THE OHIO STATE UNIVERSITY

COLUMBUS, OHIO

History of the Department of Physics
1873 - 1970

INTRODUCTION

The development of an organization is often crucially influenced by a relatively small number of men whose talents and qualities of leadership give it its distinctive direction and style. This has, I believe, been true of the Department of Physics of The Ohio State University. Most of its ninty-seven year history is closely linked to the names of such men: Thomas Corwin Mendenhall, Stillman W. Robinson, Benjamin F. Thomas, Alfred Dodge Cole, Alpheus W. Smith, and Harald H. Nielsen.

Among these Alpheus W. Smith is first in terms of length of service. As Assistant Professor of Physics from 1909 to 1917, as Professor from 1917 to 1946, as Chairman of the Department of Physics from 1926 to 1946, as Dean of the Graduate School from 1939 to 1946, and as President of the Ohio State University Research Foundation from 1946 to 1958, Alpheus Smith served the Department of Physics and the University for almost fifty years.

Not the least of his many services was the preparation of the history, "Nine Decades of Physics and Astronomy at The Ohio State University" which Dean Smith completed in 1963. It is difficult to think of anyone more qualified to write such a history, and, although his health and eyesight were then beginning to fail, Dean Smith's writing still reflects the broad range of interests, the insight into the development of physics, the concern for quality in instruction and in research, and the forward-looking philosophy which characterized his more active years and which were so important in their influence on the Department and the University.

Dean Smith died in April 1968 at the age of ninty-two. It is likely that had he lived he would have written also the history of the tenth decade. His account of the first nine decades is reproduced here as a memorial to him and to his many important contributions. Aside from the correction of some obvious typographical errors it is as he wrote it.

E. L. Jossem
November 1969

THE FIRST PERIOD OF THE PHYSICS PROGRAM (1873-1908)

Physics During the First Period (1873-1908)

To understand fully the scientific climate in which the Department of Physics was initiated in the last quarter of the nineteenth century, we must recall our limited understanding of physical phenomena in that period. Of course, nineteenth century physics carried forward the developments in physics which had taken place in the preceding centuries. The most important of these developments was the classical work of Newton, whose contributions to mechanics established the firm foundations for classical physics. His preeminent role in the field of philosophy and physics is vividly indicated in the following quotation from Alexander Pope:

"The world was closed in night.
God said: let Newton be
And all was light."

The caloric theory of heat had been replaced by the concept that heat is due to molecular motion. The laws and properties of gases at ordinary temperatures and pressures, including liquifaction of gases, had been formulated with a fair degree of accuracy. The Law of the Conservation of Energy had been experimentally verified by the work of Joule in England and by that of Rowland in America. The experiments of Lavoisier had established the Law of the Conservation of Matter. It remained for Einstein's Theory of Relativity to show that these two laws must be unified into one law requiring the conservation of matter and energy, the transformation of matter into energy, and the converse transformation.

The early decades of the nineteenth century initiated the Age of Electricity. This period included the work of Oersted on the magnetic field associated with electric current, the verification of Ohm's law and Faraday's work on electromagnetic induction. The application of these and of associated discoveries to electrical machinery was being continuously extended. Applied electricity resulting in the evolution of dynamos, motors, and the electric telegraph and telephone was assuming increased importance in the last quarter of the nineteenth century. The electromagnetic theory of light as formulated by Maxwell and verified by the experiments of Hertz opened the modern field of electrical communications. The properties of ferro-magnetic substances were receiving attention especially with regard to their applications in electrical machinery.

The corpuscular theory of light had given way to the wave theory. Geometrical optics had received attention from the time of the Greeks and the Arabs and its essential principles had been established. The verification of the wave theory was derived from the experiments of Thomas Young on interference and diffraction. The wave theory of light explained the colors of thin plates and the diffraction colors of scratched or striated surfaces. The phenomena of polarized light in crystals had been examined by Sir David Brewster. Foucault had found that the velocity of light was not the same in different media, and thus was able to account for the refraction of light in passing from one medium to another medium. In 1862, he measured the absolute velocity of light with accuracy greater than heretofore known. This velocity was found to be very large. The assumption that light was transmitted through an elastic medium required that the medium have an extraordinarily large coefficient of elasticity and an extremely small density. These two very unusual properties were assigned to the hypothetical medium called the luminiferous ether. Doppler had shown that the wavelength of light emitted by a luminous moving body in the line of sight increased if the light moves away from the observer and decreased if the light moves toward the observer.

The analysis of the spectra emitted by different substances was at its very beginning. Atomic line spectra had been observed in emission by Wallenston and later by Swan, and in absorption in the sun spectrum by Fraunhofer. The study of spectra in flames had been extended by Kirchhoff and Bunsen. The effect of a magnetic field on spectral lines had been investigated by Zeeman. The spectral lines of many luminous gases and vapors had been described, and tables of wavelengths prepared, for visible spectra, and for the near ultraviolet as well. No analysis of these spectral lines had been made until 1884 when Balmer proposed an empirical formula describing the hydrogen lines known at that time. Radiation consisting of wavelengths both longer than and shorter than the visible spectrum had been explored in the preliminary manner.

The electro-magnetic theory of light, electromagnetic and electrostatic induction, and the transmission of the light through empty space, and related phenomena required the existence of a medium connecting the interacting bodies or the unacceptable hypothesis of action at a distance. To account for these phenomena on the basis of forces transmitted through a medium, it was customary in the nineteenth century prior to the theory of relativity to postulate the existence of a medium called ether. . . a postulate which Foucault had found necessary to account for the extremely large velocity of light. The existence and properties of this medium was a subject of intensive study toward the end of the nineteenth century. In 1887 Michelson and Morely performed their now famous experiment to determine whether the earth moves through a hypothetical medium called ether or whether the earth drags the ether along with it. The results were negative and indecisive, but they were the foundation of Einstein's Theory of Relativity and the abandonment of the ideas about a hypothetical medium called ether.

The electric discharges through rarefied gases were being intensively studied in this period. One of these studies resulted in the discovery of x-rays in 1895. This great discovery was followed in 1896 by the discovery of radio activity made by Becquerel and by the discovery of the electron in 1897 by J. J. Thomson. These discoveries and related observations near the end of the nineteenth century demonstrated that an atom could not be considered an indivisible particle, and that the constitution of matter and the chemical properties such as valence could no longer be described in terms of indivisible atoms. With these discoveries begins the rise of modern physics.

Initial Plans for the Department of Physics

In making the initial plans for the University, the Board of Trustees, with unusual scientific vision, recognized the central role which physics would play in any program for a land grant university in which there was to be great emphasis on science and technology. With this fact in mind, the Board decided that a Professor of Physics and Mechanics was to be the first member of the staff chosen for the new University. For the position, they selected Professor Thomas C. Mendenhall. Under Professor Mendenhall's title of Professor of Physics and Mechanics was included the beginnings of mechanical engineering.

At the time he was elected a member of the faculty of The Ohio State University, Professor Mendenhall was a teacher in the High School of Columbus. He had had no formal education beyond that offered by the public schools of his day. Such a choice indicates the fact that properly qualified instructors in physics who had had graduate work and experience in research were not available at that time. However, this rather unusual choice was fully justified because of the exceptional intellectual capacities of Mr. Mendenhall as shown by his later career. In 1878 he resigned his position as Professor of Physics and Mechanics to accept the chair of Physics at the Imperial University of Japan. After his resignation effective June, 1878, Stillman W. Robinson, was called from the Illinois Industrial University to the Chair of Physics and Mechanics. He entered upon his duties in September, 1878. He had held at what is now the University of Illinois the position of Professor of Mechanical Engineering and Instructor of Physics. Our professorship covered the same ground, but the subjects had been developed with the emphasis on physics. In calling Mr. Robinson, President Orton stated, "We have secured the best trained and most successful Professor of Mechanical Engineering in the west, and in so doing you have signified your purpose to give this side of the department a balanced and proportional expansion." This action amounted to the beginning of the Department of Mechanical Engineering and its later development and separation from the Department of Physics.

Professor Robinson served in the capacity of Professor of Physics and Mechanics until 1881 when Professor Mendenhall, then of the Imperial University of Japan, expressed a willingness to return home. His wish to return was cordially approved by the Board of Trustees and he was elected Professor of Physics, with the deletion of mechanics from the name of the title of the department. Simultaneously, the Department of Mechanical Engineering was created and Professor Robinson was elected to the Chair of Mechanical Engineering. In November, 1884, Mendenhall again resigned to accept a position as Professor of Electrical Science in the United States Signal Service at Washington, D.C. For the remainder of the academic year the work of the department was carried on by the assistants, J. E. Randall and E. H. Mark, Secretary of the Ohio Meteorological Bureau.

In June, 1885, Benjamin F. Thomas, Professor of Physics at the University of Missouri, was elected Professor of Physics and Head of the Department of Physics. He began his duties in September, 1885, and served in this capacity until 1908, at which time he ceased to be Head of the Department of Physics, but served an additional three years as Professor of Physics. During this time he, together with his colleagues, began building up facilities with which the later programs in physics have been developed. It was a period in which classical physics in America was receiving increased emphasis and attention. The work of Faraday, Maxwell, and Hertz had been done, and there was thus laid the foundation for the beginnings of electrical engineering, culminating in the extraordinary developments in modern methods of communication. Interest in physics in the University as shown by the enrollment in the Department of Physics increased significantly. The enrollment during the period which Professor Thomas was responsible for the administration of the Department of Physics tripled or quadrupled. The courses in physics were enriched in content and increased in number. This increased emphasis was particularly evident in applied electricity to which Professor Thomas gave serious attention introducing instruction in courses covering the theory and performance of dynamos, motors, and electric batteries.

Facilities and Equipment

Originally the Department of Physics was housed in the basement and in a limited part of the first floor of University Hall. The lecture room was on the west end of the first floor. In this room and in a small adjoining room there was equipment for lecture demonstrations, much of which had been imported in the early years. Recitations and lectures were always held in the morning and the room was used for elementary laboratory in the afternoon. One room on the first floor was used as an office. It included a showcase containing standards of weights and measures in use at that time. Also one room on the second floor was used for recitations. The basement directly under the lecture room was divided into six or seven rooms, each approximately 400 square feet in area. The large Geneva cathetometer was located in one of these rooms. In another there was a calorimeter, and in one of the neighboring rooms a gas engine, and in another a storage battery. The uses of the other rooms varied with the conditions. In a room between the lecture room and the office there stood a large dividing engine. The principal novelties of the laboratory equipment in the 1880's consisted of quite a collection of Crook's vacuum tubes, which were just being introduced to physicists, illustrating what was then sometimes called the "Fourth State of Matter," a state of extreme attenuation of particles, so to speak.

In 1886-87, the Board of Trustees provided funds for the purchase of a number of superior items of equipment. They included a Geneva cathetometer, a magnetometer, a Browning Spectroscope, standard thermometers, projection lanterns, two quadrant electrometers, an Edison dynamo machine, two Rowland diffraction gratings, a Hipp's chronoscope, a Wiedimann galvanometer and a Thompson galvanometer.

Professor Thomas was especially interested in applied electricity which was coming into prominence in the early 1890's. He undertook to provide for instruction in simple direct current motors and generators and electric batteries. In 1888 a steam engine was secured from the New York Safety Power Company and a six-volt dynamo from Thompson Huston Electric Company. This and other equipment created a necessity for a suitable place to put them. Later a small building in the rear of University Hall was built for them. This development in applied electricity pointed the way to the creation of the Department of Electrical Engineering in 1896, under the direction of Professor Caldwell.

As the University expanded, most of the sciences left the main building. Physics, however, remained there until 1905, when it was moved to the central portion of a new building, now known as Mendenhall Laboratory. In this new building the Department of Physics was sufficiently well housed to care for its program at that time. No sufficient funds were provided for the purchase of proper equipment for laboratories in general physics either for engineers or arts students.

Courses of Instruction and Enrollments

The initial courses offered by the Department of Physics were concerned primarily with the element of physics. These courses consisted of topics characteristic of classical physics in the last quarter of the nineteenth century and were intended for students preparing for careers in engineering. When the University was founded in 1873, the high schools of the state were found ordinarily in the cities. The villages and rural communities had rarely made provision for secondary education which would qualify graduates of their schools for admission to college. Consequently, the University found it necessary to provide, along with its other educational program, for preparatory work which would supplement the training of some students sufficient to admit them to the regular freshman courses. Under these conditions, the Department of Physics found it necessary to offer one course in introductory physics, equivalent in content and difficulty of courses normally offered in secondary schools of that period. The offering of this course was later discontinued when the secondary schools were sufficiently well developed to care for the educational needs of students applying for admission to the University.

In 1886-87 the courses of instruction in physics comprised three grades of work. In the preparatory course, the elements of general principles of physics were taught during the second and third terms. The work consisted, in the main, of a daily recitation, for which lectures by the instructor were occasionally substituted. The course was strictly elementary in its character and was fully illustrated by experiments throughout. It was based on Gage's Elements of Physics, and restricted to: elementary principles of solids and liquids, gravitation, falling bodies, Newtonian Laws of motion, three states of matter, molecular forces, elements of sound, light, heat, and static and current electricity.

During the sophomore year in Engineering all regular students had a recitation on three days of each week. In this course a textbook was used, and the work consisted of recitations and lectures combined. Experiments were made use of whenever necessary to elucidate the subject. This course in physics for sophomores was based on a textbook of physics by Anthony and Brackett. The contents of this textbook give an approximate indication of the level of instruction in the last decade of the nineteenth century. The topics included:

mechanics	mechanics of masses, mass attraction, molecular mechanics, mechanics, mechanics of fluids
sound	origin and transmission of sound, sounds and music, vibrations of sounding bodies, an analysis of sounds and sound sensations
heat	measurement of heat, transfer of heat, effects of heat, thermodynamics

magnetism and electricity	magnetism, electricity in equilibrium, electrical currents, chemical and magnetic action of currents, thermoelectric and luminous effects of currents
light	propagation, reflection, and refraction, interference and diffraction, dispersion, absorption and emission, double refraction and polarization.

The courses in applied electricity in 1891 were based on Cumming's Electricity and Mascart and Jourbert's Electricity and Magnetism. They covered such topics as electrical machinery, including direct and alternating current generators and motors. This phase of the work was later organized in the Department of Electrical Engineering under the direction of Professor Caldwell.

In order to give an indication of the enrollments in physics in typical classes, the enrollments for four years have been selected as representative of the teaching load in physics in the decade between 1881-1891.

Enrollments

Courses	Years			
	1881	1884	1887	1891
Secondary Preparatory	62	97	72	122
Sophomore	13	49	33	56
Laboratory	11	24	16	21
Applied Electricity	--	--	--	39

Scale of Salaries

The economic conditions, nationally and internationally, were entirely different from those with which we are currently familiar. This fact is indicated by the scale of salaries which were in effect in the early period of the University's history. A table indicating the scale of salaries initially enforced at the University is included to show the financial restrictions imposed on the selection of the physics staff in the early days of the University.

Scale of Salaries During the Year 1875

Professor	$2500
Assistant Professor	$1500
Instructor	$ 750
Assistant	$ 450

The Physics Staff During the First Period (1873-1908)

The following were members of the departmental staff who served during the first period, with an indication of the interval over which their service extended. In some cases this interval extends into the second period. In such cases they will appear a second time. Temporary instructors and assistants have not been included in the following list.

Mendenhall, Thomas G.	Professor and Head of the Department, (1873-78 and 1881-84)
Robinson, Stillman W.	Professor and Head of the Department, (1878-81)
Thomas, Benjamin F.	Professor and Head of the Department, (1885-1908)
Blake, Fredric C.	Assistant Professor, (1907-08)
Boyd, James E.	Assistant, Assistant Professor, (1891-1901), became Head of the Department of Mechanics in the College of Engineering
Caldwell, Frank C.	Assistant Professor, (1893-96)--in 1896 became Head of the Department of Electrical Engineering
Cole, Alfred Dodge	Professor, (1901-07)
Earhardt, Robert F.	Assistant Professor, (1903-08)
Kester, Frederic E.	Instructor, Associate Professor, (1895-1908)
Sheard, Charles	Instructor, (1907-08)

Brief biographical sketches of these members of the staff will be found in a later section.

THE SECOND PERIOD OF THE PHYSICS PROGRAM (1908-1946)

The Rise of Modern Physics

In order to understand the conditions under which the program of the Department of Physics developed in the second period, it is desirable to recall briefly the scientific interests of physicists of that period. The following very brief summary suggests the advances of physics in this period, the directions which its development would take in succeeding decades, and the scientific conditions under which the program of the Department of Physics developed in this period.

Near the end of the nineteenth century, Roentgen discovered x-rays; Bacquerel, Rutherford, and the Curies discovered and formulated the principles of natural radio-activity; J. J. Thomson isolated the electron, determined the ratio of its charge to its mass and explored related phenomena; and Plank developed the theory of radiation based on the postulate that radiation is emitted as bundles of energy called quanta. These classical discoveries opened up new vistas in physics, limited only by the imagination and intellectual capacities of the scientists interested in natural phenomena. They have served as the foundations for the development of modern physics. They have required new and unfamiliar modes of thought and analysis. Prior to these discoveries the atom had been considered an indivisible entity and there had been no theory accounting for the emission of spectral lines by excited atoms. Utilizing the results of Rutherford's observations on the scattering of alpha particles by the atomic nuclei and Plank's concept that radiant energy is emitted as quanta, Bohr developed a theory of atomic structure which accounted for the Lyman, Balmer, and Paschen and Brackett series of spectral lines in hydrogen. His theory yielded the result that the hydrogen atom may be thought of as a miniature solar system consisting of a relatively massive nucleus or core and one satellite of negligible mass moving around the nucleus in privileged orbits. To arrive at this important result, Bohr departed from traditional Newtonian mechanics and initiated a type of analysis which led to the development of quantum mechanics which has been effectively applied to the description of atomic and other small scale phenomena. This system of mechanics is not concerned with cause and effect, but rather with an accurate mathematical description of the phenomena. This system of mechanics has served not only as a basis for the analysis of atomic spectra including x-rays, but also in the analysis of molecular spectra and the structure of molecules.

The research work of Decquerel, the Curies, Rutherford, and others on natural radioactivity showed that many of the elements in the Periodic Table are more or less in a state of disintegration. These results on natural radio activity of the element suggested at once the possibility of producing artificial disintegration of the atomic nuclei by bombardment with high velocity charged particles, protons or deuterons. In order to explore these possibilities, it was necessary to devise electrical apparatus for imparting very high velocities and energies to electrified particles. Professor Lawrence of the University of California pioneered in the construction of the electrical apparatus called a cyclotron for accelerating positively electrified particles by causing them to circulate in orbits of increasing radii in a magnetic field.

It is especially adapted to the production of radioactive elements by bombarding other elements with electrified particles and to the transformation of one element into another. Professor van de Graaff of Massachusetts Institute of Technology designed another type of electrical apparatus for accelerating charged particles. It is known as the Van de Graaff electrostatic generator and is especially adapted to experiments in nuclear spectroscopy. Other types of equipment for the acceleration of electrified particles have been designed and used successfully. The results obtained with such equipment have opened up the new field of modern physics.

In this period the advances in theoretical physics were revolutionary. The penetration experiments on the nature and structure of both matter and radiant energy required the introduction of revolutionary concepts. Radiant energy could no longer be interpreted exclusively as a wave motion. In many instances it was found necessary to think of it as quanta of energy--the magnitude of the quanta being determined by the frequency of the radiation. On the other hand, the behavior of charged matter such as electrons and protons, in some cases, found simpler and more satisfactory interpretations if they were described as wave motions. There was thus developed a duality in nature, a wave motion and a particle description of many physical phenomena. Particles and waves thus became complementary and not mutually exclusive. There was a second very important change in the theoretical interpretation of the relation of matter and energy. Basically it was described in Einstein's theory of relativity and is stated in the now famous equation $E = mc^2$, where E is the energy, m is the mass, and c is the velocity of light. This equation states that mass may be transformed into energy and that energy may be changed into mass. In other words there is an equivalence of mass and energy--that is, mass may be transformed into energy and conversely. This concept of equivalence of mass and energy at once accounts for the continuous radiation of light and heat by the sun and by other luminous astronomical bodies. It also provides a basis for understanding the release of large quantities of energy in the fission and in the fusion of atoms, as was first demonstrated in the production of the atom bomb, later in the hydrogen bomb, and in the development of the reactors now in operation for industrial and military purposes. In brief, the experimental verification of Einstein's equation and its far reaching consequences in atom bombs, reactors, and in further advances in fundamental physics, introduced a new epoch in military preparedness, in industry, and in penetrating analysis of physical, chemical, and biological phenomena. The epoch may be properly described as the Atomic Age.

In addition to the developments in fundamental physics during the first half of the twentieth century, there were many developments of great significance in applied physics and in the application of physics to related sciences. The experimental verification of electromagnetic waves by Hertz, and the study of emission of electrons from hot bodies by Richardson and others laid a firm foundation for modern methods of communication. Less conspicuous, but nevertheless very important developments in applied optics and applied accoustics were made in this period. In other fields closely related to physics, such as chemistry, metallurgy, medicine, and engineering, there were many new and important applications of physics.

In this scientific environment the Department of Physics at The Ohio State University developed during the early decades of the first half of the twentieth century. Its resources and personnel were very limited, but its purposes and program were clearly defined and laid a proper basis for later developments.

The Beginnings of Graduate Study

In 1908 Alfred D. Cole was appointed Professor of Physics and Head of the Department of Physics to succeed Benjamin F. Thomas, who gave up his administrative duties, but retained his position as Professor of Physics. Professor Cole received his AB degree and his AM degree from Brown University and he later studied at Johns Hopkins University and the University of Berlin. He was especially interested in electric waves, a branch of physics which was receiving much attention at that time stimulated by the classical work of Hertz. Formerly Professor Cole had served as Assistant Professor of Physics at The Ohio State University, Professor of Physics at Denison University, and Professor of Physics at Vassar College. He appreciated the necessity of developing graduate work and research in the Department of Physics. Prior to his service as Head of the Department of Physics, emphasis had been placed almost exclusively on undergraduate instruction in physics. Neither the departmental staff nor the physical facilities were adequate for graduate work and research, and the demand for graduate instruction was very limited. The Graduate School was not organized until 1911. Until that date advanced work beyond the undergraduate programs was administered by a Faculty Committee on graduate studies with Professor Bowen as its chairman. Professor Cole served as a member of the first Graduate Council and consequently participated in the formulation of policies and purposes in the early days of the Graduate School which was designed to organize, administer, and promote graduate work at the University.

Facilities for Teaching and Research

During the earlier years of Professor Cole's service as Head of the Department of Physics, the Department was housed in the central part of the building now called Mendenhall Laboratory. The East and West Wings were not built until a later date. On the basement floor of the building provision was made for a very well equipped laboratory for electrical measurements, primarily for students of the Department of Electrical Engineering. This electrical equipment included a very excellent storage battery (110 volts and 10 volts) with a DC generator to charge it and to be used for other purposes. There was a small room equipped with photometers for the comparison of the candle power of electrical lights and for other measurements on sources and intensities of illumination. Another small room was used as a mechanical shop. It was equipped with a good milling machine, an engine lathe, a bench lathe, a drill press, a power saw, and small tools of different types. There were two constant temperature dark rooms, one of which was used as a research room. As an extension of the main electrical laboratory, there was a small adjoining room which was used primarily for the storage of electrical apparatus. The first floor of the building provided for a general office for the Head of the Department, his secretary, and two members of the departmental staff. It also provided a general laboratory designed to accommodate the laboratory work associated with courses in general physics for students of engineering and students in the College of Liberal Arts. On either side of this laboratory there was a small room with suitable cases for the storage of laboratory apparatus when not actually in use. The laboratory although well enough designed for its purposes was very meagerly equipped. Laboratory work as part of the instruction in general physics had been largely neglected.

On the first floor there also were two additional small rooms, used for research purposes, one by Professor Blake and the other by Professor Smith. They were not originally intended to be research rooms but had been adapted, as well as possible, for that purpose. On the second floor there was a large auditorium, seating about two hundred fifty students and a small room just off of it, for the storage of demonstration apparatus for general lectures in physics. In addition to these rooms on the second floor, there was one recitation room, one room for a general office, a photographic dark room, and a small room for the storage of chemicals and for the preparation of chemicals required in the laboratories. The third floor consisted of four recitation rooms. The laboratory also included a small elevator hand powered for taking apparatus and supplies from one floor to another, and an open shaft extending from the basement to the third floor intended for the installation of a long heavy pendulum to show the rotation of the earth. Except for the equipment for the electrical measurements laboratory, little provision had been made in the earlier years for the equipment of the laboratory with apparatus appropriate for either teaching or research. Aside from a limited number of student spectrometers, spectroscopes, etc., there was almost no optical or spectroscopic equipment, although spectroscopy was at that time a very important field for teaching and research in physics.

In 1914 the East Wing of Mendenhall Laboratory was built to house temporary offices and recitation rooms for the Department of English. This department had previously been partially housed in a small building in the rear of University Hall. When this building was destroyed by fire, it was decided to build the East Wing of the Physics Building for some of the offices and recitation rooms necessary for English until more adequate quarters could be provided. The space in the East Wing was divided into three rooms on each floor including the basement. The rooms were essentially equal in size. Two were subdivided to make offices for the English staff. The other rooms with one or two exceptions were used as class rooms. When the old chemistry building was remodeled to yield what is now called Derby Hall, offices and recitation rooms for the English Department were provided in that building and the space previously occupied by the Department of English in the East Wing of the Physics Building was released to the Department of Physics and to the program in applied optics later known as optometry. Demands for offices, recitation rooms, and laboratories in physics and applied optics required changes in the assignment of the space thus released to the Department in the East Wing of the Physics Building. The final assignment of this space and its essential characteristics and uses are indicated in later paragraphs.

The southeast corner room of the basement was transformed into a machine shop, with suitable work benches, and some additional mechanical equipment and machines. One additional technical assistant was employed and the construction of teaching and research apparatus was facilitated. The northeast corner room of the basement was transformed so as to house two concave gratings each with a twenty foot radius of curvature--one for investigations of the Zeeman effect and the other for comparison of the intensities of spectral lines. The gratings were mounted on separate concrete piers but they used the same slate circle on which the photographic plates were mounted. A large electromagnet was designed and built in the shop and installed with auxiliary apparatus in an anteroom which formed part of the concave grating room. To supply the necessary electric current for the electromagnet, a direct current generator which would supply one hundred amperes constantly was installed in the small room neighboring the shop. The central room in the basement was converted into a research room for the investigation of x-rays and a small office for the technical assistants. Three rooms on the first floor in the east wing were modified so they could be used as additional laboratories for the general course in physics. The School of Optometry was assigned the central room on the second floor as general offices and the northeast room as a laboratory for mechanical optics. The southeast room at one time was used as a small lecture room and later housed the clinic for optometry. The southeast room on the third floor was used as a recitation room and the northeast and central rooms were used for a laboratory for geometrical optics.

In 1922, the West Wing of Mendenhall Laboratory was built. It was designed for the general use of the Department of Physics. There were three rooms on each floor including the basement. The three rooms in the basement were each subdivided into two or three compartments for research purposes chiefly in spectroscopy--one for the study of absorption spectra in liquids and for investigations of vacuum spectroscopy in the near and far ultra-violet region of the spectra. The other small research rooms in the basement of the west wing were used for a variety of research purposes. In one of them was installed a ten foot concave grating on an Eagle mounting and also a very large Hilger quartz spectrograph. The three rooms on the first floor were all laboratories for intermediate physics, one for physical optics, one for electronics and radioactivity, and the other for experiments in heat and related phenomena. The three rooms on the second floor were equipped with lecture tables and black boards so they could be used for lecture-recitation rooms. The three rooms on the third floor were originally designed to be recitation rooms. Later they were readapted and used to house the Cole Memorial Library to which was added the advanced books and periodicals in Mathematics.

Additional Facilities for Teaching and Research

In order to develop the undergraduate instruction, graduate work, and research beyond their status when Professor Cole relinquished the chairmanship of the Department of Physics and was succeeded by Alpheus W. Smith, it was necessary to expand and readapt space in the laboratory, to construct and to purchase physical equipment for teaching and research, and to secure the services of additional members of the staff, competent to both teach introductory courses and to carry on important investigations in their chosen field of physics. Since it was impossible to conduct research in all important fields of fundamental and applied physics, a carefully considered choice of the fields of research to be incorporated in the program became necessary. Considering the state of knowledge of physics at that time and the fields in which there was most active research, it was decided to restrict research efforts to x-rays, atomic spectroscopy, molecular spectroscopy, and later to nuclear physics.

Progressively the laboratory space available in the building was adapted and equipped as far as possible for selected research problems in these fields. One of the constant temperature dark rooms was transformed into a photographic dark room. The other constant temperature dark room was used as a research room for infra-red investigations on absorption spectra in gases and vapor. The small room directly off of the electrical laboratory which was formerly used for the storage of apparatus, was adapted for use as a research room for Professor Barnett's experiment on magnetization in iron by rotation, and later for experimental work on the application of supersonic sound waves by Alva W. Smith.

On the first floor in the central part of the building three rooms were used for research--one for nuclear physics, one for x-rays, and one for molecular spectroscopy. There was no space available for research on the second floor. It was used for offices, lecture and recitation rooms. On the third floor four rooms which formerly had been used for recitation purposes were changed so that they could be used as laboratories for x-ray research, for spectroscopy, for high voltage equipment, and for physiological optics. In 1929 the large lecture room was remodeled so the space could be used more efficiently. Originally the lecture room had been designed as a two story high room seating about two hundred fifty students. The accoustics were poor, making it difficult for students to understand the lectures or to see clearly the demonstrations. It was decided to construct a ceiling and a third floor which divided the lecture room. The size of the auditorium was somewhat reduced by partitioning off a portion to the rear of the lecture table, moving the lecture table forward, and using the space thus made available for the storage of demonstration and lecture apparatus. The seating capacity of the lecture room was thus reduced to about two hundred and its accoustics greatly improved. The space made available on the third floor was subdivided into eight small rooms to be used for research, for photographic dark rooms, and for the installation of special apparatus which must be operated in the dark.

Sufficient funds for the proper equipment of teaching and research laboratories were not available during this period. With the exception of the laboratory for electrical measurements, the other teaching laboratories were provided with only a minimum supply of desirable equipment and were obliged to depend on student laboratory fees for their improvement and proper maintenance. Student laboratory fees in physics were authorized to provide for breakage, obsolescence, etc. but in fact, they have often been used for replacement and for purchase of necessary additional equipment. The funds provided by the University for current expense and for the purchase of new equipment have been used largely for the purchases of research apparatus and equipment. After the Development Fund was established, much very valuable financial assistance has been provided by it for the purchase of research equipment and for other types of support for research projects. The following is a partial list of apparatus, purchased or constructed in the departmental shops during this period, for research and for advanced laboratory experiments.

In many instances, parts of the apparatus were purchased and the remainder of the instrument constructed and assembled in the departmental shop or in one of the laboratories.

1. A large glass three prism spectrograph for investigation of the Stark effect. The optical parts--three large prisms and two lenses--were purchased from Bausch and Lomb and the spectrograph constructed and adapted to serve its purposes by the mechanics in the shop and by the investigator who was to use it. Later this spectrograph was redesigned and reconstructed to form a more flexible large glass spectrograph.

2. AFrey quartz spectrograph (Hilger).

3. An E-3 quartz spectrograph (Hilger).

4. An E-1 quartz spectrograph (Hilger).

5. A large quartz spectrograph, the optical parts purchased from Hilger and the spectrograph constructed in the machine shop.

6. Two constant deviation prism spectrographs (Hilger).

7. A quartz monochrometer (Hilger).

8. A small infra-red spectrometer (Hilger).

9. A Nuting photometer (Hilger).

10. A Fabry-Perot interferometer (Hilger).

11. A Michelson interferometer (Gaertner).

12. A ten foot radius of curvature concave grating on Eagle Mounting.

13. Two twenty foot radius of curvature concave gratings mounted on a common pier in the grating room.

14. One large electromagnet excited by 100 amperes for research on the Zeeman effect.

15. One motor-generator set to deliver 100 amperes at constant voltage for research on the Zeeman effect.

16. One 1000 volts motor-generator set for research on Zeeman effect and other types of investigation.

17. One vacuum spectrograph with auxiliary equipment and pumps for research in absorption in the ultra-violet region of the spectra.

18. One vacuum grating spectrograph used at grazing incidence, and auxiliary equipment for research on the spectra in the extreme ultra-violet region of the spectra.

19. An x-ray spectrometer constructed in the machine shop, the divided circle and microscopes were purchased.

20. Two high voltage transformers for x-ray research.

21. Two large infra-red grating spectrometers with auxiliary equipment, amplifiers, etc. one of them located in the McMillin Observatory.

22. X-ray diffraction apparatus.

23. Knip and Son densitomer with auxiliary galvanometer, etc.

24. Electron microscope.

25. Cyclotron.

26. Van de Graaff electrostatic generator (initiated).

27. Supersonic equipment for producing very high frequency sound waves.

Applied Physics

Prior to 1923 no curriculum or program in either fundamental or applied physics had been formulated for students who might be interested in majoring in physics with supporting courses in chemistry and mathematics. It was recognized that some students in the College of Engineering would be more effectively served by a curriculum which placed greater emphasis on physics, mathematics, and chemistry rather than so much emphasis on engineering applications of these subjects. These students should prepare to major in physics in some good graduate school or to find employment after graduation in an important industrial or government research laboratory. In view of the fact that the Department of Physics at that time was administered in the College of Engineering, it undertook to organize and to offer a program in applied physics which would consist primarily of physics, chemistry, and mathematics with sufficient introductory courses in engineering to give students some understanding of the relation of fundamental and applied physics to the engineering sciences. The program finally inaugurated, included a Freshman year which was the same as the Freshman year for each of the other curricula offered in the College of Engineering. The three following years included courses in organic and physical chemistry, calculus, differential equations, vector analysis, advanced calculus, etc. The remainder of the program was made up of general physics, and intermediate courses in mechanics, light, electricity, electrical engineering, etc. The completion of this four year curriculum led to the degree of B. Sc. in Physics. This curriculum is known as Engineering Physics, and in 1925 Louis M. Heil was the first graduate to complete this curriculum. In later years when all the curricula in the College of Engineering were extended to five years this curriculum was also extended to a five year curriculum by the inclusion of additional courses in the physical sciences and appropriate courses in the social sciences. This program in applied physics assumed that it might very properly be extended to include graduate work in applied or fundamental physics in the Graduate School.

Transfer of the Department of Physics to the College of Arts and Sciences

In the early history of the University the different departments were not allocated to a specific college for purposes of administration. The departmental budgets were prepared in the Office of the President and in the Office of the Business Manager of the University. The duties of the Deans of the several Colleges were restricted primarily to presiding over the meetings of the faculty and their respective colleges, directing the formulation of curricula, coordinating the courses offered by the different departments, and similar functions where their educational leadership might be appropriate. At the suggestion and urging of Dean Edward Orton of the College of Engineering, the different departments were allocated to what seemed the appropriate college for more effective administration. At that time the Department of Physics, together with the Department of Chemistry, the Department of Mathematics, the Department of Astronomy, and the Department of Geology, was assigned to the College of Engineering. The assignment was made primarily on the basis of the number of students registered in courses required to be taught in that college. This assignment continued until Walter J. Shepard was appointed Dean of the College of Liberal Arts. At that time the name of the College of Liberal Arts was changed to the College of Arts and Sciences and, in the year 1929, the Department of Physics and also the Department of Astronomy were transferred from the College of Engineering to the College of Arts and Sciences for administrative purposes. This change in administration lent emphasis to the development of additional courses which were not entirely directed toward instruction of students preparing for careers in engineering. With this broader concept of the functions of the Department of Physics, its growth and services were accelerated and provisions were made for students to major in physics in the College of Arts and Sciences and to continue their work in the Graduate School.

Unified Physics and Astronomy Program

Prior to 1933, astronomy was administered as a separate program. The enrollment in the course had greatly diminished and the general interest in astronomy was at a low level. The staff of the department consisted of one professor, also acting as director of the observatory, and one student assistant. The interest in astronomy at that time was largely in the field of astrophysics, which related the astronomy program more and more closely to physics, especially to spectroscopy and nuclear physics. In consideration of these and related facts, Dean Shepard, of the College of Arts and Sciences suggested that it might be appropriate to unify astronomy administratively with physics in the hope that cooperation of the two sciences might somewhat revitalize astronomy and at the same time widen the interests of the physics program. A committee appointed by President Rightmire to survey the administration of the different departments and the instruction offered by them at the time of the Great Depression, recommended to the Board of Trustees that the astronomy program be combined with the physics program under one administration and that the name of the Department of Physics be changed to the Department of Physics and Astronomy. This recommendation was approved by the Board of Trustees, and the Chairman of the Department of Physics assumed administrative responsibility for the astronomy program.

The Alfred Dodge Cole Memorial Library

After the death of Professor Cole in 1928, it seemed very desirable to provide some type of memorial for him in recognition of his services to the Department of Physics and to the University. A careful consideration indicated that a library for the Department of Physics would be most appropriate. Prior to this time physics books and periodicals had been housed in the Main Library where they were not too easily accessible to physics students and members of the departmental staff. It was decided that a physics library housed in Mendenhall Laboratory would greatly facilitate the use of physics books and periodicals thus contributing much to the intellectual growth and interests of both students and members of the departmental staff. Consequently the department undertook to raise funds from former students and friends of Professor Cole to endow a library for the Department of Physics with the understanding that it would be housed in Mendenhall Laboratory and with the further understanding that the income from such an endowment would only supplement, but not replace the funds which the Department of Physics and Astronomy normally received from funds appropriated by the Ohio legislature for the purchase of books and periodicals for the entire University.

In order to proceed with the solicitation of funds for the endowment of the Physics Library, a committee consisting of C. E. Skinner, Westinghouse

Electric Corp., Chairman; Frederic C. Blake, Professor of Physics, Secretary; H. B. Brooks, physicist, U. S. Bureau of Standards; H. C. Bumpus, Consulting Director of Buffalo Museum of Science and President of Mt. Desert Island Biological Laboratory; George H. Calkins, General Electric Corp.; Edward A. Deeds, Wall Street; A. C. Fieldner, U. S. Bureau of Mines; W. E. Forsythe, Nela Research Laboratory; Frank P. Graves, President of the University of the State of New York; E. A. Hitchcock, Dean of the College of Engineering; W. H. Johnson, Editor of the Columbus Dispatch; F. E. Kester, Professor of Physics, University of Kansas; Charles F. Kettering, General Motors Corp.; J. G. Lovejoy, General Electric Company; Paul M. Lincoln, Director, School of Electrical Engineering, Cornell University; James Lincoln, President of Lincoln Electric Corp.; C. F. Marvin, Director, U. S. Weather Bureau; D. C. Miller, Case School of Applied Science; Robert A. Milikan, Director of the Norman Bridge Laboratory of Physics; D. H. Morris, Ohio Bell Telephone Company; Edward Orton, Jr., Manufacturer; Michael I. Pupin, Columbia University; Charles F. Scott, Yale University; Charles Sheard, Mayo Clinic; W. H. Siebert, Professor of History; Carl E. Steeb, Business Manager, the Ohio State University; Julius F. Stone, Board of Trustees; George B. Thomas, Bell Laboratories; W. O. Thompson, President Emeritus, was authorized to solicit funds from students and friends of Professor Cole. The work of solicitation proceeded very satisfactorily. Mr. Charles F. Kettering and Mr. Edward A. Deeds, special friends of Professor Cole, were exceptionally generous with their gifts. The endowment provided amounted, in June 30, 1962, to $33,000, yielding an income of $1,971. It is deposited with the Treasurer of the State of Ohio, and the income is available only for the purchase of physics books and periodicals. Two rooms on the third floor of Mendenhall Laboratory, formerly used as recitation rooms, were provided with shelves, tables, and desks to make them available for use as a library. Mrs. Cole gave Professor Cole's private library as a nucleus of this library. The physics books and periodicals in the Main Library were transferred to the new Physics Library and a full time library attendant provided for it. Later the Department of Mathematics decided to transfer its advanced books and periodicals in mathematics to the Cole Library. An additional adjoining room was made available for these mathematical books and periodicals. The Cole Memorial Library thus became a library for both the Department of Physics and Astronomy and the Department of Mathematics.

The provision of the departmental library in Mendenhall Laboratory, where books and periodicals were easily available to students and staff contributed greatly to the scientific development of the staff and students.

Courses of Instruction

With the continuously increasing interest in physics and its applications, the enrollments in the different types of courses in physics in the period under consideration (1908-46) consistently increased except for the period interrupted by the first and second World Wars. A sequence of three introductory basic courses (five credit hours) were taught for premedical, predental, prepharmacy, and preoptometry students registered in the College of Arts and Sciences. These same courses were elected by other students in the College of Arts and Sciences, the College of Education, and the College of Commerce and Administration. Another sequence of the three five hour courses, more advanced than the one offered in the College of Arts and Sciences, was provided for students (sophomores) in the College of Engineering. It was assumed that students electing these courses were simultaneously studying calculus or had previously studied calculus, and had taken a year of high school physics. Still another sequence of courses on electricity and magnetism was offered for sophomore students in the Department of Electrical Engineering. They were partly lecture and recitation and partly electrical laboratory work, with emphasis on basic electrical measurements. A sequence of three courses on physical and geometrical optics, each for five credit hours including laboratory work, was offered for students of Optometry.

An analysis of the registration in these basic introductory courses in physics showed that a small percentage of the students in the University was electing physics or astronomy and thus gaining an understanding of the subject matter and methods of these physical sciences during their residence in the University. It was therefore decided to develop a different type of course, better adapted to the interests of the students who had no thought of specializing in either the physical or the biological sciences or their applications. It was to be organized and taught as an essential part of a liberal education, giving an insight into the elements of both physics and astronomy and the methods of scientific thought by which these fields of science have been developed. A sequence of three five credit hour courses was offered under the name of "The Nature of the Universe". Later the sequence was reduced to two five credit hour courses, taught primarily by the lecture and recitation method with liberal demonstrations in the lectures and with special types of laboratory experience. This sequence of courses was developed by Professor C. E. Hesthal with limited assistance and cooperation from other members of the Department. This experiment in developing and teaching a course including both introductory physics and astronomy had wide appeal to students without any special scientific interest, and proved to be very successful. It has been widely elected and seems to have served a very desirable purpose.

With increasing interest in advanced courses in physics, the intermediate courses designed for advanced students and beginning graduate students were increased in number and considerably changed in content. Several of them dealt with classical physics, i.e. mechanics, kinetic theory of gases, thermodynamics, physical optics and electricity and magnetism. As the field of spectroscopy and nuclear physics developed, introductory courses in spectroscopy, nuclear physics, and quantum mechanics were introduced. As the number of students in the Graduate School working for advanced degrees increased the group of courses (primarily for graduate students) was enlarged from time to time. This group of courses was concerned primarily with theoretical physics. It included such courses as advanced mechanics, electromagnetic theory of light, advanced quantum mechanics, molecular spectroscopy, etc.

The following is a typical list of the courses of instruction offered for advanced undergraduates and graduates by the Department of Physics prior to 1946:

For advanced undergraduates and graduates: Heat and Thermodynamics, Statistical Theory of Gases, Geometrical Optics, Physical Optics, Design and Theory of Optical Instruments, Advanced Electricity, Conduction of Electricity through Gases, Thermionics and High Vacuum Phenomena, Periodic and Transient Electric Currents, Electromagnetic Field Phenomena, Introduction to Nuclear Physics, Wave Motion and Sound, Modern Atomic Spectroscopy, Spectra and Structure of Molecules, X-rays and Atomic Structure, Introduction to Theoretical Physics.

For graduates only: Thermodynamics, Electromagnetic Field Theory, Electromagnetic Theory of Light, Line Spectra and Atomic Structure, Quantum Mechanics, Advanced Quantum Mechanics, Statistical Mechanics, Applications of Statistical and Quantum Mechanics, Advanced Dynamics, Molecular Spectra, and Mathematical Physics.

Colloquia

In order to keep the staff of the Department and the graduate students abreast of the current advances in physics and astronomy, the Department maintained colloquia each week in which important current contributions to physics and astronomy were discussed and interpreted. In general there were two types of colloquia: one concerned primarily with experimental physics and astronomy, and the other concerned primarily with theoretical interpretations of physical phenomena. Both the staff and the graduate students availed themselves of these opportunities to learn about the research activities in other physical laboratories and astronomical observatories. The colloquia on theoretical physics and astronomy was less generally attended by the staff and students than the one concerned primarily with experimental physics and astronomy for the reason that the reports in theoretical physics and astronomy were more difficult to understand. These colloquia in which both members of the staff and graduate students participated proved to be very effective in keeping both staff and students informed about the important contributions and activities of physicists and astronomers.

Research Programs (1908-1946)

As the different fields of modern physics developed and sufficient literature in the field became available, intermediate and graduate courses were organized and taught as conditions justified. Personnel who had specialized in the different fields were appointed on the departmental staff. It was not possiblė to carry on research in all the important fields. Neither the staff nor the facilities were at hand for such a program. A selection of topics for which adequate facilities and properly qualified personnel could be provided was made, and these fields of research developed while other important fields were omitted. The following is a brief outline of the fields of research which were included in this period (1908-46).

Atomic Spectroscopy. When Bohr's theory of the atom became understood and was found effective in interpreting the spectra of atomic hydrogen, great interest was stimulated in atomic spectroscopy. The formulation of the quantum theory further enlarged and clarified the concepts necessary for and understanding of atomic spectra so that spectra more complex than that of hydrogen could be analyzed.

Facilities for research in atomic spectroscopy were developed as rapidly as possible. A twenty-one foot grating was located in a room specially adapted and treated to provide the constancy of temperature and freedom from building vibration necessary for acceptable results. A second concave grating was mounted in this room and adapted for the comparison of the intensities of spectral lines. Auxiliary equipment included a large magnet for the study of Zeeman and Paschen-Bach effects in the spectra of atoms and the hyperfine structure of spectral lines. One vacuum spectrograph with auxiliary equipment was available for the study of the spectra of highly ionized atoms produced in a hot spark discharge. A second vacuum spectrograph was used for the study of absorption spectra, particularly the predissociation of complicated molecules. Several quartz spectrographs and others with either glass or quartz optics made possible investigation of atomic spectra in the visible and near ultra-violet spectral regions.

A number of scientific papers were published on emission and absorption spectra in the visible, ultra-violet, and far ultra-violet regions of the spectra in gases and liquids. This field of investigation was primarily but not exclusively the research interest of Professor Robert V. Zumstein. The splitting of electric lines by a magnetic field and the hyperfine structure of spectral lines were very fully investigated by Professor Jerome B. Greene. The work resulted in the publication of a long series of papers. The comparison of the intensities of spectral lines was the primary interest of Professor C. E. Hesthal. The effect of the electrostatic field on spectral lines was the subject of a dissertation for the Ph. D. degree by a graduate student.

Spectroscopy and Molecular Structure. The field of molecular spectroscopy developed into a field of special interest for the Department of Physics. At the beginning the Department was without suitable spectrographs for this type of research. Professor Harald Nielsen designed and had constructed in the shop of the Department of Physics two very superior prism-grating spectrographs for the examination of infrared spectra of vapors and gases. They were of very high resolving power. One was provided with methods of evacuation so that extraneous absorption lines could be identified and eliminated. With these spectrographs and auxiliary equipment, Professors Nielsen and Shaffer and their graduate students conducted a series of investigations extending over a period of years. These investigations were both experimental and theoretical. Analysis of their results in terms of the quantum theory contributed much to the understanding of polyatomic molecules.

X-rays and Crystal Structure. The discovery of x-rays opened up many new vistas for a study of the nature of things. Soon after the announcement of this discovery, Professor B. F. Thomas, the head of the Department of Physics, and Dr. Early, a physician in Columbus, undertook to explore the possibility of employing x-rays in the field of medicine and surgery. At that time the nature and properties of x-rays were not understood. Controlled methods for their production and techniques for safely using them for such a purpose had not been worked out. Consequently observations at that time could only be exploratory in nature. Years later, after the characteristics, properties, and effects of x-rays had been carefully studied and understood, Professor Blake began a series of studies on x-rays and their applications. They included the determination of Planck's constant, critical absorption of x-rays, crystal structure of solid solutions and alloys, and intensity measurements of the scattered energy in x-ray analysis of crystals. The x-ray laboratory was equipped with x-ray diffraction cameras, x-ray spectrometer, high-voltage transformers, rectifiers, and auxiliary apparatus. In some of these studies he cooperated with Professor W. J. MacCaughey of the Department of Mineralogy and Professor Edward Mack of the Department of Chemistry. Their investigations yielded a number of scientific papers on which several graduate students had cooperated. Two of these students, Robert J. Havinghurst and Preston Harris, used the results of their investigations to satisfy the requirements for the Ph. D. degree dissertations in physical chemistry. Their abilities and achievements were sufficiently superior to earn the award of a National Research Council Fellowship for each of them for post doctoral research. A plan to construct, equip, and operate an x-ray laboratory primarily for industrial radiology was initiated just before World War II. It was to be equipped with facilities for generating very high frequency x-rays, with lower voltage x-ray equipment, with x-ray diffraction cameras, photographic and other equipment necessary for industrial radiology. The plans for the building to house this laboratory were drawn up, the x-ray diffraction cameras and equipment for generating 250,000 volt x-rays and Picker x-ray diffraction cameras were secured, but the involvement of the United States in World War II interrupted the program and it was abandoned.

Electron Optics. The program in electron optics had its origin in the development of the electron microscope in Germany. This research interested two graduate students at the University of Toronto, Albert F. Prebus and Hilyer. They constructed and used for investigational purposes the first electron microscope in the Western hemisphere. After they had completed the work for their doctor's degrees at the University of Toronto, Dr. Prebus came to The Ohio State University on a post doctoral fellowship, the funds for which were provided by Mr. Julius F. Stone. This post doctoral fellowship was set up as a cooperative undertaking between the Department of Physics and Astronomy and the Department of Electrical Engineering. Dr. Prebus began at once to redesign, construct, and apply very successfully the electron microscope to problems where extremely high magnification was necessary, cooperating effectively with some of the biological departments. Later he accepted a position with Bell Telephone Laboratories, but after one year he decided that he preferred academic work rather than commercial work and accepted a position as Associate Professor in the Department of Physics and Astronomy, where he has continued his work on electron optics. The general objective of the research in this field is the extension of the usefulness of the electron microscope and the diffraction camera. They afford opportunities and facilities for agronomists, biologists, chemists, and physicists to collaborate in the study of sub-microscopic particles and structures. It provides means of examining structual units which are too small to be observed with the most powerful optical microscopes. These structural units include collodial particles, crystallites, fibrids, micells, and macromolecules.

Nuclear Physics. When the very important field of nuclear physics was opened in the United States by the development of the cyclotron by Professor E. O. Laurence and the electrostatic generator by Professor van de Graaff, the Department of Physics realized that an important new field of science had emerged and that it would involve the cooperation of physics, chemistry, electrical engineering, and medicine for its proper development. It therefore undertook with limited resources to develop a program of nuclear science, which would involve the cooperation of other physical and biological sciences. This program was formulated and partially unified under the name of the Radiation Laboratory with a supervisory committee representing physics, chemistry, electrical engineering, and medicine. This laboratory was an expression of the fact that in the field of nuclear science individual and isolated research projects in the universities must be superseded by unified and carefully planned programs in which scientists in related fields cooperate. In order to make a beginning on this program it was decided to build a cyclotron.

The more salient features of the cyclotron are a large electromagnet, a vacuum chamber, and a high frequency oscillator. The electromagnet consisting of a soft iron core weighing about eighty tons is wound with copper tubing arranged in pancake coils with series-parallel connections. These copper coils weigh about nine tons. The poles of the magnet are forty-two inches in diameter and ten inches apart. A magnetic field of fourteen thousand guass is produced by a current of three hundred amperes in the magnetizing coils. Water circulating through the copper coils insures constant temperature. The copper tubing was insulated by weaving glass fiber around it and then coating the glass fiber and the tube with bakelite varnish. A vacuum chamber consisting of brass walls and ends made of soft iron discs forty-two inches in diameter and two inches thick was located between the poles of the magnet. It contained two semicircular electrodes across which high frequency potentials were applied. Ten ports in the cylindrical walls permit the insertion of control devices or make provision for necessary connections. The high frequency oscillator operates at ten megacycles and has a power rating of about eighty kilowatts. The cyclotron can be used primarily to produce artificial radioactive isotopes of different elements. With the aid of auxiliary apparatus, the characteristics of these isotopes can be studied. Their rates of decay and transformation products give important information about the structure and behavior of atomic nuclei.

Originally the cyclotron was housed in two small rooms on the northeast corner of the first floor of the Engineering Experiment Station. These two rooms were inadequate for the purpose necessary for the operation of the cyclotron Later a special laboratory for it was constructed on the bank of the Olentangy River. This Laboratory consisted of two rooms, one to house the cyclotron and the oscillator and the other to house the controls for the cyclotron, a small shop and a laboratory for making experiments on short lived radioactive substances. The two units were connected by a tunnel which was underground. The unit housing the cyclotron was partially underground and designed to reduce danger from radiations developed in the operation of the cyclotron.

Mr. Julius F. Stone, for many years a member of the Board of Trustees, provided approximately $20,000 for the initial construction of the cyclotron and its auxiliary apparatus. This fund was supplemented by funds from other sources and the mechanical work of construction carried largely by the technicians in the machine shop of the Department of Physics. Professor M. L. Pool was responsible for the supervision of the project and for a considerable amount of actual construction. Professor W. L. Everett of the Department of Electrical Engineering contributed much advice and service directed toward the construction of the oscillator and original power source for the cyclotron.

The electrostatic generator was designed just prior to the involvement of the United States in World War II. The construction was interrupted by the War, but some work was done on it. Notwithstanding the War, a suitably designed laboratory was built just east of Robinson Laboratory. The generator was constructed and assembled but the necessary testing, refinement, etc. to insure its proper performance were not carried out. It consists primarily of an endless belt of insulating material, passing over two pulleys with their axes parallel to each other so that the belt travels in a horizontal plane. A charge is communicated to the belt by spraying positive ions from a direct current generator. This charge is carried by the belt to the interior of a hollow electrode where a high difference of potential is used to project charged particles down a long evacuated tube. A cascade tube built up out of porcelain cylinders makes it possible to focus the ions or electrons moving along the axis of the tube somewhat as rays of light are focused by means of lenses. This focusing of the ion or electron beam prevents flashovers along the walls of the vacuum tube with the result that high voltages may be applied between the ends of the tube. The accelerating tube is surrounded by a corona system which consists of copper tubing. This corona system insures a uniform potential gradient along the entire length of the vacuum tube. In order to reduce corona losses and to insure uniform atmospheric conditions, the belt, hollow electrode, corona rings, charging devices, etc. are enclosed in a steel tank five feet in diameter and twenty feet long. This tank is divided into sections, one of which is permanently mounted on a cement foundation, and the other on wheels, making it possible for that section to be rolled back and give easy access to the interior of the generator when adjustments or changes are necessary. Dry air or freon gas can be forced into the tank with a compressor until a pressure of eight to nine atmospheres is reached, and the accelerating tube can be evacuated by means of a suitable vacuum pump. The electrostatic generator is used for experimental work on nuclear spectroscopy. It is housed in a specially designed laboratory with very thick walls for purposes of insulation.

The construction and design of the generator was supervised by E. R. Gaertner and Kenneth R. More. After the close of World War II, Professor John N. Cooper was appointed to the staff and he and his students undertook with success to complete the construction and necessary refinements of the generator to make it yield valuable results in the field of nuclear spectroscopy.

Just prior to the beginning of World War II, the Department of Physics and Astronomy in cooperation with the Department of Electrical Engineering undertook to build and operate a betatron. It was agreed that a beginning would be made by constructing a small betatron and after that experience was gained, a larger and more powerful betatron would be constructed. A betatron is an apparatus for producing high speed electrons. After electrons are injected into a vacuum chamber which is in the form of a doughnut, they are accelerated in a varying magnetic field. When these high speed electrons are stopped by a suitable target, very high frequency x-rays are produced. These high speed electrons and high frequency x-rays are of great importance in diagnostic and therapeutic work. Dr. Wang, a member of the staff of the Department of Electrical Engineering, assumed responsibility for the design and construction and installation of the betatron and the necessary auxiliary equipment. Provision was made for housing it in part of a small laboratory built to house the Van de Graaff Electrostatic Generator. This Laboratory which was located just east of Robinson Laboratory obtained its electrical power from underground electric cables connected to sources of electrical power in Robinson Laboratory. Dr. Wang visited the University of Illinois and studied the installation with Professor Kerst had developed at its Physical Laboratory. With the help of this information and experience he successfully built and succeeded in operating a small pilot betatron which would have served as a satisfactory pattern for the construction of a larger betatron. Before the construction of a larger betatron could be undertaken, Dr. Wang accepted a position at the United States Bureau of Standards and consequently this program was permanently interrupted. Subsequently the College of Medicine incorporated a betatron especially designed for medical research into its radiation laboratory.

In addition to these major units of the research program already described, auxiliary equipment necessary for the study of nuclear physics and chemistry was made available. The following is a brief list of the more important items.

1. Cloud Chamber--devised for studying atomic processes by actually observing the paths made by charged particles. It consists of an expansion chamber filled with air which is saturated with water vapor. The air in the chamber can be expanded causing the air to be supersaturated with water vapor.

2. Beta Ray Spectrograph--consists essentially of an electromagnet with parallel pole faces. A cylindrical brass vacuum chamber with top and bottom coverings of brass plate is inserted between the poles of the magnet. This instrument is used to measure the energy distribution of beta rays from a source introduced into the vacuum chamber.

3. Mass Spectrograph--used for measuring the ratio of the charge and mass of an ion. When a narrow pencil of ions passes through an electron field between

two parallel plates and then through a magnetic field at right angles to the electric field, ions having the same ratio of charge to mass can be made to strike a photographic plate at the same place. Other necessary equipment such as the following: an electrochemograph, a centrifuge, a Wuld unifilar electrometer, a Lauristen electroscope, a dunking type of Geiger counter, and ordinary types of Geiger counters with ionization chambers, were available.

The principal research areas for which plans were made and primary facilities provided have been outlined in the preceding sections. It was of course clearly recognized that research projects must originate in the inquiring minds of the investigators and that no effort should be made to formalize or to regiment the creative thoughts of the staff. It was, however, possible by a careful selection of the staff to develop certain preferred research areas and to neglect others. After such plans had been carried out, other interesting research projects arose in the minds of some of the members of the staff and these were provided for within the resources of the University. The following is a partial list of such research projects carried on in this period:

1. Samuel J. Barnett conducted a very important and very successful series of experiments on magnetization by rotation. These experiments undertook to determine whether it was possible to magnetize a cylindrical iron rod by rotation, where other reasons for magnetization had been eliminated. The experiment required very critical observations made under difficult conditions. Their effect was small but positive. The results were considered so important that he was awarded the Comstock prize for his work.

2. Fredric C. Blake before becoming interested in x-rays, continued his investigations on standing waves in a Lecher wire system. These investigations had been started at Columbia University while he was a graduate student there.

3. Robert F. Earhart studied sparking distances in gases and carried on investigations on the properties of natural gas.

4. Alpheus W. Smith conducted a series of investigations on the thermomagnetic and galvamagnetic effects in metals and alloys, and the relation of these effects to electrical and thermal conductivity. The primary interest of the nature of electrical and thermal conductivity in metals and alloys was under investigation in these experiments.

5. Herman G. Heil studied the elastic indentation of steel balls under pressure and published a paper on the application of the Wynn-Williams bridge valve amplifier to microphotometry and absorption problems.

6. Alva W. Smith carried on some work on supersonics and investigation of magnetic permeability at high frequencies.

7. Willard H. Bennett investigated the emission of electrons from cold surfaces and designed and fabricated with the aid of the Shop a special form of the electrostatic high voltage generator.

Theoretical Physics

In formulating the program for the Department of Physics and Astronomy, it was recognized that superior experimental research cannot be carried on unless experimental physicists realized very fully the theoretical importance of the experiments which they were conducting and could give penetrating interpretations of the results of these experiments. They often need the assistance of very competent theoretical physicists who can cooperate with them on the theoretical aspects of their investigations. Hence, for this and other reasons, care was taken to insure that the Departmental staff included superior theoretical physicists. Since limited emphasis had been placed on theoretical physics in America at that time, we looked primarily to Europe for theoretical physicists and found one in Germany, Professor Alfred Lande, and one in England, Professor L. H. Thomas. Later two young Americans, one, George H. Shortley and the other Wave H. Shaffer were added to the staff. Professor Lande's principal interests included the foundations of quantum mechanics, relativity and electromagnetic theory. Professor Thomas was fundamentally trained in classical physics, quantum theory, and astrophysics. Dr. Shortley was primarily interested in classical mechanics, theory of spectra, and statistical mechanics. Dr. Shaffer was primarily interested in classical mechanics, principles of quantum mechanics, and the structure of the molecule. In addition to carrying on their own researches in theoretical physics, these members of the staff cooperated with other members of the staff and students in the interpretation and meaning of the experimental results obtained in their investigations.

The Impact of the Great Depression and of World War II on the Physics Program

The Great Depression initiated by the collapse of the stock market in 1929 imposed very severe limitations on the teaching and research programs in physics and astronomy. The Ohio Legislature found it impossible to appropriate the necessary funds for the continuation of the University's educational program at its normal level of activities. Consequently the University found it necessary to restrict its program temporarily so that it could be carried on with the available funds. The salaries of members of the teaching, research, technical, and service staff were reduced significantly. Some members of the staff not on permanent tenure were not continued in service. Educational and Administrativ functions which could be temporarily discontinued were abandoned with the expectation that they would be restored later. Courses with limited enrollment were either withdrawn or combined with other courses or offered in alternate years. These interruptions of the University's educational and research programs were very severe and significantly lowered the morale of the staff. Of course, the Department of Physics and Astronomy, like other departments was caught in this financial maelstrom and obliged to restrict its activities and to postpone its constructive plans to a future time. As soon as the most severe phase of the Depression had been passed, increased appropriations began to be available and restorations of the reductions in salaries were made, abandoned functions and activities were once more undertaken and the educational, research, and service program of the University, including the Department of Physics and Astronomy began once more to move forward. However, before the disasterous effect of the Great Depression could be eliminated the nation was involved in World War II.

Our involvement in World War II made it necessary for the Department of Physics, as well as the entire University, to modify its teaching and research program so as to contribute the maximum toward national defense and the War effort. The introductory courses in physics were adjusted to meet as fully as possible the needs of students preparing to enter one of the branches of the military service. Registrations in intermediate and graduate courses consisted essentially of students not subject to the military service for one reason or another. The research program was almost discontinued except as it was concerned with the problems which were related to national security and defense. Harald H. Nielsen was granted partial leave of absence to participate in an Infrared Testing project without severing his connection with the department. Many members of the departmental staff asked for leave of absence to assist on research work in one of the laboratories or other agencies carrying on research immediately concerned with the war effort and national security. These leaves of absence and the purposes for which they were granted are as follows:

1. Professor L. H. Thomas to work at the Aberdeen Proving Grounds.

2. Dr. E. R. Gaertner and Dr. Kenneth L. More to work at the Radiation Laboratory of the Massachusettes Institute of Technology.

3. Assistant Professor Wave Shaffer and Assistant Professor H. P. Knaus, and George H. Shortley to work at the Applied Physics Laboratory at Johns Hopkins University.

At the end of the War several of these members of the staff elected not to return to the Department.

1. L. H. Thomas returned to the Department for one year and then decided to accept a position with Watson Laboratory, a division of the International Business Machines.

2. George H. Shortley returned to the University for one year and then accepted a post with a government research agency.

3. E. R. Gaertner accepted a position as research physicist in the research laboratory of General Electric Company.

4. Kenneth R. More resigned to accept a position with Phillips Petroleum Company.

5. Harold P. Knaus accepted a position as Professor of Physics at the University of Connecticut.

6. Associate Professor Jerome B. Green resigned to accept a position at the Naval Ordnance Laboratory.

The influx of G. I. students at the close of World War II taxed the teaching facilities and the staff to the limit. Gradually, conditions began to return to normal. The graduate students returned, the departmental staff was reassembled and assumed its proper responsibilities. The research programs were begun again and the Department began to move forward.

Physics Staff During the Second Period

The following is a list of the members of the physics staff for this period (1908-46), and their ranks and periods of service. Student assistants, graduate assistants, technical assistants, and research assistants have not been included. Short biographical sketches can be found in a later section.

Cole, Alfred D.	Professor and Chairman (1908-26), Professor (1926-28)
Smith, Alpheus W.	Assistant Professor, Professor and Chairman (1909-46)
Barnett, Samuel J.	Professor (1911-18)
Bennett, Willard H.	Instructor, Assistant Professor (1930-38)
Blake, Fredric C.	Assistant Professor, Professor (1908-46)
Brubaker, Wilson	Instructor (1936-37)
Earhart, Robert F.	Assistant Professor, Associate Professor, Professor (1908-33)
Gaertner, E. R.	Instructor (1940-44)
Green, Jerome B.	Instructor, Assistant Professor, Associate Professor (1927-43)

Heil, Herman G.	Instructor, Assistant Professor, Associate Professor (1909-46)
Hesthal, Cedric E.	Instructor, Assistant Professor (1929-46)
Houston, William V.	Instructor (1922-25)
Inglis, David R.	Instructor (1931-34)
Jarvis, Charles W.	Instructor (1920-25)
Kester, F. E.	Associate Professor (1908-09)
Knaus, Harold P.	Instructor, Assistant Professor (1928-44)
Kurbatov, J. D.	Assistant Professor, Associate Professor (1941-46)
Lande, Alfred	Professor (1941-46)
More, Kenneth R.	Instructor (1938-44)
Nielsen, Harald H.	Instructor, Assistant Professor, Associate Professor, Professor (1930-46)
Nordheim, L. W.	University of Goetingen, Visiting Professor
Pool, Marion L.	Instructor, Assistant Professor, Associate Professor, Professor (1928-46)
Robinson, Howard A.	Instructor (1936-37)
Shaffer, Wave	Instructor, Assistant Professor (1940-46)
Sheard, Charles	Instructor, Assistant Professor, Professor (1908-19)
Shortley, George H.	Instructor, Assistant Professor (1935-42)
Smith, Alva W.	Instructor, Assistant Professor, Associate Professor, Professor (1921-46)
Thomas, Benjamin F.	Professor (1908-11)
Thomas, L. H.	Assistant Professor Associate Professor, Professor (1929-35)
Woodbury, Dwight	Instructor (1914-25)
Zumstein, Robert V.	Instructor, Assistant Professor, Associate Professor (1927-46)

The following invited lecturers served for one term of a summer quarter:

Birge, Raymond T.	University of California
Foster, James S.	McGill University
Swann, W. F. G.	Bartol Research Foundation
Watson, William W.	Yale University
Wilson, H. A.	Rice Institute

THE THIRD PERIOD OF THE PHYSICS PROGRAM (1946-70)

Moving into the Atomic and Space Age

The third period (1946-70) in the development of the program of the Department of Physics and Astronomy may be thought of as beginning approximately with the conclusion of World War II, more specifically with the production of the first atomic bomb and the beginnings of the scientific and technological work on the exploration of outer space. These epoch-making scientific and technological advances were, of course, preceded by important intensive scientific and technological investigations which opened up new and unexplored fields of physics, chemistry, and engineering. The Department of Physics and Astronomy in the preceding period had participated in some of these major developments and its program in the third period was greatly influenced by the scientific and technological climate of the atomic and space age. The following paragraph gives a very brief sketch of some of the fundamental discoveries in physics which served as the background and the foundation of the atomic and the space age.

In order to account for the scattering of alpha particles as they pass through matter, Rutherford assumed that an atom consists of a very small nucleus surrounded by quasi planetary electrons. He assumed further that the volume of the nucleus is very small compared to the entire volume of the atom and that nearly all the mass of the atom is concentrated in its nucleus. Later it was shown that atomic nuclei, with the exception of the nucleus of the atom of ordinary hydrogen, consist of varying numbers of protons and neutrons. In order to investigate the nature of atomic nuclei and the possibility of transforming them into other types of atomic nuclei, physicists devised apparatus for accelerating electrofied particles such as the protons and deuterons to very high speeds in order to bombard atomic nuclei with them. In some cases it was found that these high speed electrofied particles were captured by the nucleus of an atom producing an unstable atom of higher atomic weight.

This unstable atom was artificially radioactive and after a longer or shorter time decayed into a more stable form. In the case of one of the isotopes of uranium (with an atomic weight of 235) and an artificially produced element called plutonium, it was found that bombardment with neutrons having proper velocities caused the uranium atom or the plutonium atom to split into fragments consisting of two elements and one or more neutrons. The sum of the atomic masses of the fragments was less than the mass of the original atom. This decrease in mass showed up as energy satisfying Einstein's well known equation, $E = mc^2$, where E stands for the energy releases, m for the decrease in mass, and c for the velocity of light. These results indicated that the capture of one neutron had resulted in the release of one or more neutrons and a given amount of energy, suggesting the possibility of establishing a sustained chain reaction in which great quantities of energy could be produced. This conclusion was verified experimentally and the way was opened for making the great storehouse of atomic energy available for useful purposes. This scientific development came while we were concerned with World War II and very naturally attention was directed toward the production of atomic bombs. When this undertaking was successfully completed, attention was directed toward the peaceful uses of atomic energy and to thermal nuclear reactions by which atomic energy can be released by the fusion of atoms of low atomic weight such as those of hydrogen. The successful conclusion of these epoch-making investigations yielded the hydrogen bomb. The research directed toward the peaceful uses of atomic energy has been focused primarily on the development of reactors which yield power for a variety of purposes. These and related important developments in the production and uses of atomic energy marked a new epoch in modern physics and technology. Another important concurrent scientific and technological development was the application of scientific methods and techniques for the explorations of outer space which have opened up important new frontiers in both the physical and biological sciences. Investigations of nuclear physics and the explorations of outer space have been so far-reaching that the last half of the twentieth century will probably be known as the Atomic and Space Age.

The University Faces the Future

At the termination of World War II the University found it necessary to make many revisions and adjustments in its educational and administrative programs in order to assume the responsibilities imposed upon it by the new era. Members of the administrative, teaching, and research staffs who had been given leaves of absence to participate more effectively in the war effort began to return to their former posts. Some of them elected to invest their talents and special training in other endeavors and did not return permanently to the University. Others who had remained at the University during the war but had been deflected from their usual duties to contribute to the war effort reassumed their normal responsibilities. President Howard L. Bevis, having reached the normal age for retirement, was made President Emeritus and Dr. Novice G. Fawcett was appointed to succeed him. President Fawcett made very important changes in the organization of the administration of the University in an effort to adapt it more effectively to the pressing problems which would face it in the approaching decades. The return of many former students who had served in one of the branches of the military services imposed great difficulties both on the teaching staff and the physical facilities. The building program which had been very seriously interrupted by the Great Depression and World War II was resumed and carried forward vigorously. This program included provisions for dormitories, classrooms, offices, and research and teaching laboratories. The scientific difficulties encountered in World War II demonstrated that the nation must support and encourage scientific research as it had never done before. As more generous financial support for research from government, industry, and private sources became available, the University provided additional research laboratories and enlarged technical and research staffs. The establishment of the Research Foundation for the administration of contract research and the creation of the Research Center for housing the administrative offices of the Research Foundation and for additional research laboratories contributed greatly to the facilities, prestige and efficiency of the University's research program.

The New Physics Laboratory

In 1945 the Ohio Legislature made an appropriation of $600, 000 for the construction of the first unit of a new physics laboratory. At the next meeting of the Legislature the appropriation was increased by $300, 000 making $900, 000 available for the first unit of this new physical laboratory. The University cabinet authorized the erection of the building directly west of McPherson Chemical Laboratory and east of Robinson Laboratory, so as to form in the end a kind of physics-chemistry quadrangle. The chairman of the department, Professor H. H. Neilsen, appointed a committee from the members of the permanent staff to plan for the new building. This committee studied available reports from other physical laboratories, made estimates of the department's demands for space, for teaching, research, and administrative services, and suggested sizes, necessary facilities, and the location of the various types of rooms to be incorporated in the new building. The funds available were insufficient to erect a laboratory with sufficient space and facilities to provide for all activities of the department. Consequently, it was necessary to continue the use of much of the space and facilities in Mendenhall Laboratory. The report of the committee took account of this fact indicating which activities be housed in the new building and which would remain in Mendenhall Laboratory. It was found necessary to retain space in Mendenhall Laboratory for the shops, for an x-ray research laboratory, for infrared research laboratory, for some offices, and for recitation and lecture rooms.

The new building which was occupied in early 1951 is a four story and basement structure of modified classical Renaissance architecture. The structure is of red brick trimmed with limestone. The building contains generous vertical service shafts which provide for the distribution of gas, water, compressed air, and vacuum and electrical service connected to the different laboratories, lecture rooms, and recitation rooms. The vacuum service is produced by a large vacuum pump located in the basement of the building. The design of these service shafts is such that it is relatively easy to have any of the special facilities which a physicist is likely to require in his research laboratory.

In 1955 the Ohio Legislature provided a million dollars for the construction of the second unit of the physical laboratory, directly north of the first unit with provisions for further additions as supplementary funds become available. The following gives a brief description of the nature and purposes of the different rooms in this physics laboratory as of 1962.

On the basement floor are located nine research rooms for infrared spectroscopy and molecular structure, two laboratories for atomic spectroscopy, four research laboratories for low temperature and solid state physics, three laboratories for nuclear magnetic resonance research, an electron paramagnetic resonance research laboratory, one research dark room, and three laboratories for nuclear research. In addition to these rooms there is a room for the generator and battery and for the physical plant mechanical equipment.

On the first floor space is provided for three air-conditioned lecture rooms, one of which seats 235; another, 116. The large lecture room is a two story structure, basement and first floor. It has an entrance both from the basement and from the first floor. The room has no outside windows but is illuminated by flourescent lights. It connects directly to the lecture preparation room. The two smaller lecture rooms are one story in height and entirely on the first floor. They are also connected directly to the lecture preparation room. In addition to the lecture rooms and their associated apparatus and storage rooms there are three recitation rooms, one seminar room, a suite of rooms devoted to low temperature research, an apparatus receiving room, physics departmental office, office of the Chairman, and seven other offices for members of the Departmental staff, and a janitor's room.

The second floor contains five recitation rooms, the Cole Memorial Library, three advanced laboratories, three offices, seven nuclear research laboratories, a student shop, and two janitor's rooms.

On the third floor space is provided for a neutron research laboratory, two nuclear research laboratories, a low temperature research laboratory, four advanced student laboratories, five beginning undergraduate student laboratories, a beginning student supply laboratory, three research dark rooms, four offices, one additional laboratory, two janitor's rooms, and physical plant mechanical equipment.

On the <u>fourth</u> floor space is provided for four infrared research laboratories, three laboratories for nuclear research, two laboratories for research in biophysics, ten departmental offices, one combined office and nuclear research laboratory, one combined office and electron optics research laboratory, a graduate student study room, two beginning undergraduate laboratories, and two janitor's rooms.

<u>Subcritical Reactor.</u> In 1956, the Department of Physics and Astronomy, the Department of Chemistry, the Department of Chemical Engineering and the Department of Mechanical Engineering requested funds from the Atomic Energy Commission for the purchase of a sub-critical reactor with accessory apparatus to be used in laboratory courses in nuclear sciences offered by these departments. The request included the necessary quantity of uranium, a Pu-Be neutron source, a tank container made of aluminum, and measuring equipment for the reactor. The request was granted in 1957 and the subcritical pile secured and installed in Mendenhall Laboratory.

When this equipment was secured it was assumed that it would be integrated into the nuclear science program for which funds had been obtained from other sources. The equipment was designed and installed with the thought of carrying on such investigations as the following: neutron distributions, determination of the Fermi Age of the fission neutrons, an estimate of the absolute thermal-and-fast neutron flux, experiments on the activation of various samples for radioactive decay and characteristic radiations, and measurements of cross sections for certain nuclei such as Dy164, Ho165, and Lu175.

<u>Reactor for Laboratory Teaching Purposes.</u> In 1957, the Department of Physics and Astronomy, the Department of Chemistry, the Department of Chemical Engineering, and the Department of Mechanical Engineering, working cooperatively, requested funds from the Atomic Energy Commission for a Reactor for laboratory teaching purposes. This request was granted with the understanding that The Ohio State University would provide a suitable building in which it could be installed. This building was constructed at the Research Center and the reactor installed in it, so that it could be used for laboratory teaching in nuclear science for the use of instructors and students in physics, chemistry, chemical engineering and mechanical engineering.

This reactor was designed and constructed to allow studies on such subjects as the following to be carried out by instructors and their students: reactor safety procedures, neutron detectors and reactor instruments, reactor operation and control, critical mass determination, critical loading, excess reactivity determination, control rod calibration, temperature coefficient of reactivity, reactor power measurement by coolant temperature method, foil activation and flux mapping, diffusion of neutrons in water, determination of Fermi Age for thermal neutrons in graphite, reactor shielding, power calibration and thermal flux, and distribution in fuel elements.

Electrostatic Generator. When the second unit of the New Physical Laboratory was designed, it was found necessary to remove the small laboratory which housed the Van de Graaff electrostatic generator. This small laboratory was located directly north of the first unit of the New Physical Laboratory and its presence interfered with the building of the second unit of the New Physics Laboratory; moreover, the Van de Graaff generator which was housed in it was too small and too ineffective for the highest type of research in nuclear spectroscopy. It was therefore decided to build a more suitable laboratory to house this generator in the Research Center and later to build a larger laboratory to house a larger electrostatic generator for more extensive and more revealing research in nuclear spectroscopy.

Shops. The main shop is located in Mendenhall Laboratory. It is supplemented with lesser shop facilities within each of the larger research laboratories. The main instrument shop is fully equipped with precision machine tools, and is operated by a staff of professional instrument makers. The supervisor is a highly skilled craftsman with a long background of experience in the development of physical research apparatus. A student shop located in the New Physics Building is maintained for the construction of minor items of research equipment frequently needed in the personal work of faculty and students. Here graduate students get experience in design and construction of apparatus and the use of excellent tools. Some of the research laboratories, for example, the cyclotron laboratory, the Van de Graaff Laboratory, and the low-temperature laboratory, have special small shops used for the construction of apparatus associated with each of their research programs.

Teaching and Research. The interest in physics, especially in nuclear physics, was greatly increased by the successful release of nuclear energy in the atomic bomb. Later the use of atomic energy in the production of power by means of reactors stimulated further interest in the study of physics. An additional interest in the study of physics and of astronomy resulted from the explorations of outer space by means of rockets and satellites. These unusual developments directed the attention of many students to the possibilities of careers in physics and increased the interest in many fields of research, especially those related to nuclear physics. Also investigations in the fields of solid state and low temperature physics opened up new fields for research in both fundamental and applied physics. Advanced instruction and research activity in the closely allied fields of mathematics, chemistry, metallurgy, and engineering contributed to this increased interest in the study of physics. Research programs in the biological sciences are in many instances linked with the research programs in physics. These contacts between physics and other physical and biological sciences provided a stimulating intellectual atmosphere for those desiring satisfying careers in the research in physics or in the teaching of physics and this tended to increase the demand for instruction and research in the field of physics.

The influx of both undergraduate and graduate students of physics and the increased emphasis on research made severe demands on the facilities and staff of the Department of Physics. A number of additional members of the staff were appointed, new and improved facilities for both teaching and research were made available in the new physics laboratory, research assistants and technicians were secured, and new emphasis was placed both on teaching and on research. The facilities provided for lecture, for demonstration, for introductory laboratory courses, and for research equipment greatly increased both the teaching and research responsibilities which arose in the early years of the atomic and space age. Low temperature and solid state physics were added to the program by securing an outstanding physicist to direct this work and providing him with an appropriate laboratory and with superior research equipment. More funds became available from government and from private sources for fellowships and scholarships. The Research Center on the West Campus provided space and facilities for a special laboratory for the study of infra-red absorption by the atmosphere at high altitudes. A non-critical atomic reactor and teaching reactor contributed to the study of atomic energy and its applications. An increased number of graduate students and visiting scholars from abroad came to the Department for study for a longer or shorter period of time. The participation of students and instructors from different countries tended to broaden and intensify the program. Funds became available in greater measure to enable some members of the staff to have leaves of absence for research for one or more quarters. Several of these members of the staff elected to use their leaves of absence for study abroad. Some of them on fellowships and visiting professorships had opportunities to lecture as well as to carry on research in other university laboratories.

Meteorology and Atmospheric Physics. Prior to 1948 the work in meteorology was administered as part of the Department of Geology. At that time it was realized that meteorology and atmospheric physics are more closely related to the Department of Physics and Astronomy than to the Department of Geology. Consequently the courses in meteorology were transferred to the jurisdiction of the Department of Physics and Astronomy, and a serious attempt was undertaken to develop both teaching and research in meteorology and atmospheric physics. Dr. A. M. Dingle, who had received his training in meteorology at the Massachusetts Institute of Technology, was added to the Departmental staff to organize and to direct the work in meteorology. Appropriate elementary and advanced courses were arranged and made available for students interested in meteorology. A beginning was made toward providing the necessary instrumentation for both teaching and research. In cooperation with Prof. C. E. Nielsen, investigations of the role of condensation, freezing and sublimation nuclei, and of the processes of forming ice crystals in the atmosphere were inaugurated. Laboratories for teaching and research in meteorology were provided in a new physical laboratory. In 1954, Dr. Dingle resigned to accept a position at the University of Michigan. Dr. John Shaw, who was primarily interested in research and in atmospheric physics, assumed also the responsibility of teaching the courses in meteorology.

Indepartmental Programs. Since physics is such a fundamental and comprehensive science, there are many significant opportunities for cooperative teaching and research programs between it and the other sciences. The fact that both astronomy and meteorology are administered as integral parts of a single department, the Department of Physics and Astronomy, provides excellent opportunities for cooperation, both in teaching and in research, between these sciences and physics to which they are so closely related. The current emphasis on astrophysics makes it increasingly evident that astronomy should be closely affiliated with physics, and the investigations of outer space have extended the subject matter and methods of physics and astronomy into regions previously unexplored.

Nuclear physics is another field offering many fruitful opportunities for cooperative teaching and research between physics and other sciences. The cyclotron laboratory, the sub-critical nuclear reactor, and the teaching atomic reactor were secured and maintained as cooperative facilities for the Department of Physics and Astronomy, the Department of Chemistry, the Department of Electrical Engineering, the Department of Chemical Engineering, the Department of Mechanical Engineering, the Department of Metallurgical Engineering, and some of the biological sciences. The cooperation which has been possible in these laboratories has been so productive that there is urgent need for the organization and maintainance of an institute for nuclear studies in which the potentialities of cooperative investigations in the field of nuclear science can be more fully realized.

Another area in which there are many important opportunities for cooperative research is the borderline between the physical and chemical, and the biological sciences. It is in the borderlines between the established and conventional sciences that important scientific advances may be expected. The borderline between physics and chemistry on the one hand and the biological sciences on the other hand is one of the most challenging scientific fields for intensive exploration. It involves for the most part cooperative research between biophysics, biochemistry, physiology, medicine, and a number of other biological sciences. Some attention has already been given to producing cooperative programs involving biophysics and biochemistry.

A carefully planned and organized research institute is urgently needed for the development of this borderline field of science. Atomic and molecular spectroscopy, nuclear physics, electron microscopy, and electronics would contribute much to its successful development.

Graduate Center at Wright-Patterson Air Force Base. In 1946, Wright-Patterson Air Force Base requested The Ohio State University to provide graduate instruction in such subjects as physics, mathematics, and electrical engineering for the employees on the base. In brief, Wright-Patterson Air Force Base desired to provide opportunities for the continuation of scientific and technical education for their employees concurrently with their regular employment. Since this request gave The Ohio State University an opportunity to extend its graduate instruction in a way to be helpful to the Air Force, it looked with favor on this request. After a series of conferences between representatives of Wright-Patterson Air Force Base and the University, a limited program of graduate instruction in physics, chemistry, electrical engineering, and mathematics was initiated. The program has expanded and increased in effectiveness over a periodof years. It now includes not only instruction in physics, chemistry, mathematics, and electrical engineering, metallurgical engineering, psychology, economics,business organization, but also related topics of interest to the Air Force. Qualified research personnel at the base may enroll in graduate courses given there by the Ohio State graduate faculty. Each year since the inauguration of this program the Department of Physics and Astronomy has offered several graduate courses in physics and a few courses in astronomy. Approved research work done at the base in some field of fundamental or applied physics may be used, under proper supervision, for the completion of the requirements for the thesis for the Master's degree. Instruction is given by members of the faculty of the Department of Physics supplemented from time to time by qualified personnel on the base from the Air Force Institute of Technology or from one of the neighboring colleges or universities. The requirements for the Master's degree are precisely the same as they are for students on the campus of The Ohio State University. A number of physics students have completed the requirements of the Master's degree by means of graduate work done wholly or in part at Wright-Patterson Air Force Base. Others have completed the requirements for the Master's degree and have continued with more advanced graduate courses leading toward the Ph. D. degree, and have then come to the University campus for the completion of the remainder of the requirements for the Ph. D. degree. This graduate program at Wright-Patterson Air Force Base has made it possible for the Department of Physics and Astronomy to make important contributions to the proficiency of Wright-Patterson Air Force personnel requiring additional training in physics, mathematics, and astronomy for the successful performance of their duties.

Supplementary Facilities and Advances. In order to make it possible for members of the faculty of The Ohio State University to avail themselves of superior research facilities not available at the University, the University entered into cooperative agreements with several research agencies to provide facilities and opportunities for research, especially in the field of nuclear science. The following brief list indicates the nature of these agreements and facilities as they apply to research in nuclear physics.

The Ohio State University and the Battelle Memorial Institute agreed upon a policy of cooperation on the use of their facilities for research in nuclear physics. This agreement makes it possible for interested members of the staff of the Department of Physics and Astronomy to have a limited use of the Battelle Memorial Institute's reactor at Canal Winchester. In order that a staff member may use any of the equipment belonging to the Battelle Memorial Institute for research in nuclear physics, he must first prepare a statement of his needs which should include the following: first, a description of the proposed research; second, the duration of the proposed program; third, the source of funds. The proposal must be approved by the Chairman of the Department, the Dean of the College of Arts and Sciences, and the Vice President for research.

In 1956, a proposal for the use of the facilities available at the Battelle Memorial Institute for the study of neutron diffraction was initiated by Professors R. A. Erickson, Department of Physics and Astronomy; R. Speiser, Department of Metallurgical Engineering; P. M. Harris, Department of Chemistry, was approved by the proper authorities and undertaken as planned.

In 1958, a number of midwestern universities which had been participating institutions in nuclear research at Argonne National Laboratory formed a non-profit corporation called the Associated Midwest Universities. The purpose of this corporation as set forth in its Articles of Incorporation is as follows:

1. "To promote, encourage, and conduct research and education in all branches of science including, but not limited to, nuclear science in relation to all other fields of science.

2. "To establish means for facilitating the use of Argonne National Laboratory and other laboratories by duly qualified personnel and students from the several cooperating institutions.

3. "To establish, maintain, and operate laboratories and other facilities as necessary for research and education."

The Ohio State University is a member of this corporation and its participation in the activities of the corporation has offered opportunities for research in nuclear physics that otherwise might not have been available.

The Midwestern Universities Research Association was conceived as a result of discussions among a group of midwestern physicists. They had their interest focused on the need in the midwest for a cosmotron for the study of high energy physics. In the spring of 1953 at the Institute of Nuclear Studies in Chicago, a committee of senior physicists from the Universities of Minnesota, Illinois, Chicago, Michigan, Indiana, and Wisconsin began to guide the development of such a facility. It soon became apparent that such a facility was beyond the capabilities of any one university both in terms of cost and manpower. Consequently the interested physicists approached their home universities with an idea of a joint venture. The administrative officers of these universities gave their full cooperation toward the development of the idea. As a result of many meetings held in the summer of 1953 and the following winter, the Midwestern University Research Association was incorporated as a non-profit organization under the laws of Illinois. The original members were: University of Illinois, University of Indiana, University of Minnesota, University of Iowa, Iowa State College, University of Michigan, University of Wisconsin, and Purdue University. As a result of a request from the Atomic Energy Commission to expand the Midwestern Universities Research Association, the membership of the corporation was enlarged in 1955 to include the University of Chicago, Michigan State University, Northwestern University, The Ohio State University, Notre Dame University, Washington University of St. Louis, and the University of Kansas. Since its inception, the Midwestern Universities Research Association encountered many administrative and financial difficulties both with respect to the location of the equipment and the source of funds for its support. On June 1, 1956, headquarters were established at Madison, Wisconsin. Much attention was given to securing adequate funds for the project. The appeal for funds was primarily to the Atomic Energy Commission and there was much confusion between the program for building an accelerator at the Argonne National Laboratory and the one conceived by Midwestern Universities Research Association. With the completion of models under construction (1961), it will be necessary either to expand facilities and start on a final model before construction of a large machine begins, or stop operations altogether and disband. Professors Mills, Sessler, Carl Nielsen, and Hausman and some of the graduate students of the Department of Physics and Astronomy participated in the development of this research program in nuclear physics. Its future development is of major importance to The Ohio State University, especially to the Department of Physics and Astronomy.

Symposium on Molecular Structure and Spectroscopy. Under the guidance of Professor Harald H. Nielsen, a research program involving infrared spectroscopy was developed. This included both the assembling of infrared spectroscopic equipment and the development of techniques for analyzing the data obtained therefrom in order to learn about the structure of molecules. During his first ten years at The Ohio State University, Professor Nielsen and his students brought this field of investigation to a high level. As a result, it was appropriate that in 1941, a symposium dealing with the use of infrared spectroscopy as a tool for studying molecular structure should be held in Columbus, Ohio.

During the early 1940's, the emphasis turned from the more academic use of infrared data to instrumentation development and applications, particularly in the chemical industries. Because of the success of the Columbus meeting in 1941, a similar meeting was held in 1943 at Ann Arbor, Michigan. The Michigan and Ohio physics staff personnel worked together in supporting this meeting.

The wartime developments brought focus on the need for additional meetings of this kind. In 1945, a group of persons from industry and universities met in New York City to discuss the possibility of additional infrared symposia. Questions were raised as to whether this could be done in connection with other national meetings or would it be better done if held separately from other meetings. Professor Nielsen extended an invitation for the first of any such series of meetings to be held at The Ohio State University in June 1946.

What may now be considered as the first of the annual meetings of the Symposium on Molecular Structure and Spectroscopy was actually held in Columbus in June, 1946. Although it was supposed at this time that the meeting might rotate among several universities where infrared research programs were being conducted, it turned out that the physical facilities and the excellent organization of the meeting resulted in the enthusiastic request of the participants that a similar meeting be held in Columbus the following year. This was arranged, and each year since that time a similar meeting has been held.

Although initially, the topics were limited to infrared and Raman spectroscopy, the range has broadened until more recently the spectral region covered ranges from x-rays to radio waves. A considerable emphasis is placed on such fields as microwave spectroscopy and nuclear magnetic resonance. The number of participants has increased from about 100 to an excess of 500 each year. It can be said that almost without exception every leader in these fields of research has been a participant in this annual symposium at one time or another. Some of the persons have come only a few times; many have been participants every year. This includes not only researchers from the United States but from Europe and Asia as well.

Financial support for this symposium has been provided by the Graduate School, the National Science Foundation by an occasional grant to bring participants from Europe, the Office of Naval Research in their support of the publication of the program and abstracts, and other groups who have assisted in one way or another.

In the early 1950's, a similar symposium was started in Europe. This is held every second year, and while it covers the same topics in general, it does rotate from one university to another in Europe. In 1962, a Symposium on Molecular Structure and Spectroscopy was held in Tokyo. In a sense, these can be considered as meetings, patterned after the Ohio State symposium, which are offsprings of the Columbus meeting and which serve the same purpose in other localities.

The number of papers, the number of participants, the general interest, and all other aspects of the symposium are increasing. Hence there is every reason to expect that the influence of the Symposium on Molecular Structure and Spectroscopy started by The Ohio State University on a regular basis in 1946 will continue for several years in the future.

Research Programs During the Third Period

The research interests and activities have, of course, changed from year to year during this period. These changes have arisen for two primary reasons: first, changes in departmental personnel bring with them new ideas and research interest, and second, important discoveries and developments on the frontiers of physics and astrophysics. In so far as possible without restricting the creative capabilities and research interests of the staff an effort has been made to adhere to a consistently well planned and organized research program for which reasonable facilities and competent personnel were available. The following is a brief outline of the principal field of research to which serious attention has been directed during this period.

Atmospheric Physics. The research program in atmosphere physics is mainly concerned with attempts to understand the behavior of the atmospheres of the earth and other planets by using the theories and techniques developed by infrared spectroscopists. The Atmospheric Physics laboratory possesses two grating spectrometers, several prism spectrometers and a collection of accessory equipment including an absorption cell in which radiation paths up to one mile in length can be obtained.

With this equipment it has been possible to study the absorption by various atmospheric gases under controlled conditions and to measure the dependence of this absorption on the physical conditions of the absorbing gases. Such data is of fundamental importance in studying, for example, the heat balance of the earth and atmosphere. In addition it is also necessary to know the composition of the atmosphere as accurately as possible. The careful mapping of the solar spectrum by workers in this laboratory revealed for the first time that carbon monoxide and methane are permanent atmospheric gases, and it has been possible to determine the total amounts of these gases in a vertical path through the atmosphere. Current investigations are concerned with the measurement of the local concentrations of these gases and also nitrous oxide at various places at ground level. Other studies have included measurements of the emission of thermal radiation by the atmosphere and studies of the infrared spectrum of Mars.

One of the grating spectrometers in the laboratory has been completed and tests indicated that it will be one of the most powerful instruments in the world available for the study of the detailed structure of infrared spectra. With such instruments better information can be obtained about the interaction of infrared radiation with atmospheric gases.

Much of this work has been supported by contracts with the United States Air Force through the Geophysics Research Directorate of the Air Force Cambridge Research Laboratories. It is directed by Professors J. H. Shaw, D. Williams and H. H. Nielsen.

Atomic Spectroscopy. During the second period the department had been active in the field of atomic spectroscopy. The twenty-one foot grating, with its circle was originally in a room in Mendenhall Laboratory especially adapted and treated to provide the constancy of temperature and freedom from building vibration necessary for acceptable results. Provisions for the grating were made in the New Physics Laboratory but currently it has not been installed.

The other spectroscopic instruments and facilities have been transferred and partially installed in the New Physics Laboratory but systematic investigations in Atomic Spectroscopy have been almost completely suspended thus far during the third period.

Cloud Chambers and Ionized Gases. In this laboratory, cloud chambers filled with single pure substances have been used. A cloud chamber filled with argon alone, or with water vapor alone can be operated. Such cloud chambers make possible quite different types of research:

1. In the photography of atomic and nuclear events a new range of low energies become accessible to cloud chamber observation.

2. In the study of ionization and gas discharge phenomena, extremely sensitive to impurities, effects due to the impurities can be observed and measured.

3. The relation of plasma to controlled thermonuclear reactions can be studied.

The program is under the direction of Professor C. E. Nielsen.

Electron Microscopy. The department laboratory for electron microscopy is equipped with a high resolution RCA electron microscope and adequate auxiliary equipment for the processing of specimens. The facilities are employed for the investigation of physical and chemical properties of metals and alloys and of silicate compounds in mineralogic and ceramic materials. The laboratory is under the direction of Professor A. F. Prebus.

Far Infrared Spectroscopy. A program of investigation of infrared radiation of wavelengths greater than about 15 microns was initiated in 1946. Because the techniques were new, the early stages of the investigation were devoted to development of suitable instrumentation. As well as design of optical systems, the instrumentation problem involves studies of filters, detectors, and sources.

After the apparatus was functioning to cover the spectral region between 15 and 500 microns, investigations were made of the rotational spectra of many gases. These utilized the high resolution characteristics of the instrumentation. In addition, reflection and transmission measurements of solids, including semi-conductors, were made over a wide range of temperatures.

In the late 1950's, as the usefulness of the longer wave spectroscopy became apparent, other investigators developed the techniques for investigation further. As a result, both prism and grating spectrometers covered portions of this region, the latter being used extensively to wavelengths as long as 200 microns. By 1961, there were available commercial instruments covering wavelengths as long as 200 microns. As a result, the emphasis on the research activities at this University were pushed to still longer wavelengths.

Although optical techniques were used in the beginning, microwave techniques had some merit. Accordingly, in 1960 a start was made in using the higher harmonics of radiation from klystrons to push in from the millimeter region toward shorter wavelengths.

Also about this same time, it also became apparent that investigation of semiconductors at low temperatures could lead to the development of more sensitive detectors. Accordingly, an investigation was initiated along this line.

In addition to regular spectroscopic instrumentation, viz. involving dispersion by a grating, interferometric techniques proved to be useful both as replacements for filters for eliminating higher order radiation and as devices to replace the dispersing devices themselves. Studies along this line were undertaken, and a new far infrared spectrograph incorporating an interference modulator was constructed. The new spectrograph and associated equipment was placed in operati in the New Physics Building in 1961.

At the time of writing, it appears that all of the present lines of investigation have the potentiality of providing considerably better far infrared apparatus. With the increased interest in the physics of solids, it is anticipated that this spectral region will be of increasing importance.

Throughout most of the period in which the far infrared investigation was conducted, financial support was provided by the AirForce. During part of this time, a grant from the National Science Foundation provided partial support.

The staff members directly involved during the entire history of the program were Ely E. Bell and Robert A. Oetjen. In addition, considerable assistance was given through the extended stays on the campus of several leading investigators in this field. These included Hiroshi Yoshinaga, Ludwig Genzel, Shigeru Fujita and John Rohrbaugh.

Infrared Spectroscopy. Studies of molecular absorption spectra in the infrared lead to very precise values for the moments of inertia, internuclear distances, and valence angles of polyatomic molecules. Furthermore, investigation with high resolution infrared spectrometers is one of the most effective means of obtaining knowledge about the effects like Fermi resonance, l-type resonance and Coriolis perturbations.

Success in this field is based on the ability to correlate experimental results with theory. The excellent coordination between experimental and theoretical pursuits at The Ohio State University has been evidenced in the many contributions that have been made to the scientific literature during the past twenty-five years. For instance, the observations of the Coriolis resonance interactions as well as the significance of interaction between vibrations and rotation were first worked out at this University. Moreover, the present program of interpreting the experimental data concerning the anomalous values for the moments of inertia and centrifugal distortion constants and the anomalous intensity distribution in infrared bands provides challenging possibilities for a theoretician.

It is unlikely that as much excellent infrared spectroscopic equipment has ever been gathered in one place as that concentrated at The Ohio State University. This equipment includes low dispersion apparatus for survey purposes and prism-grating spectrographs operated in vacuum for high resolution work. The versatility of these instruments facilitates studies in any part of the infrared between 1 and 40 microns. Means are available for accurate calibrations in the entire spectral region. Experiments are also in progress to obtain higher resolving power and more precise wavelength measurements by combining interferometers and grating spectrometers. Tritium-substituted and other isotopic molecules have been studied in cooperation with the Los Alamos Scientific Laboratory.

The program is directed by Professors H. H. Nielsen, F. P. Dickey, W. H. Shaffer, and K. N. Rao.

Low Temperature and Solid State Physics. Prior to 1946 no serious attention to instruction and research in low temperature and solid state physics had been included in the departmental program. The results of research in other laboratories especially during the period of World War II demonstrated the importance of systematic research on the nature of the solid state, especially as it manifests itself at low temperatures. It was also evident that other important problems in low temperature physics would be of increasing importance. It was therefore decided in 1946 to undertake the development of an additional unit in the departmental program concerned with instruction and research in the field of low temperature and solid state physics. Professor John C. Daunt formerly of the Department of Physics at Oxford University was added to the staff to formulate and direct this development. The facilities for this phase of the departmental program were negligible, but over the intervening years, under the creative direction and stimulation of Professor Daunt, they have been built up until they are exceptionally superior in most respects. An active program of research centered about the facilities which were assembled and organized under Professor Daunt's direction has resulted in many important contributions to our knowledge of the properties of materials in the solid state, and of the unusual properties of the rare isotope, Helium-3. The discovery of the superconductor technetium, having the highest known transition temperature, was made at this laboratory. The specific heat anomaly of cobalt was first observed and clarified by members of the staff. Some of the more recent work has been concerned with superconductivity, high-field superconducting magnets, liquid and solid Helium-3, solutions of Helium-3 and Helium-4, nuclear orientation at very low temperatures, magnetic properties of paramagnetics with special emphasis on synthetic ruby, and nuclear magnetic resonance studies at very low temperatures. This program is under the supervision of Professors J. G. Daunt, D. O. Edwards, and J. R. Gaines. Visiting professors, often from abroad, frequently join the staff in support of this work.

Under the direction of Professor C. V. Heer there is under investigation the production of slow atomic beams, the development of a low temperature stable oscillator using slow atoms, and the development of extremely high-Q cavities through the employment of superconducting surfaces.

Much of this work involves investigations at temperatures below 1°K, obtainable only by magnetic cooling. Extensive facilities are available and include magnetic refrigerators, originally devised by Professors Daunt and Heer, and many cryostats which are provided with large electromagnets. Two 3 1/2 ton and one 45 ton electro-magnets are used to provide the intense magnetic fields required for magnetic cooling. The cryostat used with the 45 ton magnet is for large scale experimental work down to temperatures of about 0.01°K.

Microwave and Radio Frequency Spectroscopy. These have been major areas of research in the department since 1946. The earliest nuclear magnetic resonance (NMR) studies were concerned with precise determinations of the nuclear magnetic moments of various nuclear species, and results for some 32 different species have been reported. In recent years, the NMR techniques have been applied to various problems in solid state and chemical physics. The laboratory facilities include several large magnet installations. One of the associated spectrographs has a resolving power of 1,000,000. The attainment of this high resolution has opened up entirely new areas of investigation.

The earlier microwave work was concerned with the investigation of unusual molecular properties by study of the absorption spectra of gases. More recently, electronic paramagnetic resonance (epr). Techniques have been developed, and these are being applied to problems in solid state physics including such topics as radiation damage, nuclear moments of radioactive nuclei, and the structure of free radicals. The program is directed by Professors Dudley Williams and L. C. Brown.

Nuclear Physics. As indicated in earlier sections the program in nuclear physics was initiated by the construction of a cyclotron and later by the construction of an electrostatic generator. The research program in nuclear physics prior to World War II was centered almost exclusively about the cyclotron and its accessory apparatus. The electrostatic generator was constructed but not really used effectively until after the termination of World War II when Professor John N. Cooper was added to the departmental staff. The creation and utilization of the atom bomb near the end of World War II gave new emphasis to the study of nuclear physics, nationally and internationally. In line with these developments the departmental research program in nuclear physics received increased attention and greater financial support. The more salient features of the current program are indicated in the following paragraphs.

The cyclotron was modified in the early years of the period under consideration so that the beam could be utilized for experimental purposes outside of the vacuum chamber. It is focused by a pair of strong quadrupole-type magnetic lenses and a 15-degree spectrometer magnet. The reaction products are detected by means of the high resolution double focusing magnetic spectrometer used in conjunction with fast and slow coincidence circuits, and multi-channel pulse height analyzers. It accelerates protons to an energy of 6.5 Mev, deuterons to an energy of 13 Mev, and alpha particles to 26 Mev. Later He^3 will be accelerated to an energy of 18 Mev. The current research utilizes the external proton beam of the cyclotron for studying scattering and proton induced nuclear reactions. Experiments now include studies of the angular distributions of particles inelastically scattered from thin targets and the angular correlations of these particles with electromagnetic radiations from the excited residual states.

Other investigations involve stripping reactions, determinations of spins and parities of excited nuclear states, angular distributions of elastically scattered particles, and coincidence correlations between cascade radiations from excited nuclear states. The program is under the direction of Professors M. L. Pool and H. J. Hausman.

The Van de Graaff electrostatic accelerator with auxiliary equipment and shop facilities is located in a new, fully air-conditioned building at the Research Center of the University. The accelerator, which was reconditioned in 1958, furnishes a beam of charged particles with a maximum energy of 2 Mev. The stability and high resolution of the bombarding beam energy make this accelerator ideally suited for studies in nuclear physics.

Experimental programs include precision measurements of charged particle reaction cross sections, the study of neutron induced reactions, and the investigation of the angular correlations of reaction products. It was realized that the electrostatic generator just described does not provide a beam of charged particles of sufficiently high energy to make it possible to carry on very important investigations in the field of nuclear physics. It was therefore proposed to secure an electrostatic generator which would provide 5. 5 Mev. Such an electrostatic generator has already been purchased with accessory equipment. It is housed in an extension of the present electrostatic laboratory located in the Research Center. The funds for the construction of this extension to the electrostatic laboratory are being provided from University funds. Funds for the purchase of the electrostatic accelerator and accessory equipment have been provided by the National Science Foundation, which provided a grant of $449, 200 for this purpose. The University provided $175, 000 for the erection of the building to house the electrostatic generator. It is a 75 foot high concrete and steel-paneled building constructed in the University Research Center on Kinnear Road. The general types of programs planned for the new accelerator, which provides an electron beam of 5. 5 Mev, would be very similar to the ones planned or in progress on the existing accelerators, except they would be carried to higher levels of nuclear energy. Angular correlation experiments now performed on the cyclotron will be carred out more satisfactorily on the new Van de Graaff. Neutron experiments involving time-of-flight measurements now carried out on the 2 Mev Van de Graaff will be carried over and extended on the new accelerator. The research program on the Van de Graaff accelerator is directed by Professors J. C. Harris, D.F. Herring, H. Hausman, and K. W. Jones.

The program in low energy nuclear physics has been directed to problems of nuclear structure, to parity non-conservation in beta decay, and to low temperature nuclear orientation.

This work has included beta and gamma coincidence spectroscopy, using fast coincidence techniques capable of measuring times of the order of 10^{-9} second. The experiments related to parity nonconservation included determination of the longitudinal polarization of electrons emitted in beta decay, measurements of the transverse component of electron spin in beta-gamma correlations to test time-reversal invariance of beta decay, gamma-ray circular polarization measurements, and nuclear resonance fluorescence. The nuclear orientation program has been carried on in cooperation with the low temperature physics group and is concerned with both nuclear structure and solid state problems. The program is under the direction of Professor P. S. Jastram.

Nuclear Transmutation and Related Phenomena. The investigations of nuclear transmutations and associated phenomena have been directed toward the solution of a variety of problems in related fields. A 10-kw swimming-pool type of enriched Uranium reactor furnishes a wide selection of radioactive nuclei for study. A neutron flux trap, "rabbit", fission plate, neutron chopper, and beam ports provide facilities for numerous reactor experiments. A 400-channel analyzer, a large cloud chamber, etc. assist in the collection of pertinent nuclear data. Transmutation cross-sections, reaction rates, and captured gamma-rays are some of the topics of interest. A subcritical reactor is also available.

The radiations from reactor or accelerator produced radioactive nuclei are analyzed with scintillation crystals connected to the 100-channel or 200-channel analyzer. The gamma and beta spectra, and gamma-gamma and gamma-beta coincidence measurements are made. K- and L-x-rays from electron capture transitions and from the internal conversion process are recorded with special detectors. These data with appropriate "unscrambling" and interpretation lead to an energy level diagram of the emitting nucleus.

Thermonuclear reactions and high temperature plasma physics is being investigated with the aid of a four-foot long magnetic bottle and a three-phase three-kilowatt four megacycle exciting oscillator. At cyclotron resonance, energy is absorbed by the introduced hydrogen until temperatures of the order of millions of degrees are reached. 1000 amperes are required to produce the magnetic bottle which has a field of 10,000 gauss. Plasma phenomena are measured by optical spectrographic means, and nuclear syntheses of hydrogen into heavier elements are recorded by neutron and gamma scintillation spectrometers. This program is under the direction of Professor M. L. Pool.

A second research group in the field of nuclear spectroscopy, which is closely associated with the radio-chemistry group of the Department of Chemistry carries on research with many isotopes which have not been previously investigated because of the difficult radio-chemistry involved. It directs special attention to the study of the beta-decay process as well as the determination of the nuclear energy levels of various isotopes. This work was directed by Professor J. D. Kurbatov, prior to his retirement in 1961.

A program of neutron diffraction research is maintained cooperatively by the Departments of Physics, Chemistry, and Metallurgical Engineering. The neutron source is the two-megawatt Research Reactor of the Battelle Memorial Institute. The laboratory equipment consists of two complete and independent diffractometer assemblies, one used mainly for powder specimens, the other for single crystals. Both may be operated from the same reactor port. The wavelength of one exit beam is readily variable. Both diffractometers are equipped for fully automatic data recording following a preset program. Auxiliary apparatus for this laboratory includes cryostats and furnaces for studies over a wide range of temperatures and a crystal growing furnace for the preparation of specimens.

The research program in physics is directed mainly to studies of atomic magnetism and magnetic transitions in solids. It is under the supervision of Professor R. A. Erickson.

Photosynthesis. The program is primarily directed toward the study of the initial step in photosynthesis: the energy transfers and transformations which occur before new chemical species are formed. The program encompasses investigation of related dye and pigment-sensitized processes in solids, and the photoelectric and spectroscopic properties of dyes and pigments. The nature of the photoconductive process in dyes, energy levels in dye solids, photoelectric and photovoltaic effects, and photographic sensitization are topics under investigation. These investigations are directed by Professor R. C. Nelson. This research program is essentially cooperative in nature, involving also Chemistry, Biophysics in the College of Medicine, and the Kettering Research Foundation at Antioch College. It has recently gained an enhancement of facilities by the installation of a 27 Mev Betatron in the laboratories of the Medical Research Center. In order to further extend the opportunities and facilities for research in this field, The Ohio State University entered into an agreement with the Kettering Research Foundation which makes it possible for Ph. D. candidates to carry out at the Foundation the research work essential for a dissertation. The research program at the Foundation is directed largely to a study of chlorophyll and photosynthesis.

Theoretical Physics. Professor Alfred Lande, who has had a long and distinguished career in the field of quantum theory of atomic structure, became Emeritus Professor in 1959. However, he continues to be active in his most recent field of study, the philosophical foundations of quantum mechanics. His most recent papers on this subject have appeared in philosophical journals as well as in physical journals. His lectures at colloquia and seminars are always well attended and prove stimulating to faculty and students alike.

In the field of molecular structure and infrared spectroscopy, the program of theoretical study is directed by Professors H. H. Nielsen and W. H. Shaffer. The major objective of this work is the interpretation of band spectra. Current investigations are concerned with the fine details of rotational structure of rotation-vibration bands of molecules of relatively low molecular weight; gross aspects of vibrational spectra of relatively large molecules; and relative intensities, scattering and the like.

The work of Professor Jan Korringa and his graduate students deals primarily with the theory of the structure and properties of solids. Problems in magnetism, magnetic resonance and relaxation, electronic band structure of metals, and electronic structure of impurities in solids (with emphasis on applications and extension of the many particle theory) are among those actively studied. Close contact is kept with the experimental work at The Ohio State University particularly in the fields of low temperature physics, nuclear magnetic resonance, and x-ray spectroscopy.

Professors R. L. Mills and A. M. Sessler, prior to his resignation, engaged with the students in investigating problems in field theory, nuclear physics, and low temperature physics. Problems concerning the nature of heavy nuclei, scattering of particles by nuclei, the properties of liquid helium at low temperature, and elementary particles have been subjects of recent investigations. Many of these studies have been undertaken in close cooperation with the experimental groups at The Ohio State University, and all have been supported by grants from the National Science Foundation.

X-ray Spectroscopy. Studies of characteristic x-ray emission and absorption spectra with instruments of high resolving power furnish basic information about the electronic band structure of solids. This structure determines the electrical, magnetic, mechanical, optical, and other solid state properties of the material. The spectroscopic studies are carried out with a precision two-crystal vacuum x-ray spectrometer which covers the wavelength range from about 0.1 to 15°A. A new grazing-incidence grating spectrometer which is designed to operate under ultra-high vacuum conditions extends the range of wavelengths which can be studied to about 1000°A.

Studies of the atomic structure of gases, liquids, and solids are carried out by the use of various x-ray scattering techniques. Specially constructed apparatus permits the structures to be investigated over a wide range of temperatures. In particular, much work has been done near the absolute zero of temperature. Surface properties of solids are investigated by means of total reflection and small angle scattering techniques.

This program of research is directed by Professors C. H. Shaw and E. L. Jossem

Physics Staff During the Third Period

The Department of Physics and Astronomy was, of course, involved in the administrative and educational changes of the University at the close of World War II. Many changes in the staff occurred during, at, or near the close of the second World War. Alpheus W. Smith, who had served as Chairman of the Department and Dean of the Graduate School, having reached the normal age of retirement in 1946 was made Professor Emeritus and Dean Emeritus of the Graduate School. Professor Harald H. Nielsen was appointed Chairman of the Department of Physics to succeed him. Other changes were as follows:

1. E. R. Gaertner accepted a position as research physicist with the Research Laboratory of General Electric Company.

2. Kenneth R. More accepted a position as research physicist with the Phillips Petroleum Company.

3. Harold P. Knaus accepted a position as Professor of Physics at the University of Connecticut.

4. Jerome P. Green accepted a position at the Naval Ordnance Laboratory.

5. Professor L. H. Thomas who had been on leave of absence for war research at Aberdeen Proving Grounds returned for one year and then resigned to accept a position with Watson Laboratories.

6. Professor George H. Shortley returned for one year and then resigned to accept a position with the Operations Research Office - Johns Hopkins.

7. Professor F.C. Blake retired in 1946 and was appointed Emeritus Professor of Physics.

To fill these vacated positions in the staff and to provide for necessary expansion required to care for teaching and research, replacements and additional members of the staff were secured as rapidly as possible.

The following is a list of the personnel participating in the third period and of their ranks (not including Assistant Instructors, Assistants, Research Associates, Research Assistants, Technical Assistants) and period of service. Brief biographical sketches are included in a later section.

Nielsen, Harald H.	Professor and Chairman, (1946--)
Bell, Ely	Instructor, Assistant Professor, Associate Professor, Professor (1948--)

Blake, Frederick C.	Professor Emeritus (1946-56) (deceased)
Brown, L. Carlton	Research Associate, Assistant Professor, Associate Professor (1955--)
Cooper, John N.	Assistant Professor, Associate Professor, Professor (1946-56)
Cooper, Leon N.	Research Associate, Assistant Professor (1955-5
Darling, Byron T.	Assistant Professor, Associate Professor (1947-53)
Daunt, John G.	Assistant Professor, Associate Professor, Professor (1946--)
Dickey, Frederick P.	Instructor, Assistant Professor, Associate Professor, Professor, Vice-Chairman (1946--)
Dingle, Albert	Research Associate, Assistant Professor (Meteorology) (1943-54)
Edwards, D. O.	Assistant Professor (1961--)
Erickson, Richard A.	Assistant Professor, Associate Professor (1954-
Gaines, J. R.	Assistant Professor (1961--)
Harris, James C.	Assistant Professor, Associate Professor, (1950--)
Hausman, Hershel J.	Assistant Professor, Associate Professor (1952--)
Heer, Clifford V.	Assistant Professor, Associate Professor (1951--)
Heil, Herman G.	Associate Professor, Emeritus Associate Professor (1946-57) (deceased)
Herring, David F.	Assistant Professor, Associate Professor (1957--)
Hesthal, Cedric E.	Associate Professor (1946--)

Jastram, Philip S.	Assistant Professor, Associate Professor (1955--)
Jones, Keith W.	Assistant Professor (1958--)
Jossem, E. Leonard	Research Associate, Assistant Professor, Associate Professor (1950--)
Kim, Young S.	Visiting Assistant Professor (1962--)
Kobe, Donald H.	VisitingAssistant Professor (1961--)
Korringa, Jan	Associate Professor, Professor (1953--)
Kurbatov, J. D.	Associate Professor, Associate Professor Emeritus (1946--)
Lande, Alfred	Professor, Emeritus Professor (1946--)
Margolis, Bernard	Associate Professor (1959-61)
Mate, C. F.	VisitingAssistant Professor (1961--)
Mills, Robert L.	Assistant Professor, Associate Professor, Professor (1956--)
Mulligan, Bernard	Visiting Assistant Professor (1961--)
Nelson, Richard Carl	Associate Professor (1949--)
Nielsen, Carl E.	Assistant Professor, Associate Professor (1953--)
Oetjen, Robert A.	Assistant Professor, Associate Professor, Professor (1946--)
Ploughe, William D.	Assistant Professor (1962--)
Pool, Marion L.	Professor (1946--)
Prebus, Albert F.	Associate Professor, Professor (1949--)
Rao, K. Narahari	Research Associate, Associate Professor (1954--)

Reibel, Kurt	Assistant Professor (1961--)
Riley, William R.	Instructor, Assistant Professor (1951--)
Sessler, Andrew M.	Assistant Professor (1954-61)
Seyler, Richard G.	Visiting Assistant Professor (1961--)
Shaffer, Wave H.	Associate Professor, Professor (1946--)
Shaw, Charles H.	Associate Professor, Professor (1946--)
Shaw, John H.	Research Associate, Assistant Professor, Associate Professor (1949--)
Shortley, George H.	Professor (1946-51)
Smith, Alpheus W.	Professor Emeritus (1946--)
Smith, Alva W.	Professor (1946-48) (deceased)
Williams, Dudley	Associate Professor, Professor (1946--)
Yang, Chen-Ping	Assistant Professor (1961--)
Zumstein, Robert V.	Associate Professor (1946--)

ASTRONOMY

The need for an astronomical observatory of a type suitable for instruction in practical astronomy, was deemed urgent as early as 1891. The Board of Trustees, recognizing this need, appropriated $3000 for the equipment of an observatory. At the October meeting, 1891, Professor Lord, then an assistant in mathematics, presented plans, specifications, and estimates for the building of the Observatory. They were approved and an appropriation of $1200 was made. However, at the November meeting of the same year, it was ordered that all operations relating to the proposed observatory be suspended because the funds were insufficient.

No further action with respect to the observatory was taken by the Board of Trustees until 1895 when Mr. Julius F. Stone discussed the need for a properly equipped astronomical observatory with Mr. Emerson McMillin, an eminent industrialist and financier of New York City. As a result of this discussion, Mr. McMillin asked Mr. Stone to give him an estimate for the cost of the equipment desirable for an astronomical observatory at The Ohio State University.

After consulting with Professor Lord, Mr. Stone forwarded the desired information to Mr. McMillin. In response he received from Mr. McMillin the following offer: "if you will erect a suitable building on university grounds in which to place the observatory apparatus, I will pay for the complete equipment, the cost not to exceed ten thousand dollars... ".

At the April meeting of the Board of Trustees, Mr. McMillin's offer to provide funds for the purchase of equipment of an astronomical observatory was accepted with appreciation.

At the same meeting, plans for an observatory building as proposed by Professors Lord and Bradford were approved. Then later Mr. McMillin agreed to pay for the construction of the observatory building provided that the cost did not exceed $5000 and that the Board of Trustees spend an equal amount on improving the grounds in the immediate vicinity of the observatory site.

This second proposal of Mr. McMillin was adopted by the Board of Trustees.

Following is a list of the more important equipment of the observatory as originally furnished by Mr. McMillin: a 12-inch refracting telescope and attachments, including a spectroscope, chronograph, and position micrometer; a 3-inch ShegMuller combined transit and zenith telescope; an astronomical clock by Piefler; a comparator; induction coil; and astronomical books valued at approximately $1500.

At the June meeting of the Board of Trustees in 1895, Henry C. Lord was elected director of the Emerson McMillin Observatory and Associate Professor of Astronomy. The formal opening of the observatory took place on the afternoon of June 16, 1896. At this dedicatory exercise it was announced that Mr. McMillin had provided a fellowship in astronomy for five years with an annual stipend of $300.

In 1902 the University added to the building a lecture room capable of seating 30-40 students, with a large basement used originally as a workshop and two additional observing rooms. The equipment of these rooms included five theodolites, one of them a 12-inch theodolite, and a 2 1/2-inch zenith telescope.

Numerous gifts received from time to time had added much to the equipment of the observatory. Several important items are gifts of Mr. Julius F. Stone.

In the early period of its operations the observatory through original investigations made important contributions to astronomical science. These contributions, characteristic of the research interests in astronomy in that period, were largely in the field of positions and motions of astronomical bodies. Interest in astrophysics was just beginning to develop.

In 1923, Professor Lord retired as director of the observatory and Professor Edmund Mansen was appointed to succeed him.

In the period preceding the year 1931, instruction and research at the observatory had considerably diminished and the staff of the observatory had been reduced to Professor Mansen, Director of the Observatory, and a student assistant. The development of astrophysics had brought instruction and research in astronomy close to physics. Recognizing this development, Dean Shepherd of the College of Arts and Sciences recommended that the administration of the program in astronomy be transferred to the Department of Physics and that the name of the Department of Physics be changed to the Department of Physics and Astronomy. This recommendation was approved by the Board of Trustees and from that time until 1962 astronomy has been part of a unified program in physics and astronomy, directly responsible to the Chairman of the Department of Physics and Astronomy.

The members of the staff who served prior to the time at which Astronomy was combined with Physics to form the Department of Physics and Astronomy were: Henry C. Lord, Associate Professor of Astronomy and Director of Emerson McMillin Observatory, 1895-1900, Professor and Director of Emerson McMillin Observatory, 1900-23; Edmund S. Mansen, Professor and Director of Emersom McMillin Observatory, 1923-46; and Donald H. Menzel, Assistant Professor, 1925-6.

The Perkins Observatory

In the early years of the Great Depression, the Ohio Wesleyan University realized that it would not be possible for it to finance properly the research and teaching program of the Perkins Observatory in such a manner that the Observatory might make its proper contribution to research and teaching. The fact that the Observatory was not located on the main campus of Ohio Wesleyan University increased the expenses for its maintenance and care. Supplementary expensive equipment would be required to make the telescope effective as a high grade research instrument. An enlarged staff of competent astronomers and technicians would be required to utilize effectively the large reflecting telescope and the necessary auxiliary equipment for a significant research program. For these and related reasons, the Ohio Wesleyan University decided to seek sources of additional funds for the administration and operation of the Observatory. To this end, the President of Ohio Wesleyan University and the representatives of its Board of Trustees requested that The Ohio State University consider the possibility of entering into a suitable cooperative agreement with Ohio Wesleyan University for the maintenance, operation, and further development of Perkins Observatory.

After careful consideration by the administrative officers and agencies of each of the universities, an agreement for the accomplishment of these objectives was formulated in 1935, and properly approved by both universities. The more essential conditions of this original agreement were as follows:

1. The affairs of Perkins Observatory were to be governed by a joint administrative committee consisting of the two University Presidents and a representative from each Board of Trustees.

2. The members of the observatory staff were to be on the faculties of both universities with limited teaching duties at Ohio Wesleyan University.

3. Ohio Wesleyan contributes a specified return on the Perkins-Howard Endowment Foundation, and the major portion of the maintenance expenses is borne by The Ohio State University.

4. The Observatory and property therein at the time of signing the agreement remain in the control of Ohio Wesleyan University, but all equipment added after July 1, 1935, becomes the property of The Ohio State University.

5. Ohio Wesleyan University retains the income of its Endowment Fund for the purpose of securing a highly qualified professor to teach Astronomy at Ohio Wesleyan University and to serve as a member of the staff of the Observatory.

6. The Ohio State University pays to Ohio Wesleyan University the sum of $400.00 per month as rental for the use of the facilities of the Observatory. Ohio Wesleyan University agrees to use this sum for all major or permanent improvements at the Observatory.

7. The Ohio State University further agrees to pay for all operational expenses including janitor services, heat, light, power, water, and other departmental expenses within the limits of the available University funds.

8. Ohio Wesleyan University pays the costs of insurance on the property.

9. All instructors, professors, and research associates are to be accredited to both The Ohio State University and Ohio Wesleyan University in their respective catalogues.

10. All books, serials, and periodicals acquired by the Observatory since May 16, 1935 are and will be the property of The Ohio State University. All books, serials and periodicals acquired by the Observatory prior to May 16, 1935 remain the property of Ohio Wesleyan University.

11. The Chairman of the Department of Physics and Astronomy of The Ohio State University will make recommendations through the regular channels covering the appointment of a Director of the Observatory.

12. The operations of Ohio Wesleyan University and The Ohio State University under this contract shall be controlled and directed by a Joint Committee of six persons, three from The Ohio State University and three from Ohio Wesleyan University. The respective Presidents shall be members of the Joint Committee, and each President shall appoint two other persons to be members of the Joint Committee.

Auxiliary Equipment as of 1962. The library contains more than 3200 bound volumes including files of technical journals published in many languages. In the basement of the Observatory are located several large laboratory rooms, a well-equipped machine shop, and a large dark room equipped for all branches of photographic work. The dark room contains an enlarger, a contact printer, a refrigerator, and an elaborate developing tank. The telescope is equipped with a double-slide plate holder for direct photography and an objective grating for measuring the magnitudes of faint stars. The grating, one of the largest in existence, has a clear aperture of 70 inches and a spacing of 2/5 of an inch. It is made entirely of aluminum. A thermoelectric photometer, designed by Dr. Stetson, is used for measuring the densities of star images on celestial photographs. The observatory possesses a Gaertner comparator for the precise measurement of spectrum photographs, three standard computing machines, and a large, two-prism spectrograph attached to the telescope at the Cassegrain focus. The spectrograph was designed by Dr. C. E. Hesthal and constructed by Mr. W. B. Decker in the observatory shop. A unique feature of the instrument is the long collumator (effective focus 130 cm.) which greatly increases its efficiency by permitted the use of a wide slit. The main camera contains a Petzval-Moffitt f 4. 8 lens which gives a dispersion of 25 angstroms per mm. at

4340 and a spectrum in good focus from 3600 to 6600. There are two other cameras with Rayton lenses of speeds f 2.5 and f 1.75. The instrument is completely housed within a well-insulated temperature jacket, and temperature is automatically held within a range of about one-tenth of a degree. A large grating spectrograph, for investigations of starlight in the red and infra-red region of the spectrum is available.

Shock Tube Laboratory. The luminous shock tube in the basement of the McMillin Observatory has been completed by the Department of Physics and Astronomy machine shop under the direction of Professor Slettebak, with the help of funds from the Air Force Cambridge Research Center. After testing of the installation, astrophysical investigations began in the summer of 1960. This is one of the few such laboratories in the country specifically set up to obtain data of astrophysical interest.

Research. A few projects involving direct photography at the Newtonian focus have been undertaken from time to time. These include studies of various globular star clusters and investigation of the distribution of stars in certain regions of the Milky Way. The main research program of the Observatory lies in the broad field opened up by spectroscopic analysis of starlight. The members of the staff have chosen to concentrate their attention upon stars with peculiar spectra, seeking to learn more about the physical conditions within such stars. Reasons are sought for the abnormal behavior of these stars which sets them apart from ordinary stars of their general classes. Among the types of stars under spectroscopic observation by members of the staff may be listed relatively cool, red stars in which chemical compounds are found, high-temperature variable stars of regular period, stars whose spectra give evidence of what appear to be incompatible physical conditions, high-temperature stars with extensive atmospheres, unstable stars which change their light output by large or small amounts, and stars which alter the quality of their light periodically or sporadically.

Open Nights. The Observatory is opened to the public on two nights each month. On each open night a popular lecture is delivered by a member of the staff, and opportunity is afforded for observation with the large telescope, weather permitting. On cloudy nights a complete demonstration of the telescope in operation replaces the observation period.

The Radio Observatory

Research in radio astronomy at The Ohio State University began in 1951. At that time Ohio State was one of three universities in the United States active in this new science.

Radio astronomy involves the exploration of the universe by radio techniques and both complements and extends the older methods of optical astronomy. Many celestial sources or "radio stars", which are not observable by optical telescopes, have been discovered by radio techniques. Radio methods also appear to be very well suited for the study of the most distant parts of the universe and for providing experimental evidence to choose between different cosmological theories.

In 1951 a large helix array type radio telescope was constructed at the West Campus Radio Observatory. This was increased in size in 1953 to a 96 helix array measuring 160 by 22 feet. Several smaller auxiliary antennae were also constructed at this site. In 1956 work was started on a much larger radio telescope at a site provided by the Ohio Wesleyan University in accordance with an agreement outlined in subsequent paragraphs. This telescope has a fixed standing parabola 360 feet long by 70 feet high and a tiltable flat reflector 260 feet long and 100 feet in slant height. It is expected that this telescope will be completed early in 1962. It will be one of the largest radio telescopes in the world and will provide almost unparalleled opportunities for advanced research. The telescope is designed to operate over a very wide frequency range extending from 50 Mc to 2, 000 Mc. At a frequency of 2, 000 Mc, the resolution of the telescope is 10 minutes by 30 minutes of an arc.

Current research programs at the Radio Observatory include radio sky mapping, source spectra, hydrogen line studies, radio star scintillation, earth satellite observations, and the design and development of low noise radiometers and high resolution antennae.

The Radio Observatory is under the direction of Professor John D. Kraus, and administered cooperatively with the Department of Electrical Engineering. The staff includes Professor H. C. Ko, Assistant Director; Professor R. C. Higgy; Dr. R. T. Nash; and Dr. Martti Tiuri.

Agreement between Ohio Wesleyan University and The Ohio State University concerning the Radio Observatory. In 1956, the agreement between the Ohio Wesleyan University and The Ohio State University for the operation of Perkins Observatory was modified to provide for the cooperative establishment and operation of a Radio Observatory. The salient features of this agreement are briefly summarized below. For further details, reference is made to the unabridged copy of the agreement.

1. Ohio Wesleyan University agrees to the construction of a radio observatory in accordance with the general specifications outlined in the preceding paragraphs on a site of about 20 acres situated approximately 1/4 mile east of the present site of Perkins Observatory.

2. The Ohio State University agrees to be responsible for the construction of the RadioObservatory and associated facilities.

3. Ohio Wesleyan University agrees to restrict the use of their property at and in the vicinity of the site in such a manner as to prevent interference, radio or otherwise, with the Radio Observatory.

4. The Ohio State University agrees to pay for the operational expenses of the Radio Observatory including janitor services, heat, light, power, water, and other departmental expenses within the limits of the available University funds.

5. Any equipment or structures installed by The Ohio State University at the Radio Observatory may be removed at any time or at the termination of this contract.

6. The operation of the Perkins Observatory and the Radio Observatory shall be controlled by a Joint Committee consisting of eight members, four representing Ohio Wesleyan University and four representing The Ohio State University.

7. The facilities of the Radio Observatory may be utilized by the faculty and students of The Ohio State University and Ohio Wesleyan University and by others under such limitations as may be prescribed by the Joint Committee and the Director of the Radio Observatory.

8. The Director and all the Instructors, Professors, and Research Associates of the Radio Observatory shall be accredited to both Ohio Wesleyan University and The Ohio State University in their respective catalogues.

9. The Chairman of the Department of Electrical Engineering of The Ohio State University will make recommendation through the Dean of Engineering to the President of The Ohio State University for the appointment of a Director of the Radio Observatory.

A Cooperative Research Program Between Perkins Observatory and Lowell Observatory

It is generally recognized that atmospheric conditions in central Ohio are unfavorable for an effective astronomical research program based on a large reflecting telescope. There are so many cloudy or partially cloudy nights each year, so many atmospheric disturbances, and unstable temperature conditions that it is nearly impossible to carry forward a satisfactory astronomical research program without many delays and frustrations. For these and related reasons it has seemed very desirable to move the Perkins telescope to a more favorable location where it could be used more continuously and more effectively for research. It was found possible to realize this objective by entering into a cooperative agreement with Lowell Observatory for the transfer of the Perkins telescope to a location near Flagstaff, Arizona and for its installation in an observatory where staffs of the two observatories could carry on a cooperative research program. This agreement also provided for the installation of a Schottland 32-inch telescope to replace the 69-inch telescope in the Perkins Observatory dome, and for the installation of the Schottland 16-inch Schmidt telescope in a separate housing at the Perkins Observatory. The essential features of the agreement are indicated in the following summary.

1. Ohio Wesleyan University and The Ohio State University agree that the 69-inch telescope and the necessary and proper accessories and equipment be moved from Delaware County, Ohio to an appropriate site in or near Flagstaff, Arizona.

2. Lowell Observatory agrees to select and acquire use of an appropriate site, to erect the necessary dome and related buildings thereon, to arrange the safe transfer of the 69-inch telescope, accessories and equipment to such site and properly to install the telescope at such site all at the sole cost and expense of Lowell Observatory and further agrees that the arrangement for the installation of the telescope shall be entirely complete before it is removed from Delaware, Ohio.

3. It is agreed that title to and ownership of the 69-inch telescope and accessories and equipment shall be and remain in Ohio Wesleyan University.

4. Lowell Observatory agrees to assume the supervision, operation, and proper maintenance of the 69-inch telescope.

5. The scheduling of observing time with the 69-inch telescope shall be the responsibility of the Directors of the Lowell and Perkins Observatories assigning it as nearly as possible in equal measure to the staff of Lowell Observatory and to the staff of Perkins Observatory.

6. In any publications involving the 69-inch telescope, it is to be referred to as "the Perkins Reflector of Ohio Wesleyan University and The Ohio State University at the Lowell Observatory". Cost of publications involving members of both staffs may be divided as agreed in each case.

7. A travelling fund shall be deposited by Lowell Observatory with Ohio Wesleyan University to defray travel expenses of members of the staff of Perkins Observatory from Ohio to Arizona.

8. Lowell Observatory agreed to grant to and deposit with the Ohio Wesleyan University and The Ohio State University the sum of $18,000 to defray the cost of the installation of the Schottland 32-inch telescope to replace the 69-inch

telescope in the Perkins Observatory dome, and for the installation of the Schottland 16-inch Schmidt telescope in a separate housing at the Perkins Observatory. Financial support for the latter installation, plus the purchase of an ultra-violet glass objective prism for the Schmidt, was requested from the National Science Foundation in a separate proposal administered through Ohio Wesleyan University. This proposal was also granted by the National Science Foundation, in an amount of $41, 700.

For further details of this agreement reference is made to a copy of the original agreement.

Kitt Peak Observatory

In order to provide facilities and opportunities for astronomical research in addition to those available for Perkins Observatory and for the joint program between Perkins and Lowell Observatories, The Ohio State University decided to cooperate with several other universities to foster the establishment of a National Observatory located in a region where climatic conditions are as favorable as possible. The initial universities undertaking the project were The Ohio State University, University of California, University of Chicago, Harvard University, University of Indiana, University of Michigan, and University of Wisconsin. Later Yale University and Princeton University were added to this list. To this end these universities decided to organize the Association of Universities for Research in Astronomy and on October 28, 1957 decided to incorporate it under the laws of the state of Arizona. The National Science Foundation negotiated a contract with the Association of Universities for Research in Astronomy to build and operate the projected observatory. Funds for this purpose amounting to nearly $9, 000, 000 have been appropriated to date. In addition, the cost of the public access road will be $2, 890, 000.

The articles of incorporation and by-laws specify that:

1. "The objects, purposes, and general nature of business in which this corporation shall engage are as follows:

a. 'To acquire, construct, establish, own, equip, and operate an observatory or observatories for the purpose of astronomical and related scientific study and research.

b. " The business and affairs of the Corporation shall be managed by a Board of Directors composed of two institutional directors designated by each member institution, and of no more than five additional directors (to be known as director-at-large) elected by the Board of Directors... "

After careful study, it was decided to locate the National Observatory near Tuscon with the headquarters adjoining the campus of the University of Arizona and its major research instruments on Kitt Peak. At the headquarters are the administrative and research offices, the library, laboratory, and shop facilities, and storage vaults for the photographic records. On Kitt Peak there is an office and laboratory building, a dining-assembly, a shop and maintenance facility, and a dormitory. The instruments on Kitt Peak will include two telescopes of major size for stellar research, a solar telescope, several types of spectrographs, and auxiliary equipment.

The solar telescope will give a picture of the sun 33.5 inches in diameter, and with its powerful spectrograph, it will permit detailed observations never before possible. The stellar telescopes at Kitt Peak will be provided with the three basic types of auxiliary equipment: 1. the camera for direct photography; 2. the photometer for measuring brightness and color of celestial objects, and 3. the spectrograph for detailed analysis of their light. For observations of faint or distant objects where high speed is required, a low dispersion instrument is most suitable. Here the spectrum may be only a fraction of an inch in length. For high dispersion work on bright objects, the powerful Coude spectrograph can give a spectrum extending over a length of several feet. With the varied equipment available at Kitt Peak, research in a wide range of problems will be possible.

To maintain efficiency and continuity of operation, the observatory will employ a small permanent staff of astronomers. Provision will be made for graduate students working for the Ph. D. degree. Foreign astronomers will be granted the use of the observatory facilities for problems of special importance. Astronomers from participating observatories and visiting astronomers from other American observatories will constitute an important part of the staff.

Astronomy--a Separate Department

In November 1962 the Board of Trustees of The Ohio State University on the recommendation of the Dean of the College of Arts and Sciences and Faculty Council authorized the separation of the program in Astronomy from the Physics Program. The recommendation provided for the establishment of a separate Department of Astronomy and the change in the name of the Department of Physics and Astronomy to the Department of Physics. In approving the separation of these programs it was recognized that the work in Astronomy had developed so significantly in recent years and its program had become so important that Astronomy would be more appropriately administered as a separate department in which its special needs, points of view, and research and teaching program could be more effectively cared for.

Astronomical Staff

Bobrovnikoff, Nicholas T.	Associate Professor, Professor (1935--) Acting Director and Director of Perkins Observatory (1934-51)
Keller, Geoffrey	Instructor, Assistant Professor, Associate Professor (1948-59), Director of Perkins Observatory (1953-59)
Slettebak, Arne E.	Assistant Professor, Associate Professor, Professor (1950--), Director of Perkins and McMillin Observatories (1959--)
Bonsack, Walter	Assistant Professor (1960--)
Cherrington, Ernest H., Jr.	Instructor, Assistant Professor (1936-46)
Hynek, J. Allen	Instructor, Assistant Professor, Associate Professor, Professor (1935-60)
Keenan, Philip	Assistant Professor, Associate Professor (1946--)
Ko, Hsien Ching	Associate Professor, Associate Director of the Radio Observatory
Kraus, John D.	Professor of Electrical Engineering and Director of the Radio Observatory (1952--)
Lord, Henry C.	Associate Professor, Professor, Director of McMillin Observatory (1885-1923)
Manson, Edmund S.	Instructor, Assistant Professor, Associate Professor (1907-23), Professor and Director of McMillin Observatory (1923-46)
Menon, Thuppalay K.	Associate Professor at Radio Observatory
Menzel, Donald H.	Assistant Professor (1925-6)
Merrill, John E.	Assistant Professor, Associate Professor (1938-50)
Mitchell, Walter, Jr.	Instructor, Assistant Professor (1957--)

Short biographical sketches are included in a later section.

THE SCHOOL OF OPTOMETRY

In 1914 Charles Sheard, then an assistant professor of Physics, became interested in an educational program for the preparation of those interested in optometry as a profession. At that time Ohio had no laws regulating the practice of the profession of Optometry. A number of practicing optometrists desired to have optometry legalized and regulated much as the practice of medicine, dentistry, pharmacy, and veterinary medicine are regulated by Ohio laws administered by properly constituted boards. In the case of Optometry there was one major difficulty in realizing this objective. It was the fact that in the State of Ohio there was at that time no school or college for the proper training of prospective optometrists. In cooperation with Professor Sheard, a committee representing the optometrists in Ohio requested the President of The Ohio State University to consider the possibility of establishing at The Ohio State University a curriculum, the completion of which would prepare prospective optometrists to pass qualifying examinations for the practice of optometry. President Thompson sympathetically considered this request and as an initial step a two year curriculum in optometry leading to a certificate of achievement was authorized with the emphasis on opthalmic optics. It was called a curriculum in applied optics for two reasons. First, optometry at that time was not ordinarily considered an appropriate curriculum for a University; and, second, Professor Sheard hoped that the program might be expanded to include further aspects of applied optics. In was budgeted and administered directly in the office of the President of the University with the cooperation of the Dean of the College of Liberal Arts. Interested optometrists contributed limited funds for its support and some manufacturers of optical equipment contributed demonstration and clinical apparatus. The program was housed in two or three rooms in Mendenhall Laboratory with an informal administrative relation to the Department of Physics. Ten students completed the work offered in this initial program. It soon became evident that it would be impossible to provide the preparation of prospective optometrists in a two year curriculum. Consequently, in 1915-16, the curriculum was revised and extended, by the inclusion of additional fundamental courses in physical and biological sciences, into a four year curriculum leading to the degree of Bachelor of Science in applied optics, administered in the College of Engineering. The faculty of theCollege of Engineering voted the degrees but other administrative controls remained in the office of the President of the University.

In 1920, Professor Sheard who had served as Director of the program in applied optics, resigned to accept a position with the American Optical Company. He was replaced by Howard D. Minchin as Professor and Director of the Courses in Applied Optics. Minchin served in this capacity until 1930. In 1921 Morgan C. Davies, who had completed the two year program leading to the Certificate in Applied Optics, was appointed Instructor. In 1922, he received the Bachelor of Science Degree in Applied Optics and continued as an Instructor until 1927. In 1930 he replaced Minchin as Professor and Director and served in this capacity until 1934. In 1927, C. R. Ellis replaced Davies as Instructor. At that time

Ellis had earned the degree of Bachelor of Science of Applied Optics and was a practicing optometrist. In 1931 his title was changed to Instructor and Director of the Eye Clinic. In 1934 he was promoted to Assistant Professor and Director of the Courses in Applied Optics, replacing Morgan Davies. In this capacity, he served for one year. At that time the program in applied optics was assigned to the Department of Physics and Astronomy for administrative purposes. The Department of Physics and Astronomy accepted this assignment with the implicit understanding that a staff be selected with greater emphasis on scientific work and proficiencies and less emphasis on the technical skills of optometry as a profession. In conformity with this understanding, Glenn A. Fry was appointed Assistant Professor and Director of the program in applied optics. At the time he was not authorized as a practicing optometrist. Such authorization was later secured. Dr. Fry's academic record and research interests and experience were as follows: Davidson College, A.B. (1929 Duke University, M.A. (1931), Ph.D. (1932 in psychology), National Research Fellow (1932-4) in biophysics and electrophysiology in the Department of Ophthalmology at Washington University School of Medicine, Research Assistant in Ophthalmology (1934-5).

Transfer from the College of Engineering to the College of Arts and Sciences. When the Department of Physics was transferred from the College of Engineering to the College of Arts and Sciences for administrative purposes, the work in applied optics was included in this transfer.

After this transfer had been realized and the supervision of this program had become a responsibility of the Chairman of the Department of Physics and Astronomy, attention was directed toward the development of a professional program, which could properly be included in the work of the University. Under the direction of Glenn A. Fry the four year program was changed in content and purpose by decreasing the emphasis on technology and increasing the emphasis on basic physical and biological sciences. The name of the program was changed from Applied Optics to Optometry and organized as a separate school within the Department of Physics and Astronomy which at that time was administered in the College of Arts and Sciences. The authorization and this change is recorded in the minutes of the Board of Trustees as follows:

> "That the administration of the work in Applied Optics be transferred from the College of Engineering to the College of Arts and Sciences and that a School of Optometry be created within the Department of Physics and Astronomy under the administration of that department to carry on the work hitherto known as Applied Optics, effective July 1, 1937...
>
> Further, that one year of preliminary study be required for admission to the School of Optometry, effective at the opening of the school year 1939-40...

And further, that the degree granted upon the completion of this curriculum be changed from Bachelor of Science in Applied Optics to Bachelor of Science in Optometry."

Five Year Program. A five year program was initiated in 1939 requiring those admitted subsequent to July 1939 to have completed 45 quarter hours of prescribed academic work at the college level and also by requiring them to complete four additional years of prescribed professional courses. This expansion of the program permitted the inclusion of more math, bacteriology, and physiology to strengthen the training in basic science, and to provide additional work in physiological optics and optometry especially in such fields as orthoptics, contact lenses, aniseikonia, and subnormal vision.

Graduate Study and Research. In 1937, when the professional courses in optometry and supporting courses in the physical and biological sciences had been organized into a successful five year curriculum, the Director of the School of Optometry addressed himself to the development of a program of graduate study and research in physiological optics and related professional topics in optometry. A sequence of advanced courses in physiological optics was organized and approved by the Graduate School. A proper selection from these courses was adjudged adequate to satisfy the course requirement for either the Master's degree or the Ph. D. degree. Opportunities for research in physiological optics could satisfy the requirements for either a thesis or dissertation. Some of the more important topics which have been included in the research program of the School of Optometry are as follows: color vision and other sensory visual functions, refraction and motility of the eyes, contact lenses, visual acuity, accommodation-convergence relations, subnormal vision, bunocular coordination of the eyes, sensory mechanisms of vision, and fusional movements of the eyes.

Through its graduate study and research program, the School of Optometry has occupied a position of leadership in the development of professional optometry. Between the years of 1937 and 1952, eleven candidates earned either the Master's degree, the Ph. D. degree, or both of these degrees. Prior to the initiation of this program, there were almost no opportunities for training in optometry beyond the undergraduate programs. Teaching and research in physiological optics were almost exclusively confined to the field of psychology. The opportunities for securing advanced training in physiological optics and optometry as a profession were negligible. Through its graduate study and research program the School of Optometry has been able to train a number of leaders in this field of education and research who are participating effectively in the educational research programs based largely in colleges, universities, and industries. Improved training based largely on the emphasis on the graduate program and research has manifested itself in wider acceptance by the public of optometry as a profession and the recognition of the service rendered by optometrists in specialized situations involving the armed services and industry.

Funds for the Development of the Program. In 1937 a group of optometrists in Ohio and surrounding states formulated a project called the Sheard Foundation for Education and Research in Vision at The Ohio State University. The group called itself the Standing Committee of the Sheard Foundation. However, the group decided that the first phase of its activity should be aimed at the provision of funds for an Optometry Development Program. This organization raised over $100,000 to be applied toward a new building. The state legislature supplemented this by appropriating $200,000. The contract was let in 1947 and the building was occupied in January 1951.

The Sheard Foundation for Research in Vision was created May 29, 1944. Original grants from Dr. Charles Sheard and others which with additions through the years has made the value of the endowment approximately nineteen thousand dollars in 1962.

The Emil H. Arnold Optometric Scholarship was established November 17, 1944 by Dr. Emil H. Arnold and supported entirely by him by additions through the years. The proceeds from this endowment are to be used for graduate and undergraduate scholarships in the School of Optometry. Preference will be given to residents of the State of Michigan. The 1962 value of this endowment is approximately twelve thousand dollars.

The Lionel Topaz Memorial Library of Visual Science was established January 18, 1943 by the sons and daughter of Lionel Topaz for the interest to purchase books and periodicals for this library located in the Optometry Building. The value of this endowment is approximately fifty eight hundred dollars in 1962.

The James A. Bing Memorial was established February 20, 1947 through the members of the Ohio State Optometric Association to provide for a cash award for a graduating senior in Optometry for research in perceptual seeing. The principal is fifteen hundred dollars.

Howard Fenimore Haines II Fund for Visual Research was established January 18, 1943 by Dr. and Mr. Howard F. Haines and supported by them with additions through the years. Interest from this fund is to be used for support of visual research. Value of the principal in 1962 is approximately five thousand eight hundred dollars.

Research in Optometry, created March 12, 1948 by the Ohio State Optometric Association and supported by optometrists through The Ohio State University Development Fund. Value of the principal in 1962 is approximately eight thousand seven hundred dollars.

The following grants in aid have been made available.

1. White Haines Fellowship--1939-40, 1940-41 and possibly an additional year. $1000 per year. Money came from Bausch and Lomb Optical Company. Held by Hofstetter. Univis Lens Company contributed $1000 per year for 1939-40 (Kehoe) and 1940-41 (Ellerbrock) for Univis Fellowship.

2. Bausch and Lomb Grant for Research in Physiological Optics (Research Professorship) 1944-47. Three years at $5000 per year.

3. Grant from American Academy of Optometry for help in constructing a colorimeter. Approximately $2000.

4. Univis Fellowship 1951-52, $1500. P. R. Haynes was the recipient.

5. Grant from Soft-Lite Lens Company for the study of the effect of sunglasses on visual acuity. George Knox was the principal investigator.

Research Foundation Projects

1. Joint project between L. G. Mitten and G. A. Fry. Timken Roller Bearing Company. Visual factors in the inspection of roller bearings. Approximately 1949-51.

2. Office of Naval Research. Fry supervisor and H. O. Ward principal investigator. 1951-53 approximately. Study of chromatic adaptation.

3. Effect of flashes of light on visual acuity. Wright Field, 1951-53 approximately. Fry supervisor.

4. Design and construction of a colorimeter. Office of Naval Research. 1951-52. Fry supervisor.

Institute for Research in Vision

In response to a request made by a group of men on the campus interested in research in vision the Dean of the Graduate School appointed a committee to study the need for such an institute.

In 1947, the Graduate Council approved a report of the committee which recommended the establishment of an Institute and described its functions to be:

1. To sponsor research in vision, to provide opportunities for cooperative investigations by various groups, and to obtain financial support of such research with the cooperation of the Development Fund.

2. To hold periodic meetings for the discussion of the various research programs in progress; and

3. To hold symposia on vision at which members of the University staff and distinguished investigators from other institutions would speak on various aspects of research in vision.

The approved report of the Committee also provided for an organization to conduct and promote the activities of the Institute.

On March 12, 1949, the committee made its final report to the Graduate Council, recommending the appointment of Professor Glenn A. Fry, Director of the School of Optometry, and Professor Arthur M. Culler, Chairman of the Department of Ophthalmology, as Co-Directors of the Institute. An Executive Committee to conduct the business affairs of the Institute and a Council to represent the wide academic interests in research in vision were also recommended. The organization was approved by the Graduate Council and by the President and Board of Trustees and was established as of October 1, 1949.

Funds made available to the Institute through the Development Fund and through special grants have been used in support of various research projects in vision in different departments. Conferences and symposia have also been sponsored. Prior to 1952, the most useful purpose served by the Institute was the encouragement of cooperative thinking and planning resulting in numerous joint projects. Later the Institute for Research in Vision became an active research laboratory in the Research Center with its staff, facilities, and supporting funds.

A Change in Administration

In 1952 it was realized that the education and research programs of the School of Optometry had developed sufficiently to make it undesirable to have its administration dependent on the Department of Physics and Astronomy. It was furthermore realized that it was an administrative anomaly to have the School of Optometry administered as part of the Department of Physics and Astronomy. Furthermore, the professional status of the educational and research program in optometry had sufficiently developed under the wise guidance of its director, Professor Fry, that the School of Optometry should be made an independent administrative unit in the College of Arts and Sciences. For these and other reasons, on April 14, 1952, the Board of Trustees approved separate status for the School of Optometry, so that it would be administered as a school in the College of Arts and Sciences separate from the Department of Physics. From this date forward the activities of the School of Optometry cannot be appropriately included in this report.

Departmental Staff in Optometry (1935-52)

Fry, Glenn A.	Assistant Professor, Associate Professor, Professor and Director of the School of Optometry (1935--)
Allen, M. J.	Assistant Professor (1949-53)
Bridgeman, Charles S.	Instructor, Assistant Professor, Associate Professor (1938-48)
Ellerbrock, Vincent J.	Assistant Professor, Associate Professor, Professor (1948--)
Haines, Howard	Practicing Optometrist and Part-time Instructor
Hoffstetter, Henry W.	Instructor, Assistant Professor, Associate Professor, (1942-49)
Knox, George W.	Assistant Professor, Associate Professor (1947--
Mote, Herbert	Practicing Optometrist and Part-time Instructor
Paul, Frederick W.	Instructor (1937-40)
Reese, Ellsworth	Practicing Optometrist and Part-time Instructor
Stewart, C. R.	Assistant Professor (1951-52)
Zinnecker, K. S.	Practicing Optometrist and Part-time Instructor.

Since 1935 full time staff members have either held the Ph. D. degree at the time of appointment or were near completion of the requirements and later obtained the degree. Staff members like G. A. Fry, C. S. Bridgeman, and G. W. Knox were Ph. D.'s in psychology. Fred Paul was a Ph. D. in physics. The rest have been Ph. D.'s in physiological optics either from The Ohio State University or the University of California. Most of the staff members were optometrists before becoming Ph. D's. Paul, Knox, and Bridgeman earned degrees in optometry after obtaining their Ph. D. degrees. Part-time clinical instructors have been practicing optometrists holding the B. Sc. in optometry or its equivalent. Some of these men like H. G. Mote, E. E. Reese, K. S. Zinnecker, and H. Haines hold M. Sc. degrees in physiological optics.

Brief biographical sketches of members of the staff will be found in a later section.

SHORT BIOGRAPHICAL SKETCHES OF MEMBERS OF THE DEPARTMENTAL STAFF

These short biographical sketches of members of the staff give the salient facts concerning their professional careers before and after joining the staff. Biographical sketches of Visiting Professors, temporary instructors, research assistants, graduate assistants, student assistants, and technical assistants have not been included. In case a member of the staff has elected to accept a position elsewhere, his biographical sketch is ordinarily terminated with a statement indicating the position, employment, or activity which he has chosen.

Physics

Arns, Robert G. was born in Buffalo, New York on July 24, 1933; he received a BS degree from Canisius College in 1955; MS and Ph. D. degrees from the University of Michigan in 1956 and 1959; Instructor, University of Michigan 1960; Assistant Professor, 1960-63 and Associate Professor 1963-64 University of Buffalo; Associate Professor, The Ohio State University, 1964--; he is a member of the American Physical Society and the American Association of Physics Teachers.

His research interest is in low and medium energy nuclear physics.

Barnett, Samuel J. was born in Woodson County, Kansas on December 14, 1873; received AB degree from Denver University in 1894 and Ph. D. degree from Cornell University in 1898; Instructor in physics and biology, Denver University, 1894-5; Assistant, Astronomical Observatory in Virginia, 1896; Magnetic Observer, U. S. Coast and Geodetic Survey, 1902-4; Assistant Professor of Physics, Tulane University, 1905-11; Professor, Ohio State University, 1911-18.

He received the Compstock prize in 1918 for research on magnetization by rotation. He was a member of the following learned societies: American Association for the Advancement of Science, American Physical Society, Geophysical Union, American Academy of Science. He was the author of a treatise on electricity and magnetism and a number of scientific papers in his chosen field of research, experimental electricity and magnetism.

He resigned in 1918 to accept a position as research physicist at the Carnegie Institution, Department of Terrestial Magnetism.

Bell, Ely E. was born in Trinidad, Colorado on December 26, 1915; received BA degree from the University of Colorado in 1938 and MA degree in 1940; received Ph. D. degree from The Ohio State University in 1947; Research Fellow, Ohio State University, 1946-7; Instructor, 1947-9; Assistant Professor, 1949-55; Associate Professor, 1955-60; Professor, 1960--; Physicist, Naval Research Laboratory, 1952-3; member of the American Physical Society.

His research interest is infrared spectroscopy.

Bennett, Willard H. was born in Findlay, Ohio on June 13, 1903; received AB degree from The Ohio State University in 1924, MS degree from the University of Wisconsin 1926, and the Ph. D. degree from the University of Michigan in 1928; National Research Fellow, California Institute of Technology, 1928-30; Instructor, Ohio State University, 1930-3; Assistant Professor, 1933-8; Fellow of the American Physical Society.

His research interests were in the fields of infrared spectroscopy, the emission of electrons from cold surfaces, and negative atomic ions. He also designed a high voltage electrostatic generator.

In 1938 he resigned to accept a position as Director of Research, Electric Research Corporation.

Blake, Fredric C. was born in Decatur, Illinois on October 30, 1877; received his Ph. B. degree from Colorado College in 1901 and his Ph. D. degree from Columbia University in 1905; John Tyndall Fellow, Columbia, 1904-7; student at Cambridge University, 1905-6 and at the University of Berlin, 1906-7; Assistant Professor, Ohio State University, 1907-12; Professor, 1912-46; Emeritus Professor, 1946-56.

He was a member of the following learned societies: American Association for theAdvancement of Science, American Physical Society, Association of Physics Teachers, Engineering Education, and Ohio Academy of Science. His fields of research interest were as follows: electric waves, resistance of metals in a magnetic field, standing waves in a Lecher wire system value of Planck's constant from x-rays, critical absorption and precision measurements of x-rays, crystal structure of solid solutions and alloys, self and mutual elastance, intensity relations of the scattered energy in the several methods of x-ray analysis of crystals, and generalization to the mixed crystal theory.

Blatt, S. Leslie was born in Philadelphia, Pennsylvania on June 10, 1935; received his AB from Princeton University in 1957 and the MS and Ph. D. degrees from Stanford University in 1959 and 1965; Assistant Professor, Ohio State University, 1966--; member of the American Physical Society.

His research interests are in the field of low and medium energy nuclear physics.

Boyd, James E. was born near Stovertown, Ohio in November of 1863; received his BS degree from The Ohio State University in 1891 and his MS degree from Cornell University in 1896; Assistant, Ohio State University, 1891-5; Assistant Professor, 1896-1901.

In 1901 he was appointed Associate Professor of Mathematics, severing his connection with the Department of Physics at that time.

Brown, L. Carlton was born in Mineral Springs, Arkansas on March 26, 1915; received AB degree from Henderson State College in 1937, MA from Florida State University, 1952, and Ph. D. degree from The Ohio State University in 1955; Research Associate, Ohio State University, 1955-7; Assistant Professor, 1957-9; Associate Professor, 1959-65; Professor, 1965--; member of the American Institute of Physics and the American Physical Society.

His research interests are nuclear magnetic and electron skin resonance.

Brubaker, Wilson M. was born in West Alexandria, Ohio on July 9, 1906; received AB degree from Miami University in 1932 and Ph. D. from the California Institute of Technology in 1936; Assistant, Physics, California Institute of Technology, 1932-6; Instructor, Ohio State University, 1936-7; member of the American Physical Society.

His research interests were nuclear physics and neutron energies.

He resigned to accept a position as research engineer at the Westinghouse Electric Corporation.

Caldwell, Frank C. was born in Ithaca, New York on December 25, 1868; received AB degree from Cornell University in 1890 and ME degree in 1891; studiec at the Polytechnic Institute in Zurich, 1892-3; served as expert for the Thomas-Houston Electric Company, 1891-2; Assistant Professor, Ohio State University, 1893-6.

The Department of Electrical Engineering was organized at this time and Professor Caldwell appointed as its administrative head.

Chu, William T. was born in Seoul, Korea on April 16, 1934; received the BS in 1957, the MS in 1959 and the Ph. D. in 1963 from Carnegie Institute of Technology; Research Associate, Brookhaven National Lab. 1963-4; Assistant Professor, Ohio State University, 1964--.

His research interests are experimental high energy physics.

Cole, Alfred D. was born in Rutland, Vermont on December 18, 1861; received his AB degree from Brown University in 1884 and his AM degree from Brown University in 1887; studied at Johns Hopkins University from 1884-5 and at the University of Berlin in 1894; Instructor of Physics and Chemistry, Denison University, 1885-7; Acting Professor, 1887-8; Professor, 1888-1901; Professor of Physics, Ohio State University, 1901-7; Professor of Physics, Vassar College, 1907-8; Professor of Physics and Head of the Department, Ohio State University, 1908-26; Professor, 1926-8 (deceased); member of the following learned societies: American Association for the Advancement of Science; American Physical Society and the Ohio Academy of Science.

His research interests were electric oscillations in wires, electric waves in space, and reflection and absorption of electric waves by semiconduction liquids.

Cooper, John N. was born in Kalamazoo, Michigan on February 4, 1914; received AB degree from Kalamazoo College in 1935 and Ph. D. degree from Cornell University in 1940; Instructor, University of Southern California, 1940-3; Assistant Professor, University of Oklahoma, 1943-6; Assistant Professor, Ohio State University, 1946-51; Associate Professor, 1951-55; Professor, 1955-6; Research Physicist, Radiation Laboratory, California, 1944-5; Sandia Corp., 1951, 1952, 1953; member of the American Physical Society andthe Association of Physics Teachers.

His research interests were x-rays and nuclear physics. He resigned in 1956 to accept a position at the Naval Post Graduate School.

Cooper, Leon N. was born in New York City on February 28, 1930; received the AB degree from Columbia University in 1951 and the AM degree in 1953; received Ph. D. degree from Columbia University in 1954; Fellow of the National Science Foundation, Institute for Advanced Study, 1954-5; Research Associate in Physics, University of Illinois, 1955-7; Assistant Professor, Ohio State University, 1957-8; member of the American Physical Society; Consultant, Physical Science Study Cmt, 1956-9.

His research interests were theoretical physics, nuclear physics, and low temperature physics. In 1958 he resigned to accept a position as Associate Professor at Brown University.

Darling, Byron T. was born in Napoleon, Ohio on January 4, 1912; received BS degree from the University of Illinois in 1933, MS degree from the University of Wisconsin in 1939, and Ph. D. degree from the University of Michigan in 1939; Instructor, (Mathematics), Michigan State College, 1939-41; Research Physicist, U. S. Rubber Company, 1941-6; Research Associate, Universities of Wisconsin and Yale, 1946-7; Assistant Professor, Ohio State University, 1947-51; Associate Professor, 1951-3.

His research interest was theoretical physics. In 1953 he accepted a position in physics at Laval University.

Daunt, John G. was born in Killiney, Ireland on June 30, 1913; received BA degree from Oxford University in 1935; MA and Ph. D. in 1937; Lecturer, Physics, Exeter College, Oxford, 1940-6; University Lecturer, 1945-6; Assistant Professor, Ohio State University, 1946-7; Associate Professor, 1947-50; Professor, 1950-65; fellow of the American Physical Society and the London Physical Society: Guggenheim Memorial Fellow, 1953.

His research interest was low temperature physics. He accepted a position with the Stevens Institute of Technology in 1965.

Dickey, Frederick P. was born in Zanesville, Ohio on September 1, 1916; received BS degree from Muskingum College in 1938, MS degree from The Ohio State University, 1939; Ph. D., 1946; Instructor, Ohio State University, 1946-7; Assistant Professor, 1947-54; Associate Professor, 1954-60; Professor 1960--; Vice Chairman of the Department 1960-67; member of the American Physical Society.

His research interests are infrared spectroscopy and radio frequency phenomena.

Dingle, Albert was born in Bismarck, North Dakota, May 22, 1916; received BS degree from the University of Minnesota in 1939 and MS degree from Iowa State College in 1940; received SM degree from the Massachusetts Institute of Technology in 1941 and ScD in 1947; Assistant Professor (Meteorology), Ohio State University, 1947-54; member of the American Association for the Advancement of Science, the American Meteorological Society, the International Society of Bioclimatology and Biometeorology.

His research interests were cloud and precipitation physics and instrumentation and air polution.

In 1954 he resigned to accept a position at the University of Michigan.

Donoghue, Timothy R. was born in Milton, Massachusetts on May 3, 1936; he received the BS degree from Boston College in 1957; Ph. D. from the University of Notre Dame in 1963; Instructor, University of Notre Dame, 1962-3; Post Doctoral Fellow, Ohio State University 1963-64; Assistant Professor, 1964-8; Associate Professor 1968--; member of the American Physical Society.

His research interests are low and medium energy nuclear physics.

Earhart, Robert F. was born in Toledo, Indiana, on February 2, 1873; graduated from Northwestern University with a BS degree in 1893; received Ph. D. degree from the University of Chicago in 1900; studied at Johns Hopkins University, 1897-8; served as electrician, Peoples Power Company in Moline, Illinois from 1893-7; Instructor in Physics, Michigan Military Academy, 1900-01; Instructor, Rose Polytechnic Institute, 1901-3; Assistant P ofessor, Ohio State University, 1903-9; Associate Professor, 1909-12; Professor 1912-33; member of the American Association for the Advancement of Science and the American Physical Society.

His research interest was sparking distances.

Ebner, Charles A. was born in Willimantic, Connecticut August 24, 1940; he received the AB degree at Cornell University in 1962; the MS and Ph. D. degrees from the University of Illinois in 1963 and 1967; Post Doctoral Research Fellow, University of Paris, Orsay, France, 1967-8; Assistant Professor, The Ohio State University 1968--.

His research interest is theoretical solid state physics.

Edwards, David O. was born in Liverpool, England on April 27, 1932; received BA degree from Oxford University in 1953 and Ph. D. degree in 1957; Assistant Professor, Ohio State University 1961-2; Associate Professor, 1962-5; Professor, 1965--.

His research interest is low temperature physics.

Erickson, Richard A. was born in Bryant, South Dakota on September 12, 1923; received BS degree from the South Dakota School of Mines and Technology, 1944; Fellow, Oak Ridge Institute of Nuclear Studies, 1949-51; received Ph. D. degree from Texas A and M College in 1952; Research Associate, Texas A & M College, 1947-9; Assistant Professor (Physics), University of Tennessee, 1951-3; Assistant Professor, Ohio State University, 1954-62; Associate Professor, 1962--

His research interests are neutron diffraction and low temperature physics.

Gaerttner, E. R. was born in February 27, 1911; graduated from Denver University with BS degree in 1932; received MA and Ph. D. degrees from the University of Michigan in 1933 and 1937; appointed National Research Fellow and Rockham Fellow for post-graduate study at California Institute of Technology from 1937-9; Instructor, Ohio State University, 1940-2; Assistant Professor, 1944; granted leave of absence for war work at Radiation Laboratory of M. I. T.

He resigned at the close of World War II to accept position as research physicist at the General Electric Corporation.

Gaines, James R. was born in Cincinnati, Ohio on September 8, 1935; received BS degree from Berea College in 1956 and Ph. D. from Washington University (St. Louis) in 1961; Assistant Professor Ohio State University, 1961-4; Associate Professor 1964-7; Professor 1967--.

His research interest is solid state physics.

Green, Jerome B. was born in New York City on December 28, 1888; graduated from the College of the City of New York with BS degree in 1918; received MS degree from the University of Wisconsin in 1921 and Ph. D. degree from the University of Wisconsin in 1925; Assistant in physics, University of Wisconsin, 1924-5; National Research Fellow, Harvard University, 1925-7 and Guggenheim Memorial Foundation Fellow, Tubingen, in 1931; Instructor, Ohio State University, 1927-32; Assistant Professor, 1932-36; Associate Professor, 1936-43; member of the American Physical Society.

His research interests were the Zeeman effect, Paschen Back effect, and fine line structure of spectral lines. He was granted leave of absence for war work at applied physics laboratory at Johns Hopkins University in 1943-5 and at the close of the war resigned his position at The Ohio State University to accept a position at the Naval Ordnance Laboratory (1945).

Harris, James C. was born in Illinois on February 10, 1920; received his BA degree from Rice Institute in 1942, MA in 1944, and Ph. D. in 1948; Assistant Professor, Ohio State University 1950-6; Associate Professor, 1956--; member of the American Physical Society.

His research interest is experimental nuclear physics.

Hausman, Hershel J. was born in Pittsburgh, Pennsylvania on August 19, 1923; received BS & MS from Carnegie Institute of Technology, 1948 & 1949; Univ. of Pit Ph. D., 1952; Instructor, Physics, University of Pittsburgh, 1949-50; Research Associate, 1950-2; Assistant Professor, Ohio State University, 1952-9; Associate Professor, 1959-63; Professor, 1963--; member of the American Physical Society and the Associate of Physics Teachers.

His research interests are nuclear physics, nuclear scattering problems, and cyclotron development.

Heer, Clifford V. was born in Burlington, Ohio on May 31, 1920; received BSc degree from The Ohio State University, 1942; Cattrell Fellow, 1948-9; Ph. D., 1949; Instructor, Ohio State University, 1949-50; Assistant Professor, 1951-6; Associate Professor, 1956-61; Professor 1961--; member of the American Institute of Physics and Fellow of the American Physical Society.

His research interests are low temperature physics, solid state physics, and physics related to space technology.

Heil, Herman G. was born in Chicago, Illinois in 1882; graduated from the University of Chicago with a PhB degree in 1905; Instructor, University of Wisconsin, 1907-9 and Instructor, Ohio State University, 1909-17; Assistant Professor, 1917-44; Associate Professor, 1944-53; Emeritus Associate Professor, 1953-7; member of the American Physical Society.

He studied the elastic indentation of steel balls under pressure and published a paper on the application of the Wynn-Williams bridge valve amplifier to microphotometry and absorption problems.

Herring, David F. was born in Louisville, Kentucky on September 21, 1929; received BS degree from Wake Forrest College in 1951; MS degree from the University of North Carolina in 1953; and Ph. D. degree from the University of Wisconsin in 1957; Assistant Professor, Ohio State University, 1957-62; Associate Professor, 1962-64; member of the American Physical Society.

His research interest was nuclear physics. He resigned in 1964 to take a position with the General Dynamics Corporation.

Hesthal, Cedric E. was born in San Francisco, California on December 13, 1903; received AB degree from Stanford University in 1924 and MA and Ph. D. degrees from Stanford University, 1928-9; Instructor, Ohio State University, 1929-34; Assistant Professor, 1934-44; Associate Professor, 1944-66; Emeritus Associate Professor 1966. He died in 1966. He was a member of the American Physical Society and the American Optical Society.

His research interests were spectroscopy with special interest in the intensity of spectral lines.

Houston, William V. was born in Mt. Gilead, Ohio in January, 1900; graduated from The Ohio State University with both an AB and BS degree in 1920; received MS degree from the University of Chicago in 1922 and Ph. D. degree from The Ohio State University in 1925; Instructor, Ohio State University, 1922-5; member of the American Association for the Advancement of Science and the American Physical Society.

His research interests were spectroscopy and electron theory of solids. He was appointed National Research Fellow, California Institute of Technology in 1925.

Inglis, David R. was born in Detroit, Michigan on October 10, 1905; graduated from Amherst College with AB degree in 1928; received ScD degree from the University of Michigan in 1931; Instructor, Ohio State University, 1931-4; Assistant Professor, 1934; member of the American Physical Society.

His research interest was theoretical physics. He resigned to accept a position at the University of Pittsburgh in 1934.

Jastram, Philip S. was born in Providence, Rhode Island on February 28, 1920; Received BS degree from Harvard University in 1943, Ph. D. from the University of Michigan in 1948; Research Associate, Radio Research Laboratory, Harvard University, 1943-5; Instructor of Physics, University of Michigan, 1947-8; Research Physicist, U.S. Navy Project, 1949; Assistant Professor, Physics, University of Washington (St. Louis), 1949-54; Assistant Professor, Ohio State University, 1955-7; Associate Professor, 1957-64; Professor, 1964--; member of the American Physical Society and the Institute of Radio Engineering.

His research interests are nuclear spectroscopy, angular correlation, fast counting techniques, and nuclear orientation at low temperatures.

Jones, Keith W. was born in Lincoln, Nebraska on August 30, 1928; received AB degree from Princeton University in 1950; MS from the University of Wisconsin in 1951; and Ph. D. in 1954 from the University of Wisconsin; Assistant Professor, Physics, University of North Carolina, 1954-5; Research Associate, Columbia University, 1955-8; Assistant Professor, Ohio State University, 1958-62, Associate Professor, 1962-3; member of the American Physical Society.

His research interest was nuclear spectroscopy. He resigned in 1963 to accept employment at the Brookhaven National Laboratory.

Jossem, E. Leonard was born in Camden, New Jersey on May 19, 1919; received BS degree from the City College of New York in 1938; MS from Cornell University in 1939; and Ph. D. from Cornell University in 1950; Instructor of Physics, Cornell University, 1942-5; Research Assistant, 1946-50; Research Associate, 1950-5; Acting Assistant Professor, 1955-6; Assistant Professor, Ohio State University, 1956-9; Associate Professor, 1959-64; Professor, 1964--; Professor and Chairman, 1967--; member of the American Association forthe Advancement of Science, the American Physical Society and the Association of Physics Teachers.

His research interests are solid state physics, x-ray spectroscopy of solids and nuclear physics.

Kester, Fredric E. was born in Eaton, Ohio in 1873; received ME degree from The Ohio State University in 1895; MA degree from Cornell University in 1905; Assistant, Ohio State University, 1895-8; Instructor, 1901-7; Associate Professor, 1907-9; member of the American Association for the Advancement of Science and the American Physical Society.

His research interests were phosphorescence, grouping of asteroids, and the Joule-Thomson effect in gases. He resigned to accept a position as Professor of Physics and Head of the Department at the University of Kansas.

Knauss, Harold P. was born in Lehigh County, Pennsylvania on July 12, 1900; received BS degree from Muhlenberg College in 1922; MS degree from New York University in 1924; and Ph. D. degree from the University of California in 1928; Instructor of Physics, New York University, 1924-5; Instructor, Ohio State University, 1928-32; Assistant Professor, 1932-46; member of the American Association forthe Advancement of Science and the American Physical Society.

His research interests were band spectra and excitation of molecular spectra in active nitrogen. He was given leave of absence during World War II for research with the Monsanto Chemical Company. He resigned at the close of the war to accept a position as Head of the Department of Physics at the University of Connecticut.

Korringa, Jan was born in Heemsted, Netherlands on March 31, 1915; State University, Leiden, 1939; received DSc degree from the Technical University of Delft in 1942; Assistant and Instructor, Technical University of Delft, 1941-6; Lecturer and Senior Lecturer, State University, Leiden, 1946-53; Associate Professor, Ohio State University, 1953-5; Professor, 1955--; member of the Physical Society, Netherlands.

His research interests are the physics of metals and paramagnetic solids.

Kurbatov, J. D. was born in Russia on August 25, 1894; received Ph. D. degree from the University of Moscow in 1922; Instructor, Moscow Polytechnicum, 1920-2 Assistant Professor, 1922-6; Associate Professor, 1926-30; Assistant Professor of Physics and Astronomy, Ohio State University, 1941-3; Associate Professor, 1943-61; Emeritus Associate Professor, 1961--; member of the American Chemical Society and the American Physical Society.

His research interest is nuclear spectroscopy.

Lande, Alfred was born in Eberfeld, Germany on December 13, 1888; Malburg; Gottingen; received Ph. D. degree from the University of Munich in 1914; Privat-docent, University of Frankfurt, 1920-2; Professor of Physics, University of Tubingen, 1922-31; Professor of Physics, Ohio State University, 1931-60;

Emeritus Professor, 1960--; member of the American Association for the Advancement of Science and of the American Physical Society.

His research interest is theoretical physics including atomic structure and quantum theory, spectral lines, Zeeman effect, muliplet theory, etc. and is the author of several books in his field of scholarship.

Margolis, Bernard was born in Montreal, Canada on August 15, 1926; received BS degree from McGill University in 1947; MSc from McGill University in 1949; and Ph. D. degree from the Massachusetts Institute of Technology in 1952; Instructor of Physics, MIT, 1953-4; Columbia University, 1954-7; Research Physicist, 1957-9; Associate Professor, Ohio State University, 1959-61; member of the American Physical Society.

His research interest was theoretical physics. In 1961 he resigned to accept a position at McGill University.

Mendenhall, Thomas C. was born in Hanoverton, Ohio on October 4, 1841; was educated in the public schools, awarded Honorary Ph. D. degree from The Ohio State University, LLD degree from the University of Michigan, and ScD degree from Rose Polytechnic Institute; Professor of Physics and Mechanics and Head of the Department, Ohio State University, 1873-8; Professor of Physics, Imperial University of Japan, 1878-81; Professor of Physics and Head of the Department, Ohio State University, 1881-4; Professor of Electrical Science in the United States Signal Corps, 1884-6; President, Rose Polytechnic Institute, 1886-9; Superintendent, United States Coast and Geodetic Survey, 1889-94; President, Worcester Polytechnic Institute, 1894-1901; member of several important commissions and the recipient of three medals.

He was also a member of several learned societies and of the Board of Trustees of The Ohio State University from 1919-24. He had wide research interes

Mills, Robert L. was born in Englewood, New Jersey on April 15, 1927; received AB degree from Columbia University in 1948; BA degree from Cambridge University in 1950; MA in 1954; Ph. D. degree from Columbia University in 1955; Fellow of the National Science Foundation, 1952-3; Research Associate, Physics, Brookhaven National Laboratory, 1953-5; studied at Institute for Advanced Study, 1955-6; Assistant Professor, Ohio State University, 1956-9; Associate Professor, 1959-62; Professor, 1962--; member of the American Physical Society.

His research interests are theoretical physics, nuclear physics, and field theory.

Kim, Young Sik was born in Korea on November 15, 1935; received BA degree from Brigham Young University in 1957; Ph.D. degree from Purdue University in 1962; Visiting Assistant Professor, Ohio State University, 1962-3; Assistant Professor 1963-6; Associate Professor 1966--; member of the American Physical Society.

His research interests are experimental high energy physics.

Mate, Charles F. was born in Buffalo, New York on September 14, 1931; received the BA degree from Oxford University in 1955; Ph. D. in 1958 and MA in 1961; Visiting Assistant Professor, The Ohio State University, 1961-3; Assistant Professor, 1963-5; Associate Professor 1965--.

His research interests are low temperature physics; liquid helium.

More, Kenneth R. was born in Vancouver, British Columbia, Canada on January 9, 1910; graduated from the University of British Columbia with an MA degree in 1931; received Ph. D. degree from the University of California in 1934; appointed Royal Society of Canada Fellow, MIT, 1935-6 and Steling Fellow, Yale University, 1936-8; Instructor, Ohio State University, 1938-44; Assistant Professor, 1944-5; member of the American Physical Society.

His research interests were spectroscopy and nuclear moments. He was granted leave of absence for war work atthe Radiation Laboratory at MIT during World War II. At the close of the war, he resigned his position at The Ohio State University to accept a position as research physicist at the Phillips Petroleum Company.

Mulligan, Bernard was born in Montgomery, Alabama on August 31, 1934; he received the BS degree from the University of Alabama in 1956; the Ph. D. degree from the Massachusetts Institute of Technology in 1962; Visiting Assistant Professor, The Ohio State University, 1961-2; Assistant Professor, 1963-6; Associate Professor 1966--.

His research interests are theoretical nuclear physics.

Nelson, Richard Carl was born in Stillwater, Minnesota on May 1, 1915; received AB degree from the University of Minnesota in 1935; Dorr Fellow, 1936-7; received Ph. D. degree from University of Minnesota in 1938; Agent, Tung research, U.S. Department of Agriculture, 1939; Research Fellow, plant physiology, University of Minnesota, 1940-2; Spectroscopist, Armour & Co. 1942-3; Chief Chemist, Citrus Concentrates, Inc., Florida, 1943-4; Manager, Pectin Products Division, 1945-6; Research Associate, Northwestern University, 1946-9; Associate Professor, Ohio State University, 1949-64; Professor, 1964--.

His research interests are photoconductivity, near infrared spectroscopy, ripening process in fruits, citrus processing technology, and mineral nutrition.

Nielsen, Carl E. was born in Los Angeles, California on January 22, 1915; received AB degree from the University of California in 1934, MA degree in 1940, and Ph. D. degree in 1941; Instructor, University of California, 1941-5; Lecturer, 1945-6; Assistant Professor Denver University, 1946-7; Ohio State University, 1947-53; Associate Professor, 1953-64; Professor, 1964--; member of the American Physical Society.

His research interests are cosmic rays, condensation in supersaturated vapor, and cloud chambers.

Nielsen, Harald H. was born in Menomenee, Michigan on January 25, 1903; studied at St. Olaf College from 1923-5; received BS degree from the University of Michigan in 1925, AM degree and Ph. D. degree from the University of Michigan in 1927, 1929, respectively; Assistant, University of Michigan, 1926-7; American Scandinavian Foundation Fellow, Copenhagen, 1929-30; Instructor, Ohio State University, 1930-33; Assistant Professor, 1933-6; Associate Professor, 1936-41, Professor, 1941--; Chairman of the Department of Physics, 1946-67; Science attache, American Embassy, Stockholm, 1952-3; Fullbright Lecturer, University of Paris, 1958-9; served as editor of the Journal of Molecular Spectroscopy; received three medals--Cross of the Order of Leopold, 1953, Medal of the University of Liege, Liege, Belgium, 1949, and Cross of the Order of the Knight of Dannebrog, Denmark, 1957; fellow of the American Physical Society; member of the Liege Royal Society Association of Physics Teachers, and the International Union of Pure and Applied Physics.

He is the author of many scientific papers in the field of experimental and theoretical molecular spectroscopy.

Oetjen, Robert A. was born in Detroit, Michigan on March 31, 1912; received AB degree from Asbury College, 1936; MS degree from University of Michigan, 1938; and Ph. D. degree in 1942; Chemist, Mellon Institute, 1936-7; Physicist, Texas Company, 1941-6; Assistant Professor, Ohio State University, 1946-51; Associate Professor, 1951-7; Professor, 1957--; Assistant Dean of the College of Arts and Sciences, 1957-9; Associate Dean of the College of Arts and Sciences, 1959-67; Chief Scientist, National Science Foundation, American Embassy Tokyo, 1962-64; member of the American Physica Society, American Optical Society and Association of Physics Teachers.

His research interests are infrared spectroscopy and infrared spectra of the isomeric octanes.

Petruzzella, Nicholas was born in Flushing, New York on May 16, 1939; received BS degree from Antioch College, 1960; Ph. D. degree from The Ohio State University, 1964; Senior Physicist, Xerox Corporation, 1965-6; Assistant Professor, Ohio State University Mansfield Branch, 1966-8; Assistant Professor, Ohio State University, 1968--.

His research interests are in solid state physics; biophysics.

Ploughe, William D. was born in Fort Wayne, Indiana on March 30, 1929; received the BS degree from the University of Indiana, 1951; MS, 1953; Ph. D. degree from Purdue University, 1961; Instructor, University of Florida, 1953-6; Assistant Professor, Ohio State University, 1962-6; Associate Professor, 1966--; member of American Physical Society, American Institute of Physics and American Association of Physics Teachers.

His research interests are in low and medium energy nuclear physics.

Pool, Marion L. was born in Bushnell, Ilinois on October 26, 1900; received the BS degree from the University of Chicago in 1924; and the Ph. D. degree in 1927; Assistant in Physics, University of Chicago, 1925-8; Instructor, Ohio State University, 1928-32; Assistant Professor, 1932-6; Associate Professor, 1936-41; Professor, 1941--; Howald Scholarship, University of Michigan, 1936-7; member of the American Association for the Advancement of Science and a Fellow of the American Physical Society; Fellow of the Ohio Academy of Science.

His research interests are metastable states, fluorescent radiation, and nuclear physics.

Prebus, Albert was born in Edmonton, Alberta, Canada on April 19, 1913; received AB degree from University of Alberta in 1935; MS degree from University of Alberta in 1937; Ph. D. degree from the University of Toronto in 1940; Research Fellow, 1939-40, University of Toronto; Fellow, Ohio State University, 1940-1; Assistant Professor, electrical engineering, 1941-5; Associate Professor, 1945-8; member of Technical Staff, Bell Telephone Laboratories, 1948-9; Associate Professor, Ohio State University, 1949-58; Professor, 1958--.

His research interest is electron microscopy.

Rao, K. Narahari was born in Kaveer, India on September 5, 1921; received BSc degree from Andhra University, India in 1941, MSc in 1942, and Ph. D. degree from the University of Chicago in 1949; with the Indian Meteorological Service from 1942-6; Science Officer, National Physics Laboratory, 1950-2; Research Associate, Duke University, 1952-3; Research Associate and Assistant Professor, University of Tennessee, 1953-4; Research Associate, Ohio State University, 1954-60; Associate Professor, 1960-3; Professor, 1963--; member of the Optical Society of America and American Astronomical Society.

His research interests are structure of molecules and high resolution absorption spectra in the infrared.

Reay, Neville W. was born in Los Angeles, California on January 22, 1937; received BS from Occidental College in 1957; Ph. D. degree from the University of Minnesota in 1962; Research Assistant, University of Minnesota, 1957-61; Instructor, University of Rochester, 1961-6; Assistant Professor, Ohio State University, 1966--.

His research interests are experimental high energy physics.

Reibel, Kurt was born in Vienna, Austria on May 23, 1926; received BA degree from Temple University in 1954; MS degree from the University of Pennsylvania in 1956, and the Ph. D. degree from the University of Pennsylvania in 1960; Research Associate, University of Pennsylvania, 1959-61; Assistant Professor, Ohio State University, 1961-4; Associate Professor, 1964--; member of the American Physical Society.

His field of specialization is high energy nuclear physics.

Riley, William R. was born in Bellaire, Ohio on July 31, 1922; received his AB degree from Hiram College in 1944; BSc degree from Ohio State University in 1951, MA and Ph. D. degrees from Ohio State University in 1952 and 1959, respectively; Instructor, mathematics and physics, Hiram College, 1946-8; Instructor, Physics, Ohio State University, 1951-9; Assistant Professor, 1959-64; Associate Professor, 1964--; member of the American Association for the Advancement of Science, Teachers Association, and the Association of Physics Teachers.

His research interest is science education.

Robinson, Howard A. was born in Rotterdam, New York on July 30, 1909; graduated from MIT with BS degree in 1930; received Ph. D. degree from MIT in 1935; American-German Exchange student, Munich, 1930-1 and Teaching Fellow, MIT, 1932-5; Irving Langmeiur Fellow, American-Scandinavian Foundation, Uppsula, 1935-6; Instructor of physics, Ohio State University, 1936-7; Fellow of the American Physical Society and member of the American Association for the Advancement of Science.

He research interest was spectroscopy. He resigned in 1937 to accept a position as research physicist at the Armstrong Cork Company.

Robinson, Stillman W. was born in South Reading, Vermont in 1838; graduated from the University of Michigan with CE degree in 1863; awarded Honorary DSc degree from The Ohio State University in 1896; Assistant Engineer, U.S. Lake Survey, 1863-66; Assistant Professor of Mechanical Engineering and Geodesy, University of Michigan, 1866-70; Professor of Mechanical Engineering and Physics, Illinois Industrial University (now University of Illinois), 1870-8; Professor of Mechanical Engineering and Physics, Ohio State University, 1878-81;

Professor of Mechanical Engineering, 1881-95; member of the American Society of Mechanical Engineers, the American Society of Civil Engineers, American Society for the Advancement of Science, and the Society of Naval Architects and Marine Engineers.

He held forty patents and was responsible for fifty inventions. In 1881 he became Head of the Department of Mechanical Engineering at The Ohio State University and ceased to be a member of the Physics Department.

Romanowski, Thomas A. was born in Warsaw, Poland on April 17, 1925; received the BS degree from the Massachusetts Institute of Technology in 1952; and the MS and Ph. D. degrees from Case Institute of Technology, 1955 and 1957, respectively; Research Physicist, Carnegie Institute of Technology, 1956-60; Physicist, Argonne National Laboratory, 1960--; Professor (part-time), Ohio State University, 1964--; member of the American Physical Society.

His research interest is in high energy physics.

Sanderson, Richard B. was born in Waltham, Massachusetts on July 20, 1935; received BS degree from Massachusetts Institute of Technology, 1957; MS and Ph. D. degrees from Syracuse University in 1959 and 1963, respectively; Research Associate and Visiting Assistant Professor, The Ohio State University, 1962-65; Assistant Professor, 1965--; Member of the Optical Society of America.

His research interest is infrared and molecular physics.

Sarwinski, Raymond E. was born in LaSalle, Illinois on January 11, 1936; received the BA, MA and Ph.D. degrees from the University of Illinois in 1960, 1961 and 1966 respectively; Visiting Research Associate, Ohio State University, 1966-7; Assistant Professor, 1967--; member of American Physical Sc

His research interest is low temperature physics; liquid helium.

Sessler, Andrew M. was born in Brooklyn, New York on December 11, 1928; received BA degree from Harvard University in 1949; MS degree from Columbia University in 1951 and Ph. D. degree from Columbia in 1953; Fellow of the National Science Foundation, Columbia University, 1952-3 and Cornell University, 1953-4; Assistant Professor, Ohio State University, 1954-61; member of the American Physical Society.

His research interest was theoretical physics such as the structure of atoms and nuclear physics. In 1961 he resigned to accept a position at the University of California.

Seyler, Richard G. was born in DuBois, Pennsylvania on June 14, 1933; received the BS, MS and Ph. D. degrees from Pennsylvania State University in 1955, 1959 and 1961, respectively; Visiting Assistant Professor, Ohio State University 1961-3; Assistant Professor, 1963-6; Associate Professor, 1966--; member of the American Physical Society.

His research interest is theoretical nuclear physics.

Shaffer, Wave H. was born in Wasseon, Ohio on May 23, 1909; received AB degree from Hiram College in 1933, MA from Ohio State University in 1936 and Ph. D. from Ohio State University in 1939; National Research Council Fellowship, University of Chicago, 1939-40; Instructor in Physics, Ohio State University, 1940-2; Assistant Professor, 1942-6; Associate Professor, 1946-50; Professor, 1950--; Leave of Absence, research physicist, Johns Hopkins University, 1945; member of the American Physical Society, the Ohio Academy of Science, and the American Association for Physics Teachers.

His research interest is theoretical physics, primarily molecular spectra and structure of molecules.

Shaw, Charles H. was born in Los Angeles, California on January 26, 1908; received AB degree from the University of California at Los Angeles in 1930 and Ph. D. degree from Johns Hopkins University in 1933; National Research Fellow, Cornell, 1934-6; Fellow of the American Philosophical Society, Johns Hopkins University, 1936-8; Instructor, Johns Hopkins University, 1938-42; Assistant Professor, 1942-6; Associate Professor, Ohio State University, 1946-54; Professor, 1954-67 (deceased); Research Physicist, Johns Hopkins University, Applied Physics Laboratory, 1942-46; civilian with Office of Science, Research and Development, United States Navy, 1944; member of the American Physical Society and the Association of Physics Teachers.

His research interests were x-ray lines and absorption edges, electronic band structure, industrial radiography, x-ray satellites, electron scattering in gases, and x-ray scattering at low temperatures.

Shaw, John H. was born in Sheffield, England on January 25, 1925; received his BA degree from Cambridge University in 1946; MA in 1950, Ph. D. in 1951; Research Associate, The Ohio State University, 1949-56; Assistant Professor, 1955-8; Associate Professor, 1958-64; Professor, 1964--; member of the American Physical Society and the Royal Meteorological Society.

His research interests are infrared spectroscopy and infrared study of atmospheric gaseous constituents.

Sheard, Charles was born in Dolgeville, New York on May 26, 1883; graduated from St. Lawrence University in 1903 with AB degree, received AM degree from Dartmouth College in 1907 and Ph. D. degree from Princeton University in 1912; Instructor, Ohio State University, 1907-9; Assistant Professor, 1909-13; Professor of Physics and Applied Optics, 1914-9; member of the American Association for the Advancement of Science, the American Optical Society, and the American Physical Society.

His research interest was physiological optics. In 1919 he resigned to accept a position with the American Optical Company.

Shortley, George H. was born in Minneapolis, Minnesota on March 3, 1910; received BEE degree from the University of Minnesota in 1930, AM degree from Princeton University in 1932, and Ph. D. degree from Princeton University in 1933; Gordon MacDonald Fellow, Princeton University, 1931-2; Jacobus Fellow, Princeton University, 1932-3; National Research Fellow, MIT and Harvard University, 1933-5; Instructor, Ohio State University, 1935-7; Assistant Professor, 1937-42; Leave of Absence for war research, 1942; Professor, Ohio State University, 1946-51; member of the American Physical Society and the American Astronomical Society.

His research interests were theoretical physics, quantum mechanics, and theoretical spectroscopy. In 1951 he resigned to accept a position with a government agency.

Smith, Alpheus W. was born in Philippi, West Virginia in 1876; graduated from West Virginia University with AB degree in 1900; received AM degree from Harvard University in 1903 and Ph. D. from Harvard in 1906; awarded honorary DSc from Ohio Wesleyan University in 1942, DSc from Capital University in 1950, and LLD from The Ohio State University in 1946; Instructor in Physics, Bowdoin College, 1906; Instructor, Haverford College, 1906-7; Instructor, University of Wisconsin, 1907-9; Assistant Professor, Ohio State University, 1909-17; Professor, 1917-46; Chairman of the Department, 1926-46; Dean of the Graduate School, 1939-46; Professor Emeritus and Dean Emeritus, 1946-1968 (deceased); President of the Research Foundation, Ohio State University, 1946-58; awarded the Distinguished Service Citation, Ohio State University, 1956; and in 1958 the Air Force Medal for Exceptional Civilian Service; Fellow of the American Physical Society and of the American Association for the Advancement of Science, member of the American Association of Physics Teachers.

His research interests were galvanomagnetic and thermomagnetic effects in metals and alloys and their relation to electro and thermal conductivity.

Smith, Alva W. was born in Fayette, Ohio on August 26, 1885; graduated from The Ohio State University with AB degree in 1912; received AM degree and Ph. D. degree from Ohio State University in 1914, and 1921, respectively; Instructor, Ohio State University, 1915-21; Assistant Professor, 1921-30; Associate Professor, 1930-40; Professor, 1940-8; Bureau of Standards, 1923; member of the American Association for the Advancement of Science and the American Physical Society.

His research interests were magnetization at high frequencies, electrical measurements, and supersonics.

Stanton, Noel R. was born in Dover,New Jersey on December 29, 1937; graduated from Rutgers University with a BS in 1960; Ph. D. Cornell University, 1965; Research Associate, University of Michigan, 1965-8; Assistant Professor, Ohio State University, 1968--; member of the American Physical Society.

His research interests are experimental high energy physics.

Sung, C. C. was born in Nanking, China on March 15, 1936; Received BS degree from the National Taiwan University in 1957; Ph. D. degree from the University of California in 1965; Research Associate, Ohio State University, 1965-68; Assistant Professor, 1968--.

His research interests are theoretical solid state physics.

Tanaka, Katsumi was born in San Francisco, California on March 1, 1925; received BA degree from the University of California in 1949 and Ph. D. in 1952; Associate Physicist, Argonne National Laboratory, 1952-64; Professor, Ohio State University, 1964-- ; member of the American Physical Society.

His research interests are theoretical high energy physics.

Thomas, Benjamin F. was born at Polymyra, Ohio on October 14, 1858; graduated from Ripon College in 1874 with BSc degree; received MS degree from Ripon College in 1877 and Ph. D. degree from Stevens Institute of Technology in 1880; Instructor of Mathematics and Physics, Carleton College, 1876-9; Research Assistant, Stevens Institute of Technology, 1879-80; Professor of Physics, University of Missouri, 1880-5; Professor of Physics and Head of the Department of Physics, Ohio State University, 1885-1908; Professor, 1908-11; Fellow of the American Association for the Advancement of Science, member of the American Physical Society.

His research interests were rapidly varying phenomena in electric circuits, photometric standards, and photometry of arc and incandescent lights.

Thomas, L. H. was born in London, England on October 21, 1930; received BA degree and Ph. D. degree from Cambridge University in 1924 and 1927, respectively; Issac Newton Student, 1925-8; studied at University of Copenhagen, 1925-6; Assistant Professor, Ohio State University, 1929-30; Associate Professor, 1930-6; Professor, 1936-46; leave of absence for war work at Aberdeen Proving Grounds, 1943-5; member of the American Association for the Advancement of Science, the Royal Astronomical Society, and the Cambridge Philosophical Society.

His research interests were theoretical physics, astrophysics, and dynamics of quantum mechanics. In 1946 he resigned to accept a position at Watson Laboratory (IBM) as research physicist.

Torgerson, Ronald was born in Minneapolis, Minnesota on September 20, 1936; received BS degree from College of St. Thomas in 1958; MS and Ph. D. degrees from the University of Chicago, 1965; Instructor, University of Notre Dame, 1965-68; Assistant Professor, Ohio State University, 1968--; member of the American Physical Society.

His research interests are theoretical high energy physics.

Tough, James T. was born in Chicago, Illinois on May 4, 1938; received BS degree from the University of Illinois, 1960; Ph. D. degree from the University of Washington, 1964; Research Associate, Ohio State University, 1964-5; Assistant Professor, 1965-8; Associate Professor, 1968--; member of the American Physical Society.

His research interests are experimental low temperature physics, liquid helium.

Wada, Walter W. was born in Loomis, California on February 26, 1919; received BA degree from the University of Utah, 1943; MA and Ph. D. from the University of Michigan in 1946 and 1951, respectively; Physicist, U. S. Naval Research Laboratory, 1951-5; Visiting Physicist, Brookhaven National Laboratory, 1955-6; Physicist, Naval Research Laboratory, 1956-62; Visiting Professor, Physics, Northwestern University, 1962-4; Professor, Ohio State University, 1964--; member of the American Physical Society.

His research interests are experimental high energy physics.

Wigen, Philip E. was born in LaCrosse, Washington, on May 11, 1933; received BA degree from Pacific Lutheran College in 1955; Ph. D. degree from Michigan State University in 1960; Research Scientist, Lockheed Research Laboratories, 1960-65; Associate Professor, Ohio State University, 1965--; member of the American Physical Society.

His research interests are experimental solid state physics; magnetic resonance physics.

Williams, Dudley was born in Covington, Georgia on April 12, 1912; received AB, MA, and Ph. D. degrees from the University of North Carolina in 1933, 1934, and 1936, respectively; Instructor in Physics, University of Florida, 1936-8; Assistant Professor, 1938-41; Staff Member, Radiation Laboratory, MIT, 1941-3; Assistant Professor, University of Oklahoma, 1943-4; Staff Member, Los Alamos Science Laboratory, California, 1944-6; Associate Professor, Ohio State University, 1946-50; Professor, 1950-63; Acting Chairman of the Department, 1952-3; Civilian Scientist, Office of Science, Research, and Development, 1941-3; Manhattan District Engineers, 1944-6; Fellow of the American Physical Society.

His research interests were infrared spectroscopy, microwave transmission, mass spectroscopy, nuclear physics, microwave absorption in gases, determination of nuclear magnetic moments, and atmospheric physics. He resigned in 1963 to accept the position of Professor and Head of the Department of Physics at the North Carolina State University.

Yang, Chen-Ping was born in Peiping, China on November 17, 1930; received BS degree from Brown University in 1952; MS from Harvard University in 1953; and Ph. D. degree from Johns Hopkins University in 1961; Assistant Professor, Ohio State University, 1961-4; Associate Professor, 1964--.

His research interests are in the field of solid state physics.

Yaqub, Mohammed was born in Lahore, Pakistan on June 16, 1924; received the MSc degree from Punjab University in 1948; BA degree from Cambridge University in 1952; MA from Oxford University in 1956; Ph. D. degree from Oxford University in 1957; Postdoctoral Fellow, London University, 1957-8; Research Associate, Washington University, 1959-61; Research Physicist, MIT, 1961-3; Research Associate, Ohio State University, 1963-5; Associate Professor, 1965-8; Professor, 1968--.

His research interests are experimental solid state physics; superconductivity.

Zumstein, Robert V. was born in Wellandpost, Ontario, Canada on December 26, 1896; graduated from the University of Toronto with a BA degree in 1917 and MA degree in 1918; received Ph. D. degree from the University of Iowa in 1924; National Research Council Fellow, University of Michigan, 1924-5; Instructor, University of Iowa, 1920-3; Instructor, Ohio State University, 1927-32; Assistant Professor, 1932-6; Associate Professor, 1936-67; Associate Professor Emeritus, 1967 (deceased); member of the American Physical Society.

His research interest was x-rays and the absorption spectra of metallic vapors and hydrides.

Zych, Dale was born in Cleveland, Ohio on April 8, 1938; received BS degree from Case Institute of Technology in 1961; MS degree from Ohio State University in 1963 and Ph. D. degree from Case Institute of Technology in 1967; Postdoctoral Research Assistant, Ohio State University, 1967-8; Assistant Professor, 1968--; member of the American Physical Society.

His research interests are experimental solid state physics; superconductivity.

Astronomy

Bobrovnikoff, Nicholas Theodore was born in Russia on April 29, 1896; studied at Petrograd, 1914-17, at Kharkov, 1917-8, and at Prague, 1921-4; received Ph. D. in Astronomy from the University of Chicago in 1927; Kellogg fellow, Lick Observatory, California, 1927-9, National Research Fellow, physics, 1929-30; Assistant Professor in Astrophysics, Ohio Wesleyan, 1930-4, Associate Professor of Astronomy, 1935-45; Acting Director of Perkins Observatory, 1934-7; Director of Perkins Observatory, 1947-51; Professor of Astronomy, 1945--; member of American Association for the Advancement of Science, American Astronomical Society, and History of Science Society.

His fields of research interest are theory of comets and physical properties of comets.

Bonsack, Walter was born in Cleveland, Ohio on April 14, 1932; received his BS degree from the Case Institute of Technology, 1954; Van Maanen fellow, California Institute of Technology, 1957-8; Ph. D., 1959; Research fellow, Astronomy, California Institute of Technology, 1958-60; Assistant Professor, The Ohio State University, 1960--; member of the American Association for the Advancement of Science, American Astronomical Society.

His research interests are chemical composition and physical condition of stellar atmospheres and stellar spectroscopy.

Cherrington, Ernest H., Jr. was born in Westerville, Ohio on September 10, 1909; received AB degree from Ohio Wesleyan University in 1931 and MS in 1932; received Ph. D. degree (astrophysics) from the University of California in 1935; fellow of Perkins Observatory, 1931-2; fellow, Lick Observatory, 1932-5; Instructor of Math and Astronomy, University of Syracuse, 1935-6; Assistant Astronomer, Perkins Observatory, 1936-46; Instructor Ohio State University and Ohio Wesleyan University, 1936-40; Assistant Professor, 1940-6.

In 1946 he resigned to accept a position as Assistant Dean at the University of Akron.

Hynek, J. Allen was born in Chicago, Illinois on May 1, 1910; received BS degree from the University of Chicago, 1934 and Ph. D. in astrophysics, 1935; Instructor 1935-41; Assistant Professor, 1941-6, Associate Professor, 1946-50; Professor, 1950-6; on leave as director of Smithsonian Astrophysics Observatory, 1956-60; Assistant Dean of the Graduate School, 1950-3; on leave for war work, applied physics laboratory, Johns Hopkins University, 1942-6; member of the American Association for the Advancement of Science and the American Astronomical Society.

His research interests were stellar spectroscopy and F type stars. In 1960 he resigned to accept directorship of the Northwestern University Astronomical Observatory.

Keller, Geoffrey was born in New York City, New York on June 12, 1918; received BS degree from Swarthmore College, 1938; Ph. D. degree in astronomy from Columbia University, 1948; Associate Physicist, Bureau of Ordnance, Navy Department, 1941-5; Instructor, 1948-9; Assistant Professor, 1949-52; Associate Professor, 1952-9; Director of Perkins Observatory, 1953-9; member of the American Astronomical Society and the American Physical Society.

His research interests were internal constitution of stars, stellar photometry, spectroscopy, and dynamics. In 1957 he resigned to accept a position with the National Science Foundation.

Keenan, Phillip was born in Wilkes-Barre, Pennsylvania on August 24, 1900; received BS degree from University of Arizona, 1929; MS, 1930; Ph. D., University of Chicago, 1932; Assistant Astronomer, Yerkes Observatory, 1929-35; Instructor, Perkins Observatory, 1935-6; Yerkes Observatory, 1936-42; Physicist, Bureau of Ordnance, U.S. Navy Department, 1942-6; Assistant Professor, Perkins Observatory, 1946-8; Associate Professor, 1948-62; Professor, 1962; member of the American Astronomical Society; fellow of the Royal Astronomical Society.

His research interests are stellar spectroscopy and spectral classification.

Kraus, John D. was born on June 28, 1910 in Ann Arbor, Michigan; received BS degree, MS degree, and Ph. D. degree from the University of Michigan in 1930, 1931, and 1933, respectively; Research Associate, Department of Engineering Research, 1934-5; Research Physicist, Department of Physics, 1936-7; Physicist, Naval Ordnance Laboratory, 1940-3; Research Associate, Radio Research Laboratory Harvard University, 1943-6; Associate Professor, Electrical Engineering, The Ohio State University, 1946-9; Professor, 1949--; Director of the Radio Observatory, 1952--; member of the American Physical Society, the American Astronomical Society, and the Institute of Radio Engineers.

His research interests are electromagnetic theory, antennas, and radio astronomy.

Lord, Henry G. was born in Cincinnati, Ohio on April 17, 1866; received BSc degree from University of Wisconsin in 1889; Student Assistant, Washburn Observatory, 1887-9; with Thomson-Houston Electric Company 1889-91; Assistant in mathematics and astronomy at The Ohio State University, 1891-5; Associate Professor of Astronomy and Director of Emerson McMillin Observatory 1895-1900; Professor of Astronomy and Director of Emerson McMillin Observatory, 1900-23; member of Astronomy and Astrophysics Society, American Physical Society, Optical Society; fellow of Royal Astronomical Society.

His research interest was stellar motion in the line of sight.

Mansen, Edmund S. Jr. was born in Scituate, Massachusetts on December 1, 1875; received BS degree from MIT, 1897; MS in 1898; Computer, Lowell Observatory, 1899-1901; Assistant at Harvard College Observatory, 1902-7; Instru in Astronomy at Ohio State University, 1907-8; Assistant Professor, 1908-9; Associate Professor, 1902-23; Professor of Astronomy and Director of Emerson McMillin Observatory 1923-46; member of the Astronomy and Astrophysics society; fellow of Royal Astronomical society.

His research interest was measurements of positions of asteroids.

Menzel, Donald H. was born in Florence, Colorado on April 11, 1901; received AB degree from the University of Denver in 1920; AM degree in 1921; and AM and Ph. D. degrees from Princeton University in 1923-24, respectively; Instructor in Mathematics, University of Denver, 1919-21; Assistant in Astronomy, Princeton Fellow, 1921-2; Thaw Fellow, 1922-23; Proctor fellow, 1923-4; summer assistant at Harvard College Observatory, 1924; Instructor in Astronomy University of Indiana, 1924-5; Assistant Professor, Ohio State University, 1925-6.

His resignation in 1924 was for the purpose of accepting a position of astronomer at Lick Observatory. His research interest was astrophysics.

Mitchell, Walter, Jr. was born in Franklin, Massachusetts on November 16, 1925; received BS degree from Tufts University in 1949; MS degree from the University of Virginia in 1951, and Ph. D. degree from the University of Michigan in 1958; Assistant Astronomer, University of Michigan Observatory, 1951-2; Observer, Infrared Project, Mt. Wilson Observatory, 1953-55; Visiting Assistant Professor, Brown University, 1956-7; Instructor, The Ohio State University, 1957-8; Assistant Professor, 1958--.

Slettebak, Arne E. was born in Danzig, Poland on August 8, 1925. Received BS degree from the University of Chicago in 1945, Ph. D. in 1949; Instructor, University of Chicago in 1946-50; Assistant Professor, 1950-8; Associate Professor 1958-9 Professor and Director of Perkins and McMillin Observatories, 1959--; member of the International Astronomical Union and the American Astronomical Society.

His research interests are stellar spectroscopy, stellar axial rotation, and spectroscopic investigations of peculiar stars.

Optometry

Allen, M. J. was born in San Antonio, Texas, on August 2, 1918; received MSc from The Ohio State University in 1942 and Ph. D. in 1949; Assistant Professor, The Ohio State University, 1949-53.

His research interests were objective measurement of accommodation, eye movement, and pupillary responses. He resigned to accept a position at Indiana University.

Bridgeman, Charles S. was born on January 24, 1913 in Rochester, New York; He received AB degree from Union College in 1934; MS degree from Brown University in 1935, and Ph. D. degree (psychology) from Rochester University in 1938; Instructor, The Ohio State University, 1938-43; Assistant Professor, 1943-6; Associate Professor, 1946-8; fellow of the Psychological Society and the American Academy of Optometry.

His research interest was physiological optics.

Ellerbrock, Vincent J. was born in Delphos, Ohio on March 13, 1918; received the BSc degree from The Ohio State University in 1940, MSc degree in 1941, and Ph. D. in 1947; fellow, Dartmouth College, 1944-6; Assistant Professor, The Ohio State University, 1948-51, Associate Professor, 1951-7; Professor, 1957--; member of the American Academy of Optometry.

His research interests were fusional movements of the eyes and biophysics.

Fry, Glenn A. was born in Wellford, South Carolina on September 10, 1908; received the AB degree from Davidson College in 1929, MA degree from Duke University in 1931, and Ph. D. degree (psychology) from Duke University in 1932; National Research Fellow, Washington University, St. Louis, 1932-4; Assistant Professor, The Ohio State University, 1935-42; Associate Professor, 1942-6; Professor and Director of the School of Optometry from 1946--; member of the International Society Color Council, 1945; Vision Committee, Armed Forces National Research Council, The American Optical Society, the Illuminating Engineering Society, and the American Optometry Association; fellow of the American Academy of Optometry and the British Optical Association.

His research interests are electrophysiology of the retina, color vision, visual acuity, accommodation, and convergence.

Haines, Howard received the BSc degree (Business Administration) from The Ohio State University in 1923 and the BSc degree in Applied Optics from The Ohio State University in 1932; received MSc degree, The Ohio State University, 1938; Practicing Optometrist and part-time instructor.

Hoffstettler, Henry W. was born in Windsor, Ohio on September 10, 1914; received BS degree from The Ohio State University in 1939, MSc in 1940, and Ph. D. in 1942; received Honorary DOS from Los Angeles College of Optometry in 1954; Instructor, The Ohio State University, 1942-5; Assistant Professor, 1945-8; Associate Professor, 1948-9, resigned to accept Deanship at Los Angeles College of Optometry; member of the Advisory Research Council of the American Optometry Foundation, American Optical Society, American Optometry Association; Fellow of the American Academy of Optometry.

His research interest is physiological optics.

Knox, George W. was born in St. Louis, Missouri on April 16, 1911; received BA degree from Denison University in 1933; MA degree from The Ohio State University in 1936 and Ph. D. degree (psychology) 1940; Research Associate Psychiatrist, Billings Hospital, Chicago, Illinois, 1941-2; Assistant Professor The Ohio State University, 1947-53; Associate Professor, 1953--; member of the American Psychologist's Association and the American Academy of Optometry.

His research interests are vision, optometry, and psychology.

Mote, Herbert received his BSc degree(Business Administration) at the University of Akron, 1928; BSc degree (applied optics) The Ohio State University, 1935; MSc degree from The Ohio State University in 1938; Practicing Optometrist and part-time instructor.

Paul, Frederick W. was born in Seattle, Washington on June 5, 1911; received the AB degree from Willamette College in 1933; MS degree from MIT in 1935 and Ph. D. degree in 1937; BSc degree from The Ohio State University in 1940; Instructor, The Ohio State University, 1937-40; resigned to accept a position at the University of Rochester; member of the American Physical Society and the American Optical Society.

His research interest was spectroscopy and related subjects.

Reese, Ellsworth received the BSc degree from The Ohio State University in 1929 and MS in 1939; Practicing Optometrist and part-time instructor.

Stewart, C. R. was born in Oklahoma City on October 20, 1918; received the MSc degree from The Ohio State University in 1950 and Ph. D. in 1951; Assistant Professor, The Ohio State University, 1951-2; resigned to accept position in the School of Optometry in the University of Houston.

His research interests were the fusional movements of the eyes and screening school children for visual defects.

Zinnecker, K. S. received the MSc degree from The Ohio State University in 1952; Practicing Optometrist and part-time instructor.

LIST OF DOCTORAL DISSERTATIONS AND AUTHORS

The following list records the titles, the authors, and the place of publication of the dissertations in physics, astronomy, and physiological optics since 1920, the date at which the first Ph. D. degree in physics was conferred.

1920

GEORGE, ENOCH F. The absorption of light by solutions of inorganic salts.

1921

SMITH, ALVA W. (a) Measurement of inductance and capacity by an electrometer method. (b) The effect of a superposed constant magnetic field upon the alternating current permeability and energy losses in iron.

1922

BROWN, WILLIAM B. Thermal conductivity of metals in the solid and liquid state.

1923

LOWRY, ERWIN P. The absorption spectrum of carbon monoxide.

1924

PHEBUS, WILLIAM C. The x-ray analysis of certain alloys.

1925

HOUSTON, WILLIAM V. The structure of the red line of hydrogen and the interpretation of doublets in other elements.

1926

JARVIS, CHARLES W. Ionization and resonance potentials in gallium, indium and mercury.

1927

FUJIMOTO, TADASHI. Determination of the Piezo-electric constant of a quartz resonator at high frequency.

1928

SAPPENFIELD, JAMES W. Absorption spectra of organic liquids in the near infrared.

SERVICE, JERRY H. The transmission of sound through sea water.

SNYDER, RUFUS H. The stark effect of several elements.

WILSON, EARL D. Molecule absorption spectra of OH, CS_2 and ICL.

1929

None.

1930

HUBER, PAUL L. The spectrum of diatomic sulfur.

NORRIS, CHARLES S. The Raman spectra of certain organic liquids.

PYLE, W. R. Dielectric constant of certain organic liquids at medium frequency.

ROSSELOT, GERALD A. Line intensity measurement and the influence of optical excitation on transitions involving the 2^3P_o level of mercury.

1931

HEIL, LOUIS M. The determination of the total electric polarization and the electric moments of certain organic molecules.

HIGH, M. E. Raman effect in certain organic compounds.

KNORR, HARRY V. Photometric study of the appearance of spectra lines in a condensed spark.

MEARA, F. L. Magnetic susceptibility of some binary alloys.

PATTY, JOHN R. Absorption in the infrared by formaldehyde vapor.

ROTH, HERMAN. A slowly contracting and expanding sphere and its stability.

1932

AMOS, CARROLL ELY. Application of integral equations to potential and diffraction problems.

GRAY, DWIGHT E. The Paschen-Bach effect in the Zn Triplet 2p-3d.

LORING, RALPH A. The Zeeman effect of Lead II, Lead III and Lead IV.

1933

EVERITT, WILLIAM LITTELL. The calculation and design of alternating current networks employing triodes operating during a fraction of a cycle.

FORD, EARL WILLIAM. The crystal structure of fayalite.

1934

ALLEN, JOHN STANLEY VALENTINE. Intensity relations in the chromium spectrum.

BARROWS, WILLIAM MORTON. Zeeman effect in the spectrum of arsenic.

SHEARIN, PAUL EDMUNDSON. The infrared absorption spectra of solid hydrogen chloride.

1935

SHAWHAN, ELBERT NEIL. Band spectra of diatomic lead and tin sulphide.

STEWARD, WENDELL BELDING. The infrared absorption spectrum of silane.

1936

FRALISH, HOWARD JOSEPH. The thermal conductivity of refractory materials of high temperature.

MORGAN, FRANK. The absorption spectra of the diatomic halides of bismuth, lead and magnesium.

SPRAGUE, AUSTIN D. The fine structure of the infrared spectrum of hydrogen sulfide.

WHITMER, CHARLES AUSTIN. Nuclear studies with a lithium ion source.

1937

BUNDY, FRANCIS P. An attempt to observe a visible spectrum of double excited helium. Part II. A determination of the excitation functions of the auroral bands of nitrogen and the comet tail bands of carbon monoxide when excited by electron impact.

JORDAN, WALTER EDWIN. Nuclear transmutations by low energy particles.

MAXWELL, HOWARD NICHOLAS. The Zeeman effect of gold and of singly ionized nitrogen.

SEARS, WILLIAM C. The infrared absorption spectrum of the deuterium selenides.

STANLEY, PAUL ELWOOD. The determination of the crystalline structure of some of the spinels and certain spinel solid solutions.

STRONG, HERBERT M. A study of the spectrum of carbon dioxide as excited by the electrodeless ring discharge.

1938

CAMPBELL, EDWARD CHARLES. A numerical method of obtaining the lowest characteristic value of the problem of three bodies in quantum mechanics for an attractive force of small range.

PEOPLES, JAMES ALEXANDER, JR. The Zeeman effect and the Paschen-Bach effect of neon.

HARRINGTON, ROBERT ASHLEY. An electron diffraction study of artificially formed oxide films on certain metals.

1939

FRIED, BERNARD. Zeeman effect in the spectrum of argon.

RENSE, WILLIAM ALFONZO. The spectra of Yttrium V and Zirconium VI.

SHAFFER, WAVE HENRY. The rotation-vibration energy states of certain polyatomic molecules.

STINCHCOMB, GEORGE ALFRED. The infrared absorption spectrum of pentane.

WELLER, ROYAL. Contributions to the photoelastic method of stress analysis.

WHITCOMB, STUART ESTES. The normal vibrations of the paraffin hydrocarbons and the infrared spectrum of undecane.

1940

BOWMAN, DONALD WHITNEY. The Zeeman effect and Paschen-Bach effect of krypton.

DOOLEY, DONALD. The infrared absorption spectrum of methane at low temperature.

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