial climate surrounding the University, the Board subjected the faculty to especially close scrutiny in the spring of 1887. Members of the visiting committee attended classes of every instructor, including those of such veteran professors as Currier, Leonard, and Calvin, and noted what they saw and heard. Regent J. J. McConnell visited the laboratory, then attended a class of Veblen's, and reported in these words:

> March 22, 1887
>
> The laboratory was in good condition. Professor Veblen seems to be possessed of fine skill in constructing and repairing apparatus and is evidently interested in his work.
>
> March 23, 1887
>
> Visited Veblen's class in Sophomore physics. Special subject—electricity. No. in class—16 students. Blood, Mock, and Miss Taylor made excellent recitations. Miss Pennock made a fair recitation. Murphy was rather listless. Summers and Clark were worthless in recitation—whispered most of the time. Professor Veblen is open to criticism for allowing this listlessness and whispering. He has the ability to control his class and needs only to assert himself with more force. He is a valuable man. [9]

During the next year Veblen strengthened his status in the eyes of the President and the Board by his work in improving the laboratory, revamping, for instance, the basement of North Hall to double the floor space for Physics. And on June 19, 1888, Physics officially became an independent department, separated from Chemistry by action of the Board. President Schaeffer and the faculty had submitted the following recommendation:

> Whereas—in the opinion of this faculty the work of the professors of Physics and Chemistry is distinct in its nature and should be divided between two independent chairs:
>
> Resolved—that the faculty recommends that instruction in Physics should hereafter be placed under the charge of a full Professor and that assistant professor A. Veblen be respectfully recommended to the Board of Regents for the Chair of Physics.

As expressed in the Minutes of the Board of Regents,[10] the establishment of the independence of the department was couched in these words:

> On motion of Mr. Duncombe the following passed:
>
> That Professor A. A. Veblen be made 'acting professor of physics' without increase in salary,
>
> And that the title of Professor L. W. Andrews be Professor of Chemistry.

On October 6, 1888, the University Mirror came out with a description of the work of the new department:

> By recent action of the Board of Regents, Physics has been made a distinct department; and has started out with a very excellent prospect. The class in Physics at present numbers 67 students, who take notes on the various lectures. The lectures are then supplemented by practical examples in the subject treated. During the winter term the subject of electricity and magnetism will be taken up. Here the dynamo* will supply a long-felt want and will be one of the most interesting apparatus used. In the laboratory work which commences about the middle of the winter term, each student will have the opportunity of making the most accurate observations. To this end a balance has been lately imported from Germany, which cost about $200. Professor Veblen had just ordered an

excellent cathetometer, a very accurate instrument for measuring small differences in heights. It will probably cost the University about $175 ...

*The dynamo which the Mirror refers to had just been set up in the basement work shop of North Hall. Driven by a two-horsepower kerosene engine, the dynamo supplied electricity for all parts of the Laboratory and lighting for evening meetings of the Baconian Club in the building's lecture room.

In the post-Hinrichs 1880's, until after its coming of age as an independent department in 1888, Physics offerings consisted of three terms listed simply as I, II, and III. Although topics covered sometimes shifted with the quarterly seasons, I was normally the mechanics of rigid bodies, liquids, and gases; II, electricity and magnetism; and III, sound, light, and heat. Laboratory practice in physical measurements accompanied the work in II and III.[11]

A standard basic text in use then was Atkinson's Ganot, a newer version than Peck's Ganot, which Hinrichs used in the middle '60's, before he introduced his own textbooks for his students.

By the year 1890-91 the I, II, and III of the elementary course had multiplied into a listing from I through X, according to the University Catalog.

I Mechanics, Heat, five times a week, fall term

II Electricity and Magnetism, five times a week, winter term

III Sound, Light, three times a week; laboratory work twice a week through the spring term

IV Physical Measurements and Observations

V Physical Measurements and Determination of Constants

VI a. Crystallography b. An investigation into some special subject

VII Dynamos and Motors, lectures and laboratory work, five times a week, spring term

VIII Theory of Electricity, Theory and Practice of Photometry, special laboratory work, ten times a week, fall term

IX Theory of Electricity, Transformers, special laboratory work, ten times a week, winter term

X Lectures on Distribution and Transmission of Electricity, Telegraph and Telephone, special laboratory work, ten times a week, spring term

In addition to the above, lectures and laboratory courses in selected topics will be given as circumstances may require or the facilities for the instruction will permit.

This I-X array of offerings continued until 1895-96 when the University Catalog list expanded to I-XV. The additional course numbers augmented the previous VII to X studies of electricity and of electrical apparatus, to provide separate courses for electrical and civil engineering students. Thus the expansion of offerings in the 1890's was largely in programs in cooperation with and later to be incorporated within the College of Engineering. Except for No. XIV, Shop Work, introduced as a separate course in 1895-96, the additional courses repeated much of the content of the earlier courses but with more engineering application.

During 1892-93 the Department of Chemistry moved into a newly constructed building (the Hall of Chemistry and Pharmacy two blocks to the east), and the University Catalog was able to give the following description of expanded Physics Department facilities in 1894-95:

THE PHYSICAL LABORATORY

The Physical Laboratory occupies the first floor and the basement of the North building, with an available floor space of more than 8000 square feet.

In the basement is the large engine and dynamo room, containing a gas engine which drives a shaft twenty feet long. To this shaft are belted the dynamos, of which there are five of from one to ten horse power capacity and representing several types. Here also is a cable switch-board, meters, lamps, and other apparatus. In the battery are some 45 accumulators of different varieties. A large and commodious photometer room is supplied with a complete Krüss photometer. Two other large rooms in the basement are used partly as laboratories and partly as shops, being supplied with benches and tools both for wood and metal working. A fine lathe is arranged to be driven by electric motor or by foot power.

> On the floor above are eight rooms. The lecture room, with seats for some 70 students, is supplied with water and gas and with wires from the dynamos and the accumulators. The window can be easily darkened, and there are conveniences for making projections by sunlight or by electric or other artificial light. A large and well lighted room is devoted to the uses of a general laboratory, especially in the line of Mechanics, and contains a number of balances, air-pumps, a cathetometer, and a number of other measuring instruments. Another large room contains most of the apparatus for electrical testing. Here also is the special physical library and the journals taken by the laboratory. Three smaller rooms are given respectively to heat, light, and magnetism, and are well equipped with apparatus. There are also two offices, for the professor in charge and the assistant professor.
>
> The Laboratory is fairly well supplied with lecture apparatus and among the instruments of precision are many of the best and finest to be had. The equipment is especially full in mechanics, optics and electricity. Most of the apparatus has been purchased in recent years, and has been selected with great care, and some has been constructed for particular uses in this laboratory.

Other than the annual catalog accounts of the facilities and course offerings, very little information remains to account for Department activities during the 1890's. The Chemistry Department under Professor Andrews received some attention from the University student newspaper, but most of the interest centered around botany, geology, and zoology and the growing herbariums, collections of fossils and minerals, and the bird and mammal museums.

In addition to being the Cinderella sister among the sciences, Physics Department development suffered a major setback from a bolting blow from the heavens. In the early morning of June 19, 1897, lightning struck the top of uninsured North Hall, and the resulting fire destroyed almost all the books in the 33,000-volume library. Physics equipment sustained considerable damage from descending water and in the hurried removal of delicate apparatus.[12]

Construction of the large new Collegiate Building—later to be named the Hall of Liberal Arts and in 1934 Schaeffer Hall—was about to begin at a cost of more than $150,000. Consequently the fire severely strained University funding. As the library had to be restored and the books replaced as soon as possible, very little support remained for the instructional departments beyond the minimal salary allocations. Although Veblen repeatedly petitioned funds to rectify the damage to the Physical Laboratory, his requests were continuously postponed for the attention of later meetings of the Board of Regents.

During the summer of 1897 Veblen and his assistants worked strenuously with meager support to clean up the rooms, repair instruments, and to bring the department into a usable condition for the start of the fall classes. Veblen suffered a long illness and was not able to meet his classes until December.

The University doubled in student enrollment during the last decade of the century--from an attendance count of 737 in 1889-90 to one of 1,542 in 1900-1901.[13] While the demand for classes in physics was well under that for courses in other sciences (only sixty students in Physics I in the Fall of 1900),[14] more and more floor space was needed, especially for the engines and generators set up for laboratory courses in conjunction with the training of electrical engineers. The 8,000 square feet that the department was pleased to achieve in 1894 was becoming overcrowded. Like all the physical science professors before him, from J. M. Stone in 1856 through Gustavus Hinrichs, Veblen needed more room, especially for large electrical apparatus.

The completion of the Hall of Liberal Arts in 1900 provided a new home for the University Library and expansion for the Department of Physics. During the summer of 1901 the books and study tables moved to their new quarters, and Physics inherited the second floor of North Hall, renamed the Hall of Physics. After a year's wait for renovation funds, the Board of Regents came through in June 1902 with the largest appropriation since Physics had become a separate department—a total of $4,900 for the next year: $1,000 for building renovation, $400 for apparatus and supplies, $400 for student assistants, and salaries of $2,200 for Veblen and $900 for Instructor Charles Lorenz.[15] Later the Board approved an additional request of $25 for a drawer and shelving unit and $12 to connect the Hall of Physics with the Iowa City Electric Light Company's circuit.[16]

Among other things, the early 1900's was a period of effort by the administration and Board of Regents to upgrade the faculty to provide coursework leading to advanced degrees. The Graduate College was established in 1900, along with the undergraduate College of Liberal Arts. President George MacLean directed the new deans to move toward the replacement of professors whose academic qualifications limited them to more elementary coursework.

Although Veblen had a long record of loyal and arduous service, he was to be eased out in the development of an advanced degree program. In June 1904 he was relieved as Professor and Head and named Professor of Experimental Physics with a $400 cut in salary.[17] Arthur George Smith, in the mathematics department, was shifted into physics as an interim head of department with the title of Professor of Physics and Mechanics. For the next several years the department possessed two full professors. In 1909 Smith moved to head mechanical engineering and in 1911 to head the Department of Mathematics and Astronomy.[18]

For the first semester of 1904-05 the University Catalog shows Smith lecturing twelve hours a week--three hours in General Physics; four in a course named Mechanics, Sound and Light; and five in Theoretical Mechanics. Veblen was listed for a total of five lecture hours a week that first semester--one in instrument measurements, two in Electricity, and two in Meteorology. Instructor Charles Lorenz had four lecture hours--two in Electricity and Magnetism and two in Kinetic Theory of Gases. Veblen and Lorenz, with two student assistants, conducted the laboratory work.

The same catalog, printed in June 1905, updated its description of The Physical Laboratory,[19] which had expanded throughout the whole building and benefited from considerable remodeling during the previous three years:

> The department of physics occupies the entire three stories of the Hall of Physics, a plain rectangular structure 60 by 90 feet.
>
> The large north room of the basement is equipped with a gas engine and dynamos and other apparatus with a switchboard wired to all parts of the building. Another basement room is given to the storage battery.
>
> The basement also contains a shop furnished with electric power and equipped with wood and metal working lathes, drill press, cabinet maker's bench and necessary tools. This shop furnishes an opportunity for the making of new and the repair of old apparatus.
>
> On the floor above are the offices and several special laboratories for optics, electricity, heat, etc. One room contains the special physical library, and serves also as reading and seminary room.
>
> The second floor, formerly occupied by the general library of the University, has been remodeled and adapted to the use of this department. A lecture room with a seating capacity of 175 has been fitted up with conveniences for physical demonstrations, such as facilities for darkening the room, and for projection by sunlight and various sources of artificial light. Connected with the lecture room is a commodious apparatus and preparation room. A recitation room, a large well-lighted elementary laboratory, and a photographic laboratory occupy the remainder of the space on this floor.
>
> The former library gallery is used as a room for advanced students in the study of special problems and in which they may be free from outside disturbance.
>
> The laboratory is well supplied with lecture apparatus, and among the instruments of precision are many of the best and finest to be had. The equipment is especially full in mechanics, optics, and electricity. Most of the apparatus has been purchased in recent years and has been selected with great care, and some has been constructed for particular uses in this laboratory.

In the spring of 1905 Veblen, who had been persuaded in 1886 to shift from mathematics to physics for the good of the University, was prevailed upon to resign for the same reason. The administration had decided that the development of the department required a professional physicist of demonstrated research and teaching ability. Dean Laenas Weld, head of mathematics and astronomy since 1888 and Dean of the Graduate College since its establishment in 1900, led the search for a physicist of established reputation.[20]

The man Dean Weld found was Karl E. Guthe, at that time a specialist in electrical measurements with the U. S. Bureau of Standards in Washington, D. C. German by birth and education, Guthe had taught and conducted research at the University of Michigan from 1893 to 1903. He held a Doctor of Philosophy degree from the University of Marburg and was the author of two laboratory manuals in physical and electrical measurements and of twenty-eight published papers,[21] nine of them in the Physical Review, which was established in 1893.

The student newspaper, The Daily Iowan, briefly noted Guthe's first assembly lecture on November 1, 1905:

> The talk at assembly this morning was given by Prof. Guthe, who was connected with the United States bureau of weights and measures ... agreeably surprised the students who thought from the announcement of the subject that it must necessarily be dry.

Unlike its predecessors, The University Reporter and the Vidette-Reporter, the DI was by then heavily oriented toward sports and other student activities, front-paging the football games. But it still gave lengthy play to the popular scientific lectures of Samuel Calvin, Thomas Macbride, and C. C. Nutting. The new physics professor and his department drew very little attention. During the remainder of 1905-06 the student paper had nothing more to relate about the physics department except for announcements of lectures by Guthe on "Whistling and Speaking Arc Lights" in February, and on "The Invisible Spectrum" in April.[22]

In March 1906, however, a DI Story, "University Science Professors Held in High Esteem" included Guthe among the seven SUI personages listed as "among the 1,000 leading students of science in the United States."[23]

Interested in making statistical studies of eminent men, Psychologist J. McKeen Cattell of Columbia University had just published his first edition of American Men of Science. Among the more than 4,000 scientists with biographical resumés in the work, a star had been placed by Cattell next to the research specialty of the 1,000 whom he intended to use in his studies. In the field of physics, for instance, he had asked several prominent physicists to make lists of outstanding men and women. From a composite of these lists Cattell cited a total of 150 physicists.

Besides Guthe there was Francis Nipher, a student of Gustavus Hinrichs in the late 1860's and his assistant from 1870 to 1874, and later Professor of Physics at Washington University in St. Louis. There was also George W. Stewart, at the University of North Dakota in 1906, and in 1909 to succeed Guthe as head of the Department of Physics at the State University of Iowa.[24]

During Guthe's period as head of the department a more systematic curriculum with fewer applied engineering courses appeared on the Physics pages of the University Catalog--no longer the I-X and I-XV listings of Veblen's time. The 1908-09 volume showed a faculty of four--Professors Guthe and A. G. Smith, Assistant Professor L. P. Sieg, and Instructor A. G. Worthing--and the following grouping of courses:

A. Courses for Undergraduates
B. Courses of Undergraduates and Graduates
C. Courses for Graduates

Under A for the first semester were General Physics (Guthe) and Advanced Physics (Sieg). Under B appeared Meteorology (Smith), Electrical Measurements (Guthe) and Analytical Mechanics (Smith). Under C were Theoretical Mechanics (Smith), Theory of Light (Sieg), Theoretical Electricity and Magnetism (Guthe), Theory of Gases and Solutions (Guthe), and Research (Guthe), the last course requiring a reading knowledge of French and German. Instructor Worthing conducted the laboratory work for the courses which required it. Professors Guthe, Smith, and Sieg each had ten hours of lecture and recitation time per week.

Under A for the second semester were General Physics (Guthe) and Advanced Physics (Sieg). Under B appeared Meteorology (Smith), History of Physics (Worthing), and Analytical Mechanics (Smith). Under C were Theoretical Mechanics (Smith), Theory of Sound (Smith), Thermodynamics (Guthe), Theoretical Electricity and Magnetism (Guthe), Electricity in Gases (Worthing), and Research (Guthe). During this semester Professor Guthe had eight hours of lecture-recitation time weekly; Smith, twelve; Sieg, seven; and Worthing, four. Sieg took over part of the laboratory work from Worthing's schedule.[25]

Guthe had deep convictions concerning the values of history. A product of the academic traditions of the German intellectual aristocracy, he strongly advocated that scientists become acquainted with the history of their science:[26]

> The gross ignorance among some physics teachers of the development of physical theories and of the work of the intellectual giants, to whom mankind is indebted for its present civilization, is appalling.

While Instructor Worthing taught the formal course in the history of physics, Guthe gave several public lectures on the subject under the general title "The Growth and Development of Physical Ideals". During the summer of 1908 he prepared to begin a history of natural philosophy and physics over the preceding half-century at the State University of Iowa. For information for this work he wrote a series of letters to living alumni and faculty members of the earlier years and to some of their descendants.[27] He did not carry out his historical project; 1908-09 was to be his last year at SUI, and the information he received was too scant for so thorough-going a scholar.

In 1912, at the request of Clarence Aurner, SUI historian engaged in writing a history of science at the University, Guthe submitted copies of some of his correspondence of 1908. A paragraph of some interest to these Annals appeared in a letter to Guthe from Nathan R. Leonard, professor of mathematics and astronomy at SUI, 1860-87, and in 1908 serving as President of the Montana School of Mines. The paragraph was descriptive of the teaching of Oliver M. Spencer in 1860-62:

> As Professor of Physics and Chemistry he found himself but scantily provided with apparatus and means of illustration, but making the best use of what he had, he prepared a course of illustrated lectures that early in the second year of his incumbency had made his the most attractive department of the University. I attended some of these lectures, and greatly admired his manner of presenting the subjects under discussion and the neatness with which his experimental illustrations were conducted.

In the course of his four-year stay at Iowa, Guthe was the author of more than ten published papers and technical-book reviews in science journals. He contributed a chapter "Heat" to Duff's Physics, published by Blakiston's Sons and Co., 1908, and he prepared with J. O. Reed of the University of Michigan a second edition of their A Manual of Physical Measurements.[28]

He was also active in national organization leadership, serving, for instance, as a vice-president and physics section chairman for the American Association for the Advancement of Science at its June 1908 meeting in Hanover, New Hampshire and again at its December 1908 meeting in Baltimore.[29]

The years of 1905-09 were also a time of planning and anticipating a large modern building. There was some uncertainty about its site, for a dotted outline of a "Proposed Gymnasium" appeared to the southwest of Old Capitol on the campus map in the front of the University Catalog of 1905-06 and again in 1906-07. This was on the site where South Hall and the Medical Building stood together until they were destroyed by the same fire in 1901. A "Proposed Library" is similarly shown on the above maps on the site on the northwest of Old Capitol.

In the catalog maps of 1907-08 and 1908-09 "Proposed Hall of Physics" replaced "Proposed Gymnasium", which replaced "Proposed Library" on the northwest side.

The official action toward the erection of the fourth building of the later-termed Pentacrest took place in the meeting of the Board of Regents of September 25, 1906:

> Moved by Regent Wright that the architects be instructed to prepare plans for a physics building at a cost not to exceed $150,000 ... to be built of stone.[30]

The plans were drawn up, but no further progress occurred during the next three years. The completion of housing for Engineering, for Law, and for Medicine--all in temporary quarters since the fire of 1901--was deemed more urgent in the use of available capital funds. Like the future occupants of the proposed gymnasium and of the proposed library, the physicists had to wait for their new building.

During the summer of 1909 Guthe resigned to accept a post at the University of Michigan. He was the first professor in charge of the department to leave for what he considered a more rewarding position. The first, J. M. Stone, left in 1858 when the University closed for two years for lack of funds. The second, Oliver Spencer, became University President in 1862 and then gave up his chair of physical science to Gustavus Hinrichs, who was discharged twenty-three years later. Launcelot Andrews headed the department for a three-year interim (1885-88) while Chemistry and Physics were separating; then led the Department of Chemistry for sixteen years until he too was dismissed for his hostility toward the policies of President MacLean. Andrew Veblen plodded and persevered until 1905 when he was eased out to make way for an established physicist to invigorate the department.

George W. Stewart, Guthe's successor in 1909, was to become the only departmental leader to remain to reach emeritus status (1946). Stewart observed in memoirs written in 1952 that Guthe left because of the delay in constructing a new building, recalling that Guthe threatened to leave and then carried out his threat.[31] But the Iowa City Citizen reported a salary increase of fifteen per cent--from $2,600 at Iowa to $3,000 at Michigan--as the influential reason.[32]

However much the building and salary situations affected his move, Guthe was returning with senior status to a prestigious department where he had conducted productive research as a junior professor before joining the U. S. Bureau of Standards. At Ann Arbor he would have fewer classes with more advanced students--the University of Michigan had some twenty graduate students in physics at the time--and prospects for increased status. (He succeeded John O. Reed, his longtime friend and co-author, in 1911 as Director of the Physical Laboratory, a title synonymous at the University of Michigan then with Head of the Physics Department. He was appointed Dean of the Graduate School in 1912.)[33]

In the quarter century chronicled in this chapter, Physics advanced considerably in the space it occupied, if little in prestige and influence compared with other University science departments. Floor space used by Physics increased more than ten-fold--from a varying amount of less than 1,000 square feet of the first floor of North Hall to the whole building (around 11,000 net square feet) after Chemistry moved to its new home in 1893 and the University

Library acquired new quarters on the third floor of the Hall of Liberal Arts in 1901. North Hall was renamed the Hall of Physics after the library left.

University enrollment over the period grew almost five-fold, from 502 in 1885-86 to 2,473 in 1908-09.[34] A relatively small proportion of the latter number were taking one or more physics courses--some two hundred different students, according to class registration lists maintained in the Registrar's Office. But equipment for the laboratory crowding work in electricity and magnetism, in thermodynamics, etc. required growing spreads of space. If the technological nineteenth century can be called the Age of Steam, then the early twentieth century was becoming the Age of Electricity. In the course of such developments, SUI physicists began to anticipate more spacious and modern areas in which to teach and to work with the forthcoming apparatus.

Notes and Sources

[1] From "Record of University Attendance," p. 6 of University of Iowa News Bulletin, Oct. 19, 1927.

[2] Some of the heaviest attacks occurred in the Iowa City Post almost every week during the winter and spring of 1885-86. In a lengthy editorial on Jan. 27, 1886 Editor-Publisher Max Otto assailed the cost and early use of the newly constructed Natural Science building:

> The building as it now stands, including the elegant laboratory tables and the black walnut plate glass cases, has cost the State $60,000; for one half the day it houses thirty students--that is, at the rate of two thousand dollars a head!.

[3] William C. Lang, History of the State University of Iowa: The Collegiate Department from 1879 to 1900.

[4] They were Nathan R. Leonard, professor of mathematics and astronomy since 1860 and Acting President, 1866-68; Leonard F. Parker, professor of Greek language and history since 1870; and Stephen N. Fellows, professor of philosophy and didactics since 1867.

The Board asserted a decline in their teaching effectiveness as the reason for their removal, but most observers thought they were dismissed because of their outspoken campaigns against the sale and use of liquor. Iowa Governor William Larrabee sided with these prohibitionists of the 1880's. In his 1888 Message on the State of Iowa, he used these words in his discussion of the condition of the State University:

> We should have at least 1,000 students here. I see but one obstacle in the way. The Prohibitory Law is not enforced with sufficient vigor in Johnson County to make it effective as it should be to harmonize with the sentiment of those who most desire to patronize the institution. Hence we have only about one-half the number of students at the University that we should have. Hundreds of students now seek other places for this reason.
>
> --from Benjamin Shambaugh, Messages and Proclamations of the Governors of Iowa, Vol. VI, p. 50, State Historical Society of Iowa.

[5] Biographical article on L. F. Andrews, University Reporter, Sept. 19, 1885.

[6] Minutes of the Board of Regents, June 16, 1886.

[7] Bergmann, Leola N., Americans from Norway, pp. 258-261, Lippincott, Philadelphia, 1950.

[8] A. A. Veblen, "At Luther College," Palimpsest, Sept.-Oct. 1975.

[9] Minutes of the Board of Regents, June 20, 1887.

[10] Ibid., June 19, 1888.

[11] University Catalogs of 1885-86 and 1887-88.

[12] Accounts of the fire damage to North Hall appeared in the Vidette-Reporter, Sept. 16, 1897 and, with a fuller account, in the University News Bulletin of May 1, 1900.

[13] Op. cit., University News Bulletin, Oct. 19, 1927.

[14] From Class Enrollments on Microfilm, University Registrar's Office.

[15] Minutes of the Board of Regents, June 22, 1902.

[16] Ibid., Jan. 23, 1903.

[17] Ibid., June 16, 1904 and in a letter from President George MacLean to Veblen of June 27, 1904 [in the MacLean papers, University Archives, B 1 (1)].

[18] Biographical sketch of Arthur George Smith at the time of his death in 1916, MSS Archives.

[19] University Catalog, 1904-05.

[20] Minutes of the Board of Regents, April 11-13, 1905:

> The committee on the College of Liberal Arts recommends that the resignation of Professor A. A. Veblen which has been presented to the Board, be accepted; that a new man be selected for the head of the department of physics and mechanics at a salary of $2,200 and that the salary of Mr. Smith be advanced from $1,300 to $1,600, with the suggestion to him that this is as far as the Board can go this year, but we hope next year we can make it $1,800.

[21] From Guthe's bibliographical contribution to Clarence Aurner's unpublished and untitled manuscript labeled as "Relating to the Teaching of Science" in the collection of the State Historical Society of Iowa (written around 1912 and 1913).

[22] Daily Iowan of Feb. 1, 1906 and of March 22, 1906:

> There was a paucity of items about physics in the University newspapers in the 1890's and early 1900's. When such occurred they were likely to be of the nature of the following in the Vidette-Reporter of April 5, 1898:
>
> "The physics class began its work in the laboratory on Monday." (End of story!)

[23] Daily Iowan, March 8, 1906:

> The other State University of Iowa professors cited among the top 1,000 scientists by Cattell then were Samuel Calvin, Geology; Thomas Macbride, Botany; G. L. Houser and C. C. Nutting, both in Zoology; and G. T. W. Patrick and Carl Seashore, both in Philosophy and Psychology.

[24] J. McKean Cattell, American Men of Science, 1906.

[25] University Catalog, 1908-09.

[26] Karl. E. Guthe, "Some Reforms Needed in the Teaching of Physics," the lead article in Science, Jan. 7, 1910.

[27] Op. cit., Aurner's unpublished manuscript relating to the Teaching of Science, State Historical Society of Iowa.

[28] From Guthe's bibliography, op. cit., Aurner's manuscript.

[29] Physical Review, XXVIII, p. 140, 1909.

[30] Minutes of the Board of Regents, Sept. 25, 1906.

[31] George W. Stewart, Incidents in Connection with the Construction of the Physics Building at the University of Iowa, 1909-1911, pp. 5-6, written in 1952 for the Archives of the University Department of Physics.

[32] Iowa City Citizen, July 9, 1909.

[33] From "The Department of Physics," pp. 680-701, Vo. II, in The University of Michigan: An Encyclopedic Survey, The University of Michigan Press, Ann Arbor, 1951.

[34] Op. cit., p. 6, University News Bulletin, Oct. 19, 1927.

Chapter Five

A New Building: Base for More Research

The year 1912 was one of portentous development and discovery in experimental physics, but campus students of the science attended most to their locally realized anticipations. They now had a solid and spacious home for their work.

1912 was the year that C. T. R. Wilson, using cloud chamber photography, revealed distinguishing tracks of electrons and protons from radioactive materials. His work provided experimental evidence for models of the atom under development by Ernest Lord Rutherford, Niels Bohr, and others.

That year solid state physics became a branch of study when Max von Laue showed that crystals can diffract X-rays.

It was the year that Viktor Hess reported that he had measured earth-bombarding particles at altitudes up to six miles. Robert Millikan later christened these cosmic rays.

But in Iowa City it was the new Physics Building that was most celebrated. In addition to its research and undergraduate laboratories and its lecture rooms and shops for physics, the five-floor building provided new quarters for mathematics, for electrical engineering, and for the fine arts.[1] Much of the structure's interior planning, and some of the exterior design, was the work of George W. Stewart, who had painstakingly directed the project since his appointment as professor and head of the department in August 1909.

Recommended by the departing Karl Guthe as a competent scientist and educator who might be willing to come to Iowa, Stewart had taught at the University of North Dakota since 1903. A native of Missouri, he had earned his A.B. degree at DePauw University in 1898 and his Ph.D. in 1901 at Cornell University, where he was then an instructor for two years. In memoirs written late in his long life, Stewart observed that he accepted the chance to go to the University of North Dakota to be "more on my own where there would be broader demands on ability ... I reasoned also that education in the Middle West was growing apace and that if I succeeded at North Dakota, I would be called elsewhere in that region."[2]

In the period of 1901 through 1908, Stewart had published six papers in the Physical Review, including, for instance, "The Spectral Energy Curve of the Acetylene Flame" in 1901, "Architectural Acoustics" in 1903, and "A Satisfactory Form of High Resistance" in 1908. Guthe had talked to him on several occasions at meetings of the American Physical Society and of the physics section of the American Association for the Advancement of Science.

During his earliest years at the University of Iowa, Stewart continued with the departmental course of study which Guthe had built. With only three men on the faculty--Stewart and Assistant Professors L. P. Sieg and F. C. Brown in 1909-1910--the new department head was teaching an average of four three-hour classes each week[3] and still devoting more than half of his time to the new building. He was determined to make it the most modern and durable Physical Laboratory in the nation, a basic guarantee of the future of physics in the University of Iowa.

Site and architectural plans in harmony with the other stone buildings near Old Capitol, as approved by the State Board of Education, imposed certain limitations: a maximum length of 230 feet and width of 75 feet, a rectangular structure of five floors, and a budget by legislative appropriation of $150,000.[4]

Much as Gustavus Hinrichs had traveled during the summer of 1865 in his quest to make the planned North Hall a major physical laboratory center, Stewart visited and inspected in 1909 and 1910 the physical science buildings at the Universities of Illinois and Toronto and at Yale, Cornell, and Princeton Universities.[5]

In planning sessions with architects, contractors, and University administrators, Stewart insisted the building be durable enough to serve the needs of science for more than a century, and solid and rigid enough so that delicate experiments could be performed on any floor. He succeeded in attaining floors capable everywhere of supporting at least two hundred pounds per square foot, with a solid footing for the building on the sloping west side thirteen feet in width.[6]

Wiring and plumbing were to be strung and laid for easy access for repairs and alterations. Most of the walls dividing the rooms were to be sufficiently changeable to adapt room size to different needs in the future. Basement research laboratories were to be as first-class in livability as rooms on the upper floors, working quarters with ample window space and without steam pipes in their ceilings. Stewart had labeled so many rooms with the words "Research Laboratory" on his layout that President John Bowman suggested that the naming was overly extensive and optimistic for a department that so far had performed so little research. The physicist came up with a compromise. He alternated the words "Research" and "Laboratory" on the stencils for the glass on ten of the doors.[7] It was a stratagem acceptable to the President and the Deans and still presaged the future as Stewart envisioned it.

Also looking toward the future, he had an elevator shaft constructed within the building. He did not see a necessity--nor did he have the funding--for an elevator at that time, but he convinced the administration that one might be needed in later years. Never to be used for its original purpose, the shaft served Stewart as a lever for appropriations for equipment which he wanted considerably more. He would ask for funds for an elevator, then settle for an apparatus purchase at a somewhat less cost.[8]

Stewart continued throughout the construction period to involve himself ardently in almost every aspect of the building, from the foundations to the roof. He wrote letters of inquiry and experimented with finishing compounds for the cement floors. He informed himself on various stains and varnishes for the woodwork and chose those which he preferred. He decided in favor of long, continuous chalkboards of slate rather than follow the prevailing fashion toward sliding blackboards. He urged and got lecture room seating of special fabrication and three-fourths of an inch higher than the standard seats sold to colleges at that time.[9]

In extensive discussions and correspondence with University Deans and with President Bowman, Stewart pressed for additional funds for new apparatus and furniture. A maximum of $30,000 had been appropriated for these items in the new building, and the University Administration held firm on this budget. Stewart estimated a minimum need of $15,000 for furniture and $24,000 for apparatus. He pointed out the comparative prosperity of other midwestern physics departments in this regard. Whereas "the actual value of our own equipment is certainly not more than $10,000," the value of apparatus, exclusive of furniture, at the University of Chicago was $90,000; at the University of Illinois, $70,000; at the University of Wisconsin, $45,000; and at the University of Minnesota, $40,000. He also noted that the average yearly funding for apparatus needs in other midwestern universities, including Kansas and Nebraska, was more than $3,000, while Iowa's support had been less than one-third as much during recent years, only $1,000 annually.[10]

As the cost of construction overran the preliminary budget by fifty percent--totaling $225,000 rather than $150,000--Stewart did not get the extra $10,000 he wanted for furniture and equipment. But he did succeed in increasing the department's annual allotment for supplies, equipment, and furniture from $1,000 to $2,500 for each of the next several years.

Enlisting the support of Iowa Senators and Representatives, Stewart campaigned for the establishment of a U. S. weather station within the new building. He pointed out that such a facility would enrich departmental instruction in meteorology, and he cited the precedent of Gustavus Hinrichs' pioneer work in weather reporting and analysis in the period of 1878-88. The National Weather Bureau rejected the offer of room in the building on the grounds that the Des Moines Weather Bureau adequately served the Iowa area.

Also concerned with the heritage of the past, Stewart sought to enshrine the names of major achievers who had appreciably increased understanding of matter and energy and brought his science to its current state of knowledge. He had the frieze of the building's entablature cut with the surnames of thirty-six men, from Archimedes through late nineteenth-century contributors like Josiah Gibbs and Heinrich Hertz. Stewart intended the names to follow one another by date of birth, but some of them got up there a few years out of order--those of Augustin Fresnel and Georg Ohm, for instance, and those of Joseph Henry, Michael Faraday, and Nicolas Carnot. In his memoirs of 1952 Stewart notes that he reached the stone cutter one day in 1912 just in time to have a second "h" put in the name of Gustav Kirchhoff.[11]

The building was ready for occupation for the fall semester of 1912. To some 2,200 returning and new students, the Daily Iowan rhapsodized on September 15 over the "splendid new stone building."

> Looming up with its five-story elevation, the beautiful gray structure ... is easily the leading attraction to swarms of incoming students ... This structure is probably the best adapted for physics in the United States and, architecturally considered, it is probably not excelled.

Two weeks later the department hosted an open house with guided tours and refreshments. The Daily Iowan of September 29 extolled the building's "noteworthy and unique features:"

> It is possible to go from any one room to any other room with an electrical wire and not pierce a solid wall to do so. This is made possible by a system of tunnels and

> conduits. There are about twenty miles of wire in the building and over eight miles of this was ordered at the same time and is of the same size.
>
> There is a constant temperature room in which by automatic controllers the temperature of the room is kept at a uniformity at all times and under all conditions. Another interesting feature is a dark room without a door.

The new lecture room on the top floor attracted many to a variety of University programs outside the normal class times. But for physics faculty members and students its real inauguration occurred one Saturday morning, November 23, 1912, when Karl Guthe, by then Dean of the University of Michigan Graduate School, returned to the campus and lectured on "The Ether."

An even more noteworthy event in the first-year use of the new building took place on January 25, 1913. Reported the Iowa Alumnus in February:

> Iowa's physics department was the scene of state interest here January 25 when physicists from all over the state gathered to hear the address of Prof. R. A. Millikan of Chicago University on "The Elementary Electrical Charge."

But the "informal dedication" of the building took place during the summer of 1912, according to the Iowa City Daily Press of July 20, when Stewart gave a tour of the structure to the summer session students in physics. Glowed the Press:

> The structure, fully equipped, promises to be the finest Hall of Physics in the West, and it will rival fairly any of the great institutions of the East. In the personnel of its faculty, it may defy the world.

Local pride no doubt swelled the faculty evaluation into an overstatement. Yet there is ample evidence that since 1905 the department under Guthe, then Stewart, was staffed by vigorous and productive young men, all of them destined for distinguished careers later at other universities or in governmental or industrial research. This may be an appropriate time in this history to give some account of the work over the years of the junior members of the department.

By 1912 Physics was 24 years old as a separate department and 56 years old as subject matter taught at the U of I under the varied headings from Natural Philosophy, through Physical Science, and Chemistry and Physics. Until the turn of the century (in order) Stone, Spencer, Hinrichs, and Veblen had offered all or most of the instruction. As their budgets allowed, and the popularity of their programs rose and waned, Hinrichs and Veblen employed one or two assistants, primarily to help with the student laboratories. A teaching faculty of three did not develop until 1904, with the staff expanding to four members in 1906.[12]

A. L. Arner, appointed as an instructor in 1890 and promoted to assistant professor during his last year at Iowa, 1894-95, was the first non-Iowa graduate to assist the Professor of Physics (then Veblen) in departmental instruction. Arner was a graduate of the University of Wisconsin. He was succeeded by Iowa graduates C. H. Bowman, instructor from 1896-99, and then by C. F. Lorenz, instructor from 1900 to 1906. Professor Guthe brought A. G. Worthing from the University of Michigan into the department as an instructor from 1906 to 1909. Worthing returned to Michigan with Guthe to complete his work toward the Doctor of Philosophy degree there in 1911.[13]

During the first few years in the new building, from 1912 up to America's entry into World War I, the faculty, which the Press evaluated as able to "defy the world," consisted of Stewart and junior staff members Lee Paul Sieg, Fay Cluff Brown, and Homer L. Dodge. It was a youthful faculty, with Stewart, 36 in the fall of 1912; Sieg, 33; Brown, 31; and Dodge, 25. Two of the four, Sieg and Dodge, received their professional education at the U of I. Brown had earned his A.B. at the Indiana University in 1904, his A.M. at the University of Illinois in 1906, and his Ph.D. at Princeton University in 1908.[14]

Sieg (B.S., 1900; M.S., 1901; Ph.D., 1910--all at the U of I) had been working in the department since 1899 as a student assistant, graduate fellow, instructor, and assistant professor—except for a period of three years (1903-06) when he taught at Carleton College in Minnesota. His Doctor of Philosophy degree was the first to be granted within the U of I Department of Physics.[15]

Dodge, a graduate of Colgate College in 1910, came to Iowa to earn his M.S. degree in 1912 and his Ph.D. in 1914. His payroll titles were progressively assistant instructor, demonstrator, instructor, and, following his doctorate, assistant professor.[16]

In the period between 1906 and 1944, the appearance of new editions of <u>American Men of Science</u> gave cause for prideful reports in U of I publications.[17] The AMS editors--J. McKeen Cattell of Columbia University, succeeded by son Jacques Cattell--added stars to the biographical listings of those whose work was evaluated as most valuable by their peers in each science. The starred list invariably included an impressive number of U of I professors. This AMS practice of distinguishing at first about one-fourth to later about one-tenth of the listed scientists continued through the volume's seventh edition in 1944.

Physics at the U of I was represented among the scientists of distinction first by Guthe in 1906, by Stewart in 1911, by Stewart and Sieg in 1921, by Stewart in 1927, and by Stewart and Alexander Ellett in the editions of 1933, 1938, and 1944.

The roll of distinction in <u>American Men of Science</u> over many of these years also included several physicists who had taught at the U of I, then departed to other universities or to research laboratories of industry or the U. S. government.

These included:

Francis Nipher (U of I, 1870-74) who moved to Washington University in St. Louis;

Archie G. Worthing (1906-09), to the University of Michigan and then to the NELA Research Laboratory of the National Electric Lamp Association, Cleveland;

Matthew Luckiesh (1909-10), also to NELA in Cleveland;

Fay Cluff Brown (1909-19), then to the U. S. Bureau of Standards, Washington, D. C.;

Otto J. Stuhlman, Jr. (1917-19), then to the University of North Carolina;

Clarence W. Hewlett (1919-22), then to the General Electric Company research laboratories in Schenectady, New York; and

Edward O. Hulburt (1921-24), then to the Physical Optics Division of the Naval Research Laboratory, Washington, D. C.[18]

While a star of distinction in American Men of Science edified many within the communities of the honored scientists, the professional persons themselves aspired more to have their work recognized in their own journals and at their national and regional meetings. Beginning in 1893 as a publication of Cornell University, the Physical Review became the major journal devoted to physics in America. The American Physical Society was organized in 1899 with a first-year membership of fifty-nine Fellows.[19] During the early years of its growth, the APS generally met in conjunction with Section B (Physics) of the long-established American Association for the Advancement of Science.

Guthe was the first physicist later to be at the U of I to have his work in the Physical Review. In Volume 7, the December 1898 issue, appeared "A New Determination of the Electro-Chemical Equivalent of Silver," by George W. Patterson, Jr. and Karl E. Guthe, both of the Physical Laboratory of the University of Michigan.

Stewart was next among future Iowa physicsts to be published in the Physical Review, in 1901 when he was a post-doctoral instructor at Cornell University. The third physicist to work later at the U of I and to appear in the Phys. Rev. was F. C. Brown, with an abstract of his research on selenium in 1905 when he was a graduate student at the University of Illinois. The fourth, and the first physicist in residence at the U of I to make his debut in the Phys. Rev. was L. P.

Sieg. His doctoral studies on the elastic properties of platinum-iridium brought forth three research contributions to be published in the journal between 1908 and 1912.[20]

In the years following the occupation of Iowa's new Physics Building, the staff devoted increasingly more time to research. During the 1909-12 period, Stewart had published only one paper, "Acoustic Shadow of a Rigid Sphere," in the Physical Review (1911). In 1913 he published three papers in the journal on the topics of sound diffraction, binaural localization, and relative sound intensities.[21]

While Stewart was concentrating on a wide range of acoustical research, the younger members of the staff intensified studies of the photometric qualities of the rare element selenium. Brown had been working on this element for several years, starting with his graduate work at Illinois and at Princeton. Sieg passed on to the younger Dodge his work on the physical properties of various kinds of wires and joined Brown in the study of the non-metallic element which resembles sulfur chemically. To the physicists selenium was most promising research material because of its reaction to light. They envisioned useful applications of the substance whose electrical resistance decreases as its exposure to light increases.

Brown and Sieg prepared for publication papers with such titles as "Wave-Length Sensibility Curves for Light Sensitive Selenium" and "Isolated Crystals of Selenium and the Physical Conditions Determining Their Production."[22]

The Daily Iowan proclaimed in front-page stories "DRS. BROWN-SIEG IN NEW RESEARCH" and "DR. BROWN DEVISES AUTOMATIC LIGHTER" on April 20 and December 18, 1915. In the earlier story the DI noted that Brown had announced the results of Iowa work with selenium in lectures in Syracuse, New York and in Washington, D. C. and in many other places. Said the DI account:

> Nowhere in the United States has such excellent work been done in the development of the possibilities of selenium than at Iowa under the direction of the physics department, which is now prepared to disclose work done along this line.

In the later story the DI pointed to uses of selenium to control the opening and closing of electrical circuits, with the possibility of military applications in the discharge of mines; also in the development of a machine to enable the blind to read print.

On February 19, 1916 the DI was pleased to quote a current article in the New York Post:

> The world will welcome any invention that makes happier the lot of the blind. Never have there been so many for whom the world has become a darkened room as now. The war has multiplied tremendously the sightless.
>
> If through his phonopticon Dr. Brown can give back to them a little of what they have lost, he will have achieved more than any general who has captured a city.

This appears to be the first time in some forty years (since the heydays of Gustavus Hinrichs) that the work of a physical scientist at the U of I was lauded in an eastern metropolitan newspaper.

As the time of America's entry into World War I approached, Stewart's research in acoustics and its application in sound reception discriminations attracted the interest of the nation's defense organization. He published in the Physical Review: "Acoustic Phase-Difference at the Ears," 1914; "Variation of Sound Intensity with Distance," 1916; "Binaural Beats," 1917.

He spent much of the summer of 1917 in Washington, D. C. consulting with the war department on problems of locating and identifying aircraft and submarines. In armed service laboratories around the nation's capital and at the anti-aircraft station at Pensacola, Florida he helped to develop acoustic receivers to amplify the detection of sound by the human ear. During the war he served on the

National Research Council's committee on the location of airplanes and as a civilian consultant to the U. S. Navy.

The history of the University's participation in the first World War[23] indicates the prominent role of the physics department in contributing to the war effort. Shortly after the United States declared war on Germany on April 6, 1917, President Jessup named a seven-man committee from the University faculty to aid the National Research Council. He appointed Stewart to be the committee's chairman.

Following Stewart's summer of 1917 in acoustical research with the military, the laboratories and shops of the Physics Building became scenes of activity for the national defense. He and Dodge, assisted by graduate students and instrument maker J. B. Dempster, worked to construct improved microphones for the location and detection of invisible aircraft. In August 1918 Dodge shipped an Iowa-modified microphone to the Western Electric Company.[24] Stewart, in Washington again that summer, reported to President Jessup:

> The navy has ordered sixty machines designed by me. Our form of apparatus is distinctly superior in its ability to enable the operator to distinguish between different types of airplanes ...[25]

Brown and Sieg were granted leaves of absence for 1918-19 to serve in U. S. Army research programs. Brown was commissioned a captain and later promoted to major in the Ordnance Department in Washington, D. C., where he worked on bomb ballistics and on military applications of light reflection on water. Sieg, a captain in the Army's aviation research group, concentrated on photographic studies of aircraft trajectories. Dodge was appointed in the Army's special training program as a civilian consultant on coursework in physics.[26]

The American Physical Society meeting of April 25-28, 1919, in Washington, D. C. was "given over entirely to special papers and exhibits of apparatus illustrating the application of physical principles to the solution of problems arising from war conditions."[27]

Stewart, Sieg, and Brown were among those who were invited to present the fifty-two special papers of the occasion: Stewart, "Location of Aircraft by Sound"; Sieg, with A. W. Duff, "Photography of Trajectories"; Brown, "An Interesting Observation of Light Reflection on Water and its Application." Sieg and Brown were also the authors of papers among the 188 additional titles which were submitted as records of work accomplished: Sieg, "Photographic Method for Air-Speed Determination" and Brown, "Certain Results on Air Resistance as Affecting the Flight of Drop Bombs."[28]

The newness, then, of the airplane and the strong federal support for his work created considerable interest in Stewart's presentation, in which he pointed out the accuracy and the range of long conical horns as sound locators. According to the printed abstract of his paper, some of the results achieved:

> With the horns 18 feet in length and diameter of opening 4.5 feet the range under fair night conditions for airplane elevation of 6,000 feet was approximately three times that of the unaided ear. Experiments indicated, however, that the amplification of the apparatus was 100, thus showing great diffusion in the atmosphere.
>
> Similar airplanes could be separately located by such a device if more than 5 degrees apart, and, if engine noises were sufficiently marked, a separate location could be secured with only one degree actual separation.[29]

Stewart elaborated further on the atmospheric conditions in a brief article in the October 1919 issue of the Physical Review, "Propagation of Sound in an Irregular Atmosphere."

For an Iowa City audience he gave an account of his aircraft sound research, along with some of the work of Sieg, Brown, and others in a U of I summer session lecture, July 1, 1919: "Some Applications in Physics During the War."[30]

From 1906 through 1942 the University Catalog printed each summer a list, "Public Lectures, Addresses and Recitals," covering the preceding academic year. During the earlier years of this period, most of the lectures sponsored by the Department of Physics were offered by members of the faculty, with some by scientists from other institutions in Iowa and from neighboring states, occasionally one by a more distant visitor.

At times Stewart succeeded in bringing to the campus prominent physicists from Eastern states, despite the long train ride for them to and from Iowa City. For instance, on March 4, 1915, Dayton C. Miller of the Case School of Applied Science, Cleveland, came to lecture on "The Science of Musical Sounds." April 18-19, 1917 Percy W. Bridgman of Harvard University gave two lectures on "High Pressure Phenomena."

Occurring a few days after America's entry into World War I, Bridgman's research reports were the last to be formally sponsored by the Department of Physics until the summer of 1919, when Stewart spoke on the military uses of physics. The cessation of such lectures is indicative of the preoccupation of the physicists with the war.

The visiting lecturers served to supplement the reading of professional journals in keeping the U of I physicists aware of developments in their science. A course entitled Modern Physics, generally taught by Stewart, presented the theories and experiments of such major European innovators as Max Planck, Lord Rutherford, Alfred Einstein, Niels Bohr, and Max von Laue. At times a member of the faculty would offer a popular lecture with such a title as "Inside the Atom" or "New Discoveries in Physics."

One winter evening in 1913, for instance, some seventy members of the Baconian Club and visitors climbed the stairs to Room 301 to hear L. P. Sieg on "Recent Advances in Physics." Observing that the present status of the science could be a matter for jest in the future, he concluded that the growth of physics was so rapid that "even within as short a period as five years" much of his presentation that night "would need serious restatement, at least, and some of it perhaps would have to be cast aside altogether."[31]

Notes and Sources

For Chapter Five's period of 1909-19, the sources used in the earlier chapters have been augmented by materials in the Physics Building, primarily the bound volumes of the Physical Review and the early editions of American Men of Science in the Physics Library; also unpublished memoirs written by G. W. Stewart for Physics Department Archives.

[1] G. W. Stewart, "The New Physics Building at the University of Iowa," pp. 8-15 of Contributions from the Physical Laboratory, State University of Iowa Bulletin, No. 2, 1913.

[2] From Biographical Memoirs of the National Academy of Science, Vol. XXXII, p. 385 (The Columbia University Press, 1958).

[3] University Catalog, 1909-10.

[4] Minutes of the Board of Regents, Sept. 25, 1906, and Minutes of the State Board of Education, Sept. 10, 1909.

[5] Incidents in Connection with the Construction of the Physics Building at the University of Iowa, 1909-1911, p. 11. Written in December 1952 for the Archives of the Department of Physics by G. W. Stewart.

[6] Ibid., p. 16.

[7] Ibid., p. 30.

[8] Ibid., pp. 38-39.

[9] Ibid., pp. 32-33.

[10] From a letter by G. W. Stewart summarizing discussions and stating the department's outlook on furniture and equipment. Directed to President John Bowman, Feb. 1, 1912.

[11] Op. cit., Incidents in Connection with the Construction, p. 27.

[12] Information on faculty dates and backgrounds gleaned from University Catalogs over the years. Corroborated by biographical data from the early editions of American Men of Science and by information in Clarence Aurner's unpublished and untitled manuscript which he began 1912-13 (located at the State Historical Society of Iowa). Alphabetical faculty file cards in the University of Iowa Archives have also served in checking the men and their dates.

[13-16] From sources of information as accounted above.

[17] For example, 12 OF FOREMOST SCIENTISTS HERE, front page story of the Daily Iowan, June 29, 1921.

[18] Gleaned from examining the first seven editions of American Men of Science, extending from 1906 through 1944.

[19] Bulletin of the American Physical Society, Series II, Vol. 18, No. 8, August 1973, p. 942.

[20] From Table of Contents, Physical Review, 1908-1912.

[21] Ibid., 1913.

[22] Letter to the Dean of the College of Liberal Arts from G. W. Stewart, May 12, 1915.

[23] H. F. Bangsberg, The University and World War I, M. A. Thesis in the Department of History, State University of Iowa, August 1951.

[24] Ibid., p. 131.

[25] Ibid., p. 131.

[26] "Physics Profs in Service," Iowa Alumnus, February 1918.

[27] Physical Review, Vol. 14, p. 152 (August 1919).

[28] Ibid., pp. 153-159.

[29] Ibid., pp. 166-167.

[30] University Catalog, 1919-20, "Public Lectures, Addresses, and recitals."

[31] Baconian Club Minutes, Vol. VIII, pp. 73-75. Sieg wrote into the minutes of the meeting of January 11, 1913 an abstract of his lecture, for example:

> The contradictory experiment of Michelson to detect relative motion of the earth and the ether has found an explanation in the Principle of Relativity of Einstein. This principle rests on two postulates concerning the constancy of the velocity of light and of the laws of motion and wave propagation with reference to a moving set of coordinates.

Chapter Six

Postwar Regrouping and Rethinking

As with many other organizations, the war disrupted the Iowa physics department. In the fall of 1919 two of the four who had worked together since 1910 did not return to their Physics Building offices and laboratories. F. C. Brown chose to remain in Washington with the National Bureau of Standards where he was soon advanced to assistant director. H. L. Dodge moved to the University of Oklahoma as head of the department.

Stewart had struggled to keep the group intact. In the spring of 1919 he urged that the salaries of Sieg and Brown be advanced to \$2,750, an increase of \$500 over their pre-war stipends. In a letter to Dean George Kay of the College of Liberal Arts,[1] Stewart pointed out that both men had grown in power and usefulness through their successful scientific work with the U. S. Army. He added that they had become accustomed to a higher standard of living in the Washington, D. C. area.

Sieg returned at \$2,750 for 1919-20, with the assurance that he would be advanced the next year to a full professorship with an additional \$1,000 in salary. The replacement for Brown was Clarence W. Hewlett, who had earned his Ph. D. degree at Johns Hopkins University in 1912 and had been teaching at the North Carolina College for Women. Partly because of this experience, Hewlett inherited the Home Economics Physics course, which Dodge had been teaching. There was no continuing replacement for Dodge until 1921 when Edward O. Hulburt, another Johns Hopkins Ph. D. (1915), joined the staff.

The early 1920's were an exciting time in the science of physics. Quantum mechanics and Einsteinian relativity were revising classical explanations of atomic and sub-particle behavior. Artificial disintegration of the nitrogen nucleus in 1919 brought anticipations of many transmutations of the elements. By 1924 Ernest Rutherford and James Chadwick had succeeded in knocking protons out of the nuclei of most of the lighter elements. Soon men were to work with atoms as they had been working with chemical molecules.

Although the Iowa Physical Laboratory was remote from such centers of scientific ferment as Cambridge, Berlin, and Goettingen, Stewart and Sieg were reading the emerging papers and explaining the new developments. Influential as a member of the governing board of the American Physical Society, Stewart was able to persuade a number of prominent physicists to come to Iowa City and report on their work. Some of these had or would win the Nobel Prize in Physics. Some were to participate in the Solvay Conference in Brussels, the most select and celebrated meetings of the physicists of the world.

Visiting lecturers appearing in the Physics Building during the 1920's included:

Arthur H. Compton, then at Washington University at St. Louis, Dec. 9, 1920: "The Nature of the Ultimate Magnetic Particle"

Hendrik Lorentz, University of Leyden, March 16, 1922: "Old Plus New Mechanics." The 1902 Nobel laureate and President of the Solvay Conference since 1911, Lorentz made only six university lecture stops during his visit that year to the United States.

Arthur J. Dempster, University of Chicago, March 26, 1923: "Isotopes" and "Positive Rays"

Chandrasekhar Raman, University of Calcutta, Sept. 24, 1924: "Color of Earth and Sky"

Karl Manne Siegbahn, Upsala Physical Institute, Sweden, Jan. 19, 1925: "X-Ray and Atomic Structure." He had just won the 1924 Nobel prize.

J. H. Van Vleck, then at the University of Minnesota, Nov. 22-23, 1926: "Foundations of the New Quantum Mechanics: Some Significant Features of the New Theory; Comparison of the Matrix and Schroedinger Wave Viewpoints; the New Interpretation of the Hydrogen Spectrum and Other Applications"

Erwin Schroedinger, then at the University of Zurich, Feb. 9, 1927: "The Undulatory Theory of Atomic Structure"

Paul A. M. Dirac, Cambridge University, April 11-12, 1929: "Introduction to Quantum Mechanics" (two lectures)

On such occasions physics educators based within a half-day's ride from Iowa City came to hear and to join in luncheons and dinners honoring the eminent visitor. Daily Iowan writers, briefed by Stewart beforehand on the scientific prominence of the speaker, struggled bravely to chronicle the event.[2]

> Dr. Siegbahn proceeded in his quiet careful way to show how vast a knowledge had been gained of the structure of the atom.

When Van Vleck, then twenty-seven, appeared, the DI emphasized the youth of the speaker:[3]

> Dr. Van Vleck, though but thirty years of age, is one of the foremost theoretical physicists in this country and an authority on quantum theory and atomic structure.
>
> The occasion for the present lectures was the remarkable development which the quantum theory has seen during the last year in the hands of the European physicists Heisenberg, Born, and Schroedinger. During the last twenty-five years there have been very serious questions as to the nature of light. The older wave theory was successful in many fields, but as the experimental physicists delved more and more deeply into the nature of the atom, it became increasingly apparent that the older theory was inadequate. Professor Van Vleck told of recent experiments along these lines and pointed out the more recent theories evolved.

When Schroedinger, described as "author of a new theory of matter, light and electricity," visited the campus in 1927, the DI sought guidance from a member of the U of I faculty and thus reported:[4]

> According to Prof. J. A. Eldridge of the physics department, the investigations of Prof. Schroedinger have excited great interest in physics circles during the last year, and one is tempted to predict that Dr. Schroedinger's work is to introduce a new era in physical thought in which the electron will be replaced by a more fundamental concept.

Stewart's major triumphs in bringing eminent physicists to Iowa City in the 1920's were the appearances of Lorentz, Raman, Siegbahn, Schroedinger, and Dirac. The four Europeans and one Asian were making cross-country trips, and a two-day stop in the Midwest provided a break for them in their railway travel. Visitors from abroad generally stopped off in Chicago, and some of them added Iowa City to their itineraries. A persuasive letter would point out, among other things, the "unexcelled facilities" of the Physics Building.

The building continued to serve as a drawing card for professional visitors and for students intending to major in physics. It was not until 1928-1929, when the building was sixteen years old, that the description of the Physical Laboratory in the University Catalogs was changed from the "construction of the building which is new" to the "construction of the building is modern."

Hewlett (1919-1922) and Hulburt (1921-1924) each remained at the U of I for only three years. Both men were primarily interested in research activity and aspired to achieve positions where they could work solely as research scientists. With four publications in the Physical Review in 1921 and 1922, Hewlett departed in the summer of 1922 for the research atmosphere of the physical laboratory of the General Electric Company in Schenectady, New York.[5] Hulburt was remarkably prolific in publication during his brief period at the U of I, with fourteen papers accepted and printed in professional journals from 1922 through 1924. He moved to the Naval Research Laboratory in 1924.

The examples of these two men served to spur the completion of research by graduate students. During the three years 1922, 1923, and 1924 a total of nine Ph.D. degrees were awarded in the department, a number equal to those awarded during the previous twelve years.

During the summer of 1924 the department lost L. P. Sieg, who had been associated with U of I physics for a quarter of a century.

As a student and as a faculty member he had worked under three department heads: Veblen, Guthe, and Stewart. A mainstay of the Iowa physics program, he served as the professor in charge during Stewart's absences from the campus. On Sieg's departure to become head of the department of physics at the University of Pittsburgh, Stewart said:[6]

> Dr. Sieg is the most distinguished of the physicists who are alumni of Iowa. While his teaching and his personality have won for him the highest regard from students and citizens of our community, his published researches in physics have been known to physicists both in the United States and abroad. He has had a prominent share in the development of the department of physics at Iowa.

At the end of his first year at the University of Pittsburgh, Sieg was named dean of the institution's graduate school. In 1934 he became President of the University of Washington.

The early post-war staff of Hewlett, Hulburt, and Sieg were succeeded between 1922 and 1925 by four young men who were to stay on and provide a continuing and stable core for many years. Claude J. Lapp and Alexander Ellett remained until the World War II years. John A. Eldridge and Edward P. T. Tyndall stayed on until they became professors emeriti, in 1958 and 1960, respectively.

All of the four new faculty members had earned their Ph.D. degrees within a year of each other at different graduate schools. Lapp, who came to the U of I in 1922, was a native of Michigan. He had earned his A.B. in his home state's Albion College in 1917 and his Ph.D. at the University of Illinois in 1922. Tyndall, a native of South Africa, arrived at the U of I in 1923. He had received his B.A. at Richmond College in Virginia in 1912 and his Ph.D. at Cornell University in 1922.

Joining the U of I staff in 1924, Eldridge, a native of Washington, D. C., had earned his A.B. at Wesleyan College in Connecticut in 1913 and his Ph.D. at the University of Wisconsin in 1922. He was an instructor at Wisconsin from 1918 until 1924. Ellett came into the Iowa department in 1925. A native of Missouri, he received his A.B. at the University of Colorado in 1921 and his Ph.D. at Johns Hopkins University in 1923.

In addition to their regular coursework and research activities, the four younger men joined with Stewart in a team-instruction course, Modern Phenomena, to convey the recent developments in their science. This course presented new theories on the structure of the atom, as well as lectures on radioactivity, spectra, and the burgeoning applications in communications engineering.

The rising expectations of the mid-1920's resulted in an increased summer session program in physics, much of it directed toward high school and college instructors wishing to update their teaching. Summertime physics came to occupy as much course listing and description space in the University Catalog as that of the fall and spring semesters. In July 1926, for instance, Stewart pointed out a registration of thirty-three in an advanced theoretical course entitled X-Rays and Constitution of Matter. Sixteen of these summer students held teaching positions in colleges in eight different states.[7] It was evident that physicists were coming to Iowa City to find out what was happening in the laboratories and theoretical institutes of Great Britain and North Central Europe.

Stewart was influential in promoting the Iowa staff and the Iowa building as central in transmitting knowledge of the new physics. He offered leadership in this respect in a keynote address as vice-president and chairman of Section B (Physics) at the Boston meeting of the American Association for the Advancement of Science in December 1922:[8]

> It is doubtful if ever there has been a more inviting appeal to imaginative reason than can be found at present in atomic structure and radiation theories. The search in this field is, in fact, so exciting that we can easily forget the mysteries in our own hypotheses. The progress of the last decade has been rapid.

In this address, "Certain Allurements in Physics," Stewart went on to give an account of the work of Rutherford, Bohr, and some of their associates. Much of his presentation in Boston was a summary version of a Graduate College lecture at the U of I that October: "Present Evidence Concerning the Content, Structure, Size, Shape, and Electric Field of the Nucleus; the Quantum Theory and Certain Applications in Atomic Structure Theory."

Stewart's October 1922 lectures were heralded by the Daily Iowan as "a three-day conference on the topic of atomic structure, one of the most current and prominent problems in physics." The DI pointed out that Stewart, presiding and lecturing, "is making a a special study of this problem" and that invitations had gone out to the physicists and chemists of Iowa.[9]

While the lectures on the new physics received some attention, activities in the laboratories rarely drew any reportage in the campus publications of the 1920's. On November 21, 1924 the Daily Iowan found a major story in an intensive year-long search for Element No. 61 in the atomic table. In the quest for the rare-earth element, Professor Lapp and graduate student Robert A. Rogers were using a vacuum x-ray spectrograph, built in 1920 by former graduate student Robert V. Zumstein. The complicated apparatus was "one of four or five in existence today," the DI said.

The story noted that success in the search would be the first discovery of a new element by an American. It would also be the subject of Rogers' doctoral dissertation. But the discovery of No. 61, promethium, was not to be reported until 1947, by Jacob Marinsky and others of the Massachusetts Institute of Technology. Rogers' dissertation (1926) dealt with elements found many years before. He wrote on "The M-series Absorption Spectra of Osmium, Iridium and Platinum," published in the Physical Review in December 1927.

Then in November 1926 the U of I News Bulletin cited Stewart's investigations in acoustics in refuting a provocative charge by

H. L. Mencken that no important discoveries had been made by scientists in American universities.

> For one thing he has devised a sound filter which is capable of filtering certain frequencies of vibrations from a complexity of such vibrations. The sound filter possesses many possibilities in practical applications. He has also done outstanding work in the development of sound resources.

The News Bulletin found a story for its December 1929 issue in an exploit of Professors Lapp and Louis Waldbauer, chemistry:

> DISCOVER LOST RADIUM
>
> First on record in University of Iowa scientific circles is the radium detection feat performed at Davenport by Claude J. Lapp and Louis Waldbauer, faculty members.
>
> These men, working with a delicate electroscope, ferreted out about 80 percent of the $5,000 worth of radium from the large ash pile outside St. Luke's hospital.

According to the story, the hospital had lost ten hollow steel needles filled with radium and requested help from the university scientists. Lapp and Waldbauer decided that the material must have gone into the incinerator. They combed the ash pile (thirty feet long, five feet wide, four feet high) and recovered most of the radium.

In his early research at the U of I, Lapp had joined with Stewart in investigations in the field of acoustics. In 1923 he published a paper, "A Simple Device for Recording Sound Waves," and in 1924, "A Simple Audiofrequency Mechanical Alternator." Later he concentrated on problems involved in the teaching of physics and became active in physics education organizations. He produced articles for the American Physics Teacher, writing on such subjects as achievement tests and the use of audiovisual aids.

Lapp worked with other University science departments on matters of mutual interest, serving as head of the science program at University High School 1926-28. He led in the establishment of a University degree with a major in general science. To graduate with this major, the student was required to earn at least four credit hours in each of five sciences--botany, chemistry, geology, physics, and zoology. In one of the five, he was required to complete a minimum of sixteen hours.

One hundred men and women graduated with a major in general science in June 1929, according to the U of I News Bulletin, which quoted Lapp as saying that the program was "unique and the only course of its kind in an American University."

In conjunction with the College of Education and the Department of Mathematics, Lapp helped with a survey of weaknesses in mathematics among college freshmen. The nature and frequency of errors by students at the University and also at Iowa Wesleyan, Morningside, Parsons, and Simpson Colleges were counted and tabulated. The results were published in the University of Iowa Studies in Education of October 1932: The Arithmetical and Algebraic Disabilities of Students Pursuing First Year College Physics.

Tyndall conducted research primarily with the physical properties of metals in the form of crystals and thin films. He had come to Iowa in 1923 with considerable laboratory experience in micro-measurement. Prior to his doctoral studies at Cornell University, he had worked during World War I with the National Bureau of Standards on such projects as the detection of invisible writing and the optical aspects of military camouflage.

He published, for instance, during his earlier years at the U of I such Physical Review papers as "Optical Properties of Some Metallic Sulfides" (1923), "Magnetic Properties of Thin Films of Electrolytic Iron" (1927), "Resistivity of Single Crystal Zinc" (1931).

He was particularly adept and painstaking in the fashioning of intricate assemblies of tabletop apparatus for this work with tiny pieces of metal. For example, he designed and reported to the Journal of the Optical Society of American and Review of Scientific Instruments "A Sensitive Magnetometer, Insensitive to Extraneous Disturbances." In this instrumentation he devised an artificially applied magnetic field and used an astatic pair of magnets on a single suspension. "So far as the writer knows, this device has never been applied to a magnetometer before, and it has decided advantages," Tyndall wrote.[10]

Besides his extensive work with such solids as metallic crystals, Tyndall served as the department's specialist in the field of optics. For advanced students in stage lighting in the Department of Speech and again for graduates in opthalmology in the College of Medicine, he devised and taught special courses in optics. In 1931 he prepared a text, Light and Color, for use in these courses.

Eldridge was both a theoretician and an experimentalist, the most versatile member of the faculty. Working on a variety of topics, he published, for instance, in the Physical Review "The Spectrum of Mercury Below the Ionization Potential" (1924), "Polarization by Electron Impact" (1926), and "Radiation by Accelerated Electron in Classical Electron Theory" (1929). Later he made a series of studies of the collisions of gas molecules.

In his early research at Iowa Alexander Ellett concentrated primarily on studies of the polarization of resonance radiation. He worked with this phenomenon under a variety of experimental conditions, including the impact of electrons and with magnetic fields of varying strength. Around 1926 he began to conduct experiments to test aspects of the wave-particle theories that were emerging from the European continent. He took the lead in the department in reporting and discussing the significance of the work of Louis de Broglie, Werner Heisenberg, and Erwin Schroedinger.

Launching a series of studies of the reflection of atoms from crystals, Ellett joined forces with some of the nation's most distinguished physicists--men like Arthur Compton, Karl Compton, and C. J. Davisson--in efforts that would help to bring the particle-wave theories to the status of indisputable physical realities.

Ellett made a preliminary report of this work to Science in July 1928 in "Velocity of Cadmium Atoms Regularly Reflected from a Rock Salt Crystal." In this report he carefully suggested "that this phenomenon could be interpreted in terms of the phase waves of de Broglie."

A year later in the Physical Review of August 1929 Ellett affirmed that "these facts indicate that associated with motion of translation of uncharged atoms and molecules there is a wave phenomenon of the type postulated by de Broglie." This was the last sentence of the abstract of the PR article, "The Reflection of Atoms from Crystals." In more detail he continued:

> The fact that a beam of atoms incident upon a clean cleavage surface of a crystal may give rise to a well defined reflected beam making the same angle with the normal to the crystal surface as does the incident beam suggests at once the wave-particle dualism exhibited in the Compton effect and the Davisson and Germer experiments. To understand this phenomenon in terms of the hard elastic spheres of Maxwell's kinetic theory or of the planetary atomic systems of Bohr, is difficult, at least. On the other hand the wave, or, more properly superposition characteristics of the new quantum theory, lead us at once to expect just such phenomena.

Such work and other evidence of his intellect prompted an associate on the Iowa staff, Professor Tyndall, to refer to Ellett as "a genius with an intuitive awareness of what was important."[11]

Although the input from American physicists was increasing, the major progress toward the understanding of matter and energy continued to originate in Europe. Scheduled at three-year intervals, the Solvay Conferences at Brussels brought the leaders together to examine the developments in their science. Men like Max Planck, Albert Einstein, Hendrik Lorentz, and Niels Bohr made up the central core of the group. The Solvay scientific committee headed by Lorentz kept the number of participants small and select. Starting with the second conference, in 1913, one or two Americans would be invited to participate.[12]

In addition to the Iowa faculty's interest in the reports emerging from the Belgian center, there were tenuous connections with the earliest American participants. The first U. S. scientist to be invited to a Solvay Conference was Robert W. Wood of Johns Hopkins University. Iowa professors Hewlett, Hulburt, and Ellett were products of Wood's graduate program in experimental physics. In 1924 Ellett co-authored with Wood the Physical Review paper, "Polarized Resonance Radiation in Weak Magnetic Fields." That same year, Eldridge, while still at the University of Wisconsin, published a companion paper, "Theoretical Interpretation of the Polarization Experiment of Wood and Ellett." In this paper Eldridge concludes that "the fundamental fact of the fluorescent light being plane polarized is hard to reconcile with the assumptions of the quantum theory of atomic radiation."

Other relationships occurred with Solvay conferees who visited the Iowa physics department. R. A. Millikan was the second U. S. physicist to be invited to Brussels (1921). A. H. Compton was the sixth, in 1927. J. H. Van Vleck was the eighth, in 1930.[13]

During the middle 1920's U of I faculty and graduate students made substantial showings of research work at meetings of the American Physical Society, when the APS met as near as Chicago or Kansas City. Then the Iowa group would number from six to twelve out of a total attendance of 150-200. (The APS had approximately 1,500 members nationally around 1925.) At the more distant meetings, as in Washington, Philadelphia, or Boston, Stewart might be the only U of Iowan, if any, in attendance.

In the 136th meeting, for instance, of the APS in Kansas City, December 28 –30, 1925 the attendance totaled 150 according to the Proceedings of the meeting in the Physical Review. Out of 53 papers presented, nine were from the U of I. Stewart and Eldridge were authors of two, and seven graduate students gave the others.[14]

The 1926 Christmas Holiday meeting was held in Philadelphia. The attendance totaled 300 and there were 77 papers. G. W. Stewart offered "Molecular Space Array in Liquid Primary Normal Alcohol," and A. Ellett read "Polarization of Resonance Radiation in Strong Magnetic Fields."

At the December 28—30, 1927 meeting at Nashville, Stewart read "X-Ray Diffraction in Liquid Normal Paraffins" and Tyndall presented "Factors Governing the Growing of Zinc Crystals by the Czochraski-Gomperz Method."

But at the previous meeting in Chicago at Thanksgiving time, 1927, five graduate students--K. J. Miller, G. W. Schneider, E. H. Collins, W. D. Crozier, and Roger M. Morrow--were among the 165 attending and also among the 52 who presented papers.

While others in the department worked with their variety of laboratory studies, Stewart experimented primarily in the field of acoustics up to the year 1927. Besides his scientific papers he prepared an introductory text for his students. Its first edition was multigraphed at the U of I in 1923, and a second revised edition appeared in 1925. Later with Robert B. Lindsay of Brown University, he co-authored a more advanced text, Acoustics: Theory and Applications, published in 1930 by D. Van Nostrand, New York. In 1932 Stewart published an elementary, non-mathematical text, Introductory Acoustics, also with D. Van Nostrand.

In 1927 Stewart turned his attention to studies of liquid structures by means of x-ray diffraction techniques. During the next nine years he was identified as author or co-author with twenty-six listings on the subject in the Physical Review. In order to differentiate liquid structure from solid, or crystalline structure, he used Greek roots for "space" and "arrangement" and added a new term "cybotaxis" to the dictionaries of physics. For his work in this field he was responsible, for instance, for the following listings in The International Dictionary of Physics and Electronics:[15]

> CYBOTACTIC GROUPS. A term introduced by Stewart in connection with the structure of liquids, particularly those liquids containing long-chain molecules. A microcrystalline structure is assumed in which the groups consist of molecules which are arranged side-by-side, or end-to-end, in an orderly manner. These groups are considered to be in dynamic equilibrium with the molecules which have random orientation.
>
> CYBOTAXIS. The three-dimensional arrangement of molecules of a substance; in general, the term is applied to liquid, non-crystalline substances. Two of the most common arrangements are the end-to-end AB - - BA and the side-by-side $\begin{matrix}\mathrm{AB}\\ \mathrm{AB}\end{matrix}$ forms, with coordinate bonds, such as exist between certain contiguous atoms or radicals ...

Stewart added a graduate course in the nature of the liquid state to the department's offerings. With new equipment, including large torsion pendulums to rotate within containers of liquids, he launched studies to compare viscosities with the molecular arrangements determined by x-ray diffraction.

"What marvelous ideas and apparatus the Physics Building hides!" the University News Bulletin proclaimed in December 1931:

> Most passers-by do not realize that in this large, limestone building, the laws and the motions of the entire universe itself are being studied. They do not realize that in this building are being investigated conditions that range down even to the activities of the very small bit of energy, the electron.
>
> A subject, as physics, that deals with objects of such varying sizes necessarily requires a large amount of apparatus. In a small out-of-the-way basement room is a rather simple looking machine, which upon examination is

found to be a direct current generator capable of producing one thousand amperes. In another room nearby is the electrometer with which it is possible to measure currents as small as 10^{-14} amperes.

A cable with a large ball attached at the lower end hangs through three stories of the Physics Building, thus making a Foucalt pendulum. This is set swinging in a certain direction at eight o'clock every morning. At six o'clock in the evening, the pendulum appears to be swinging in a line at right angles to that which it made when it started. In this way the movement of the earth is realized, for actually the pendulum is still moving in the same direction that it was swinging in the morning. The earth has turned, changing the relation of the Physics Building and the immediate surroundings to the pendulum. This experiment deals with the earth, a mass of 5.98×10^{27} grams, an enormous amount of matter.

The Foucalt pendulum operated in the empty elevator shaft, which was never to be used for the purpose for which it was assigned. At times Stewart would use it as a gigantic speaking tube. If he wished, for instance, to reach the janitor, he would call into the shaft. The janitor would come to the grating on the floor where he was working and push a button which would activate an indicator flag in the departmental office. Stewart would then come to the grating on his floor and give instructions.[16]

Stewart continued to strive to make the Physics Building a midwestern center for discussions of the latest contributions to physical knowledge. At the close of the 1920's he proceeded to inaugurate a prestigious series of lectures to enhance the summer sessions at the University. For the period of June 17 through August 12 of 1930, he lined up six visiting lecturers to give a total of twelve topical presentations:

June 17—W. F. G. Swann, Bartol Research Foundation, "Fundamentals of the New Quantum Mechanics"

July 10-11—Karl T. Compton, Massachusetts Institute of Technology, "General Features of Electrical Discharge in Gases" and "Thermal Equilibrium at Arc Electrodes"

July 14-15—J. T. Tate, Editor of the Physical Review, University of Minnesota, "Ionization of Gases by Electron Impact" (two lectures)

July 21-22—Arthur H. Compton, 1927 Nobel laureate then at the University of Chicago, "Arrangement of Electrons in Atoms" and "The Nature of Light" and "Significance of Cosmic Rays"

July 28-29—Otto LaPorte, University of Michigan, "Prediction of Spectral Energies" and "Certain Functions in Wave Mechanics"

August 11-12—C. E. Mendenhall, University of Wisconsin, "Recent Theoretical and Experimental Developments in Photo Electricity" (two lectures).

That summer of 1930 was an auspicious beginning for Stewart's ambitions. But he was unable to do so much for the summers to follow. For one reason, the Great Depression was beginning to affect education in Iowa, curtailing funding for programs in excess of regular routines.

On June 18, 1931, F. K. Richtmyer of Cornell University appeared to lecture on "X-Ray Satellites" and on June 23-24, J. H. Van Vleck, then of the University of Wisconsin, came for a series of three lectures: "The Classical Theory of Dielectric Constants" and "Magnetic Susceptibilities" and "Recent Developments in the Quantum Theory of Magnetism".

There were no visiting lecturers during the summer of 1932, and in 1933 the local faculty provided the stimulation in the advancement of science: June 14, Lapp, "The Rise of the Robot"; July 5, Eldridge, "Smashing Atoms"; and July 12, Stewart, "We Are Discovering--."

As the department continued into the decade of the 'thirties,' the depression had its affect upon faculty salaries. Over the previous fifteen years, from 1916-17, the stipends, in general, had doubled in amount, until in 1931-32, they ranged from $3,500 for the two associate professors up to $6,500 for the long-established head of the department, who also served as the associate dean of the Graduate College.

For 1932-33 the salaries of the faculty members were all reduced by five percent. For the next year they were all further reduced by another twelve per cent, and the annual stipends for 1933-34 ranged from $2,955 to $5,400.[17]

Though much of the earth was in the throes of the depression, developments on both sides of the Atlantic were about to lead the physicists into the beginnings of the atomic age. Tools and techniques were emerging for the exploration of the nucleus, for experimental verification of the theoretical formula $E = mc^2$, for fission achievements and controls that would bring atomic reactors and bombs of massive destruction. With the assistance of scientists from Europe, the United States would become the supreme power in nuclear science and the first nation to use the fearful new weapons.

Notes and Sources

As in previous chapters the writer has relied upon the annual University Catalogs and upon the bound volumes of the University of Iowa News-Bulletin and The Daily Iowan and other materials in the custody of the University Archives. University publications gave increasingly less attention to the Department of Physics after the close of World War I. There was a growing multiplicity of departments. The research became more and more specialized, esoteric, and ever more difficult to report in popular language. It also became a stable department, engendering few changes and controversies likely to interest general readership.

Because of these circumstances and the lack of surviving records for the department in the 1920's and 1930's, the preparation of this chapter has depended heavily upon materials in the Physics and Astronomy Library: the bound volumes of the professional journals, notably the Physical Review, and a wide variety of books with historical and biographical information relating to developments in the various fields of physics.

[1]From copy of letter from G. W. Stewart to Dean George F. Kay, April 1, 1919.

[2]Daily Iowan, January 20, 1925 under the heading X-RAY SPECTRA IS ATOM'S LANGUAGE, SIEGBAHN STATES.

[3]Daily Iowan, November 24, 1926. The DI story concluded:

> The occasion for the present lectures was the remarkable development which the quantum theory has seen during the last year in the hands of the European scientists Heisenberg, Born and Schroedinger. During the last twenty-five years there have been very serious questions as to the nature of light. The older wave theory was successful in many fields, but as the experimental physicists delved more and more deeply into the nature of the atom it became increasingly apparent that the older theory was inadequate.

[4]Daily Iowan, February 10, 1927.

[5]In a communication dated April 30, 1976, Paul S. Helmick of Des Moines, a graduate student at the time, recalled that Hewlett was a versatile and ingenious experimenter who could make do with what was available. With his own home-made motor, a large brass ring mounted on a wooden frame and other materials, "he set up, from scratch, a rotating crystal spectrograph" in a corner of one of the laboratories.

[6]Iowa Alumnus, XXII, 1, p. 9, September 29, 1924.

[7]From copy of letter to C. H. Weller, Professor of Journalism, July 8, 1926 and passed on to President W. A. Jessup. Stewart concluded:

> I believe if the college teachers of physics throughout the entire middle west knew of this concentration of interest at Iowa we would have a still larger representation.

[8]G. W. Stewart, "Certain Allurement in Physics," Science, LVII, January 5, 1923.

[9]Daily Iowan, October 15, 1922.

[10]E. P. T. Tyndall, Journal of the Optical Society and Review of Scientific Instruments, October 1924.

[11]From a communication from E. P. T. Tyndall dated January 20, 1976.

[12]Information gleaned from Jagdish Mehra's 1975 book, The Solvay Conferences on Physics: Aspects of the Development of Physics Since 1911, pp. 75-76. Mehra offers reasons why the first American scientist was invited:

R. W. Wood had made important discoveries in optics, including the spectra of complicated resonances which defied all explanation at the time, and he gave a report on these resources. They would ultimately be explained by Bohr's theory of atomic levels.

[13] Ibid., pp. 95, 115, 133, and 183.

[14] From accounts of American Physical Society meetings as detailed in the Physical Review, Vols 24 through 31.

[15] Published by McGraw Hill, 1956.

[16] For this account of Stewart's use of the elevator shaft and for other recollections of the U of I physics department the writer is again indebted to Paul S. Helmick. He recalled that H. L. Dodge was best known to many Iowa Citians as an adventurous canoeist who applied his knowledge of hydrodynamics in going over the rapids at the Burlington Street Dam when the Iowa River was running high. "Dodge said that in the very unlikely circumstance that he would capsize, the current over the dam was so fast and deep that he would be carried well below the deadly turbulence directly at the foot of the falls."

[17] From annual budgets of the College of Liberal Arts, 1931-34, University Archives.

Chapter Seven

Into the Nuclear Age and World War II

> However you look at it, this has been a great century--so far. And, as I write, the prospects are that there will be plenty of adventure in the future. Only a third of a century! What changes these years have seen ... In science, and particularly in physical science, the greatest part of what we know has been written since 1900.[1]

J. A. Eldridge radiated optimism and enthusiasm over the progress of his science in his 1934 book, The Physical Basis of Things. An animated teacher who demonstrated with dramatic showmanship, Eldridge wrote his book primarily, he said, "to give appreciation of the meaning of modern physics." It was published as one of the decade's McGraw-Hill International Series in Physics.

He popularized much of his book with such devices as short direct questions to the reader, making frequent analogies from everyday experience, and working historical material into the text. For the 28 chapter headings he interspersed lively titles like "Your Point of View and Mine," "The Dance of the Molecules," and "Atoms a la Bohr" among more conventional titles like "Conduction Through Gases," "Properties of X-Rays," and "Light Waves and Photons." He divided the 380 pages of text into seven sections, allotting 40 pages to Relativity, 107 to Kinetic Theory, 90 to Quanta and Optical Spectra, 45 to X-Rays, 20 to Infra-Red Spectra, 32 to The Nucleus, and 46 to The New Physics.

The Physical Basis of Things received brief and favorable notices in the American Physics Teacher and in Chemical and Metallurgical Engineering.[2] The APT termed it "A readable and attractively prepared textbook of sophomore grade for the student of general interests."

The British science journal Nature reviewed the book in some 250 words, saying

> The author has given, in an interesting style, a vivid account of the physics of today.[3]

Then Nature modified its laudatory tone with some reservations concerning

> ... the style of interesting narrative ... lost in a catalogue of spectrum series, energy levels and electron spin, to be regained, however, when nuclear physics is reached. Here the transformation of atoms is described, along with the discoveries of the deutron, neutron, and positron. In view of the importance of these discoveries they might have been described at greater length.

With this notice of his work, Eldridge appears to have been the first physical scientist at the University of Iowa to receive such attention in Nature since 1871, when the journal evaluated and praised The Elements of Physical Science by Gustavus Hinrichs and then lauded his pioneering development of student-use laboratories.

Largely because of Eldridge's concentration on his book in the early 1930's and on teaching activity rather than on research investigations, the faculty publications as a whole decreased in number. Listings in the Author Index of the Physical Review declined from a U of I faculty total of 51 over the 1925-29 period to 39 over 1930-34. In both five-year periods Stewart and Ellett were connected with 15 to 20 Physical Review papers, abstract, or letters, whereas Eldridge's total listings dropped from ten to two. Remarking that "it gave more balance to the department," Stewart staunchly supported the emphasis of Eldridge and Lapp on physics education. Yet Stewart felt that the department needed more manpower to provide coursework in the new fields that recent research had opened.

According to letters in the University Archives files of Presidents W. A. Jessup (1916-1934) and E. A. Gilmore (1934-1940), Stewart campaigned vigorously in 1934 and 1935 to add another faculty member to the department staff. The number had reached a peak of five in 1923 with the arrival of Tyndall and had remained at this same level for more than ten years. The growth in University enrollment and the expansion of fields of investigation stimulated by the New Physics had meant additional course offerings, particularly in quantum and wave mechanics theory. Although Ellett and Tyndall were primarily experimentalists in their research interests, they were assigned to teach the theory courses.

"The need for a theoretical physicist is very pressing and should be regarded as the next step in progress in this department," Stewart urged in a letter on August 24, 1934 to Dean George F. Kay of the College of Liberal Arts.

In this letter he pointed out that Harvard, Massachusetts Institute of Technology, and Wisconsin each employed three theoretical physicists and that Chicago, Minnesota, and Illinois each had two. Stewart warned Dean Kay that Iowa was losing ground among the prominent physics departments of the United States.

He followed up with another appeal on May 10, 1935 in which he called attention to the twelve departments starred as outstanding in the recent Hughes report on graduate colleges for the American Council of Education. "Not one of these departments is without a theoretical physicist," he said.

Stewart accompanied his appeal with a color-keyed map of the United States on which he showed with red dots the twelve "outstanding" departments, each with one to four mathematical physicists. He used orange dots to locate seven others with from one to three such physicists, and blue dots to show the seven, including the U of Iowa, with no specialists in this growing field. In spite of this handicap, he noted that "according to the secret ballot, to which I have had confidential access, the Iowa Physics Department placed 14th among the 25 institutions" that were judged to be adequate.[4]

Despite Stewart's efforts and the apparent reasonableness of his request, the department was to continue without a theoretical physicist until 1941, then obtained only temporarily as a replacement for faculty on leave for service in the war effort. During the middle thirties the effects of the Great Depression, while beginning to abate, persisted in curtailing funds available for expansion of the physics faculty.

To relax and to reflect upon a philosophy of living,[5] Stewart spent the summer of 1935 in a leisurely ocean voyage around South America. He returned to renew his efforts to bring the physicists of Iowa and adjoining states together in June meetings on the U of I campus.

As announced in the Daily Iowan of June 5, 1936,

> Physicists from Iowa colleges and high schools will participate in an informal meeting, designated as the summer colloquium, at the University of Iowa this month.
>
> The affair in charge of Prof. George W. Stewart, head of the physics department, will occur June 11, 12, and 13. It is the first meeting of its kind held at the university in the summer. Five Iowa physics faculty members will give talks or conduct round tables.

Newpaper publicity and daily listings of the events of this first Summer Colloquium were plentiful. The Iowa City Press Citizen followed the DI on June 9, 1936 with

> The three-day conference, planned to bring together all of the state's college physicists to inform them of the latest developments in physics and the latest trends in teaching will open Thursday, June 11.

On June 11 the P.C. reported that more than thirty Iowa high school and college physics instructors were in attendance at the first meeting. The numbers were to grow substantially over the years as the June meetings continued annually through 1959 with the exception of the war years of 1943, 1944, and 1945. Average attendance over the total of 21 yearly sessions turned out to be an annual 105 persons representing an average of 19 states and 65 institutions. Among the more prominent of the visiting lecturers were men in the forefront of physical science: E. U. Condon, Richard Feynman, George Gamow, Thomas Gold, Harlow Shapley, Edward Teller, George Uhlenbeck, Harold Urey, and J. H. Van Vleck.[6]

The inaugural Summer Colloquium in 1936 relied wholly upon the U of I faculty for lectures and round table discussion leadership. C. J. Lapp opened the meetings with an account of the news of the year in the teaching of physics. Here he was a news maker as well as a news bringer, serving then as chairman of the Committee on Tests of the American Association of Physics Teachers. The third annual report of his committee was being prepared for publication, to appear in the coming September issue of the American Journal of Physics.[7]

Following this opening session, the charter members of the Summer Colloquium heard J. A. Eldridge on "Significance of Elementary Electrical Concepts," G. W. Stewart on "The Nature of Electrolytes," E. P. T. Tyndall on "Physics of Metals," Lapp on "Teaching the Unusually Able Student," and Eldridge on "Kinetic Theory to Date." The group visited the hydraulic research laboratory of the College of Engineering and had opportunities for golf, tennis, and swimming as guests of the Department of Physical Education. At a picnic at Lake Macbride the "admission fee" was a two to five minute anecdote from the history of physics.

The next summer the attendance more than doubled for the second annual Colloquium, June 17-19, 1937, with the meetings drawing physicists from the neighboring states of Illinois, Missouri, and Nebraska. This time four of the lecturers came from other campuses, matching in number the four from the U of I Department--Eldridge, Ellett, Stewart, and Tyndall. The visiting speakers were G. W. Fox, Iowa State College, "Physicists at Work"; J. C. Jensen, Nebraska

Wesleyan University, "Studies in Lightning and Related Phenomena"; E. W. Skinner, Northwestern University Dental School, "Physics Problems in Dentistry"; and H. K. Schilling, Union College, Lincoln, Nebraska, "Acoustic Phenomena." Skinner and Schilling had been graduate students at the U of I, the former earning his Ph.D. in 1930, the latter in 1935. The 1937 Colloquium continued the picnic with a historical anecdote as the price of admission.

The program broadened its scope considerably more in the summer of 1938. Guest lecturers were drawn from Pennsylvania, Illinois, and Missouri. Ellett, presenting the "Physical Basis of Valence," was the only programmed speaker from the local department. A symposium "Physical Phenomena in Living Things" involved professors from other Iowa science departments--J. H. Bodine, Zoology, and W. F. Loehwing, Botany.[8]

The 1938 Colloquium period closed with a dinner of tribute to Professor Stewart. Many of his former students joined in presenting him with his portrait, an oil painting by W. H. McCloy of Drake University.[9] Graduate Dean Carl Seashore represented the University of Iowa administration at the occasion, June 18 in the Iowa Memorial Union, concluding his laudation with

> Let the Historian count this citation as a legend for the portrait now unveiled and to be appropriately associated with the projected murals. The University takes great satisfaction in thus marking a milestone at the present vantage ground in your distinguished career.

The June meeting of 1939 broadened the Colloquium much further to relate the role of physics in the history of man. A six-speaker symposium, "Physics and Society," called attention to the significance of physics in education, in philosophy, and in social history. Visiting speakers for the 1939 Colloquium came from New York, Ohio, Minnesota, and Illinois. It was the first year that no local physicist appeared on the program. In addition to the broad symposium theme, lecturers from the Iowa College of Medicine--H. Dabney Kerr and Titus Evans--spoke on the applications of x rays to the practice of medicine and to biological research.

The American Physics Teacher in October 1939 devoted 14 pages to "Physics and Society--A Symposium," reprinting the papers presented in Iowa City and giving an account of the E. O. Dieterich Memorial mural, "Physics and Society," which was unveiled at the occasion in the Iowa Physics Library.

Dieterich was the third man (after Sieg, 1910, and Dodge, 1914) to earn a doctor's degree (in 1916) in physics at the U of I. When he died in 1936 his colleagues at the Goodrich Company in Akron, Ohio, where Dieterich was a research director, made up a purse of $162 as a start for a memorial in the Iowa Physics Building. Stewart suggested that the fund might be used for a painting. Artist Grant Wood, then on the U of I faculty, recommended a large mural. A graduate student in the Iowa Department of Fine Arts, Richard Gates, undertook the mural to express man's conquest of such forces of nature as electrical energy.[10]

Outside the classes and laboratories in the late 1930's, the summer colloquia had become the principal medium through which the department strove to contribute to the growth and understanding of physics. The faculty were also active in national programs to enrich the teaching and learning of their science. Lapp continued his work in the development and analysis of learning materials and student testing. Another matter of general concern was the attainment of a convenient and dependable handbook on terms and concepts. There was then no counterpart in English to Felix Auerbach's Worterbuch Der Physik which had been a helpful desk reference to German students since 1920.

Accordingly the Iowa department gave their support to a project headed by a former Iowa student, Le Roy D. Weld (M.A. 1902, Ph.D.

1922) who had become professor of physics at nearby Coe College. The project was a Glossary of Physics, a compact (255 page) book of definitions published by McGraw-Hill in 1937. The executive Council of the American Physical Society had recommended the compilation of terms to the Division of Physical Sciences of the National Research Council. In 1933 the NRC appointed a five-man committee for the work with Weld as the chairman and Stewart as one of the members, then a group of fifty special consultants to work with Weld and his committee. Two of these consultants were Ellett and Tyndall in the company of such widely known physicists as P. W. Bridgman, E. U. Condon, C. J. Davisson, and J. H. Van Vleck.[11]

References to supplement the definitions were cited in the glossary for many of the some 3,000 terms in the book. For example, for the term coined by Stewart:

> cybotaxis. The space arrangement of molecules in a liquid, with orientation simulating crystalline structure but without stability or permanence at any point. Studied by the x-ray diffraction patterns of the liquid. Adj. cybotactic. Cf. liquid crystal. (See Davey, A Study of Crystal Structure and its Applications, 1934, chap. 16; Stewart, J. Chem. Phys. 2, 147, 1934)[12]

Glossary of Physics received scant attention in the American periodicals of science and technology, and surprising no mention in the American Journal of Physics, which was then the principal organ of the nation's physics teachers. But the venerable British journal, Nature, observed the book's appearance and availability in a brief and laudatory statement in its issue of April 23, 1938:

> The rapid development of physics during recent years has, of necessity, required a very large addition to the vocabulary. In reading the literature of a particular branch of the subject in which one has not specialized, one comes across unfamiliar terms; in such instances to have an accurate glossary to hand is of the greatest use. Prof. Weld and his collaborators deserve the warmest thanks for providing such a glossary. We can well believe that it was "impracticable to make sure of complete agreement

> among the various persons concerned on each of the many definitions and statements"; but although perhaps a few experts may not favour a definition here and there, the vast majority of physicists and those concerned with its manifold applications will find this an indispensable volume. A pleasing feature of the book is the inclusion of references in connexion with most of the terms, which enable the reader to gain supplementary information.
>
> The book is well arranged and produced, and of convenient size; we hope that the demand for it will justify the issue of future editions at a price that the average physicist is more likely to be able to afford.

During the 1930's, with the faculty continuing to be the same five men as in the 1920's, the department was a stable one, adhering to a status quo of operations, with little in the way of change perceptible to persons outside the building. Even the description of the Physical Laboratories remained the same, word for word, in the University Catalogs of 1936-1937 through 1940-1941.

> The Physics Building, one of the central group, is occupied exclusively by mathematics and physics. It offers unexcelled opportunities for study and research. In it is the Mathematics-Physics Library of about 14,000 volumes with 190 current journals. In the laboratories the equipment is abundant, diversified, and in some aspects unique. The more specialized apparatus is described in bulletins published by the laboratory. Recent research has been chiefly in the newer physics, atomic and nuclear structure, intensity and polarization in spectra, resonance radiation, electron impacts, and X-rays, though contributions are constantly being made in other lines.

In the late 'thirties the department was considerably undermanned for the scope and variety of its teaching and research programs. The five men extended themselves considerably to offer an increasing number of courses. In 1938-1939 and in 1939-1040 the University catalogs showed a total of some sixty semester courses for each academic year. Of these sixty, around twelve courses were given in alternate years. With only two of the sixty--Meteorology and Problems in Teaching High School Physics--taught by graduate students, the breadth of offerings resulted in the five professors spreading themselves over a schedule of twenty-two courses each semester.

In teaching loads Eldridge, Lapp, and Tyndall averaged twelve semester hours of class instruction. The department head, Stewart, averaged eight. Ellett, who was leading the local development of apparatus and research projects in the rapidly growing field of nuclear physics, also had a teaching load of eight semester hours.

Some breakdown in the division of labor is shown, for instance, in the University Catalog for 1938-39. Eldridge offered the most elementary course, College Physics, for those with no high school credit in physics. Lapp gave College Physics for those with preparation in high school physics. Stewart, Ellett, and Tyndall shared in presenting General Physics, the more intensive course with a prerequisite of a full year of college mathematics.

Ellett and Tyndall also shared in instructing the course Introduction to Theoretical Physics. Ellett taught one advanced theoretical course, Problems of Quantum Theory, while Tyndall gave the other advanced course, Wave Mechanics.

During the later years of the decade, Ellett and Tyndall served as the major professors for students preparing their dissertations for the degree of doctor of philosophy. Consistently from 1937 through 1940 there were three successful candiates each year for the degree.

1937 OLSEN, Leonard O. The mechanism of formation of mercury hydride and mercury deuteride. Optical excitation of cadmium deuteride.

ROUSE, Arthur G. Large angle scattering of potassium ions by heavy gases.

WAY, Harold E. Electrical resistivity of single crystals of some dilute solutions in zinc.

1938 HUNTOON, Robert D. Distribution in angle of the protons from the deuteron-deuteron reaction.

JOHNSON, Arthur J. M. The M-absorption frequencies of metallic platinum and gold.

WEBB, Wayne. A study of beta brass in single crystal form.

1939 McGRATH, James W. The differences in the gold M_5 and M_4 edges in gold and in a gold-copper alloy.

MILLER, Bertrand J. Effect of hyperfine structure upon the magnetic rotation of the plane of maximum polarization of resonance radiation.

VAN ALLEN, James A. Absolute cross section for the nuclear disintegration $H^2 + H_2 \rightarrow H^1 + H_3$ and its dependence on bombarding energy.

1940 RINEHART, John S. Temperature dependence of Young's modulus for single crystals of beta-brass.

WHITSON, William L. Distribution in angle of the alpha-particles from boron bombardment by protons.

YOUNG, Victor J. Distribution with angle of alpha particles from the $Li^7 + H^1 \rightarrow 2\ He^4$ reaction.[12]

In addition to manifesting a consistent distribution of Ph.D. output over these years, the above list shows the emergence of nuclear studies in an aggregation of dissertations which were predominantly based on the properties of crystals and metallic surfaces. The doctoral papers of Huntoon in 1938, of Van Allen in 1939, and of Whitson and Young in 1940 were made possible, as well as implemented, by the department's new Cockroft-Walton accelerator with a potential of 400 keV.

The English-Irish partnership of John Cockroft and Ernest Walton at Cambridge University had brought forth in 1929 an instrument to multiply voltages, accelerating protons to energies higher than those of natural alpha particles. In 1929-31 the American physicist Robert Van de Graaff advanced the art of nucleus smashing by building electrostatic generators at Princeton and then at the

Massachusetts Institute of Technology. During these same years at Berkeley, California, Ernest Lawrence developed the cyclotron, in which protons were pushed in circular paths to still greater energies.

Following the developments in England, in Massachusetts, and in California in the emerging publications, Ellett began planning to obtain a nuclear accelerator. The Iowa laboratory needed higher voltages for their developing studies of atomic and nuclear beams and for joining other laboratories in efforts to disintegrate the lighter elements. Inhibited at first by the curtailed funding of the years of the Great Depression, Ellett proceeded step by step in the middle thirties to set up a voltage multiplier. One problem for the erection of a large and tall machine was housing space. With the assistance of the Works Progress Administration, a new building was constructed across the river for the Department of Fine Arts. The artists moved out of the third floor of the Physics Building, and a large high-ceiling room became available as a nuclear laboratory.

At that time the Cockroft-Walton was a much more dependable machine than the higher-voltage Van de Graaff. The cascading tower generator which had been inaugurated at the Cavendish laboratory was more within the resources of the department than the relatively expensive cyclotron. And, after all, Cockroft and Walton had succeeded in disintegrating lithium nuclei in 1932 with protons accelerated to five hundred kilovolts.

The years of 1934 through 1937 were a time of preparation to increase the resources for the advent of atom smashing at the University of Iowa. Ellett and a few graduate students devised and built, utilizing the department's machine shop, equipment to be associated with the machine. Several of the master's degree theses in the middle and late thirties were linked with apparatus to be used in conjunction with the accelerator. The machine began to be operational in 1936.

Huntoon, becoming Ellett's principal assistant in this work, prepared his master's thesis in 1935: Design of a Sensitive Ionization Gauge for the Measurement of Atomic and Molecular Beams. In 1936 Bertrand J. Miller followed with A Thyratron "Scale of Two" Counter. In 1937 Victor Young came through with An Amplifier for the Ionic Detection of Single Particles. In 1938 William Bailey provided Investigation of a Positive Ion Source for Nuclear Research and that same year Floyd Bowling, Design and Construction of a Velocity Filter for Molecular Beams.[13]

Huntoon's doctoral dissertation, dated August 1938, was entitled Distribution in Angle of the Protons from the Deuteron-Deuteron Reaction. The first illustration in this dissertation pictures a transformer rectifier system, a Cockroft-Walton capable of a six hundred kilovolt potential. In a paragraph of acknowledgment

> The author wishes to express his appreciation to Professor Ellett for suggesting the problem and for valuable assistance and suggestions throughout the investigation; and to express his thanks to D. S. Bayley, J. A. Van Allen, and V. J. Young for assistance during the course of the measurements and to J. G. Sentinella for helpful technical advice and construction of equipment.[14]

With this dissertation, published two years later in the Physical Review of July 14, 1940, nuclear research with a voltage accelerator was well under way at the University of Iowa. Huntoon's former helper J. A. Van Allen followed in this sequence of studies with a dissertation in 1939: Absolute Cross Section for the Nuclear Disintegration $H^2 + H_2 \rightarrow H^1 + H_3$ and its Dependence on Bombarding Energy.

During the following years the Cockroft-Walton was employed in research leading to four more dissertations--those of William Whitson and Victor Young in 1940, of James A. Jacobs in 1941, and of Fred Atchison in 1942. Among the lighter elements added to the target nuclei were boron, lithium, and fluorine. But to achieve a wider range of experiments on nuclear structure and dynamics, the department needed a machine of much higher voltage, and Ellett prepared to obtain and install a Van de Graaff linear accelerator.

In May 1940 steam shovels excavated for an underground room on the east side of the Physics Building. To be connected by labyrinthine passageways into the building's basement, the subterranean room was to house a Van de Graaff with a potential of ten times the voltage of the Cockroft-Walton. The size of the machine's compression tank, forty feet in length, and the radiation hazards associated with high voltages required its placement outside the building.[15]

During the late 1930's Stewart had been taking longer vacations, traveling and relaxing more, accepting the tributes coming to him as rewards for his long life of teaching and research and for his leadership in professional organizations. For 1938-1941 he was elected for the third time as a member of the governing council of the American Physical Society. (He had previously served in the APS Council in 1915-1918 and 1927-1930.) This term he advanced to Vice-President for 1941 and succeeded to the presidency for July-December of the year, following the resignation of George B. Pegram. In the language of the Society's secretary reporting the Providence, Rhode Island meeting of June 20-21, 1941:

> ... it was announced that Dean Pegram had resigned the presidency of the society owing to the burden of duties connected with defense, and that by action of the council Professor G. W. Stewart had succeeded him as President for the remainder of the year...[16]

Stewart presided at the Chicago meeting of the APS in November 21-22, 1941. Two weeks later came the attack on Pearl Harbor and direct entry of the U.S. into global warfare. Another two weeks passed and Homer Dodge, then the graduate dean at the University of Oklahoma, reported to Stewart on the upcoming responsibilities and opportunities for the physics profession. Dodge had participated in an emergency session of the National Advisory Committee for Engineering, Science, and Management Defense Training (ESMDT) in Washington, D. C., December 19-20.

From his prestigious and influential position as the titular leader of the nation's physicists, Stewart set out to rally his profession into a war effort which would prove to be mutually advantageous to the country and to the scientists. Among other things he called a Special Meeting of the Colloquium of College Physicists in Room 301 of the U of I Physics Building for January 31, 1942 to discuss ways and means of increasing the number of physics majors, securing draft deferments for them to complete their degree work, and expediting learning in the electronics courses of the national defense training programs.

As he invited the college physicists to attend the special meeting, he wrote:

> Although the atmosphere has been cleared by the Japanese act of December 7, physics in particular is now so much concerned with its possible immediate service in the winning of the war that a discussion of our new problems cannot wait until June...
>
> This is a "physicists' war," and we are told that no matter what we do, we cannot create too many physicists for the industrial and government laboratories. They mean by "physicists" those with the A.B., the M.S., and the Ph.D. degrees.[17]

Completion of the Van de Graaff installation was suspended until after the close of World War II. The University was organizing and marshaling its resources for an extensive role in national defense education and research. Early in 1940 President Virgil Hancher had appointed Francis M. Dawson, Dean of the College of Engineering, to be the leader of the U of I defense program. Stewart had held a similar but less extensive post in World War I. From 1940 through 1945 Dean Dawson bore the titles (1) Chairman, University Committee on Selective Service and Military Affairs and (2) Institutional Representative for the Engineering, Science, Management War Training Program. In 1944 he was also named Chairman, Committee on Physics-Engineering Development Project (Proximity Fuse) in Cooperation with the National Defense Research Council.[18] Stewart acted as senior consultant to Dawson and as a member of the PEDP committee.

During 1940 Alexander Ellett made several trips to Washington, D. C., to confer with other scientists and with Army and Navy officials of the National Defense Research Committee. And on January 16, 1941, nearly eleven months before the attack on Pearl Harbor, Ellett was granted an indefinite leave of absence to serve as a consultant physicist with the NDRC in its Division of Arms and Ordnance. As the scientific-military establishment expanded in numbers of programs and personnel, Ellett became a division chief, serving as an administrator and as a liaison coordinator between the National Bureau of Standards and research groups of the armed services, industries, and universities.[19]

Chosen to succeed Ellett as the leader of the nuclear research program at the U of I was James A. Jacobs, who had earned his Ph.D. degree in 1941. Promoted to an assistant professorship in 1942, he was the first faculty member with all his degrees from the U of I since L. P. Sieg, who was on the staff from 1898 through 1924. Jacobs was also the first Iowa Ph.D. in the departmental faculty since Homer Dodge, who earned his doctorate in 1914.[20]

As the United States rapidly increased its participation in the war in 1941 and 1942, its leaders saw a national emergency situation in its shortage of technically and scientifically trained personnel. Accordingly the University of Iowa was encouraged to become an "arsenal of education," especially in such areas as engineering, the physical sciences, and mathematics. National defense contracts came to support a variety of militarily oriented research projects, special courses to prepare employees to work in war industries, and training programs for army and navy cadets.

In the spring of 1942 President Virgil Hancher and Dean Dawson requested University departments to list areas of competency for war funded research projects. The Department of Physics tentatively sketched their areas:

Electronic circuits and devices--E. P. T. Tyndall

Acoustics and supersonics--G. W. Stewart

Nuclear problems--J. A. Jacobs

Thermonics and vacuum phenomena--J. A. Eldridge

Theoretical physics (problems in magnetism and the liquid state)--G. Wannier.[21]

Wannier, employed as a replacement for Ellett in the fall of 1941 with the title of Lecturer, was the first theoretical physicist in the department. Swiss-born and holder of a Doctor of Philosophy degree from the University of Basel, Wannier had previously taught at the Universities of Pittsburgh and Texas.

One of the early short courses was Acoustics and Acoustical Engineering, geared for war workers in sound and communications industries and for military personnel in the Signal Corps and in other units involved in aircraft and submarine detection and location. An intensive four-week program, with two lectures, and a laboratory period daily, the course was held in the Physics Building during the summer of 1942. Stewart gave the lectures for the first three weeks, and Harry F. Olson, Director of Research for the Bell Telephone Laboratories, those for the fourth week. Jacobs conducted the laboratory sessions in the use of acoustical and electronic apparatus.[22]

Olson had earned his master's degree at the U of I in 1925 with the thesis <u>The Action of Acoustic Wave Filters in Solids as Dependent Upon Dimensions</u>, and his Ph.D. degree in 1928 with the dissertation <u>Polarization of Resonance Radiation in Mercury</u>.

During the war years the department was extended well beyond its basic teaching and research functions to provide special coursework for thousands of students in uniform and to develop military devices (e.g., the proximity fuse and bombsight modifications) in secret laboratories and workshops.

There were also temporary faculty members in the physics department. Former Iowa student Albert G. Hoyem (M.S., 1928; Ph.D., 1931) took leave from his post at Augustana College, Sioux Falls, South Dakota to assist with war-oriented research and to help with the Army and Navy pre-flight training. Vernon A. Suydem, age 72 in 1944 and professor-emeritus at Beloit College, returned to active duty at the U of I to assist in instruction and research during the years 1944-1946. Paul Kambly, head of science in the University High School, was also added to the physics faculty during the later years of the war.

Such graduate students as W. E. Nickell, R. E. Holland, and J. S. Wahl held responsible roles in the military research and development while others taught physics fundamentals as preparation for training in meteorology, in theory of flight, and in airplane engine operation.[23]

In 1943, for instance, physics graduate student Richard Gilbert taught primary courses in both mathematics and physics in the Elementary Course Curriculum of the War Training Service Program.[24] Derived and developed from the Ground School Course of the Civil Aeronautics Administration program for Civilian Pilot Training, the ten-week schedules were staggered throughout the year to provide training for some 8000 students annually.

For the period of January 18 through March 13, 1943 Gilbert's "fundamentals of physics" was an intensive survey course extending over 24 class hours. The following segment from the course of study provides some idea of the scope and nature of the elementary ground school course in physics:

5th hour:	Accelerated motion. Laws of motion, constant acceleration. Momentum and impulse, curvilinear motion, centrifugal force.
6th hour:	Work period, problems and demonstrations.
7th hour:	Fluids at rest, properties, pressure distribution buoyancy. Atmospheric pressure, maps, isobars, barometers.
8th hour:	Work and energy, definitions, types. Friction. Viscosity.
9th hour:	Work period, problems and demonstrations.
10th hour:	Review and examination.
11th hour:	Fluids in motion, velocity and energy. Bernoulli principles, applications.[25]

Despite the host of campus activities related to winning the war, the Physics pages in the University Catalog for 1943-1944 showed academic business continuing as usual. In the department's offerings the description of only one course indicated that there was a war going on--Elementary Electronics, taught by graduate assistant John S. Wahl:

> A course in electricity arranged specifically for those who wish assignment in electronics upon induction or enlistment. Prerequisite, college course in electricity or equivalent experience. War service course.

As the war years continued, the number of master's degrees awarded declined from the department's record high of fourteen in 1942 to only three in 1943; with three again in 1944 and one in 1945. Only one doctorate was completed in the years 1943 through 1945, that of Irvin H. Swift in 1943: Internal Friction in Zinc Single Crystals, under the direction of Professor Tyndall.

Preoccupied as the staff was with militarily oriented training and research added to their normal programs, relatively little happened in professional publication. Stewart, for example, completed in 1943 his Part Two of a 1939 article in the Journal of Chemical

Physics: "The Variation in the Structure of Water in Ionic Solutions." He occasionally contributed short articles to the American Journal of Physics to convey some of his views on the teaching of his science.

The Oersted Medal of 1942 for Notable Contributions to the Teaching of Physics was presented to Stewart at the New York meeting of the American Association of Physics Teachers on January 22, 1943. Stewart then spoke to the group on the subject "Teaching of Tomorrow." He emphasized the transmission from teacher to student of a spirit of creativeness, but he did not supply any specific methodology for its achievement:

> Yes, I have been speaking of education of the future without mentioning any details of curriculums and courses. The spirit that must be emphasized should transcend in importance any details. There may be many ways of arranging details; the spirit is basic.[28]

Notes and Sources

In addition to the records in the University of Iowa Archives, as noted at the conclusions of previous chapters, the writer is indebted to some other sources in the preparation of Chapter Seven. The American Journal of Physics, begun in 1933 as The American Physics Teacher, has been useful in following developments in the broad range of the profession. Other records include the collection of the annual programs of the Colloquium of College Physicists and the lists of graduate theses and dissertations preserved in the U of I Department of Physics and Astronomy

Papers and Records in the University Archives for the College of Engineering have provided some materials since Engineering Dean Francis M. Dawson headed the University's war efforts. Letters from G. W. Stewart to the presidents and to the deans of the University have also been helpful in the writing of this chapter. He wrote lengthy letters to draw attention to the work of his department and to its needs for more resources.

[1] John A. Eldridge, The Physical Basis of Things, p. 148.

[2] American Physics Teacher, 3:92, May 1935.

[3] Nature, 135, suppl. 389, March 9, 1935.

[4] Letter from G. W. Stewart to Dean G. F. Kay of the College of Liberal Arts, May 10, 1935.

[5] From W. Willard Lampe's tribute at Professor Stewart's funeral, August 20, 1956. Dr. Lampe's remarks were printed in George W. Stewart, 1876-1956, A Biographical Memoir, published by the National Academy of Sciences. These remarks included:

> Mrs. Stewart and he had spent the summer on a leisurely ocean voyage around South America, stopping at several ports en route. He had taken no books with him. He had assigned himself no papers to write. No persons or places were the specific object of his visit. There were no problems he wanted to solve--except one, the central problem of any serious mind, viz., what is the most satisfactory philosophy of life?
>
> The formula at which he arrived, and for which he became a zealous protagonist and missionary both in spirit and in many active endeavors ... was this: The most satisfactory philosophy of life is for one to be loyal to the highest and best that one knows. Just that simple and profound!

[6] From annual programs of the summer meetings as compiled in a souvenir record of the Colloquium of College Physicists, 1936 through 1959; prepared by J. A. Van Allen and J. P. Wells in May 1960 to announce the discontinuation of the annual meetings.

[7] Ibid.

[8] Ibid.

[9] Letter from Alexander Ellett to President Eugene Gilmore, June 14, 1938.

[10] G. W. Stewart, The E. O. Dieterich Memorial Mural, MSS in the University of Iowa Archives.

[11] LeRoy D. Weld, Glossary of Physics, preface.

[12] From departmental lists of advanced degrees.

[13] Ibid.

[14] Robert D. Huntoon, acknowledgement page to his dissertation, 1938: Distribution in Angle of the Protons from the Deuteron-Deuteron Reaction

[15] News Bulletin, University of Iowa, June 1940, p. 1.

[16]Physical Review, 69, p. 166.

[17]From G. W. Stewart's letter to the membership of the Colloquium of College Physicists, Jan. 10, 1942.

[18]From information in the College of Engineering papers turned over to the University Archives by Dean Francis M. Dawson.

[19]News Bulletin, University of Iowa, November 1945, p. 1.

[20]In a conference with President Hancher Feb. 11, 1942, Stewart observed that it had long been a rule of the department not to give faculty positions to Iowa Ph.D.'s. But he was making an exception in the case of James A. Jacobs because of his outstanding qualifications for leading nuclear research and assisting in the war effort.

[21]Contributions from the Physics Department, dated Spring 1942 in the papers of the College of Engineering, University Archives.

[22]Communications of G. W. Stewart to Dean Dawson, June and July 1942, in the College of Engineering papers.

[23]News Bulletin, University of Iowa, November 1945.

[24]Gilbert listed as instructor in State University of Iowa War Training Service Program, January 18--March 13, 1943.

[25]Ibid.

[26]American Journal of Physics, 11, pp. 89-95, April 1943.

Chapter Eight

From "Physicists' War" Into Physicists' Peace

> How nice to be a physicist in this our year of grace,
> To see the scornful world at last admit your rightful place,
> To see the senators defer to every wise pronouncement,
> To fascinate the women's club and star at each commencement ...[1]

With such lyrical lines Arthur Roberts wryly celebrated the post-war elevation of his profession in the public mind. A multi-talented New Yorker who joined the U of I physics staff in 1946, Roberts was an off-hour practitioner of the musical arts. He had worked on radar projects during the war at the Radiation Laboratory of the Massachusetts Institute of Technology. To some of his colleagues Roberts had also become their special Gilbert and Sullivan type of spokesman.

After the V-G and V-J terminations of the war, it became widely known that the work of physicists had been markedly influential in the victorious close of hostilities. Out of their basic theories and experiments had developed major military applications to increase enormously the devastation inflicted by Allied strikes and to reduce the effectiveness of enemy power. Radar and the atomic bomb had come out of the theoretical and experimental work of Maxwell, Hertz, and others in radio wave reflection and out of the basic studies of Einstein, Fermi, Hahn, and others in the fission of the uranium nucleus.

Some of the physicists viewed their rise to fame as a mixed blessing. While increased recognition and support added to the resources of many physical laboratories, industries and government installations competed with the universities for the best trained manpower. The demands of war had slowed the increment of basic knowledge, and many physicists were looking forward to years of peace in which they could resume their pre-war research. Yet they had to contend with new demands occasioned by their popularity.

> Before the bomb, contemplation was the physicist's stock in trade .... It's a luxury now .... The bomb showed so-called practical men that physicists aren't necessarily vague long-hairs, and now they won't let us alone.

Thus did Samuel Goudsmit express some of his post-war misgivings when interviewed for a profile piece in New Yorker magazine.[2]

Writing on "The Physicist Returns from the War" for the Atlantic Monthly, Isidor Rabi reviewed some contributions of physical science in the conduct of the war and reflected upon the current exaltation of the physicist:

> Thus by the very success of his efforts in this war, the physicist has been placed in an embarrassing position. The inheritor of the tradition of Galileo, Newton, Faraday, Maxwell, Gibbs, Rutherford, Michelson, and Einstein now is hailed as the messiah who will bring us a new world with push-button facilities, new industries, an expanding economy, and jobs for all.[3]

The overwhelming knowledge of the A-bomb and the impact of the many other crucial events around the end of the war tended to obscure the revelation of another major item in military inventories. The proximity, or VT (variable time), fuse was an offshoot of the development of radar, which had grown out of the basic knowledge that radio waves reflect differently from various objects. Adapted and packaged to ride within exploding projectiles and in bombs dropped by aircraft, the fuse devices detonated their carrier payloads at positions to inflict the maximum damage upon their targets. Such fuse-equipped shells and bombs proved to be enormously effective in 1944 and 1945.

A few weeks after V-J Day, the Department of Defense raised some of the security curtains, and Iowans learned that physicists and engineers in their University had a significant part in the development of proximity fuses, particularly those for use with mortar shells and with bombs.

As the Daily Iowan reported in its major story of October 2, 1945:

> With a staff personnel of more than 300 working day and night under constant wartime protection of armed guards, University of Iowa scientists played a vital role in the development of the VT radio proximity fuse. This is the secret weapon recently announced from Washington as having played a decisive part in the early termination of the war.

The DI story went on to relate that the project had grown from a few men working in one room of the Physics Building during the winter of 1942-1943. By the spring of 1945 the small Electronic Physics Project had become the large-scale Physics Engineering Development Project. The work had spread through several downtown commercial buildings, and the PEDP had added a 1500-acre testing facility along the Mississippi north of Clinton.

The University's involvement in the proximity fuse project had actually commenced more than a year before the United States entered the war as a combatant. Alexander Ellett was called to Washington, D. C. in November 1940 at the request of the National Defense Research Council to work with Merle A. Tuve, a senior physicist of the Carnegie Institution. Tuve had been directed by the NDRC to take the lead in the scientific aspects of the project.

U. S. activity to develop the fuse had begun in September 1940 when a British scientific mission led by Henry Tizard came to Washington to exchange information on defense apparatus and techniques with members of the NDRC. The British had been employing radar with considerable success in their defense programs. They had also designed and developed a radio detonating fuse, an innovation initially proposed by W. S. Butement, a telemetry scientist credited with the instigation of several other devices. The British mission staunchly advocated the new fuse for use in the war but lacked the resources to develop it and to standardize its performance and quality for mass production. The island had too few qualified scientists and engineers to divert a sufficient number to the project. English instrument manufacturing was already overburdened by the quantity of military needs.

As J. G. Crowther and R. Whiddington pointed out in their historical account of the participation of British scientists in World War II:

> The later development and manufacture of this fuze were taken over by American scientists and engineers. Many very difficult problems had to be solved before it could be produced reliably in quantity. This was done just in time to meet the flying-bomb menace to London, and at the end of that attack, nearly 100 percent of all the flying-bombs approaching London were being shot down by anti-aircraft guns using V-T fuzes invented in England, and developed and manufactured in the United States ....
>
> ... Our American allies were able to put 1500 persons on to the development of this fuze: at no time were we able to put more than 50 persons on to the same task. The Americans performed the prodigy of making 150,000,000 of the special valves for these fuzes.[4]

One response of the National Defense Research Council to the British mission in 1940 was to assign to Tuve the scientific leadership of a proximity fuse project and bring in Ellett and others to assist him. After the Iowa scientist was granted an indefinite leave of absence from the University in January 1941, he was put in charge of a group to work on fuses for bombs, rockets, and mortars. In late 1941 the work under Ellett was moved out of Tuve's "Section T" into a separate "Section E" and headquartered at the National Bureau of Standards. This move enabled Tuve's section at the Applied Physics Laboratory of Johns Hopkins University to speed up the development of the artillery shell fuses which the U. S. Navy, as well as the British, was requesting with increasing urgency.[5]

Until late in 1942 Ellett's leadership role was the main Iowa connection with the project. In September 1942, James A. Jacobs went to Washington to confer with Ellett and other officials of the NDRC. He returned with the expectancy of the University being "asked if we will accept a contract for three months with the possible expenditure of $5000," as G. W. Stewart reported October 14, 1942 in a letter to Dean Carl Seashore of the U of I Graduate College.[6]

It was from this small conditional contract that the Electronic Physics work developed at Iowa for the local escalation of military research. In none of the correspondence and related documents in the archived files of President Hancher and of Dean Dawson is there any hint of the type of work being done by Jacobs and his associates.

Along with the atom bomb, the proximity fuse was one of the most closely guarded secrets of the war. To prevent enemy nations learning enough to prepare such devices of their own and/or taking precautions against its effective use, the project operated in an environment of tight security measures.

As the program expanded through 1943-1945 at the U of I, armed guards were posted at the entrances to the work areas. Tight screening processes were developed for the selection of working personnel, who were enjoined not to divulge to outsiders any details of the nature of their work. Steel bars appeared in the windows of the ground floor of the Physics Building and in other work areas. Both in Iowa City and throughout the national spread of the program, the operations were split up and disseminated around the various research, production, and testing areas so that only a few persons around the top of the organizational pyramids actually knew the nature of the project.

According to the top-secret organizational chart, the U of I and the University of Florida were the two educational institutions contracted to assist in developing the fuses to be specialized for bomb, rocket, and mortar shell carriers. For these the fuses had to be powered and stabilized by wind-driven generators and fins. The National Bureau of Standards coordinated the work through the laboratories, industrial production centers, and into the proving areas for combat use.[7]

Several other universities, including Michigan, New Mexico, Princeton, and Johns Hopkins, were at work on the rifled spin-type of fuses for the heavy artillery and anti-aircraft guns. The development and combat employment of these fuses were under the general coordination of the Applied Physics Laboratory of Johns Hopkins University.[8]

In its essential parts the V-T fuse contains a radio transmitter and receiver, a selective amplifier, an electronic switch, a detonator, an electric power supply, and arming and safety devices. Upon striking a target, waves sent out by the transmitter reflect back to the receiver. The signal is amplified enough to trip the switch or thyraton, fire the detonator, and explode the projectile. The arming system had to be set up so that an explosion could not take place until a safe distance had been reached from the point of firing the gun or dropping the bomb.

Fuse production required the highest possible standards of accuracy, durability, and safety for the effective performance of the device. The number of parts and the number of different models complicated the production. A typical fuse for a bomb had more than 250 different parts, and some 30 different models were designed for the variously sized and shaped carriers.[9]

At the University of Iowa the initial missions of the Electronic Physics group were (1) to solve design problems as they arose in the production of early models of the fuses and (2) to develop equipment for testing the performances of the electrical circuits. Additional assignments came to the Iowa location as the project grew in manpower, supporting resources, and in the recognition of the proficiency of the work. In June of 1944 the local group was requested to engage in field testing to determine how the various storage practices and conditions might affect the reliability of the fuses. In the course of this work the Iowans developed a device for the parachute recovery of fired mortar shells.

In February 1945 the Office of Scientific Research and Development requested the University to proceed with a six-fold expansion, and the rapidly broadening operation acquired a new name--Physics Engineering Development Project. The expansion included a pilot production line to bring the laboratory improvements into the mass manufacturing procedures with the least possible delays. The testing field north of Clinton took on the experimental firing of mortar shells and construction rose to support the operations in the field--a radio laboratory and workshop, storage buildings, a boathouse and landing dock, and observation and guard towers in addition to concrete gun emplacements.[10]

Jacobs continued as the technical head of the PEDP and as director of its research activities under the University Project committee consisting of President Hancher, Dean Dawson, Administrative Dean A. W. Dakin, Liberal Arts Dean E. J. McGrath, and G. W. Stewart. A large old gold and black badge for security identification (PEDP-1-SUI) remains in President Hancher's archived files for the year of 1945.

When the war ended, the project had moved into the development of a new type of fuse for very large bombs. Some models had been constructed, and the device was ready for the production line. But with the arrival of V-J day, the Physics Engineering Development Project was terminated. Some personnel--and much of the equipment, material, and records--moved within a few days to the Naval Ordnance Test Station at China Lake, California. By the end of September 1945 only thirty employees remained, to clean up the operational areas and to take care of the quantities of government property. Much of this property was turned over to the State of Iowa. The University Purchasing Office prepared a 200-page catalog of items available at small amounts of their original costs. In addition to large quantities of apparatus (including 18 oscilloscopes), machine tools, electronic parts and supplies, the catalog dated September 27, 1946 listed 49 executive desks, 42 stenographic desks, 205 laboratory stools, and 84 four-drawer file cabinets among the items of furniture available to University departments upon their requisitions for purchase. Considering that much of the project property had moved to California and elsewhere, the extensive remainder for the catalog listings indicated something of the expansion of the PEDP during the final months of the war.

In the Physics faculty E. P. T. Tyndall had worked with Jacobs as a senior research scientist and C. J. Lapp as business operations manager. Project personnel from the College of Engineering included, for instance, L. A. Ware, Iowa Ph.D. in Physics in 1930 who had become professor of electrical engineering. Eight of the fourteen Ph.D. graduates in the Department of Physics in the years 1938 through 1943 had responsible roles in the project. The two at the Iowa installation (PEDP) were Jacobs, the research director, and I. H. Swift (Ph.D., 1943).

Off campus at the National Bureau of Standards in Washington were R. D. Huntoon (1938), B. J. Miller (1939), and F. S. Atchison (1942). J. S. Rinehart (1940) was also in Washington as assistant to the Chief of the Division, Alexander Ellett. J. A. Van Allen (1939) and W. A. Good (1941) were in Merle Tuve's division working with fuses for artillery shells at the Applied Physics Laboratory in Silver Spring, Maryland. Van Allen was later commissioned as a scientific officer in the U. S. Navy to help introduce the spin-stabilized fuse into combat operations and to observe the performance of the device.

While the first proximity fuses for artillery shells were used as early as January 1943 in U. S. anti-aircraft guns in the western Pacific, the mortar, bomb, and rocket fuses whose development primarily engaged the Iowa scientists were not used until much later in the war. The risk of enemy intelligence of the new weapon accessory from the recovery of duds on the ground was deemed to be too great. James P. Baxter 3rd, the official historian of the Office of Scientific Research and Development, reported in 1946:

> The radio proximity fuzes functioned satisfactorily in bombs of all sizes from 100 to 4000 pounds, and were first used with great effect by bombers of the 7th Air Force against Iwo Jima in February 1945. They were reported as having paralyzed anti-aircraft fire on this and other occasions in the Pacific, European, and Mediterranean theaters. VT-fuzed general-purpose, fragmentation, and 'gel-gas' bombs were used with deadly effect by the 12th Air Force in Italy against personnel and material shielded from ordinary ground bursts by walls, revetments, or foxholes. In the strikes by the Third Fleet against the Japanese mainland from July 10 to August 15, 1945, about one third of all bombs dropped by the carrier planes had VT-fuzes.[11]

In further discussions of the extreme secrecy of the project as related to the combat use of the fuse, C. H. Page and A. V. Astin of the National Bureau of Standards reported in 1947 in the American Journal of Physics:

> To accomplish our objective of keeping the enemy uninformed of our own achievement, the extent of our use of proximity fuzes was severely restricted. Until December 1944 when the VT fuze was used effectively to help stop Von Runstedt's counteroffensive, no VT fuzes were used when there was any possibility that even one might be recovered by the enemy ... until December 1944, the use of the fuzes was confined to the anti-aircraft role and to localities where unexploded shells would fall either in the deep waters of the ocean or in completely protected territory. Even our battleships were forbidden to use the VT fuzes against attacking bombers when the ships approached too close to enemy-held islands.[12]

Baxter concluded his historical account of the World War II weapon accessory with strong praise for all concerned:

> If one looks at the proximity fuze program as a whole, the magnitude and complexity of the effort rank it among the three or four most extraordinary scientific achievements of the war. Towards the close of hostilities it monopolized 25 per cent of the facilities of our electronic industry and 75 per cent of the nation's facilities for molding plastics. The job never could have been done without the highest degree of cooperation between American science, American industry, and the armed services. That it was done at all borders on the miraculous. The results are writ large in the story of the war on land and sea and in the air.[13]

As it was after World War I, changes in Physics Department personnel and programs followed the return to peace. The year of 1945-1946 was singularly one of planning to cope with additional expectations and responsibilities. Such rapidly developing fields as theoretical and nuclear physics required special attention, and, with G. W. Stewart reaching the age of seventy in February 1946, University administrators were looking for a new man to head the department. After managing with the same group of five in the 1920's and 1930's, the professorial staff grew to eight shortly after the war and then continued to increase. While only one from the pre-war five did not return to the campus, the department added three new members at the opening of the school year of 1946-1947, the largest number of newcomers to appear at one time in the annals of the organization.

Stewart had indicated his wish to relinquish the executive leadership but he wanted to remain active in the building which he had planned and cherished. Among other things he wished to continue to teach acoustics and to conduct the summer Colloquium for College Physicists. In terms of his research leadership and his national reputation Alexander Ellett appeared to be the most likely candidate within the department to become the new head.

University administration files for 1944-1945 reveal that there was some consideration of Alexander Ellett as Stewart's successor. Some concern was expressed about the contrasting styles of the two men, with Ellett noted for his taciturnity and his disinterest in the social and political relationships of the University. Ellett himself resolved the situation by accepting an offer to become Director of Research for the Zenith Radio Corporation. And in October 1945 there came an interested inquiry from the kind of man who was being sought--a mature physicist of established reputation with a background in nuclear physics and a record in research administration.

Then 47, Louis A. Turner had been a member of the Princeton University faculty since earning his Ph.D. there in 1923. He had a substantial record of publication in nuclear physics and had worked in 1937-1938 in the prestigious institute of Niels Bohr in Copenhagen. During the beginnings of U. S. considerations to develop nuclear fission into a military weapon, Turner was exploring the potential powers of uranium and plutonium in the group then based at Princeton. For the duration of the war he served first as a group leader, then as a division head, in radar research and development at the Radiation Laboratory of the Massachusetts Institute of Technology.

Stewart had told President Hancher that he did not wish to be consulted about his successor, but when Turner appeared as a prospect, he willingly accepted the role of seeking appraisals of the candidate's qualifications. Writing to John A. Wheeler of Princeton, for instance, Stewart questioned whether Turner was sufficiently aggressive. Wheeler warmly recommended his colleague for his responsibility, productivity, and leadership. He also called attention to Turner's work in bringing together and reviewing the 1938-1939 papers on nuclear fission for a comprehensive article on the subject which appeared in Reviews of Modern Physics in January 1940.

In preparing "Nuclear Fission" for the RMP, Turner had started with Enrico Fermi's 1934 paper on the bombardment of uranium and continued on to analyze the nearly 100 papers which had appeared after the critical experiment of Otto Hahn and Fritz Strassmann in December 1938. Besides contributing this summary of the state of knowledge on nuclear fission, Turner had been credited with an early proposal for the use of plutonium for atomic bombs. When the National Academy of Sciences formed a committee to screen the content of scientific journals, one of the first papers they decided to hold back until after the war was one by Turner for the Physical Review on the prospects of plutonium fission.

Other replies to Stewart's queries highly commended the candidate, and, in a letter of January 15, 1946 Dean Earl McGrath of the U of I College of Liberal Arts informed Turner that

> You are to become the head of the department beginning with the academic year 1946-47 ...

Dean McGrath assured him that a theoretical physicist could be hired and that the Van de Graaff nuclear accelerator project would be supported at an average of $15,000 annually for the next three years.

With the acceptance and announced coming of Turner as the new head of the department, the staff would soon reflect much more of the wartime experience of U. S. physicists. Both persons of scientific orientation and laymen in the Iowa City area were eager to hear from a man who had inside information on major scientific-military developments of the war: in pre-atomic-bomb activities at Princeton and in the radar programs at MIT. On June 14, 1946 Turner obliged with a lecture, "Microwave Radar," before the Colloquium of College Physicists, which had reconvened its annual meetings after suspending them during 1943, 1944, and 1945.

During the summer of 1946 the U. S. conducted test-explosions of two more A-bombs, these at Bikini Atoll in the Marshall Islands. The considerable public interest in these events prompted the Daily Iowan on July 7 to present an extensive Symposium on Atomic Energy with a panel of four from physics, two from political science, and one from history.

C. J. Lapp considered the first topic question: "What Kind of a War Would an Atomic War Be?" His answer, briefly summarized, was that such a war would be much more sudden and much more violent than any previous war. "Atomic weapons of mass destruction are too dangerous to have in existence at all," he said.

G. W. Stewart had the next question: "In What Way Will Science and the World Have Profited from the Atomic Bomb Test?" He stressed that the discovery of nuclear fission and the development of the A-bomb had proved the high degree of competence and leadership of physicists in practical affairs. The record now showed "four bombs, no duds, no mistakes." Agreeing with Lapp's statement on the threat to mankind, he said that "the use of atomic energy as a weapon must be abolished."

J. A. Jacobs answered "What Types of Atomic Secrets Would the U. S. Be Giving the World?" He pointed out the futility of trying to prevent other nations from building their own A-bombs. Nuclear fission is a basic natural process, and any technologically advanced country can proceed from atomic science into the creation of atomic weapons. "I do not believe we have any secrets worthy of the name to give away ..." noting that "General Motors undoubtedly has many tricks in the manufacture of automobiles which they keep to themselves, but this does not prevent Ford from building automobiles."

L. A. Turner responded to the question "If We Turn Atomic Energy to the Ends of Peace, What Can We Expect?" (citing the enormous expense of atomic reactor installations). He expressed doubt that atomic energy would be widely used as a source of power.

> In summary, I will hazard the opinion that the most important peacetime consequences of the development of atomic energy will be indirect ones in new fields of research and in the application of new tools made available.

One of Turner's first tasks was to find someone to take the lead in the teaching and research of theoretical physics. While still at MIT during the early months of 1946, Turner corresponded with the nation's senior theoreticians for their recommendations. Budget limitations (under $6000 in annual salary) called for a young man of bright future promise, currently uncommitted elsewhere, and possessing a record of substantial publication. Upon the recommendations of Hans Bethe of Cornell, of Eugene Wigner and John Wheeler of Princeton, and others, Turner, in counsel with G. W. Stewart (who had campaigned for so many years for a strong theoretical physicist in the faculty) selected a candidate.[14]

Swiss-born Josef Jauch, then 31, had earned his Ph.D. at the University of Minnesota in 1939 and had taught at Princeton during the war as a temporary replacement for Wigner, one of the leading theoreticians in the A-bomb development. A specialist in quantum mechanics and with broad interests in physics history and education, Jauch then had five listings after his name in the cumulative index of the Physical Review. For instance: "On the problem of degeneracy in quantum mechanics" (1940) and "On the meson field theory of the magnetic moment of proton and neutron" (1943). At Princeton he had worked with the Wolfgang Pauli, Nobel Laureate of 1945, on the application of Dirac's method of field-quantization to the problem of emission of low frequency photons (1944).

At the time of the selection of Jauch, the department had a theoretical physicist on a temporary basis. Since 1941 Gregory Wannier, with the title of lecturer, had been serving in part as a wartime replacement of Alexander Ellett, who had taken the lead during the pre-war years in theoretical physics teaching in addition to his other work. While the senior members of the department were reluctant to urge the departure of Wannier, they felt that he would not be able to make theory a strong and flourishing part of the department. During their correspondence during the spring of 1946 Stewart and Turner considered Jauch and Wannier sharing an office. Wannier resolved the situation by resigning to become a research associate with the Socony-Vacuum Oil Company.[15]

After the appointment of Jauch, the department looked for another young physicist with a background in nuclear and electronic physics to support the work of James Jacobs in the Van de Graaff laboratory; also to build up a research program in microwave spectra and in beta-ray spectroscopy. Turner chose Arthur Roberts, then 34, who had worked with him on radar projects during the war at the Radiation Laboratory of the Massachusetts Institute of Technology. A man of varied talents, Roberts was a graduate of the New York Conservatory of Music in addition to his doctorate in physics from New York University. While at MIT he had taught at times at the New England Conservatory of Music.

The composer-ballader of his profession, Roberts had written both music and lyrics for "The Cyclotronist's Nightmare, or Eighty Millicuries by Half-Past Nine" (1939); "It Ain't the Money" (1944, on the occasion of the award of the Nobel Prize in Physics to I. I. Rabi) and "Take Away Your Billion Dollars" (1946, to lampoon big operations in physics supported by the military-industrial complex). Some years later he was to compose "Overture for Dedication of a Nuclear Reactor," performed by the Oak Ridge (Tennessee) Symphony Orchestra in March 1952. The overture's third movement was entitled "Atomic Pile Going Critical."

For the years of 1936 through 1946 the index of the <u>Physical Review</u> showed eighteen listings of articles, abstracts, and letters under the name of A. Roberts and under him and his collaborators in research. Subjects of these contributions included the disintegration of alpha-particles of Li^7, radioactive isotopes of iodine, and disintegration schemes of radioactive substances. He also had two published articles in the <u>Review of Scientific Instruments</u>. During 1945-1946 he served as editor of <u>Radar Beacons</u>, Volume 3 of a series reporting the wartime work of the Radiation Laboratory at Masschusetts Institute of Technology.

Upon his arrival at the U of I Roberts was assigned to teach courses entitled Electricity and Magnetism, Electrical Measurements, and Advanced Electrical Laboratory. At the first weekly Colloquium of the fall of 1946 he was asked to report on certain papers which had been presented at the last meeting of the American Physical Society, the papers relating to accelerators used in nuclear research.

It was now a year after the war's end, and the faculty had become sixty percent larger than its long continuing core of five who had persevered through the 'twenties and the 'thirties. Jacobs had been added to the group near the beginning of the war; Turner, Jauch, and Roberts in 1946. Still more faculty were anticipated so as to broaden and strengthen programs and to meet the growing expectations of a science at its zenith of potential influence. Departmental leadership hoped for more of an infusion of younger men, with an amplitude of years ahead in which to make substantial contributions in the developing fields of the science.

Late in 1946 C. J. Lapp began to consider leaving the position he had held since 1923. His opportunity was the position of assistant director of the Office of Scientific Personnel for the National Research Council in Washington, D. C. The correspondence of the time shows that he was not discouraged from accepting a post so much in line with his abilities and interests.[16] While the University was reluctant to lose so able and experienced a teacher of elementary physics, Lapp's departure in January 1947 created an opening for a more research-oriented person to work in quantum mechanics and elementary particle theory.

In time for the fall term of 1947-1948 the department was able to locate and employ a young man with the desired qualifications to help Josef Jauch in developing a program of graduate research and professional publication in theoretical physics. He was Fritz Coester, then 26 and a research associate at the University of Geneva. Born in Berlin, Coester had completed his secondary schooling and college undergraduate work in Freiburg, Germany, then moved to Switzerland where he earned his Ph.D. at the University of Zurich in 1944. Jauch had worked at Zurich in 1942-1943, had observed Coester's grasp of mathematical physics, and decided the young man would be an able collaborator with him at the U of I.

At long last, after so many years as a have-not in the area, the department now possessed a theoretical physics group, a pair at least of men teaching, directing graduate research, and publishing; bringing the University of Iowa to a contributory status in national professional sessions in quantum and elementary particle physics. The first Ph.D. product of this new order turned out to be Kenneth M. Watson with his dissertation in 1948: The Polarizability of the Meson-Charge Cloud of a Neutron in an External Electro-Static Field. Results of Watson's studies were actually published prior to his graduation in the Physical Review in 1947 and in early 1948.

A foothold in theoretical physics secured, the principal concern of the department was to provide more opportunities in nuclear research, with sufficient experimental apparatus to attract graduate students interested in this then predominant field of modern physics. Between 1937 and 1940 the Cockroft-Walton accelerator had served for several studies with its multiplication of energy up to 450 keV. Advanced students of Alexander Ellett had accomplished research on the angular distribution of the products of nuclear disintegration and in the determination of absolute cross section. With the beginnings of the installation in 1940 of a machine capable of ten times as much voltage, the Iowa physicists had been anticipating a host of new activities with proton and neutron beams.

During the summer of 1944 Stewart had informed President Hancher that about two years work, with an estimated expenditure of $8000 the first year and $3700 the second year would "complete the plant and get it into operation." As it turned out, he was much too sanguine in his estimate. He had not counted on the deterioration of the Van de Graaff through lack of attention during the war years. Much of what had been started in 1940 had to be redone. Considerable rust had to be removed from the inside of the walls of the tank and from the vacuum tube system. Textolite support columns had become warped and had to be replaced. A considerable array of associated apparatus had to be constructed or purchased.[17] The initial expenditure of approximately $30,000 in 1940 had climbed by 1948 into a University investment totaling more than $100,000. The machine was still a long way from effective usefulness, and further funding had become a difficult problem to the administration of the University.

In 1947 and again in 1948 the nuclear group sought outside support to defray some of the costs of the Van de Graaff operation. Their proposal for a research contract with the Office of Naval Research, in which they requested some $46,000 to add to $52,000 expected to be allocated from University funds, was perhaps too vague and tentative:

> It seems likely that some of the problems concerning cross sections of processes produced by fast neutrons and scattering would be of interest in connection with practical utilization of nuclear energy. Little has been published about this matter, presumably for reasons of security, so we have no knowledge of its status and can only speculate as to possible significance of work that we might do.
>
> It is hardly necessary to make here any detailed explanation of the general importance of such nuclear studies.
>
> The training of the research assistants and graduate students working on such projects is something that is apparently of government interest.[18]

The Office of Naval Research did not provide the requested funds but did respond to a proposal for support from Arthur Roberts for a project on microwave spectroscopy studies of molecules in conjunction with the U of I Department of Chemistry. It was not until 1950-1951 that the Van de Graaff obtained outside support. The

Atomic Energy Commission began to provide $40,000 annually for this work.

During 1948-1949 the development of the Van de Graaff, with the subsequent expansion of capabilities in nuclear research, had reached the point that Turner and Jacobs anticipated the addition of a new assistant professor to the nuclear physics staff. I. I. Rabi recommended Edward B. Nelson, one of his graduate students who was awarded the Ph.D. at Columbia University in 1949. Nelson, then 33, had the desirable combination of considerable teaching experience and professional research in atomic beam studies of nuclear structures. Born in Kentucky, he had earned his B.S. at Western Kentucky State Teachers College in 1937 and his M.S. at Vanderbilt University in 1938. As an advanced graduate student at Columbia, he had taught elementary courses as a lecturer and as an instructor and had served as a research physicist on the Manhattan Project in 1944-1946. He had contributed a paper at the American Physical Society meeting in Washington, D. C., April 29--May 1, 1948. It was published as an abstract in the Physical Review of November 1948; then as an article in December 1949. On a problem proposed by Professor Rabi and written with the collaboration of John E. Nafe, the title of this paper was A Comparison of the G-Value of the Electron in Hydrogen with That in Deuterium.

By the late spring of 1949 Turner had come to despair of achieving what he had hoped to do at the University of Iowa. When he had accepted the post, he had expected the department to receive substantially increasing support, particularly for the development of nuclear research, with some of its applications contributing to the biological and medical sciences. But the budgetary allotments for 1949-1950 had no increases for faculty and graduate assistant stipends over the previous year, and the general expense funds remained at $15,000 for the department and at $11,400 for the nuclear physics development of the Van de Graaff accelerator.

The lack of adequate support was attributed to the State Legislature and to Iowa Governor William Beardsley, for University leadership was struggling to conduct expanded programs for a growing student body without accompanying growths in state appropriations. An early 1949 presentation of the University's financial needs from the office of President Hancher pointed out that the U of I share of the total state revenue in 1947-48 was only 2.67 percent, the lowest proportion in recent years. In the early 1930's the presentation claimed that the University had received more than 5.33 percent of the state's revenue.

Meanwhile Turner was very much aware that the Argonne National Laboratory was rapidly advancing in its funding and equipping for experimental studies of elementary particles. In 1947 he had been elected to succeed Arthur Holly Compton on the governing board of this laboratory complex near Chicago. Late in 1949 Turner was offered a principal research directorship at the national laboratory. Reluctant to turn down an opportunity so much in line with his interests and qualifications, Turner submitted his resignation from the U of I in January 1950.

While University administrators regretted the loss of a man of Turner's professional stature, they soon concurred with the faculty of the department on the choice of a successor. The desired candidate was James Van Allen, whose name has appeared earlier in this history: as a graduate student working under Alexander Ellett in nuclear research in the late 1930's and as one of the principal Iowa graduates engaged in the development of the radio proximity fuse.

Since Van Allen had been an outstanding graduate student at the University, his former mentors in the physics faculty had followed his developing career with interest and a large measure of pride. They had welcomed the reports of his research at the Carnegie Institution in Washington, of his proficiency as a scientific-technical officer with U. S. Navy Ordnance, and of his leadership of high altitude research for the Applied Physics Laboratory of Johns Hopkins University. Working under Merle Tuve of the Carnegie Institution at the advent of the war, Van Allen had made various contributions to the development of the gun-fired types of proximity fuses. In his naval service he held key roles in bringing the weapon auxiliary into effective use in the theatres of combat. After the Armistice he had led in the transformation of captured German V-2 rockets into the Aerobee research rockets. Then with the Applied Physics Laboratory he had organized and supervised its High Altitude Research Group. In 1949 and 1950 he had led scientific expeditions into the Central Pacific and to the Gulf of Mexico, concentrating on studies of cosmic radiation in the upper atmosphere.

Professor Tyndall has recalled the highly favorable impressions Van Allen created when he appeared at the 1948 Colloquium of College Physicists to lecture on "Upper Atmospheric Research by Means of Rockets." Among other publications, his papers in the Physical Review included "The Cosmic-Ray Counting Rate of a Single Geiger Counter from Ground Level to 161 Kilometers Altitude" (1948) and "On the Azimuthal Asymmetry of Cosmic-Ray Intensity above the Atmosphere at the Geomagnetic Equator" (1950).

In March of 1950 Van Allen was one of three candidates for the departmental leadership who were invited to visit the University of Iowa. Dean Dewey B. Stuit requested statements of preference from members of the physics faculty. The letters he received indicated that Van Allen was the unanimous choice. Consequently Dean Stuit wrote the University's official offer on April 13, 1950, beginning:

> Dear Dr. Van Allen:
>
> After consultation with the members of the Department of Physics and the University Provost, I am pleased to offer you the position of Professor and Head of the Department of Physics of the State University of Iowa. Our first step, after the headship of the department became vacant, was to make a careful study of the type of person needed for this position. We have reached the conclusion that by virtue of

> your scholarly achievements, personal qualifications, research interests, and professional experience you are the person whom we would like to have as the successor to Dr. Turner.

Van Allen requested a few more months to carry out some of his commitments at the Applied Physics Laboratory before beginning his new position. The request was granted, and E. P. T. Tyndall was appointed as acting head for June through December 1950. While still at the APL, Van Allen began to look for someone to fill a vacancy at the U of I. Arthur Roberts had resigned in the spring to accept a position at the University of Rochester. Marcel Schein of the University of Chicago, a national leader in cosmic ray research, recommended Melvin Gottlieb, who was slated to receive his Ph.D. that June at Chicago. As a research assistant under Schein, Gottlieb had constructed a large cloud chamber apparatus and then used it at Climax, Colorado to study nuclear interactions initiated by cosmic ray particles at the 11,000-foot elevation. Then 33, Gottlieb had considerable background as an instructor in electronics at Chicago and as a research associate on radar countermeasures at Harvard.[19]

With his arrival in the department in September of 1950, the faculty not only had someone to carry on some of the teaching which Roberts had been doing but also to prepare for the beginning of cosmic ray research before the arrival of Van Allen. The new department head had indicated in a letter to Dean Stuit that he would "propose to undertake a modest program of balloon flights to high altitude for the investigation of the interaction cross-sections and transition effects of the primary radiation in various elements."[20]

In respect to drawing the attention of persons outside the building, the academic year of 1950-1951 was quiet and uneventful for the Physics Department. The <u>Daily Iowan</u> did not appear to recognize the department's new leadership until May 20, 1951 when the campus paper reported that

> Prof. James Van Allen, head of the SUI Physics Department, spoke on "The Techniques of High Altitude Research" at the spring banquet meeting of Phi Lambda Upsilon, the national honorary chemical society, last Thursday evening.

Some months earlier the University News Service had noted in a press release on gifts and grants dated January 28, 1951:

> The Research Corporation of New York granted $2,500 to support research under the direction of James A. Van Allen, head of the physics department, in "Interaction of the Primary Cosmic Radiation with Various Materials."

This financial item, which was not used by the DI, turned out to be the announcement of the pump-primer money to begin the funding of upper atmospheric research at the U of I. The grant provided some of the initial materials and wages for students who were starting to construct cosmic ray apparatus to be uplifted by small balloons. By the summer of 1951 the funding for cosmic ray research was augmented by a grant from the Office of Naval Research which provided for expenditures of $8000 for the fiscal year of 1951-1952.

The Daily Iowan gave the biggest play of that semester to an event in physics when it reported G. W. Stewart's plans for the June colloquium, featuring four lectures by George Gamow, the much-traveling associate of many of the great men in modern physics and an ardent popularizer of recent discovery. Front-paged by the DI, the June 10 story began:

> More than 130 physicists from 75 institutions and 22 states are expected to attend the 12th annual Colloquium of College Physicists at SUI ...

Then associated with George Washington University, Gamow, a native of Russia, lectured on Origin and Evolution of the Universe (2) and Physics of Living Matter (2).

Notes and Sources

This chapter deals largely with a department in transition--from its wartime position bolstered by federal funds to a peacetime status supported only by the state; also through major changes in personnel, with new leadership in 1946 and again in 1950. Physicists found themselves in higher repute than ever before, a situation incurring greater expectations and heavier demands upon their time. With the University administration trying to find and then to hold men to lead Iowa physics into national recognition, the department struggled to strengthen its foothold in nuclear studies and to make a strong start in theoretical research. It was a time marked by insufficient resources to support the rising expectations.

As in preceding chapters the University of Iowa Archives continue to be the major source of information, ranging from the annual University Catalogs through the documents preserved from the files of the Presidents. Bound volumes of professional journals in the Physics Library have been helpful, and there are several books which give special accounts of the contributions of physical scientists to the war effort.

[1]Arthur Roberts, "How Nice to be a Physicist," Scientific American, September 1948. Under the same heading is his "Take Away Your Billion Dollars," in which he particularly lampoons the campaigns of Ernest Lawrence for ever larger and costlier accelerators at Berkeley. Its final stanza:

> Take away your billion dollars, take away your tainted gold.
> You can keep your damn ten billion volts, my soul will not be sold.
> Take away your Army generals; their kiss is death, I'm sure.
> Everything I build is mine, and every volt I make is pure.
> Take away your integration; let us learn and let us teach.
> Oh beware this epidemic Berkelitis, I beseech.
> Oh dammit! Engineering isn't physics, is that plain?
> Take, oh take, your billion dollars, let's be physicists again.

[2]Daniel Lang, "A Farewell to String and Sealing Wax," New Yorker, November 1953. Collected in 1959 in a book of Lang's works, From Hiroshima to the Moon.

[3] I. I. Rabi, The Atlantic Monthly, October 1945.

[4] J. G. Crowther and R. Whiddington, Science at War, pp. 81-82.

[5] Chester H. Page and Allen V. Astin, "Survey of Proximity Fuse Development," American Journal of Physics, March-April,1947. A similar historical account is presented by J. P. Baxter in Proximity Fuzes: A Challenge to Air Power," in the Atlantic Monthly of September 1946. This article particularly discloses the magnitude of the project and the effectiveness of the device.

[6] Letter from G. W. Stewart in the files of President Hancher for 1942-1943. This contract "may well be the opening wedge to successful and more extensive participation of this laboratory in war research," Stewart optimistically observed.

[7] Op. cit., Page and Astin.

[8] Ibid.

[9] Ibid.

[10] From the information released to the Daily Iowan, October 2, 1945 supported by other accounts.

[11] Op. cit., Baxter.

[12] Op. cit., Page and Astin.

[13] Op. cit., Baxter.

[14] From faculty folders (Josef Jauch, Louis Turner) in the Department of Physics.

[15] Ibid.

[16] From folders of Turner and C. J. Lapp, Department of Physics.

[17] From "Conversation of Feb. 12, 1948 of J. A. Jacobs and L. A. Turner" in Physics Department folder of President Hancher's archived files of 1947-1948.

[18] "Proposal for a Research Contract between the Office of Naval Research and the State University of Iowa for Nuclear Research with the Van de Graaff Generator" sent to Washington by Professor Turner 4-28-1948.

[19] From Melvin Gottlieb's folder in Department of Physics files.

[20] In letter from J. A. Van Allen to Dean Dewey B. Stuit dated 17 March 1950 in Physics folder for the year in files from the College of Liberal Arts now in the University Archives.

Blank page

Chapter Nine

In Pursuit of Cosmic Rays

> The subject is unique in modern physics for the minuteness of the phenomena, the delicacy of the observations, the adventurous excursions of the observers, the subtlety of the analysis, and the grandeur of the inferences.[1]

Cosmic ray physics received the above tribute from Karl K. Darrow, longtime (1941-1966) Secretary of the American Physical Society. While some might well challenge him for considering the qualities of minuteness and delicacy to be unique to this one field of physics, few would differ with him on "the adventurous excursions."

Explorers of the intense and highly penetrating radiation have carried their research gear deep into mines, lakes and oceans and up the slopes of mountains. Their electroscopes and detector-counters have flown in balloons, airplanes, rockets, and recently in many spacecraft.

It was around 1900 that the search began for a mysterious something that was imparting an extra bit of ionization to electroscopic instruments. By the year 1912 Austrian Viktor Hess had reported from his balloon-flight data that the rays were coming in from outside the earth. He called the extra charges on his electroscopes "Hohenstrahlung," or high-altitude radiation. American physicist Robert A. Millikan is credited with supplying the name of cosmic rays in 1925.

At the University of Iowa experimental research in cosmic rays began with the arrival of Melvin Gottlieb in September 1950 and that of James Van Allen in January 1951. With the assistance of such graduate students as Leslie Meredith and Raymond Ellis, preparations started for a variety of "adventurous excursions."

In November 1951 Van Allen disclosed some of his plans for 1952 at a national symposium on the upper atmosphere meeting in San Antonio, Texas. He presented a paper, "The Nature and Intensity of the Cosmic Radiation."[2]

After summarizing much of the current state of knowledge on the topic, he emphasized some recent developments in sensing apparatus and equipment carriers. Encounters with the primary radiation, before its disintegration upon striking atmospheric particles, were now feasible.

Van Allen reviewed some of the results of rocket measurements above White Sands, New Mexico and above naval vessels between the Equator and the Gulf of Alaska. Then he said that his Iowa group was now planning to probe into the cosmic radiation above some higher latitudes:

> The north magnetic pole (near Thule, Greenland) is readily accessible during the summer months. The author and his associates are, at present, organizing a rocket firing expedition to this region with the assistance of the Office of Naval Research and the Navy Bureau of Aeronautics. Pending the outcome of this expedition (probably summer, 1952) one must be content with such data as now exist.[3]

The months following Van Allen's announcement were busy ones in the relevant parts of the Physics Building. The south end of the basement brimmed with supplies, tools, and apparatus and with rocket cases and instruments under construction. Directly above the design and assembly laboratories the departmental machinists built frames and other structural parts for the particle counters, altimeters, and transmitters.

Large quantities of aluminum and magnesium and alloys of each were added to the metal stocks of the shop. Weight had become a more critical factor in the specifications. Instrument machinists J. G. Sentinella, Edmund Freund, Robert Russell, and Robert Markee also joined in some of the activities outside the shop--in the launching of balloons and in helping to follow the flights from the top of the building.

On January 27, 1952, for instance, a cluster of small balloons rose from the University's playing fields on the west side of the campus. .The cluster carried the instrumentation of graduate student Leslie Meredith: three geiger counters, an altimeter, and a radio transmitter. This assembly was expected to descend somewhere in Illinois, but it disappeared in the snow of the Midwestern winter.

"There was good data, however, from the first day of the flight," Meredith told the Daily Iowan on February 2.

Such preliminaries, followed by balloon-rocket sequences lofted in May and June at White Sands, New Mexico, served as testing exercises for the summer launches in the Arctic. As the DI was to report on July 25, 1952, Van Allen and Meredith had left the campus on the day before with some 3,000 pounds of apparatus and supplies for a series of balloon-rocket launchings from a ship in the waters to the west of Greenland. The balloons were to carry the rockets to altitudes around 55,000 feet before their firings by means of time and altitude release mechanisms. The balloons were expansible to 55 feet in diameter. The rockets were 12 feet long.

Besides the Arctic expedition other extracurricular events occupied the time and minds of members of the department. Most notably, the American Association of Physics Teachers (AAPT) chose to hold its national summer meeting in Iowa City in conjunction with the annual Colloquium of College Physicists, June 11-14. George Stewart, then 76, served as host for the joint sessions.

The combined presentations attracted a record June attendance, more than 175 physicists from 80 colleges in 25 states. In the top feature of the Colloquium part of the program, George Uhlenbeck of the University of Michigan gave a series of four lectures, two of them on the topic, "The So-Called Elementary Particles." A major paper of the AAPT program was "A Survey of General Physics Laboratories in the U.S." presented by Sanborn Brown of the Massachusetts Institute of Technology.

One of the fruits of combining the AAPT and CCP sessions was the achievement of the first written record of the proceedings of the annual June meetings at the U of I. From tape recordings of most of the program, transcripts were sent to the speakers for editing and revising. Each author was then to provide 250 copies of his paper for the volumes to be bound.

As a result of these procedures the books reflected a variety of copying processes and lacked continuous pagination. But the committee in charge of preparing the volumes hoped

> ... that this book will serve as an intermediate stage between presentation of ideas at a meeting and publication in the American Journal of Physics. The result should be a better article when finally published in the journal.[4]

The volumes also listed and described in considerable detail some thirty demonstrations of teaching devices, an annual exhibit event which had been a part of the summer colloquium since 1939. Frank Verbrugge of Carleton College was awarded a first prize of $40 for his "Dynamic Model of Magnetic Resonance Phenomena."

Early in July during that strenuous summer Van Allen broke away briefly from the preparations for the upcoming Arctic trip to assume a twofold role at the summer meeting of the American Physical Society in Denver, Colorado. On July 2 he both presided at a session on the upper atmosphere and presented a paper: "The Distribution of Atmospheric Ozone between 25 and 65 km Altitude."[5]

For the readers and audiences of the area's news media the Arctic expedition became the most celebrated activity of the year involving The University of Iowa. Van Allen, Meredith, and electronics technician Lee Blodgett returned to the campus to find themselves viewed as pioneers and major achievers. The top head story of the Daily Iowan on October 16, 1952 began:

> A 'first' in scientific history has been scored by three State University of Iowa physicists who recently combined man's oldest device for flight, the balloon, with his newest, the rocket, and sent electronic instruments to a height of 47 miles above their floating base, a coastguard vessel in the icy waters west of Greenland.
>
> Today the U.S. Office of Naval Research released the story of the seven balloon and rocket flights which recorded cosmic ray intensities as high as 250,000 feet above the geomagnetic north pole region.

As the story unfolded in the DI and in other accounts of the pioneering expedition:

On July 29 the Iowans boarded the East Wind, a 269-foot ship, at Thule, then a relatively secret U.S. base on the west coast of Greenland. The ship then moved through the glacier flanked channels above Baffin Bay with supplies for the Canadian and American weather observers at Alert on the northern tip of Ellesmere Island. During the three weeks of the up-and-back trip amid the floating ice, Van Allen, Meredith, and Blodgett uncrated and assembled their apparatus. They improvised a shipboard laboratory.

Near Thule again, on August 21 they released their first balloon-rocket combination from the icebreaker's deck. The rocket, however, did not fire in the 40-below-zero climate reached by the balloon. In a second attempt two days later the timing mechanism again failed to trigger the rocket.

Van Allen then improvised a switch warmer, inserting a heated and insulated can of orange juice into the release gear for the third attempt. On August 28 the rocket shot out of its balloon suspension at a height of 38,000 feet and soared above 200,000 feet. On the next day two more flights reached altitudes of around 250,000 feet. On August 31 and September 4 flights six and seven attained some 225,000 feet each.

The first scientific report from the data acquired on the trip bore the title, "The Cosmic Ray Intensity Above the Atmosphere Near the

Geomagnetic Pole." Van Allen was to present the report as an invited paper on November 28 at the St. Louis Meeting of the American Physical Society, but a Thanksgiving weekend blizzard hit the Midwest. The train which Van Allen was riding from Iowa to St. Louis was delayed, and he did not arrive in time to deliver his paper. He then submitted it for publication in the Italian science journal Nuovo Cimento, where it appeared in the May, 1953 issue.

The Arctic atmosphere probes of 1952, followed by similar expeditions up there during the next three summers, resulted in widespread recognition of the department's efforts in cosmic ray research. With the altitude surveys later augmented by the balloon flights of Frank McDonald and Kinsey Anderson, the atmospheric explorations of the department received the most public attention during the early 1950's. Yet the major effort in experimental research in the department, both in terms of the man-hours and of the funds expended, was devoted to developing the equipment in the nuclear laboratories.

After the post-war closing out of the radio proximity fuse project, in which the nuclear physics group led by James Jacobs was especially involved, these men returned to work with their accelerators. Graduate students who had responsible roles in the department's work on the weapon accessory--William Nickell, Robert Holland, John Wahl, and Philip Malmberg--resumed their programs in nuclear research. In both the late 1940's and the early 1950's the nuclear group had the bulk of both graduate students and technicians within the department.

The nuclear faculty of Jacobs and Edward Nelson, who had arrived in 1949, was augmented in September 1951 by another young assistant professor. Richard R. Carlson, then 28, came from the Enrico Fermi Laboratory of the University of Chicago, where he had completed his work for his doctorate early that summer. The Physical Review published Carlson's dissertation at Chicago, Energy Release in the Disintegration of Be^8, in November 15, 1951 as an article of nuclear research.

Jacobs and his associates, students, and technicians were to work for several years at the rebuilding and refurbishing of the statitron accelerator which Alexander Ellett had acquired before the war. Although it was reported early in 1948 that a small and usable ion beam had been achieved, the Van de Graaff continued to break down and to be plagued with one problem after another. The inner support structures had to be replaced. Multiple improvements also of the circuitry and of the power and vacuum systems were needed before the machine and its associated apparatus could be ready for the continuous and reliable operations necessary for it to contribute to a research program.

Despite the numerous man hours of concentrated labor in the laboratory and in the supporting machine shop, it was not until 1953 that the Van de Graaff was cited as apparatus contributing to research reports and published articles.

During these years of frustration the Cockroft-Walton accelerator of pre-World War II effectiveness was revived and extensively refurbished to fill the gap in supplying the needed ion beams. In 1950 graduate student Wayne R. Arnold described the machine's renovated usefulness in an article for the Review of Scientific Instruments: "A 500-Kilovolt Linear Accelerator Using Selenium Rectifiers." Arnold had been able to use the Cockroft-Walton for his 1950 dissertation: Angular Correlation in the Reaction $F^{19}(p.\alpha)O^{16}(\gamma)O^{16}$.

The Cockroft-Walton then served as the beam apparatus for other graduate students and for studies by Nelson and Carlson. As late as 1955 there were three U of I contributions that year in the Physical Review in which this accelerator was cited as research apparatus.

While the nuclear group persevered in the advanced training of their students and in offering a modest amount of publishable research, they were forced to expend a major portion of available resources, in time as well as in money, on efforts to bring their troublesome equipment to a level of adequacy. Free of these large-machine burdens, the new cosmic ray group and the theoretical physicists were more visibly making progress in their special fields.

During the 1950's in the Iowa Physics Building it was the theorists who felt that they were doing the most significant work within the department to extend the frontiers of physical knowledge. They were defining and relating the basic building blocks of matter and energy. They were the greatly enriched heirs of a procession of break-throughs in elementary particle studies. Further enhancing the prestige of their field was the awareness that theorists like Einstein, Bohr, Wigner, and Wheeler had cleared the way toward the development of nuclear fission and fusion.

Josef Jauch evinced considerable pride in the competence of his group in a letter to the Graduate and to the Liberal Arts deans on March 19, 1954. He asked for the employment of another theorist to help with the growing work.

> With the addition to the present staff of one research associate this can become one of the best theoretical research centers in the middle west, successfully competing for students and general recognition with all the neighboring institutions except perhaps Chicago.[6]

To this letter he added a bibliography of 24 papers and reports published by the theoretical group in the period of 1947 through 1953. As to work in progress toward publication Jauch said that

> Dr. Rohrlich and I are about to finish the manuscript of a book on the theory of photons and electrons, technically known as quantum electrodynamics. It is the first book of its kind and contains a great deal of new material.[7]

Jauch had begun to formulate plans for this book in 1951 when he was holding a Fulbright research scholarship at Cambridge University. He had felt that there was a need to compile and systematize the accumulating agenda in quantum mechanics. This work was to engage a large part of his time for the next four years. With Fritz Rohrlich, who had joined the U of I staff in 1953, as co-author, The Theory of Photons and Electrons was published in 1955.

Like Jauch and Coester a migrant from central Europe, Rohrlich had been lecturing at Princeton in 1951 to 1953 on the subject of quantum electrodynamics. In so doing he had organized some of the future contents of the book while preparing his lecture notes.

Born in Vienna in 1921 Rohrlich had earned a Chemical Engineering degree in 1943 at the Institute of Technology in Haifa, Israel. He had then come to the United States where he progressed to a Ph.D. degree in physics in 1948 at Harvard University. During his first three postdoctoral years he worked with the well-known theorist Hans Bethe as a research associate at Cornell University.

Over the years 1948-1952 Rohrlich had ten listings in the Physical Review. In 1950, for instance, the journal published his "Quantum Electrodynamics of Charged Particles Without Spin" and his "The Self-Stress of the Electron."

In common with other scholarly publications The Theory of Photons and Electrons used footnotes and an author index at the end of the book to acknowledge contributions of other physicists. In this index two names--Bethe, H. and Pauli, W.--were each followed by sixteen different page numbers. The authors' colleague at the U of I--Coester, F.--was followed by seven page listings. And in a page 142 footnote of the book, Jauch and Rohrlich relied on their Iowa associate to help them make a point:

> F. Coester (Phys. Rev. 84, 1259 [1951]) has shown that the principle of detailed balance holds generally if the summation over the spins of the initial and final states is carried out.

As the years followed one another in the 1950's, the cosmic ray group continued with their summertime explorations above the waters west of Greenland. During the 1953 expedition Melvin Gottlieb, Leslie Meredith, and Raymond Ellis released 16 combinations of balloons and rockets, reaching a top altitude of 64 miles. They were able to start their rockets from greater balloon heights in their firing procedures.

At the beginning of the summer of 1953 Van Allen started a year's leave of absence at Princeton University, where he helped to develop models of apparatus to harness the thermonuclear energy of deuterium. Van Allen had been consulting with Professor Lyman Spitzer of Princeton on this project since early in 1952; in particular on a controlled fusion device known as the B-1 stellerator.

After his return from his 1953 summer in the Arctic, Meredith went to Princeton to serve as an assistant to Van Allen during the 1953-1954 academic year. When Van Allen returned to Iowa in the summer of 1954 it was Gottlieb who took his place in the fusion work at Princeton.

The 1950's were also years when the nuclear scientists of middle America worked and campaigned strenuously to obtain a huge high-energy accelerator so that the Midwest might have a machine comparable to those being built at Brookhaven, N.Y. and at Berkeley, California. All the Big Ten Universities and several others joined forces in the Midwestern Universities Research Association (MURA) which was organized to design and to take steps toward procuring such a machine. Most of the member universities also proposed sites near their campuses as suitable locations for a giant new cyclotron.[8]

During the early planning years for the MURA accelerator Josef Jauch represented the U of I on the scientific board of directors. In support of the program he pointed out that midwestern scientists had done much of the pioneering work with such sub-atomic particles as the recently discovered mesons but needed a multi-billion volt accelerator in order to clear up some of the mysteries of the properties of the mesons.[9]

Francis Cole, who had joined the U of I faculty as an instructor in 1951 prior to receiving his Ph.D. from Cornell University in 1953, served from 1954 until 1964 as the U of I's member of the design staff for the proposed machine. This working group started at the University of Illinois, then moved to the University of Wisconsin, and later to the University of Chicago. In 1956 James Jacobs succeeded Jauch as the U of I scientist on the MURA board.

Up until fiscal year 1956 the nuclear group received and spent the major portion of the department's funds for research. That year the cosmic ray group in its preparations for the multiple vehicles of the International Geophysical Year (1957-58) first surpassed the nuclear group in funding. More than tripling its expenditures from federal funds from 1955 to 1956, the cosmic ray research outlays grew from $37,608 to $105,354 from the one year to the next.[10]

For the fall semester of 1954-1955 the department enjoyed the presence of a visiting professor of considerable distinction and of far-reaching influence. He was Sydney Chapman, English geophysicist who had become the principal leader in the organization and preparations for the International Geophysical Year (IGY) of 1957-1958. Thus, the Physics Building for several months became a focal site in the planning for the largest and most widespread cooperation of Earth's scientists.

In a sense the department had some involvement in IGY from its beginnings in the minds of a few men. The global enterprise can trace its roots to an after-dinner discussion at the home of James Van Allen on April 5, 1950, then in Silver Spring, Maryland. At that time a research director for the Applied Physics Laboratory there, he had invited a few people to talk with Professor Chapman who was visiting in the Washington, D.C. area.[11]

Out of their discussion grew the conviction that the time was approaching for another international cooperation like the Polar Years of 1882 and of 1932. Most of the world was relatively peaceful, and 1957-1958 would be a peak period of sunspot activity. One of the guests that evening was Lloyd Berkner, a veteran of the first Antarctic

Expedition with Admiral Byrd and long a spokesman-administrator in international scientific relationships. Berkner is credited with making the opening suggestion for IGY. Another guest was S. Fred Singer, an early advocate of an earth satellite program. And as early as 1948 Van Allen had presented a paper on the scientific usefulness of an orbiting spacecraft, this at a meeting of the International Union of Geodesy and Geophysics held in Oslo, Norway.

From its inception among a few scientists that spring night of 1950 IGY planning began to grow. Chapman, Berkner, and others advanced and promoted the program with the leadership of international and national organizations in the sciences. By 1952 the International Council of Scientific Unions had adopted the recommendation for an IGY extending through the eighteen months from July 1, 1957 to December 31, 1958. The Council appointed a special committee CSAGI (Comite Special de l'Annee Geophysique Internationale). Chapman was named as president and Berkner as vice-president of CSAGI. Then came the formation of national committees, and Joseph Kaplan, a physicist of the University of California at Los Angeles, became the chairman of the United States National Committee for IGY. Kaplan had been a major organizer of the influential symposium of 1951 in San Antonio, Texas, Physics and Medicine of the Upper Atmosphere. For that occasion he had chosen Van Allen to summarize the current knowledge of cosmic radiation, also to chair a session on research vehicles into high altitudes.

Thus, during the formative years of IGY, Van Allen's associations with scientific leadership and his own considerable amount of professional work brought increasing recognition of the cosmic ray group in Iowa City. Despite their remoteness from national centers of space technology, despite their lowly to modest facilities and resources, they moved persistently toward a role in the pioneer explorations with the nation's rocket systems. In basement laboratories obscurely deep within America's Corn Belt they developed apparatus for a variety of carriers.

On July 29, 1955 the White House announced that the U.S. would launch a "small unnamed earth circling satellite" as part of the U.S. participation in IGY. The next day the Soviet Union made a similar announcement.

On September 9 a letter from the Department of Defense authorized the Secretary of the Navy to proceed with a rocket system proposed by the Naval Research Laboratory and designated as Project Vanguard.

Dated September 28, 1955 was the first plan for an onboard satellite experiment to reach Chairman Kaplan of the U.S. National Committee for IGY. Submitted by James Van Allen, George Ludwig, and others at The University of Iowa, "A Proposal for Cosmic Ray Observations in Earth Satellites" included a cost estimate of $66,125. for approximately three years work, including data reduction and publication of findings. Their flight apparatus could be completed in about one year's time, if need be. The necessary instrumentation could be adapted for a larger spacecraft if a more powerful rocket than the Vanguard's first stage should become available.[12]

At the time of the U of I's first satellite instrument proposal, Ludwig was still an undergraduate student, of senior standing and employed in the department as a research aide. Actually, he was performing as the satellite project engineer. Then 28, he had served six years in the U.S. Air Force as a pilot and electronics officer before coming to the University in 1953. He was a take-charge type of person, as well as skillful with hand and machine tools; in general, he was the kind of man Van Allen needed to manage much of the transitional work from "rockoon" to satellite apparatus. Ludwig had been on the 1954 summer expedition to the Arctic.

Student research assistants contributed considerably to the cosmic ray group's explorations with uplifted instruments, through a progression of carriers from balloons and rockets to spacecraft. In addition to Ludwig, in 1955 the principal student assistants included:

Laurence Cahill, a native of Maine and a 1946 graduate of West Point, who after a few years as an army officer, elected to come to Iowa for graduate work in physics.

Carl McIlwain, a Texan youth, had earned his first degree in music education at North Texas State University in 1953. He came to Iowa to do graduate work principally in acoustics, then became most interested in cosmic ray research.

Ernest C. Ray came from St. Joseph, Missouri to earn all three of his degrees in physics at Iowa--B.A., 1951; M.S., 1953; Ph.D., 1956. After receiving his doctorate with emphasis on the theoretical and mathematical aspects of space physics, he became an assistant professor in the U of I physics department.

On the teaching and research faculty in the cosmic ray group, Frank B. McDonald, a Georgian with his Ph.D. from the University of Minnesota, took the place of Melvin Gottlieb who left in 1954 for Princeton University.

In 1955, as the scope of cosmic ray research and its funding at the U of I continued to expand, Kinsey Anderson, another U of Minnesota Ph.D., was brought in as a research associate.

Shortly after the U of I space group submitted the first proposal for experimental apparatus on America's first spacecraft a national scientific planning committee was established, in part to give more attention to those who would actually use the craft for knowledge of Earth's environment. On October 2, 1955 the U.S. National IGY Committee named a Technical Panel for the Earth Satellite Program. One of the eight members of the TPESP was James Van Allen.[13]

In January 1956 the TPESP formed a Working Group on Internal Instrumentation, with Van Allen as chairman. While this group did not hold its first formal meeting until March 2, the chairman made an early start on the problems that would be coming up. The Upper Atmosphere Rocket Research Panel, which had begun at White Sands, New Mexico in 1946 and of which Van Allen was chairman, was holding its annual meeting at Ann Arbor, Michigan on January 26-27. The meeting's agenda include a Symposium on Scientific Uses of Earth Satellites. To this symposium research groups across the nation were invited to present plans and specifications for experiments suitable to the early spacecraft.

The proposals for satellite cargo space turned out to be various and numerous. Van Allen collected a twenty-pound stack of paper from the two-day meeting, too bulky a pile for his luggage back to Iowa City. He resolved this problem by stuffing a laundry-mailing case which he bought in an Ann Arbor store near the University of Michigan.

Problems of arriving at a priority list for the on-board space cargoes proved to be very difficult. The situation was aggravated by uncertainties as to the shape, size, and weight of the container to be orbited. Some of the most concerned persons, including Van Allen in particular, sought a cylindrical spacecraft with the most possible weight devoted to their scientific experiments. Others wanted a spherical shape to simplify the tracking from the ground, to avoid tumbling problems, and to achieve more temperature control, particularly by putting an inner sphere within the outside shell. Such a double globe, however, would greatly increase the inert weight at the expense of any scientific payload.

Only a few months after the Ann Arbor meeting a compilation of thirty-three of the presented papers became a book, Scientific Uses of Earth Satellites, edited by Van Allen and published by the University of Michigan Press during the summer of 1956. The papers printed therein ranged from orbital and tracking analyses through various proposals for on-board experiments, including the U of I's plan for cosmic-ray observations. The editor pointed out in the preface of the volume:

> The authors are, for the most part, seasoned veterans of physical research at high altitudes, using rockets as vehicles. Such work forms the tangible foundation for the competent utilization of satellites for scientific purposes.

The months following the symposium in Ann Arbor became a time of anticipation, repeated frustrations and much dogged labor in the small rooms off the basement hallway of the Physics Building in Iowa City. Since September of 1955 the total weight of the spacecraft to be orbited in Project Vanguard had been tentatively set at 21.5 pounds. Ludwig and his helpers succeeded in scaling down the U of I experiment to around eight pounds, but the schematic design of the Naval Research Laboratory was allotting only two pounds out of the 21.5 to experimenters' instruments.

Van Allen wrote to John Hagen, Vanguard director, to urge that half of the initial group of satellites carry a payload of cylindrical shape, each of them 18 inches long and six inches in diameter. Such configurations could reduce the inert weight of the orbiting body by half and thus provide eight pounds for scientific instruments. The Iowa group had an instrument assembly to detect and record whatever radiation was up there, provided they could secure adequate cargo space.[14]

At any rate, the preparatory activities of the cosmic ray group were beginning to make The University of Iowa a focal point for the anticipated Age of Space. Throughout the state Iowans were becoming increasingly aware that something in the nature of a complex learning device, built on Iowa land, might soon be hurtling hundreds of miles above them at speeds approaching 20,000 miles per hour. And they were told that the carrier of the U of I apparatus might even be visible in southern Iowa, to someone peering upward with good binoculars at the appropriate moment.

It is generally assumed that the Age of Space abruptly opened with the launching of Sputnik 1 into orbit on October 3, 1957.

Perhaps that event could be termed the grand, or formal, opening of on-the-site exploration beyond the Earth's atmosphere. Yet programs of such magnitude grow over periods of time with preliminary stages of development and accomplishment.

Actually the first penetration of space (clearly beyond the then known atmosphere) with an instrumented payload was achieved in February 1949 above White Sands in New Mexico. A two-stage rocket known as the WAC-Corporal reached an altitude of 244 miles. Then in September 1956 the upward reach was more than doubled. A combination of propulsion units engineered by Wernher Von Braun for the U.S. Army climbed to 550 miles as it ranged a distance of 3300 miles.

This feat of the Army's Redstone system, along with its capability of lifting a much larger payload, raised many questions about relying wholly on the unproven Vanguard system to hoist America's first earth satellites. Van Allen was an early supporter of the Redstone, which had been developed from the German V-2 rocket. He had had several discussions with Ernst Stuhlinger, one of Von Braun's principal associates, on the subject of rocket performance.

When the Vanguard was chosen in August 1955, scientific leadership for the IGY and Department of Defense (DOD) officials had concurred on using a non-military system for US-IGY launchings. The nurturing of international cooperation seemed to call for a minimum of secrecy and for non-association with the machines of war. The DOD was also concerned about non-military diversions from the development of long range ballistic missiles. Other considerations included estimates of comparative costs and the avoidance of aggravating the rivalries among the branches of the armed services.

Largely because of its record in applied research operations, particularly with Viking rockets at White Sands, the Naval Research Laboratory (NRL) was placed in charge of the Vanguard project. Scientist-administrator John P. Hagen, the superintendent of NRL's astronomy and astrophysics division, was named as director of the project. The first-stage booster rocket was to be a slim 40-foot variation of the Viking, also to be built by the Glenn L. Martin Company.

Then followed some thirty months of tribulations for Director Hagen and for the other leading figures in the US-IGY satellite program. Difficult contractual discussions, with many conflicts between the NRL engineers and scientists and the officials of the prime contractor, delayed the progress of the new rocket system. Configurations, weight, and power requirements for each of the three stages had to be ironed out. The prospective size and shape of the spherical payload fluctuated and shrunk, to the almost continuous frustration of would-be investigators, like, for instance, the cosmic ray group at The University of Iowa.

Disenchantment spread from the involved people across the national public scene as a result of the events of two days late in 1957:

On October 3 Russia announced the first launching of an earth satellite: Sputnik 1. When the news came to Washington, D.C. many U.S. space scientists and engineers were attending a party in the Russian Embassy for members of the International Rocket and Satellite Conference. Van Allen was not there. He was on a rockoon-launching cruise into the Antarctic. But George Ludwig was at the conference and the party, representing the Iowa group and presenting their papers at the meetings. He expressed his feelings about the Russians being able to put several hundred pounds into orbit while the U.S. was still unable to achieve a twenty-pound satellite.

Then on December 6 the first Vanguard attempt to lift all three stages, an event preceded by considerable anticipation and ballyhoo, resulted in a blow-up on the launching pad. The explosion further upset the Americans who were chagrined over Russia's first entries into space. The combination of Sputnik successes and Vanguard failures affected public attitudes on the effectiveness of scientific and technological education in the United States.

On November 8 a new Secretary of Defense, Neil McElroy, instructed the Army to go ahead with its own satellite launchings. The directive had been anticipated at the Redstone Arsenal at Huntsville, Alabama, at the Jet Propulsion Laboratory in Pasadena, Calif., and at the University of Iowa. Stages of the Jupiter-C rocket system and the instrumental payload for the satellite were all in the processes of being made ready for flight. As early as October 9, Maj. Gen. John Medaris, Commander of the Army Ballistic Missile Agency, had ordered Wernher von Braun to take a Jupiter-C rocket off the shelf and get it ready to go to Cape Canaveral.

On November 1 Ludwig took the prototype of the U of Iowa cosmic ray experiment to the Jet Propulsion Laboratory (JPL) in order to adapt the equipment to fit into the fourth stage of the Army's satellite system.

In the words of Ludwig in the introduction to his 1959 master's degree thesis on the instrumentation for the first Explorers:

> Following the successful orbiting of the first USSR satellite in October 1957, the U.S. Army was given permission and support by the National Academy of Sciences to place a series of satellites in orbit with its tested and proven Jupiter C rocket configuration. At this time, the Iowa program was at a logical breaking point, with design of the apparatus completed and with fabrication of flight payloads ready to begin. Because this program could be completed to fit the Jupiter C rocket configuration with a minimum of modification and delay, it was transferred from project Vanguard to the U.S. Army satellite project by NAS on 6 November 1957. Since the University of Iowa laboratories lacked the facilities necessary to fabricate and test the instrumentation in as short a time as was desirable, this work was delegated to the Jet Propulsion Laboratory, Pasadena, California.

With the national leadership in the space program pushing for a January 1958 launch of the Jupiter 6 system, there was little more than two months for the changeover from the Vanguard system. The additional weight of the tape recorder would have meant too much extra work for the limited time on the spin stabilization of the propulsion system, so the on-board data storage device was postponed for a later flight.

Ludwig was the lone Iowan in the conversion and adaptation procedures at the Jet Propulsion Laboratory, and he was working with senior scientists and engineers of that large and prestigious organization. Despite his experience and competence he was bound to be viewed as a young man of junior status, a graduate student from a relatively small and rustic laboratory. He was in Pasadena with the cosmic ray experiment from Iowa because it was the most feasible apparatus to convert from one system to another. The JPL people took over the leadership and publicized their role, virtually excluding the Iowa contribution to the effort in the national press releases.

Late in the evening of January 31, 1958 Explorer 1 lifted off smoothly into its earth orbit. Two hours later an anxious and soon a jubilant nation learned that "Goldstone has the bird," meaning that the satellite was successfully completing its first orbit and its telemetry had been picked up by the dish antenna in southern California. In Washington, D.C. a picture was taken and widely printed of Wernher Von Braun, James Van Allen, and William Pickering, Director of JPL, in a joyous posture. The three men were holding a model of the satellite high above their heads.

In early February magnetic tapes from receiving stations around the world began arriving at JPL, where they were transcribed and then sent on to Iowa City. The charged particle counts in the orbits over the United States tended to match expectations, but something mysterious seemed to be happening in the higher reaches of the satellite over South America. (Explorer 1 ranged from 224 miles in its first perigee to 1,584 miles in its first apogee.) From the data coming from Quito, Lima, and Antofagasta the counts were going up rapidly around 500 miles up; then they dropped to zero.

Puzzled by the gaps and lapses in the incoming information, the Iowa group wondered if there might be some strange functioning in their apparatus, some disorderly conduct between detector and transmitter. They also considered the effectiveness of the receiving equipment in the ground stations. They looked forward to the flight of the next Explorer, which would carry the tape recorder and would release whole orbits of data on command. With Explorer 1 the receiving stations were able to pick up only about ten percent of the spacecraft's telemetry. Over much of the oceans and over much of the land areas no station was near enough or sufficiently prepared to receive the data.

On March 5 a malfunction in the ignition and separation of the fourth-stage rocket plopped the Explorer 2 satellite into the Atlantic Ocean, and with it the first tape recorder to be launched. A backup system was soon brought to readiness. On March 26 the crowds at Cape Canaveral saw Explorer 3 lift off toward what proved to be a productive series of orbits.

The magnetic tape in the data storage device collected full orbits of information. Then its return spring released 116 minutes and 30,000 miles of travelog in a reporting span of six seconds. Girdling the earth like nothing before it, the tape recorder unburdened itself a dozen times a day to a "picket line" of receiving stations from Blossom Point in Maryland to Santiago in Chile.

Although it was designed for maximal durability and performance, the tape recorder weighed only eight ounces and measured just 2½ inches in diameter. Under Ludwig's direction, Edmund Freund, a department instrument maker, fabricated and joined the parts of four of these devices during 1956 and 1957. He averaged about 500 man-hours of work on each tape recorder.

As Explorer 3's voluminous supply of data confirmed the charged particle counts of Explorer 1's much lesser amounts of information, excitement mounted among the data analysts in the Physics Building. They knew they were closing in on something big in the environmental phenomena of their planet. They might very well have achieved the finding of experimental evidence in situ for the speculations of such theorists as Carl Störmer and Jules Poincaré some fifty years previously, and of Sydney Chapman and Hannes Alfvén in the 1940's. In essence the work of these astrophysicists had pointed toward the trapping of charged particles in zones of the earth's magnetic field.

Within the first few days of April the Iowa group decided that they had enough evidence to make a credible first report. If they were to delay the announcement of the experience of their instruments, others might beat them to the draw. It was possible that one of the Sputniks might have gleaned something of the same phenomenon. The history of science contains a number of examples of delays in the reporting of pioneering work, with the result that discovery events have been clouded and obscured.

Van Allen conferred with US-IGY leaders, and it was decided that he announce the satellite findings in a Washington, D.C. setting appropriate for the occasion. There he would present a research paper, "Observation of High Intensity Radiation by Satellites 1958 Alpha and Gamma," the work of four U of I physicists--Van Allen, G. H. Ludwig, E. C. Ray, and C. E. McIlwain.

In Iowa City, under the guidance of Ernest Ray, the University Information Service prepared a news release to be available for distribution in Washington in conjunction with Van Allen's presentation of the paper:

> WASHINGTON, D.C., May 1 -- Unidentified radiation so intense as to overwhelm cosmic ray counters aboard Explorers I and III was revealed today at a special joint meeting of the National Academy of Sciences and the American Physical Society.
>
> In the satellites' reports from the far reaches of their orbits--beyond 1,000 miles out--counts of particle pulses per second soared to rates hundreds of times greater than had been expected, Iowa physicist James A. Van Allen reported.
>
> While Explorer I's cosmic ray counts ran about 30 to 40 per second some 200 to 300 miles above southern California observing stations, the counts climbed to more than 35,000 per second at the highest altitudes of both satellites when these were above South America and adjoining waters.

> In fact, the radiation became so intense that it jammed the geiger tube so that it did not put out any counts, and "it took some detective work to find out what was going on," he said.
>
> To check the high counting rates in space, the four physicists used a "spare" of Explorer I which Ludwig recently brought to the Iowa campus from the Jet Propulsion Laboratory in Pasadena, Calif., where the final stages were prepared for the Jupiter-C launchings of Jan. 31 and Mar. 26. The apparatus in the "spare" was irradiated by an X-ray machine in the Iowa physics laboratory to test responses to such highly intense radiation.

Van Allen's report excited considerable interest around the world. Newspapers across the nation, and in many foreign countries bannered such headlines as FIND NEW PERIL IN SPACE and DANGEROUS BELT OF RAYS SURROUNDS EARTH on their front pages. Questions about the welfare of space travelers were raised in such accounts in the mass media. There was considerable bolstering of national pride. The report from Iowa had moved the United States a long step forward in the international space race, in the area of scientific discovery at least.

It could be advanced that no day in all of Iowa's history brought more recognition than May 1, 1958 to both the state and its university. In contrast with some other parts of the United States, international headlines rarely emerged from the state of Iowa, whether in the bannering of accounts of discovery, innovation, catastrophe, or sensational crime. Historical happenings of interest within the state seldom radiated beyond the boundaries and into other states. Even in the chronicles of westward expansion, the more famous explorers--Joliet and Marquette, LaSalle, and Lewis and Clark--seem to have circumvented the Iowa land. Military conflicts had their memorable battle sites elsewhere.

In the months to follow, the crowded basement of the Iowa Physics Building came to be viewed as one of the most famous laboratories in the world. Newsmen and other writers, aerospace officials, politicians, and scientists flew to Iowa City to talk to Professor James Van Allen and his young associates. Visitors included a television crew with Walter Cronkite from the Columbia Broadcasting System and a delegation of Russian space scientists led by Leonid Sedov and Anatoli Blagonravov, both men in the forefront of the Soviet space program and each a veteran leader of his country's representatives at international conferences.

Such visitors to the Iowa mecca of space science were often nonplused to find the laboratory area so small, crowded and unprepossessing, so lacking in modern furnishings and accessories. Publicized descriptions of the inadequate quarters for achievements of global influence helped to prepare the way for a new building for the department a few years later. It was pointed out that Van Allen's people were forced to do their work in a cluttered basement hallway.

The building which George Stewart had prophesied would serve the science of physics for at least a hundred years had turned out to be inadequate within less than fifty years. But in 1910 Stewart could not have foreseen the great increases in student enrollments, the rise of the Nuclear Age in the 1930's and 1940's and the Age of Space in the 1950's.

The much-publicized basement hallway ran the full length of the building's lowest level--a distance of 220 feet. The establishment of small offices at each end cut the length to 190 feet. With the north and central parts of the basement housing a variety of activities, including nuclear and solid state office-laboratories, the cosmic ray group was largely confined to the south end. The senior researchers with balloon-borne equipment, Frank McDonald and Kinsey Anderson, and their student assistants were established in the southwestern corner, and the "rockoon" program preempted the southeastern corner.

So it happened that the satellite instrument program was largely restricted to the office-lab of Ludwig, Cahill, and McIlwain (B6--300 ft^2) and the activity there spilled out into an enclosed 35-foot long section of hallway. Fortunately, the building had been designed with corridors of eleven-foot widths, and this basement section could be lined with workbench surfaces on both sides.

During the summer and fall of 1958 the work area of space physics expanded into and through the north end of the basement. The additional space was needed primarily for data reduction, with its growing numbers of tape recordings, reading and transcribing units manned and augmented by an increasing crew of data analysts, mostly student research aides.

Explorer 4, almost wholly a U of I production, was launched on July 26. It carried a quartet of detectors--two geiger tubes and two scintillation counters--as compared with the single geiger counters of both Explorer 1 and 3. The instrumental payload of this summer satellite had been engineered and assembled primarily by McIlwain and Ludwig through long days and often nights of intense activity in the south end of the basement. Explorer 4 and its backup Explorer 5 (which failed to go into orbit in August) were largely supported by funds from the Department of Defense.

The craft had a dual role: extending knowledge of the naturally trapped radiation discovered by the earlier Explorers and monitoring artificial spreads of particles following U.S. explosions of hydrogen bombs over the south Atlantic. The incoming data on the natural and on the artificial phenomena had to be separated. The information from the bomb blasts of Project Argus was for many months kept secret under military classification procedures.

Around two months of data from Explorer 4 represented some 3,600 passes of several minutes each from the satellite as these were recorded on magnetic tapes in 25 ground stations around the earth. The mass of transcribed tapes enabled the Iowa physicists to plot the intensity of the radiation at various latitudes and longitudes for altitudes up to 1,300 miles.[18]

Having scouted this far up into the radiation population, space physicists were eager to extend their reach. Van Allen succeeded in placing U of I detectors aboard the moon-directed spacecraft planned for the fall and winter of 1958-1959. Launched Oct. 11, 1958, the first lunar probe, Pioneer 1, climbed to nearly 70,000 miles out and revealed a little information, enough to give some confirmation to the speculation that the radiation continued out many thousands of miles. During the next month the Pioneer 2 launch was a victim of malfunctioning. But on its flight beginning Dec. 6 Pioneer 3, although falling far short of its intended goals, had a very successful trip out and back. Its data showed that there were at least two radiation belts around the earth.

Van Allen revealed the findings from the Pioneer 3 probe on December 27, 1958 at the annual meeting of the American Astronautical Society in Washington, D.C. He said that the instruments provided continuous data all the way through two distinct zones, with the first one peaking in particle intensity about 2,000 miles out and the second one strongest around 10,000 miles out.

His report on that occasion was "Survey of Radiation Around the Earth to a Radial Distance of 107,400 Kilometers." Listed as the report's co-author was Louis Frank, then a junior class undergraduate who had assisted in reducing and interpreting the data.

In another account of the productivity of the Pioneer 3 flight Van Allen wrote the following in an article entitled, "Radiation Belts Around the Earth," which appeared in the Scientific American issue of March, 1959:

> Although this rocket was intended to reach the vicinity of the moon, we were almost as pleased when it failed to do so, for it gave us excellent data on both the upward and downward legs of its flight, cutting through the radiation region for 65,000 miles in two places.

After the sensational break-throughs of 1958, Iowa instruments rode farther and farther into Earth's outer environment. In March of 1959 Pioneer 4, again with Iowa detector apparatus on board, passed the moon at a distance of 37,000 miles and then went into a perpetual orbit of the sun. The first American spacecraft to escape Earth's gravity, its solar orbit would take it to space locations more than 100 million miles from the sun and at times even farther from the planet of its origin.

In such deep space probing, the Russians, however, had again come in first. Two months earlier, during the first week of January, 1959, the USSR probe Luna 1 photographed the back side of the moon from a distance as close as 3,728 miles before lapsing into its solar orbit. Furthermore, the Russian spacecraft weighed 800 pounds, as compared to the 13 pounds of Pioneer 4.

In 1961 and 1962 the reach of Iowa instruments within Earth's magnetic field grew with satellite apogees of 48 and 61 thousand miles on the flights of the Explorers numbered 12 and 14. The radiation belts were revealed as parts of an encompassing magnetosphere extending outward to around ten Earth radii (about 40,000 miles). Instruments of other research agencies on other spacecraft filled more details into the blank areas of the developing spatial charts. These sensors expanded, corroborated, and revised the geophysical pictures pioneered by the earliest apparatus on the first Explorer satellites and on the first Pioneer probes.

While the cosmic ray group continued to advance their instruments and expanded into a growing space physics organization, an annual tradition in the Physics Building came to a close. The summer Colloquium of College Physicists terminated after its June sessions in 1959. George Stewart, who nurtured the Colloquium as his major emeritus activity, died in August 1956. Van Allen then managed to keep the annual event alive for three more years.

During the years of the 1950's the most celebrated portion of the Colloquia was the concurrent Associated June Lectures, in which a widely known and eminent physicist each year delivered a series of four lectures. These designated speakers were Edward Teller, 1950; George Gamow, 1951; George Uhlenbeck, 1952; E. U. Condon, 1953; J. H. Van Vleck, 1954; Bruno Rossi, 1955; Norman F. Ramsey, 1956; Richard P. Feynman, 1957; Arthur C. Ruark, 1958; and Thomas Gold, 1959.

Then with a letter bound into a historical souvenir record for the years 1936-1959 and dated May 6, 1960 Van Allen informed the Colloquium members of the discontinuance of the annual programs. In so doing he noted, e.g., the following reason for the decision:

> The welter of summer institutes and society meetings which are engulfing our profession--when coupled with the ease of modern travel--has obliterated the relative isolation which often characterized our situations as teachers of physics in the past. Hence, I feel that the unique role of the Iowa Colloquium no longer exists.[16]

Throughout the world of physics the broad-scope meetings for physicists in general were giving way to more limited gatherings of specialists exchanging the results of their work. At the U of I in the late 1950's, for instance, the theory group began to emphasize the regional conference as an interchange of their kind of research and as an opportunity for recognition in their area of expertise. Jauch, Coester, and Rohrlich hosted the Midwest Conference on Theoretical Physics in March 1956 and again in March 1957.

At the spring meeting of 1956 conferees representing twelve institutions from Nebraska to Ohio heard a total of fourteen papers. Coester presented "Rotational States of Spheroidal Nuclei." Kenneth Watson, a 1948 Ph.D. at the U of I who had become a professor of physics at the University of Wisconsin (Madison), offered "Many-Particle Scattering in Quantum Mechanics."

In the March of 1957 the meeting grew to include conferees from 22 institutions from Los Alamos, New Mexico to Columbia University in

New York City.[17] Rohrlich's paper, "Universal Weak Interaction" represented the U of I among the offerings on the program. The most anticipated and heralded paper was that of C. N. Yang, the year's Nobel Laureate from the Institute for Advanced Study, Princeton, N.J. His presentation bore the title, "Violations of Conservation Laws in Weak Interactions."

In some respects the years of the midwest conferences could be viewed as the peak prosperity time of theoretical physics at the U of I. The group was becoming restless and looking for greener pastures: it was to dissolve and scatter within a few years time. Jauch, who had provided spirited leadership for the theorists since 1946, resigned during the summer of 1959 to assume a professorship at the University of Geneva. Back in his native country he would again be closer to what he deemed the centers of advancing thought in his field.[18] Coester and Rohrlich stayed on until 1963, at which time Coester joined the theoretical physics division of Argonne National Laboratory and Rohrlich left for a post at Syracuse University.

In 1960 Max Dresden, then at Northwestern University, was persuaded to fill the gap that Jauch left by his departure to Switzerland. A native of Holland, with his undergraduate work at Amsterdam and at Leyden, Dresden had earned his Ph.D. degree in 1946 at the University of Michigan. He had then taught at the University of Kansas until 1957 when he joined Northwestern as chairman of the department of physics there. When at Kansas he had led in the beginning of the Midwest Theory Conference in 1950. Over the years he had been an invited participant and lecturer at a number of international conferences in the United States and in Europe. He was a visiting lecturer for the American Institute of Physics in a program to bring recent research to small colleges.

During some twenty years after World War II the Iowa physics department was not given the kind of continuity and stability provided by a faculty remaining for lengthy tenures. Scientists often viewed a stay at one university as a preliminary phase in their careers. The mushrooming expansion of challenging and profitable positions in academia, in government, and in industry had created an imbalance of demand well beyond the supply of qualified applicants. For instance, of those physicists who joined the U of I faculty between 1945 and 1958, only three chose to remain until at least 1980--Edward Nelson (1949--), James Van Allen (1951--), and Richard Carlson (1951--).

The theory group was to suffer the most disruption from staff departures, with Josef Jauch on leave in 1958-1959 before finally resigning. His successor, Max Dresden, remained only four years (1960-1964), departing for the State University of New York at Stony Brook, near Brookhaven National Laboratory and various Eastern centers of theoretical physics. After the resignations of Rohrlich and Coester in 1963, Dresden had become the lone senior theorist at the U of I. He was beset with the responsibilities of directing all the advanced work, and much else, in his and related fields. At that time the department could not attract another theorist of sufficient experience.[19]

While not lacking in senior personnel and in a continuing supply of able graduate students, the nuclear group experienced trying and frustrating times during the 1950's. Much of their productive research time was lost in the maintenance and in the delays for repairs of the outmoded and deficient Van de Graaff accelerator. In 1960 James Jacobs, the group director, who had been on the staff since his doctorate at the U of I in 1941, left to assume the departmental chairmanship at Virginia Polytechnic Institute. Richard Carlson succeeded Jacobs in the leadership role, and Edwin Norbeck came from the University of Minnesota to fill the vacancy in the faculty.

A native of Seattle with his B.A. degree in chemistry at Reed College, Norbeck had earned his Ph.D. degree at the University of Chicago in 1956. He served at Minnesota as a research associate in physics from 1957 until 1960. During 1957 he had been published twice in the <u>Physical Review</u>, both times on the subject of nuclear reactions induced by lithium ions.

Despite the continuously heavy outlays for accelerator rebuilding, the combination of state and federal funding enabled the nuclear group to enlist the services annually of postdoctoral staff members. One of these research associates, Stanley Bashkin, appointed in 1953, stayed on to rise in the ranks to assistant professor and then to associate professor. A native of Brooklyn, N.Y., he had earned his Ph.D. at the University of Wisconsin in 1950 and had then served for three years on the faculty of Louisiana State University.

Bashkin's active role in the reporting of research experiments substantially increased his group's contributions to the Physical Review. In 1954, for instance, he published "$Li^7(d,p)\ Li^8$ Yield Curve." In 1955 he supplied, with R. R. Carlson and E. B. Nelson as co-authors, the paper "Radiative Capture of Protons by N^{14}"; in 1957, with Carlson as co-author, "Gamma Rays from the Proton Bombardment of N^{15}."

Bashkin worked at the U of I until 1962 when he resigned to accept a professorship at the University of Arizona. The vacancy in nuclear physics was then filled by Raymon T. Carpenter, a graduate of the University of Kansas with his Ph.D. degree from Northwestern University in 1962.

Two words "and Astronomy" were added to the title of the Department of Physics in the fall of 1959. The practitioners of space physics, it was generally considered, had come to have more kinship with the searchers of the heavens than did the mathematicians, whose curricula had contained some astronomy at the U of I for more than a century. During the winter of 1857-1858 Frederick Humphrey, professor of mathematics, first directed some of his more advanced students in the use of Bowditch's Navigator and Peirce's Spherical Astronomy, as detailed in this history's Chapter One.

The university built its first observatory in 1874 to house its new 5" refractor telescope, and astronomy became a topic of considerable interest on the campus during the late 1870's under the direction of Nathan Leonard. Site of that first observatory was on the location of the modern University administration building, Jessup Hall.

After the disruptive educational and political quarrels of the 1880's, during which time Hinrichs was dismissed in 1885 and Leonard in 1887, the teaching of astronomy revived during the 1890's under the leadership of Laenas Weld, the head of the department of mathematics and astronomy. After Weld became Dean of the Graduate College in 1900, astronomy continued with an on-again, off-again status, precariously low on the totem pole of its department's offerings. Over a quarter of a century various astronomers arrived for a brief stay, then left for more promising professional opportunities, for observatories with more equipment and status. Some years between 1900 and 1925 the University had an astronomer; some years it didn't.

Then for twenty-nine years the U of I had a continuing and durable astronomer. Charles C. Wylie, a native of Kansas with his Ph.D. degree at the University of Illinois in 1922, became widely known for his studies of meteors and his searches for meteorites. He published a book for children, Our Starland, in 1938 and another book in 1942, Astronomy, Maps, and Weather, designed for pre-flight training in the Army Air Corps, for which Wylie was a war-time consultant.

When Wylie retired in 1954 at age 68, his replacement was Hugh M. Johnson, a native of Des Moines. He had received his A.B. degree in 1948 and his doctorate in 1953, both at the University of Chicago. Johnson broadened and deepened the astronomy program with an increased emphasis upon distant stars, the other galaxies, and the developing science of radio astronomy. About fifteen miles west of the campus he set up a dome with a 12" reflector telescope for observations unimpeded by city lights.

On leave of absence during 1958-1959 at Mount Stromlo in Australia, Johnson was expected to return to Iowa to become the first astronomer of the Department of Physics and Astronomy, but he chose instead to accept an opportunity at the University of Arizona.

With no professional astronomer on hand for 1959-1960, theorist Fritz Rohrlich volunteered to teach the elementary course. Pamela Rothwell, who had come from the University of London in 1958 to work with Carl McIlwain on the interpretation of data from Explorer IV, instructed a course in radio astronomy. Then in February 1960 Satoshi Matsushima (M.S. Kyoto, 1946; Ph.D. Utah, 1954) came up from Florida State University to present a research paper at a Colloquium. Next fall he became the first astronomer of the expanding department.

During the years when the Russians followed the U.S. lead by fashioning their own hosts of nuclear weapons, many Americans grew increasingly apprehensive about their futures under political-military leadership. Among the most gravely concerned were those who were relatively knowledgeable about the consequences of a profusion of spreading radioactivity. These included the physicists of The University of Iowa, from whom emerged one of the most widely considered protests against a contemplated civil defense program. Starting with their luncheon conversations in an Iowa City hotel, their dissent took form in a letter to the editor of a local newspaper.

To prepare the American public to face a threatening confrontation with the USSR, the administration of President Kennedy tried to begin some program for survival from a possible nuclear attack. The planning of gigantic public shelters or of mass evacuations from populous areas appeared to be highly impractical, doomed to fail because of the tremendous costs, the lack of time, and the chaotic panics. Consequently, the administration began to promote what seemed to be the easiest and most popular program: the family fall-out shelter in basements and backyards. In this campaign a series of articles under the general title of "You Can Survive Atomic Attack" appeared in hundreds of newspapers across the country. The articles carried the name of Willard Libby, a Nobel Laureate in chemistry and a leader of the Atomic Energy Commission, as the author.

Fifteen of the Libby articles were published in the Iowa City Press-Citizen between Nov. 6 and Nov. 24, 1961. The first of these began with the words:

> For $30. I built a fall-out shelter in my backyard. It gives my family 100 times more chance of surviving nuclear fall-out than if I had done nothing.

Such a simplistic presentation disturbed Max Dresden, Fritz Rohrlich, and other members of the U of I physics faculty. To them the Libby name and reputation gave the articles the appearance of scientific authority for a dubious diversion from the real consideration: the prevention of nuclear warfare.

After sounding out his colleagues for their views and contributions, Dresden drafted a letter, which was then signed by eight members of the faculty, in alphabetical order from Stanley Bashkin through James Van Allen.

A key sentence in the summation paragraph of the letter declared:

> It is extremely dangerous to give the impression to the public that the building of fall-out shelters will enable the average citizen to survive a nuclear war.[20]

The Press-Citizen used the letter Nov. 20 on the top of its front page under the headline: 8 SUI PHYSICISTS DIFFER WITH LIBBY ON NUCLEAR PERIL. On Nov. 22 the Des Moines Register front-paged the letter under the top head of 8 SUI SCIENTISTS RIP LIBBY and the next day followed with FALL-OUT SHELTERS as the lead editorial, which began:

> The eight University of Iowa physicists who have spoken out in rebuttal of Willard F. Libby's statements about survival from nuclear attack deserve applause.
>
> Dr. Libby is a renowned physicist who received a Nobel prize and served on the Atomic Energy Commission. His rather absurd observations about fall-out shelters carry great weight with the ordinary citizen. It is a valuable public service for a group of dissenting physicists including another "big name"--that of James A Van Allen, Iowa's famous space scientist--to take Libby apart.
>
> They did so in decisive fashion.

On the following Sunday, Nov. 26, the Register's front page led with CALL FALLOUT SHELTER PLAN A "DECEPTION." Under this the paper printed an open letter signed by 194 faculty members of eastern Iowa colleges, including 149 members of the U of I faculty outside the physics department.

Media services fanned the Iowa physics letter across the nation. Many of the papers which had been running the Libby series printed the protest against the fall-out shelter becoming accepted as significantly helpful in a nuclear holocaust. Even Libby's hometown paper, the Pasadena Star-News, used the Iowa letter.

While editors emphasized the well-known name of Van Allen as Libby's principal opponent in the controversy, his role in the matter was relatively passive as compared to that of Max Dresden, who was also talking on the subject at meetings of various organizations in the Iowa City area.

Among the assertions which Dresden questioned was Libby's prediction that 90 to 95 percent of the U.S. population could survive with the widespread use of family shelters. Department of Defense and Rand Corporation estimates for nuclear-attack survival, the Press-Citizen letter pointed out, were around 60 percent:

> Obviously, not even the best-informed person can meaningfully predict such a figure. It depends on the length of a future war, the number, size, and distribution of bombs actually dropped and many unforeseeable circumstance.

Besides objecting to the unverifiable assertions of the Libby articles, the letter scorned the advertising and public relations styles of persuasion. For example:

> To represent the gruesome, frightening, primitive life in a fall-out shelter (even Professor Libby suggests that one take sleeping pills) as a two-week vacation in a model home is irresponsible in the extreme.

The letter closed with such affirmations as "ways and means exist to resolve the clash between Communism and freedom" and "these means do not involve the destruction of our civilization."

The Iowa dissent was by no means the first publicized expression of concern to be disseminated about the role of fall-out shelters. Some 200 college faculty members of the Boston area prepared "An Open Letter to President Kennedy," which appeared in advertisement space on page 25 of the New York Times of Nov. 10, 1961. Several faculty groups in various parts of the country had the Times letter reprinted in their local papers.

But the Iowa response to the shelter campaign attracted more attention across the nation. It simply mushroomed from the talk of a few men with the help of a small newspaper and the adversary positions attributed to Libby and Van Allen. It stirred receptive publics unreached by such dissenting groups as those around Boston, New York City, and Chicago.

In its January, 1962 issue the Bulletin of Atomic Scientists reviewed recent developments in civil defense activities. The journal noted a shift in government policy from an emphasis on the building of private shelters toward the favoring of community shelters using areas of public and other large structures.

Under its sub-topic, Civil Defense Protests, the Bulletin gave the most play in its account, a full column, to a summary of the U of I physicists' letter to the Iowa City Press-Citizen.

Notes and Sources

This chapter relates largely the rise and influence of the cosmic ray group. Sketching and summarizing events that call for voluminous treatment, these few pages may serve to answer some questions until there is a full account of the work of James Van Allen and his colleagues, both in Iowa City and in the mainstream areas of scientific-political activity. Here perhaps is the largest question: How did a small group in Midwestern hinterlands come so much to the fore in America's earliest explorations of space?

While the heading and content of this chapter deal mainly with one group, the 1950's were also years of growth and increased activity for other research groups of the department. Theory and nuclear areas also added to their personnel so that the faculty grew from eight in 1949 to eleven in 1953. But the building population increased most markedly in the growing personnel in support of the Age of Space: engineers, technicians, draftsmen, data workers, and extra clerical assistants.

The publicized "rockoon" expeditions and the satellite instrument pioneering resulted in newspaper and magazine files becoming major sources of information for much of the material in this chapter. As before in these annals, the University Archives and the Physics Library have been valuable retrieval areas. The Archives preserve the correspondence from the offices of the University Presidents and of the College of Liberal Arts. The Library contains the bound volumes of the professional journals, most notably for this author's purposes, the Physical Review. There is also a plethora of books on the entry of the United States into the exploration of space, on the development and activities of the International Geophysical Year, and on the programs and agencies of the National Aeronautics and Space Administration.

[1]Darrow's remarks, without providing the time and place, are quoted by Bruno Rossi on a preface page of his book Cosmic Rays, a McGraw-Hill book, 1964.

[2]Physics and Medicine of the Upper Atmosphere, p. 239:

For this volume of the proceedings of the symposium in San Antonio, published by the University of New Mexico Press in 1952, Van Allen also provided "The Angular Motion of High Altitude Rockets," p. 412.

[3]Ibid., p. 252.

[4] American Association of Physics Teachers and Colloquium of College Physicists, meetings at The University of Iowa, June 11-14, 1952.

[5] Denver meeting of the American Physical Society as logged in the Physical Review, 1952.

[6] Letter from Josef Jauch to Dean Dewey B. Stuit in the files of the College of Liberal Arts, University Archives.

[7] Ibid.

[8] Story on MURA location proposal in University News and Information Release dated April 9, 1956.

The SUI proposal was a 640 acre site just west of the University Golf Course.

[9] University News Release, Jan. 15, 1955.

[10] Compiled by author from account figures in the University Business Office.

[11] Among the many accounts of the origins of the IGY, one of the clearest and most readily available is that in Vanguard: A History, by Constance Green and Milton Lomask, Smithsonian Press, 1971.

[12] Ibid., pp. 113-115, Iowa's first proposal substantiated.

[13] Ibid., pp. 117-122.

[14] Ibid., p. 129.

[15] In an after-dinner address April 19, 1959, Van Allen remarked (and the Daily Iowan reported) that the basement of the Physics building was "stacked with enough Explorer IV tape read-outs to stretch from here to Tiffin" (eight miles west of Iowa City). In this talk to a district convention of Rotarians, he compared the dogged movement of the students counting the jagged lines on the read-outs with "inching a peanut with one's nose all the way to Tiffin."

[16] "Colloquium of College Physicists," souvenir-record pamphlet in Physics file of the University Archives, p. 1.

In the enclosed letter to the Colloquium's participants Van Allen pointed out that no faculty member was willing to reassume George Stewart's dedicated leadership of the annual event.

[17] From Proceedings of the Midwest Conference of Theoretical Physicists, March 1957, prepared and edited by E. C. Ray, in manuscript collection of the Physics and Astronomy Library.

[18] Jauch explained why he was leaving Iowa in a letter of resignation, now in the faculty files of the departmental office.

[19] Dresden cited some of the problems of the theoretical physics group in his letter of resignation, now in the files of the departmental office.

[20] The letter in the Iowa City Press-Citizen of Nov. 20, 1961 had enough impact to justify giving the full text:

Letter to the Editor:

During the last two weeks the Iowa City Press Citizen has run a series of articles which give us cause for concern. The articles bear the title "You Can Survive Atomic Attack" and are signed by Prof. Willard Libby. As physicists we have high regard for Professor Libby's scientific work and competence.

We are consequently the more surprised at certain statements and assertions made by him in these articles; these statements are neither scientific fact nor are they based on more than mere personal opinion; and they should not be given the appearance of scientific authority.

The basic ideas underlying these articles were expressed in the second installment of the series, subtitled "Fact vs. Fallacy--95 Per Cent Could Survive." We shall, therefore, take issue especially with the views stated there. The following five points are particularly important:

(1) Dr. Libby states as a fact that 90 to 95 per cent of us could survive with proper protection. This statement, however, is not a scientific fact, but is at best an estimate--and an extremely optimistic one at that. Thus, it should be contrasted with those numbers given by the Rand Corp., which does a large share of the operational research of the armed forces; their estimate is 50 to 75 per cent. The armed forces currently give a figure of 60 per cent. Dr. Linus Pauling, also a Nobel prize winner, recently quoted 10 per cent. Obviously, not even the best-informed person can meaningfully predict such a figure. It depends on the length of a future war, the number, size, and distribution of bombs actually dropped and many unforseeable circumstances. However, even 95 per cent survival would mean that nine million Americans would be killed. This is to be compared with the U.S. armed forces casualties of all previous wars combined (including the Civil War): 900,000 dead, i.e., only one tenth of the most optimistic estimate of a future war.

(2) Professor Libby states, "Blast could bring down buildings eight miles to ten miles away, in the case of a 10-megaton bomb." But he omits mentioning that the same size bomb will set fires over an area 50 miles wide. These fire storms are not a pessimist's nightmare, but have already occurred during the last war, as the inhabitants of the German city of Hamburg well know. A basement fall-out shelter is poor protection when the house is on fire, not to speak of suffocation resulting from the lack of oxygen consumed by the fire. A 20-megaton explosion over Cedar Rapids might cause 100 per cent casualties in Iowa City.

(3) We read: "Great areas would not be touched...We could rebuild..." But we all know that large cities have been crippled by milk strikes, elevator strikes, and power failures; events which are completely insignificant when compared to the aftermath of atomic attack. Following such an attack, it is eminently reasonable to anticipate little or no transportation, food, medicine, or fuel, not to speak of contaminated water supplies. What life will those people lead who emerge from their fallout shelters after successfully surviving those two weeks?

(4) Professor Libby asserts that people would not give up and become animals. "They've usually helped one another and shared burdens in natural disasters, such as hurricanes and earthquakes." It should be noted, however, that one of the first actions taken after any national disaster is to call out the National Guard to prevent looting. This does not give one confidence that when individual survival is at stake, everyone will behave with compassion. Communities around Los Angeles are already organizing armed groups to repel the anticipated hordes of refugees from the city. This is hardly a sign of the co-operation and help expected by Professor Libby.

(5) Finally, we would like to take issue with the illustration of a fallout shelter that accompanied the article. To represent the gruesome, frightening, primitive life in a fallout shelter (even Professor Libby suggests that one take sleeping pills) as a two-week vacation in a model home is irresponsible in the extreme.

These points illustrate the rather debatable position held by Professor Libby. It is extremely dangerous to give the impression to the public that the building of fallout shelters will enable the average citizen to survive a nuclear war. This gives a false sense of of security. The percentagewise small margin of safety gained in no way detracts from the very real possibility that an atomic war will mean the end of the civilization of both opponents. Such a war therefore defeats the very purpose for which we are fighting: the preservation of freedom.

We are not prophets of doom and gloom. We do not believe that our alternatives are "Red" or "dead." We do believe that ways and means exist to resolve the clash between Communism and freedom. And these means do not involve the destruction of our civilization and with it of our freedom. These means do not involve atomic war.

STANLEY BASHKIN
RICHARD CARLSON
MAX DRESDEN
SCOTT E. FORBUSH
CARL McILWAIN
EDWIN NORBECK
FRITZ ROHRLICH
JAMES A. VAN ALLEN

Chapter Ten

To Spacious New Quarters

With societies generally inclined to provide increasingly larger and greener pastures for their sacred cows, the scientists and technologists of the mid-twentieth century were bound to receive expanded and enriched laboratories. The awesome feats of such programs as the Manhattan Project and the Explorer spacecraft stimulated sequel undertakings and a profusion of scientific real estate. Whole professions profited from the prestigious work of their major achievers.

Opportunely for the teachers and research leaders of physics, a 1961 book bore the title Modern Physics Buildings: Design and Function. Of large format and 324 pages, it was the major opus of a three-year project of the American Association of Physics Teachers and the American Institute of Physics, with supporting funds from the Ford Foundation. In the book's preface authors R. R. Palmer and W. M. Rice noted that a 1958 survey showed that "during the next few years the chairmen of some 200 physics departments expected to be involved in the design or building of new physics buildings for their institutions."

So it was at the University of Iowa, where physicists and their building neighbors in mathematics were becoming increasingly cramped for elbow room. In 1958 the need for expansion for the two departments reached the point that the State Board of Regents requested \$1,250,000 for a 40,000 ft^2 add-on between the Physics Building and Schaeffer Hall. It turned out for the better that the legislature did not fund the request. The suggested space was too little and the prospective site too limited for expansion in the future. Besides, a structure at that spot would mar the symmetrical layout for the Pentacrest and would block the view from the south of

Old Capitol, to many Iowans the most treasured historical building of the state.

With the option of a more suitable site and with expectations for additional funding from federal sources, a state appropriation did appear in the spring of 1961. The 59th General Assembly funded $1,410,000 for a Physics and Mathematics Building. Soon afterward the state provided an additional $300,000 for a structure to house a 6 MeV Van de Graaff accelerator, which had become available through the auspices of the National Science Foundation.

It was soon evident that Physics and Mathematics required considerably more expansion space than those state funds could provide. Queries to the National Aeronautics and Space Administration and to the National Science Foundation revealed a receptiveness to help in the providing of research facilities for Physics and Astronomy. In a less advantageous bargaining position and eager for the building program to start, the Department of Mathematics was willing to accept the more than 18,000 net square feet which would be released following the completion of the building for the new accelerator and the principal building to be known as the Physics Research Center.

In March 1962 the University formally applied for federal matching funds, requesting $610,000 from NASA and $750,000 from NSF. These proposals were approved, and the next year the State of Iowa followed with $385,000 more for moving, equipping, and furnishing costs.

The site chosen for the Physics Research and Accelerator complex was an early Iowa City park area which over the years had become a University parking area. Its location was four blocks northeast of the existing Physics Building, which would continue to be used for undergraduate instruction. The nature of the federal support restricted the use of the new building to research and research-oriented operations.

During the planning years from the summer of 1961 through the fall of 1963 a small Physics administration office served as a center for collecting and plotting the many and various recommendations. University architects provided a series of preliminary drawings, which suffered considerable sketching, erasing, and re-sketching in the efforts to make desired allocations fit into suitable spaces.

The dimensions of the site, coupled with the construction economies required for a maximum number of square feet under the likely funding, seemed at first to call for a long rectangular edifice. During the summer of 1961 the physics department planners worked with maximum floor areas of 70 x 260 feet. While the layout amateurs, Stanley Bashkin and James Wells, relished the creativeness and responsibility of their tasks, they experienced considerable frustration and dismay. Before the building's limitation to research activities, they were trying to fit all the teaching, research, and service needs of the department within a gross area of less than 100,000 ft^2. They could not seem to get it all in there, even by cramping the sizes of classrooms and storage areas. And the architects were saying that many square feet would cost an extra million dollars.

Through the ensuing months of layout sketching, the floor lengths shrank and the building height grew with additional floors, primarily to leave more space on the east end of the site for an anticipated teaching wing. The greater height helped to justify a desired second elevator, but the stacking of extra floors reduced the amount of assignable space and increased the circulation and building service areas.

As staff members aired their views, they stressed the attainment of areas and conveniences which the old building lacked. These included a loading dock and receiving area, elevators, air conditioning, isolated and insulated quarters for high voltage and high radiation and for work accompanied by noise, dust, and odors. A several-fold expansion of office space was strongly urged for the graduate students, most of whom had been limited to small desks in crowded laboratories or in apparatus storage rooms.

Although the building was to be planned primarily for research purposes, it also had to become the center for departmental activities. The new structure would need to house the general, business, and publications offices, the whole of the Physics and Astronomy Library, and the conference, seminar, and other meeting rooms. Such services as drafting, instrument machining, and equipment maintenance and repair would also be moving to the new building.

All of the faculty, including those who were primarily engaged in teaching basic courses, chose to have their offices in the new structure. They would travel to the old building for some of the undergraduate classes but would use the new facilities for most of the advanced instruction. For their offices most of the faculty envisioned the second and third floors as most desirable locations--above street floor traffic, low enough for less need of elevators, and near the central offices, library, and meeting rooms. Not everyone, however, could be housed on Floors Two and Three, and some preferred to have their offices near the laboratories of their special interests.

Departmental tastes, encouraged and supported by the architects, pointed toward a simple functional structure, free of ornamental details and strongly contrasting colors. The building was to have a timeless quality, avoiding modes of fashion. It was not to appear glossily new when first occupied nor antiquated too early in the 21st century. Somehow the outlines and colors should become an intermediate phase between the classic limestone structures of the central campus and the tan and red brick buildings on the east.

By March 1962 the planning had congealed enough for the submission of a 20-page booklet, "Proposed Physics Research Building," to NASA and NSF for supporting funds to match the state appropriation. With an estimation of $2,720,000 as total project cost, including fixed equipment, the department proposed a structure of 72 x 192 feet in its external dimensions, with five stories above a full basement.

Amounting to some 83,200 ft^2 in gross floor and wall space, the proposed area seemed more than enough for the near-future needs in the research of the department. Yet prudence dictated the providing for unpredictable expansions in such changing fields as the sciences of physics and astronomy. The total area also seemed to be as much as could be constructed and equipped under the probable total of the funding. Members of the building committee chaired by Richard Carlson had analyzed the costs of other new University buildings and of some contemporary physics buildings on other campuses.

While the physics committee members assumed from their analyses that their building could be constructed for less than $25 per square foot, the university architects, George Horner and Richard Jordison, presented more like $30 as a practical estimate. The architects pointed out that so large a quantity of heavy equipment required stouter foundations, more supporting piers, and other reinforcements. They also said that a scientific research building required additional utility services and that various change orders and other currently unpredictable items would appear to substantially increase the cost of the project before its completion.

As a part of the overall project for new facilities for physics and astronomy, tentative planning for an out-of-town optical observatory for a 24-inch reflector telescope was submitted April 6, 1962 as an addendum to the Physics Research proposal of March 20. This supplementary building proposal envisioned a domed one-floor structure of 1,650 ft^2 on an elevated site on the Lake Macbride Field Campus of the University, located some twelve miles to the north of Iowa City.

It was decided soon afterward to erect the observatory twelve miles southwest of the central campus. Astronomer Satoshi Matsushima stressed the importance of a southern outlook for viewing in the Northern hemisphere. The lights of Iowa City and vicinity would be too close to the south if telescopes were mounted near Lake Macbride. Consequently Matsushima spent considerable time driving around the farm lands south and west of Iowa City. He looked for a relatively isolated piece of high ground that the owner might be willing to lease or sell to the University.

After he found the kind of site he wanted and the portion of funding set aside for the observatory seemed likely to be increased, he was encouraged to enlarge the size of the structure, with a second floor and basement, to a gross area which became 3,800 ft^2 by the time of its completion in the summer of 1965.

During the summer of 1964 a second astronomer joined the U of I staff, and Matsushima gained some assistance on the project. John S. Neff had earned his Ph.D. degree at the University of Wisconsin in 1961 and had then become something of a specialist in the design of astronomical instruments during three years as a research associate at Yerkes Observatory.

During the detailed design period (the summer of 1962 through the summer of 1963) the length of the Physics Research building was shortened to 73 x 163 feet and another floor was added. The interior structures and room divisions developed into relatively simple and uniform module layouts for most of the floors. This modular plan created units of approximately 270, 560, and 800 ft^2 for most of the rooms, all located around rectangular hallways enclosing the central utility and service cores. One result of this plan was much larger offices for faculty and other staff members.

While the amount of assignable space was somewhat diminished by the extra hallways, an increased sense of roominess and privacy would prevail through more of the building.

The uniform simplicity of the interior layouts for most of the floors was but one of the developments which led to surprisingly low bids by the construction and utility service contractors. The architects had prepared specifications for relatively low cost materials, and they directed the supply of heavier electrical services mainly to focal points in laboratory areas. Various voltages were to be distributed later as required and at additional costs. For the most part, the specifications seemed to call for minimal provisions.

As the time for the opening of the bids neared, the tenants-to-be sensed that the University Administration was being overly cautious and thrifty and might be trying to save some of the appropriation for physics and mathematics to divert to capital improvements elsewhere on the campus. This skepticism mounted to indignation when the bids of contractors were opened October 8, 1963. The low bids on the prime contracts to construct and service the 83,200 ft^2 of the Physics Research Center totaled only $1,431,440. The bidding climate had turned out to be remarkably good for the buyers, for the totals were some $500,000 below what the building committee had come to expect from the advice of the architects.

A major development from reactions to the totals of the low bids was the granting of an additional floor. When the extra-floor bids were opened on November 19, the total prime contract costs increased by another $220,000. The state later provided an additional $385,000 for furnishing and moving and for other costs that came up before the building was completed.

Other redistributions of funds accrued after the openings of the construction bids. On the construction which was underway on the housing for the new accelerator, an overrun of some $120,000 beyond the state appropriation of an initial $300,000 was resolved and absorbed. The sum of $50,000 which had been set aside from the state appropriation for physics and mathematics to be used for the building of an optical telescope observatory twelve miles southwest of the campus, was raised to $75,000. (It turned out that the basic construction costs would amount to $113,000; and the total outlay for the observatory, irrespective of the telescope and associated apparatus, would eventually run to well over $130,000.)

On October 30, 1963 the Iowa City firm of Viggo-Jensen, which had offered the lowest bid for the general construction contract, started clearing the site for the Physics Research Center. While there were no earth-turning ceremonies, it was a day of considerable relief for the planners of the building. After two years of designing, negotiating, and the other work of the preliminaries, the project was about to take a visible form.

Within the next two years the new facilities for Physics and Astronomy were to grow to a total of some 113,000 ft^2 of gross area. Of this amount the Physics Research Center would comprise 99,600 ft^2. Its southwest wing, the housing for the nuclear accelerator, would add 9,600 ft^2 more. The Hills Optical Observatory, twelve miles to the southwest of the campus, would contribute another 3,800 ft^2 to the gross total.

Actually by 1965 the aggregate holdings of the department would add up to some 140,000 ft^2 of gross building area. From 1965 until 1971 the physicists were still using nearly half of the old building for undergraduate instruction. (This area amounted to about 37,000 ft^2 in gross calculations--around 20,000 ft^2 in net assignable space.)

The extent of the new construction was to put the University of Iowa well into the top ranks nationally at the time in terms of working space for physics and astronomy. According to the floor layouts in Modern Physics Buildings and in a supplement to the book in 1963, only a few American universities enjoyed larger gross areas of modern construction: in order of size--Ohio State, Illinois, Michigan, Maryland, and the Massachusetts Institute of Technology.

By 1971, with the Iowa department then using approximately three-fifths of the new 94,000 ft^2 teaching addition on the east end of the Physics Research Center, the U of I may have passed all but Ohio State and Illinois in its modern totals for physics instruction and research. But this assumption should be accepted with some skepticism. Some universities have portions of their physics facilities housed in a variety of other buildings shared by other science and engineering departments. Some institutions possess and/or manage large research installations at various distances from their central campuses. The Yerkes Observatory in Wisconsin, for instance, belongs to the University of Chicago. And in some state and private institutions academic staff members work in collaboration with federally employed research staffs. A notable example is the intertwined relationship in Pasadena of the California Institute of Technology and NASA's Jet Propulsion Laboratory.

But the 1960's did show the University of Iowa approaching in its expansion the holdings of more widely known and richer institutions in terms of total facilities devoted to physics and astronomy. In effect, departmental space more than tripled over one decade, from some 31,000 ft^2, net assignable, to more than 95,000 ft^2. The new total included the large portion of the teaching addition of 1970 and all of two out-of-town installations, the Hills Optical Observatory (1965) and the North Liberty Radio Observatory (1967).

Staff and student anticipation of living in a commodious new building was increasingly evident as the inhabitants of the limestone structure on the Pentacrest watched their new home rising four blocks away. Relatively little delay in the progress of the construction occurred because of adverse weather, labor negotiation difficulties, and time-consuming change orders. Some major problems did arise with the electrical contractors and elevator suppliers lagging some months behind the general contractors in their commitments.

So that furniture deliveries could begin in July and August of 1965, the principal purchase orders were issued in February and March. Inopportunely the Steelcase office furniture began to arrive in June, much too early for the moving and set-up crews. The loading dock and the appropriate entrances were not yet ready for use, and the elevators were not operating. The Hallowell laboratory and shop benches also came in much earlier than anticipated: all 350 of them.

On sometimes muddy ground and amid the peripheral debris of construction work the loads of huge semi-transports were pulled onto plank ways into side entrances and stairways. The second floor then contained the only rooms that were near enough and sufficiently completed for the storage of the masses of new furniture, including 40 office desks, 70 tables, and 127 filing cabinets. The floor also became a jungle of irregular lines of stacked chairs and stools. The sight of a Steelcase furniture van parked beside the new construction at 7:00 a.m. was a sobering experience for the moving supervisor. The day would be a strenuous one of much laborious lifting, pushing, and hauling out of the van and into the building and up the stairs.

By late August, 1965, even though much of the building was as yet unfinished, especially the basement and the first floor, the mass cross-campus moving was well under way. The department was trying to ready itself for the beginning of the school year in late September at that time. Thus the central offices and the academic areas on the second and third floors received the highest priorities to become settled enough for work. The exodus of the physicists was spurred also by the mathematicians who were trying to expand in the old building and get settled for the start of their fall classes.

The various physics research groups and their engineering and clerical supporters also began to move in late August and in September. Motley processions of conveyances created traffic and parking problems around the exits from the old building and near the entrances into the new structure. In addition to the trucks carrying the heavier and bulkier objects, numerous private cars joined in the moving operations. Several long carts for hospital patients, which the department had procured via the University Surplus Equipment Pool, rolled back and forth innumerable times. The use of these "cadaver carts" was particularly valued for the transport of delicate equipment which was difficult to disassemble and pack without injury. Many small and fragile items were even hand-carried across the campus. The some 15,000 volumes of the department's part of the separating Physics-Mathematics Library moved over in a period of four rainy days, transported aboard an enclosed step van, a vehicle similar to those used for the home deliveries of milk.

Moving processions into the new building also came from two other directions, from the old Law building just north of the Pentacrest and from a leased commercial structure in the east end of Iowa City's downtown. For three years the physicists had occupied six small offices, totaling 1,130 ft^2 of net assignable space and housing up to fourteen research associates and graduate students in theoretical physics. In 1962 Max Dresden had zealously campaigned for working room for his overflow of people and had succeeded in persuading Ray Mossman, University business manager, to provide some offices.

Also in 1962 James Van Allen managed to acquire the upper floor of the Miller Building at 330 East Washington Street for the department's satellite data reduction operations. This 1,800 net ft^2 area soon filled with heavy quantities of magnetic tapes and data books, sometimes to the anxious concern of the people below in the American College Testing program, who were using the lower floor at that time as their temporary headquarters.

The eastward surge of 1965 marked the fourth time in the 110 years of instruction at the U of I that physics had changed its quarters. Except for the first move of a humble array of natural philosophy apparatus from Mechanics Academy to the abandoned Capitol in 1858, the other moves had been of less than 300 feet: to the new chapel and laboratory building in 1868 and from there to the Physics Building of 1912. In two of the earlier times the realization of a new house of science had been occasions of spreading elation and pride. Ceremonial publicity surrounded the prolonged openings of Gustavus Hinrichs' new laboratories in 1868-1869 and of George Stewart's new facilities in 1912-1913.

By the 1960's the attendant conditions and circumstances were much different. The new center for Physics and Astronomy was only one of several University buildings in various stages of construction, and in the Nuclear-Space Age milieu many physical scientists had come to consider large outlays for facilities and equipment to be their overdue rewards and privileges.

Comments of the new occupants generally expressed impatience and irritation with unfinished and imperfect aspects of the building: the incomplete distribution of electrical power, the unreliability of the elevators, the leaking pipe joints and roofs. The moving operations protracted sporadically over many months, partly because of the massive amounts of equipment and supplies to be handled and relocated, partly because some groups had to wait for contractual work to be completed in their special areas.

Thus the opening of the new premises brought no gala events and scant attention from the public media. The pressures to move as early as possible into an unfinished building, with minimal pauses and breaks in ongoing programs, tended to dispel the celebratory ardors.

The ultimate construction report from the department to the National Science Foundation and to the National Aeronautics and Space Administration bore the date 15 August 1966. The report chronicled much of the planning and financing and cited some of the conventional and salient features. It summarized the shape and dimensions in the following manner:

> ... the new Physics Research Center, fully air-conditioned, comprises a full basement and seven floors in rectangles of 163 x 73 feet, with two stairwell extrusions 13 x 7 feet on the north side of the building. The lighting of these stairwells adds considerably to the night skyline of the University's east campus. The building is surmounted by a roof house in the shape of a block I, with a 75 x 25 feet inside rectangle and with 36 x 16 feet cooling tower enclosures at each end.
>
> The ground floor is extended on the west by a 36 x 18 feet concrete and buff brick entrance canopy area and on the southeast side by a 12 x 14 feet loading dock and by a vestibule and tank storage area connecting the new building with the Accelerator Building which was completed during the summer of 1964. The basement is extended on the south by an areaway for bringing in heavy equipment and by an underground addition to the transformer room.

As distinctive interior features of the new building the report cited:

> ... modular rectangles around the central service cores, the impressive stairwells, and large focal areas on Floors One, Two, and Three for such essential research services as the machine shops, the computer and associated data analysis area, and the research library.

The report also called attention to a number of enlarged and improved facilities:

> (1) The library of 3480 ft^2 provided shelving for 20,000 volumes and display racks for 360 periodicals.

(2) The 1250 ft^2 Colloquium Room offered formica-covered strip writing surfaces and walnut chairs. The 550 ft^2 Conference Room held a boat-shaped table of 16 1/2 foot length. The 800 ft^2 Commons Room contained comfortable upholstered seating and a round table of seven feet in diameter.

(3) The 120-foot-long Machine Shop could line up as many as forty power machines under movable cranes. Three auxiliary shops for general use were located in the basement.

(4) Computer and data analysis activity had 3,300 ft^2 in an L-shaped area on the second floor. Drafting services and the preparation and handling of publications and mail had some 1,800 ft^2 at the other end of the same floor.

(5) The west entrance lobby was flanked by ten glass display cases for public information and for eductional exhibits of the work of the department.

(6) Basement rooms for testing and calibrating space probing instruments held an electronic shaker drum, an X-ray transformer, an environmental chamber, and a 2 MeV Van de Graaff linear accelerator.

As a consequence of the relatively low totals of the construction contracts and other developments, the department had around a half-million dollars to work with in their moving, furnishing, and equipping operations of 1965 and 1966. Assured that a sufficient quantity of new furniture could be purchased for less than \$200,000, the building committee proposed that some \$250,000 be used for basic research apparatus and technical service equipment. The request from the department to the University Administration on January 5, 1965, explained, for example, that

> A substantial amount of this budget is for basic research apparatus on the grounds that it will be necessary for an increased personnel working in a much larger area and on a greater diversity of research projects. The requested apparatus is of a nature unprocurable under research contracts but is expected to be present as 'overhead facilities' when contracts are negotiated with this department.

The total cost of the new furnishings purchased in 1965 turned out to be around $165,000. Much of the furniture in the old building was in good condition or recently renovated and was moved over. Bids from the larger suppliers came in lower than anticipated. According to some of the manufacturers' representatives, their furnishing of the new Physics Building could be a prestige item to cite in their other sales campaigns.

Despite the quantities of older furniture, the department's staff and students gained some 460 new benches, desks, and tables as their work surfaces for the coming years. There were 350 new chairs and stools, and 650 new storage units (shelving, files, and other cabinets) to inaugurate life in the new building in the fall of 1965.

The extra funds gained for equipment other than furniture enabled various research groups and technical services to buy considerable amounts of apparatus and machines. The nuclear experimental group was the greatest beneficiary, to the extent of some $74,000 in purchases on building account Y434. The solid state group, which had had little to start with in the nature of apparatus, benefited to the extent of at least $70,000. The more generally prosperous and extensive space physics groups totaled around $60,000 from the equipping funds, with about half of the amount for special flooring and air-conditioning for the data computer room. The machine shop was able to requisition equipment to the extent of some $50,000. Other basic and special equipment beneficiaries were research in astronomy (to the extent of around $30,000 in addition to the new 24-inch telescope) and lesser amounts to the drafting, business, and publications services of the department.

While the Physics Research Center was financed and planned in large part for the expansion of space physics activities with much better working facilities, also for the continuation of the on-going nuclear and theoretical research programs, it was the recently renewed solid state group which received the greatest percentage boost in facility area and in new equipment. Advanced and special studies of the physical properties of metals, alloys and semiconductors had suffered a lapse of several years prior to the arrival of William R. Savage in 1963. During 1958-1959 the burgeoning needs of space physics had moved into the relatively inactive basement laboratories for metal crystal studies. At that time E. P. T. Tyndall was relinquishing his research programs prior to his retirement in 1960. He had led the U of I studies of the physical constitution and properties of metals since 1924, besides teaching a wide variety of courses over his 36-year tenure. He also served as acting head of the department on several occasions.

As a consequence of the several-year hiatus in the program and the spatial limitations of the old Physics Building, Savage found himself with only one small and meagerly equipped laboratory for recommencing the department's work in the solid state of matter. By much borrowing and refashioning of apparatus from the equipment of other groups, he managed to start some investigations of alloy structures and of some temperature resistivities of semiconductors.

With the completion of the new building solid state received some 4,000 ft^2 on the sixth floor for the group's instruction and research. With its new two-ton magnet with twelve-inch pole faces and a nearby cryostat apparatus, Room 608 became the center for studies of magnetic susceptibility, specific heat and resistivity at low temperatures. A smaller lab was available for optical studies with such equipment as an electron microscope, and other labs were used for chemical operations and for sample preparations.

In the fall of 1966 John W. Schweitzer, who had just earned his doctorate at the University of Cincinnati, arrived to become the theorist of the solid state group. The initial emphasis of his work and that of his students was on the theoretical bases of the magnetic properties of various alloys.

By the fall of 1969 the U of I solid state program had reached the point that the group felt ready to host a meeting of their peers from other universities. The Midwest Solid State Conference met for two days in October in the new building. The featured address was that of Morrel H. Cohen of the University of Chicago on the topic "Glassy Semiconductors."

In the meanwhile, during the first few years in the new building, the space physics groups prepared instrument packages for four Orbiting Geophysical Observatories (the OGO satellites) and for four Interplanetary Monitoring Platforms (the IMP's). The bulk of the space work areas and personnel were busy with Injun 5 (Explorer 40), the 185-pound "made-in-Iowa" satellite, which was launched August 8, 1968.

Despite the continuing programs in the space labs, the late 1960's had become for much of the department a period of trying to become settled in the Physics Research Center while continuing most of the undergraduate instruction in the partly vacated old building. Those first years in the new building were similar to the experiences of those aboard shakedown cruises of ships at sea. Numerous troublesome imperfections persisted, were discovered, and by and large corrected, although elevator breakdowns, sometimes briefly entrapping passengers, continued to plague the new tenants.

Rooms were gradually changed and adapted to better serve their functions, with special-use fixtures, added equipment, and various types of partitioning. Research groups made progress toward collecting their people and apparatus in adjacent rooms in relatively unified and increasingly sovereign areas. Large-scale shiftings of personnel occurred less often each year. Empty areas began to fill with magnetic tapes of data from U of I experiments on various spacecraft and with other accumulations.

In the meantime, many inhabitants felt incompletely settled because of the four-block separation between the teaching and the research districts of the department. Especially during winter months the teachers and many of the students wearied of donning their wraps to go back and forth to classes in the increasingly lackluster old building.

As early as 1961 members of the department had begun drawing up layouts for instructional areas to bloom at the new site. In the fall of 1965 the planning for undergraduates resumed in earnest under the leadership of Edward Nelson, associate head of the department and the veteran overseer of the basic physics courses. He had gradually inherited this head teacher role while John Eldridge was relinquishing his responsibilities prior to his formal retirement in 1958.

The planning continued through designing and redesigning phases with the encouragement of the University Administration and the mathematicians in particular. Prospects grew for capital funding from the Iowa Legislature with supplementary funds from the U.S. Department of Health, Education and Welfare.

As it was during the formative years of plotting the research building, the workers on the instruction layouts went through a series of trial runs of sketching, erasing and beginning anew. Through all the sessions they sought the general goals of larger, modern, and better equipped areas for the learning continuum from starting freshmen through beginning graduate students. They proposed to at least double the elementary laboratory space and to more than triple the advanced and special field areas. In the old building, for example, there were no rooms for bench exercises and student experiments in astronomy, and enrollment in this study was growing vigorously. Van Allen himself began teaching the course General Astronomy in the fall of 1966, to a 67 per cent larger class than that of the previous fall.

The old building also lacked cubicles for the continued and secure setup of individual projects and suitable areas for the accessible storage of teaching apparatus apart from the laboratories. For large classes and for meetings requiring more than one hundred seats there was only one such room in the old building. The planners of the new instructional facilities wanted to have at least two large lecture rooms with optimal acoustical qualities and chalkboard visibility and with booths and fixtures for the ready use of audio-visual equipment.

By late 1966 the planning was well under way for the teaching addition (called Physics Research Center II until the name of parts I and II were changed in 1971 to Physics Building). As early as December, 1966 the University Administration and the State Board of Regents initiated a provisional $433,000 as a step toward the total funding required, particularly in the eliciting of matching funds from the federal government.

The financial preparations for the addition did not approach adequacy, however, until the Iowa Legislature appropriated $1,710,000 in the spring of 1967 and federal matching funds to the extent of some $700,000 were then assured. Actual construction preparations began in March, 1968 with the selection of Fane Vawter and Company of Des Moines as the general contractor. The architectural firm of Dubuque which detailed the designing of PRC I was again employed for PRC II, but during the interval between the two structures the name of the architectural firm had changed from Durrant and Bergquist to one listing five partners--Durrant, Deininger, Donner, Kramer, and Gordon.

The scheduled completion date for the building addition of some 90,000 ft^2 was set for July 1, 1970 with the anticipation that occupation could begin for the academic year of 1970-1971. By the time of its completion in late 1970, the addition was to gross around 94,000 ft^2 with some 140 rooms totaling a net assignable space of 49,500 ft^2. The percentage of gross space which became net assignable in PRC II was only 53% as compared with the 63% of PRC I.

The teaching addition provided considerably more lobby space, at the entrances to the lecture rooms in the southeast wing of the building and around the nine east elevator doors--sub-basement, basement, and Floors One through Seven. Considerably more building space was also used for interior walls and short corridors in PRC II than in the earlier construction. For example, Physics Floors Five and Six for advanced and special instruction was to have 36 small project rooms and cubicles.

Approximately half of what came to be the east section and the southeast wing of the Physics Building complex was to be used for purposes other than education in physics and astronomy. There were to be thirteen lecture rooms and classrooms for the general use of the University, the fourth floor of twenty rooms for the Science Education Center of the College of Education, with a net assignable area of 5,500 ft^2; and the Physics and Astronomy Library was extended by 2,200 ft^2 into the new section.

A departmental report on the size and configurations of the new complex in 1972 described the whole of the structure in this fashion:

> In size and space the Physics Building is a seven-floor structure of basic rectangles 295 x 73 feet, with two broad wings on the south--one linking with the earlier-built nuclear accelerator laboratories and the other with the lecture room extension of the newest addition. An 18-foot entrance canopy on the west end extends the building's over-all length to 313 feet. Two stairwells each extrude seven feet out on the building's north side.
>
> Constructed on a slight slope, the building ranges in height from 85 feet on the east end to 80 feet on its west end. Superstructures on the roof add to the height skyline. These range from the eleven-foot high roof-house to the 65-foot tower for the dish antenna of the space research groups.

The whole of the Physics Building complex on the University's east campus had grown by 1971 to a total of 203,200 ft^2 of gross structural area. In 1975 the Department of Physics and Astronomy was occupying 89,750 ft^2 or 75.6% of the total net assignable area of 118,700 ft^2 of the building complex. The astronomers of the department also had two small telescope domes on the east end of the roof for educational purposes: one for a 16-inch Celestron reflector, the other for the century-old 5-inch Grubb refractor which had been refurbished and moved over in 1972 from the former Physics Building's roof.

Twelve general use lecture rooms and classrooms in the east section and the southwest wing of the building complex totaled 11,080 net ft^2. The three lecture rooms, all with upholstered chairs on rising elevations from the speaker's area, held 304, 153, and 80, respectively for their fully seated audiences. Lecture Rooms I and II, with their modern acoustical and audio-visual appointments and with their attractive brick-faced side walls, served the University community also as small auditoria for special lectures, programs, and meetings.

By 1975 the Science Education Center had doubled its initially planned occupancy area of the teaching addition. At the moving-in time in the fall of 1970, the Center occupied more than half of Floor Seven. Later Science Education expanded through two large rooms on Floor Three which had first been used in physics education. They also acquired a small room on the east end of the Library's extension into the teaching addition of the building.

While the construction for PRC II was under way, the department's teachers worried about the securing of adequate funds for furnishing the new rooms. It appeared during most of 1968 and 1969 that the amount to be available for new equipment would not exceed $40,000 and that this sum would be earmarked for the general use needs of the auditoria and classrooms. With the PRC II lab areas virtually tripling such space in the old building, Edward Nelson and James Wells and their student workers set about fashioning dozens of lab benches and other items in a variety of ways. Sections of iron pipes were attached as legs under tops of bench assemblies which the Hollowell firm had supplied for PRC I. A motley array of tables, chairs, and many other items were requisitioned from other University departments via the University Surplus Pool. Renovated furniture began to fill some of the halls and storage areas of PRC I, to await the coming occupancy of the teaching addition.

Then came assurances that there would be a provision of at least $140,000 for the equipping and furnishing of PRC II. While large quantities of reconditioned objects were going back to the Surplus Pool, the department was able to anticipate a total of 143 new lab benches, 214 stools, and a more than adequate number of desks, chairs, and other items. As it had been in the summer and fall of 1965, the late summer and early fall months of 1970 witnessed the arrival again of large furniture vans to be unloaded and their contents distributed. This time, however, the elevators were generally operating, and the loading dock was not only usable but had been extended in length to more than double that of the first part in PRC I.

For many months at intervals from late 1970 through 1973, the teaching apparatus and supplies were laboriously brought down from the upper floors of the old building and across the campus to the new instructional areas. Nelson and his assistants preferred to bring over loads small enough for quick and orderly distribution in the new apparatus rooms. The hospital or "cadaver" carts continued to be a cross-campus traffic phenomenon.

Eventually both the teaching and research facilities of the department were contained within one city block, except for the outlying optical and radio observatories near Hills and North Liberty. At long last the staff and students of the Department of Physics and Astronomy had been freed from the cramped confines of the building which had been built in 1910-1912 "to serve Science for a hundred years" in the words then of George W. Stewart. But few could then anticipate how rapidly the sciences would outgrow their 20th century-antebellum homes.

Concluding Notes and Sources

This chapter and the next and final one manifestly differ from the earlier parts of the history. Chapter Ten became largely an account of the building programs of the 1960's, with relatively little about individual roles. Chapter Eleven rounds out and concludes the long narrative with an upbeat extolling man's farthest outposts carrying University of Iowa instruments. ("Extolling" may well be the appropriate word; its origin is the Latin extollere--to lift up.)

Since this writer was actively involved in the planning, construction, and occupancy phases of the new building, he felt motivated and obligated to summarize the activities he experienced. (The memoirs of George W. Stewart on the construction of the former Physics Building were not written until forty years afterward.)

Another consideration in writing about the 1960's and the 1970's is the reluctance of the author to give brief and fragmentary mention of present members of the departmental staff. There have been many of them over the past twenty years, and most have been working in relatively narrow fields of specialization. Thus the names that do appear are primarily in connection with events and situations in which they have been directly involved.

Some attention was given to the revival of advanced studies of the solid state because it was a salient situation of the 1960's and affected the planning and equipping of the new building. The growth of plasma studies appears in the final chapter as an influential movement of the 1970's, with major additions to personnel and some marked changes in building use. Other research groups--nuclear and theoretical, for instance--received more attention in earlier chapters.

As source materials the departmental files, which will probably move eventually into the custody of the University Archives, have served to enrich and instrument the writer's memory. These voluminous sources supply ample documentation of the negotiations and other business of the planning and building years, of the department's explorations of Earth's environment and of deeper space, and of many other matters.

As in the earlier chapters various newspaper and magazine accounts give some inklings of public interest and recognition of the work of the department. Besides the volumes and reports cited in the text of the final chapters, a number of books and periodical articles have contributed background and some sense of perspective relationships. A book published in 1978, The Physicists by Daniel J. Kevles, has given some direction to the later writing of this history of the Department of Physics and Astronomy at the University of Iowa (this despite the fact that Kevles' index is devoid of items relating directly to the physicists of Iowa City). Another broadly provocative book, Physics and Its Fifth Dimension: Society by Dietrich Schroeer, in 1972, has also had some influence upon the writing of these annals. Articles virtually too numerous to mention in Physics Today, in Scientific American, in the Bulletin of Atomic Scientists, and in other periodicals have had some impact. This author is grateful for the dedicated work of many writers.

He also acknowledges the valuable assistance of many thoughtful people, especially that of some librarians in Iowa City, in Urbana-Champaign, and in Indianapolis and of the several typists who have done their part to make his work presentable.

At this point the Notes and Sources portions of these annals comes to a close so that the final words of the last page of the book can be the quoted " ... the universe is now able to reflect upon itself."

Blank page

Chapter Eleven: L'envoi

Various Growths and Astounding Reaching Outward

A Physics Building display comprising a three-billion-mile expanse of the solar system held blue and green pins to advance the locations of MAN'S FARTHEST OUTPOSTS. Other colored pins on the sketch in the building's lobby exhibits in the late 1970's marked the orbital movements of planets Earth, Jupiter, and Saturn.

The blue pins tracked spacecraft Pioneer 10 on its route via Jupiter and on a path out of the solar system; also the trail taken by Pioneer 11, again past Jupiter and toward the first exploration of Saturn's environment. The green pins symbolized Voyagers 1 and 2, the dual American envoys within Jupiter's domain during the March and the July of 1979; then on toward Saturn (eventually perhaps to Uranus and beyond).

All four of these much the farthest ranging of all spacecraft carry boxes of apparatus designed and built at the University of Iowa. Each of the Pioneers bears a set of charged particle detectors under the direction of James Van Allen. Each Voyager holds a radio and plasma wave receiver of Donald Gurnett's VLF group. Only two other academic institutions, the University of Arizona and the California Institute of Technology, also have experimental equipment on all four vehicles.

By May 1979 Pioneer 10 had sped more than 1.8 billion miles from its terrestrial birthplace. Moving outward more than 200 million miles annually from the sun, the craft's Iowa instruments were still reporting the diminishing encounters with solar wind particles and such other phenomena as cosmic radiation. By 1987, after crossing the orbital path of Pluto, the Iowa package on Pioneer 10 will be soaring for several years through the outskirts of the solar system and then continue, perhaps endlessly, within interstellar and intergalactic space.

In all the years of recorded history it was not until 1957 that man achieved (with Sputnik II) an altitude of 1,000 miles in the lofting of instruments outward from his planet. Nineteen years later Pioneer 10 advanced the on-the-scene reporting range to one billion miles out. At some time in the year 1989 its distant location should exceed four billion miles (six speed-of-light hours), or roughly the radius of the solar system according to the current state of knowledge.

In extending the reach of their instruments in situ, the Iowa space physicists needed less than five years time to make the transition from the early Explorer satellites to a probe of the environment of the nearest other planet. U of I particle detectors were counting away on Mariner 2's fly-by of Venus (within 21,600 miles) in December 1962. With this event Van Allen and his associates and students commenced what developed into a twenty-year epoch of planetary exploration.

When Mariner 4 flew out more than 130 million miles to encounter Mars in July 1965, an Iowa package was part of the experimental cargo which approached within 6,000 miles of the planet. Then in October 1967 Mariner 5 had Venus again as its target area, and achieved a close fly-by which took it within 2,500 miles of the cloudy outskirts of the planet.

In the meanwhile detector apparatus built in the department laboratories and shops steadily became more sensitive, more accurate, more durable, more miniaturized--and more expensive. During the middle 'sixties the group led by Louis Frank developed a sophisticated addition to the flight apparatus of the department. This item is an electrostatic analyzer for the detection and measurement of low energy protons and electrons. The analyzer also has the capacity to distinguish between positively and negatively charged particles. Beginning with the earth satellite OGO 3 in June 1966, Frank's LEPEDEA apparatus has flown on more than a dozen spacecraft through the year 1979. (LEPEDEA is an acronym for Low Energy Proton Electron Differentiating Electrostatic Analyzer.)

By the 1970's the instrumentation of Van Allen's group was well on its way toward readiness for the exploration of the radiation environments of the outer planets, Jupiter and Saturn. It became the responsibility of Roger F. Randall, chief engineer on the project, to design, procure, and assemble component systems durable enough to survive the 640-day, six hundred million mile journey into and through Jupiter's magnetosphere. The largest of the planets was almost certain to have enormously stronger and larger radiation environments than Earth's.

Pioneer 10 took off toward Jupiter March 2, 1972. It carried a dozen different experiments, including a Geiger-tube telescope box from the U of I. It was the first spacecraft to go through the asteroid belts beyond the orbit of Mars. Its instruments reported and survived the intense radiation it met near Jupiter. On December 3, 1973 Pioneer 10 flew by the huge planet within some 82,000 miles of its swirling surface.

With a similar cargo of experiments, including a slightly changed Iowa package, Pioneer 11 followed a year later with a different and closer approach to Jupiter. Launched on April 5, 1973 Pioneer 11 swept within 27,000 miles of the crackling surface of the turbulent planet on December 2, 1974. At the closest point in the fly-by, Pioneer 11 was whiplashed by Jovian gravity to a top speed of 107,000 miles per hour. This force turned the 570-pound craft back within the orbit of Jupiter and on a path toward a meeting with Saturn in 1979.

From the voluminous data received from Pioneer 10, Van Allen reported that Jupiter's far-reaching magnetosphere consisted of two major parts: (1) an outer disc-like region extending from 800,000 to more than four million miles out; and (2) an inner, dipolar region of extreme intensity within 500,000 miles of the planet. He was to report later that Pioneer 11 instruments in one location experienced radiation 10,000 times as intense as at any point in Earth's magnetosphere.

Pioneer 10 and 11 data provided such graduate students as Daniel Baker, Davis Sentman, Michelle Thomsen, and Mark Pesses with material for their doctoral dissertations between 1975 and 1979. Baker, Sentman and Thomsen were with Van Allen at NASA's Ames Research Center (the Pioneer monitoring station near Moffett Field, California) during the historical Jupiter encounters in the Decembers of 1973 and 1974. When the craft signals reappeared after the occultation phase behind the planet, the Iowans shared the relief of learning that their instruments had survived in good shape.

While their Pioneer instruments were reporting from hundreds of millions of miles away, the department's space scientists turned some of their attention to much closer studies. The experimenters wished to chart in the fullest possible detail the contours and contents of a funneling dip in the magnetic field around 40,000 miles above the North Pole. Through this relatively neutral zone the electrons and protons of solar winds and cosmic rays can more readily drive deeper into the atmosphere.

Hawkeye 1 (also called Explorer 52) was launched into 51-hour long orbits on June 3, 1974. A successor to the Injun satellite projects of the department in the 1960's, the spacecraft was not only "made in Iowa" but also the first to bear a name associated with a U.S. state. After completing 666 of its long elliptical orbits, Hawkeye 1 re-entered the atmosphere on No. 667 on April 28, 1978. By then its masses of data had provided source materials for at least twenty published papers. In the August 1978 NASA Activities bulletin, a NASA administrator pronounced the Hawkeye-Explorer mission to have been successful; thus officially underscoring the views of the principal investigators: J. A. Van Allen, D. A. Gurnett, and L. A. Frank.

Six months after the Hawkeye launch, the Very Low Frequency (VLF) group led by Gurnett became sun approachers with one of their soaring radio wave receivers. On December 10, 1974 their apparatus was aboard the cooperative German-American spacecraft Helios A when it set off for much the closest surveyance to date of solar effects and fluctuating conditions. The heavily mirrored and multi-louvered craft reached its first perihelion on March 15, 1975 at a distance of 28 million miles from the star.

A twin Iowa package on Helios B left the earth on January 14, 1976 and reached its first perihelion on April 16. It sped within 26.3 million miles of the outer boundaries of the solar mass, whose gravity at that point pulled the craft to a record vehicular velocity of 153,800 miles per hour. (And that is almost 43 miles per second!)

With their Helios apparatus out of the labs and into solar-terrestrial orbits twice yearly, Gurnett's group completed the development of VLF receivers for much farther investigations. Known as the Mariner-Jupiter-Saturn (MJS) project during the preparatory years, the spacecraft received the name of Voyagers shortly before their launches. Their equipment was designed and nuclear powered to function for more than thirty years and to communicate from as far out as eight billion miles, about twice the known radius of the solar system.

Proclaimed the Iowa City Press-Citizen of August 18, 1977:

> The longest series of space missions ever attempted by Earthmen will commence this weekend.
>
> The University of Iowa is a participant.
>
> When the first Voyager rises from the east coast of Florida Saturday (Aug. 20) morning, it will carry a scientific package from Iowa as it speeds toward the fullest exploration yet of the outer regions of our solar system. The odyssey may continue for 12 or more years ...

> Starting with the region around Jupiter in March 1979, Voyager destinations include the vicinities of as many as four planets and a dozen of their moons ...
>
> This year is an opportune time to head for the farthest planets, which are coming around in their solar orbits so that they can all be reached from Earth in about 12 years. Such a planetary alignment will not occur again until 2157.

Voyager 1 toured Jupiter's immediate domain during the first week of March 1979. It reached a periapsis with the planet's cloud cover of 175,000 miles on March 5. The Voyager's fly-by was held much farther away than the routes of the two Pioneers in 1973 and 1974 partly because of the investigators' interests in the details of the Jovian satellites. One objective was a near approach to moon Io, which orbits Jupiter at a mean distance of 217,000 miles and which appears to act as an on-off switch during electrodynamic activity from the host planet toward the earth.

Early on during the 18-month voyage the Iowa equipment confirmed the existence of very low energy emissions from the vicinity of Jupiter. During the fly-by period the VLF receiver picked up "whistler mode" radiation waves similar to those in Earth's magnetosphere.

Such deep space probes as the Pioneers, Helios, and the Voyagers of the 1970's communicate primarily by means of dish antennae of 210-foot diameters located in California, Spain, and Australia. The U of I's 60-foot dish near North Liberty, after monitoring satellite Hawkeye 1 in 1974-1978, has been converted into a radio telescope for stellar research. Besides using the North Liberty Radio Observatory (NLRO) as a nearby experimental area, the radio astronomy group of the department has been traveling to receiving sites in particular in southern California and Puerto Rico, to conduct multiple light-year distant studies of stars in various stages of evolution. The Iowa COCOA Cross near Borrego Springs, California is three-quarters of a mile long and half a mile wide in its dimensions. Its antenna elements were constructed in Physics Building laboratories and shops during 1972-1973. (COCOA contracts and abbreviates the words "co-linear" and "coaxial.)

Under the direction of Stanley Shawhan, the Iowa COCOA Cross staff has been studying the propagation of solar wind streams through interplanetary space (via the interplanetary scintillation of compact radio sources). The array has also been used to observe dekametric radio emissions from Jupiter and to search for radio emissions from Saturn.

Following its use in the tracking of satellite Hawkeye 1, the 60-foot antenna at the North Liberty Radio Observatory was converted into a receiving station for Very-Long-Baseline Radio-Interferometry. A program of VLBI observations was developed in collaboration with the National Oceanic and Atmospheric Administration at Boulder, Colorado and the National Radio Observatory at Green Bank, West Virginia.

The continuing extension of man's reach and grasp of ever larger and more distant areas resulted, among other things, in nomenclature divisions within space physics and astronomy--from the geophysics of earth and its near environment to the cosmology of the origins and expansion of the universe. Between the geo- and the cosmo- lay the planetary and interplanetary for the solar system outside the sun and astrophysics for the other stars of the Milky Way and the farther galaxies.

With most of the perceivable matter of the universe considered to take the form of the ionized gas known as plasma, it was natural as well as helpful for scientists of the plasma state to work in conjunction with the geo- to astro-scientists. At the University of Iowa, starting in 1965 with one faculty member, plasma research grew to a five-man group by 1977.

Beginning with the arrival of David C. Montgomery in the fall of 1965, theoretical plasma research expanded year by year, with

Glenn Joyce in 1966 and Georg Knorr in 1967. Montgomery had earned his doctorate at Princeton, Joyce at the University of Missouri, and Knorr at the University of Munich. Concerned with the statistical, kinetic, and field theories of the plasma state, these men investigated such areas as plasma waves and instabilities, transport properties, turbulence, nonlinear oscillations, and thermal relaxation.

Montgomery published a book, Theory of the Unmagnetized Plasma in 1971 to present his analysis of systematic behaviors of large numbers of plasma particles. During the same year Joyce and Knorr, with Thomas Burns, research assistant, as the third author, published "Nonlinear Behavior of the One-Dimensional Weak Beam Plasma System" in The Physics of Fluids.

In the year 1973, for instance, Knorr published "Plasma Simulation with Few Particles" in the Journal of Computational Physics, while Joyce and Montgomery co-authored "Negative Temperature States for the Two-Dimensional Guiding-Centre Plasma" in the Journal of Plasma Physics.

An example of the growing cooperation between the space and plasma research groups in 1973 at the U of I was an article in Science: "Io-Accelerated Electrons: Predictions for Pioneer 10 and Pioneer 11." The article's co-authors were space physicists Stanley Shawhan and Donald Gurnett, plasma graduate assistant Richard F. Hubbard, and plasma theoretician Glenn Joyce. The same four men followed in 1975 with "Io-Accelerated Electrons and Ions," with space theoretical physicist C. K. Goertz as an additional co-author. This offering was published as a part of Proceedings, "The Magnetospheres of the Earth and Jupiter," a conference at Frascati, Italy.

During the 1970's Montgomery and Gurnett joined in the annual reporting of Plasma Physics Abstracts, a collection summarizing plasma physics publications at the U of I. Part A of this collection had Theoretical as its heading, Part B, Space Plasmas in the year 1975. These annual summaries were indicative of the growing alliances among both the plasma and space people and among the theoretical and experimental scientists of both areas.

Starting his expansion of apparatus in a corner of the nuclear target chamber area in the early 1970's, Noah Hershkowitz began to develop a plasma experimental laboratory. A Johns Hopkins Ph.D. in 1966, he came to Iowa in 1967 to work with both the solid state and nuclear research groups. After leading such projects as radiation damage following Coulomb excitation, he became more interested in experiments supportive of the theoretical computations of David Montgomery and others. Largely from government surplus depots, Hershkowitz acquired quantities of vacuum tanks, power supplies, and other gear, all of which soon overflowed the space allotted to him in the nuclear territory. The problem of finding him sufficient space with adequate power for his laboratory simulations of naturally occurring plasma phenomena became a major dilemma of the mid '70's in the department. The planners of the new building could not have foreseen a development requiring both so much power and so much floor space.

After many discussions and committee meetings and the exploration of various options, the plasma lab was moved in 1976 to the central storage room of the west end of the basement. The 600 ft^2 of storeroom B26 was augmented by extending southward through B14, then a tape storage room. The next year more interior walls were removed, and the plasma lab absorbed B13, since 1965 the department's environmental test chamber. Thus by the fall of 1977 an enclosure of some 1350 ft^2, adjacent to the building's transformer room, was housing Hershkowitz's heavy apparatus. He was then able to set up double plasma and then triple plasma devices for the acceleration and mapping of electron particles.

Starting in 1976 the work in experimental plasma physics has expanded by the presence in the faculty of Nicola D'Angelo, a member of the Plasma Physics Board of the European Physical Society and a former director of the European Space Research Institute in Frascati, Italy.

During the summer of 1977 the basement wood shop, B04, was cleared out and renovated into a laboratory for D'Angelo's experiments in which he and his students are duplicating in controllable situations plasma instabilities in the ionosphere.

In addition to the conventional coursework for the bachelor's and master's majors in physics and astronomy, departmental offerings in the 1970's reflected the increase of numbers of faculty members engaged in plasma and space research. In the University Catalog appeared a full year course of plasma physics, and, primarily for graduates, a semester class of advanced plasma physics and a seminar for discussion of current research. Those who were seeking to become specialists in space physics had the opportunities of Solar-Terrestrial Physics and the Space Physics Seminar on the lists of physics courses and of Stellar Astrophysics, Solar System Astrophysics, Theoretical Astrophysics, and Stellar Structure and Evolution on the astronomy course listings.

During the 1970's the department also broadened its appeal and service by innovative courses offering instruction of special interest and use to students in other departments of the University. A science core course, Chemistry and Physics of the Environment, attracted large enrollments to the scientific study of certain ecological problems, including various kinds of pollution and the conservation of the balance of nature. Clyde Frank of the Department of Chemistry and his brother Louis Frank of the Department of Physics jointly conducted the course.

Another new course, Physics for Artists, dealt with color, holography, and other optical phenomena relevant to the appreciation, understanding, and creation of works of art. Noah Hershkowitz presented this course.

Physics of Sound and Music, under the direction of William Savage, was intended primarily for students of music, speech pathology and audiology. To a large extent this course was a reincarnation of the acoustics courses which George W. Stewart had directed for many years. But besides the basic properties of sound waves and their propagation, reflection and absorption, more emphasis was given in the new program to vocal and instrumental production and recording.

During the spring of 1974 and again in 1976, Savage organized and conducted national conferences at the U of I. These two-day meetings on topics under the heading of Sound and Music were primarily designed for college teachers of acoustics but also attracted some practitioners in various fields of music.

While this history has called attention at various times to student work in the department, particularly in connection with theses and dissertations for master's and doctoral degrees, it seems appropriate for this concluding chapter to present a summary listing of the advanced degrees awarded in physics and astronomy. By decades:

	Ph.D.'s	M.S.'s and M.A.'s
1900-1909	0	2
1910-1919	6	27
1920-1929	23	50
1930-1939	31	49
1940-1949	11	50
1950-1959	35	56
1960-1969	56	71
1970-1979	57	64
Total, as of July, 1979	219	369

For such numbers over so many years it would be a lengthy and very difficult task to show how and where these graduates continued their professional careers. It can be said, however, that very few turned to vocations outside their educational training. For example, J. A. Van Allen summarized the post-doctoral employment of those who achieved Ph.D. degrees between 1966 and 1973. Under the topic "On-Going Departmental Evaluation and Review", prepared in 1974 for the use of a Departmental Review Committee, Van Allen pointed out:

> One type of objective evaluation is provided by the fact that only one of our Ph.D. graduates of recent years has failed to find professional employment at the level of his capability and training, despite the general professional depression that prevails at present.

For an aggregation so widely scattered over many years and much geography as were the department's achievers of advanced degrees, it would indeed be presumptuous for this writer to select the most distinguished out of nearly six hundred persons. In these times of increasing specialization, individual contributions are probably best evaluated by the esoteric peers.

One might, however, note some aspects of the careers of a few of the department's alumni without imputations of supplying gratuitous value judgments. The first two doctoral graduates, Lee Paul Sieg (1910) and Homer L. Dodge (1914) both left their teaching positions at the U of I to become department heads at other universities. Each of them soon became deans of their graduate colleges, and each concluded his career as a president of an institution of higher education.

The first two doctoral graduates in nuclear experimental physics, Robert D. Huntoon (1938) and James A. Van Allen (1939) went on to leadership roles in fields other than their graduate specialty. Huntoon held various positions in research administration, including posts within the National Bureau of Standards and the Atomic Energy Commission. Van Allen moved into atmospheric and space research and work with a variety of national and international committees. In duration as head of his department at the U of I his span is exceeded only by that of the 37 years of George W. Stewart.

Early in the first quarter of the century, in 1902, LeRoy Weld commenced the advanced degree procession, offering as his master's thesis "A Brief Elementary Treatise on Terrestrial Magnetism." Now in the early years of the last quarter of the century, terrestrial magnetism is a principal business of James Van Allen and his associates and students. The topic has broadened to the many aspects of the electromagnetic environment of the earth with extensions to the magnetospheres of the other planets of the solar system. Now, however, the language of the theses and dissertations is much more esoteric and specific. For instance, the 1979 dissertation of William S. Kurth bears the title: "Intense Electrostatic Waves Near the Upper Hybrid Resonance Frequency."

In much earlier times of more attention to the divining of the future from prophetic omens, Weld's thesis on terrestrial magnetism might well have been viewed as a foreshadowing of coming activities. But in this respect there was a portent with an Iowa connection forty years prior to Weld's work. Among the professional credentials of Gustavus Hinrichs when he migrated from Denmark to Iowa in 1861 was his authorship of a pamphlet on terrestrial magnetism.

This chronicling of the first science to be taught at the University of Iowa now comes to a close. It began in the fall of 1856 during the late campaign weeks of Presidential contenders James Buchanan and John Fremont, during the preparation years of Charles Darwin's Origin of Species, and during the pioneering work of Gustav Kirchhoff and Robert Bunsen in developing spectroscopy for the analysis of stellar composition.

For well more than a century now Physics and Astronomy at the University of Iowa have endured and grown, all the while responding to the influences and shaping effects of a number of scientific and technological "Ages". Sequentially and much of the time concurrently overlapping, these periods of time have been the Ages of Electricity, of the Automobile, of Aviation, of Electronics, of the Atom, of Space, and of the Computer. Many of the key terms of each of the "Ages" are to be found in the glossaries of physics and astronomy--from such words as "absorption" and "acceleration" in the A's through the various "waves" and "zones" in the last of the alphabet.

These annals come to a close with the work of the Department of Physics and Astronomy represented nearly halfway out of the solar system by a package on Pioneer 10 and with other apparatus on Pioneer 11 now nearing a September Saturday rendezvous with the rings and other attributes of Saturn. As it has during most of the past thirty years, U of I experimental apparatus continues in 1979 to ride in the vanguard as man advances his outposts to learn what can be learned and to dispel more of the prefix from "infinite".

The American historian Arthur M. Schlesinger, Jr. has said:

> The 20th century will be remembered, when all else about it is forgotten, as the century in which man first burst his terrestrial bonds and began the exploration of space. No one can know where this exploration will finally take us. But the pursuit of knowledge and understanding has been humankind's most abiding quest; and to have confined this quest to our small planet, to have refused the adventure of space, would surely have been a betrayal of man's innermost nature.

In a profound statement of even broader scope, urging the critical study of the whole of the evolutionary chain of events of the universe, a committee of the National Academy of Science emphasized in Astronomy and Astrophysics for the 1970's:

> Through the vast reaches of space and time, part of the matter of the universe has evolved into living matter, of which a tiny part is in the form of brains capable of intelligent reasoning. As a result the universe is now able to reflect upon itself.