BULLETIN of the BIOLOGY DIVISION

OAK RIDGE

NATIONAL LABORATORY

BIOLOGY RESEARCH CONFERENCE

ON

ANTIBODIES: THEIR PRODUCTION

AND MECHANISM OF ACTION

Sponsored by the
BIOLOGY DIVISION
of
OAK RIDGE NATIONAL LABORATORY
and the
ATOMIC ENERGY COMMISSION

MOUNTAIN VIEW HOTEL
GATLINBURG, TENNESSEE

April 8–10, 1957

PROGRAM

SUNDAY, APRIL 7 – 8:00 P.M. – A special meeting will be held for a discussion on biological effects of radiation as background for the bone marrow transplantation discussion on Monday evening. All conference participants who arrive in time are invited to attend.

MONDAY, APRIL 8 – 9:30 A.M.

Opening Remarks – *Alexander Hollaender*
Biology Division, Oak Ridge National Laboratory

Welcome Address – *Alvin M. Weinberg*, Director
Oak Ridge National Laboratory

Chairman (Morning Session)

William H. Taliaferro, Department of Microbiology
University of Chicago

William H. Taliaferro, University of Chicago. **General Introduction and Discussion of Antibody Formation**

Frank J. Dixon, Jr., University of Pittsburgh School of Medicine. **Characterization of the Antibody Response**

Chairman (Afternoon Session)

M. R. Irwin, Department of Genetics
University of Wisconsin

S. J. Singer, Sterling Chemistry Laboratory, Yale University. **Antibody Reactive Sites and Soluble Complexes**

Elvin A. Kabat, College of Physicians and Surgeons, Columbia University. **Size of the Reactive Sites on Antibody**

EVENING SESSION (8:00 P.M.)

Discussion – **Radiation Immunology with Special Emphasis on Bone Marrow Transplantation.** *C. E. Ford*, Radiobiological Research Unit, Harwell, England; *J. F. Loutit*, Radiobiological Research Unit, Harwell, England; *D. W. van Bekkum*, Medisch Biologisch Institute, Rijswijk, Netherlands; *C. C. Congdon*, Biology Division, Oak Ridge National Laboratory; *T. Makinodan*, Biology Division, Oak Ridge National Laboratory

SMOKER

Union Carbide Nuclear Company will be the host

TUESDAY, APRIL 9 – 9:00 A.M.

Chairman (Morning Session)

A. M. Pappenheimer, Jr.
New York University College of Medicine

G. David Novelli and *J. A. DeMoss*, Biology Division, Oak Ridge National Laboratory. **The Activation of Amino Acids and Concepts of the Mechanism of Protein Synthesis**

Ray D. Owen and *Richard Schweet*, California Institute of Technology. **Recent Concepts of Protein Synthesis in Relation to Antibody Formation**

David W. Talmage, Department of Medicine, University of Chicago. **The Diversity of Antibodies**

Tour – Afternoon (2:00–6:00 P.M.)

Excursion – Great Smoky Mountains: The group will leave from the Mountain View Hotel at 2:00 P.M. In case of inclement weather, the program will continue and Wednesday afternoon will remain open for a tour of the Biology Division of Oak Ridge National Laboratory.

Evening

Reception and Dinner – Huff House

Reception – 6:30–8:00 P.M.

Dinner – 8:00 P.M.

WEDNESDAY, APRIL 10 – 9:00 A.M.

Chairman (Morning Session)

Michael Heidelberger, Institute of Microbiology
Rutgers University

N. Avrion Mitchison, Department of Zoology, University of Edinburgh. **Passive Transfer of Immune Reactions by Way of Cells**

Robert W. Wissler, Division of Biological Science, University of Chicago. **The Cellular Basis for Antibody Formation**

Chairman (Afternoon Session)

Alexander Haddow
Chester Beatty Research Institute, London

Elmer L. Becker, Department of Immunochemistry, Walter Reed Army Medical Center. **Hypersensitivity**

T. Makinodan, Biology Division, Oak Ridge National Laboratory. **Some Immunological Aspects of Bone Marrow Transplantation**

GENERAL INFORMATION

MEETINGS

All sessions will be held in the Huff House.

GENERAL INFORMATION

General information will be handled by the clerk at the desk in the Huff House lower lobby.

TRAVEL INFORMATION

Travel and transportation information is handled by the Travel Clerk. This clerk will make, change, or cancel return-trip reservations for visitors. The clerk will also arrange for transportation from Gatlinburg to Knoxville or to the Knoxville airport by the Knoxville Airport Transit Service limousines.

REGISTRATION

All guests will be asked to register at the conference registration desk – Sunday, 8:00 P.M. to 10:00 P.M. in the lobby of the Mountain View Hotel. Guests arriving after 10:00 P.M. Sunday may register on Monday at 8:00 A.M.

IDENTIFICATION BADGES

At the time of registration, badges, bearing the name and designating the affiliation of each visitor, will be distributed. Please be sure to come to the desk for your badge.

TELEPHONE

Telephone charges will be added to the hotel-room bill.

MEALS

Lunch	12:00 – 2:00
Dinner	6:00 – 8:00

BIOLOGY DIVISION
OAK RIDGE NATIONAL LABORATORY
ORGANIZATION OF RESEARCH

CYTOLOGY AND GENETICS

PARAMECIUM
TRADESCANTIA
NEUROSPORA
MAIZE
VICIA
TIMOTHY
PHAGE

R. F. KIMBALL
A. D. CONGER
S. WOLFF
D. SCHWARTZ
K. C. ATWOOD
T. H. PITTENGER
R. R. COWDEN[1]
M. A. SICARD[2]
F. J. DE SERRES[3]
D. R. KRIEG
R. T. BRUMFIELD[4]

GRASSHOPPER
HABROBRACON

MARY E. GAULDEN
R. C. VON BORSTEL
J. G. CARLSON[4]
ANNA R. WHITING[4]
R. L. AMY[4]
R. P. PERRY[3]

DROSOPHILA

E. NOVITSKI
D. L. LINDSLEY
C. W. EDINGTON[5]
G. E. BROSSEAU[6]
L. M. SANDLER[3]

MAMMALIAN GENETICS AND DEVELOPMENT

SECTION CHIEF
W. L. RUSSELL

GENETIC EFFECTS OF RADIATION IN MICE

W. J. WELSHONS
W. St. AMAND
JOSEPHINE S. GOWER
L. WICKHAM

EFFECTS OF RADIATION ON MAMMALIAN GAMETOGENESIS

E. F. OAKBERG

DEVELOPMENTAL EFFECTS OF RADIATION IN MICE

LIANE B. RUSSELL

MAMMALIAN RECOVERY

HEMATOPOIETIC RECOVERY

C. C. CONGDON
P. URSO

RADIATION IMMUNOLOGY

T. MAKINODAN
N. GENGOZIAN[1]
ISABEL C. SHEKARCHI[5]

BONE MARROW TISSUE CULTURE AND CELL ISOLATION

D. BILLEN
L. H. SMITH

MICROBIAL PROTECTION AND RECOVERY

ALEXANDER HOLLAENDER*
G. E. STAPLETON
H. I. ADLER[3]
A. K. BRUCE[3]
JOHN JAGGER
NICOLE A. SICARD[2]

PATHOLOGY AND PHYSIOLOGY

SECTION CHIEF
A. C. UPTON

PATHOLOGICAL EFFECTS OF RADIATION

K. W. CHRISTENBERRY[4]
W. H. BENEDICT[4]
J. A. SPROUL, JR.[7]

PHYSIOLOGICAL AND CHEMICAL EFFECTS

T. T. ODELL
E. E. SCHWARTZ[1]

HISTOLOGY AND AUTORADIOGRAPHY

W. D. GUDE

PHYSIOLOGY

ELECTROLYTES AND CIRCULATION

C. W. SHEPPARD†
E. B. DARDEN, JR.

CELL PHYSIOLOGY

N. G. ANDERSON
W. D. FISHER[1]
J. F. ALBRIGHT[3]
S. L. SCHEINBERG[3]
E. C. HORN[4]

BIOCHEMISTRY

NUCLEIC ACID CHEMISTRY

W. E. COHN

NUCLEIC ACID ENZYMOLOGY

E. VOLKIN
L. ASTRACHAN

PROTEOLYTIC ENZYMES AND PROTECTIVE COMPOUNDS

D. G. DOHERTY
R. SHAPIRA
R. H. BRADFORD[8]

ENZYMOLOGY AND PHOTOSYNTHESIS

G. D. NOVELLI
J. W. DAVIS
M. J. CORMIER

PHOTOSYNTHESIS

W. A. ARNOLD

MICROBIOLOGY

TRACER STUDIES ON METABOLISM

S. F. CARSON†
M. I. DOLIN
E. F. PHARES
E. A. DELWICHE[4]

PLANT BIOCHEMISTRY

N. E. TOLBERT
L. P. ZILL
A. H. HABER[3]
R. RABSON[5]

BIOPHYSICS

MOLECULAR BIOPHYSICS

J. S. KIRBY-SMITH
A. FABERGÉ[5]
A. L. FAIRBANKS, JR.[3]
K. M. WILBUR[4]
J. N. DENT[4]

RADIOLOGICAL PHYSICS

M. L. RANDOLPH

BIOMETRICS

(MATHEMATICS PANEL)

A. W. KIMBALL
M. A. KASTENBAUM
G. J. ATTA

BIOLOGY LIBRARY

(ORNL LIBRARY BRANCH)

JOHN M. BOBB

*DIVISION DIRECTOR
†ASST. DIVISION DIRECTOR
[1]USPHS FELLOW
[2]VISITING INVESTIGATOR FROM ABROAD
[3]RESEARCH ASSOCIATE
[4]CONSULTANT
[5]TEMPORARY EMPLOYEE
[6]NATIONAL CANCER SOCIETY FELLOW
[7]U. S. AIR FORCE
[8]ORINS FELLOW

GUEST LIST

Seymour Abrahamson, University of Wisconsin

Peter Abramoff, Marquette University

Frederick Aladjem, California Institute of Technology

Peter Alexander, Chester Beatty Research Institute, London

Eric Andresen, University of Wisconsin

J. R. Andrews, National Institutes of Health

W. F. Bale, University of Rochester

E. L. Becker, Walter Reed Army Institute of Research

Baruj Benacerraf, NYU Bellevue Medical Center

A. S. Benenson, Walter Reed Army Institute of Research

S. E. Bernstein, Jackson Laboratory

Marvin Bloom, University of Buffalo

A. E. Brandt, U. S. Atomic Energy Commission, New York

W. E. Briles, Texas Agricultural Experimental Station

J. C. Bugher, Rockefeller Foundation

D. H. Campbell, California Institute of Technology

A. H. Coons, Harvard Medical School

B. G. Crouch, University of Tennessee

Phillip D'Alesandro, University of Chicago

F. J. Dixon, University of Pittsburgh

L. R. Draper, University of Chicago

L. C. Dunn, Columbia University

Richard Dutton, Medical College of Virginia

E. A. Edwards, State of Wisconsin State Laboratory

Richard Farr, University of Pittsburgh

Robert Feinberg, Walter Reed Army Institute of Research

F. W. Fitch, University of Chicago

C. E. Ford, Harwell, Berks, England

A. S. Fox, Michigan State University

Wallace Friedberg

Jacob Furth, Children's Cancer Research Foundation

Helen Gay, Carnegie Institution of Washington, Cold Spring Harbor

Philip Gell, New York University

Henry Gershowitz, University of Michigan

S. W. Gilkerson, Berea College

Liselotte Graf, Sloan-Kettering Institute

Alexander Haddow, Chester Beatty Research Institute, London

P. F. Hahn, Meharry Medical College

F. E. Hahn, Walter Reed Army Institute of Research

W. T. Hall, Northwestern University

Felix Haurowitz, Indiana University

Michael Heidelberger, Rutgers University

S. P. Hicks, N. E. Deaconess Hospital

J. W. Hollingsworth, Veterans Administration Hospital, Connecticut

E. C. Horn, Duke University

J. S. Ingraham, Indiana University

M. R. Irwin, University of Wisconsin

J. Jaroslow, Argonne National Laboratory

A. G. Johnson, University of Michigan

D. Johnstone, University of Rochester

J. E. Jones, National Research Council

E. A. Kabat, Columbia University

B. P. Kaufmann, Carnegie Institution of Washington, Cold Spring Harbor

J. F. Kent, Walter Reed Army Institute of Research

P. C. Koller, Chester Beatty Research Institute, London

M. E. Koshland, Brookhaven National Laboratory

W. J. Kuhns, Central Blood Bank, Pittsburgh

Mariano LaVia, University of Chicago

Philip Levine, Ortho Research Foundation

J. F. Loutit, Harwell, Berks, England

S. P. Masouredis, Central Blood Bank, Pittsburgh

P. H. Maurer, University of Pittsburgh

Harold Meryman, Sloane Physics Laboratory

Solomon Michaelson, University of Rochester

N. A. Mitchison, University of Edinburgh

Mary Joan Olsen, University of Wisconsin

A. G. Osler, Johns Hopkins University

R. R. Overman, University of Tennessee

R. D. Owen, California Institute of Technology

A. M. Pappenheimer, Jr., New York University College of Medicine

David Pressman, Roswell Park Memorial Institute

Henry Quastler, Brookhaven National Laboratory

R. W. Quinn, Vanderbilt University

C. R. Randall, Vanderbilt University

M. M. Rapport, Sloan-Kettering Institute

E. B. Reeve, University of Colorado Medical Center

R. D. Reid, Office of Naval Research

E. H. Reisner, St. Luke Hospital, New York

R. H. Rixon, Atomic Energy Commission of Canada

Gertrude Rodney, Parke, Davis & Company

Noel Rose, University of Buffalo

Elizabeth Russell, Roscoe B. Jackson Memorial Laboratory

R. F. Ruth, Carnegie Institution of Washington

J. E. Salk, University of Pittsburgh

Robert Schrek, Northwestern University

I. R. Schwartz, Jefferson Medical College

Richard Schweet, California Institute of Technology

Alex Sehon, McGill University, Canada

D. G. Sharp, Duke University

D. H. Shaw, University of Wisconsin

Sidney Shulman, University of Buffalo

S. J. Singer, Yale University

M. S. Silverman, U. S. Naval Radiological Defense Laboratory

E. L. Simmons, Argonne Cancer Research Hospital

J. H. Skom, University of Chicago

Margaret H. Sloan, National Research Council

Falconer Smith, National Cancer Institute, NIH

W. W. Smith, National Cancer Institute, NIH

Peter Stelos, University of Chicago

C. A. Stetson, NYU Bellevue Medical Center

K. M. Stevens, Merck Sharp & Dohme

W. H. Stone, University of Wisconsin

R. D. Stoner, Brookhaven National Laboratory

S. R. Suskind, Johns Hopkins University

D. H. Sussdorf, University of Chicago

W. H. Taliaferro, University of Chicago

D. W. Talmage, University of Chicago

Andrew Thomson, University of Chicago

L. M. Tocantins, Jefferson Medical College

D. W. van Bekkum, Rijswijk, Holland

J. H. Vaughan, Medical College of Virginia

D. A. Vloedman, Jr., University of Miami School of Medicine

B. H. Waksman, Harvard University

W. O. Weigle, University of Pittsburgh

R. S. Weinrach, University of Chicago

R. W. Wissler, University of Chicago

Ernest Witebsky, University of Buffalo

H. R. Wolfe, University of Wisconsin

C. G. Zubrod, National Cancer Institute, NIH

EXPENSES 1957

OAK RIDGE NATIONAL LABORATORY
OPERATED BY
UNION CARBIDE NUCLEAR COMPANY
A DIVISION OF UNION CARBIDE AND CARBON CORPORATION
UCC
POST OFFICE BOX Y
OAK RIDGE, TENN.

CHARGED to Institute

November 6, 1956

TENTH ANNUAL RESEARCH CONFERENCE

The Tenth Annual Research Conference sponsored by the Biology Division of the Oak Ridge National Laboratory will be held on April 8, 9, and 10, 1957, in Gatlinburg, Tennessee, at the Mountain View Hotel. This conference, supported by the Atomic Energy Commission, will consist of invited papers and open discussions of a nonrestricted nature on the general topic of "Antibodies: Their Production and Mechanism of Action." Some emphasis will be placed on studies involving radiation effects and bone marrow therapy.

You and a limited number of your associates who are working in this or related fields are cordially invited to attend. As this is not an information meeting, the people who attend should be either workers in the field or should have a degree of interest in the subject sufficient to enable them to participate in the discussions.

On Monday evening, April 8, Union Carbide Nuclear Company will be host at a Smoker to which all persons registered for the conference are invited. A reception and banquet will be held at the hotel on Tuesday evening, April 9. Special hotel rates given below apply only to those attending the conference who make reservations through this office:

American Plan (includes meals)

Single Room (1 person)	$11.00 and $12.00
Twin Bedroom (2 persons)	$8.00 - $8.50 - $9.00 (each person)
Double Bedroom (2 persons)	$7.50 to $8.00 (each person)

When checking out, 10% will be added to the bill to cover tips.

Limousine service between the Knoxville airport and rail depots and the Mountain View Hotel in Gatlinburg will be available at a cost of $5.00 per person each way. Bus service between downtown Knoxville and Gatlinburg is also available and the fare is $1.05 one way or $1.93 for the roundtrip.

Reservation forms are enclosed for your convenience in notifying us of your plans to attend this conference. Since Gatlinburg is very popular during the Spring season, it is imperative that reservations be made early so we can assure accommodations for all conference delegates. All reservation forms must be returned by March 1, 1957, and you will be notified not later than March 10 if you can be accommodated. The registration fee will be $2.50.

A tentative program is enclosed for your information.

We are looking forward to seeing you in Gatlinburg!

Alexander Hollaender
Alexander Hollaender
Biology Division

Enclosures

TENTATIVE PROGRAM

RESEARCH CONFERENCE OF THE BIOLOGY DIVISION
OAK RIDGE NATIONAL LABORATORY

Gatlinburg, Tennessee
April 8-10, 1957

ANTIBODIES: THEIR PRODUCTION AND MECHANISM OF ACTION

MONDAY, APRIL 8, 1957

Morning

Chairman: William H. Taliaferro, University of Chicago

General Introduction and Discussion of Antibody Formation: William H. Taliaferro, Department of Microbiology, University of Chicago

Characterization of the Antibody Response: Frank J. Dixon, Jr., University of Pittsburgh School of Medicine

Afternoon

Chairman: Albert B. Sabin, Children's Hospital Research Foundation, Cincinnati

Antibody Reactive Sites and Soluble Complexes: S. J. Singer, Sterling Chemistry Laboratory, Yale University

Size of the Reactive Sites on Antibody: Elvin A. Kabat, College of Physicians and Surgeons, Columbia University

Evening

Discussion: Radiation Immunology with Special Emphasis on Bone Marrow Transplantation

T. Makinodan, Oak Ridge National Laboratory
C. E. Ford, Radiobiological Research Unit, Harwell, England
J. F. Loutit, Radiobiological Research Unit, Harwell, England
C. C. Congdon, Oak Ridge National Laboratory
D. W. Van Bekkum, Medisch Biologisch Institute, Rijswijk, Netherlands

NOTE: On Sunday, April 7, at 8:00 p.m., a special meeting will be held for a discussion on biological effects of radiation as background for the bone marrow transplantation discussion on Monday evening. All conference participants who arrive in time are invited to attend.

TUESDAY, APRIL 9, 1957

Morning

Chairman: A. M. Pappenheimer, Jr., New York University College of Medicine

The Cellular Basis for Antibody Formation: Robert W. Wissler, Division of Biological Science, University of Chicago

Theories of Antibody Formation: Neils K. Jerne, Statens Seruminstitut, Copenhagen

Afternoon

EXCURSION--GREAT SMOKY MOUNTAINS (In case of inclement weather, the program will continue, leaving Wednesday afternoon open for a tour of the Biology Division, Oak Ridge National Laboratory)

WEDNESDAY, APRIL 10, 1957

Morning

Chairman: Michael Heidelberger, Rutgers University, Institute of Microbiology

The Diversity of Antibodies: David W. Talmage, Department of Medicine, University of Chicago

Passive Transfer of Immune Reactions by Way of Cells: N. Avrion Mitchison, Department of Zoology, University of Edinburgh

Afternoon

Antibodies to Cellular Antigens: Ray D. Owen, California Institute of Technology, Pasadena

Hypersensitivity: Elmer L. Becker, Department of Immunochemistry, Walter Reed Army Medical Center

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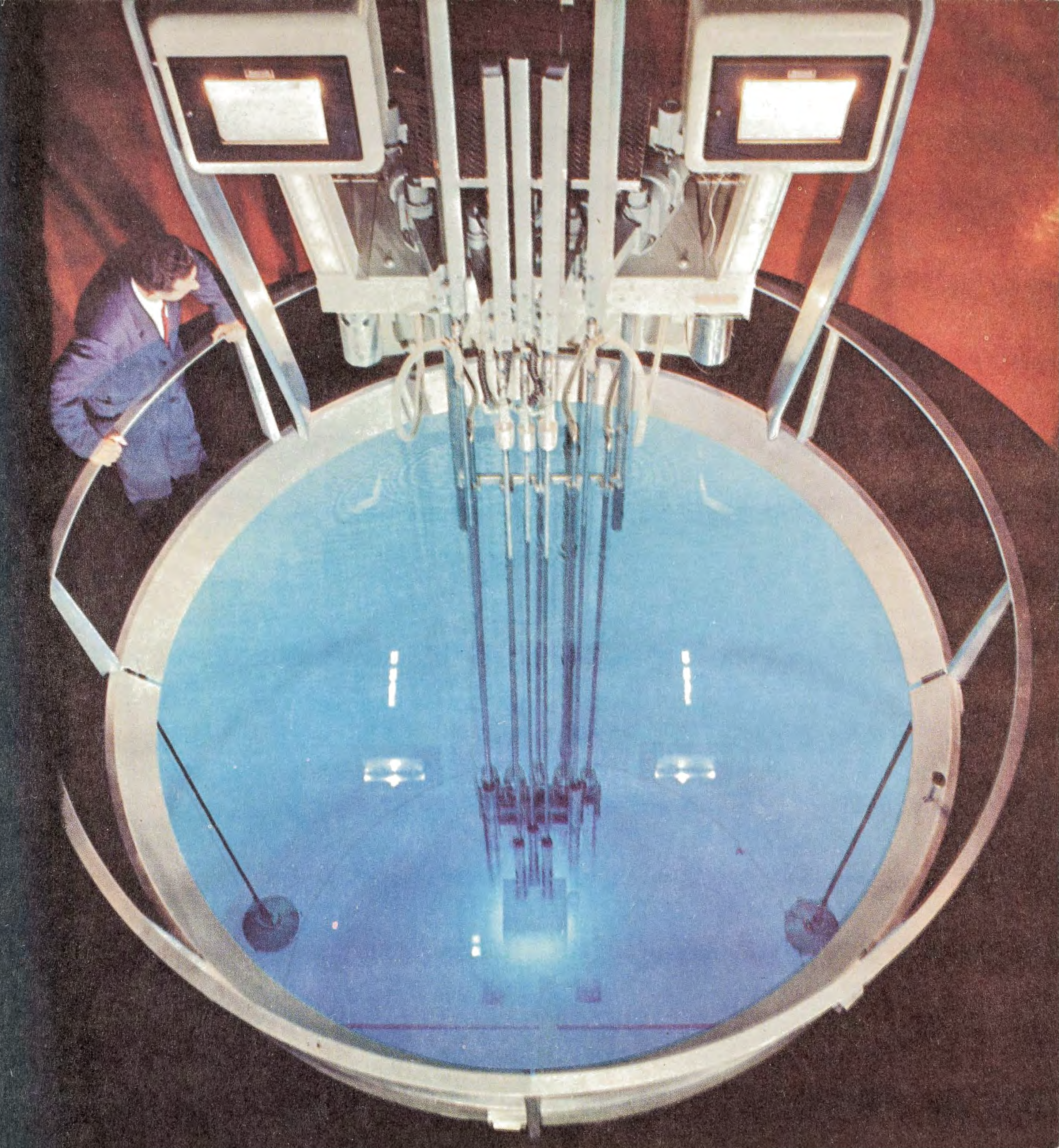
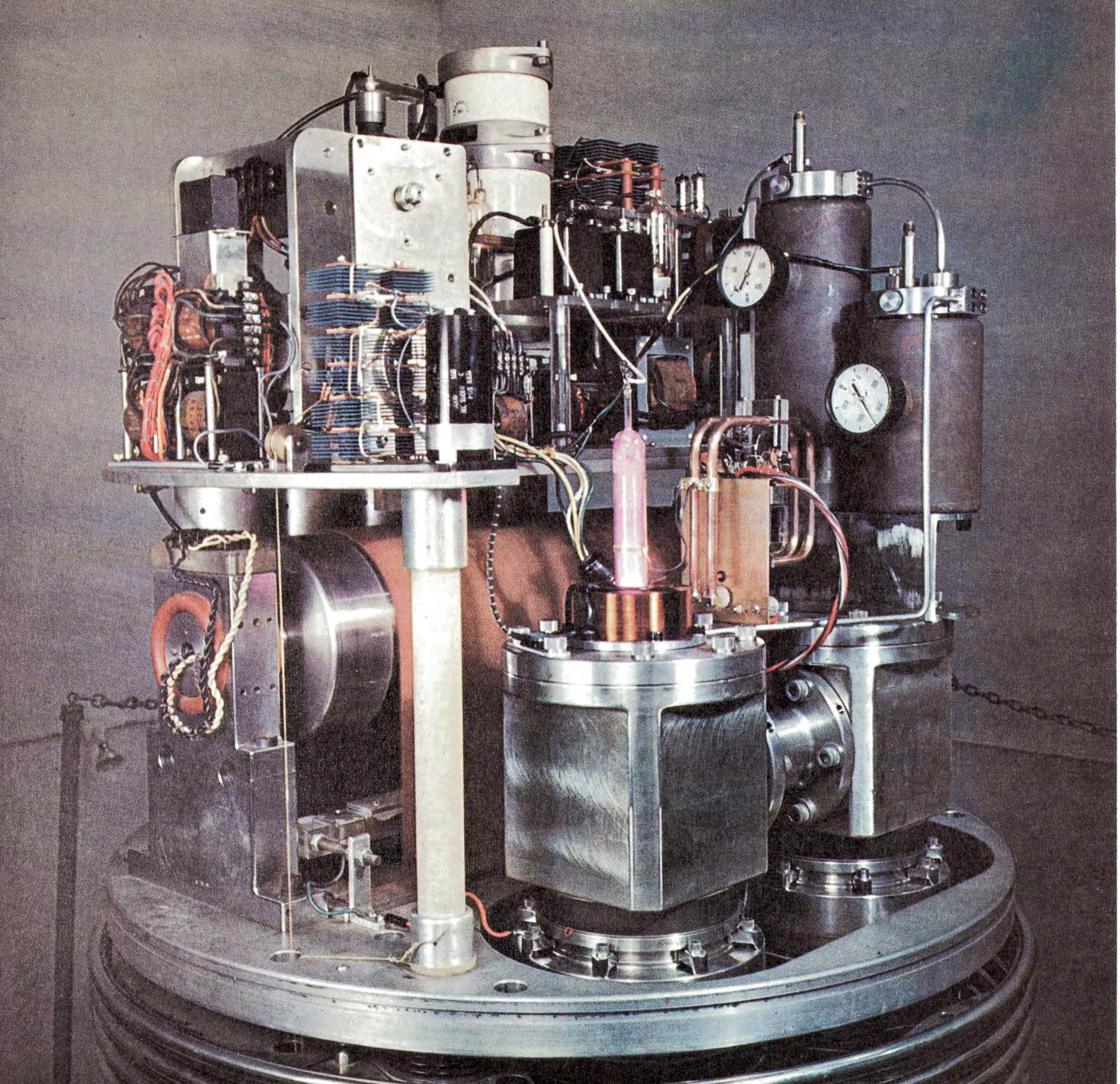
THE OAK RIDGE NATIONAL LABORATORY

and its scientific activities

operated by
union carbide nuclear co.
for the united states
atomic energy commission





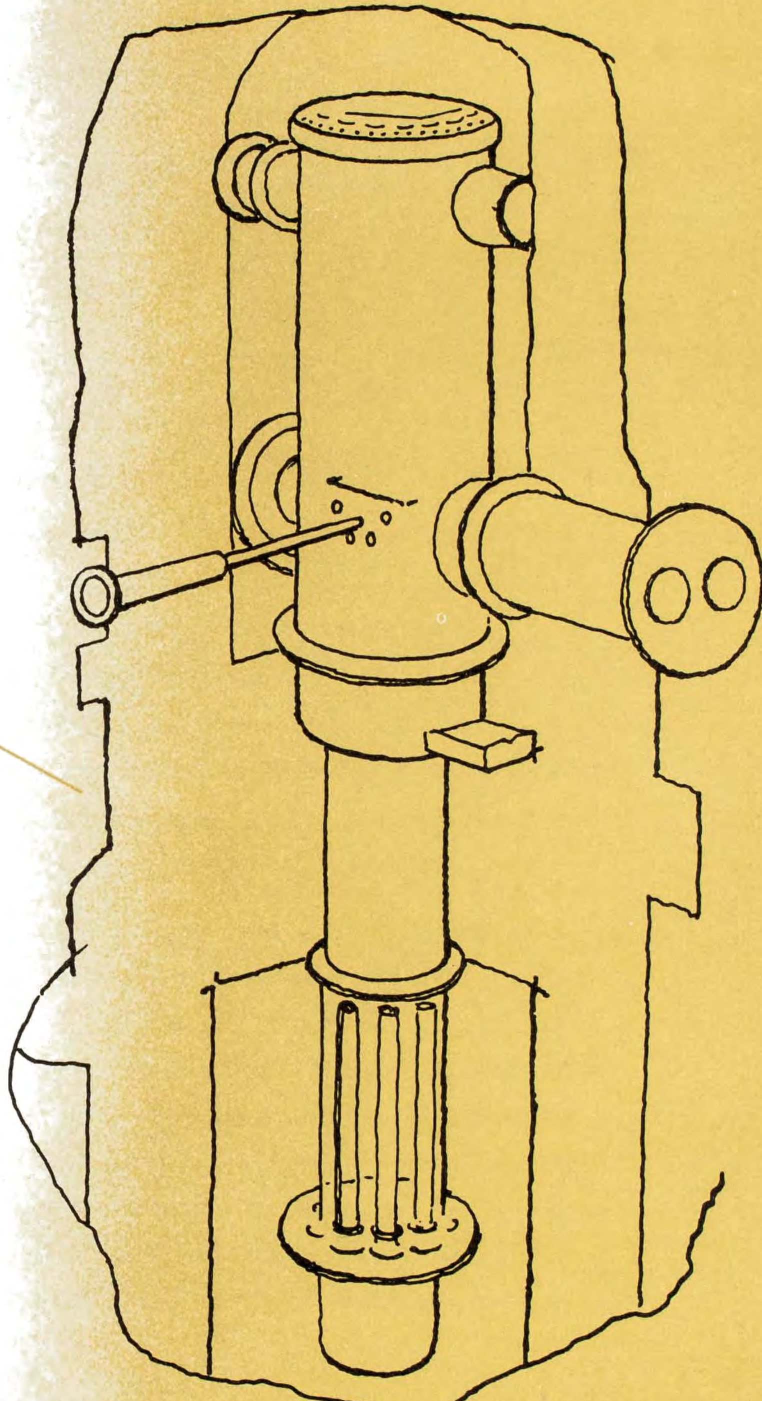
The high voltage head of the 5.5 million volt electrostatic generator, with cover removed. The pink object right of center is the radiofrequency ion source, glowing with a discharge in hydrogen. This kind of source was developed at Oak Ridge, and has been adopted for use in most electrostatic generators because of its outstandingly low gas consumption, low power requirements, and prolific output of atomic ions.

FRONT COVER

The Geneva Reactor, called "The Prettiest Reactor Ever Built".

THE OAK RIDGE NATIONAL LABORATORY

operated by
union carbide nuclear company
for the
united states atomic energy commission



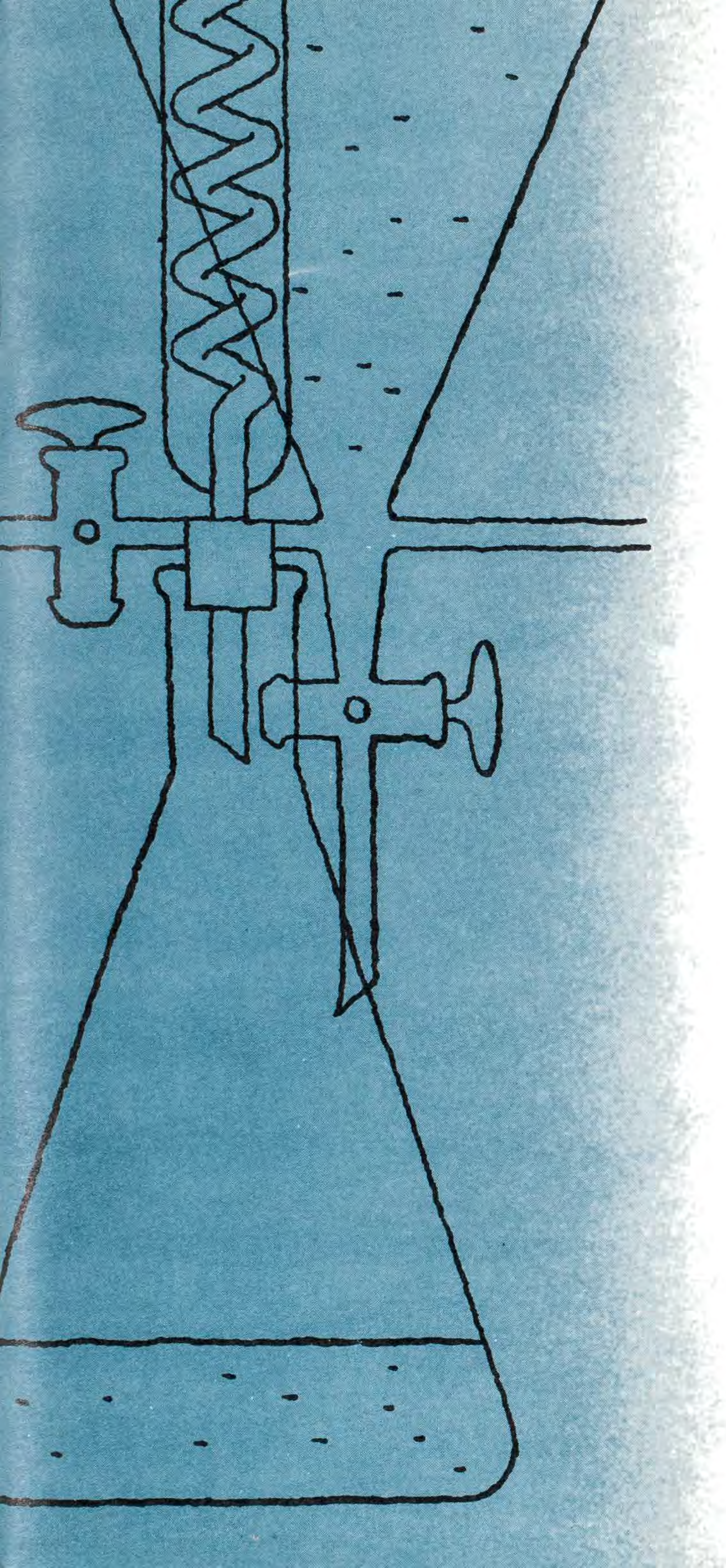
The Challenge of the Times

The forging of nuclear fission into a practical, economical energy source is one of mankind's most exciting ventures; tasks of such grand scope arise only rarely. It is the good fortune of us whose technical careers come at this period in human development to have such a worthwhile enterprise on which to expend our energy and our skill.

Since the task is a very large and difficult one, it is necessary that it be pursued in large and elaborate technical institutions. Several such institutions have sprung up throughout the world—they all have certain features in common, certain unique personalities. The existence of several institutions, both here and abroad, devoted to this task means that a certain lively competition, a certain rivalry inevitably has grown up between them. This competition is good; it serves as a stimulus to each of the institutions, and

as such hastens the day when mankind can enjoy the full benefits of successful nuclear energy. The most important aspect of this competition is of course people: an institution such as Oak Ridge National Laboratory can function effectively only if its personnel is representative of the best in American scientific and technical education. For such people there is at present an extraordinary demand; they are importuned on every hand, and some may be bewildered by the conflicting calls upon them.

This booklet has been prepared to describe to technical people who are beginning their careers the nature of the Oak Ridge National Laboratory—its scope, its spirit, its excitement. It has been written by senior staff members—engineers and scientists—for whom all this is their daily life. They have tried to capture the spirit of Oak Ridge in



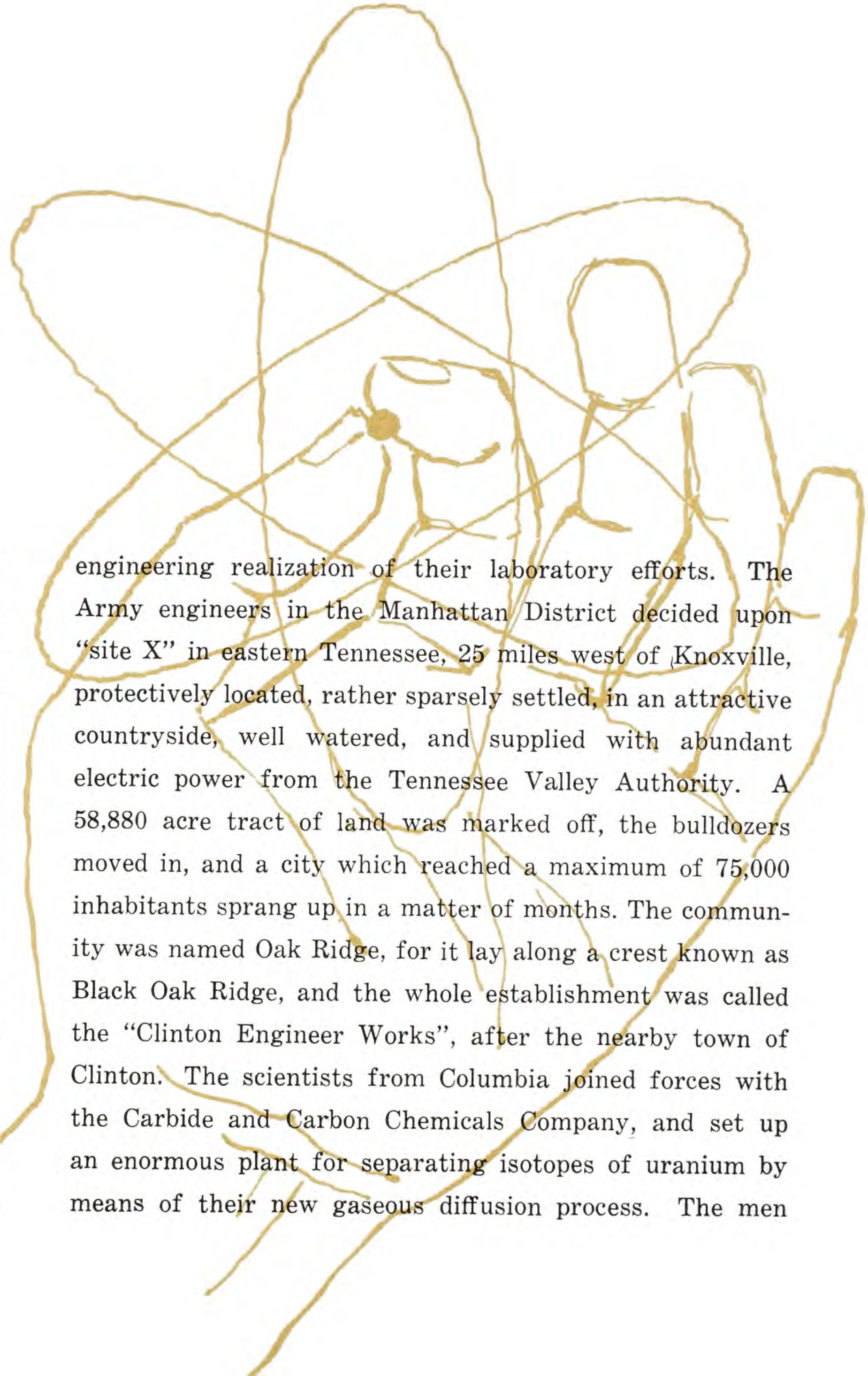
this booklet; and they hope, as does the Laboratory administration, that their message will convey to young technical people some of the enthusiasm, the glamour, and the interest which are so much a part of work at the Oak Ridge National Laboratory.

The basic mission of the Oak Ridge National Laboratory is the discovery of new knowledge, both basic and applied, in all fields relevant to the release of nuclear energy; most of the Laboratory's work is unclassified. In addition, the Laboratory produces stable and radioactive isotopes, and it carries out an extensive scientific educational program. This educational program is aimed on the one hand at the universities, particularly in the south; on the other hand, it is aimed at helping U.S. industry acquire the competence necessary to pursue the heavy technological and commercial phases of nuclear energy.

To carry out this mission, the Laboratory activities must range over all the fields of modern science and technology—from basic mathematics to heavy chemical engineering, from biology to metallurgy. It is this enormous breadth of technical coverage which enables the Oak Ridge National Laboratory to undertake successfully tasks, both in pure and applied science, which are beyond the capacity of smaller groups. It is this wide-ranging versatility which newcomers to the Laboratory find so stimulating, and so conducive to their own technical growth.

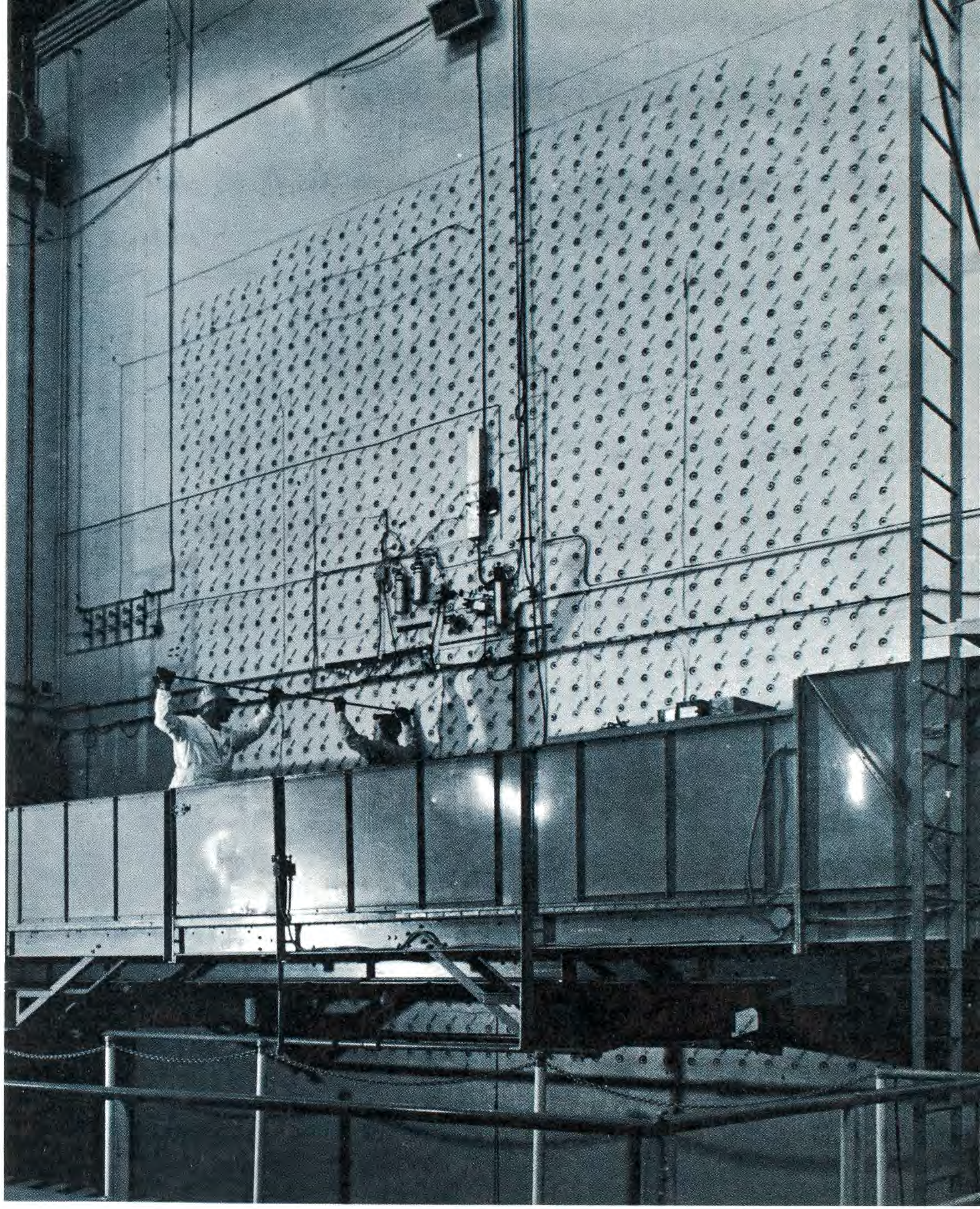
History and Organization

In the war years of 1940, 1941 and 1942 there emerged in the United States several physical research groups whose aim was centered on the exploration of techniques for releasing power from the atomic nucleus. The previously visionary nature of the idea had been somewhat modified by the 1939 discovery of fission in uranium. The groups soon combined into three main centers—one at the University of California in Berkeley, one at Columbia University in New York, and one deliberately misnamed the "Metallurgical Laboratory" at the University of Chicago. These efforts were coördinated under the sponsorship of the Office of Scientific Research and Development in Washington, but in a year they grew so big that they needed a new administration, and thus was born the now famous "Manhattan District" of the United States Army. Almost simultaneously, the three projects, plus a fourth, demanded large-scale engineering realization of their laboratory efforts. The Army engineers in the Manhattan District decided upon "site X" in eastern Tennessee, 25 miles west of Knoxville, protectively located, rather sparsely settled, in an attractive countryside, well watered, and supplied with abundant electric power from the Tennessee Valley Authority. A 58,880 acre tract of land was marked off, the bulldozers moved in, and a city which reached a maximum of 75,000 inhabitants sprang up in a matter of months. The community was named Oak Ridge, for it lay along a crest known as Black Oak Ridge, and the whole establishment was called the "Clinton Engineer Works", after the nearby town of Clinton. The scientists from Columbia joined forces with the Carbide and Carbon Chemicals Company, and set up an enormous plant for separating isotopes of uranium by means of their new gaseous diffusion process. The men



from California joined with the Tennessee Eastman Company and erected a fantastic set of magnetic separators as an independent attack on the same job. The fourth plant was designed and constructed for the separation job also, but its process, based on thermal diffusion, was deemed less promising and the project was discontinued. The physicists and chemists from Chicago had a different kind of problem on their hands. They joined forces with the DuPont Company, and it is their story that we wish to follow in particular.

Late in 1942 the Metallurgical Laboratory had succeeded in the controlled release of nuclear energy. Conditions had been found under which neutrons could propagate a chain reaction in uranium, burning the rare isotope U-235. This, however, was only the first step toward the wartime need. The chain reaction supplies extra neutrons which on being absorbed by the other uranium isotope, U-238, produce the new element plutonium. Plutonium in kilogram quantities was the objective of the moment. However, it was unsafe to operate a high-powered nuclear chain reactor in the midst of Chicago, with little shielding and under the knowledge that the reaction had in it the power to go out of control and cause a disaster. Therefore the Metallurgical Laboratory established at its branch, "Clinton Laboratories" in Oak Ridge, a much larger chain reactor,



The loading face of the historic graphite reactor.

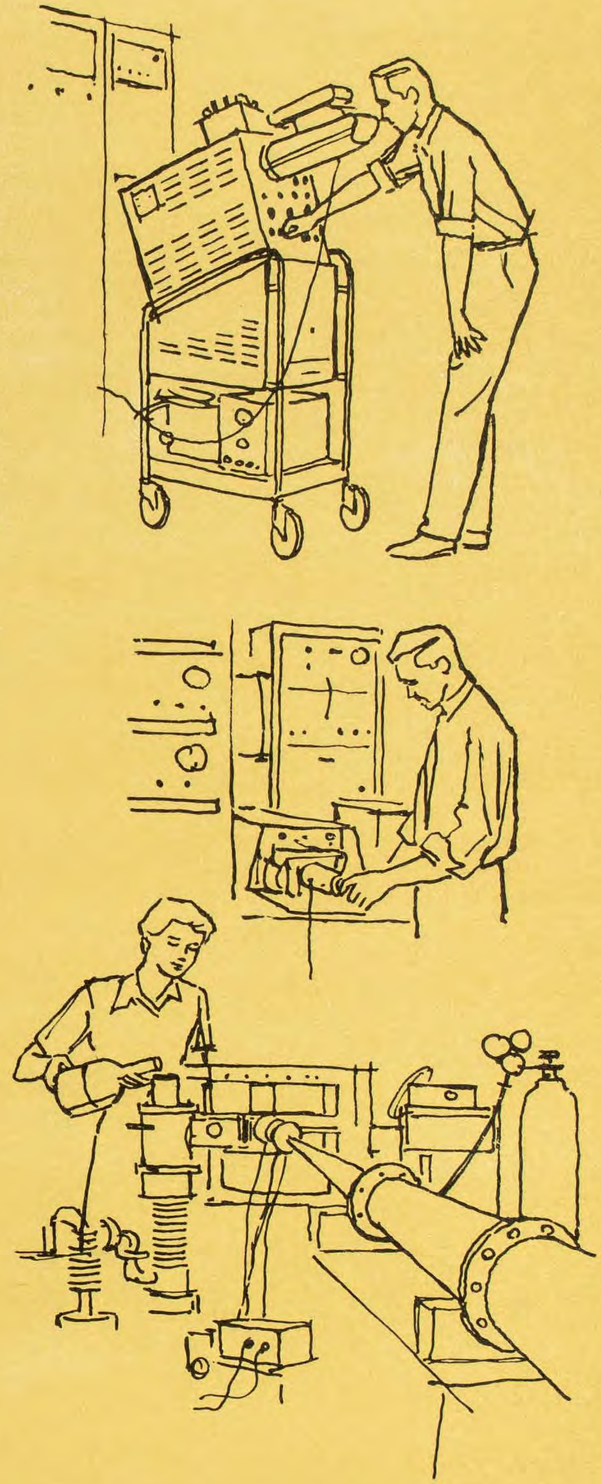
History and Organization

air-cooled and originally designed to dissipate 500 kilowatts of heat from nuclear fission, but quickly raised to several times that level. This "X-10" reactor was the first nuclear reactor to be run at power; it gave mankind its first experience in the behavior of reactors when they are operated under other than cold conditions. It also produced sufficient plutonium for testing on a pilot plant scale the plutonium-uranium chemical separation process that was adopted at Hanford in the full-scale production plants that realized the objective of the Plutonium Project.

Following the close of the war, there was an unsettled period in the new scientific community of Oak Ridge. What was its future? The new Atomic Energy Commission replaced the Army as the sponsoring government agency. The Army Headquarters office building became the Oak Ridge Operations Office of the Atomic Energy Commission. Tennessee Eastman retired from the contractual operation of the electromagnetic separation plant (the so-called "Y-12" plant), and the Carbide and Carbon Chemicals Company replaced them. Clinton Laboratories had been operated under a contractual agreement between the government and the University of Chicago, but the University soon retired from the picture. The Monsanto Chemical Company assumed the operational responsibility for a year, but then they also retired, and "Carbide" assumed the official operation of this institution also. Meanwhile there had been name changes, first to "Clinton National Laboratory" and then to "Oak Ridge National Laboratory". The contractual arrangement with Union Carbide has persisted to the present, with a change in 1955 under which a new company called the Union Carbide Nuclear Company was formed in the parent organization; it is this company that now operates the

gaseous diffusion plant, the Y-12 plant, and the Laboratory under contract with the Atomic Energy Commission. All members of the Laboratory are employees of the Union Carbide Nuclear Company. Thus the Laboratory is a unique blend of industry, university, and government; its tradition and its methods of operation have been influenced by all three.

The post-war years were also a period of readjustment for the technical staff. Many left for university positions, some went to other National Laboratories and others scattered more widely. Most of the senior staff of the electromagnetic plant returned to their positions in California, their mission in Tennessee accomplished. Nevertheless a nucleus of experienced staff members remained at the Laboratory; confidence grew between them and the Atomic Energy Commission, support was forthcoming, and there ensued a period of consolidation and growth. The basic scientific activities at the electromagnetic separations plant were absorbed into the National Laboratory. An aircraft nuclear propulsion project was launched, complementary to one previously operated by the Fairchild Company. A strong Biology Division was established. Staff members saw jobs that had to be done and obtained the necessary support, and the Atomic Energy Commission threw to the Laboratory major operational problems that were part of the burgeoning atomic energy business. Since those difficult post-war years, the history of the Laboratory has been one of continuous growth. It is now an institution of some 3,500 people, with an annual budget of several tens of millions of dollars and is to be ranked with the world's great technical institutions. Despite its comparative youth its impact upon science and engineering is respected by informed people throughout the world, and the following pages may briefly and superficially indicate some aspects of its current activities.



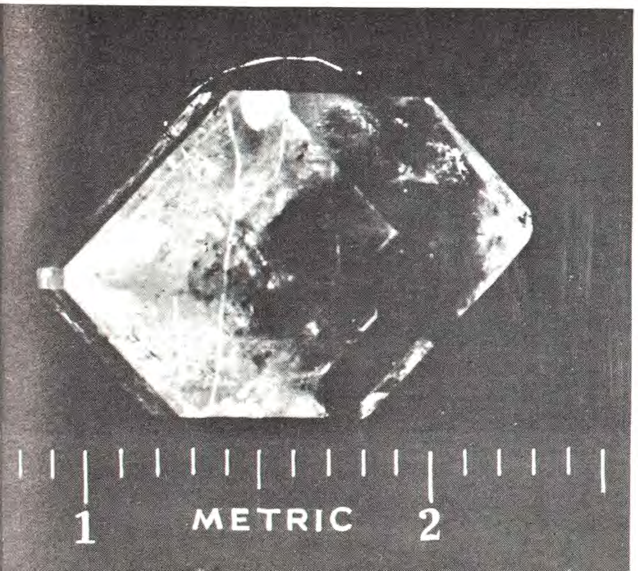
Chemistry

Technetium, one of the reactor-produced new elements

All kinds of activities in chemistry are pursued at the Laboratory; of all the National Laboratories, Oak Ridge has traditionally had the strongest roots in the chemical sciences. We shall speak of the deeper reaches of biochemistry in our section on Biology, and the very extensive Chemical Engineering efforts will also be dealt with later, but here we shall deal with "basic chemistry". Activities on the borderline between chemistry and physics include work in beta and gamma ray spectrometry, radioactive disintegration schemes, and neutron diffraction as applied to the location of hydrogen atoms in crystal lattices. The measurement of nuclear quadrupole moments by microwave methods has been pursued with rich success, the same general methods lending themselves to determination of spins and magnetic moments of radioactive nuclei and the demonstration of free radicals in solids following irradiation with gamma rays. Molecular beam methods are used to study the reactions and interactions that take place in individual molecular collisions. Radiation chemists seek to understand molecular breakdown processes in various materials under reactor radiation, gamma rays, or electrons from a Van de Graaff machine. In the field of inorganic chemistry, the Laboratory has pioneered in the use of ion exchange methods for the separation of the rare earths. The first gram amounts of plutonium, neptunium, promethium, technetium and americium have been produced here. Sorption studies involving all kinds of ion exchangers, both organic and inorganic, have led to the delevelopment of new and powerful techniques such that now almost any element can be separated from any other, quickly, efficiently and cheaply. There is great interest in high temperature chemistry in aqueous, fused salt and liquid metal systems. This is partly motivated by the problems posed by the development of high temperature power reactors, and partly it is simply in line with a strong trend in modern chemistry. The techniques are difficult; the white-hot metals and fused salts are often extremely corrosive, but nevertheless phase diagrams, densities, electrical conductivities, and self-diffusion data have been obtained in many systems of interest. In organic chemistry an important group is engaged in synthesizing carbon-14 and phosphorus-32 into specified locations in specified molecules — tools to be placed in the hands of chemical and biochemical research teams here and elsewhere, in the present and in the future. A large analytical chemistry group brings all kinds of modern techniques to bear upon problems brought to it by all sections of the Lab-

A "hot cell" for kilocurie fission product separation. The view is into the side of the cell, the heavy, white-painted lead doors of which have been swung open. Through the larger doors one sees the inside of the control face of the cell, and the slender horizontal rods serve for the remote turning of valves and for other manipulations on the apparatus, which is hidden from view to the right of the large door.

High-temperature solubility studies. The spiral object is a heater, and the investigator observes the dissolution of crystals contained in a small tube within the heater.



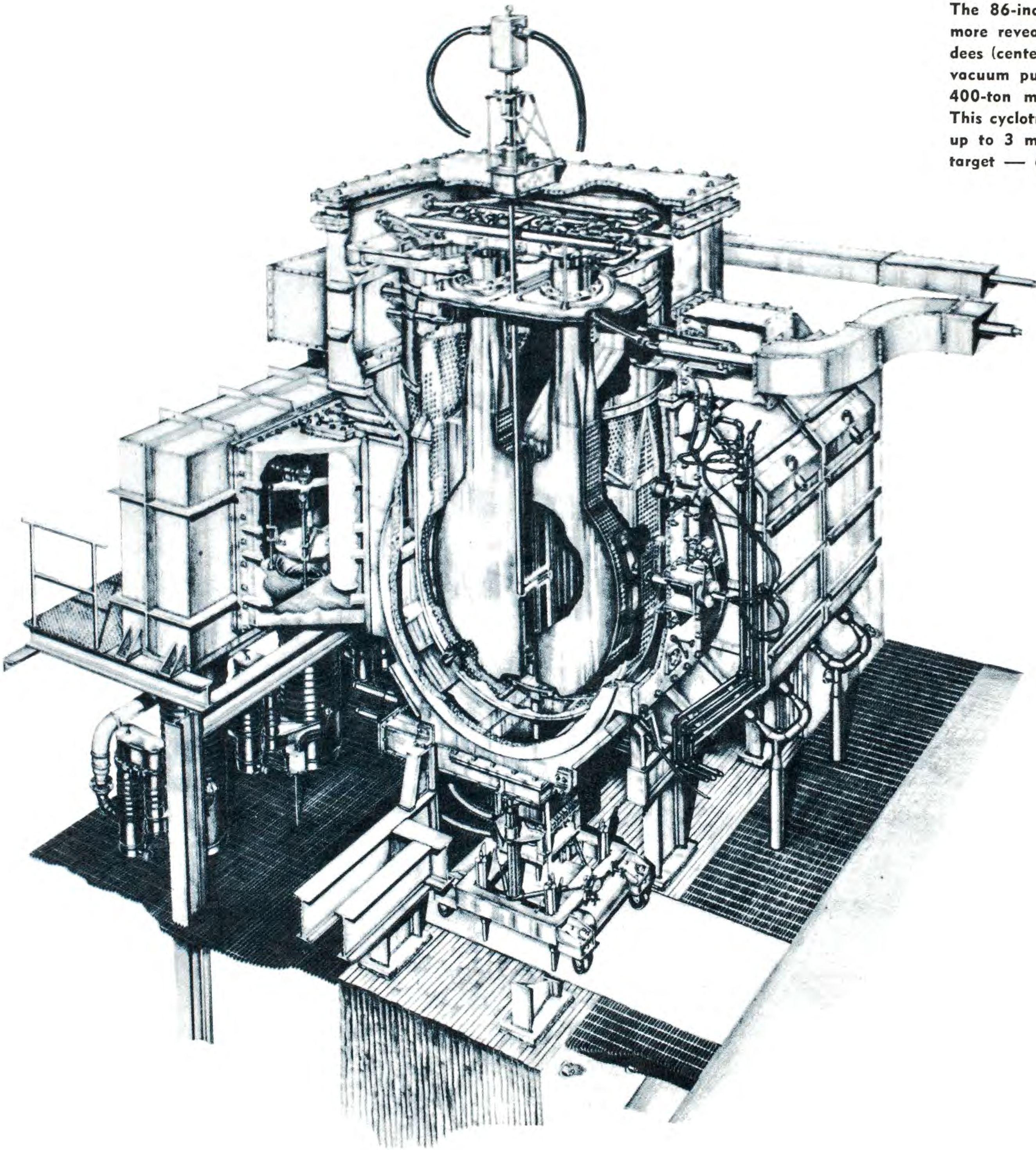
A beautiful crystal of uranyl rubidium nitrate, coated with an external layer of neptunyl rubidium nitrate, prepared in the Chemistry Division for a low-temperature nuclear physics experiment.

oratory: the old-established methods are supplemented by spectrochemical analysis, polarography with sensitivity down to a millionth molar, flame photometry, and radiochemical methods using scintillation spectrometry. Supremely sensitive activation analyses are carried out here on a service basis as part of the Atomic Energy Commission's national program. The analytical people always keep a sharp lookout for new, more accurate, faster and cheaper procedures. They have developed solvent extraction methods for protactinium, neptunium, plutonium and americium that are now widely adopted throughout the country. This group, whose main function is a valued one of service, is nevertheless infected with the same spirit of investigation that pervades all of the other Laboratory activities.

Physics

The diffraction of neutrons by crystals. The spots are caused by the concentration of the intensity of the neutrons into certain directions determined by the interaction of the neutron waves with the crystal lattice.

Physics, like chemistry, spreads widely through the Laboratory. As one of the basic sciences, it provides the satisfaction and the power that come from the understanding of nature, and it contributes to the background of knowledge upon which future technology can be built. At Oak Ridge it is of course strongly present as nuclear physics, but solid state physics, low temperature physics, biological physics, spectroscopy, mass spectrometry, chemical physics, reactor physics and theoretical physics are well represented also. The major research tools are five reactors, including the new high-flux reactor known as the Oak Ridge Reactor (ORR), three cyclotrons, two electrostatic generators, several high voltage supplies, a neutron beam chopper and other machines as occasion demands. Here the radioactivity of the neutron was observed in 1949-1950, here was the first electrostatic generator operating above 5 million volts, here the development of the field of neutron diffraction, now so important in the study of the magnetic structure of matter and in the location of hydrogen atoms in crystals, here the theory and realization of the spatial alignment of atomic nuclei, definitive and accurate measurements of the subtle effects caused by neutrino emission, and a wide variety of neutron cross section measurements. The first cyclotron built expressly for accelerating multiply-charged heavy ions has led to pioneer work on their interaction with matter, on their scattering and on the wide variety of nuclear reactions that they can produce. The high-current 22 Mev proton cyclotron serves as the primary tool in a revealing study of the diffraction scattering of protons by light, medium and heavy nuclei. The solid state physicists find a nice interplay between basic and applied work; they use the reactor radiations to induce defects so that the properties of solids can be studied in a fundamental way, then they turn around and attempt to apply the knowledge so gained to radiation damage problems that can in practice be so serious as to limit the lifetime of reactors and have determining effects upon reactor design and operating practice. They have developed a unique apparatus in which solids can be held at liquid hydrogen temperatures while in the middle of a hot reactor, the purpose being to "freeze into" the solid the

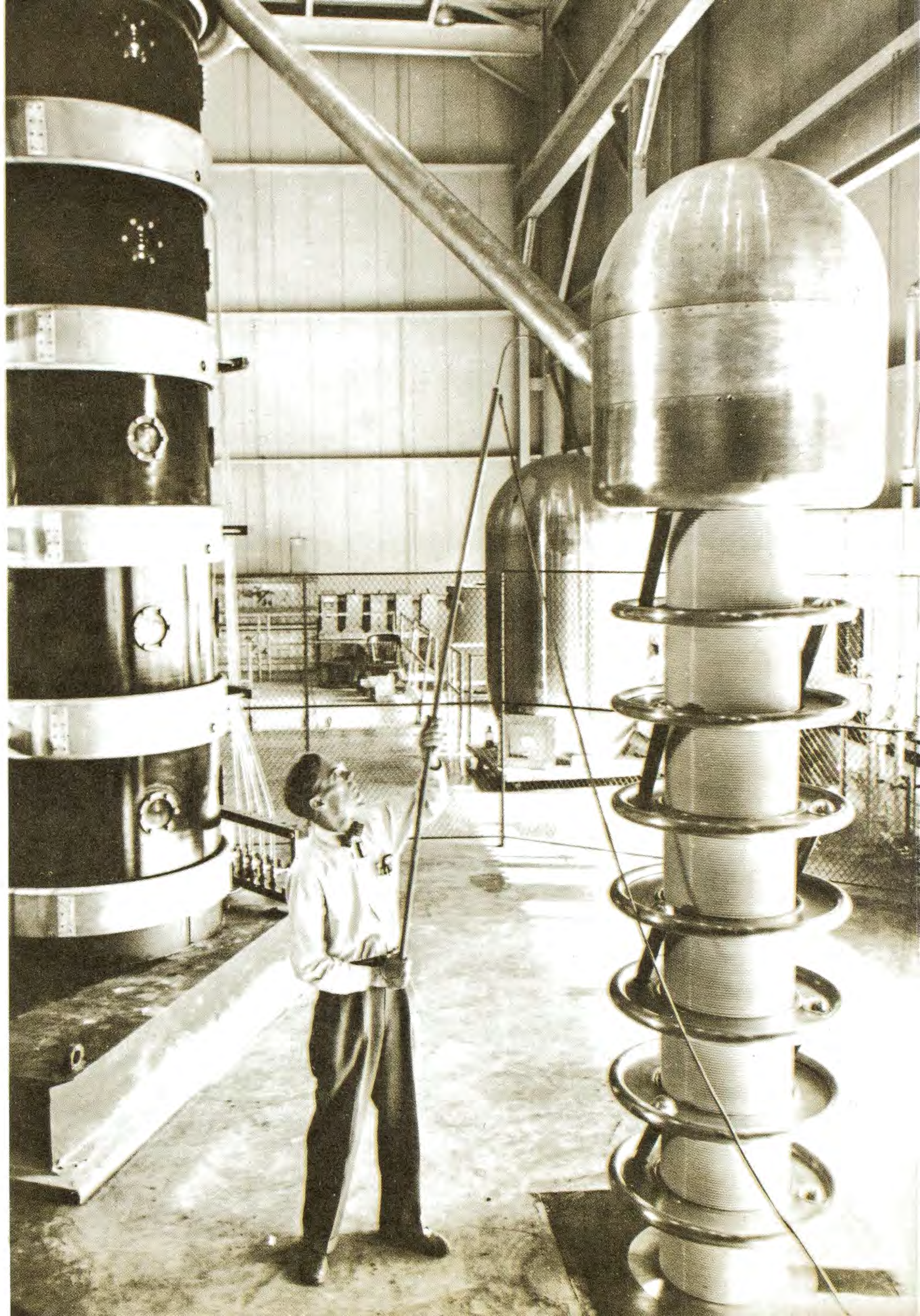


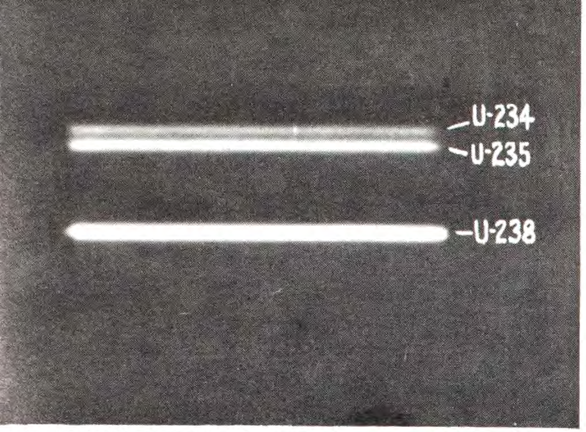
The 86-inch cyclotron. This cut-away drawing is more revealing than a photograph could be. The dees (center) hang from vertical supports, and the vacuum pumps are to the left. The yoke of the 400-ton magnet is only partly shown (bottom). This cyclotron has produced 22 Mev proton beams up to 3 milliamperes in intensity on an internal target — 66 kilowatts of beam power!

. . . *Physics*

damage that is caused by the reactor's radiations. Everywhere theoreticians consult extensively with experimentalists, and also work on problems of their own; the extensive and complex computation of internal conversion coefficients that has been in progress for several years is an example. Both theoretical and experimental physicists at Oak Ridge concern themselves with the extraordinarily difficult problem of the controlled release of thermonuclear energy. Reactor physicists devote their attention to problems of neutron diffusion, shielding, breeding, heat removal, poisoning, and so on. Their theoreticians compute the amounts of uranium needed to make a chain reaction start in a given assembly, their experimentalists test the computations by building live critical experiments in a special building, using enriched uranium. There is a close and meaningful interchange between the physicists interested in application to reactors, and the physicists devoted to more basic pursuits. The work of each group serves, mutually, to stimulate and guide the work of the other. The popular "swimming pool" reactor was originated in this Laboratory. Physical instruments like the A-1 amplifier have been developed here, adopted by manufacturers, and used in laboratories all over the country. This is how a National Laboratory contributes to the scientific strength of a country and of the world; the progress is step by step, the work is painstaking, and sometimes unspectacular, but the underlying concepts and purposes are far-sighted.

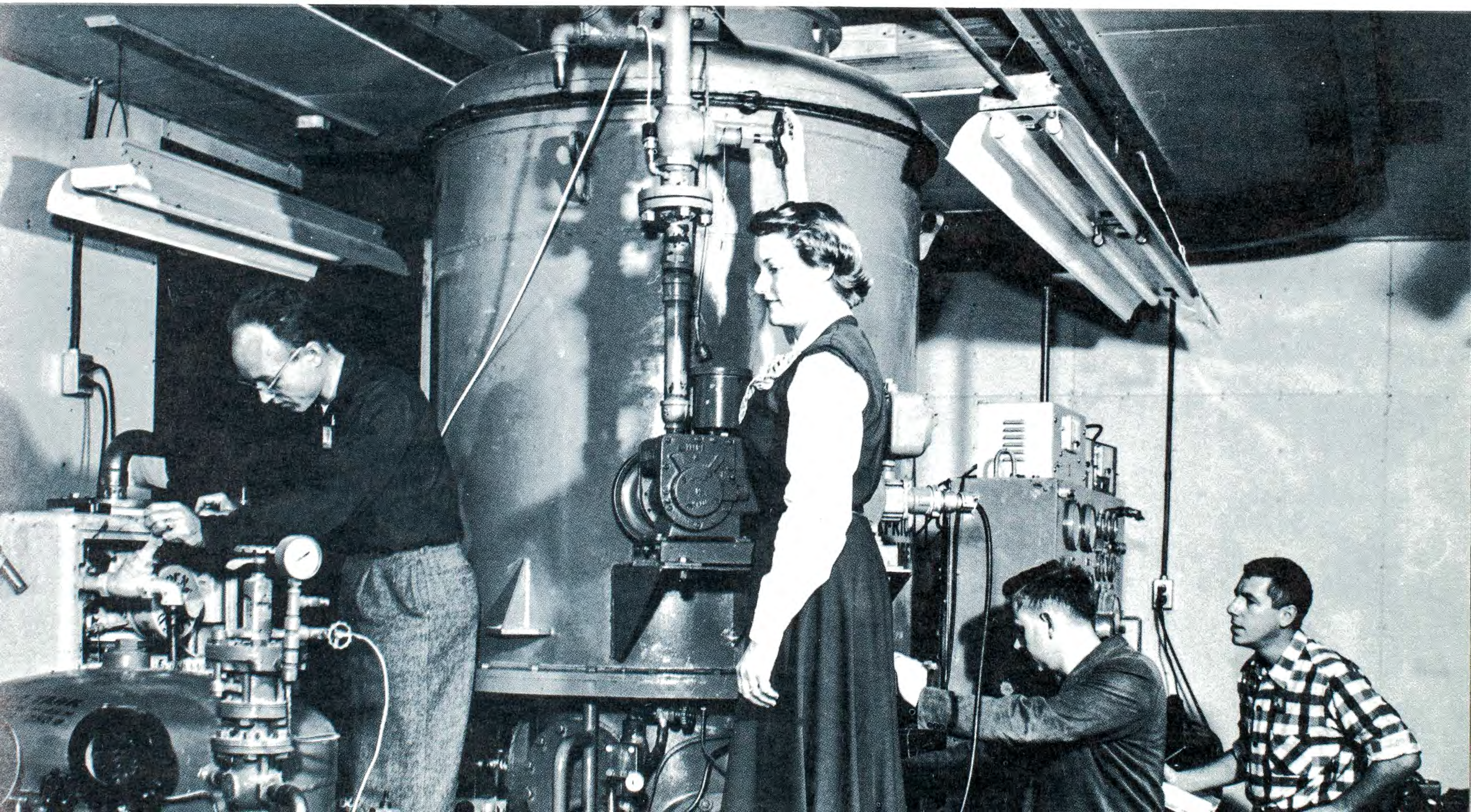
The high-tension set in the High Voltage Laboratory. At the left is the 600,000-volt d.c. power supply, and at right is an ORNL-developed vacuum bushing that takes this full voltage through a hole only 18-inches in diameter in the floor for experimental use with an ion-acceleration tube below.





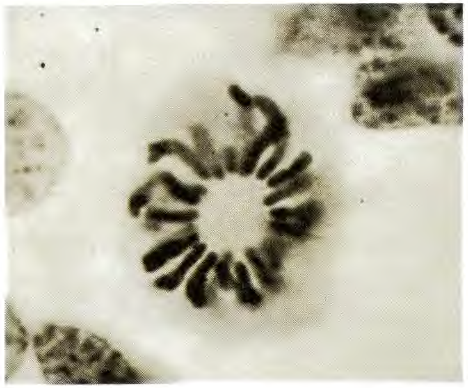
High-resolution optical spectroscopy; isotope shift observed in the spectral lines of uranium.

Helium refrigerator used for low-temperature solid state studies of radiation damage to experimental samples deep in the graphite reactor.



Biology

A neuroblast cell of the grasshopper in mitosis.



Radiation has such complex and far-reaching effects upon living things that the limitations of the subject, if indeed they exist, are far from visible to us today. At the Oak Ridge National Laboratory, a Division of a hundred and twenty people, ninety of them technically trained, is busily engaged in learning more about the basic processes of biology, and the changes that can be induced in the processes by radiation. Fundamental research on chromosome mechanics, gene action, cytoplasmic inheritance and cell division is linked with genetic, cyotological and cytochemical experiments on the effects of radiation upon such organisms as maize, Neurospora, Drosophila, Paramecium, Tradescantia, ascites tumor cells, and grasshopper neuroblasts. The question of the genetic effects of radiation in mammals is under investigation in a large program devoted to the genetic and developmental effects of radiation upon mice, the methods of observation including histopathological studies of radiation damage to the gonads, and the observations are accepted as being of closer applicability to man than previous genetic studies using (for the most part) Drosophila.

The search for protective compounds and treatments that can lessen the harmful effects of radiation has led to the synthesis of AET, the most successful of a long series of experimentally designed compounds, and the search continues. In one research program, microorganisms are used to study the protective action of physical and chemical agents. Nutritional effects receive their share of attention. The results obtained from the studies of microorganisms are carried over to mammals, where additional techniques can be brought into play; for example, hemotopoietic tissues can be added, and a number of blood studies can be carried out. Severe radiation exposure to mammals leads of course to an acute syndrome and later consequences, such as neoplasia, leukemia, cataracts and aging; the pathogenesis of these effects presents many difficulties of investigation, but effort is pointed toward its elucidation.

There are other activities, some of which have little direct connection with radiation effects. In cellular physi-

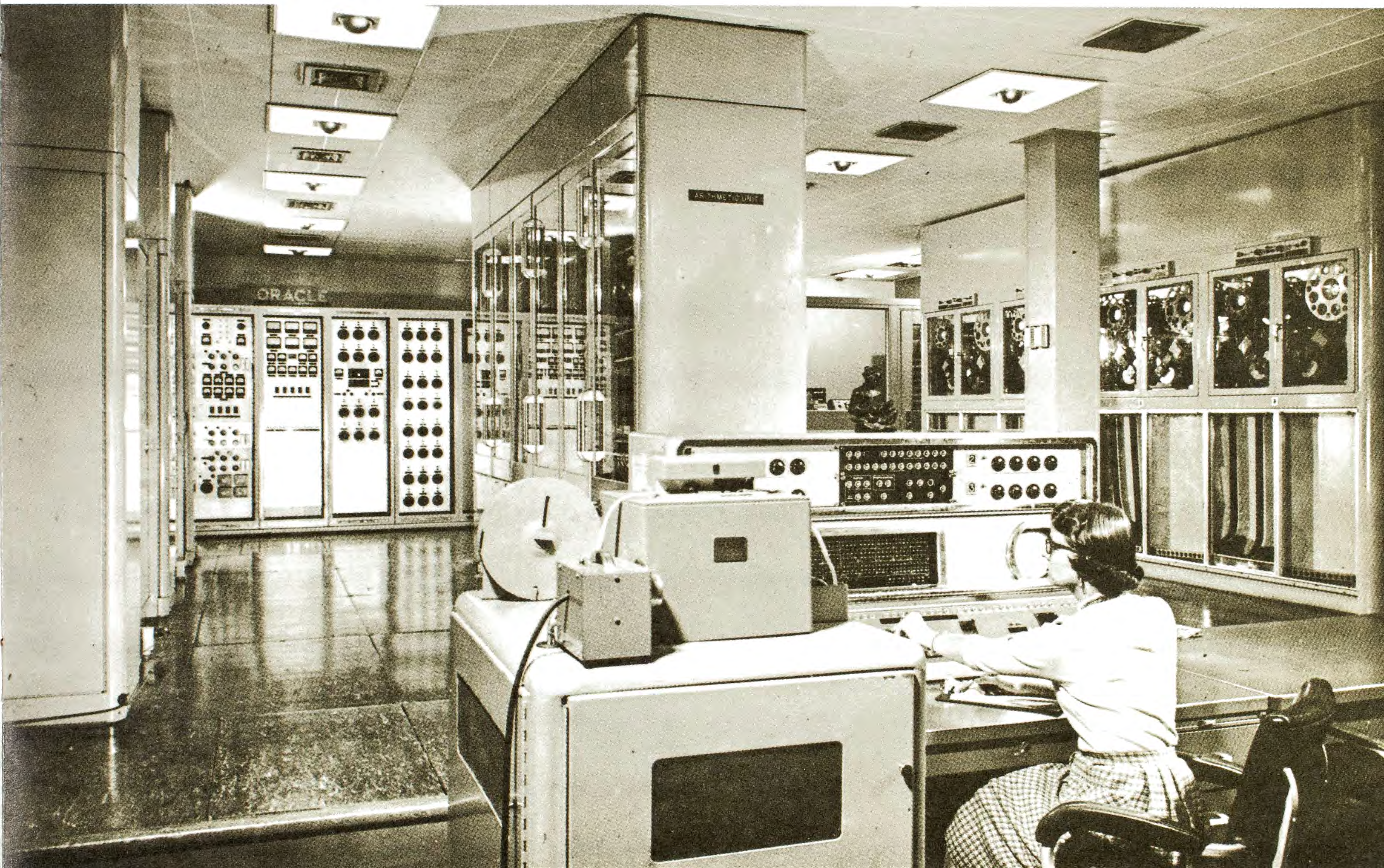
A corner of the mouse colony, where nearly a hundred thousand mice live in air-conditioned comfort.

ology, the separation and study of micro-cellular components are being carried out by advanced chemical, physical and immunological methods. Four biochemistry groups devote themselves to a varied program including the structure and functions of nucleic acids; the biochemistry of bacteriophage infection; enzymology and metabolism in plant respiration, growth and photosynthesis; enzymology of bioluminescence; and several other matters. Finally, returning again to radiation effects, a biophysics group is looking at the nature of physical interactions of various kinds of radiation with biological materials and with simple chemical model systems; these men also lend advice to their colleagues when, as frequently happens, problems of dosimetry arise.

As in the descriptions of activities in the other sciences, the catalogue we give is not exhaustive, but it will be sufficient to convey some impression of breadth and depth of the biological research.

Mathematics and Computing

A staff of twenty people is available to aid research workers in all fields in the widespread computational problems that are part of research. Experienced senior mathematicians and statisticians advise as to procedure, and competent junior mathematicians follow the problems through to their answers. The group makes extensive use of the famous "Oracle" (Oak Ridge Automatic Computer and Logical Engine), an electronic digital computer of the von Neumann type that uses electrostatic tubes for internal memory and magnetic tape for auxiliary memory. The electrostatic, very fast memory, has a capacity of 2048 40-digit words; the auxiliary, somewhat slower memory, can store several million words. Your problem might be the calculation of the amount of enriched uranium required to make a reactor of some conceptual design go critical, or it might be a problem in genetics, or it might be (as is often the case) a simpler matter of fitting the fairest curve through a set of scattered experimental points. In any case, you are apt to become one of those familiar figures going down a corridor clutching a long piece of paper covered with figures in orderly array—the printed answers of the Oracle, ready for your interpretation.



The Oracle. The bank of equipment at extreme left contains the electrostatic memory unit, the central bank contains the arithmetic unit, and the bank at right contains the magnetic tape memory units. The console is in the foreground.

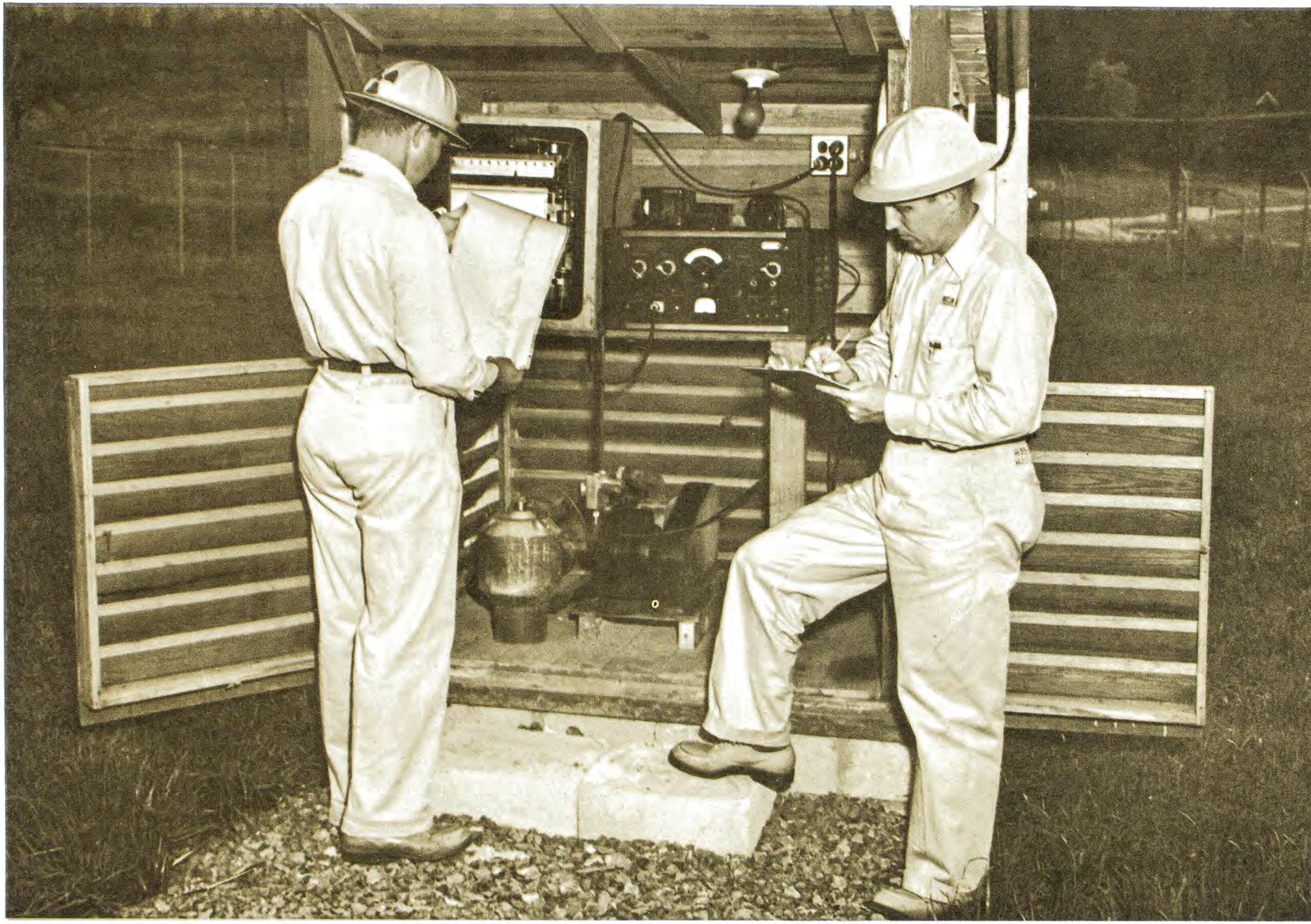
Health Physics

The utilization of nuclear machines, the threat of nuclear warfare and the impending realization of a nuclear power industry raise far-reaching questions about the basic nature of radiation health hazards. The Health Physics research program seeks to find some of the answers. How much of any one of the 40 radioactive fission elements can be tolerated in the human body? This is an example in the difficult realm of the establishment of standards of maximum permissible dose. Laboratory staff members contribute prominently in international committees that have been organized to study dosage problems of this kind. There is research into the theory of the mechanism of tissue damage, and into the theory of dosimetry. The development of instruments that will separately measure the dosage delivered by the various constituents of a mixture of radiations has been a long-standing problem, now approaching solution. The gauging of the dangers of radioactive dust particles that could lodge in the lungs, the measurement of the number and size of such particles, and the development of methods for their removal from the air constitute another set of problems. Long-range studies of the concentration in aquatic life of radioactivity in rivers and the effect of radioactivity upon balanced life systems take their logical place in the program.

There are more immediate and practical efforts too. In cooperation with the Army Engineers, Oak Ridge health physicists have designed and evaluated a truck-mounted water purification system to supply a small town with drinking water in the event of radioactive contamination of the regular supply.

The disposal of the radioactive wastes of a nuclear power industry has been a matter of concern all over the world. There will be tons of this stuff within the next decade or two, and every milligram of it will be nasty. The Laboratory's methods of ground disposal hold promise of being cheap, efficient and safe. Finally, there is a group of seventy health physics surveyors following the radiation history of all Laboratory employees, monitoring the handling of radioactive materials, and watching the radioactivity level in the atmosphere, not only at the plant site but in several nearby communities. Because of this vigilance no employee in the history of the Laboratory has had a radiation exposure that required him to take a forced vacation, nor even an average exposure exceeding the accepted weekly tolerance. The organized accumulation of accurate, reliable exposure records for this large number of persons over the years will be of tremendous value in establishing the radiation tolerance levels of the future.

Health Physics; checking an air monitor.

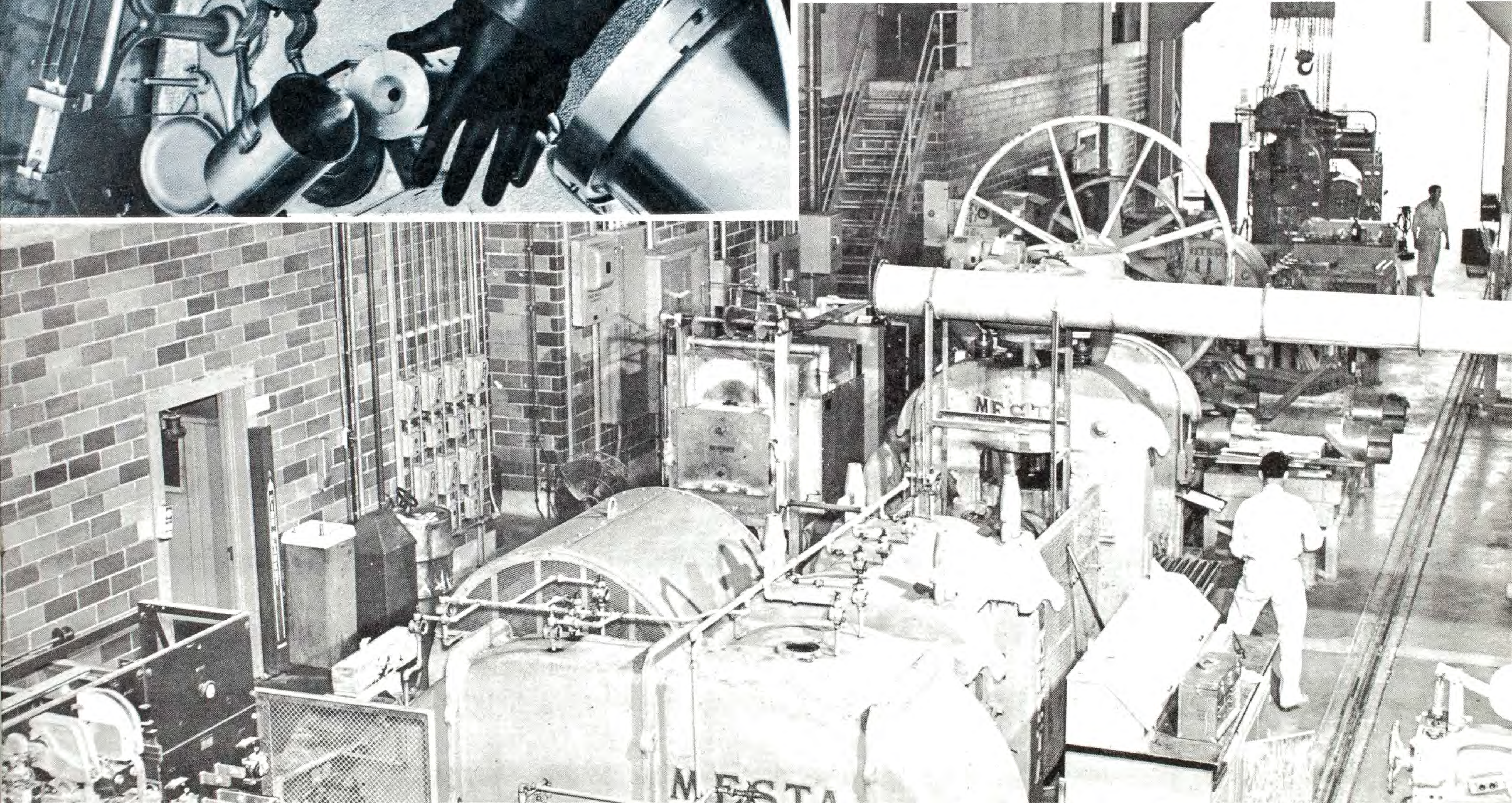


Metallurgy

Reactor engineering makes such unusual demands upon structural materials that it is inevitable that rare metals and new alloys must come into the picture. Where but in reactor fuel elements would one encounter the simultaneous requirements of high heat transfer, high corrosion resistance, chemical compatability, dimensional stability, resistance to radiation damage and low neutron absorption? About a hundred and fifty people devote their attention to the new and profound problems that have presented themselves to the metallurgist. Basic investigations are directed toward the properties of metals like zirconium, uranium and thorium, both in the pure state and in a host of alloys. The techniques of x-ray diffraction at low and high temperatures, electron diffraction, electron microscopy, and metallography are applied to systems to elucidate their microscopic structure. Corrosion and surface phenomena in non-aqueous media, the study of preferred orientation in worked material, the development of new welding methods and brazing alloys, the nondestructive testing of metals by radiography, ultrasonics and eddy current methods, stress rupture tests, and so on—the whole range of modern metallurgy finds expression in this group. There is a powder metallurgy laboratory, and a ceramics department. For the fabrication of intricate reactor components, there are vacuum furnaces, rolling mills, a swaging machine, a draw bench, and a large extrusion press. Here the "sandwich" fuel elements used in the Material Testing Reactor, the Geneva Reactor, the Bulk Shielding Reactor, the Low Intensity Test Reactor, the Army Package Power Reactor and the Oak Ridge Research Reactor have been designed and fabricated. The Division is equipped and ready to face the problems of the new kinds of reactors to come.

Metallurgy; pouring under an inert atmosphere.

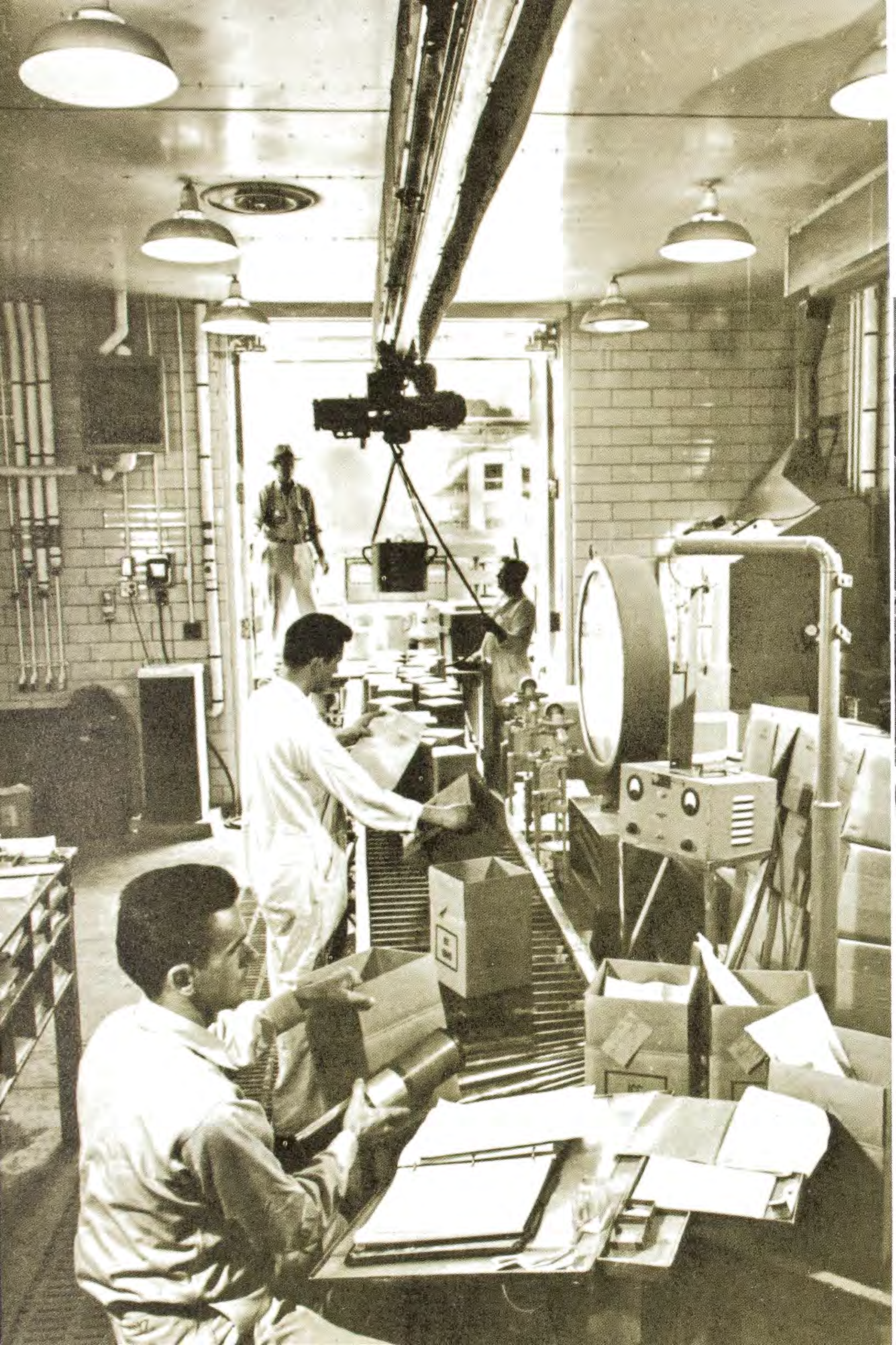
Metallurgy; part of the rolling mill building.



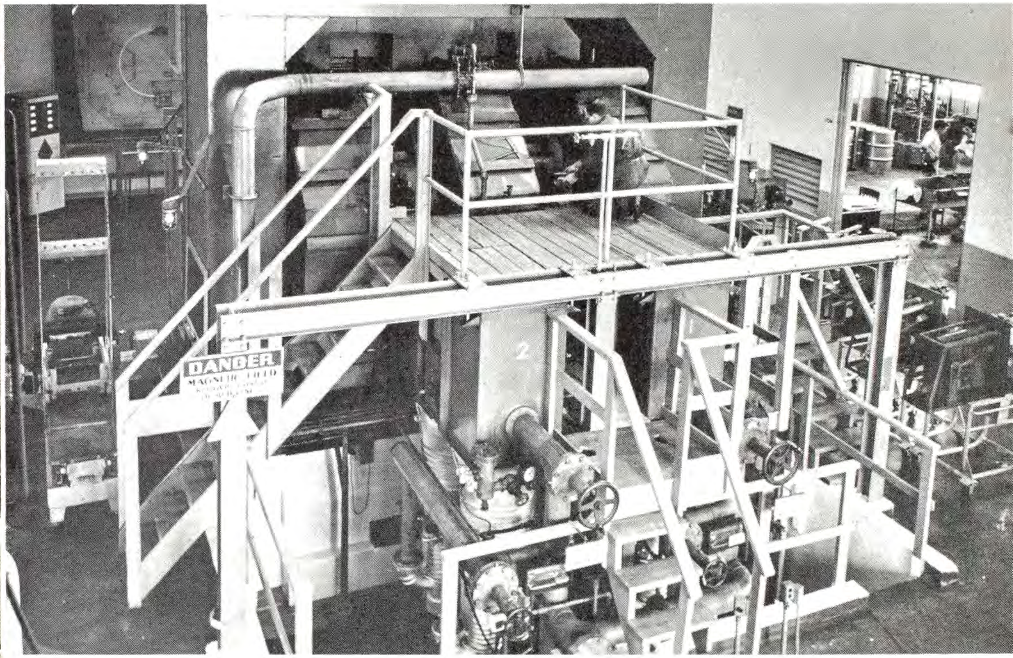
Isotope Production

"Isotopes from Oak Ridge" is a by-word throughout the scientific world. Those of the radioactive variety are mostly made by irradiation in the graphite reactor, and, as everybody knows nowadays, they are widely used in research, industry, medicine, agriculture and education. The preparation, purification and shipping facilities at the Laboratory have been in continuous use since 1946. In 1955, 13,250 shipments were made of 84 different varieties, mainly to institutions in the United States, but in lesser quantity to a dozen foreign countries. In cobalt-60 alone, 40,000 curies were shipped.

The separated stable isotopes have received less publicity than their glamorous companions, and they find their uses mainly in basic research. They have been historically difficult and expensive to separate in gram quantities, because each behaves almost exactly like its neighbor. Only a few are separable by chemical methods; for most elements the electromagnetic method must be used. The Laboratory's electromagnetic separators supply nearly all of the enriched stable isotopes used by the scientific world. Techniques have been worked out for all but a very few of the elements; each element presents its own problems in feed material, source design, operating conditions and collectors, so a priceless back-log of experience has been established. Last year 463 shipments of individual stable isotopes were sent to institutions in the United States and 43 to foreign countries. "Stable Isotopes from Oak Ridge" have formed the basis for hundreds of research articles that have appeared in scientific journals.

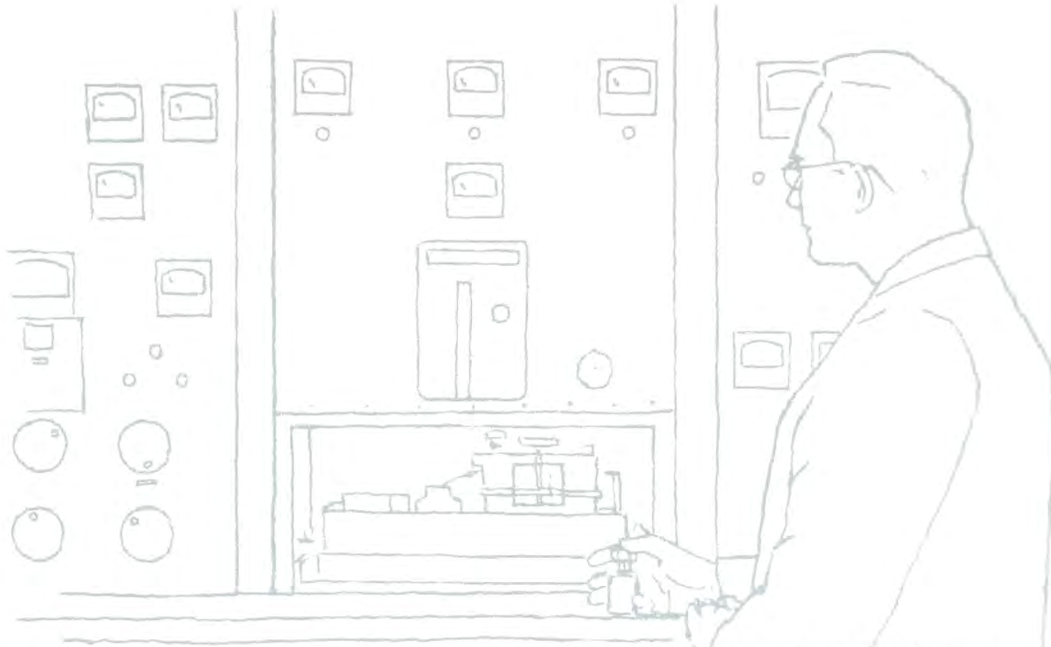


The shipping room for isotopes.



An electromagnetic separator for stable isotopes. The magnet yoke is visible behind the platform upon which a man is kneeling. Actually two separators, labelled 1 and 2, are built, side by side, into the same magnet.

Instrumentation and Controls



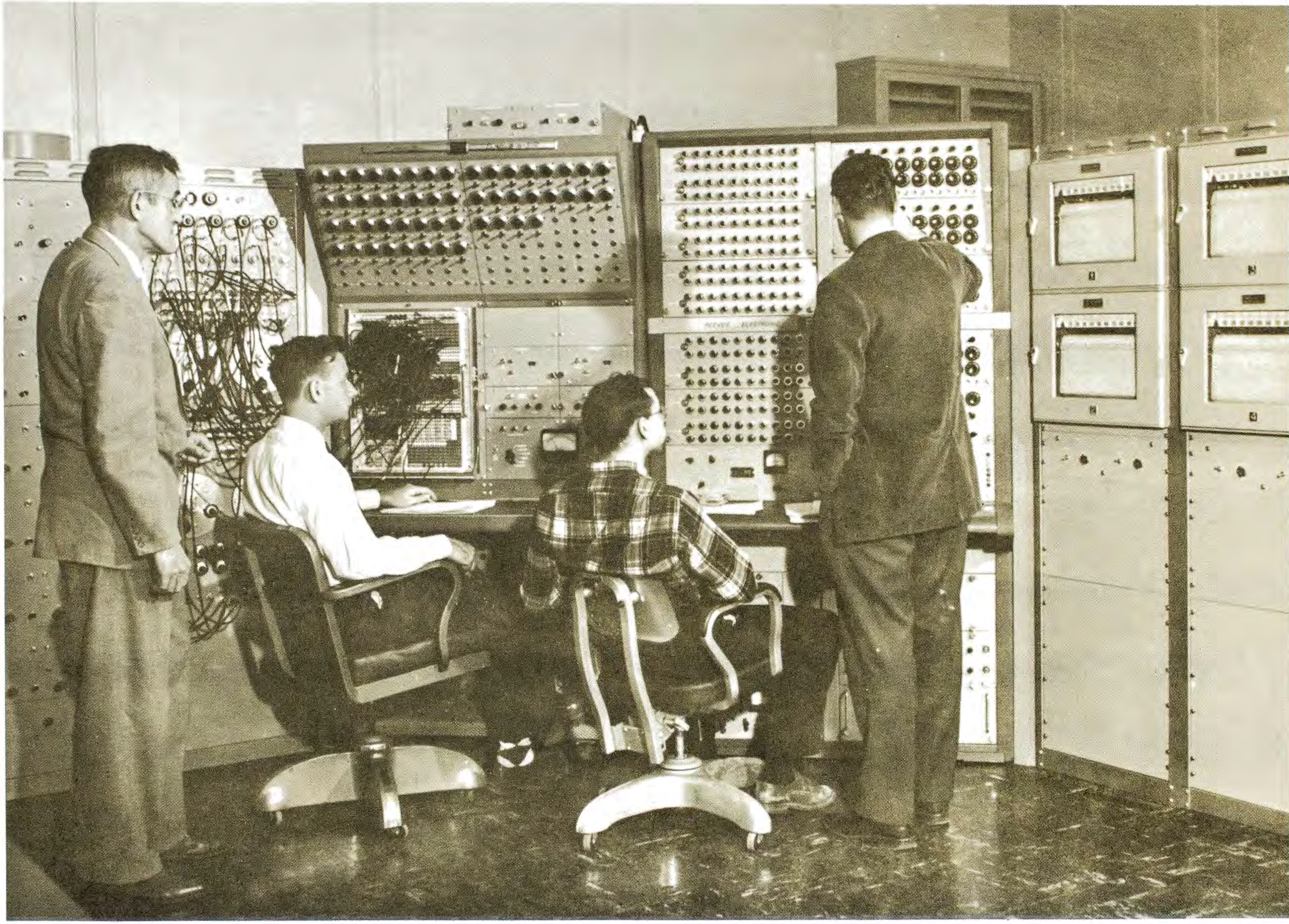
Instrumentation is a common denominator of the sciences, basic to measurement in all fields of experimental science and technology. Because of this Laboratory's diverse interests in the field of nuclear energy, basic as well as applied, the need for a wide variety of instruments, devices, and control systems provides a high professional challenge in development and design to the specialists in these fields

The fruits of development are not confined to the Laboratory. There is an impressive list of Oak Ridge electronic instruments that have been taken over for commercial production; you will find portable scintillation counters, amplifiers, precision pulsers, scalers, particle counters, pocket and table radiation monitors, counting rate meters, reactor control systems and so on, nationally advertised in the technical journals by a score of manufacturers, with the by-line "Based on a circuit developed at Oak Ridge National Laboratory".

Challenging work exists in the development of digital computers and their memory devices. "A reactor simulator" represents another kind of computer; with it one can predict the response of a reactor under all kinds of conditions. For example, a little extra fuel can be "added", or a control rod can be "withdrawn", or fission-product poison can "build up" in desired amounts, all by adjusting switches and knobs—the computer tells how a reactor would respond. Then there are always the special problems—data handling and processing, millimicrosecond pulse circuits, nuclear radiation detector design, process controls for radio-chemical plants, systems analysis, advanced circuit design, and application of transistors and other solid state devices to nuclear instrumentation and computers.

An important phase of the Division's program is in the engineering and design of reactor control systems for advanced types of experimental reactors being developed at the Laboratory. The Laboratory provides an ideal training ground for engineers wishing to make careers in Reactor Control Engineering — an increasingly important and expanding field. In addition, a long-range developmental program on advanced reactor control systems and components provides a challenge to the creative scientist.

An analog computer in operation as a "reactor simulator."



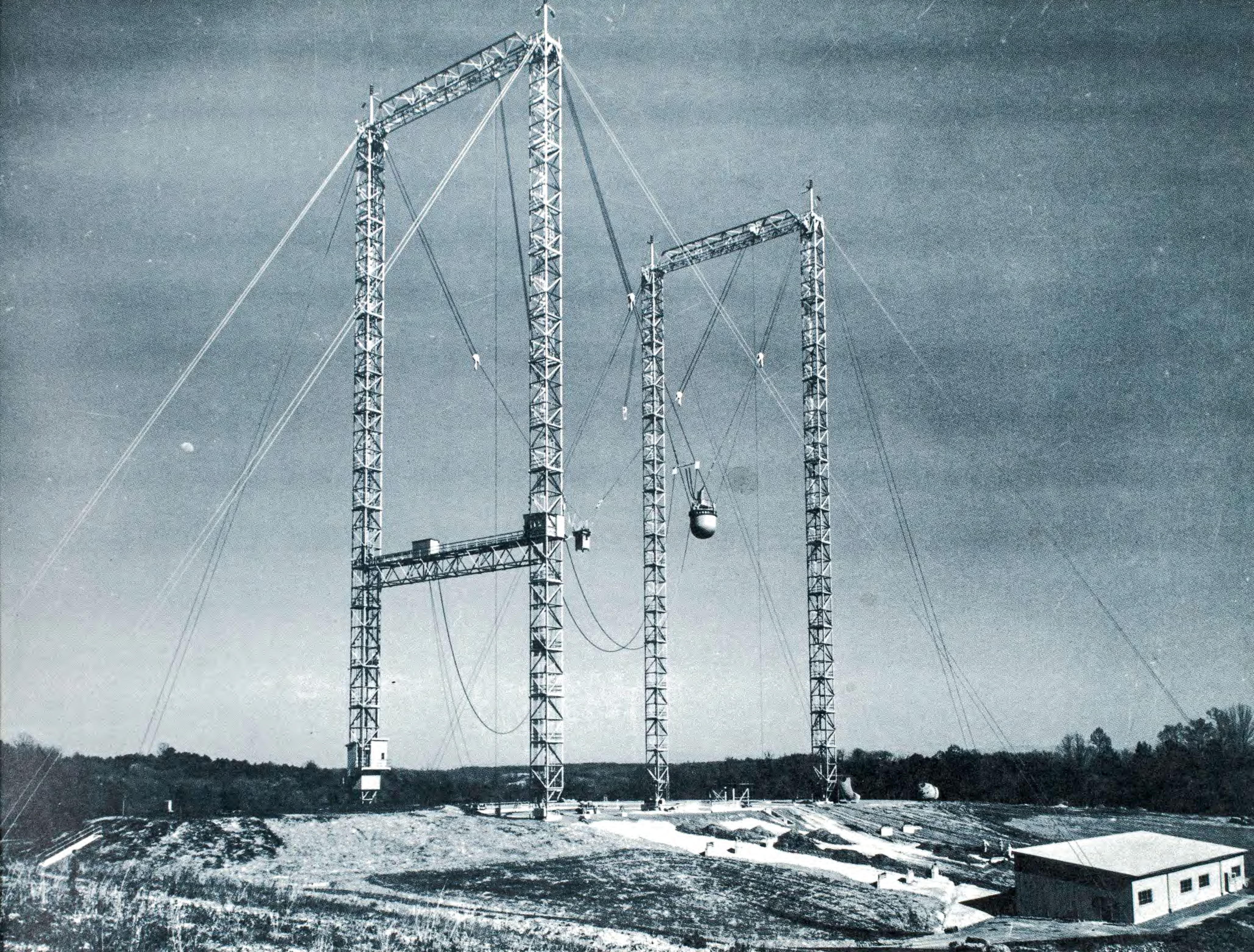
Applied nuclear physics: the Tower Shielding Facility. The round-bottomed tank high in the air contains an operating reactor.

Reactor Engineering Projects

The development of reactors toward the full realization of economic and useful nuclear power is the main engineering theme of the Oak Ridge National Laboratory. The Laboratory concentrates at present most actively on the so-called "homogeneous" reactors, but nevertheless it has been responsible for many important heterogeneous reactors, and interest in both kinds continues. The large reactor programs are organized as **projects**; in contrast to the loose organization of the pure research, the aim here is specific, and the direction strongly controlled.

The technique originated at Oak Ridge for reactor development is to build moderate-sized "reactor experiments". The reactor experiments are used to try out, on a semi-works scale, the essential features of full-scale reactors to come, so that experience can be gained and problems can be anticipated before a multi-million dollar commitment is made. The experiments involve systems of the most advanced sort, and successful completion is always an exciting event both for the Laboratory and for the country's atomic energy effort.

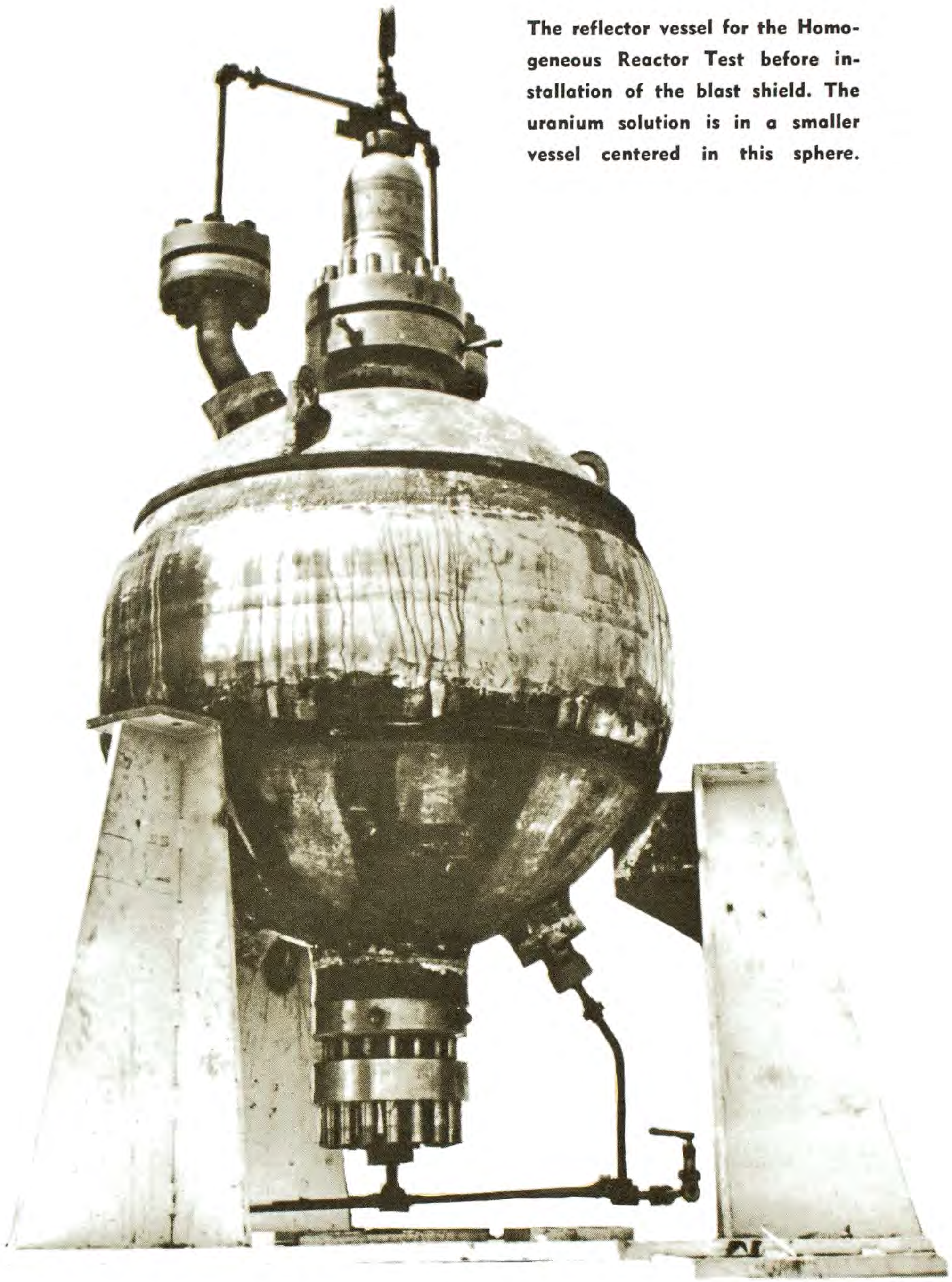
Two power reactor projects are of immediate importance at Oak Ridge: one to develop reactors for aircraft propulsion, and the other homogeneous reactors for stationary power plants. The homogeneous reactor consists of a core vessel containing a solution of an appropriate uranium salt; the solution heats itself by the nuclear chain reaction, and is circulated by a pump from the core vessel through a heat exchanger. A secondary system then generates steam. It was such a homogeneous reactor that in 1953 drove a 250 kilowatt turbogenerator and became one of the earliest nuclear plants to produce useful electricity. That experiment was successful in demonstrating a beautiful self-



Reactor Engineering Projects

controlling feature of this kind of reactor; if more or less power is demanded of the turbogenerator, the reactor automatically adjusts its power level accordingly.

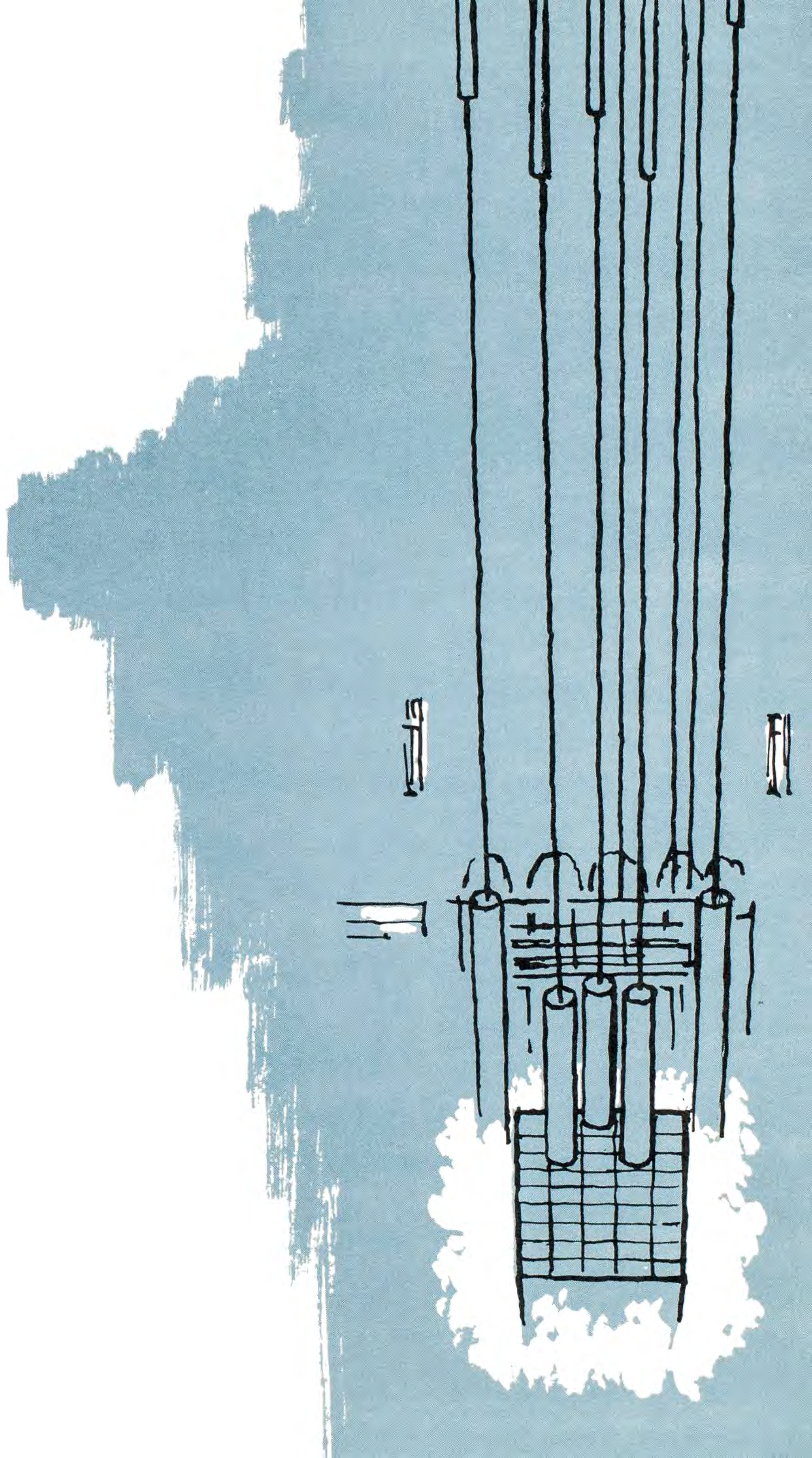
Of the various conceptual kinds of power reactors, the homogeneous variety promise to be one of the most economical because the costs of fuel element fabrication and fuel reprocessing are essentially absent. It is capable of considerable variation and perhaps also of extension into the realm of breeding—a goal of nuclear economy according to which the raw materials need not be rare and expensive, but comparatively common and cheap. The engineering problems to be faced include those of heat transfer between uncommon materials, the behavior of materials and components under the conditions of high temperature and pressure that are demanded by the requirement of efficiency, the development of pumps, valves and seals that not only are absolutely leak-tight, but also are remotely serviceable and replaceable, corrosion resistance under extreme conditions of temperature, pressure, flow rate, and radiation, and unusual stress problems arising from neutron and gamma ray heating. The family of homogeneous reactors extends to types that may involve liquid metals, high-pressure slurries, fused salts, and high-temperature gas.



The reflector vessel for the Homogeneous Reactor Test before installation of the blast shield. The uranium solution is in a smaller vessel centered in this sphere.

Other reactor projects have been taken in the stride of the Oak Ridge National Laboratory. The swimming-pool reactor has already been mentioned. The primary development of the potent Materials Testing Reactor at Idaho Falls took place in Oak Ridge. A "quickie" was the Geneva reactor—it was an Oak Ridge idea, suggested to the Atomic Energy Commission in December of 1954, approved for construction in March, 1955, designed and constructed during April and May, tested in June, shipped to Switzerland and put into operation in time for the United Nations Conference on the Peaceful Uses of Atomic Energy early in August. It was the first reactor to be opened for public inspection, and it was viewed by 60,000 people during the two weeks of the Conference. The Army Package Power Reactor was developed to meet the demand for a power plant that could be stationed in a remote place such as might be hazardous to keep supplied with conventional fuel. The preliminary plans were developed at this Laboratory and a commercial firm is now building the first such reactor at Fort Belvoir, to be used in the Army testing program.

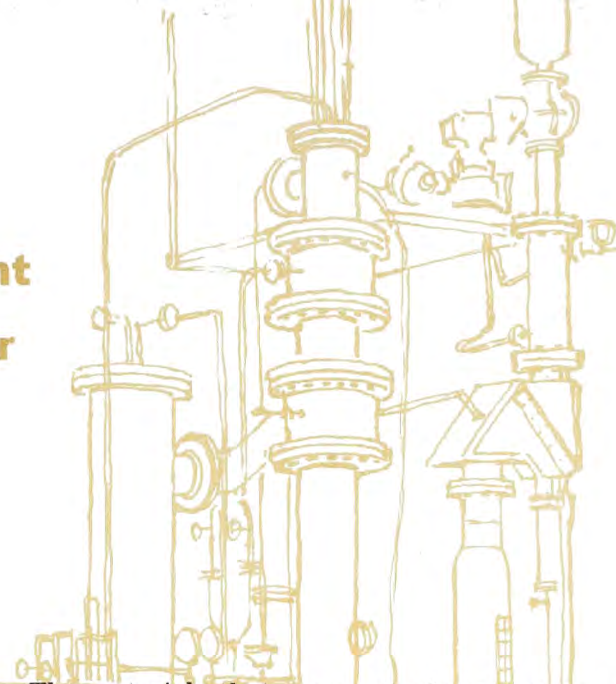
The toughest project of all is directed toward the development of a controlled thermonuclear reaction—an effort in which Oak Ridge takes a modest share with other prominent laboratories in the country's overall nuclear energy program. The difficulties confronted here are far beyond human experience, for the fuel must be burned at temperatures akin to those of the interiors of stars—and yet it must not destroy its container! There is a fascination in this project that is matched only by the richness of the promised reward, for if it succeeds, the deuterium in the oceans can be a source of abundant power for mankind extending as far as we can see into the future.



Chemical Engineering

process development for a nuclear power industry . . .

In the atomic energy business, chemical engineering divides itself into two branches: one which is concerned with the materials that go into reactors, and one which is concerned with the materials that come out of reactors. The two are vastly different. The Laboratory's efforts in the field of raw materials have led to the development of methods for the leaching of uranium from ores, and of the extraction of the uranium from the leach liquor. These processes are coming into production in new, large refineries on the Colorado plateau. The uncommon element zirconium is of interest as a reactor structural material, but it has to be freed of its chemical analog hafnium. No efficient method was known a few years ago for effecting this separation, but now it is done on a production scale by an Oak Ridge process. The requirements for special materials extend to the separation of isotopes by chemical methods on a large scale, and the Laboratory's efforts have led to an encouraging situation with regard to the isotopes of many of the lightweight elements.



A downward look into a shielded room containing part of a pilot plant designed for the separation of reactor-irradiated uranium and thorium.

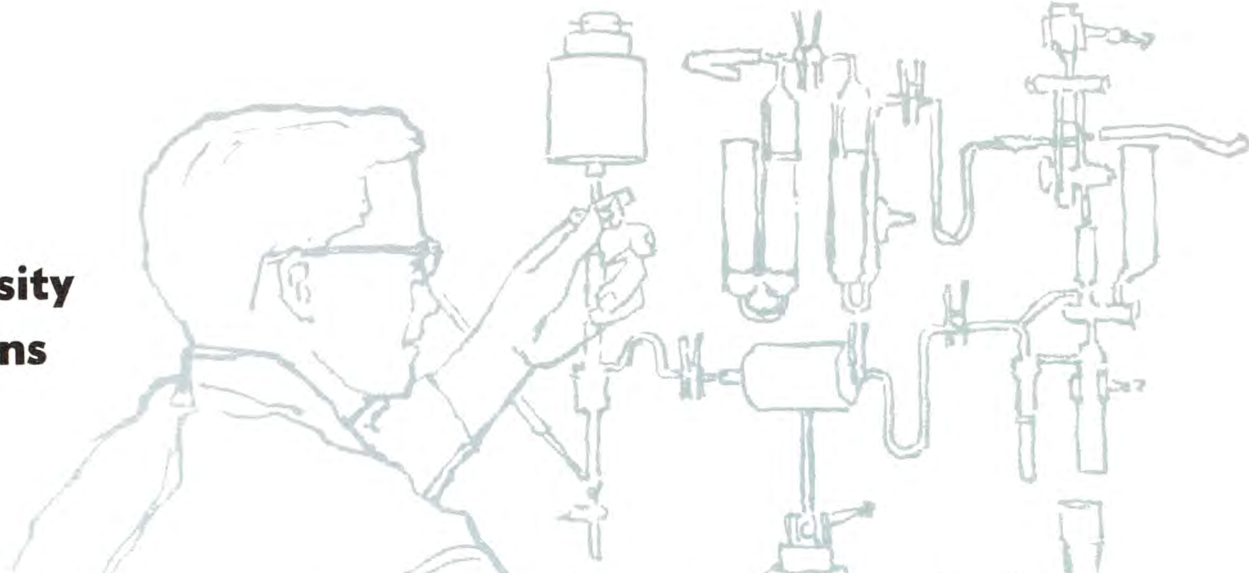
The materials that come out of reactors are marked by their overpowering radioactivity. The conditions under which the first few grams of plutonium were separated from uranium in the early days of the Laboratory were utterly unprecedented. That original pilot plant was established on the basis of a co-precipitation process. Success was demonstrated, and the way was prepared for the tremendous separation plants at Hanford. The process was adequate for the objectives of the time, but inevitably became outmoded in the swift advance of chemical technology. In particular, the new methods of solvent extraction gave promise of not only separating the plutonium, but also of recovering the unused uranium. The problem was one of decontamination of the uranium from the disagreeable radioactive fission products, and the decontamination factors required were something fantastic in the experience of chemical engineering: a round billion would be a typical figure. However, first one successful process was worked through the pilot plant stage at Oak Ridge and adopted for use at Hanford, and

then another was conceived that would be cheaper, and it likewise was developed through the pilot plant stage and adopted in full scale at Hanford and Savannah River. Meanwhile, new needs arose, because new kinds of reactors appeared, containing highly valuable enriched uranium in their fuel elements. This uranium had to be recovered from spent fuel elements, and it had to be decontaminated for re-use. An appropriate process was developed here, and adopted in a full-scale plant now functioning at Idaho Falls. Not only have processes spread from Oak Ridge, but so also have trained men. On the senior staffs of all of the National Laboratories and in all of the operating plants are men who have worked in the large chemical separations development program at Oak Ridge National Laboratory.

What of the present and the future? At present another solvent extraction process is under development for the separation of uranium from thorium, and from demonstration tests of this process have come the first large quantities of U-233. This is an important nuclide in one of the two conceivable recipes for the breeding of nuclear fuel. As for the future, there is certainly an indefinite series of new kinds of reactor fuel elements to come, and each will have its separation and decontamination problems. Then there is always the overriding challenge of the progressive reduction of expense, for chemical processing costs are an important factor to the realization of economic nuclear power.

The accomplishments of the chemical technologists present a concrete example of one of the more direct ways in which a National Laboratory can contribute to the life of the nation. This group of able people has seen its concepts come to full flower in several multimillion dollar separation plants of the Atomic Energy Commission's largest operations. The economies that have been realized by correct choice of process run into many millions of dollars.

Education, Training and university relations



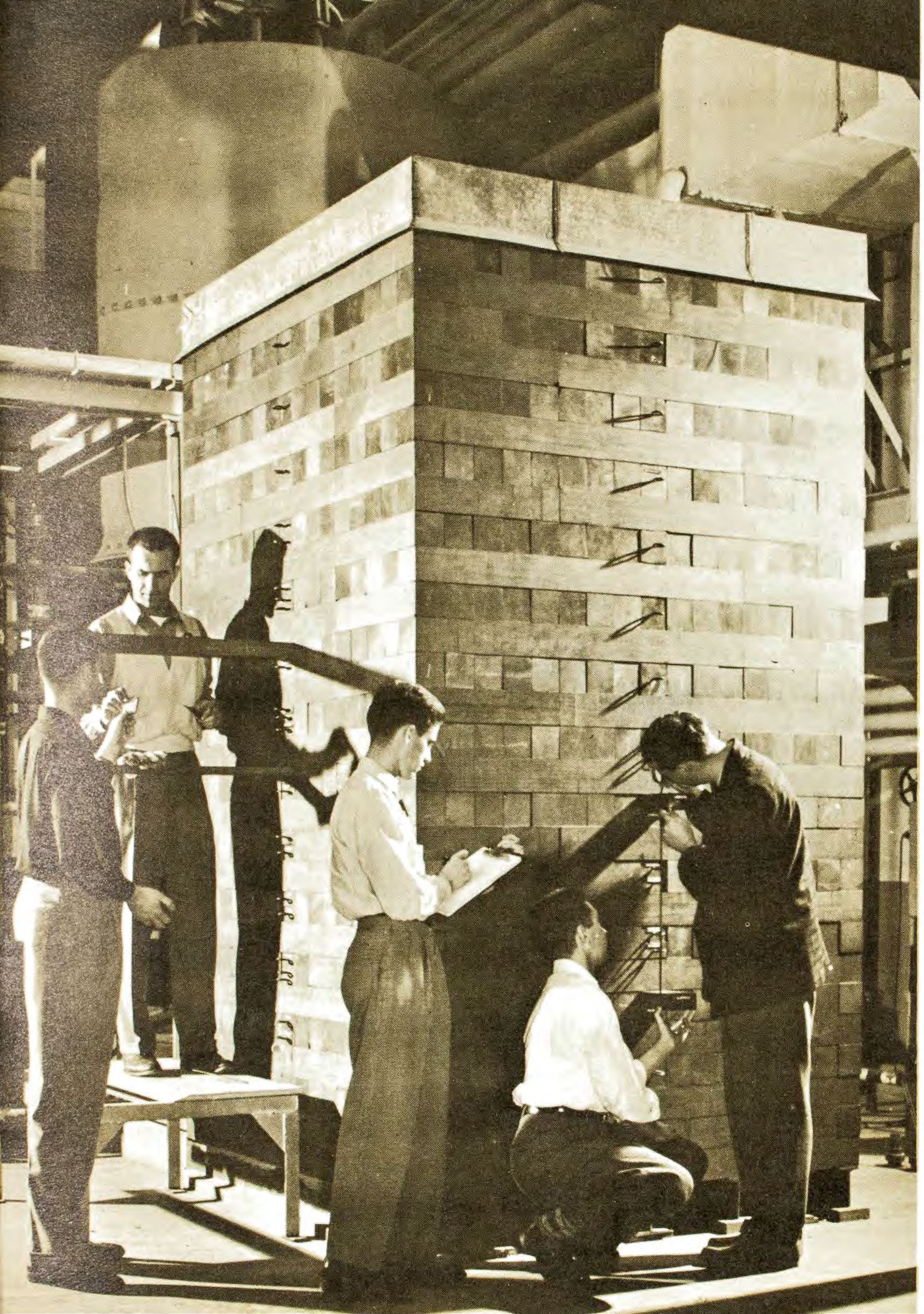
The largest single educational activity of the Laboratory is the well-known Oak Ridge School of Reactor Technology. Here up to 120 graduate engineers and scientists are given a stiff 12-month course in the theory and design of nuclear reactors.* Lecture courses are given in reactor engineering, reactor analysis, chemical technology, controls, materials and shielding. Many of the lectures are given by members of other Laboratory divisions, and the School therefore offers opportunity for teaching experience to many members of the Laboratory staff. Laboratory work on measurements of neutrons, radioactivity and fission is also included, and even brief operating and manipulative experience on the Bulk Shielding Reactor. The course concludes with group design studies of complete conceptual reactors. ORSORT graduates are in great demand, and are widely scattered in industry and in the government agencies of the United States. Each student must be attached to a sponsoring company or organization, and while at Oak Ridge remains on the payroll of his home institution.

The Laboratory is one of three centers of education in the Atomic Energy Commission's program of Special Fellowships in Radiological Physics. This is a 12-month course open to holders of bachelors' degrees, and here it is carried out in collaboration with Vanderbilt University. If a 6-month extension is granted, students may be able to qualify for a Master's degree at Vanderbilt. The Laboratory assists in the lecturing at Vanderbilt, and provides a 3-month period in which the students are in residence at Oak Ridge, where they receive working experience with the tools and problems of Health Physics.**

Some of the educational activities range more widely afield. The armed forces have a Special Weapons Project, which annually sends a dozen doctors to Oak Ridge for six weeks of intensive training in health physics. Health Physics staff members participated by invitation in the first international course in health physics, held in Stockholm in 1955, and sponsored by the World Health Organization, the Swedish Government, and the United States Atomic Energy Commission. Laboratory staff members make frequent and often leading contributions to the activities of professional societies in the South and elsewhere.

The intramural training of Laboratory employees is very active. There are many more seminars, information meetings, conferences and symposia going on than any man has

*The curriculum has recently been revised toward a system according to which the first six months' training is given at a collaborating university, and the second six months' is given at Oak Ridge. Under such a system two classes are graduated per year. Inquiries about admission to the School of Reactor Technology should be sent to: Oak Ridge School of Reactor Technology, P. O. Box X, Oak Ridge, Tennessee.



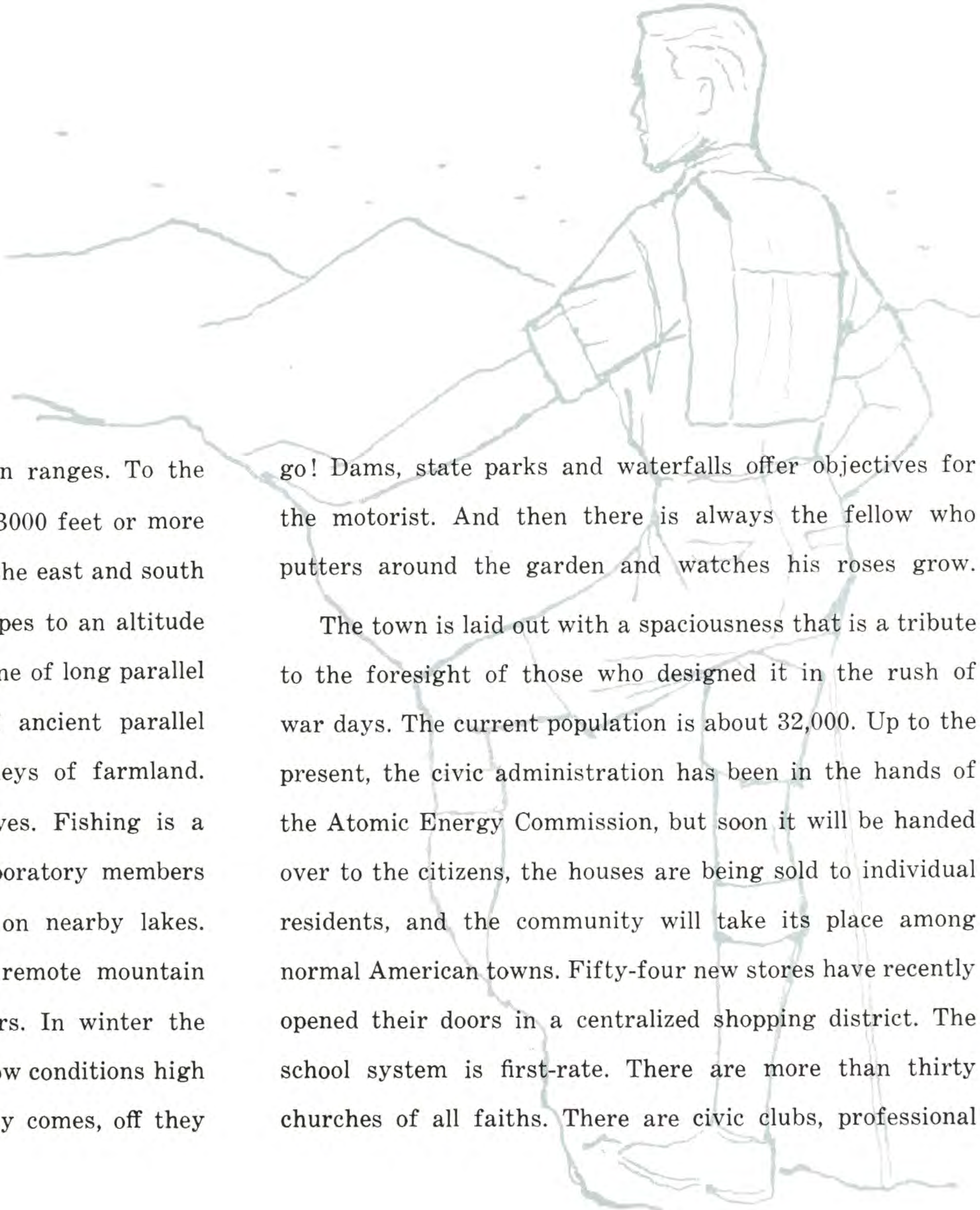
A group of ORSORT students prepare to study the distribution of neutrons in a stack of graphite.

time to attend. There is a constant stream of visiting specialists. The scientific divisions often organize lecture series in special subjects, and the School of Reactor Technology will receive qualified employees as students. The University of Tennessee in Knoxville supports extension lectures given in the evenings in Oak Ridge (the lecturers often being Laboratory scientists) and many a junior staff member of the Laboratory has availed himself of this opportunity to accumulate credit toward an advanced degree. The Union Carbide Nuclear Company supports such efforts to the extent of refunding half of the expense incurred for tuition fees and books.

Most of the university relations of the Laboratory are formalized through the friendly and efficient offices of the Oak Ridge Institute of Nuclear Studies. One of the main programs, the Research Participation Program,** enables university faculty members to spend summers or other short periods in research at the Laboratory, where opportunities are open to them that may not be available at home. A Traveling Lecture Program organizes and supports visits, conferences and seminar talks by Laboratory staff members at universities, particularly in the South. Over a hundred lectures are annually given under this plan. A program of fellowships has been established under which graduate students who have completed their course work at their home universities can carry through their thesis research at the Oak Ridge National Laboratory. The degree is granted by the university, but the Fellows make new scientific contacts at the Laboratory and gain experience in the facilities of a large institution.** New and rewarding ways are constantly being sought to make the most of the mutual benefits that can come from friendly and frequent contacts between the Laboratory and the educational institutions of the South.

**Inquiries about the Radiological Physics Fellowships, the Research Participation Program, and the Graduate Fellowships should be addressed to: The Oak Ridge Institute of Nuclear Studies, P. O. Box 117, Oak Ridge, Tennessee.

Community and Countryside



Oak Ridge lies between two mountain ranges. To the west and north the Cumberlands rise to 3000 feet or more a few miles away, while seventy miles to the east and south the Great Smokies raise their wooded slopes to an altitude of 6600 feet. The intervening country is one of long parallel tree-covered ridges, the worn edges of ancient parallel upturned strata, separated by quiet valleys of farmland. There are rivers, lakes, springs and caves. Fishing is a favorite weekend pastime, but many Laboratory members own power and sailing boats stationed on nearby lakes. Others join hiking clubs and roam the remote mountain regions. There are even a few spelunkers. In winter the skiing enthusiasts keep a sharp eye on snow conditions high in the Smokies, and when the opportunity comes, off they go! Dams, state parks and waterfalls offer objectives for the motorist. And then there is always the fellow who putters around the garden and watches his roses grow.

The town is laid out with a spaciousness that is a tribute to the foresight of those who designed it in the rush of war days. The current population is about 32,000. Up to the present, the civic administration has been in the hands of the Atomic Energy Commission, but soon it will be handed over to the citizens, the houses are being sold to individual residents, and the community will take its place among normal American towns. Fifty-four new stores have recently opened their doors in a centralized shopping district. The school system is first-rate. There are more than thirty churches of all faiths. There are civic clubs, professional

Fishing on the TVA lakes.

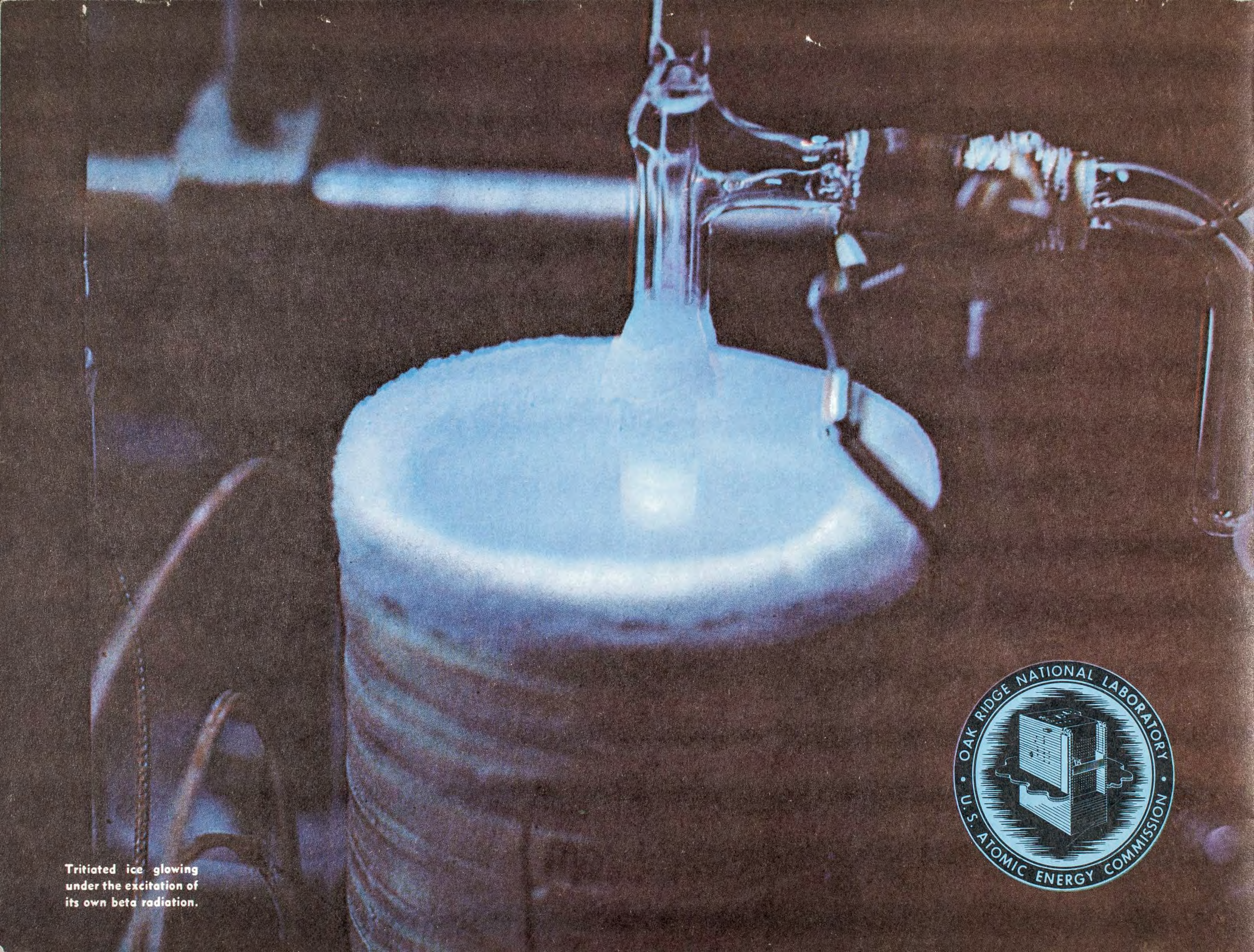
groups, and hobby clubs in variety. Two of the larger community organizations are the Oak Ridge Civic Music Association and the Oak Ridge Community Playhouse. The former supports the Symphony Orchestra and the Community Chorus, and it provides a concert series including recitals by well-known professional artists. The latter provides several full-scale plays during the season, and a variety of lesser literary and dramatic activity. There is an Art Center for those of the palette and brush.

Further organized recreational facilities include the municipal library, an enormous outdoor swimming pool, tennis courts, bowling alleys, and an 18-hole golf course. Your community and cultural life will be what you yourself make of it—the opportunities await you.

The Community Playhouse presents "The Lady's Not for Burning."

The Oak Ridge Symphony Orchestra.

Main Research Building at Oak Ridge National Laboratory.



Tritiated ice glowing under the excitation of its own beta radiation.