IOWA STATE COLLEGE

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INSTITUTE FOR ATOMIC RESEARCH

Including the Ames Laboratory of the Atomic Energy Commission — Ames, Iowa www.smecc.org

THE IOWA STATE COLLEGE

INSTITUTE FOR ATOMIC RESEARCH

SCIENCE · · · WITH · · · PRACTICE

Including the Ames Laboratory of the Atomic Energy Commission ··· Ames, Iowa

Director

Frank H. Spedding

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Boyne H. Platt
J. F. Downie Smith
Frank H. Spedding

President of Iowa State College

Charles E. Friley

Research staff.

Administrative and service staff.

Contents

Opportunities and Appointments For Graduate Students in the Iowa State College Institute for Atomic Research

Positions are available, both on the graduate and post-doctorate level, for fundamental research in the various fields involved in or associated with atomic research. Graduate students are eligible for part-time appointments in the Institute. The formal course work is given and the advanced degrees are awarded by the various departments and divisions of the College. Full-time appointments as Junior Scientists are also available to college graduates. Information concerning these appointments can be obtained by writing to: Director, Iowa State College Institute for Atomic Research, Ames, Iowa.

Purposes of the Iowa State College Institute for Atomic Research

Basic research in atomic structure has amply demonstrated during the past 40 years that nuclear reactions and the by-products from them can be applied as powerful research tools in many sciences in addition to physics and chemistry. Unfortunately until recently it has been extremely expensive to bring about nuclear reactions, even for minute amounts of materials, and it has been very difficult to obtain any of the by-products in appreciable amounts. For these reasons, the application of these tools to the other sciences has been limited. However, due to the large amount of atomic research initiated during World War II, ways have been found to liberate atomic energy in large amounts under controlled conditions and to transmute the elements in considerable quantity. Now "tagged" atoms (atoms of the same chemical properties but of different masses, or atoms which have been made radioactive) are available in reasonable amounts and at nominal cost to any research worker who possesses the specialized knowledge necessary to use them safely and economically. These "tagged" atoms enable scientists to follow a given molecule through any series of chemical reactions including those which take place in living matter. "Tagged" atoms give the chemist, physicist, biologist and medical and agricultural research workers a tool which in the future will be just as necessary to them as the microscope has been in the past.

The discovery of methods for liberating atomic energy in a controlled manner gives to the engineer a new source of energy which should play an important role in our future economy and which has led to the development of a new branch of engineering, namely nuclear engineering.

Furthermore, radiations (such as X- and γ-rays, electrons, neutrons and heavy particles of high intensity) make possible large-scale photochemical and radiation reactions which have not been feasible in the past. These radiations are being widely applied in many branches of biology including medicine, both

human and veterinary, and in the field of genetics as applied to animal and plant breeding.

Finally, the necessity of developing special materials needed for large-scale nuclear reactions—for example, high-temperature ceramics, special alloys and very pure chemicals—has stimulated research in many of the lesser known fields of physics and chemistry. Both the information obtained and the special materials developed are finding wide use in our peacetime economy.

Iowa State College played a leading part during the war in the basic research which resulted in the large-scale release of atomic energy. The Iowa State Board of Education felt that the College should maintain this leadership after the war. Therefore, on November 1, 1945, President Charles E. Friley was authorized to establish the Iowa State College Institute for Atomic Research. The Institute was set up as a separate budgetary division of the College and operates in a manner similar to the graduate school and experiment stations. It is thus able to conduct joint research programs on the basis of voluntary cooperation and agreement with the various deans and department heads.

The purposes of the Iowa State College Institute for Atomic Research are:

(1) To build up and maintain a strong group of scientists working in the fundamental sciences which apply to nuclear processes and to develop those phases of physics, chemistry, metallurgy, engineering and biology which are naturally associated with these fields.

(2) To have available on the campus a group of experts in these newer developments so that other members of the faculty can consult them concerning the application of these new tools to their own problems.

(3) To encourage cooperation and coordination in this type of research work on the campus on a voluntary basis. Particular emphasis will be placed on borderline problems between the several sciences in which expert advice is needed from several different fields of science.

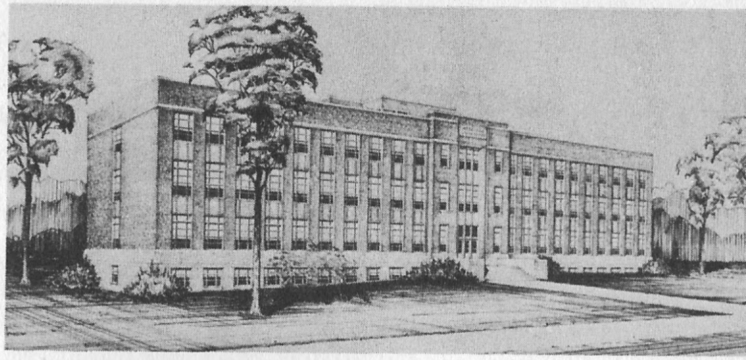
(4) To train graduate students in the science and techniques required in the field of atomic energy. By participating in the various research programs of the Iowa State College Institute for Atomic Research, they will gain the specialized knowledge and skills which will enable them to conduct independent research in these fields. The formal course work is given and the advanced degrees are awarded through the several departments and divisions of the College.

(5) To act for Iowa State College as the cooperating agency with the Argonne National Laboratory and the associated midwestern universities.

(6) To act as a central agency to deal with the United States government in the obtaining of special materials such as isotopes, radioactive tracers and special counting instruments, and to serve as a clearing house for the special information which the government has at its disposal as a result of its research programs.

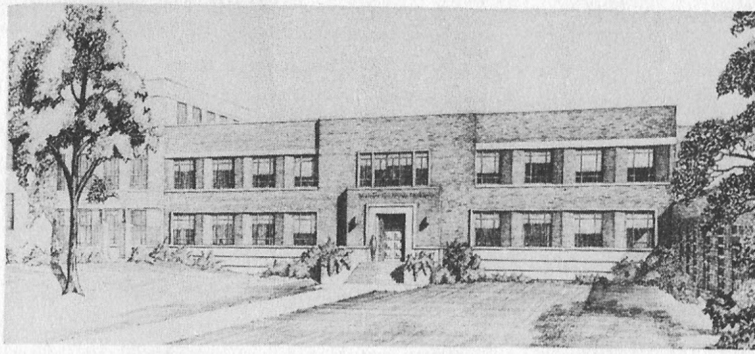
(7) To conduct research in nuclear and allied fields for the United States government when authorized by contract with Iowa State College.

In May of 1947, the United States Atomic Energy Commission formally announced the location of one of its major research facilities at Ames, to be known as the Ames Laboratory, which operates as an integral part of the Institute for Atomic Research. The State of Iowa has leased certain building sites to the Commission; the building program will be discussed in the following section.

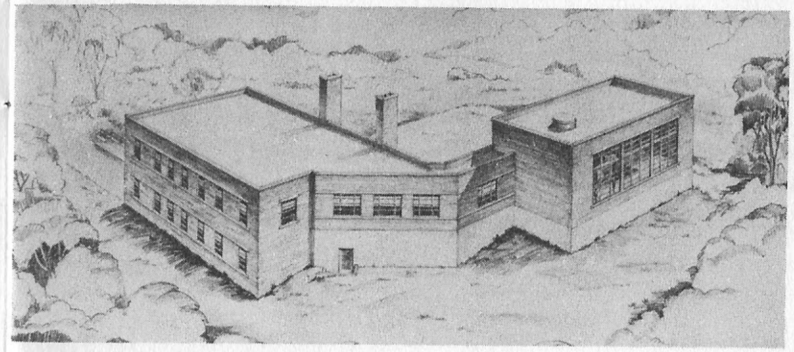


Research Building of the Atomic Energy Commission.

Metallurgy Building of the Atomic Energy Commission.



Office and Laboratory Building.



Synchrotron Building.

Facilities of the Iowa State College Institute for Atomic Research

The classified research of the Ames Laboratory of the Atomic Energy Commission and work dealing with classified materials such as uranium, thorium, etc., is generally confined to buildings erected through the Commission. However, much of the research in classified fields can be subsequently released for publication following established procedures for declassification. All research of the Institute other than that of the Ames Laboratory and most of the unclassified work of the Ames Laboratory are conducted in buildings constructed by the College.

Four new modern buildings have been completed; two of these, the Metallurgy and Research buildings, are constructed by the Atomic Energy Commission on land leased from the College. The Metallurgy Building consists of four stories and contains about 45,000 square feet of working space. The Research Building has three floors above ground, a basement and a sub-basement; it contains about 88,000 square feet of working space. The other two buildings have been constructed by the College. A three-story Administration and Laboratory Building, connecting the Chemistry and Physics buildings, contains about 25,000 square feet of working space and houses the administrative offices of the Institute, special research laboratories used jointly by the chemists and physicists, and a large physical sciences reading room. The Synchrotron Building contains the 70-million-volt synchrotron together with excellently equipped research and control laboratories for nuclear studies in high energy radiations and general research in electronics. This building has been erected on a 200-acre tract near the campus, set aside for special use by the Institute for Atomic Research. The Institute will continue the use of many excellently equipped laboratories in the Physics and Chemistry buildings. Special mention should be made of the various calculating machines of the Iowa State College Statistical Laboratory available for the treatment of theoretical problems. In addition, the comprehensive College Library provides valuable assistance in the research program. An idea of specific laboratory equipment can be gained from the descriptions of the research programs in the succeeding section of this bulletin.

In addition to the local facilities there will be available those of the Argonne Laboratory and other Atomic Energy Commission installations. From time to time, staff members and advanced students of the Institute are granted leaves of absence to go to other Commission laboratories to aid the government in government-sponsored research. The Institute maintains close contact with the other major laboratories of the Atomic Energy Commission through reports, information meetings and correspondence; it is also able, through cooperative arrangement, to obtain bombardments and irradiations of materials for use in the Institute research program. When special facilities of other Commission laboratories are required, members of the staff are sent there to carry out the required experiments.

Research Programs in the Iowa State College Institute for Atomic Research

The principal objective of the Institute is to contribute fundamental knowledge basic to the release, effects and utilization of atomic energy. When atomic fuel is placed in a nuclear reactor each fissionable atom breaks into two elemental fragments; the process leads to the formation of 40 to 50 elements, many of which are radioactive. It is at once evident that the requirements of the atomic energy program are so broad as to include all types of research from the most practical to the most highly specialized fields of science. The research programs of the Institute are discussed below.

Chemistry

The physical and inorganic chemistry groups deal with problems ranging from the separation of fission products from partially consumed atomic fuel through the use of tracers in reaction mechanisms to theoretical studies on the structure of matter. Complex ion formation, oxidation and reduction cycles and rates of reactions are being studied. Investigations are in progress on the formation of intermediates in the various stages of chemical reactions. New compounds are being synthesized, the nature of chemical bonding in heavy metal compounds is being studied, and a broad program is under way on the reaction mechanisms in inorganic chemistry. Surface phenomena, which play a large part in the many processes involving heterogeneous systems, are under investigation; these problems include adsorption of gases, adsorption from solution and the determination of conditions leading to the formation or prevention of colloidal systems. The hydrides of a number of metals have proved so useful as intermediate tools in the preparation of other compounds that they are being thoroughly investigated.

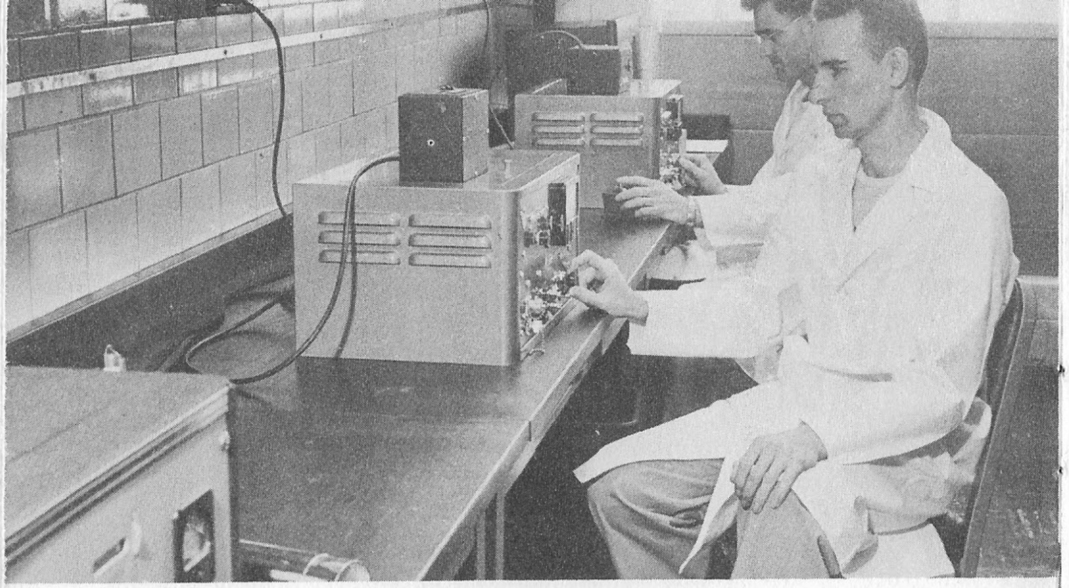
Adsorption columns used for the separation of rare earths.

The rare earths constitute a considerable portion of the fission products; some of these have undesirable nuclear properties and actually interfere with the optimum progress of the chain reaction. Emphasis is being placed on the purification and fundamental studies of these little-known elements. Ion-exchange methods have been developed in the Institute which permit the separation of many of the rare earths from each other in a few weeks instead of years as required by previous procedures. Methods have also been developed for producing the pure rare earth metals whose study will lead to a greater understanding of the nature of the metallic state.

Extensive research is being conducted by the analytical group to modify existing methods and to develop wholly new procedures. All raw materials and most finished products used in atomic research and development must be analyzed for numerous elements; many of the analyses are difficult because usual procedures do not apply due either to the high purity required or to the complexity of the mixtures involved. Moreover, the samples often contain rare or little studied elements for which no suitable analytical methods are known. Examples of the problems under investigation include the development of specific organic analytical reagents, basic studies of complexes which will permit the separation of one element from another, and special instruments such as the polarograph, spectrophotometer, magnetic susceptibility apparatus and titration apparatus using high-frequency electrical techniques to determine end points.

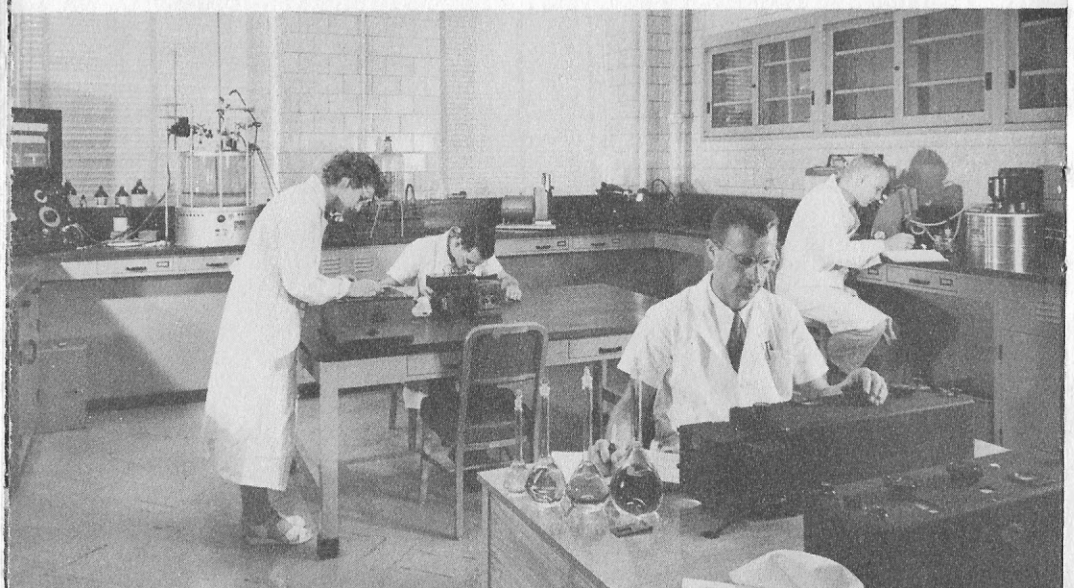
In view of the exacting requirements of analysis, research work is being conducted by the spectrochemistry group on the refinement of existing methods and the development of new procedures. Special emphasis is placed on spectroscopic methods for the analysis of systems which are not readily analyzed by chemcial means, such as the rare earths and hafnium-zirconium mixtures. Also under investigation are the excitation mechanisms and fundamental processes occurring in arc and spark discharges. To enlarge the scope of spectrochemistry, increased facilities are being installed for infrared, Raman and X-ray spectroscopy.

It is often necessary to conduct research employing the



Geiger counters, through their ability to measure minute quantities of radioactivity, find wide application in the use of tracer elements in practically all fields of scientific research.

All raw materials and most finished products in atomic research and development must be analyzed for numerous elements. Rigid specifications call for continually new and better analytical procedures.



stable (non-radioactive) isotopes such as D, C^{13}, N^{15}, etc. Three special mass spectrographs have been constructed to determine the relative abundance of the light, intermediate and heavy stable isotopes. These instruments are used in solving problems arising in the Institute and cooperating agencies of the College.

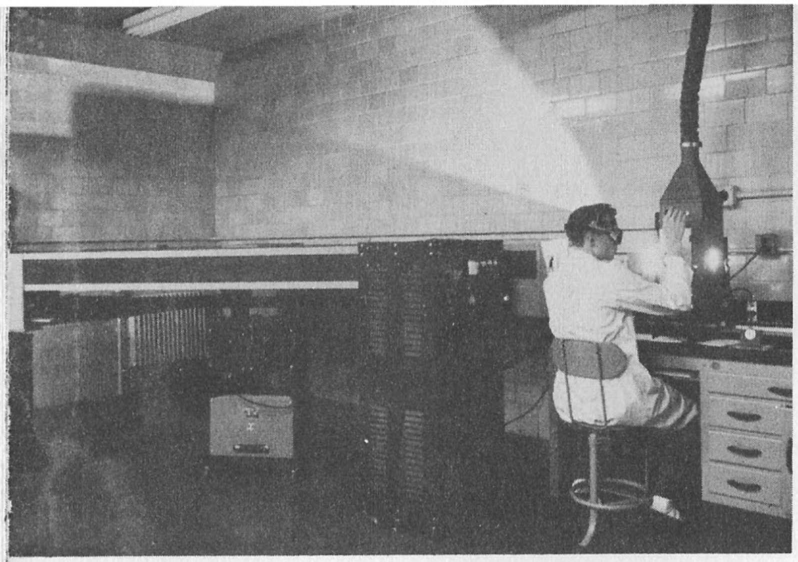
The X-ray group is interested in a number of research projects including the theory of the metallic state, valence in electron-deficient compounds, general problems in solid state physics and the structures of various new compounds prepared by other groups in the Institute. In connection with the interstitial compounds a new method, neutron diffraction, has been developed for the determination of light elements, particularly deuterium, nitrogen, carbon, etc., in the presence of the very heavy elements. Examples of cooperation with other groups include aid to the metallurgists in studies on alloy systems, to ceramic engineers and analytical chemists in the determination of the numbers and kinds of phases present in solids, to inorganic chemists in the study of dry processes in determining whether a chemical reaction has occurred, and to the chemical engineers in the determination of the nature and physical state of their products.

The radiochemistry group is engaged in the application of tracer techniques to such problems as the attack of crucibles by molten metals, exchange reactions of fission product elements in their various valence states, and solubility and complex ion formation of elements of special interest. Studies are in progress, particularly in collaboration with the physics groups, on the basic energy states of various radioactive isotopes.

Physics

The Institute research programs in physics emphasize both the experimental and theoretical approaches to fundamental problems in nuclear and solid state physics; the scope of the program is indicated by a few specific examples.

The energy states of the nuclei of various radioisotopes and the radiations which these nuclei emit are under investigation. In addition to other excellent equipment, the Institute has con-



A large grating spectrograph for analyzing materials which do not lend themselves readily to analysis by chemical means. New methods of spectrographic analysis are continually being developed.

sructed three β-ray spectrometers, a bent crystal X-ray spectrometer, proportional counters, scintillation counters, and a kevatron to study the energy of nuclear radiations. In connection with research on high-energy nuclear reactions the Institute has available a 70-million-volt synchrotron described in the section on facilities; this instrument is used to study the interaction of radiations with matter in the 20-70 Mev range.

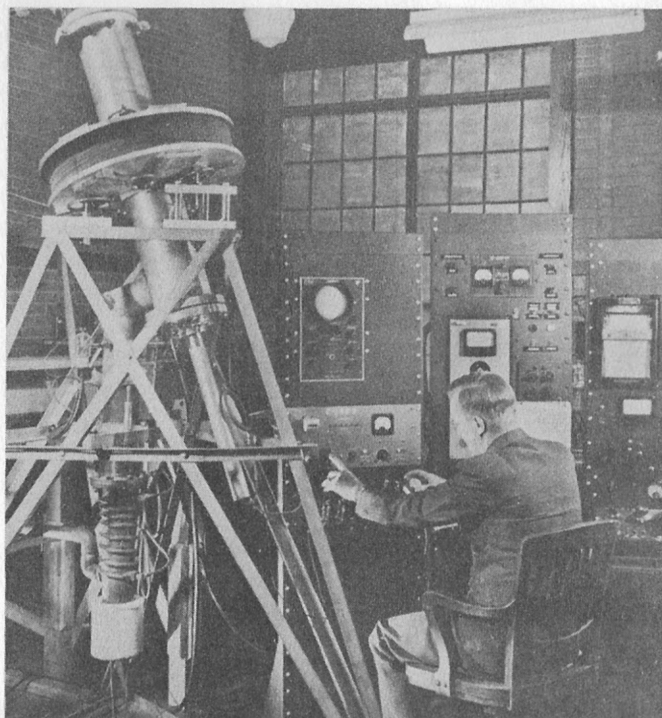
The relatively high intensity X-ray beam available from the synchrotron is being used for studies on cross sections, photonuclear disintegrations, and excitation of unstable energy levels in nuclei. The devices employed for the detection and analysis of these reactions include a large, pulsed cloud chamber; proportional and scintillation spectrometers; and a multichannel pulse height discriminator.

Studies are being made of the nuclear fission of single atoms to identify the individual fission fragments, the energies involved and the ionized state of the emitted particles; the data obtained are important to a better understanding of the nature and causes of the fission process and give valuable information on the factors concerned in the stability of nuclei.

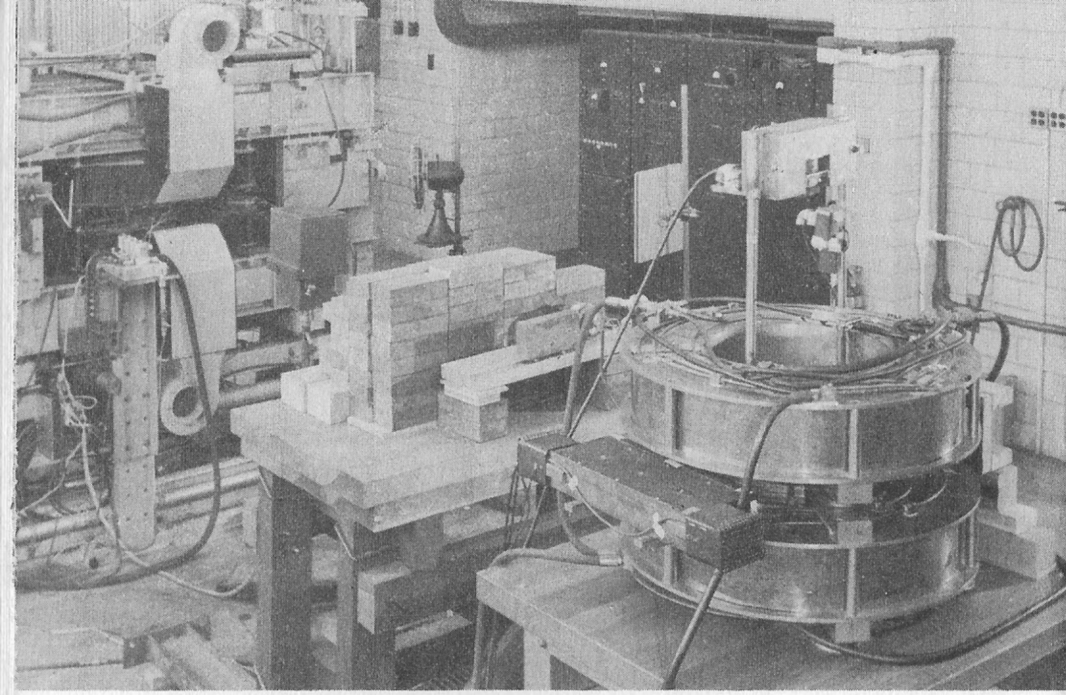
Data are being obtained on the stopping power of materials for various radiations and radioactive particles including fission products. Of particular importance are the processes by which high-speed β-particles, neutrons, protons and fission fragments are slowed down or absorbed in various materials, especially in solids.

The research programs in solid state physics include the determination of specific heats of rare earth metals, thermal conductivity, electrical conductivity and Hall coefficient of metals and semi-conductors, investigations on scintillation and conduction crystal counters, dislocations in single crystals of metals, ferroelectric and ferromagnetic phenomena, surface states in semi-conductors, and photoconductivity in valence crystals. In addition to special electronic equipment and apparatus for the growing of single crystals, laboratories are also available for low- and high-temperature work, for X-ray and electron diffraction studies, and for electron microscope examination. These facilities allow the comparison of structure and microscopic details in solids with their fundamental electronic behavior over a wide range of temperature.

The groups in theoretical physics are mainly interested in special problems arising in connection with the work in experimental physics. Examples include theories for the interpretation of data on the stopping power of various particles and radiations by matter; the nature of heat transfer; and theories relating to specific heat and other physical properties of the rare earths and other metals.

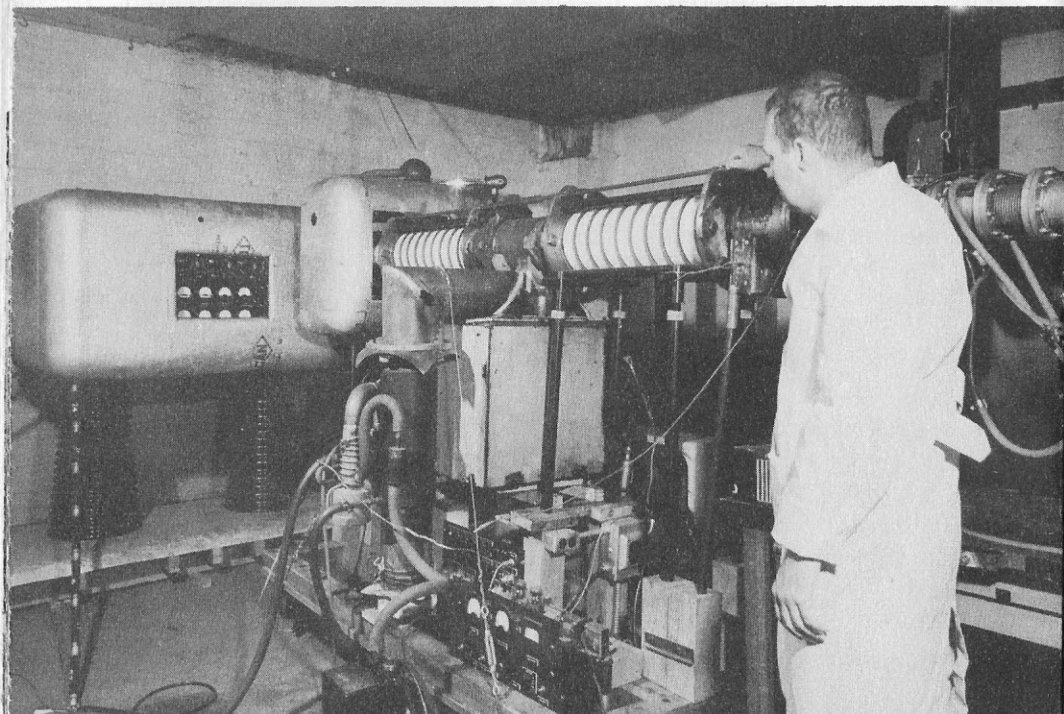


Beta-ray spectrometer.



Experimental arrangement using synchrotron beam in cloud chamber experiments.

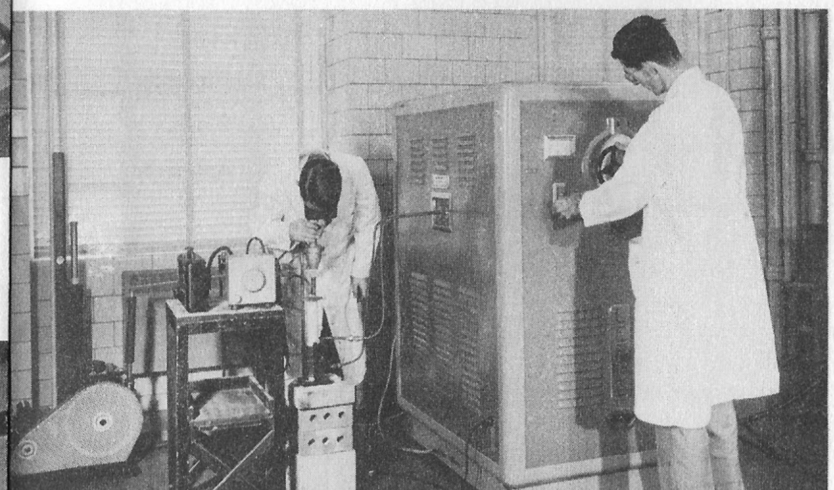
Accelerator for research on nuclear radiations in 300 kev range.



Metallurgy

The metallurgical section has excellent facilities for research and production of metals, especially those important in the development of atomic energy. The equipment includes numerous types of furnaces and devices for recording and controlling temperatures in melting, casting and heat treatment; equipment for rolling, swaging and various types of fabrication; and extensive facilities for metallographic, X-ray, spectrographic and physical testing of metals.

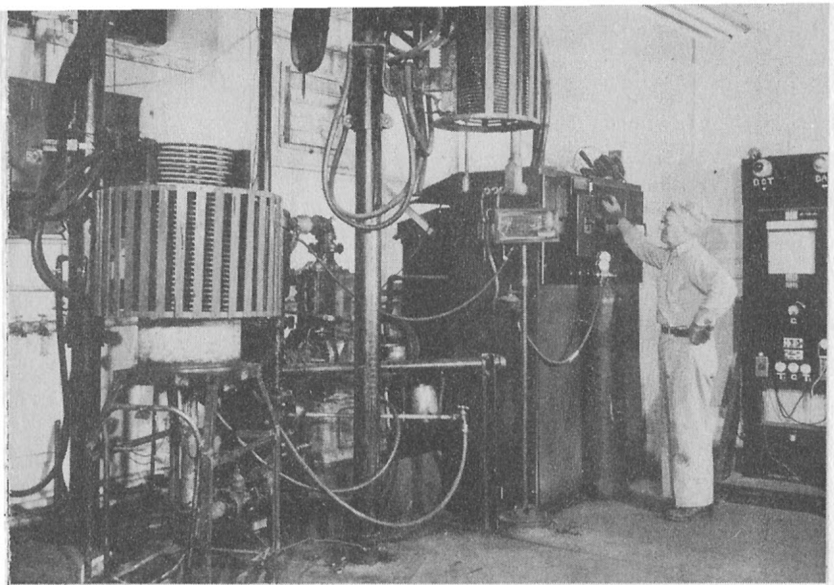
Uranium and thorium are the two source materials which



This induction furnace is used to produce the extremely high temperatures necessary for the experimental melting and casting of metals important to the atomic energy program.

contain, or from which can be manufactured, the fissionable materials used in nuclear reactors. The present industrial method for the production of uranium metal was developed at the Institute. Similar pioneering work has been accomplished here in the production of thorium metal, and this Laboratory is at present the main source of thorium for the atomic energy program while the process is being taken over by industry. Intensive research is under way to develop improved and more economical methods for the production of these metals and still meet their very high purity requirements.

Only a few of the other metallurgical problems under



Induction furnaces for melting and casting metal.

investigation can be mentioned here. An important part of the research program is the development of better methods for producing and fabricating metals used in reactors; this investigation is accompanied by research leading to a clearer understanding of their properties in the form of alloys with other metals. Corrosion studies are also involved, since the elements used as atomic fuels must be cooled by means of gases, liquids or liquid metals. The subject of coolants is under investigation as well as studies of heat transfer of various metals and alloys used in the operation of reactors. Other metals being intensively investigated, from the viewpoint of production and properties, include beryllium, zirconium, vanadium, titanium, calcium and the rare earth metals. Various phases of engineering are involved, as will be evident in the following section on the research programs in engineering.

Engineering

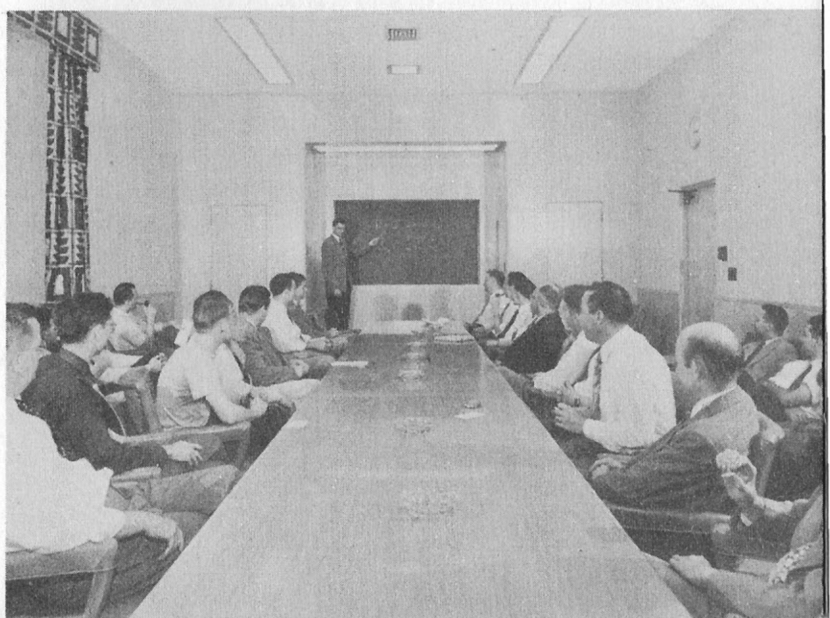
The chemical engineering division is concerned with the development of processes for production, from their ores, of compounds of uranium, thorium, zirconium and other materials which are of special interest in nuclear reactors. Processes which have been carried out only in laboratory glassware are tried on a pilot-plant scale in engineering equipment before they are adopted for commercial production. Information is obtained from pilot-plant operation that is necessary for economical design and efficient operation of a full-scale plant.

The basic chemical engineering unit operations that are important in development of processes of interest in the nuclear field, such as solvent extraction, are studied from a fundamental point of view. Treatment of by-product and waste materials from nuclear processes is being studied. Fundamental research is being carried out which promises to be useful in the design of more compact nuclear reactors.

Tracer techniques are being used in the study of phosphate fertilizer manufacture to indicate the mechanism of the reactions involved, which might lead to more efficient manufacturing processes.

Research in ceramic engineering involves such problems as the fabrication of high-temperature crucibles and other ceramic bodies and the determination of the basic properties of ceramic materials with reference to such factors as vapor pressure, reactivity toward metals and other materials, including the gases of surrounding atmosphere.

The architectural engineering group is concerned with special problems arising in connection with the building and construction program. It is evident that, in work on atomic energy, there are involved special types of laboratory units, chemical hoods, ventilating systems as well as unique building construction and materials.



A typical staff conference.

The program of the engineering development group includes the investigation of solid and fluid reactor materials and their behavior under load. Mechanical properties, such as strength, stiffness and hardness of materials of potential use in reactors are determined; facilities include equipment for conducting creep, impact and fatigue tests. Cooperation with other engineering groups on special design problems is an additional activity of the development group.

Special laboratories have been constructed by the Institute, and courses have been developed in the Division of Engineering for training graduate students in the basic techniques and principles required in the general field of nuclear engineering. Many problems involving electrical, mechanical and civil engineering are under investigation through cooperation with various specialists from the engineering staff of the College.

Biology

The research programs in biology include the fields of plant physiology, biochemistry and physiological bacteriology. In the plant physiology program, the function and metabolism of plant roots, the mechanism of photosynthesis and the movement of materials within the leaves, stems and roots are being investigated. The group in biochemistry is investigating the metabolic relationship between vitamin B_{12} and proteins, particularly tyrosine, the important protein constituent. The program in bacteriology is concerned with the nucleic acids, their formation, function, metabolism and their interrelationships with other parts of the bacterial protoplasm.

Special laboratories have been constructed by the Institute in which courses are given in the Department of Chemistry for training graduate students in the basic techniques and principles required for the use of radioactive tracers in the biological sciences, chemistry and engineering. Research programs using these tracers are in progress in these laboratories.

The medical and health physics groups have under their jurisdiction the health and safety program of the Institute. In addition the health physics group oversees the use of radioactivity by anyone on the campus, expedites the procurement of

radioactive tracers by research workers and offers advice to them regarding the use of the tracers.

History of War Research Leading to the Establishment of the Iowa State College Institute for Atomic Research

For many years previous to the war, fundamental research in nuclear chemistry, nuclear physics and related subjects had been conducted in this country, especially in university laboratories. While this research had progressed far enough to convince the scientists that atomic energy might be made practically available, and that an atomic bomb might be possible, the financial support was inadequate, being confined largely to that which the universities could afford over and above their normal teaching and research budgets. Furthermore, the several research programs were not correlated and so not only did they frequently overlap, but research in important fields which was urgently needed in order to advance the subject was entirely neglected.

After the outbreak of the European phase of the war, some financial aid, through the National Research Defense Council, was given to several university groups to stimulate research in the development of means for releasing atomic energy. However, it was not until December, 1941, that it was decided that the subject warranted an all-out effort on the part of the nation. The administration of this intensified effort was placed in the hands of the Office of Scientific Research and Development. Programs were set up at three centers: Columbia University under the direction of Dr. Harold C. Urey; the University of California under the direction of Dr. Ernest Lawrence; and the University of Chicago under the direction of Dr. A. H. Compton.

The programs at Columbia and California were chiefly concerned with the separation of uranium-235 and uranium-238. The program at Chicago had as its particular objectives studies of nuclear properties and the possibility of establishing a self-sustaining chain reaction, the development of a basic science required for the development of an atomic bomb, and the promising that the Iowa State College project was awarded a substantial sum to carry them through the pilot plant stage and to produce some tons of the metal to start the atomic energy machine which was being built at Chicago. Although these processes did not get into production until November, 1942, the Ames project furnished a substantial part of the metal used in the atomic energy pile which was first successfully demonstrated at Chicago on December 2, 1942. As a result of this proof of the feasibility of a self-sustaining atomic energy pile, there was a drastic stepping up of the program, and the direction was taken over from the Office of Scientific Research and Development by the Manhattan District of the Engineer Corps of the United States Army.

Iowa State College was asked to turn its process over to several large manufacturing corporations and, in the meantime, to produce as much metal as possible so that experience could be gained from which larger machines could be built. While the process was simple and relatively inexpensive, it required considerable skill to carry it out, so that it took some time for the companies to learn the process and to build factories to manufacture the metal. During this period, the Ames group succeeded in meeting its quota each month, and each month the quota was promptly doubled. In spite of all these increased requests, the College met all requirements and, at one point, reached a capacity equal to that of any one of the new plants which were being built at that time. This process supplanted all others, which even at their cheapest point were more than 20 times as expensive as the Iowa State College process.

During this same period, the chemical group at Iowa State College obtained much fundamental information which was published in confidential reports and which was later used in the design of atomic energy machines and in chemical processes which could be used in the large-scale separation of plutonium from other elements.

Other research developments, while not as spectacular as those previously mentioned, played an important role in the national program. Processes were worked out for the production of metallic thorium which reduced the cost of the metal to less

than a tenth of its original figure. Metallic thorium can replace uranium in certain cases and eventually may prove to be at least as important as uranium. Methods were developed for producing metallic cerium and metallic beryllium, which promises to find application in the construction of machines to utilize atomic power for peacetime purposes. A number of new ceramic materials were developed for making crucibles which will stand temperatures from 3600° to 5500°F.; such crucibles will withstand temperatures well above the boiling point of iron. Several new radioactive isotopes of ordinary metals were discovered, and advancements were made in the field of tracer chemistry in which certain molecules are "tagged" by including the atoms which are chemically similar to their own atoms, but which differ in being either radioactive or of exceptional weights.

Methods were devised for making very pure gases such as argon, helium, hydrogen and nitrogen, and procedures were devised for the rapid separation of the rare earths from one another. Extensive studies were made in the fundamental chemistry of numerous other elements and compounds. The entire program was accompanied by the development of new and better analytical procedures necessary to the progress of the research program.

The results of the wartime research of the Ames group were published in more than a hundred reports. The United States government has filed more than 100 patent applications based on this research; a number of these patents are also being applied for in Great Britain and Canada. All patent rights have been assigned to the government, and none of the research workers have received compensation other than their regular salaries. A number of scientists, trained in the Ames project, were sent by the government to responsible positions at such important sites at Oak Ridge Tenn., Hanford, Wash. and Los Alamos, N. M., as these agencies took over various production phases of the work. The Ames project on the large-scale production of metallic uranium was awarded the Army-Navy E flag with four stars, signifying two and a half years of excellence in industrial production of a vital war material. In addition, the Ames project was mentioned as one of the four outstanding university atomic bomb national projects in the original report of Secretary of War Stimson.

One of the outstanding characteristics of the program was the wholehearted and unselfish cooperation of the entire group. Without this teamwork, the success of the project, under the stress and strain of the urgency of the war effort, would have been impossible.

Staff of the Iowa State College Institute for Atomic Research

Senior Research Staff *

Director

Frank H. Spedding, *Professor of Chemistry, 1945, 1937; Professor of Physics, 1950.*
B. S., University of Michigan, 1925; M.S., ibid., *1926; Ph.D., University of California, 1929; LL.D., Drake University, 1946; D.Sc., University of Michigan, 1949.* Physical chemistry, rare earth chemistry, metallurgy, spectroscopy, solid state physics.

Associate Director

Harley A. Wilhelm, *Professor of Chemistry, 1947, 1927.*
A.B., Drake University, 1923; Ph.D., Iowa State College, 1931. Physical chemistry, metallurgy, spectrochemistry.

Assistant to the Director

Ellis I. Fulmer, *Professor of Chemistry, 1947, 1919.*
B.A., Nebraska Wesleyan University, 1912; M.A., University of Nebraska, 1913; Ph.D., University of Toronto, 1919; D.Sc., Nebraska Wesleyan University, 1944. Physical chemistry, colloid chemistry.

Assistant to the Director

Adolf F. Voigt, *Associate Professor of Chemistry, 1950, 1942.*
B.A., Pomona College, 1935; M.A., Claremont College, 1936; Ph.D., University of Michigan, 1942. Physical chemistry, radiochemistry, health physics.

Chemistry and Metallurgy

Charles A. Goetz, *Professor of Chemistry and Head of the Department, 1950, 1948; Chief, Metallurgy and Chemistry Division of the Ames Laboratory, 1950.*
B.S., University of Illinois, 1932; M.S., ibid., *1934; Ph.D.,* ibid., *1938.* Chemistry.

Charles V. Banks, *Associate Professor of Chemistry, 1949, 1941.*
B.Ed., Western Illinois State Teachers College, 1941; M.S., Iowa State College, 1944; Ph.D., ibid., *1946.* Analytical chemistry.

* First date after name indicates date of appointment to present position; second date, when the first fails to do so, indicates date of first appointment in the College.

O. Norman Carlson, *Assistant Professor of Chemistry, 1950, 1943.*
B.A., Yankton College, 1943; Ph.D., Iowa State College, 1950. Physical chemistry, metallurgy.

Premo Chiotti, *Assistant Professor of Chemistry, 1950, 1945.*
B.S., University of Illinois, 1938; Ph.D., Iowa State College, 1950. Physical chemistry, metallurgy.

Adrian H. Daane, *Assistant Professor of Chemistry, 1951, 1942.*
B.S., University of Florida, 1941; Ph.D., Iowa State College, 1950. Physical chemistry, metallurgy.

Frederick R. Duke, *Associate Professor of Chemistry, 1948.*
B.A., University of South Dakota, 1937; Ph.D., University of Illinois, 1940. Kinetics and mechanisms of inorganic reactions.

Velmer A. Fassel, *Associate Professor of Chemistry, 1951, 1941.*
B.A., Southeast Missouri State College, 1941; Ph.D., Iowa State College, 1947. Physical chemistry, spectrochemistry.

James S. Fritz, *Assistant Professor of Chemistry, 1951.*
B.S., James Millikin University, 1945; M.S., University of Illinois, 1946; Ph.D., ibid., *1948.* Analytical chemistry.

Maurice Griffel, *Assistant Professor of Chemistry, 1949.*
B.S., College of City of New York, 1939; M.S., University of Michigan, 1941; Ph.D., University of Chicago, 1949. Physical chemistry, low-temperature chemistry.

Robert S. Hansen, *Associate Professor of Chemistry, 1951, 1948.*
B.S., University of Michigan, 1940; M.S., ibid., *1941; Ph.D.,* ibid., *1948.* Colloid and surface chemistry.

Don S. Martin, *Associate Professor of Chemistry, 1947, 1946.*
B.S., Purdue University, 1939; Ph.D., California Institute of Technology, 1944. Inorganic chemistry, radiochemistry.

David Peterson, *Assistant Professor of Chemistry, 1951, 1947.*
B.S., Iowa State College, 1947. Ph.D., ibid., *1950.* Physical chemistry, metallurgy.

Bruce A. Rogers, *Professor of Chemistry, 1948, 1919.*
B.S., Iowa State College, 1916; M.S., University of Chicago, 1920; Ph.D., Harvard University, 1933. Metallurgy.

Robert E. Rundle, *Professor of Chemistry, 1946, 1941.*
B.S., University of Nebraska, 1937; M.S., ibid., *1938; Ph.D., California Institute of Technology, 1941.* Physical chemistry, structural chemistry, X-ray diffraction.

Harrison Shull, *Assistant Professor of Chemistry, 1949.*
A.B., Princeton University, 1943; Ph.D., University of California (Berkeley), 1948. Physical chemistry, spectroscopy.

Harry J. Svec, *Assistant Professor of Chemistry, 1949, 1941.*
B.S., John Carroll University, 1941; Ph.D., Iowa State College, 1950. Physical chemistry, mass spectrometry.

Leland A. Underkofler *(acting for Robert R. Sealock, deceased), Professor of Chemistry, 1949, 1928.*
A.B., Nebraska Wesleyan, 1928; Ph.D., Iowa State College, 1934. Biochemistry.

Physics

Gerald W. Fox, *Professor of Physics and Head of the Department, 1947, 1930; Chief, Physics Division of the Ames Laboratory, 1950.*
A.B., University of Michigan, 1923; A.M., ibid., *1924; Ph.D.,* ibid., *1926.* Physics.

J. Franklin Carlson, *Professor of Physics, 1948, 1946.*
A.B., University of California, 1928; M.A., ibid., *1930; Ph.D.,* ibid., *1932.* Theoretical physics, electrodynamics.

Gordon C. Danielson, *Associate Professor of Physics, 1948.*
B.A., University of British Columbia, 1933; M.A., ibid., *1935; Ph.D., Purdue University, 1940.* Solid state physics.

Donald E. Hudson, *Assistant Professor of Physics, 1951.*
B.S., University of Minnesota, 1942; Ph.D., Cornell University, 1950. High energy physics, solid state, physical electronics.

Erling N. Jensen, *Associate Professor of Physics, 1950, 1943.*
A.B., Drake University, 1932; M.A., Columbia University, 1933; Ph.D., Iowa State College, 1947. Experimental nuclear physics.

Joseph M. Keller, *Associate Professor of Physics, 1947, 1946.*
B.S., Harvard University, 1932; Ph.D., University of California, 1940. Theoretical physics, quantum theory, nuclear forces.

Julian K. Knipp, *Professor of Physics, 1948, 1946.*
B.A., University of Illinois, 1931; M.A., Harvard University, 1932; Ph.D., ibid., 1935. Theoretical physics, molecular and nuclear physics.

L. Jackson Laslett, *Professor of Physics, 1951, 1946.*
B.S., California Institute of Technology, 1933; Ph.D., University of California, 1937. Experimental nuclear physics.

Sam Legvold, *Associate Professor of Physics, 1946, 1935.*
A.B., Luther College, 1935; M.S., Iowa State College, 1936; Ph.D., ibid., *1946.* Mathematical physics, low-temperature physics.

Glenn H. Miller, *Assistant Professor of Physics, 1948, 1947.*
B.S., Wake Forest College, 1942; Ph.D., Cornell University, 1947. Experimental nuclear physics.

Daniel J. Zaffarano, *Associate Professor of Physics, 1949.*
B.S., Case Institute of Technology, 1939; M.S., Indiana University, 1948; Ph.D., ibid., *1949.* Experimental nuclear physics.

Engineering

Grover L. Bridger, *Professor of Chemical and Mining Engineering and Head of the Department, 1948, 1935; Chief, Chemical Engineering Division of the Ames Laboratory, 1950.*
B.S., Rice Institute, 1933; M.A., ibid., 1935; Ph.D., Iowa State College, 1938. Chemical engineering.

Gerhard H. Beyer, *Assistant Professor of Chemical Engineering, 1949.*
B.S., University of Wisconsin, 1944; M.S., ibid., *1947; Ph.D.,* ibid., *1949.* Chemical engineering, thermodynamics, kinetics.

Thomas K. FitzPatrick, *Professor of Architecture and Architectural Engineering and Head of the Department, 1946, 1945.*
B.Arch., Massachusetts Institute of Technology, 1932; M.Arch., ibid. *1933.* Architectural engineering.

Elmer S. Fitzsimmons, *Assistant Professor of Ceramic Engineering, 1951.*
B.S., Alfred University, 1943; D.Sc., Massachusetts Institute of Technology, 1950. Ceramic engineering.

William Millard, *Assistant Professor of Chemical Engineering, 1950.*
B.S., University of Missouri, 1941; M.S., ibid., *1947; Ph.D., Cornell University, 1950.* Chemical engineering, diffusional operations.

Glenn Murphy, *Professor of Theoretical and Applied Mechanics, 1941, 1932.*
B.S., University of Colorado, 1929; M.S., ibid., *1930; M.S., University of Illinois, 1932; Ph.D., Iowa State College, 1935; C.E., University of Colorado, 1937.* Engineering materials, theoretical and applied mechanics, nuclear engineering.

Richard T. Othmer, *Assistant Professor of Theoretical and Applied Mechanics, 1947, 1939.*
B.S., South Dakota State College, 1938; M.S., Iowa State College, 1947. Theoretical and applied mechanics.

Burrell F. Ruth, *Professor of Chemical Engineering, 1942, 1938.*
B.S., Michigan State College, 1923; M.S., ibid., *1925; Ph.D., University of Minnesota, 1931.* Chemical engineering.

Morton Smutz, *Assistant Professor of Chemical Engineering, 1951.*
B.S., Kansas State College, 1939; M.S., ibid., *1941; Ph.D., University of Wisconsin, 1950.* Chemical engineering, process control and instrumentation.

Biology

Samuel Aronoff, *Associate Professor of Botany, 1948.*
A.B., University of California (Los Angeles), 1936; Ph.D., University of California (Berkeley), 1942. Plant physiology.

Wendell H. Bragonier, *Professor of Botany and Head of the Department, 1950, 1939.*
B.A., Iowa State Teachers College, 1933; M.S., Iowa State College, 1941; Ph.D., ibid., *1947.* Botany.

Fritz Schlenk, *Professor of Bacteriology, 1947.*
Ph.D., University of Berlin, 1934. Bacterial metabolism.

Allan P. Skoog, *Industrial Physician in the Ames Laboratory of the Atomic Energy Commission, 1951, 1949.*
B.S., University of New Hampshire, 1931; M.D., Tufts Medical School, 1937. Industrial medicine, safety engineering.

Chester H. Werkman, *Professor of Bacteriology and Head of the Department, 1945, 1921.*
B.S., Purdue University, 1919; Ph.D., Iowa State College, 1923; D.Sc., Purdue University, 1944. Bacterial metabolism; physiological bacteriology and fermentations.

Medical Consultants to the Ames Laboratory of the Atomic Energy Commission

John F. Bacon, *M.D.*, X-ray.

Harriet L. Hardy, *M.D.*, Industrial Medicine.

Associated Research Staff

Associates	Title	Department
Ernest W. Anderson	Professor	Mathematics
H. E. Biester	Prof. and Assoc. Director	V. Res. Inst.
Henry M. Black	Prof. and Dept. Head	Mech. Engr.
Frank E. Brown	Professor	Chemistry
Percy H. Carr	Professor	Physics
Winifred F. Coover	Professor	Chemistry
Harvey C. Diehl, Jr.	Professor	Chemistry
Lester T. Earls	Professor	Physics
W. H. Evans	Asst. Professor	Elec. Engr.
Sidney W. Fox	Professor	Chemistry
Dexter French	Assoc. Professor	Chemistry
John A. Greenlee	Asst. to the Dean	Div. of Science
George S. Hammond	Assoc. Professor	Chemistry
Ralph M. Hixon	Dean	Graduate College
Walter Loomis	Professor	Botany
James P. McKean	Professor	Gen. Engr.
Robert W. Orr	Director	Library
Frank R. Parchen, Jr.	Assoc. Professor	V. Res. Inst.
Louis H. Schwarte	Professor	V. Res. Inst.
Dean W. Stebbins	Professor	Physics
George R. Town	Prof. and Assoc. Director	Engr. Exp. Sta.
Henry A. Webber	Professor	Chem. Engr.
John A. Wilkinson	Professor	Chemistry