INFORMATION DIVISION

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BROOKHAVEN NATIONAL LABORATORY

Associated Universities, Inc.

Progress Report
January 1 - June 30, 1949

Upton, New York

Progress Report

January 1 through June 30, 1949

BROOKHAVEN NATIONAL LABORATORY
Associated Universities, Inc.
Upton, New York

This report of progress achieved by Associated Universities, Inc. and Brookhaven National Laboratory during the period January 1-June 30, 1949, is submitted under the terms of Contract #AT-30-2-GEN-16 between Associated Universities, Inc. and the Atomic Energy Commission. It was printed at Upton, New York, for distribution to persons and organizations associated with the national atomic energy program.

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PART ONE

ASSOCIATED UNIVERSITIES, INC.

This semiannual report includes, for the first time, references to future items in the Brookhaven National Laboratory program as well as an account of progress in the past six months. The primary function of Associated Universities, Inc. has been to provide Brookhaven National Laboratory with the contractual, financial, and environmental means for accomplishing its purposes, and to supervise, on behalf of the sponsoring universities, the activities of the Laboratory which are performed under contract with the Atomic Energy Commission. This program is of a continuing nature, and needs no particular description here. In two additional respects, housing procurement and public education, the Corporation has an operating program of its own to which brief reference is made below. In other respects, this report brings up to June 30, 1949, the account of activities previously reported.

Organization and Personnel

On May 30, 1949, Dr. Henry DeWolf Smyth, Chairman of the Department of Physics at Princeton University, and a Trustee of Associated Universities, was confirmed as a member of the United States Atomic Energy Commission to replace Dr. Robert F. Bacher. This created a vacancy on the Associated Universities Board of Trustees, to which Dr. Harold Dodds, president of Princeton, has suggested the appointment of Dr. Eugene P. Wigner, a member of the Physics Department, and formerly Director of Research and Development at the Clinton Laboratories, Oak Ridge, Tennessee. Dr. Wigner's name will be placed before the Board of Trustees for consideration at its meeting in July.

Advisory Committees

At the meeting of Trustees in January, the composition of the Physical Sciences Advisory Committee was reviewed, and the President of Associated Universities was authorized to appoint to membership on the Committee a list of candidates proposed by the Director. The members of the reconstituted Committee are:

J.R. Zacharias, Chairman, Massachusetts Institute of Technology
Hans A. Bethe, Cornell University
Edward U. Condon, National Bureau of Standards
Charles D. Coryell, Massachusetts Institute of Technology
Thomas B. Drew, Columbia University
W. Albert Noyes, University of Rochester
Richard B. Roberts, Carnegie Institution of Washington
Frederic Seitz, Carnegie Institute of Technology
J.C. Street, Harvard University
Winston D. Walters, University of Rochester

John C. Warner, Carnegie Institute of Technology
Eugene P. Wigner, Princeton University

The Committee met on May 27 and 28 at the Laboratory. After a brief inspection of the reactor complex and the Cosmotron development, it reviewed, in detail, programs and accomplishments of the Physics and Chemistry Departments. This included inspection of facilities and receiving reports of key scientists on experimental work in progress. The Committee approved the conception and execution of the Laboratory's physics and chemistry programs and declared them worthy of full confidence at this stage of their development. Reports of work in the Reactor Science and Engineering Department were favorably received, but the Committee adjourned before expressing a formal opinion of the work of that department.

Plans of the Engineering Advisory Committee for a meeting of representatives of northeastern engineering schools materialized on March 14, 1949, when the persons listed below met at the Laboratory to consider its plans for engineering research. Means were discussed by which effective cooperation could be promoted between the Laboratory and the engineering schools and universities. Development of the Laboratory's policy for facilitating participation by industry in its engineering research was also given preliminary consideration.

Harding Bliss, Yale University
John L. Bower, Yale University
J.G. Brainerd, University of Pennsylvania
Gordon S. Brown, Massachusetts Institute of Technology
C.R. Burrows, Cornell University
N.A. Christensen, Cornell University
Francis H. Clauser, Johns Hopkins University
George B. Collins, University of Rochester
K.H. Condit, Princeton University
Lewis D. Conta, University of Rochester
Walter L. Conwell, Cornell University
W.A. Curry, Columbia University
J.P. den Hartog, Massachusetts Institute of Technology
Thomas B. Drew, Columbia University
J.C. Elgin, Princeton University
J.K. Finch, Columbia University
John C. Geyer, Johns Hopkins University
C.F. Kayan, Columbia University
George Kehl, Columbia University
W.B. Kouwenhoven, Johns Hopkins University
Harold S. Mickley, Massachusetts Institute of Technology
Richard Parmenter, Cornell University
D.R. Rudenberg, Harvard University
William R. Sears, Cornell University
E.K. Timby, Princeton University
Charles A. Walker, Yale University
Milton L. Wiedman, Yale University
C.H. Willis, Princeton University
G.F. Wislicenus, Johns Hopkins University
W.J. Wohlenberg, Yale University

Because of the demands of his other duties, Dr. Keith Cannan of New York University has asked to be relieved, effective July 31, 1949, of his duties as Chairman of the Advisory Committee for Biology and Medicine. The President has acceded to this request, and Dr. Edmund W. Sinnott of Yale University has agreed to serve as Chairman of the Committee thereafter. The Committee did not meet during the period under review.

The Ad Hoc Advisory Committee for Clinical Investigation met twice, on January 28 and March 28, 1949. At the first meeting, the Committee reviewed and approved plans to include clinical investigation in the program of the Medical Department; at the second, it considered a report on the progress of the planned research activities and of the medical care program.

At its April meeting, the Board of Trustees agreed to review its advisory committee system and to consider modifications in light of the successful formulation by the Laboratory of the first stages of its scientific program.

Visit of Atomic Energy Commission

On January 21, 1949, in conjunction with the quarterly meeting of the Board of Trustees, the following members of the United States Atomic Energy Commission and of its staff visited the Laboratory:

Sumner T. Pike	Vice Chairman
Robert F. Bacher	Commissioner
Lewis L. Strauss	Commissioner
Carroll D. Wilson	General Manager
Wilbur E. Kelley	Manager, New York Operations Office
H. Marshall Chadwell	Deputy Manager, New York Operations Office
Kenneth S. Pitzer	Director of Research, Atomic Energy Commission, Washington
Ralph P. Johnson	Deputy Director of Research, Atomic Energy Commission, Washington
James H. Jensen	Division of Biology and Medicine, Atomic Energy Commission, Washington
John Z. Bowers	Deputy Director of Biology and Medicine, Atomic Energy Commission, Washington
Corbin Allardice	Director, New York Operations Office, Office of Public and Technical Information
H.B. Fry	Staff Assistant, New York Operations Office
Roy Snapp	Secretary, Atomic Energy Commission, Washington

The visitors made an inspection tour of the Laboratory's major facilities and scientific departments, and attended a meeting with all employees. Thereafter, they participated in a conference with the Trustees and Officers of Associated Universities and officials of the Laboratory. Discussion was devoted to the objectives and progress of various parts of the Laboratory's program, and to some of the problems which the Trustees encounter in managing, and which the Commission encounters in financing, the enterprise. It was particularly helpful to the Trustees to learn from the Commission representatives the extent of the Commission's interest in the further development and execution of policies which the Trustees have considered to represent some of the most important obligations of Associated Universities. These include:

1. Extension of opportunity to use the Laboratory's facilities to small, as well as large, educational institutions.

2. Development of the Laboratory's programs, and use of its facilities, as supplements to those of other institutions in its area.
3. Planning of appropriate and timely means by which industry may participate in the Laboratory's work.
4. Aid to the Commission in making clear the importance of fundamental research in the nation's program of scientific development.
5. Aid to the Commission in clarifying the dividing line between classified and unclassified work.
6. Special aid to the Commission in certain technical areas.
7. Aid to the Commission in doing a necessary job in a workmanlike and circumspect manner.

Mr. David E. Lilienthal, Chairman of the United States Atomic Energy Commission, spent April 4 in a visit to the Laboratory, during the course of which he made an inspection tour, spoke to the assembled employees, and participated with Dr. Frank D. Fackenthal and other officials in broad discussions of policy and program.

Housing Procurement

The contractor's policy, approved by the Commission, of providing limited, necessary assistance to nonpermanent staff in the procurement of housing has been continued during the six months covered by this report.

The leasing of Lindenmere, the off-site guest house required during the first two years of the Laboratory's operation, has been terminated. Dispensing with this facility was made possible by the completion of an additional block of guest rooms for the accommodation of visitors at the Laboratory. A small saving in operating expense will result from this action.

The construction of six two-family houses in Stony Brook is to begin soon, in accordance with a three-year lease arranged with the owner by Associated Universities. These family units will be ready for occupancy during the coming autumn and early winter, and will be available to members of the Laboratory staff whose periods of residence at the Laboratory is expected to be of short duration.

Fiscal

During the period under review, fiscal activities of Associated Universities, Inc. were routine, with the following three exceptions:

1. At the request of the Commission, the method by which the Corporation receives reimbursement for expenditures arising out of, or connected with, contract work was slightly modified. The change reduces the size of the outstanding cash advance made available to the Corporation without endangering the minimum cash balances necessary to assure prompt payment of obligations.

2. The first two-year adjustment period provided by the insurance policies issued for workmen's compensation and general liability by the Liberty Mutual

Insurance Company under the Atomic Energy Commission Rating Plan ended April 15. An audit of the premium account was made, and a return premium of $277,177.96 has been paid by the carrier to the Corporation. This reflects the very favorable experience of Associated Universities, Inc. and its principal subcontractors for construction (The H.K. Ferguson Company and L.K. Comstock and Company, Inc.) with respect to claims and losses during the policy period. The policies continue in force, and will not terminate until canceled or until a stipulated time has elapsed following completion of the work under the contract between Associated Universities, Inc. and the Atomic Energy Commission.

3. Messrs. Haskins and Sells, the Corporation's auditors, submitted, on April 19, their report of a balance sheet audit as of December 31, 1948, accompanied by an unqualified certificate.

Public Education

A full report on the public education program from its inception will be presented to the Board of Trustees of Associated Universities at its forthcoming meeting in July. The report will review the need for public education in the atomic energy field, and will indicate some of the areas in which successful action is being taken or planned by various institutions and agencies, including the Atomic Energy Commission itself. Recommendations will be made respecting continuance of present routine activities and of the exhibit program, as well as for development of new projects particularly suited to the opportunities and resources of Associated Universities.

Since January 1, the nuclear energy exhibit has been shown principally in Long Island communities where understanding and good opinion of the Laboratory is of major importance to its future operations. Specially arranged showings at Providence, Rhode Island, under the sponsorship of the Providence Journal-Bulletin, and at Rochester, New York, under the joint sponsorship of the Rochester Museum and the University of Rochester, rounded out a full six months tour. As usual, response was generally favorable. Some 82,100 persons are estimated to have seen the exhibit; and community forums in the spirit of the "Atomic Energy Week" idea were a valuable feature of several of the exhibitions.

The major share of the time and effort of the Public Education Office was devoted to preparing necessary news releases, and to satisfying the demand for speakers, for visits to the Laboratory, and for interviews related to the preparation of feature stories about the Laboratory's program.

So far, nothing has happened to disturb the friendly relations between the Laboratory and its neighbors in the surrounding communities. It must be a continuing objective of the public education and public relations activities to see that nothing does.

PART TWO

REPORT OF BROOKHAVEN NATIONAL LABORATORY

INTRODUCTION

Organization, Personnel, and Policies

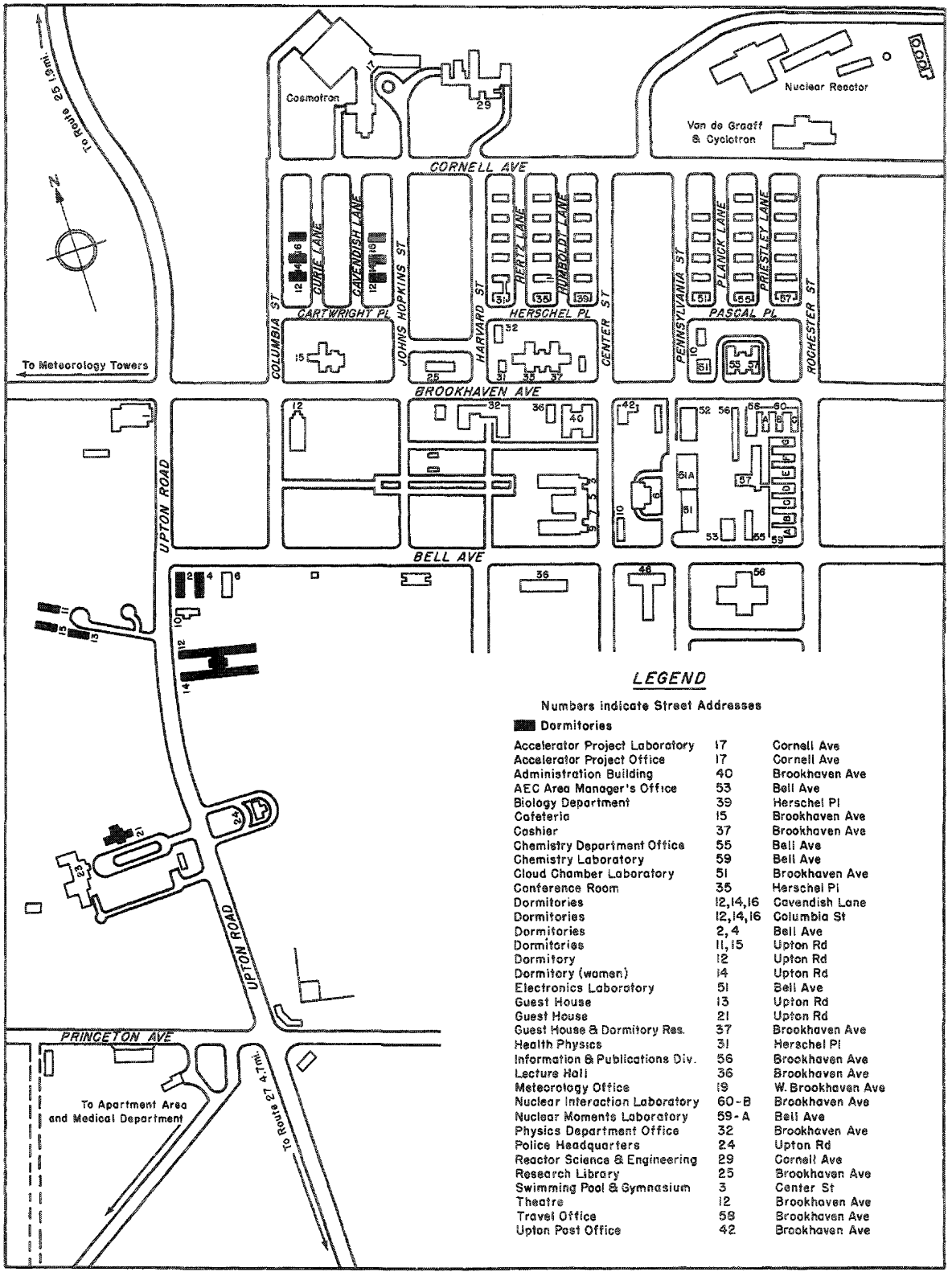
No significant changes have been made in the structural pattern of the Laboratory since January. Two changes, however, were not reflected in the organization chart for the previous July. The Instrumentation and Health Physics Department was activated in the fall; and the Engineering Department and Reactor Project were consolidated into a new Department of Reactor Science and Engineering on January 1.

During the period under review, there was a further notable reduction in the activities of the various Laboratory committees, with more responsibility being assumed by individuals, particularly department heads. The roster of standing committees remains much as it was, but, with the exception of the Policy and Program Committee, meetings are infrequent, and most matters are taken care of by operating officials in consultation with the Director.

Negotiations are under way with the Atomic Energy Commission for modification of policies with respect to sick leave, annual leave, and travel; otherwise, no major policy formulation or change has been necessary during the report period.

In common with all other enterprises, the Laboratory has been afflicted with the complications produced by the rising spiral of construction and other costs, not only in a severe fashion for the major facilities and new buildings (because of the large amounts involved), but also in costs of minor facilities and equipment for the various departments. An analysis of differences between early budget estimates and actual ultimate costs for construction, for building alterations, and for capital equipment shows that several departments have experienced rises of the same sort percentagewise. In dollar amount, the increased costs of the reactor complex and the cyclotron - electrostatic accelerator building had a severe impact on the operating budget. Approximately one and a half million dollars of operating funds were transferred to facilities accounts to meet the needs. In part, this was possible because of reductions which were achieved in clerical, secretarial, and administrative staffs; but it also made necessary a detailed re-evaluation of all activities and the specific postponement or reduction of many phases of earlier plans. The past six months has thus been a period of drastic belt-tightening for every part of the organization.

The total staff of the Laboratory on June 30 was 1411, not including 27 temporary employees and 4 employees of the Associated Universities Public Education Office. This figure represents a net gain of 98 for the fiscal year. Only one-fourth of the net gain occurred during the first half of the fiscal year; the difference reflects seasonal recruitment of scientific personnel, as was the case in the preceding fiscal year.



SITE MAP, JULY 1949

Reduction of nonscientific manpower continues, and additions to the scientific and technical staff have accelerated somewhat. The result is a notable change in the ratio of scientists to nonscientists; it now stands at 1 to 5.4, not including the 27 temporary appointments. This is in marked contrast to a ratio of 1 to 6.9 a year ago, and of 1 to 13.6 two years ago, soon after the Laboratory had taken over the site. During the next fiscal year, additions to the scientific staff while the administrative and service units remain essentially stable will further reduce the ratio, which already compares favorably even with that of other laboratories where many municipal services are provided by the community, not supported by the research organization.

The table below illustrates a marked increase in scientific and technical personnel during the past twelve months, concurrent with a substantial reduction of clerical and salaried administrative employees who were needed only in the early organizational stages. Some of the reductions occurred through transfer, others through nonreplacement of employees who terminated.

Personnel Changes Since June 30, 1948

	Regular Staff							Temporary Scientists
	Scientists	Salaried Technical and Professional	Weekly Technicians and Skilled	Weekly Semi- and Unskilled	Salaried Administrative, etc.	Clerical	Total	
1) Scientific depts., Shops & Drafting	+54*	+26	+ 80	- 6	0	+ 5	+159	+15
2) Director's Office	- 1	- 1	- 1	--	-4	- 8	- 15	--
3) Other groups	--	+ 8	+ 25	-31	-4	-44	- 46	--
Subtotal of (2) and (3)	- 1	+ 7	+ 24	-31	-8	-52	- 61	--
Total	+53	+33	+104	-37	-8	-47	+ 98	+15

*The symbol 0 means no change; -- means none employed.

The total continuing scientific staff now numbers 220, including graduate students, on-leave scientists, and scientifically-trained and supporting (as contrasted with research) personnel. By the end of the next fiscal year, this number is expected to reach 300 or higher. Term appointments represent about 40% of the 220; senior scientists on permanent tenure constitute about one-tenth of the scientific staff.

Procurement of on-leave scientists, graduate students, and other temporary appointees has been slowed somewhat by delays in bringing the reactor and the accelerators into operation. Nevertheless, there are now 14 graduate students and 21 on-leave professors at the Laboratory, and 63 temporary appointments have been made for the summer.

There are now in effect 115 consultant subcontracts. These represent affiliation with 23 different colleges and universities, 10 medical institutions, and 5 other research laboratories. Eleven of these consultants have accepted temporary appointments to the summer staff.

It is thus apparent that the Laboratory's "official family" expanded considerably during the past year, and that even greater expansion can be confidently predicted for the years ahead. The marked increase in guest scientists who are willing to work at the Laboratory at their own expense, or at the expense of their regular employers, speaks well of the power of the Laboratory to attract scientific manpower into the atomic energy program -- one of the purposes for which this institution was created.

New Members of Senior Scientific Staff*
Appointed and in Residence, January - June, 1949

Physics Department	Charles P. Baker, Earl E. Hays, William F. Hornyak, Edward der Mateosian, Andrew W. Sunyar
Accelerator Project	Edward W. Dexter, John S. Medd
Instrumentation and Health Physics Department	Roland B. Holt, Stanley I. Kramer, Joseph C. Logue
Chemistry Department	Aksel A. Bothner-By
Biology Department	None
Medical Department	Sidney C. Madden
Reactor Science and Engineering Department	Gertrude S. Goldhaber, Maurice Goldhaber, Thomas V. Sheehan, Edward J. Vanderman, Richard W. Wiswall

Administrative personnel changes included the resignations of William E. O'Brien, the Project Engineer, as the reactor complex construction approaches completion; of Norman R. Beers, Leader of the Meteorology Group, to become editor of Nucleonics, and of C.R.E. Merkle, Leader of the Health Physics Division's Survey Group, to accept a position in private industry. Both O'Brien and Beers retain consulting relationships to the Laboratory program. Maynard E. Smith was appointed Acting Leader of the Meteorology Group. Lee Gemmell, formerly executive aide to Dr. Patterson in university relations and scientific personnel, became Leader of

*Does not include summer visitors. The individuals listed above are all classified as associate or senior scientists and have been appointed for six months or longer. The criteria for listing were date of appointment and time of taking up full-time duties.

the Survey Group. Within the scientific departments, the appointment of several division heads in the Medical Department represented the chief addition to scientific-administrative staff. These appointments are recorded in the description of the Medical Department's work, as are the designations of assistant chairmen in the Reactor Science and Engineering Department. Individual full-time senior research appointments, other than those which are temporary, are listed above.

Major Facilities

During early spring, construction activities reached a peak when, in addition to completion of the reactor and its adjacent offices and control rooms, and of the fan house and various auxiliary units, there were under construction simultaneously the laboratory wings for the reactor, the hot laboratory and its associated waste storage farm, the office wing of the Cosmotron building, the new building for the cyclotron and electrostatic accelerator, the new biology building, and the wing for the high pressure cloud chamber. Substantial completion of most of these, as described on following pages, has resulted in large reductions of subcontractor personnel at the Laboratory site, and the assumption of greater work loads by the Laboratory's own maintenance forces.

Delay in loading the reactor has been occasioned by the necessity of certain alterations in the duct system and elsewhere. This permits completion of more of the complex than would have been ready by the time of initial operation and testing, which is now expected to occur in the fall and early winter.

The building for the smaller accelerators is about completed. Major components of the 60-inch cyclotron are installed; final assembly is scheduled for early fall. The electrostatic accelerator has been disassembled at the factory for shipment and reassembly at the Laboratory site this summer.

The operating staff for the reactor has moved into its quarters in the reactor building. The design group for the Cosmotron has occupied offices in the newly constructed wing of the Cosmotron complex, and is carrying out tests in a large laboratory developed by conversion of a bowling alley. These moves relieved some of the crowding elsewhere, and gave badly needed working space to the Electronics Division, the Information and Publications Division, and the expanding engineering research staff. The Biology Department is still working under space handicaps, but the modifications and additions to the building at 56 Bell Avenue are well along.

Most of the major components of the Cosmotron are on order; delivery of finished units for the magnet is expected in July. It is hoped that the accelerator can be fully assembled by early summer, a year hence.

The yoke for the large high pressure cloud chamber has been completed and installed. The generators and coils are on hand. Static pressure tests will be undertaken in a few weeks, and full operation is expected by the first of the year.

A variety of auxiliary equipment is under design or procurement in the various departments, so that when the major facilities begin to function during the coming year there will be not only laboratory working space appropriately designed and

equipped, but a respectable variety of experimental apparatus available to afford latitude in research.

The 42-bed hospital is now in full operation. It is registered with the American Medical Association, and is on the approved list of the American College of Surgeons. Its opening made possible the beginning of clinical research with cancer patients under a cooperative arrangement with Memorial Hospital in New York City.

Rapid growth of the Medical Department during this six-month interval, the activation of several medical divisions, and the beginning of nonclinical medical research rounds out the plan for developing staff and programs for the five major fields of physics, chemistry, engineering, biology, and medicine.

Among the major facilities virtually completed during the period under review is the net of test wells and holes drilled as an ancillary part of the reactor complex, under supervision of the Geology Group from the U.S. Geological Survey. This included completion of a 10-inch cased well some 1500 feet to bedrock, one of the few holes of such depth in eastern Long Island.

The next fiscal year will witness considerable completion of the major facilities, a broader and more vigorous program of research, and rapid development of the staff and facilities for engineering and medicine.

Among the less striking but nonetheless important building modifications has been the conversion of a WAC barracks into an attractive guest house. It will provide double accommodations, with private bath, for 26 people, and thus takes the place of Lindenmere for summer visitors and other guests during the year. Completion of this facility coincides with the institution of restaurant service at the cafeteria.

The Laboratory still feels the lack, however, of a centrally located social center or club comparable with the student union or faculty club of a university. Such a feature would further promote cross-fertilization of ideas in a relaxing atmosphere, would encourage scientists and others to remain at the site in the evenings, thus bringing about broader acquaintances with graduate students and visiting scientists, and would relieve somewhat for on-site residents the tedium of isolation from comparable recreational opportunities. The values to the advancement of science to be gained from such a social center are intangible; yet they are substantial enough so that every college and university has some such gathering place.

Publications

In addition to the weekly issuance of the Weekly Selected Reading List, and the periodic publication of the Guide to Russian Scientific Periodical Literature, the Laboratory produced 4 technical reports, 3 conference reports, and a progress report during the six months ending June 30. Open literature publications in scientific and professional journals (including items in press) numbered 49; twelve were abstracts of papers presented at meetings of scientific societies.

Speakers' Bureau

Interest in the work of the Laboratory on the part of the general public on and near Long Island has been increasing. This is seen in greater activity of the Speakers' Bureau, which was described in the last progress report. During the last half of the fiscal year, the Laboratory met requests for speakers from 106 organizations. These included civic, religious, educational, and cultural groups, the majority of them located within an hour's drive from the site. Sixty-six of the talks were given by members of the scientific staff, and 40 by administrative representatives of the Laboratory and of the Corporation's resident staff. The program now features the use of lantern slides, motion pictures, and demonstrations more commonly than was possible earlier. While requests for general presentation of the Laboratory's aims and facilities still predominate, there is a growing demand for popularized talks by the scientists about their own individual researches and for rather specific information about actual and potential nonmilitary applications of nuclear science.

Out of the contacts established in this manner, there developed quite naturally many requests for permission to visit the site. The number of groups which are thereby official guests of the Laboratory has been growing also. This has posed problems of scheduling visits so that the scientific work and construction activities will not be unduly interrupted, and so that individual staff members are not unfairly burdened with these educational activities. The problems have been met, in part, by scheduling these visits on Saturdays. The Laboratory is seeking the elusive balance between the general cultural value to the nation of such visits (to the Commission's program in particular) and their cost in manpower and in other respects. Present plans are to consolidate the effort and cost by setting aside two Saturdays per year when those groups which have shown an interest may see the Laboratory site firsthand and be given demonstrations of the scientific work. The extent of such general interest is indicated by the fact that, from January to July 15, groups totaling 740 visitors were entertained at the site. During the same period, four small conferences totaling 127 visitors were devoted to scientific topics and official planning.

Summer Sessions

As has been predicted, the interest in summer affiliation with the Laboratory's work has increased, both among the nine universities of the Corporation and elsewhere in the country. For the coming summer, 63 temporary appointments to the scientific staff have been made, including 24 individuals from institutions which are not members of Associated Universities. Of these 24, two are from industry, two are from other Atomic Energy Commission laboratories, and one is from the Naval Research Laboratory. These 63 appointments represent 32 different institutions. Thirteen individuals will be in the status of guest scientists, that is, will stay at their own expense rather than on the payroll. This compares with 33 scientists, representing only 19 different institutions, for the summer sessions of 1948. Had the reactor and accelerators been in operation already, the number for this year would doubtless have increased; it seems a foregone conclusion that the summer of 1950 will bring a decided influx of scientists to the Laboratory.

In contrast to previous summers when the predominant number of visitors were concerned with the Physics and Chemistry Departments, the group for this year is more evenly distributed among departments. Twenty-six are to be associated with the Reactor Science and Engineering Department and the Accelerator Project, 17 with the Physics Department, and 8 with the Chemistry Department.

No large conferences have been scheduled for this summer. Instead there will be frequent colloquia, seminars, and small, informal departmental and interdepartmental gatherings. A conference on radiation damage will be held on August 22-26, and one on corn improvement on September 8-9.

Future Work

As new programs of construction and research are delineated, they are reported to the Atomic Energy Commission in several ways: First is in the informal day-by-day contacts with the Manager of the Brookhaven Area and his staff, and in the less frequent contacts with the staff of New York Operations, and in Washington. Then, as advance thinking reaches the stage of definitive proposals, these proposals are included in the budget estimates submitted formally. Items involving major construction are spelled out in considerable detail in individual capital improvement proposals.

All of these provide the Government with knowledge of the planning at the Laboratory, but they do not reach the wide audience in other Atomic Energy Commission laboratories, and in universities and research institutions generally. For this extensive group, the Laboratory has in the past issued several separate program reports. They were written at a stage when future planning constituted a major activity of the whole staff. Now, however, with laboratories, shops, the hospital, and ancillary services in operation, the major facilities far along toward completion, and considerable research under way, planning ahead has become secondary to preoccupation with the work at hand. The writing of a separate program report at this stage would necessarily involve description of background and progress for nearly every item reported, and that would represent much duplication of material prepared for the series of semiannual progress reports. To avoid this costly repetition, the Laboratory and the Area Manager have agreed that plans for future work would be incorporated in the progress reports. Consequently, in the sections which follow, contemplated use of facilities, extension of research or changes in its direction, outlines of new facilities in prospect, and other features of programming are interwoven with the descriptions of work accomplished or currently in progress.

PHYSICAL SCIENCES AND ENGINEERING

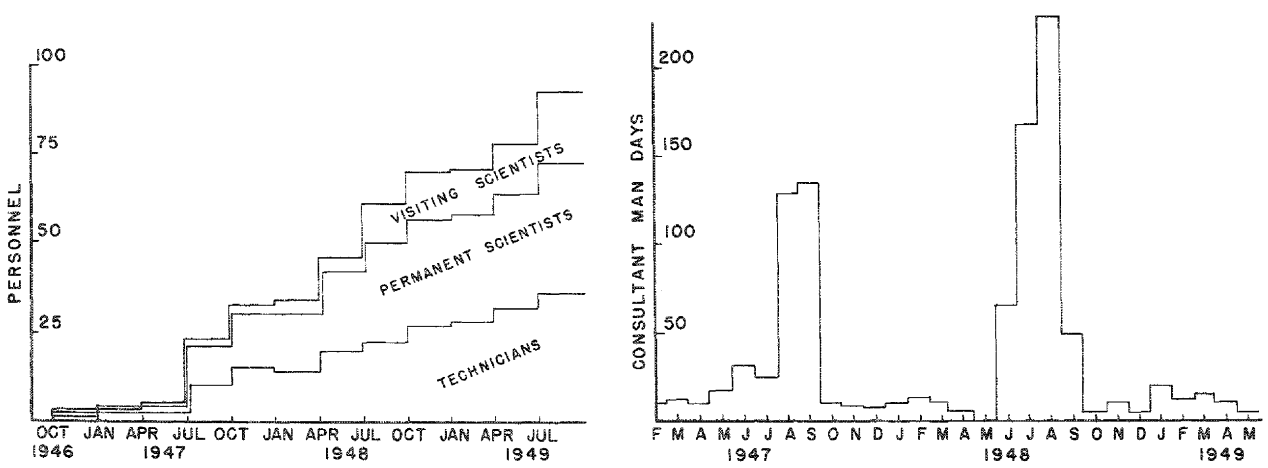
PHYSICS

The growth of the Physics Department, in terms of personnel, from the time of its organization in 1946 is shown by the accompanying graphs. Whereas initial acquisitions were about equally divided between persons intending to work on physical processes of high energy particles and those interested in neutrons and the physics of nuclei at moderate and low energies, recent acquisitions, made with a view to utilizing the reactor, the electrostatic accelerator, and the cyclotron, have favored the latter fields of research. The left-hand graph shows separately the technicians, the permanent scientific and administrative staff, and the scientists on leave from universities. The latter group, which includes graduate students working on theses, is expected to increase percentagewise when the reactor and other major facilities come into operation. The use of consultants, shown by the right-hand histogram, may be expected to increase when the reactor begins to operate, and it may show less of a seasonal trend.

With its present laboratory facilities, the Department suffers the disadvantage of being scattered over eight separate buildings, most of which were adapted at small expense from existing temporary buildings. The unifying effect of a central laboratory facility is seriously needed, but plans for such a laboratory are being held in abeyance until after the reactor laboratories are fully utilized. In the interim, additional temporary laboratories are being developed in an old mess hall at 55 Brookhaven Avenue, one wing of which is now ready for occupancy.

A number of other institutions are cooperating in the program of the Physics Department. Columbia University has a contract to develop techniques and materials for nuclear studies with photographic emulsions; the results are already proving useful in the Department's program of cosmic ray studies, and will be further utilized for neutron measurements in connection with the reactor, and for meson and

GROWTH OF PHYSICS DEPARTMENT



nuclear disruption studies with the Cosmotron. The Polaroid Company is continuing its contract for improvement of photographic emulsions and associated techniques. Johns Hopkins University is collaborating with the Moments Group in synthesizing appropriate molecules for the study of the nuclear spin and quadrupole moment of tellurium. The Department of the Navy carried photographic emulsions and small cloud chambers on high altitude balloon flights at various latitudes. The Department of the Army has allowed the Nuclear Interaction Group to use the betatron at the Picatinny Arsenal. The B-29 airplane assigned to the Laboratory for cosmic ray research flew 35 hours at altitude at Rome, New York, and over the Panama Canal Zone. Two Laboratory experiments and one of Princeton University are being carried in this cycle of flights. During the next cycle, equipment of New York University will be carried. The Laboratory is coordinating its B-29 flights with the Office of Naval Research, so that the planes will carry as many experiments as possible. The yoke for the large high pressure cloud chamber has been completed by the Bethlehem Steel Company.

Research projects are in progress in the following fields:

1. Nuclear disintegrations and excitations
2. Nuclear masses
3. Nuclear moments
4. Properties of mesons and other high energy particles in the cosmic radiation
5. Solid state physics
6. Theoretical subjects

In addition, key personnel have been engaged, and facilities are being developed, to study cross sections of nuclei for the scattering and absorption of neutrons, neutron polarization, and neutron diffraction.

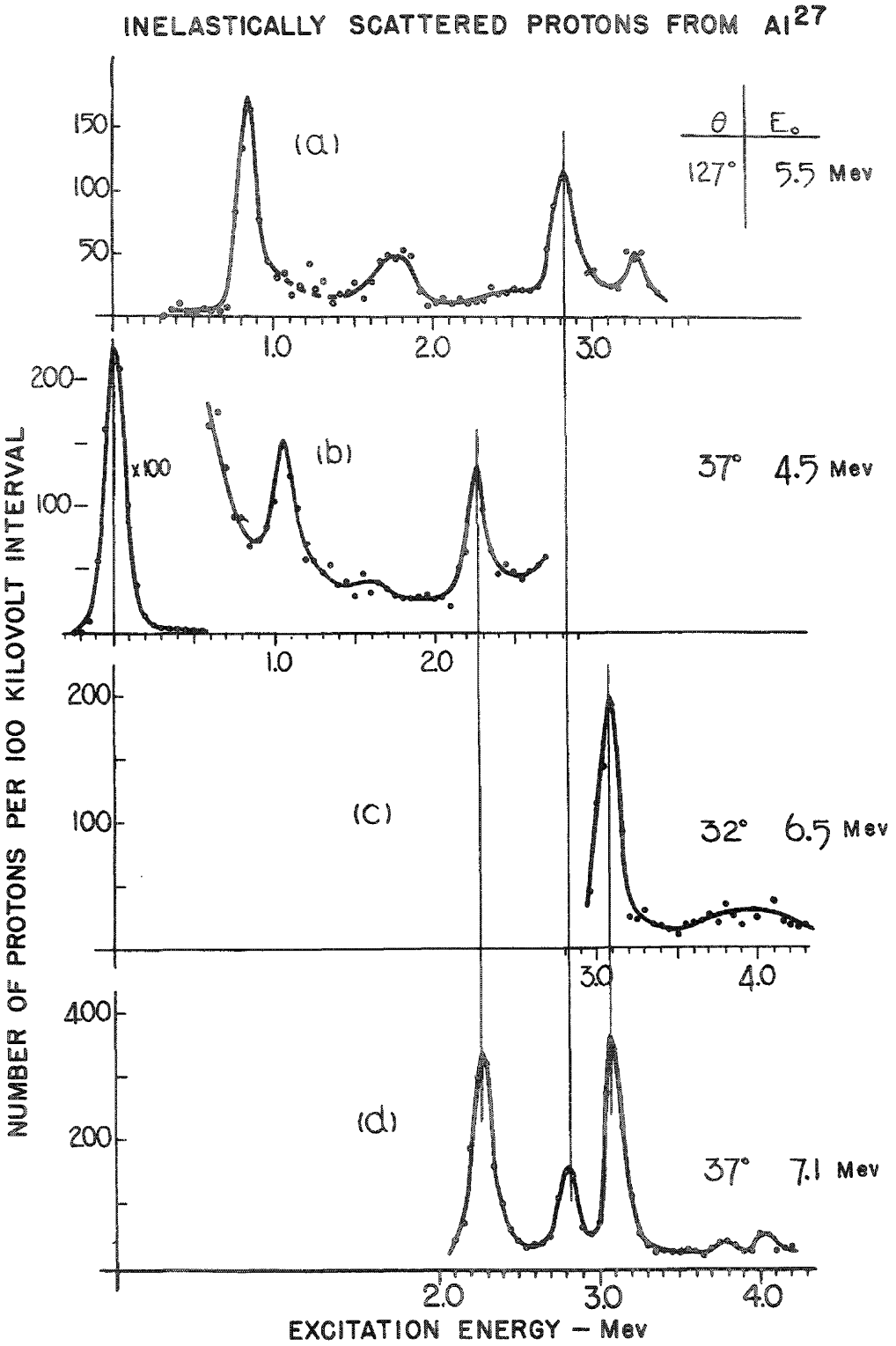
Nuclear Disintegration and Excitation

Although the major facilities for nuclear research at the Laboratory are still in the constructional and planning phases, advantage has been taken of facilities at other institutions to begin work which will later depend upon these facilities.

Making use of the University of Rochester cyclotron, studies have been made of the inelastic scattering of protons by aluminum. A strong variation of intensity with angle was found for protons within a particular energy-loss group. (See figure.) Although detailed interpretation is not yet possible, it is evident that the excitations of the nucleus depend upon the angular momentum, as well as upon the energy, of the incident proton. A more exhaustive study of these phenomena will be made as soon as the electrostatic accelerator and cyclotron are available (E.M. Hafner).

In working with nitrogen, an energy-loss group of protons was found at 2.32 Mev, in agreement with a gamma-ray level previously reported as associated with the positron decay of O^{14} (E.M. Hafner).

In experiments with the cyclotron at the Carnegie Institution of Washington,



Energy levels of aluminum excited by inelastically scattered protons. Intensities of protons of incident energy E_0 scattered through angle θ are plotted against the energy lost in the scattering process. Of interest are the facts that the heights of the peaks depend strongly upon angle, and that the patterns change with incident energy.

the energies and angles of emission of neutrons from a Be^9 target bombarded with 16 Mev deuterons have been studied, making use of photographic emulsions for observing recoil protons at various positions about the Be target. The angular distribution patterns seem to vary from one energy to another, but the experiments have not been able to resolve discrete energy groups (E.O. Salant, E. Dollman).

As the number of discovered excitation levels of nuclei increases, more emphasis will be laid upon interpretation. In the case of B^{10}, there are eight known energy levels which can be represented to within the experimental accuracies of 0.4% by the equation

$$W\ (\text{Mev}) = (0.4137\ N_1 + 0.7166\ N_2),$$

where (N_1, N_2) have values (1,0), (0,1), (0,2).....(0,7). Gamma-rays have been reported in the literature for 20 out of the 28 possible transitions given by this scheme (E.M. Hafner). A compilation was made of the energy levels for nuclei from Z = 11 to 20; this includes 33 known isotopes and 300 known energy levels (D.E. Alburger, E.M. Hafner).

The angular distribution of protons resulting from photodisintegration of deuterium is being studied using emulsions for detection and the 20 Mev betatron at the Picatinny Arsenal as a source of radiation. Preliminary results with protons ejected with high energy by gamma-rays at the upper end of the betatron spectrum indicate a strong preference for directions at right angles to the beam of radiation. Improvements in the precision of these measurements are expected to differentiate between the various theories of the deuteron binding forces (E.O. Salant, J. Hornbostel, D.W. Lee, N.W. Curtis).

Measurements of gamma-ray energies have been started with a thin lens magnetic spectrometer for electrons. The first case studied was that of Na^{22}, which emits positrons and a coincident gamma-ray. At the source position in the spectrometer, the gamma-rays are converted to electrons in a foil of heavy metal (U, Th, or Pb). It is found that the maximum electron energy is independent of converter thickness. The energy of the gamma-ray was found to have the value 1.277 ± 0.004 Mev. Combining this value with the energy of the emitted positron, one computes the mass difference (Na^{22} - Ne^{22}) as 0.003087 ± 0.000011 mass units. As a check on the accuracy of the instrument, measurements were made on Co^{60}, which has been studied elsewhere by the crystal spectrometer method. Results with the magnetic lens gave gamma-ray energies of 1.175 ± 0.006 Mev and 1.332 ± 0.005 Mev, in excellent agreement with the best crystal measurements# (D.E. Alburger).

The thin lens spectrometer has also been used to measure the beta-rays emitted by a 100-fold enriched sample of K^{40}, prepared at Oak Ridge. This naturally occurring isotope has a half-life of 4×10^8 years, and its radiation energies are important in geological theories of rock formation. The results showed a linear Fermi plot, possibly because of source thickness, in spite of the known spin change of 4, with an upper limit of the beta-ray energy at 1.40 ± 0.03 Mev# (D.E. Alburger).

# Indicates publication. See Appendix for complete reference.

In an extension of Wigner's theory of the behavior of cross sections near the threshold, one can now predict that the cross section for the (n,2n) reactions should increase in proportion to $(E - E_t)^2$ when the energy E of the incident neutron is slightly above the threshold energy E_t. The region over which this relation holds is under further investigation (G.A. Snow).

New Facilities for Nuclear Research

A magnetic spectrograph for charged particles, designed to resolve protons which are inelastically scattered from light nuclei with given excitation energies in the center-of-mass system, is being constructed for use with the electrostatic accelerator. A contract for the iron yoke has been let to the Bethlehem Steel Company; the coils are being wound by the General Electric Company at Schenectady. The pivoted table which allows the apparatus to swing through various angles about an axis running through the target is being constructed in a Laboratory shop. The completed instrument will be used in more detailed studies of the dependence upon angle and incident energy of the various energy-loss groups observed in inelastic proton scattering# (E.M. Hafner).

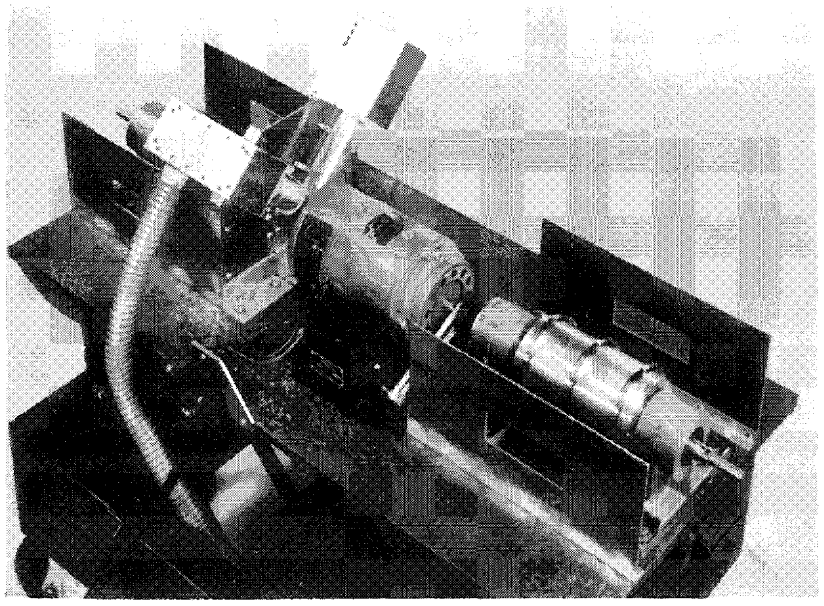
A second thin lens magnetic spectrometer, similar to the one now in use, is being constructed for studies at the reactor of the gamma-rays emitted by a nucleus coincident with neutron capture (D.E. Alburger).

For studies at the reactor of neutron absorption and scattering cross sections, and of other effects depending upon the energy of neutrons in the thermal region, the Department has under construction a velocity analyzer, consisting of a mechanical shutter with electronic circuits for sorting pulses from the detector according to the time of flight of the neutrons. Specifications for this instrument have been given in previous reports. The contract with the Airborne Instruments Laboratory, Inc. assisted by the Thorne-Brown Company, Westport, Connecticut, provides the mechanical shutter and the electronic gating circuits. In addition, the Laboratory has developed a "twin pulser" needed to test the reception rate of the scalers in each channel. Scalers with satisfactory characteristics are being obtained commercially. All components needed for operation are expected to be tested and ready before the startup of the reactor (F.G.P. Seidl).

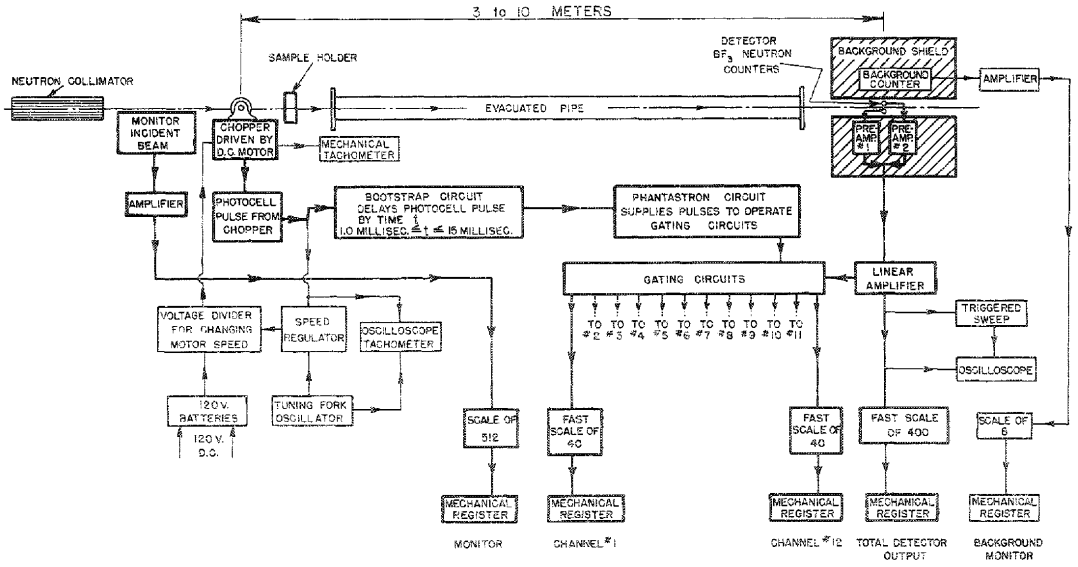
A neutron time-of-flight spectrometer for higher energies is being provided as an adjunct to the 60-inch cyclotron through a construction contract with Columbia University. This instrument will provide a repetitive pulse for modulating the cyclotron and for the gating of forty recording channels in succession after each modulation pulse. The electronic equipment can be used with either the cyclotron or a high speed mechanical shutter in one of the neutron beams from the pile. This apparatus will be used in an extensive program of nuclear cross section measurements (C.P. Baker, W.A. Higinbotham).

In a joint project with the Reactor Science and Engineering Department, a special cloud chamber is under design for studying the radioactive decay of the free neutron (A.L. Thorndike, R.P. Shutt, L.B. Borst).

An electronic device has been built for recording the state of a scaling circuit



Mechanical chopper for modulating a beam of slow neutrons. The photograph shows the tuning fork controlled driving motor, the photocell, pickup for the initiating pulse, and two neutron shutters of different characteristics which may be used alternately.



TIME OF FLIGHT

NEUTRON VELOCITY SPECTROMETER

USING ROTATING CADMIUM CHOPPER

Schematic of the electronic circuits and mechanical chopper. An initiating pulse from the photocell, delayed by the "bootstrap" circuit, starts the operation of the phanastron circuit which operates gates to the twelve recording channels in succession. Neutrons arriving at the detector during each time interval produce pulses in the BF_3 counters which are routed to the appropriate channel.

at predetermined time intervals without disturbing its normal scaling function. A resetting device can also be operated to give unit interval counts if these are preferred. The data are recorded on a paper roll. In the first model, a scale of 2^7 can be read at either 10 or 60 second intervals; in the second model, readings are taken at 1,2,3,5,10,20,30, or 60 second intervals on a scale of 2^{16}. In using the device for determining the rate of decay of several radioactive isotopes of half-life greater than 5 seconds, it was found that statistical accuracies of better than 1% could be obtained on a single run (S.E. Golian, W.A. Higinbotham, S.I. Kramer, P. Prentky).

Nuclear Masses

Considerable progress has been made with the time-of-flight mass spectrometer or "chronotron," which is being developed for measurements of masses of heavy isotopes. The system was actually tested in a readily available magnet of 15-inch pole diameter with a gap of only 2 inches. The results were surprisingly good for the preliminary test, although the dispersion was only 1 microsecond per mass unit.

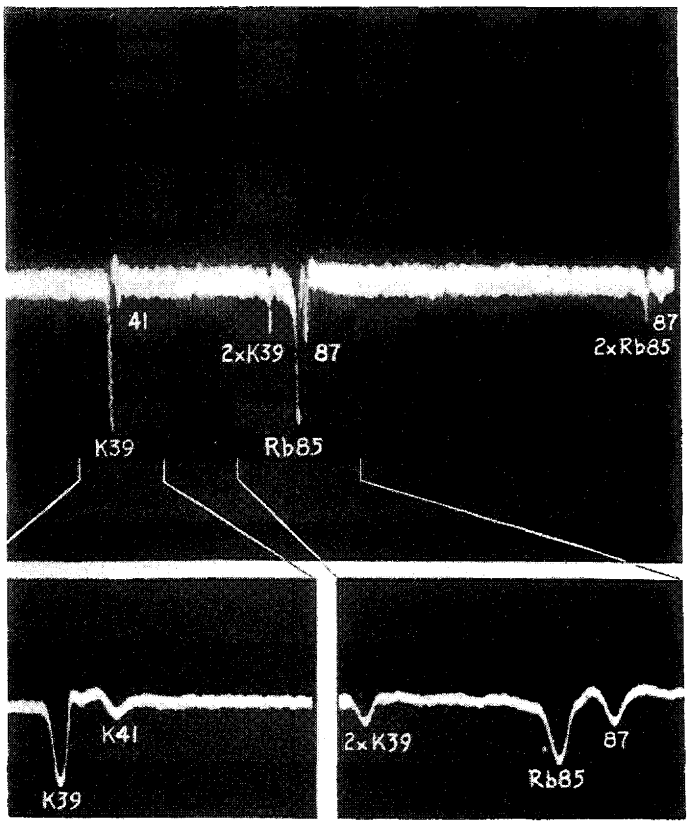
Pulses of the isotopes of potassium and rubidium, going around once and twice, could be measured easily. Sodium and cesium were also present in some of the experiments. The ion source was designed to give the same distribution of momentum for different isotopes. This insured that different isotopes would follow the same family of circles in the magnetic field.

The detector in the preliminary experiments consisted of a simple Faraday cage. It was shown that a considerable sharpening of the pulses could be achieved when ions were accelerated upon entering the Faraday chamber.

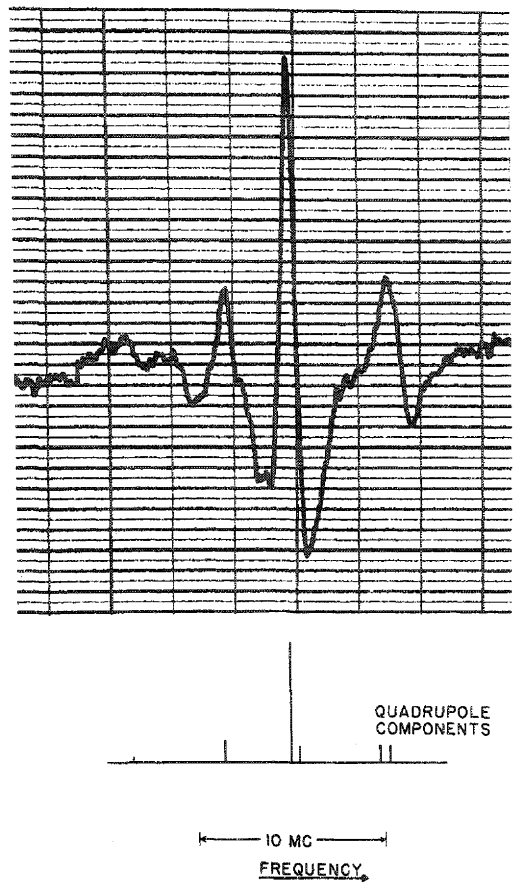
A special electron multiplier, designed for operation in the magnetic field, was constructed and tried out. The ions are accelerated before they reach the first plate; and the electrons released are bent by an electric field so as to impinge upon the ten successive plates with usual electron multiplication. This multiplier is far more sensitive than the Faraday cage; it also gives immediate response and avoids pulse lengthening due to induction.

Another successful method of detecting ions has been found on a bench test, using a phosphor and photomultiplier. It is expected that the light produced in the phosphor can be led outside the magnetic field, along a quartz or lucite rod, and sent into a standard photomultiplier.

The present magnet does not provide enough space between the pole pieces to allow more than two revolutions of the ions. However, a sphere of 19 inches internal diameter, wound with copper tubing in such a way as to produce a homogeneous magnetic field throughout its volume has been obtained on loan from Westinghouse Electric Manufacturing Company. A test of the magnetic field, using a proton probe has shown that the field is not as homogeneous as was expected. Deviations of about 0.4% occur in the volume necessary for the experiment. Nevertheless, this magnet is very suitable for extensive experimentation. A vacuum chamber has been designed, and is now being constructed, in the hope that ions going around ten times can be detected. These would give a dispersion of about 10 microseconds per mass unit.



Scale= approx 1 mass unit / 1 microsec.



Left: Cathode ray display of times of flight of the isotopes of potassium and rubidium in the chronotron (time-of-flight mass spectrometer). Pulses appear for one and two revolutions of the ions in the magnetic field.

Right: Experimental curve of the microwave spectrum J = 1 to J = 2 transition of COS^{35}, showing partially resolved quadrupole structure. The calculated pattern, assuming a nuclear spin of 3/2 and a quadrupole coupling constant of 20 megacycles, is given below.

While waiting for the completion of the vacuum chamber, some tests were made in the older magnet concerning modifications, proposed by Dr. Hipple of the Bureau of Standards, of the time-of-flight principle. The results were fairly satisfactory, but it is believed that, ultimately, higher precision can be obtained with the original scheme# (S.A. Goudsmit, L.G. Smith, P.I. Richards, E.E. Hays).

Nuclear Moments

The problem of synthesizing carbonyl sulfide, COS^{35}, from microgram quantities of radioactive sulfuric acid $H_2S^{35}O_4$ has been successfully solved, and the microwave absorption spectrum of the product has been resolved. In order to accomplish the latter result, it was necessary to improve the microwave spectrometer by the addition of a 100-kilocycle Stark effect modulator and a phase sensitive detector, the use of which gave a clean spectrum of the COS^{35} present in the absorption cell with a concentration of only 0.1%. The sample of

active sulfuric acid obtained from Oak Ridge contained only 0.4% of the active isotope. The absorption line studied was the rotational transition J = 1 to J = 2; the resolved fine structure due to nuclear quadrupole interaction with the molecular field showed clearly that the number of components corresponds to a nuclear spin of 3/2. The separation of the components showed that the strength of the interaction corresponds to a frequency of 20 megacycles and that the coupling is positive (V.W. Cohen, T. Wentink, Jr., W. Koski).

In spite of personnel shortage, some progress was made with the equipment for studying nuclear magnetic moments by paramagnetic resonance. A rectifier system with a photoelectric stabilizer was installed to excite the magnet, thereby achieving a field which is constant to one part in 50,000. A further improvement in the constancy of the field should soon be realized from the use of a controller based on the proton resonance absorption, which is now being adjusted. Another improvement which should greatly facilitate the work is a new oscillator recently constructed with a 100-fold better ratio of signal to noise. The improved instruments will be used to extend measurements of the magnetic moments of stable nuclei (V.W. Cohen, W. Knight).

Physics of High Energy Particles

The Department has made significant progress in the investigation of production of mesons by high energy protons in the cosmic radiation. Work at a mountain station in Colorado has confirmed the result, stated in the last report, that the penetrating showers give rise to mesons in the pi phase, of which the positives decay to the mu phase, in which they are detected by their characteristic half-life of 2 microseconds. In an extension of that experiment, the number of mu decays has been compared with the number of shower particles stopped in the absorber. When the efficiency of the apparatus is taken into account, it appears that most of the shower particles in the lower range of energy are mesons. In order to account for the large number of mesons observed, one has to assume that the cross section for nuclear scattering and absorption of mesons is in the order of one tenth that for protons. Further experiments on the multiplicity of meson production and the cross sections for nuclear interaction with mesons are being prepared for B-29 airplane flights scheduled to take place in the early fall. These experiments will also give the atmospheric absorption coefficients for primary rays which give rise to showers of various multiplicities (O. Piccioni, M.N. Lustgarten, C.S. Kemic).

Experiments now in progress in the B-29 airplane have already shown, by the small latitude effect at 25,000 feet and 30,000 feet of 10-15%, that there is scarcely any production of penetrating showers by primary rays of less than 10 Bev and the multiplicity of the penetrating showers, and that, therefore, the efficiency of detection in the apparatus increases rapidly above this limit with the energy of the primary radiation. Constant latitude flights have been completed through the helpful interest of the Air Material Command of the United States Air Force from the air base at Rome, New York, and from the Canal Zone. Coincidence counters were used in one instrument (O. Piccioni, T.G. Walsh); in another, an arrangement of counters and a pulse ionization chamber recorded the showers (A.J. McMahon, W.F. Burditt, B. Rossi). In the latter instrument, evidence was also obtained for a small east-west asymmetry of the shower producing radiation, the magnitude of

which will give a further indication of the variation of shower multiplicity with primary energy. In both experiments, the variations with altitude lead to an absorption path for the primaries of 115 gm/cm^2, the same value holding at both latitudes.

Cosmic ray studies with nuclear emulsions are being actively continued. Both Ilford plates, sensitive to heavily ionizing particles (such as slow mesons and protons), and Eastman plates, which also record particles of minimum ionization density, have been exposed to primary rays near the top of the atmosphere on balloon flights. These flights have been made at high latitudes, where the earth's magnetic field rejects primary particles of energy below 2.8 Bev, and near Cuba, where the magnetic cut-off at the vertical is 7.6 Bev. In analyzing nuclear disruption stars on these plates, one distinguishes between low energy particles and the very high energy particles (so-called relativistic particles).

The variation of frequencies of occurrence with latitude shown in the table indicate that the energies of many of the primary disrupting particles lie in the field-sensitive region between 3 and 8 Bev.

Production of Low Energy Nuclear Disruption Stars at 95,000 Feet Above Sea Level

Type of Star	Stars per Cubic Centimeter of Emulsion per Day		Ratio Minnesota to Cuba
	Minnesota Flights	Cuba Flights	
More than 5 prongs	927	264	3.51 ± 0.28
More than 10 prongs	150	68	2.2 ± 0.5

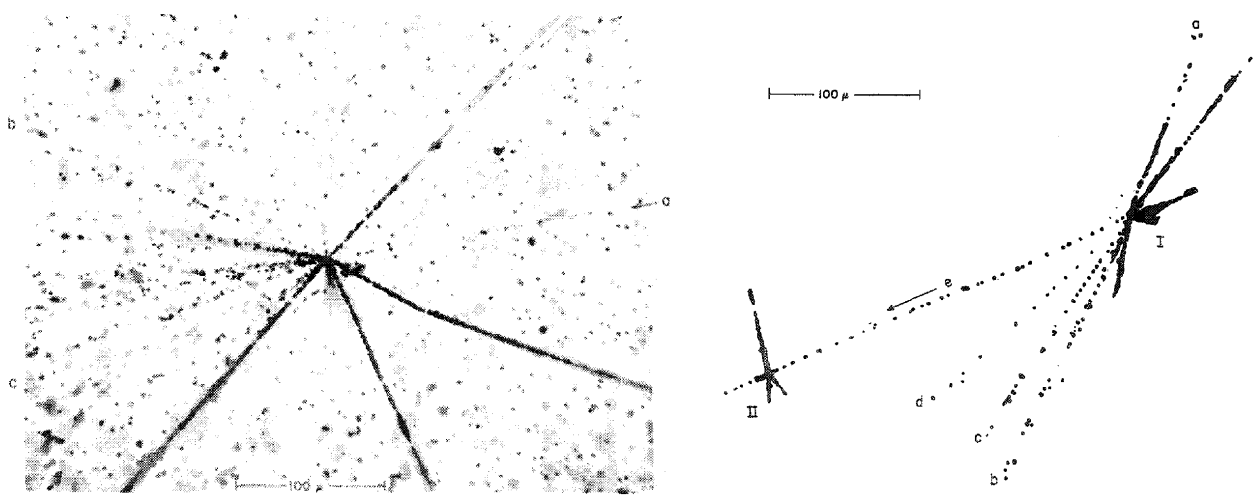
The Eastman plates flown at Cuba showed disruptions with emission of collimated sheaves of high energy particle tracks, called "brooms," which depict, in part at least, fast meson production processes. Many of these are produced by an incoming ionizing particle of energy in excess of 8 Bev. Angular divergencies in the sheaves extend up to 120°; the average multiplicity of high energy collimated particles is 5. Of the stars of this type, 90% have, in addition, so many low energy prongs that they can be accounted for only as the disruption of the heavy nuclei of Ag, Br, and I in the emulsion. Since these heavy nuclei contain 82% of all the nucleons in the emulsion, this result is consistent with the current view that fast mesons (presumably represented in the brooms) are created by the collision of an incoming particle with an individual nucleon of the nucleus, rather than with the nucleus as a whole; it carries the inference that the nucleons do not shield each other greatly from incoming particles of energy over 8 Bev.

Special attention is being given to the disruptions of the heavy nuclei. Forty-five out of 47 events have been accompanied by emission of relativistic particles, which are seldom seen in the disintegrations of the light nuclei, C, N, and O. It also appears that, in about a fourth of these cases, the disruption is caused not

by a primary particle of the cosmic rays, but by an energetic secondary particle. With the data of this study, and with the best (but none too good) available information on primary flux, the cross section of the heavy nuclei for disintegration by the primary particles of more than 8 Bev was computed; it was found to be significantly smaller than the accepted geometric cross section of these nuclei, implying some degree of transparency of the heavy nuclei toward the high energy primary particles# (E.O. Salant, J. Hornbostel, S.E. Golian, C.B. Fisk, J.E. Smith).

Further experiments are being planned to extend the energy range of the field-sensitive primaries through utilization of the east-west effect in directionally oriented plates flown at the equator (S.E. Golian).

A number of technical developments associated with the use of emulsions for nuclear research are worthy of note. Under a subcontract, the Polaroid Corporation has developed a system of dark field microscope illumination which greatly diminishes the time required to scan emulsions for the location of large stars. Under a subcontract with Columbia University, Dr. M. Blau has developed a two-bath processing method which is particularly valuable with the new minimum ionization emulsions. Heretofore, thick emulsions were processed by the temperature-change method, which was difficult to control and gave nonuniform results. The two-bath process is not only uniform in its results, but also gives less background and fewer imperfections in the emulsion than the older method. By exposing an emulsion to high humidity for an extened period of time just prior to its irradiation, Dr. Blau has also been able to eradicate tracks accumulated in the emulsion during

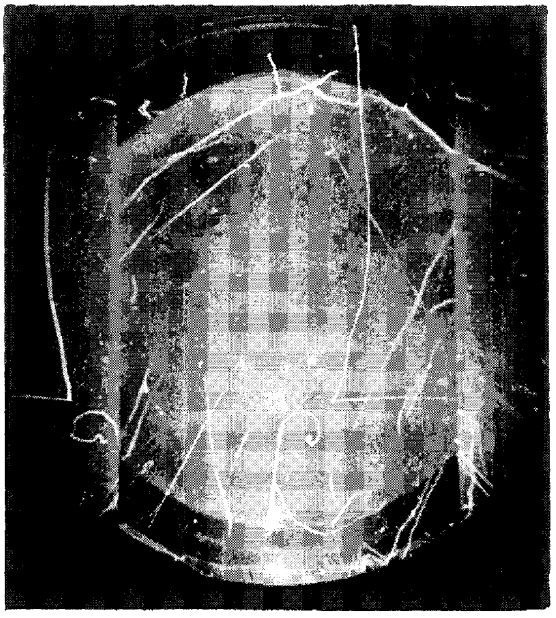


Left: Star in nuclear emulsion flown to 95,000 feet. This star has 12 heavy prongs, mostly protons of less than 100 Mev, and 13 light tracks due to particles of relativistic energy. In this photograph, many tracks are invisible because of their dip beyond the focus of the lens. The light track marked "a" is the track of the initiating particle (at least 8 Bev). Between "b" and "c" are other light tracks, produced by the collision of "a" with the heavy nucleus (Ag, Br, or I).

Right: Double star in nuclear emulsion flown to 95,000 feet (background removed for ease of viewing). Track "a" is due to an incoming primary proton (over 8 Bev) producing disruption I. Tracks b, c, d, e are all tracks of relativistic particles; heavy tracks in I are of less energetic particles (one of these obscures part of the track "a"). The particle of track "e" produces a second disintegration, II, and proceeds out into the air; it is probably a proton of over a billion electron volts. The star II consists of very low energy protons and alpha-particles (energies of the order of 10 Mev).

its previous life history, and is thus able to isolate effects under study.

The effect of temperature on grain density of proton tracks has been studied at the Laboratory, and it has been shown that the density increases by as much as 30% in the temperature range from -60°C to +25°C. Temperature control is therefore necessary if grain density is to be used to distinguish particle masses (E. Dollman).



Track of a negative mu meson which stops and decays in the high pressure cloud chamber (140 atmospheres of argon). The electron track shows curvature in the magnetic field which indicates an energy of 50 Mev. The probability for decay rather than capture in argon, as computed from theory, is 14%.

The technique for operating high pressure cloud chambers has developed to a very satisfactory state. The small chamber has operated nearly continuously for several thousand photographs with one hundred and fifty atmospheres of argon. Very dense tracks with low background have been obtained with a mixture of several alcohols and water at an expansion ratio of less than 4%. With improved temperature control, the period of pre-expansion sensitivity has been increased, and some indication has been found that the cycling rate can be increased by rapid recompression. Among the interesting events observed are several mu mesons stopping in the gas, some of which decay by electron omission, and about twenty nuclear disruptions occurring in the gas, most of which are produced by neutral particles. A number of other events difficult to interpret by familiar processes have also been seen; these may be identified as the number of examples increases (T.H. Johnson, R.P. Shutt, G.F. O'Neill, G.R. Hoke, W.A. Tuttle).

The new high pressure cloud chamber with a large magnetic field is nearing the operating stage. The steel yoke was delivered in March, and the coils have already been mounted in position. The expansion valve and hydraulic system are now being assembled for a preliminary test. A new wing of the laboratory, for the generators, is nearly completed (T.H. Johnson, R.P. Shutt, A.L. Johnson).

Five more balloon flights with cloud chambers are being prepared, and are scheduled to take place in Minnesota in July. A flight with one of the Skyhook balloons, launched by Laboratory personnel in Pennsylvania in May, showed that the temperature of the gondola is now under excellent control. Satisfactory results are expected from the next attempts (A.M. Thorndike, R.P. Shutt, A.W. Wotring, A.L. Johnson).

The dual cloud chamber with intervening magnetic field, referred to in the previous report, is nearing completion. It will be used for studies of meson scattering. The permanent magnet in the apparatus has an air gap 1-1/4 inches wide, and the pole dimensions are 11" x 11". It has been magnetized to a strength of 8500 oersteds

in the gap. Important features of the cloud chambers to be used in these experiments are a newly developed quick acting expansion valve, for minimum distortion of tracks in counter-actuated photographs, and the thin walled transparent plastic cylinders, which will reduce the errors of momentum measurements due to scattering (W.L. Whittemore, R.P. Shutt).

Solid State Physics

In transitions of the martensite type, a lattice shift occurs almost instantaneously over a region many thousand atoms across, transforming the lattice from one structure to another (e.g. face-centered to body-centered cubic). Investigations have been undertaken of several new features of such transformations in wires of 7129 iron-nickel alloy, this composition being chosen to have a transformation temperature around -30°C. Electrical resistivity measurements show that the first stages of transformation during cooling occur discontinuously in large steps, each affecting an appreciable fraction of the total volume, and that, contrary to the usual behavior, transformation continues after cooling has stopped.

The progress of transformation has also been followed visually by observing, under a microscope, slight distortions of a polished surface during cooling. These show that the martensite forms in large clusters of disk-shaped plates, each plate being confined to a single grain, and the cluster covering many grains. Subsequent transformation occurs as small clusters of plates progressively fill in the gaps between previous ones.

An arrangement was made for high speed photomicrographs during transformation, in an attempt to study the apparently instantaneous development of clusters of plates. Successful motion pictures have been obtained up to speeds of 4000 frames per second, but even at this rate, each cluster appears complete in a single frame. Further photographic studies are being made, but it appears doubtful that speed can be increased sufficiently to record growth of a single plate or even, perhaps, of a cluster (A.W. McReynolds).

The parallel plate counter, of the same type as that described in the previous progress report, has been developed for use in neutron diffraction studies. The diffracted neutrons fall on an indium-tin alloy foil stretched over an 8-inch diameter plate. The activated foil and supporting plate are then inserted as one electrode of a parallel plate counter. The spark pattern resulting from decay of the activated indium can then be photographed through the opposite electrode of 1/2-inch NESA glass, 1 to 2 mm away. Since the neutrons striking the crystal specimen will be derived from a continuous energy distribution from the reactor, the actual pattern of neutrons incident on the foil is a superposition of the patterns arising from all energies. Because of the sharp indium resonance at 1.4 ev, however, only the neutrons of the resonance energy are appreciably absorbed, and a diffraction pattern can be obtained. This selective detection feature is advantageous in that, for many experiments, it eliminates the necessity of a velocity selector device, which would otherwise greatly decrease the available neutron intensity (R.W. Weiss).

Equipment has been designed and partly constructed for evaporation onto a crystal substrate in vacuum of a thin single crystal metallic film, the final layers of which will consist of a radioactive isotope of the metal. The diffusion rate in

different crystallographic directions will be studied by scanning the film with a counter behind a system of defining slits (A.W. McReynolds, G.W. Johnson).

Theoretical Subjects

Earlier work on cascade showers was extended. A rapidly converging solution was found, from which numerical values representing the density of showers as a function of thickness of materials are easily obtained. Compared with previous results, the work is an essential improvement in accuracy for the more highly developed showers; it will have useful application in connection with high energy electrons and gamma-rays# (H.S. Snyder).

In addition to their being helpful in planning and interpreting experiments, the theorists are studying basic problems of the consistency and completeness of the quantum theory of fields. Their results are not of such a nature that they can be briefly reported here (H.S. Snyder, J.R. Pasta).

ELECTRONICS AND INSTRUMENTATION

For most of the period under review, recruiting for the Electronics and Instrumentation Division was at a low rate, largely because of lack of space. During the spring, however, the Accelerator Project began gradually vacating its portion of the building, and this permitted some expansion.

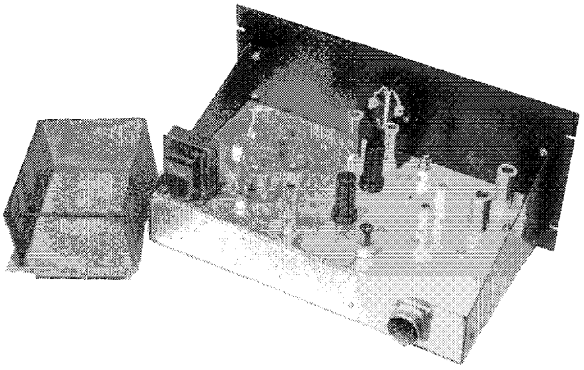
At present, the total strength of the Division is 46, a net gain of three for the six-month period. At least five summer visitors (possibly more) are expected this year. In addition, two scientists will be at the Laboratory on leave, one for seven months and the other for fifteen months. The Division now comprises the following staff: Scientists and engineers, senior 10, junior 4; technicians, 20; administrative and clerical, 2; machine shop, 5; drafting, 2 (on loan from Drafting Group); and glass shop, 3. It is apparent that this Division is approaching its final size, with most of the future recruiting to take place in the junior scientist and technician grades.

Research and Development

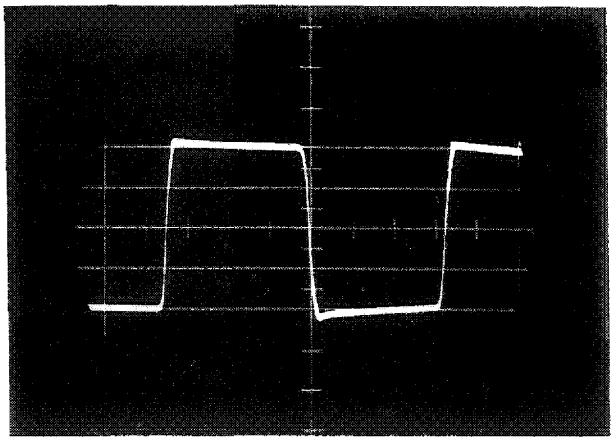
Research on parallel plate spark counters which was carried out at the Laboratory last summer by Drs. Pidd and Madansky was continued during the winter at Johns Hopkins under a research subcontract. Counters were developed with substantial improvement in time resolution characteristics over the standard gas counters. The rise time of the counter pulse was measured to be 100 volts in 10^{-9} seconds, compared with 10 volts in 10^{-6} seconds in a Geiger counter. The counter delay time was shown to be less than 10^{-8} seconds, compared with a delay time greater than 10^{-7} seconds for the Geiger counter. The problem posed by the spark counters was the low efficiency (10% for electron detection), narrow plateau (300 volts), and characteristic recovery times as long as several seconds. A cathode surface preparation technique was developed which substantially improved all these characteristics, rendering the counter useful for practical counting problems. The same figures of merit of the counters are now: 98% efficiency for electron detection, 1200 volts plateau width, and one millisecond recovery time. Work is in progress at the Laboratory this summer which utilizes the spark counter in coincidence measurements.

The following developments are of Laboratory-wide interest, or were initiated by the Electronics Division itself:

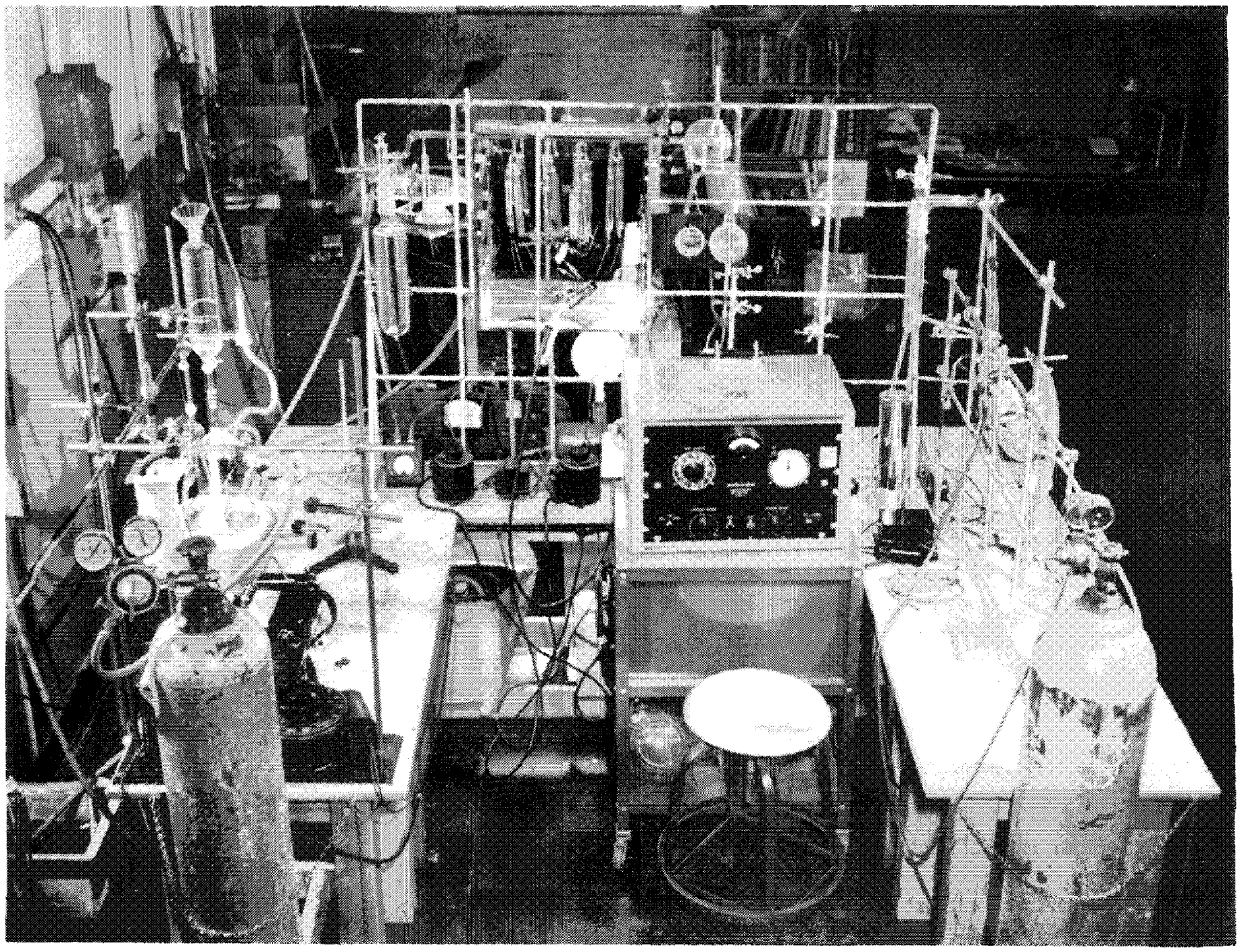
Work has continued on ZnS alpha scintillation counters, and a unit was designed to replace the parallel plate ionization chamber counter for laboratory work. A spectrograph was obtained to study fluorescent materials. Anthracene is being purified according to the Oak Ridge technique, and considerable work has been done on an oven for growing crystals for fluorescent counter work. Several vacuum and filling systems have been added. Standard G-M tubes were studied to find less photosentive cathodes and better gas fillings. End windows of counters have been coated with conducting films to cut down the number of spurious counts -- with some success. All G-M tubes show some multiple pulsing; both commercial and Laboratory



A typical chassis designed and built by the Electronics Division, a square wave modulator for the Physics Department.



Oscilloscope trace of the square wave modulator driving a 600 μμf load at a frequency of 100 kc. The peak to peak amplitude is 670 volts.



A part of the Electronics Division laboratory, showing a setup for purifying anthrancene for scintillation counters (left), a filling system for Geiger-Mueller counters (center), and a system used for filling some experimental lamps for cloud chamber illumination (right).

tubes are checked for this effect. Considerable work has been done on proportional counters, which should find much wider application.* In addition to trying different counter chambers and fillings, it was found necessary to develop a nonoverload amplifier. The present amplifier will stand an overload of 7000 times the minimum detectable signal. Further work must be done to insure good linearity. Two single channel pulse height analyzers have been built, and work has been done on two models of cathode ray pulse height analyzers.

Projects done for and with other departments are listed below:

At the request of the Physics Department, a modulator was developed for the Stark electrode in a nuclear spectrometer which will drive 600 $\mu\mu$f with a 100 kilocycle square wave of 600 volts amplitude. The rise time is less than 1/2 microsecond, and the total power consumption is only about 150 watts.* A circuit was developed, at the suggestion of S. Golian, to print out the instantaneous reading of a scaler at arbitrary intervals. The record is made on a multiple pen recorder without disturbing operation of the scaling circuit. Originally intended for measuring short radioactive decay periods, this circuit will find many other applications.* Tests were run on a number of high pressure arcs to find the best design for the high pressure cloud chamber.

A variety of more or less conventional items was also built for the Physics Department, including circuits for a proton resonance field regulator circuit, coincidence circuits, BF_3 proportional chambers, and 10 chasses for cosmic ray equipment. One associate engineer and two technicians have been on loan to the Particle Physics Division throughout the period covered by this report.

A variety of projects were worked on for, or in cooperation with, members of the Reactor Science and Engineering Department. Sensitive detecting equipment was designed for monitoring waste from sinks in the hot laboratory. Work is progressing on some aspects of the stack monitoring problem. A number of special counters have been developed, and there has been cooperation on development of proportional counters and the accessory circuits. Charging of water droplets is under study in connection with precipitator design. A sensitive smoke detector for use in a captive balloon is being constructed for meteorological studies. A scaler "read out" circuit, similar to the one described under Physics, but with an automatic reset feature, was built for measuring periods in the reactor. The electronics staff has given considerable advice and assistance on various counting problems.

Several members of the electronics staff have been looking into the computer problems involved in frequency control for the Cosmotron. A number of possibilities were analyzed, and fast counting circuits explored. A 10 megacycle scaling circuit of Columbia design was tested. Advice was given on procurement of a neutron velocity spectrometer for use with the cyclotron.

The two principal items built for the Chemistry Department were for use with the mass spectrometer. One of these was a circuit for sweeping the magnetic field in a period of about 30 minutes; the current was varied approximately as the square

*A report on this work is being prepared for publication.

root of the time, so as to give a linear mass scale on the recording paper. The other was an electronically regulated high voltage supply which is extremely stable (0.01%).

Several "Gooch crucible" proportional counters have been delivered to the Biology Department.# Work has continued on measurement of soft betas with proportional counter techniques. Special amplifiers were designed and data taken on C^{14} and H^3 to evaluate the usefulness of the counters in studying beta-ray spectra.

A great deal of effort continues to go into instrumentation for health physics, particularly for the monitoring stations. The vibrating reed electrometer gave trouble with a temperature effect which was finally traced to static charges on the insulators. This is being corrected. Seven of these electrometers are installed and operating. Other components of the monitoring stations were revised and improved; the battery-operated ratemeters were completely revised. A trailer for servicing the monitoring stations, with self-contained power source, has been completely equipped. One continuous dust monitor has been recording data on airborne alpha and beta activities. A production model is under test and parts are being assembled to equip the rest of the monitoring stations. A beta-gamma detector with remote indication was installed in the meteorological tower.

Six Kelley-Koett hand-and-foot counters were purchased. Three are installed, but are giving undue trouble in operation. The Electronics Division is supervising an Atomic Energy Commission contract with RCA on development of a new model which should be a great improvement. The Division is presently cooperating with the Health Physics Division in development of laundry monitoring equipment, a method of concentrating the activity in contaminated water by evaporation, and an alarm connected to detectors in a swinging door.

Many health physics instruments were modified or revised. Numerous counter tubes and chambers were built.

Repair and Calibration

Repair and maintenance of Laboratory electronic equipment takes about one quarter of the available man hours. In six months, 50 scalers, 16 meters, several oscilloscopes, and a wide variety of other instruments were repaired. The health physics instruments are checked and calibrated at regular intervals. These amount to some 100 instruments per month, a number of which require servicing. Electronics Division personnel also service the helium leak detectors, and do leak hunting on counters and other vacuum components.

Glass Shop

The Laboratory glass shop is under supervision of the Electronics Division. It has filled 175 orders in the last six months, and has done countless small jobs and repairs. Nearly 50% of this work was for the Chemistry Department, while the Physics and Biology Departments account for most of the remainder.

#Indicates publication. See Appendix for complete reference.

ACCELERATOR DEVELOPMENT AND CONSTRUCTION

The staff of the Accelerator Project, now numbering 54, has been augmented by the addition of 4 engineers, 11 technicians, 3 machinists, and 2 draftsmen. There is still need for a few young physicists with outstanding research abilities and interest in high energy physics. There is also need for one or two experienced experimental physicists on either a permanent or an on-leave basis.

60-Inch Cyclotron and 3.5 Mev Electrostatic Accelerator

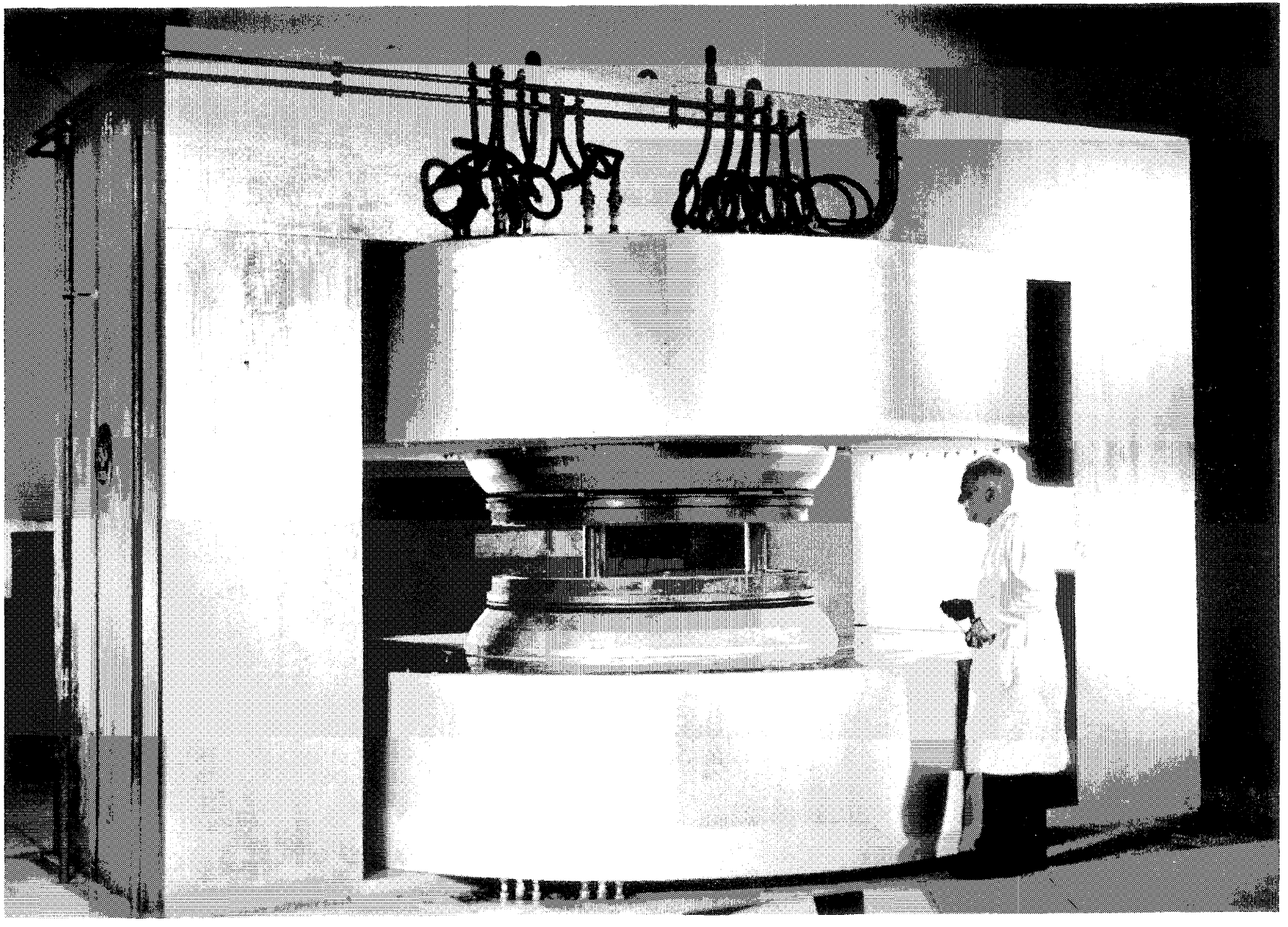
The building which will house these two machines is now virtually completed, and the installation of equipment is under way. Space has been provided for a machine shop, physics laboratories, chemistry laboratories, and stores room, in addition to the specialized rooms for the accelerators. Construction delays were frequent, but aside from the cyclotron, where magnetic field measurements are required before the deflector system can be designed, there will be no serious delay in the overall installation.

During the last six months, Collins Radio Company completed a large fraction of the heavy equipment. Delays in receiving the diffusion pump equipment have held up the vacuum testing, so that now delivery is promised for some time in October. The 264-ton 60-inch electromagnet has been set up and energized. Field tests are under way, with results to date which are quite satisfactory (W.W. Merkle).

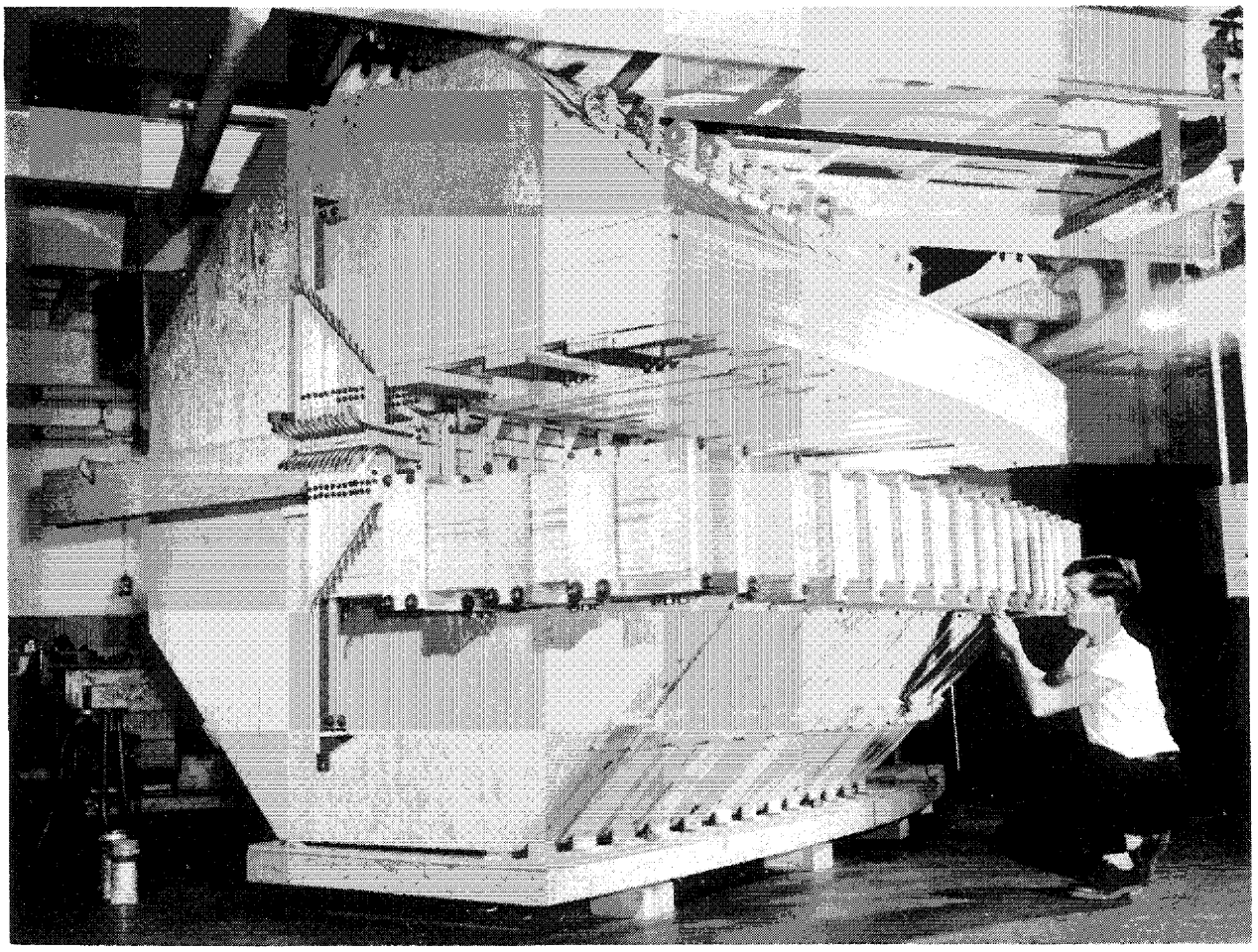
Tests on the 3.5 Mev electrostatic generator at the General Electric Company have been in progress since January 1949. A maximum column voltage of 2.5 million was obtained with a proton beam current of 5 microamperes. It does not appear that this voltage is the maximum attainable, but some seasoning will be necessary to get up to the guaranteed voltage of 3.5 million. In view of the greater testing facilities at the Laboratory, the accelerator is now undergoing disassembly and crating for shipping. In addition, some weak points in the design are being corrected before shipping (G.J. Hoey).

Cosmotron (Proton Synchrotron)

In the last six months, scale models, wooden mock-ups, and various test sections were built all with a view to making simulated operational tests on as much of the Cosmotron as possible. Though careful calculations were made on most of the components of the machine, the models have almost invariably paid for themselves rapidly by providing more accurate data. Even a full scale wooden mock-up of part of the magnet and copper winding, illustrated in this report, has shown ways of improving the coil winding technique. The most significant working models have been the 1/4-scale model of a sector of the magnet, the sample section of the ferrite ion accelerator transformer, and the ceramic vacuum chamber sections.



Interior of cyclotron vault showing the 60-inch magnet.



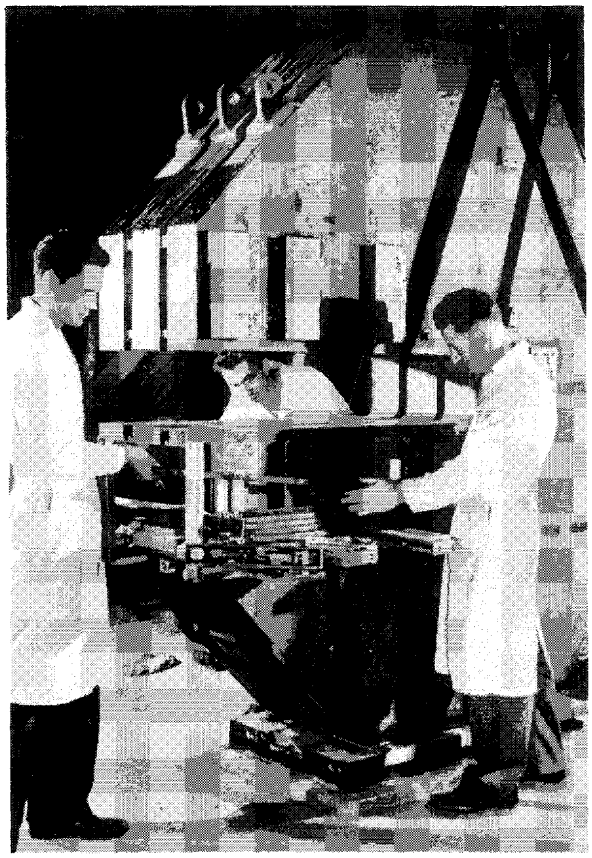
Full scale wooden model of a section of one quadrant of the Cosmotron showing method of laying in copper windings.

Testing of 1/4-Scale Magnet Model

A very accurate 1/4-scale model of a sector of the magnet was built to replace the previously studied, inaccurate 1/3-scale model. The new model is composed of 12 blocks, each block containing 12 plates. In contouring the gap, the middle block is studied because it is reasonably free of end effects. Although its primary purpose was to indicate a final contour for the pole faces, this model is now being used to test sections of various proposed metal vacuum chambers, to study the effects of lamination shorts, and to assist in the design of pole face windings. It will also be used to study the field shape at very low fields (20-100 gauss), which will be of interest in case it is ever decided to add electron acceleration to the presently planned proton acceleration (L.W. Smith).

Magnet Fabrication

Fabrication of the first pilot block has been completed, with delivery of the main order by Bethlehem Steel Company expected to begin in July and to continue to October 15. As reported earlier, the magnet is built up from rolled 1/2-inch



Assembly of three finished magnet blocks in preparation for testing the individual blocks for magnetic and mechanical properties.

steel plate, flame-cut to the desired hexagonal shape. After the gap is flame-cut to the rough dimensions, stacks of plates are put into a stress relieving furnace, heated to 1250°F for 48 hours, and slowly cooled. The stress relieved plates are then stacked up and welded into 288 blocks of twelve plates each, with special fish paper and aluminum insulation between each two adjoining plates. Each stack, or block, is then accurately machined (R.A. Meyer).

Magnet Block Testing

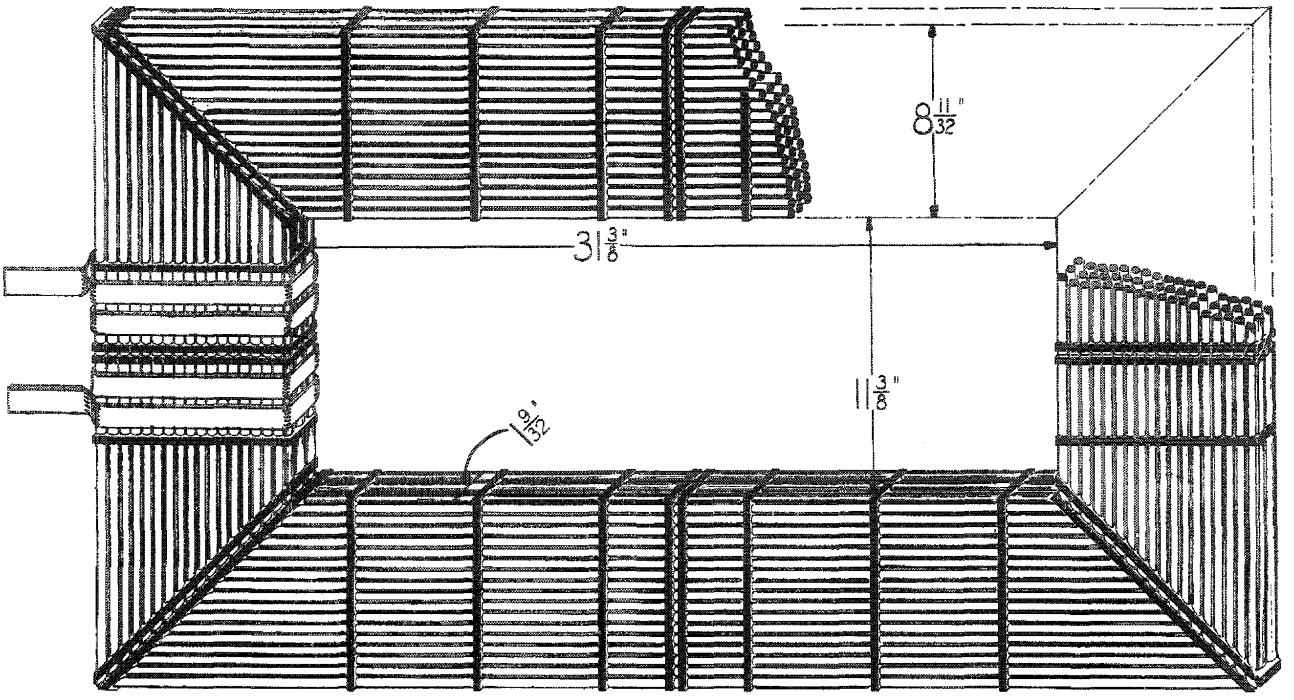
A major effort is being made to produce magnet blocks which are mechanically uniform. Since there will always remain some nonuniformity due to varying steel composition, thickness, and machining, it is planned to test magnetically each block before assembly, and to so assemble the 288 blocks as to smooth out the azimuthal variations in the field. The magnetic tests will involve a B-I curve, location of the magnetic median plane, and radial variation of the magnetic field (W.H. Moore, J.M. Kelly).

Magnet Coil

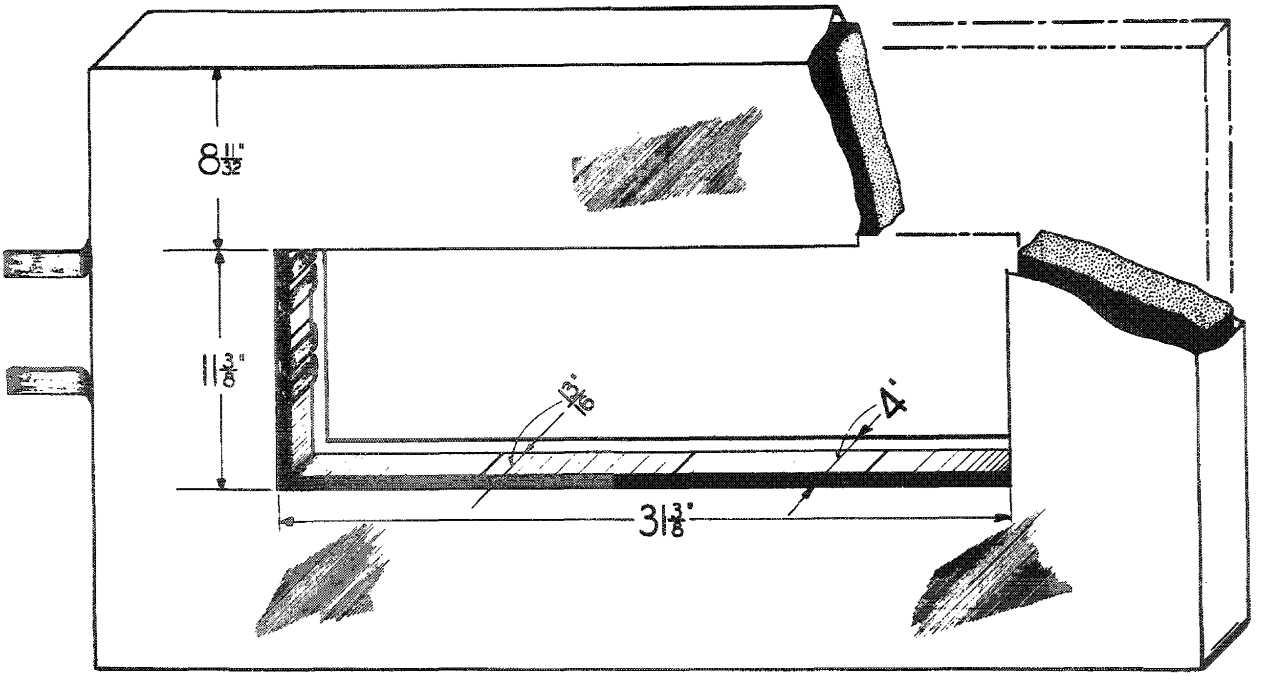
Seventy tons of water-cooled copper bus bar have been largely fabricated for the magnet coils, and the winding process itself has been contracted to an electrical firm. A large, temporary building has been erected to house the winding operation (as well as the magnet block testing operation). An accurate full scale wooden model of one quadrant will be built; on it, a complete quadrant coil system will be assembled. After a coil is completed, it will be disassembled, marked, and stored; then the next quadrant will be wound. By the time the coils are wound, the magnet should be ready to receive the finished coils (J.A. Kosh).

Motor-Generator Magnet Power Supply

Westinghouse Electric Company is well along in the manufacture of the 40,000-kva generator-ignitron set. Delivery should be complete by December 1949. Substation switchgear, transformers, etc., are also scheduled for delivery in December 1949 and January 1950. Peak power to be drawn from the flywheel and generator will be 25,200 kw, but the energy dissipated in the magnet will be only 3.12×10^6 joules per pulse, since 80% of the energy put into the magnet during the acceleration cycle will be returned to the generator flywheel by inverter action of the ignitron bank (A. Wise, G.K. Green).



Drawing of a ferrite core section built up from 3/8-inch rods of ferrite. Finished model will incorporate a copper shield around the core similar to that shown below. The complete transformer will consist of about 13 sections weighing approximately one ton.



Alternate design of ferrite transformer core section constructed of solid slabs of ferrite placed within a copper shield. Excitation of this transformer, or of transformer shown above, may eventually be distributed around the core.

Radio Frequency Components

Coupling system. Approximately 1000-2000 electron volts of energy per particle must be delivered to the revolving ion beam each trip around the magnet. As reported previously, the most promising method of coupling radio frequency power into the ion beam appears to be a transformer core, through the window of which the ion beam travels. Tests on a special ferrite material indicate that it has the requisite properties to operate over a frequency range of 0.35-4.0 megacycles. Close cooperation between the Laboratory and various manufacturers, notably General Ceramics, Radio Corporation of America, and Philips, has resulted in a drastic price reduction, as well as improvement in quality. Because of the high dielectric constant of this ferrite material (100-10,000), and its high permeability, the propagation velocity is very low; so low, in fact, that the wavelength can become small compared to the transformer dimensions. This is undesirable because standing waves can be formed in the structure, and strong phase shifts may be set up. Therefore, recourse has been had to a structure composed of extruded rods of ferrite, shown in the accompanying figure. Since the magnetic flux flows parallel to the rods, it experiences little reluctance, but the electric vector, being at right angles to the magnetic vector, encounters a dielectric constant which is close to unity because of the air between the rods. In this way, the product $\mu\varepsilon$ can be kept reasonably small. Tests which will be made soon will show whether or not this type of coupling transformer will operate satisfactorily. If the tests live up to expectations, the full transformer will be constructed, composed of 13 sections, like that shown in the figure, and weighing approximately 2000 pounds (M. Plotkin, J.P. Blewett, M.H. Blewett).

A somewhat different structure employing a "one piece" structure is shown in the lower figure. Slabs of ferrite material are joined together by a thermosetting plastic cement to form a continuous lamination. Here, as before, it is necessary to have air paths in parallel with the ferrite in order to reduce the effective dielectric constant. If this design is finally chosen, it will be necessary to operate approximately 20 core sections in parallel.

Radio frequency amplifier. A 300-kw, 10-kv rectifier is on order for the final stage of the amplifier which is to drive the ferrite transformer. Intermediate stages of the amplifier have been built and tested (T. McLean).

Variable frequency oscillator. An intensive study is being made of several types of oscillators which can be swung over the 12 to 1 frequency ratio. Beating klystrons, voltage controlled multivibrators, LC and LR oscillators with L being variable through the use of saturable ferrite cores, and ring oscillators have all given promise of satisfactory performance. The eventual choice will be made on the bases of stability, simplicity, and ease of control (A. Pressman).

Vacuum System

Vacuum chamber. Implosion tests on full sized samples of ceramic tubes indicated that considerable difficulty would be experienced in attaining sufficient structural strength to withstand the atmospheric pressure. Magnetic tests on nonmagnetic steel chambers show that a thin (0.015-inch) metal vacuum envelope, supported by a rib-like structure of 1/2" x 2" nonmagnetic steel, will not materially

distort the shape of the magnetic field. A metal chamber has adequate strength, maximum effective beam aperture, and is more easily joined together than a ceramic tube. Further work on the ceramic chamber has been dropped (W. Liben).

Vacuum pumps. With the acquisition of a number of 20-inch diffusion pumps from Oak Ridge, it was possible to increase the pumping rate above the rate originally contemplated. Twelve pumps spaced around the magnet will produce a pressure lower than 10^{-5}mm of Hg. Each pump will be part of a complete unit consisting of high vacuum pump, booster pump, mechanical pump, baffle refrigerator, valves, meters, etc. In the event of pump failure a complete pump unit can be quickly removed and a new unit put in its place (W. Liben).

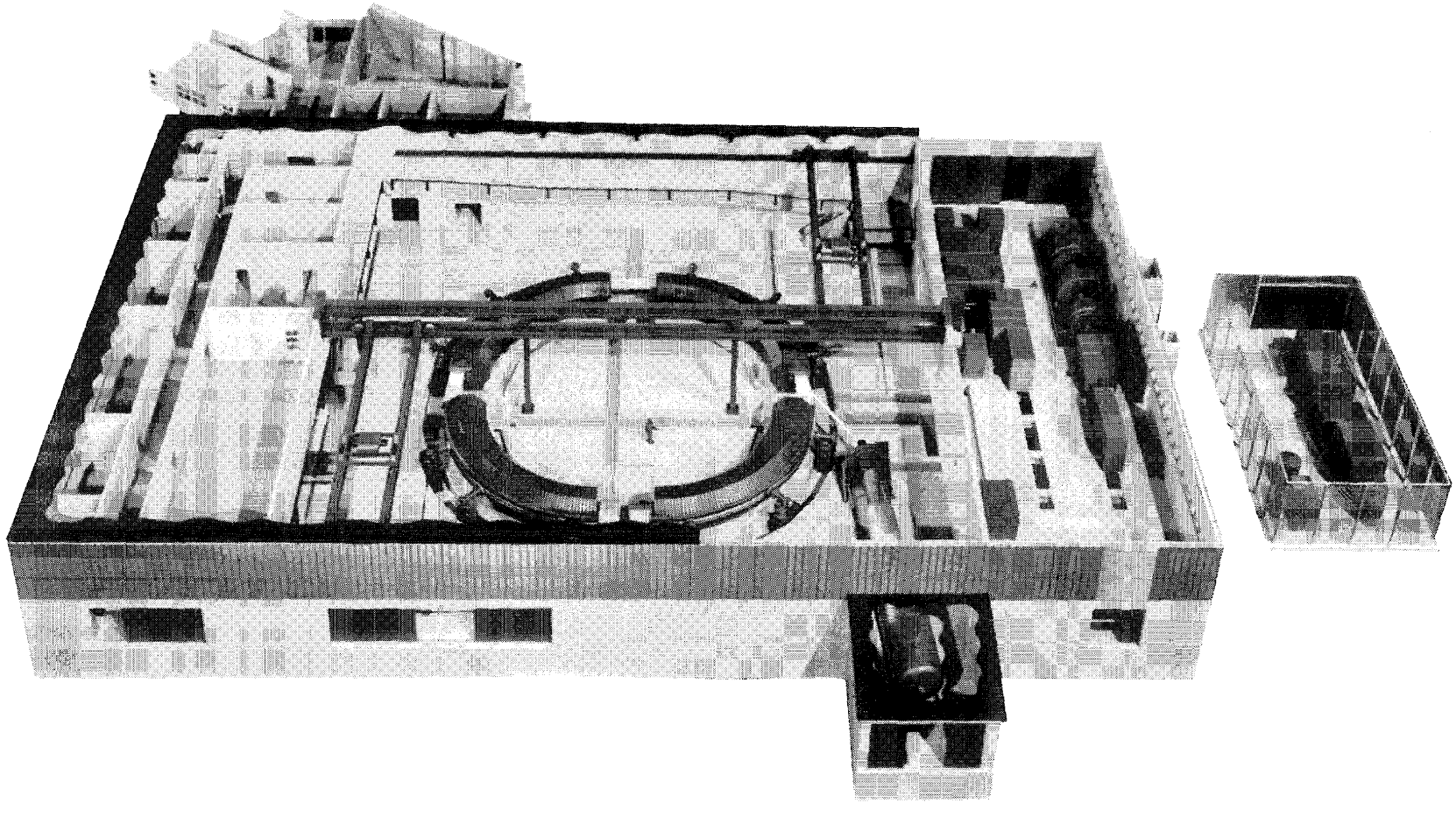
Injection System

Theoretical studies of the proton injection requirements indicate the desirability of injecting with a well defined energy and direction. In addition, the energy should be as high as can conveniently be produced, because scattering by the residual gas will disperse the beam more at low energy than at high energy. A further reason for injecting in the several million volt range is concerned with the uniformity of the guiding magnetic field. By the time the rising magnetic field has reached 300-400 gauss, most of the causes of nonhomogeneous field have either died out or have become unimportant. A Van de Graaff electrostatic generator for injecting protons at 4 Mev is now under construction by the High Voltage Engineering Corporation, and is scheduled for delivery around February 1950. A pulsed, cathodeless ion source of the PIG type will be incorporated in the initial installation. From evidence obtained at other laboratories, notably at the University of California Radiation Laboratory, there is little doubt that pulsed currents in the milliampere range will be obtained. While waiting for the injection accelerator to arrive, some experimental injection studies will be made with the Van de Graaff electrostatic accelerator which was built by the General Electric Company. Calculations have already shown that the stray magnetic field of the large synchrotron magnet will not interfere unduly with the injection deflector system.

Building Progress

Bids have been returned on the main part of the accelerator (Cosmotron) building; work will commence by July 15. Housed in the building will be the magnet, generator, controls, and all auxiliaries necessary for operation. Considerable space for assembly and test of experimental equipment has been provided. Already built and in use are the office wing and the machine shop, electronics wing. The main building is expected to be far enough along by October that the tested magnet blocks may be erected on the ring foundation. By the time the magnet is erected and wound, the main generator should be installed and ready to power the magnet.

A temporary building of 14,000 square feet was put up to house the magnet testing work and the pre-winding phase of the copper coils. After these main operations are completed, it is probable that the building will be used for preparation of concrete shielding blocks for the Cosmotron (L.D. Stoughton).



Scale model of accelerator (Cosmotron) building interior showing magnet, electrostatic injector, power equipment room, and control room.

CHEMISTRY

The staff of the Chemistry Department has grown from 29 at the beginning of this period to 40, of whom 30 are scientists. Four of the six wings of the chemistry laboratory ensemble are now occupied and in use.

The third of the series of informal conferences being sponsored by the Department was held on June 14 and 15, on the subject "Nuclear Fission and Reactor Radiochemistry."

The research program of the Department is devoted principally to investigations in: the properties of the heavy elements; the chemical effects of radiations and of nuclear transformations; the chemical uses and properties of isotopes; and the study of various nuclear problems by radiochemical methods.

The current investigations are described in the following sections. For the most part, these studies will be continued, and will constitute a significant portion of the research program of the next twelve months. Since, however, some of the principal nuclear facilities (nuclear reactor, 60-inch cyclotron, proton electrostatic accelerator) of the Laboratory are expected to come into operation during the next few months, it will also become possible to undertake problems which have been planned about them. These include structural investigations by neutron diffraction; systematic determination of the excitation functions of proton, deuteron, alpha-particle, and neutron reactions; and measurement of neutron capture cross sections of radioactive isotopes. Much of the current work will also be greatly aided by these machines.

Electronic States of the Heavy Elements

The results of the measurements of the magnetic susceptibilities of tetravalent uranium fluorides have been submitted for publication to the Physical Review. The report covers measurements for UF_4, KUF_5, K_2UF_6, Na_3UF_7, and $CaUF_6$ from liquid nitrogen temperature to 60°C. These compounds obey the Curie-Weiss law, $X = \frac{C}{T + \theta}$, over most of the temperature range, with deviations in some cases near liquid nitrogen temperature. The Weiss temperatures are unusually large, being in the range 100° to 250°. The magnetic moments calculated for the U^{4+} ion in these compounds are close to that of the corresponding rare earth ion, Pr^{3+}. An experiment is under way to investigate the cause of the large Weiss temperatures in tetravalent uranium compounds. The plan is to dilute UF_4 and UCl_4 with the isomorphous salts ThF_4 and $ThCl_4$, or ZrF_4 and $ZrCl_4$, and to measure the susceptibilities of these mixtures. It is thought that this experiment will tell whether the large Weiss temperature arises from an exchange interaction between the paramagnetic ions# (N. Elliott).

A theoretical interpretation of the present results has been attempted on the basis of a one-atom model in which the effect of the environment is represented by

# Indicates publication. See Appendix for complete reference.

an electric field of definite symmetry. The problem is thus reduced to a determination of the levels into which the ground state of the free ion is split by the simultaneous application of a crystalline electric field and an external magnetic field. The free U^{4+} ion was assumed to have the configuration $5f^2 6s^2 6p^6$ with a $^3H_4$ ground state; and in most of the calculations, the crystalline field was assumed to have cubic symmetry. Two limiting cases have been investigated: 1) where the effect of the electric field is small compared to that of spin-orbit coupling in the free ion (corresponding to the situation in the rare earths); and 2) where the effect of the electric field is large enough to break down the coupling of L and S to form a resultant J, the spin-orbit coupling then being treated as a perturbation on the levels arising from the action of the crystalline field (corresponding to the situation ordinarily encountered in the iron group). Qualitatively, the first case more nearly represents the data. However, it was not possible to obtain quantitative agreement in either case. On the basis of these preliminary studies, it appears that the one-atom model will not provide a satisfactory explanation of the paramagnetism of tetravalent uranium compounds, and that it will be necessary to take into account exchange effects as well as the crystalline field (L.M. Corliss).

Spectrographic studies of the electronic states of the heavy elements, in crystals and in solution, will also be undertaken, with emphasis on the spectra at low temperatures (S. Freed, J. Bigeleisen).

Radiation Chemistry

The quantitative study of the chemical reactions produced by ionizing radiations requires a source of penetrating radiation of known quality and physical behavior, and of high and accurately controllable intensity. For this purpose, a 2 Mev electron accelerator of the Van de Graaff type has been ordered from the High Voltage Engineering Corporation. Work is proceeding on the design of a concrete-shielded room to house this machine, and on the associated chemical laboratories. The generator is expected to be in operation by January 1950.

It is planned to concentrate attention at first on the kinetics and mechanisms of radiation reactions in water and aqueous solutions, a subject which is of particular interest in connection with the chemical mechanism of biological radiation effects. Radiation effects in aqueous solutions are believed to result from reactions of free radicals H and OH formed by the dissociation of water molecules; but the number of such radicals produced, their lifetimes, and specific rates of reaction with various molecules of interest are not known. Detailed studies of reaction kinetics under radiation should supply answers to these questions, and also provide a quantitative basis for the studies of free radical chemistry in water and chemical origins of radiobiological effects.

The electron accelerator will also be well suited for the detailed study of many other important radiation effects. For example: processes involved in the coloration of salts and oxides by radiation; effect of radiation on the oxidation of metals; reactions produced in gases by fast electrons and X-rays; and reactions of organic compounds and plastics under radiation (A.O. Allen).

A study of the photolysis, at 2537 angstroms, of methyl iodide in the presence

of silver (thesis problem) has been completed. The gaseous reaction products, methane and ethane, were determined by infrared spectroscopy. Ethane was formed in appreciable amounts only in the presence of silver, and its yield was increased markedly by rapid rotation of a set of silver vanes placed in the reaction vessel. The yield of methane was nearly independent of the presence or absence of silver, and also of the temperature. It is concluded that ethane formation is limited by a back reaction between methyl radicals and iodine formed in the primary dissociation step; when the iodine is removed by reaction with silver, the methyl radicals can combine with each other to form ethane. The methane must be formed by a process independent of competing reactions; this is concluded to be an immediate reaction with methyl iodide of "hot" methyl radicals formed with excess kinetic energy in the primary dissociation. The experiments provide strong evidence for the importance of "hot" radical reactions in photochemistry (R.D. Schultz).

Recoil Atoms and the Chemical Effects of Nuclear Transformations

An investigation is being undertaken (thesis problem) of the chemical reactions of radioactive recoil bromine atoms formed by neutron capture. The systems under study will consist of bromoform in benzene, or another hydrocarbon. The yields of the various compounds containing radioactive bromine will be determined, and the results compared with the corresponding data for CCl_4 in benzene and cyclohexane solutions (J.M. Miller, Ph.D. dissertation, Columbia University, 1949), and with current theories on the ways in which recoil atoms enter chemical combination in liquids (J. Silverman).

In general, beta emission is expected to cause rupture of the molecule in which the decay process occurred, either as a consequence of the recoil from the emitted particle, or because of the change of atomic number. In the case of C^{14} beta decay, however, it is possible that neither will cause bond rupture, since the recoil energy is quite low (maximum recoil energy 7 ev), and since the nitrogen-containing molecule formed may well be chemically stable. On the other hand, it is conceivable that dissociation may occur as a result of the readjustment of the electron configuration after the increase in Z, or of interactions with the departing beta-particle. Experiments are being performed to test these questions. The compound being studied at present is doubly C^{14}-labeled acetylene, which is expected to yield active hydrogen cyanide if molecular integrity is preserved.

$$HC^{14}{\equiv}C^{14}H = \beta + HC^{14}{\equiv}N + H^{+}.$$

Acetylene was synthesized by the method of W.J. Arrol and R. Glascock (Nature 159, 810 (1947)) from high specific activity barium carbonate supplied by Oak Ridge. The sample consisted of 29 micromoles of acetylene, containing 0.73 millicuries of C^{14}, in isotopic abundance 20%, so that 20% of all decays took place in doubly labeled molecules. After the sample stood 34 days in a sealed glass bulb at 2 mm pressure, HCN carrier was added, separated, and decontaminated. The final cyanide activity which was found corresponds to the presence of about 500 $HC^{14}N$ molecules for every beta decay which occurred in the doubly labeled acetylene molecules during the standing period. It is evident that the $HC^{14}N$ was formed in the system by processes other than the one under investigation. The

work is being continued in the hope that these irrelevant processes can be eliminated, so that the probability of bond rupture by the decay process can be measured (W.W. Miller, R.W. Dodson).

The recoil of atoms from surfaces after K-capture is being studied with the aim of measuring the energy spectrum of recoils caused by neutrino emission. Ag^{107} recoils resulting from electron capture in Cd^{107} have been observed in an experiment similar to that of B.T. Wright (Phys. Rev. 71, 839 (1947)). The Ag^{107} activity collected was independent of the potential of a retarding grid located between the source and receiver; hence it is concluded that the recoils were uncharged, as was the case in Wright's experiments. This experiment will be repeated with an apparatus of higher geometry, and the effect of varying the surface from which the recoils take place will be studied.

Two pieces of apparatus are being set up to measure the recoil spectrum in the decay of Be^7. One involves collecting the recoils which pass through a retarding grid and measurement of the current with a vibrating reed electrometer. The second apparatus consists of an electrostatic analyzer and an electron multiplier (R. Davis, Jr.).

Chemical Studies with Isotopes

Under this heading are described investigations in which isotopes are used as tracers in studying the mechanisms and kinetics of chemical reactions, the effects of isotopic substitution on the spectroscopic properties of molecules, and the effects of isotopic substitution on the rates and equilibria of chemical reactions.

Work with the Fischer-Tropsch unit has been shifted from a study of the deuterated hydrocarbon synthesis products to a study of the mechanism of the process, with deuterium as tracer. The experiments have as their aim the identification of the surface-bound radicals which are presumably intermediates in the reactions which lead to the synthesis products. The unit is operated on protium and carbon monoxide until steady production of synthesis products is insured. The catalyst bed is then evacuated, flushed with deuterium, and the products collected for mass spectrometric analysis. Under the hypothesis that the part of the molecule which is not deuterium existed as an entity on the surface, the results indicate that: 1) most of the surface radicals are groups of one to four or more carbon atoms with no attached hydrogen; 2) there are smaller amounts of CH and CH_2 radicals present; 3) no evidence for CH_3 on the surface was found (no CH_3D is formed in the flush). In a similar experiment, the catalyst was treated with carbon monoxide without hydrogen. The flush-off gas contained minimal amounts of protium, but appreciable amounts of deuterated methane, ethane, propane, and butane, suggesting that the aggregation of carbon atoms on the catalyst surface can occur without the participation of hydrogen. These inferences will be tested by further experiments in which rate phenomena on the surface will be studied (S.O. Thompson, L. Friedman, J. Turkevich).

In collaboration with members of the Chemistry Department of Princeton University, some properties of deuterium substituted toluenes have been studied. The compounds were ortho-, meta-, para-, and omega-deuterotoluenes, prepared by Grignard synthesis, and a polydeuterotoluene, with deuterium in the ring only,

prepared by exhaustive treatment of toluene with D_2SO_4. The infrared spectra of these compounds in the range 2 to 16 microns have been examined in this laboratory, and the results have been presented for publication. The compounds have characteristic absorption bands by which they can be distinguished from one another. The spectra have also been examined in the 2 to 4 micron region and in the 16 to 38 micron region by Dr. E. Plyler of the National Bureau of Standards. Mass spectrometric examination of the compounds by Dr. F. Mohler of the National Bureau of Standards has indicated that while one can distinguish between ring and side chain substitution, it is impossible to differentiate mass spectrometrically the various ring substituted mono deutero isomers. The purposes of this deuterotoluene investigation are to study syntheses involving localized substitution of deuterium in aromatic compounds, methods of characterizing such compounds, and to make a stock of such compounds for tracer studies# (J. Amick, L. Friedman, J. Turkevich).

The study of the interaction between CO_2 and charcoal has been completed. The general investigation of the processes of gasification of carbon is being continued with a study of the reaction between water and charcoal, using both deuterium and O^{18} as tracers (thesis problem). Further work is planned using oxygen-labeled CO. It is hoped that this work will lead to a better understanding of the production of water gas, a matter of considerable interest in the conversion of coal to liquid and gaseous hydrocarbons (J. Amick, J. Turkevich).

Experiments have been carried out on the reduction of acetone to propane on a platinum-charcoal catalyst, at temperatures from -70° to $0^{\circ}C$, in an attempt to determine whether it is possible to effect a localized introduction of deuterium by catalytic deuterization. The results of mass spectra analyses indicate substantial exchange with the end methyl groups in the propane under all conditions of temperature and flow rate employed (L. Friedman).

The apparatus for measuring the rate of the gas phase exchange between HBr and Br_2 has been redesigned and rebuilt in order to minimize various spurious effects. A run with the improved system at $20.5^{\circ}C$ and 1 mm total pressure showed 82% exchange in a half-second contact time, in qualitative accordance with the earlier measurements. It is hoped to obtain data for varying contact times, so that the rate can be established with confidence and the kinetics studied (H. Jacobson).

The exchange of bromine between anhydrous aluminum bromide and ethyl bromide was investigated earlier (N. Brejneva, S. Roginsky, and A. Shilinsky, Acta Physicochim., U.R.S.S., 7, #2, 201 (1937)); the reaction goes to completion at a measurable rate. It was later found (H.C. Thomas, unpublished experiments) that nitrobenzene inhibits the reaction, which is effectively stopped by a molar excess of nitrobenzene. In view of the importance of the catalytic activity of aluminum bromide, it has been thought worthwhile to investigate the kinetics of this exchange reaction. The significant results obtained to date may be summarized as follows: In solutions with mole ratio $C_6H_5NO_2/AlBr_3$ = 0.00, 0.30, 0.35, 0.42, 0.46, and 0.80, the exchange reaction goes to completion within a 2 to 3% uncertainty in 24 hours at room temperature. Solutions with mole ratio $C_6H_5NO_2/AlBr_3$ = 1.17 show no detectable exchange after 24 hours at room temperature. Precise kinetic data have been difficult to obtain. In the following tables, the velocity constants are those calculated for a second order reaction. Concentrations are in moles per kilogram of solution, and time is in minutes.

No Nitrobenzene Added 0°C			Nitrobenzene Added 0°C			
$AlBr_3$	C_2H_5Br	k	$C_6N_5NO_2/AlBr_3$	$AlBr_3$	C_2H_5Br	k
0.0629	0.1679	0.176	0.303	0.0436	0.1344	0.244
.0319	.2237	.123	.463	.0246	.1908	.122
.0278	.1263	.177	.803	.0303	.0946	.036

It appears probable that the reaction in the absence of nitrobenzene is second order. More work will be desirable on the effect of nitrobenzene as a function of its concentration, on the complex species actually present in solutions which contain aluminum bromide and nitrobenzene, and on the effect of other complexing agents such as the dinitrobenzenes and benzonitrile (H.C. Thomas).

Work is being continued on the exchange reaction between cerous and ceric cerium in aqueous solution. The procedure employed for the nitrate system and the early results have been published (J.W. Gryder, R.W. Dodson). Further work on the reaction order gives 1.07 for the cerous dependence, 0.90 for the ceric; the divergence from unity seems reproducible. The rate is markedly dependent on the acidity at constant ionic strength. The rate in 6.18 f nitrate is given by the expression

$$R = (Ce^{III})(Ce^{IV})\left[5.78 \times 10^6\, e^{-\frac{8250}{RT}} + \frac{3.02 \times 10^{20}}{(H^+)^2}\, e^{-\frac{24100}{RT}}\right],$$

where concentrations are in formal units and RT is in calories per mole. The entropy of activation for the acid independent reaction is -29 e.u. per mole. It has been found that separation from perchlorate solution can be accomplished by adding nitric acid and extracting with ether. Preliminary observations indicate that the rate in 5 f perchloric acid is the same order of magnitude as that in nitric acid (J.W. Gryder).

The theory of isotope effects in reaction rates has been applied to the effect of C^{14} substitution in the carboxyl group on the rate of hydrolysis of ethyl benzoate. This reaction has been studied experimentally at the Chalk River Laboratory, in Canada, with the experimental finding that the normal acid hydrolyzes 1.16 times faster at 25°C than the C^{14} labeled acid. A rough theoretical estimate of this effect predicts 1.14, which agrees with experiment within the limits of the approximations made in the theoretical treatment.

Systematic and detailed calculations have been made on the dissociation and exchange equilibria of the tritium halides between 273°K and 2000°K. The results are being prepared for publication. Tritium chloride and bromide are found to be 280 and 110 calories per mole more stable at 298.16°K than the corresponding protium compounds. Tritium iodide is 80 calories per mole less stable than protium iodide at 298.16°K.

Partition function ratios from 273.16°K to 2000°K were calculated for: HT/H_2, T_2/H_2, HTO/H_2O, T_2O/H_2O, TF/HF, TCl/HCl, TBr/HBr, and TI/HI. The following equilibria were calculated:

$$TX + HX' = HX + TX' \quad (1)$$
$$TX + H_2O = HTO + HX \quad (2)$$
$$2TX + H_2O = T_2O + 2HX \quad (3)$$
$$TX + H_2 = HT + HX \quad (4)$$
$$2TX + H_2 = T_2 + 2HX \quad (5)$$
$$TX + HX = HT + X_2 \quad (6)$$
$$2TX = T_2 + X_2 \quad (7)$$

The spreads in equilibrium constants at 273.16°K for the first five of these reactions are given in the following table.

Equilibrium	Low	High
1	$\frac{(TCl)}{(HCl)}\frac{(HBr)}{(TBr)} = 1.3638$	$\frac{(TF)}{(HF)}\frac{(HI)}{(TI)} = 5.6780$
2	$\frac{(HF)}{(TF)}\frac{(HTO)}{(H_2O)} = 2.3743$	$\frac{(HI)}{(TI)}\frac{(HTO)}{(H_2O)} = 13.481$
3	$\frac{(HF)^2}{(TF)^2}\frac{(T_2O)}{(H_2O)} = 1.6867$	$\frac{(HI)^2}{(TI)^2}\frac{(T_2O)}{(H_2O)} = 54.377$
4	$\frac{(HF)}{(TF)}\frac{(HT)}{(H_2)} = 0.31135$	$\frac{(HI)}{(TI)}\frac{(HT)}{(H_2)} = 1.7678$
5	$\frac{(HF)^2}{(TF)^2}\frac{(T_2)}{(H_2)} = 0.039897$	$\frac{(HI)^2}{(TI)^2}\frac{(T_2)}{(H_2)} = 1.2863$

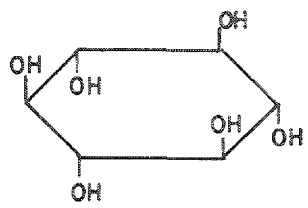
The calculations for the dissociation equilibria of the tritium halides are based in part on the dissociation of the corresponding protium halides. The dissociation of hydrogen iodide was recalculated from spectroscopic data. From the calculations and from experimental data for ΔF^o, a new value of $\Delta H_o^o = -1007 \pm 10$ calories per mole is obtained. The calculated equilibria are in good agreement with the experiments of A.H. Taylor and R.H. Crist (Jour. Amer. Chem. Soc. 65, 1377 (1941)).

Organic Chemistry

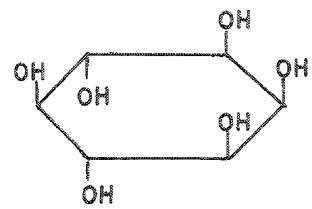
A study is being made of the structure and use in organic synthesis of the alkali metal carbonyls. The relatively simple preparation of these compounds from carbon monoxide and the pure metals and the fact that they can be converted into compounds of considerable biological and theoretical interest make them especially useful for syntheses involving C^{14}. It has been shown that meso-inositol and several isomeric cyclitols can be prepared in a small number of steps from potassium carbonyl, with no step involving isotopic dilution by carbon.

The potassium carbonyl is prepared by breaking a sealed bulb of potassium in an atmosphere of carbon monoxide. The reaction is exothermic, and occurs at room temperature if the metal and gas are free of water and oxygen. Within an

experimental limit of 1%, equimolar quantities of potassium and CO are consumed to produce the carbonyl, a dense, black material which is highly reactive to oxygen or water. This material is hydrolyzed by condensing absolute ethanol onto it at -75°C and allowing the mixture to come slowly to room temperature. The product is a reddish brown salt, which dissolves in water to give a deep red solution. For reduction to the cyclitols, acetic acid is added, the mixture made up to 40% ethanol and hydrogenated over Raney nickel at 2500 lb/sq.in. After reduction, the nickel is centrifuged off, and the solution concentrated in vacuo. From the resultant syrup, on treatment with water and methanol, a crystalline fraction is obtained which yields scyllitol and meso-inositol,



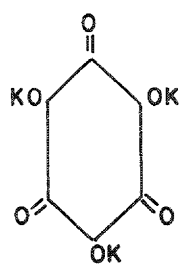
Scyllitol



Meso-inositol

the latter in about 12% yield based on the starting CO. Two other isomeric cyclitols can be obtained from this reduction, as well as a series of substances containing from 2 to 5 hydroxyl groups per cyclohexane ring.

Although the salt resulting from the ethanol hydrolysis has not yet been conclusively identified, it is likely that it is either



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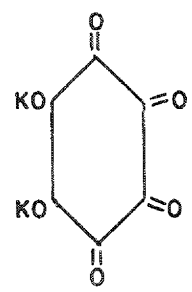

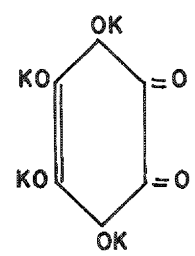

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the second formulation being preferred. The substance can be converted to hexahydroxy benzene by the addition of stannous chloride and hydrochloric acid. When the salt is refluxed with acetic anhydride and dry hydrogen chloride, hexacetyl hexahydroxy benzene is formed.

Further work on these reactions and their products is in progress. Also, the possibility of hydrogenating the unhydrolyzed carbonyl to form substances such as benzene will be investigated (R.C. Anderson, H.C. Prosser).

Analytical Chemistry

The analytical facilities of the Department are being organized, and a number of service analyses have been performed for the Metallurgy Division, the Meteorology Group, and the Chemistry Department. The following instruments have been brought into operation, and their performance has been checked with known determinations:

Coleman Model 14 spectrophotometer; Beckman Model D.U. spectrophotometer; Sargent Model XXI polarograph; Beckman flame photometer. Effort will be continued on setting up facilities for analytical chemistry and on service analyses. With the advent of operation of the nuclear reactor, neutron activation analysis will receive attention both as a means of routine analysis and as a subject of investigation (R. Stoenner, S.W. Hunter).

The study of the kinetics of the reactions which occur in a Jones reductor, operated under conditions of incomplete reduction, has been continued (thesis problem). This system is being used as a model for the flowing systems encountered in chromatographic and ion exchange separations. The effects of flow rate, temperature, and column length have been determined. Experiments are being made on the effect of change in the concentration of the influent solution (K. Knox).

Nuclear Problems

Some work has been done with the aim of isolating Se^{79} and I^{129} from reactor-irradiated uranium. Satisfactory separations of milligram amounts of added selenium and iodine were obtained in cold runs by dissolving the metal in hydrochloric acid, bubbling the evolved hydrogen through bromine water to remove H_2Se, and extracting iodine from the uranium solution with carbon tetrachloride after oxidation of the uranium to the hexavalent state with hydrogen peroxide. In the treatment of an Oak Ridge slug which had been irradiated for three years and cooled for one year, it was necessary to add iodine carrier before any iodine was found in the CCl_4 extraction. Results are not yet available on the radioactivity of the selenium and iodine fractions. The purposes of this work are to identify these fission products, establish their radioactive properties, and measure their fission yields (S. Katcoff).

A systematic search for radioactive fission products of U^{235} which are outside the known mass range has been instituted. It is hoped that this will give new information about the probability and modes of ternary fission. Since the work was started, new physical measurements have been reported on the ratio of ternary to binary fission, with results ranging from about 4×10^{-6}, for tripartition into comparable masses (L. Rosen and A.M. Hudson, Bull. Amer. Phys. Soc. 24, #4, 29 (1949)), to 10^{-2}, for the formation of particles of mass about 13 (J.T. Dewan and K.W. Allen, Bull. Amer. Phys. Soc. 24, #4, 29 (1949)). The aim of the radiochemical search is to measure all fission yields in excess of 10^{-8} of radioactive products outside the known fission product range. An upper limit to the yield of Be^7 has been established at 3×10^{-7} by analyzing $U_3^{235}O_8$ which had been bombarded in the Oak Ridge reactor for 10 days. Detection methods are being improved so that this upper limit can be reduced. Separation procedures are being devised for titanium, cobalt, and manganese (I.N. Greenberg, G. Samos, B. Burtt, W. Rubinson).

A search for new cases of nuclear isomerism has been started. It seems reasonable to expect that, in addition to the many examples now known, many more cases may exist in which a second state of a known radioactive nucleus has a half-life within an observable range of about 10^{-9} seconds to 10^8 years. The fact that few cases of very long-lived isomers are known is probably due in part to the fact that extreme chemical purification is required to prove the identity of weakly active

samples. For preliminary study, samples of copper, gallium, arsenic, and gold have been irradiated with neutrons at Oak Ridge. Each sample has decayed from about 0.1 curie to a very low level. Chemical purification will be continued until the specific activities become constant or drop below 0.1 count/min-mg. The continuation of this work will emphasize charged particle bombardment with the 60-inch cyclotron, since this method of formation may lead to a more equitable distribution of excited states in the product nuclei than neutron capture (J.J. Howland, Jr.).

About 10 mc of Np^{239} was isolated, purified, and mounted on two Zapon films for use in the beta-ray spectrum investigations of Fulbright and Tomlinson at Princeton (J.J. Howland, Jr.).

Separated nickel isotopes Ni^{58} and Ni^{62}, irradiated in the Oak Ridge reactor, were chemically purified; the nickel fractions were investigated for radioactivities, with both G-M counters and a methane flow proportional counter. From the measurements, the known cross sections of the stable nickel isotopes, and the integrated neutron flux to which the samples were exposed, it can definitely be stated that Ni^{63} is a negative beta emitter of several hundred years half-life. The maximum beta energy is about 50 kev. No gamma-rays were detected in absorption experiments. The Ni^{58} sample showed a small activity of Ni^{63}, due to the presence of a small amount of Ni^{62} in the sample. In addition, there was present a weak radiation whose absorption characteristics are compatible with its identification as cobalt K X-rays. If this interpretation is correct, the counting results, the Ni^{58} cross section, and the integrated flux indicate that Ni^{59} has an electron capture activity with a half-life of $(2\text{-}3) \times 10^5$ years (G. Friedlander).

Work has begun on the compilation of nuclear data for a loose leaf type of handbook arranged according to elements and isotopes. It will be brought up to date from time to time by the issuance of supplementary sheets and corrections. This project is sponsored jointly by the National Bureau of Standards and the Laboratory. Data for about 12 elements have been compiled in essentially final form (J.J. Howland, Jr., G. Friedlander).

Instrumentation

The reconstructed Nier type mass spectrometer was moved to its permanent location in an air conditioned area; a number of improvements have been made. Points of improvement include: regulated magnet supply, regulated high voltage supply, voltage divider network, emission regulator, ion detector, nonfractionating leak, provision for recovering tritium from the fore-vacuum line. With the present vibrating reed electrometer detector, ion currents of the order of 10^{-17} amp can be detected, and 10^{-16} amp measured by rate-of-charge measurement. The relative ionization probabilities for hydrogen ions and hydrogen molecule ions and for deuterium ions and deuterium molecule ions were measured. The results agree with those in the literature, but indicate that relatively large errors may be involved. A study has been made of the effect of mass discrimination in the ion gun. Careful appearance potential measurements have been made for helium, neon, argon, and krypton, utilizing the increased sensitivity afforded by employing the vibrating reed as a rate-of-charge collector. The data provide a consistent calibration of the

electron beam accelerating voltage. After some further study of the behavior of this instrument, the appearance potentials and relative ionization probabilities for tritium ion and tritium molecule ion will be measured (J. Hastings, O.A. Schaeffer).

A Nier type isotope ratio mass spectrometer was received from the Consolidated Engineering Corporation, and is in working order. It has been used for: hydrocarbon analyses, isotopic analysis of nitrogen for Richardson and Wilson of Harvard University, tritium and C^{14} analyses (A.P. Irsa, L. Friedman).

A permanent magnet type 180° electron spectrograph has been designed and built, and is ready for testing (G. Friedlander).

The following items of equipment were installed in the spectrographic laboratory: Baird Associates 1 meter grating spectrograph, Eagle mounting; Jarrell-Ash 21-foot grating spectrograph, Wadsworth mounting; Leeds and Northrup recording microphotometer. The 21-foot grating spectrograph will be in operating condition when a 15,000 line per inch grating is received. Actual operation of the spectrographic laboratory awaits the completion of the patchboard room for power distribution (J. Bigeleisen).

A Collins type helium liquefier was received from Arthur D. Little, Inc., and installed in temporary quarters. It has been operated both with and without liquid nitrogen precooling; the liquefaction rates are about 4.5 and 2 liters per hour, respectively. Quarters for the liquefier and associated low temperature work are being planned, and should be under construction shortly. In these quarters, it will be possible to operate the machine safely as a hydrogen liquefier when desired. These facilities are being set up with the aim of furnishing a source of low temperature for the several aspects of the research program of the Laboratory which will require it. An additional program in the field of cryogenics per se is not contemplated at present (J. Hastings, J. Bigeleisen).

A detailed study of absolute beta counting with end-window G-M tubes has been completed. RaE standards were prepared, and their disintegration rates determined by counting the RaF daughter in a methane proportional counter of known geometry for alpha emitters. The effects of variations in the geometry, and the several effects due to absorption and scattering were evaluated experimentally for the arrangement used (lead shields lined with lucite, containing lucite shelves and holders). The greatest error in the determination of beta disintegration rates by this method probably lies in the extrapolation to zero absorber; the best absorber position is concluded to be next to the window, rather than close to the source. Using the scattering and absorption corrections, the RaE standards agreed within 4% with sources calibrated elsewhere -- Co^{60} calibrated by the National Bureau of Standards by coincidence methods, RaD-E sources issued by the National Bureau of Standards (after application of an 8% self-scattering correction to these sources), and RaD-E sources standardized by Novey at Argonne National Laboratory. It is believed that the beta disintegration rates of unknown samples whose maximum beta energies lie between 0.3 and 2.3 Mev can be determined to within about 6% by applying the absorption and scattering factors evaluated in this work. The detailed procedures and results will appear in the August 1949 issue of Nucleonics# (B. Burtt).

REACTOR SCIENCE AND ENGINEERING

The Nuclear Reactor Project, which had been responsible for the development of the reactor complex, terminated its existence on January 1, 1949. A new permanent department of the Laboratory, the Department of Reactor Science and Engineering, was established. All personnel formerly attached to both the Nuclear Reactor Project and the Engineering Department became members of the new department. The Director of the Laboratory designated Dr. Lyle B. Borst as Chairman of the new department. Including the Chairman's staff, the Department totals 142 people.

Functionally, the Department is divided into three areas of activity, each of which is headed by an Assistant Chairman. These areas are Reactor Operations, under Dr. Marvin Fox; Hot Laboratory Operations, under Dr. Warren E. Winsche; and Research, under Dr. Clarke Williams.

Reactor Operations, comprising a staff of 21 engineers, 33 technicians, and 10 administrative and clerical employees, is responsible for:

1. Routine operation, instrumentation, and maintenance of the entire reactor complex, except the hot laboratory.
2. Coordination of research use of facilities.
3. Meteorological forecasting and control.
4. Isotope production and distribution, including all traffic therein within the entire Laboratory, and relations with the Isotope Division of the Atomic Energy Commission and other scientific, industrial, and academic institutions.
5. Handling and accountability for all source and fissionable materials.

Hot Laboratory Operations, comprising a staff of 9 engineers, 6 technicians, and 2 clerical and administrative employees, is responsible for:

1. Routine operation, instrumentation, and maintenance of hot laboratory facilities.
2. Preparation of short-lived isotopes, and special sources involving chemical operations at high activity levels required by the research programs in the Brookhaven area.
3. Development of processes and equipment necessary for these activities.
4. Routine operation, instrumentation, and maintenance of liquid waste control systems and processing plants.

Research, comprising a staff of 13 scientists, 22 engineers, 18 technicians, and 8 administrative and clerical employees, is subdivided into the following sections:

1. Chemical Engineering Division
2. Reactor Chemistry Group
3. Waste Concentration Group
4. Metallurgy Division
5. Reactor Theory Group
6. Shielding Group

7. Sanitary Engineering Group
8. Meteorological Research Group
9. Reactor Evaluation Group
10. Physics Group

The Reactor Complex

At the present time, the reactor complex is substantially complete, except for the hot laboratory and a few items of specialized function elsewhere which will delay the startup of the reactor until about September of this year. The item which contributes most to the delay is the repair program which it has been found necessary to carry through on the air handling systems for cooling the reactor. Fabrication and design inadequacies have shown up in tests on these systems; extensive redesign and refabrication are in progress to correct the defects. The reactor cannot be put into operation until this has been completed. Although the startup date will not be affected, a considerable amount of work remains to be done in testing and proving one of the auxiliary instrumentation systems. Otherwise, the reactor is completed and ready to receive the fuel elements which have been ready for loading for some time now.

The reactor building is finished; the operations staff has been functioning from its permanent quarters in the control portion of the building for three months. The reactor laboratories building requires nothing more than finishing touches before it will be finished and ready to receive the equipment to be installed. The equipment is on order, and will be installed before the reactor reaches routine level operation. During the next two months, the central offices of the Department, and a branch of the Classified Documents Section, will occupy their permanent headquarters in this building.

The fan house, stack, cooling towers, and pump house are all completed and performance tested; they are now in the process of being turned over to Brookhaven National Laboratory by The H.K. Ferguson Company. The hot laboratory is now at the stage of about 70% overall completion, with the construction of the hot cells, semi-hot cells bench, the installation of plumbing, heating, ventilating, and electrical systems, the waste piping, interior finishing operations, and furniture installation still remaining to be done. It is estimated that the building will be ready for occupancy during the early fall of this year.

Construction on the waste tank farm and the holdup and waste treatment area is about 50% complete. Estimated completion is also early fall of this year. It appears, then, that all the separate units of the reactor complex will have been completed by the time the reactor is ready to go into the routine operation stage.

Reactor Testing and Reactor Research

The Department plans to conduct extensive tests and studies during the initial phase of starting up the reactor. Studies conducted during the period between criticality and high level operation are capable of yielding much useful information concerning routine operating characteristics, the adequacy of the theory used in the

design of reactors of this type, and the validity of presently established values of certain constants associated with the fission process.

The Reactor Evaluation Group, working in close collaboration with the Reactor Theory Group, is planning, and will carry through, all phases of the experiments and tests which will be performed at that time. They have completed measurements on the quality of the graphite moderator as it exists in the reactor and found it to be comparable to that of other operating reactors. Several neutron sources used at the Laboratory have been standardized by comparison with those at Argonne and other Atomic Energy Commission installations. Other standardization work is in progress in preparation for the startup experiments and tests.

The Theory Group has made critical studies for the design of several pieces of experimental equipment which are under development for the reactor. During the next six months, major emphasis will be placed on the preparation and interpretation of the startup period experiments on reactor performance, on continued calculations in connection with a proposed experiment on the beta-decay of the neutron, and on studies of some contemplated problems in solid state physics.

The Chemical Engineering Division is continuing studies in several lines of investigation. One study seeks to define, and possibly extend, the safe upper limit for the neutron flux in the reactor. A second study is concerned with solid state properties of graphite under reactor operating conditions. Some properties of uranium metal are being studied under similar conditions. A substantial amount of work continues on various aspects of the air-cooling system of the reactor, including the air filtering provisions, the calibration of air flow metering devices, and the compilation of data and results of experimental work done over the past two years. A graduate thesis is concerned with a study of heat transfer problems to and through mercury carried in a cylindrical pipe. A program investigating certain methods of purifying metals is being planned as a joint effort with the Metallurgy Division.

The Metallurgy Division has completed the assembly of the fuel elements which are required for loading the reactor, and is finishing the tests performed on them. These tests will yield further information on the behavior of the elements under operating conditions. Considerable effort and time were devoted during the past six months to the structural problems of the air-handling systems, as noted above. The causes of the failures have been analyzed carefully, and the results obtained have contributed much to the decisions on redesign and refabrication which have been reached. The progress of this work is being followed very closely. Some assistance has been given to the Accelerator Project on the design and construction of the vacuum chamber for the Cosmotron. A single crystal laboratory is being set up to prepare single crystals of both organic and inorganic materials. It is anticipated that this service will be rendered to all departments in the Laboratory. The plans for remodeling the building at 77 Temple Place, where the general research program will be conducted, will soon go out for bids. Temporarily, problems in phase-rule studies, materials research, and welding research are being investigated in the limited space of the building at 29 Cornell Avenue.

A new addition to the building at 29 Cornell Avenue is the reactor chemistry laboratory, construction of which was finished early in the year. Preliminary experimental work is in progress, but most of the time has been spent in assembling

specialized apparatus, such as a high vacuum line using fluorine resistant materials throughout, fluorine handling equipment with the necessary safety devices, furnaces with controls for carrying out reactions with special gases, and a high vacuum line of conventional design. These facilities are being provided to yield basic information on fluorine compounds and reactions.

The Shielding Group is preparing and planning equipment necessary for initial studies. The first problem will be to evaluate carefully the shielding properties of our reactor shield. This is the first such reactor shield ever built, and it is important to obtain precise information on its performance. A water tank facility, which will be placed on top of the reactor through the shield, is now being planned for early construction. This will provide for the measurement of the shielding properties of gross samples of various shielding materials and composites. Several other atomic energy installations have expressed interest in a collaborative effort on fundamental shielding studies; it is expected that a program of this sort will be instituted in the near future.

The Waste Concentration Group is seeking to develop a process which will result in a large reduction in volume of stored liquid wastes. Equipment has been set up, and a series of runs has been made on pilot plant scale which demonstrates that the initial objectives are achievable, and that the present system can be improved. Work is continuing on many problems which must be solved before the process can be considered practical for large scale use.

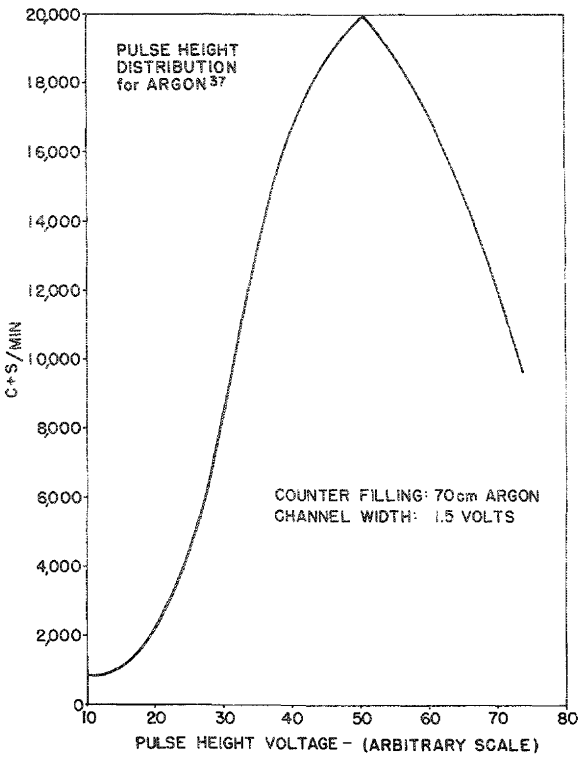
The work of the Sanitary Engineering Group is directed toward the permanent disposal of concentrated liquid wastes, and the concentration and retention of radioactive isotopes in biological systems representative of sewage treatment plants. Preliminary laboratory studies are under way, but satisfactory refinement of apparatus and techniques has not yet been attained. Arrangements have been made for a coordinated study at Yale University of certain essential chemical phases of the problem.

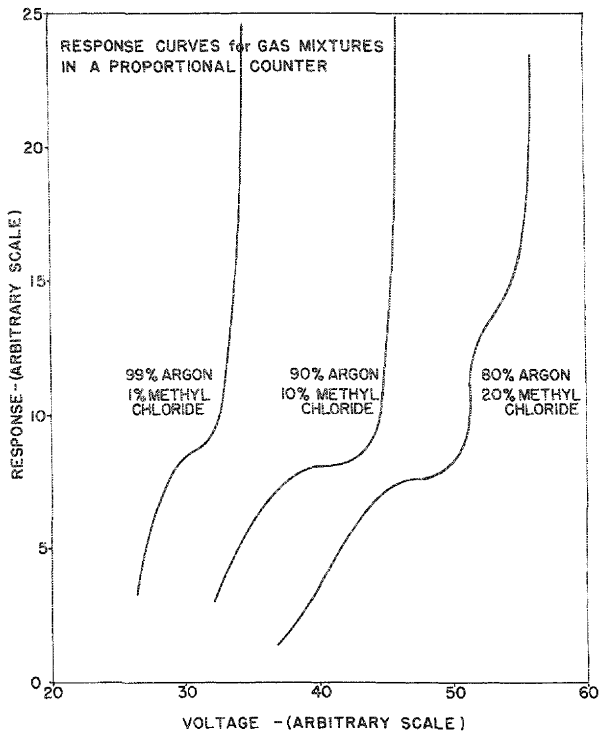
The Isotope Production and Distribution Group has processed some seventy orders for radioisotopes and labeled compounds for the Laboratory during the past six months. Most of these items were obtained from the Isotopes Division at Oak Ridge. As soon as the reactor goes into operation, the Laboratory-produced items will considerably enlarge the scope of the Group's activities. Accountability for the various types of source and fissionable materials on hand at the Laboratory is also the responsibility of this group.

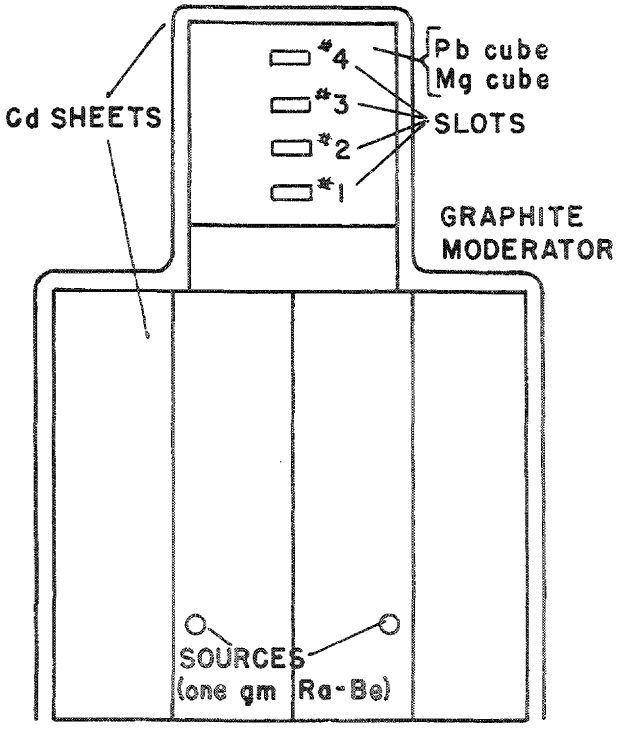
Preparation for Reactor Use

Experimental equipment designed for use with the reactor is, at present, in construction in the Laboratory shops. The principal item consists of a Zinn type neutron crystal spectrometer mounting and necessary collimating equipment. All components have been machined for the spectrometer table and mount.

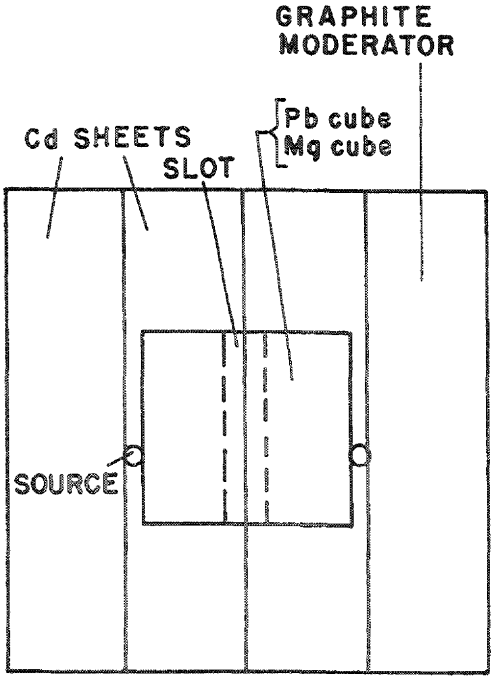
A cooperative project with the Physics Department is directed toward observation and energy determination of the beta-rays from neutron decay. A cloud chamber has been designed and is being constructed under the supervision of the Cloud Chamber







SIDE VIEW



TOP VIEW

Sigma pile structure

Division of the Physics Department. The necessary shutter and total-reflection neutron collimator is being designed, and will shortly be released to the shops.

Cooperative experiments with Dr. Norman Ramsey of Harvard University are being planned to determine the spin and moment properties of the neutron. The necessary neutron collimating equipment is being prepared.

Basic Research

Radioactivity of K^{40}

A new sample of KCl,* enriched about 100-fold in K^{40}, has been investigated to redetermine the maximum beta-ray energy. Examination of the original data shows the end point to be between 625 and 700 mg/cm^2 of aluminum, corresponding to a maximum energy E_{max} = 1.45±0.15 Mev# (L.B. Borst, J.J. Floyd).

A penetrating gamma-ray component (5.7 counts/minute) was observed. In the geometry used (approximately 21%), the ratio of gamma counts to beta counts is I_γ/I_β = 0.0014. The disintegration constant for beta decay was found to be λ_β=4.3±0.4 x 10^{-10} yr^{-1}, and that for gamma-ray emission was found to be λ_γ=0.31±0.07 x 10^{-10} yr^{-1}.

In addition to beta-ray and gamma-ray emission, K^{40} is known to decay by K-capture, giving off a characteristic X-ray whose energy is approximate 3 kev. One possible method of detection is to introduce the potassium sample on the inside of a proportional counter; by selection of proper filling gases, a preferential absorption effect can be used. The accompanying curve (left) shows the response to voltage variation when different mixtures are used.

In order to test the above method, a sample of A^{37} was obtained from Oak Ridge National Laboratory. A^{37} decays by K-capture, emitting an X-ray of about 2.6 kev. Included in the electronic equipment was a special nonoverloading amplifier and a sliding channel pulse height analyzer designed and built by the Electronics Division. The second curve (right) shows that a peak was obtained from the A^{37} X-rays. However, the pulse height analyzer will have to be calibrated in order to determine the energy at which this maximum occurs. As soon as certain improvements in technique are made, an enriched sample of K^{40} will be carefully investigated (J.J. Floyd).

Sigma Pile Experiments

Because conflicting values for the nuclear capture cross section of Mg for thermal neutrons have been reported in the past, it recently appeared of interest to determine this quantity by the sigma pile technique, a method not previously used. Work has been done in determining σ_a for Mg, and also for Pb.

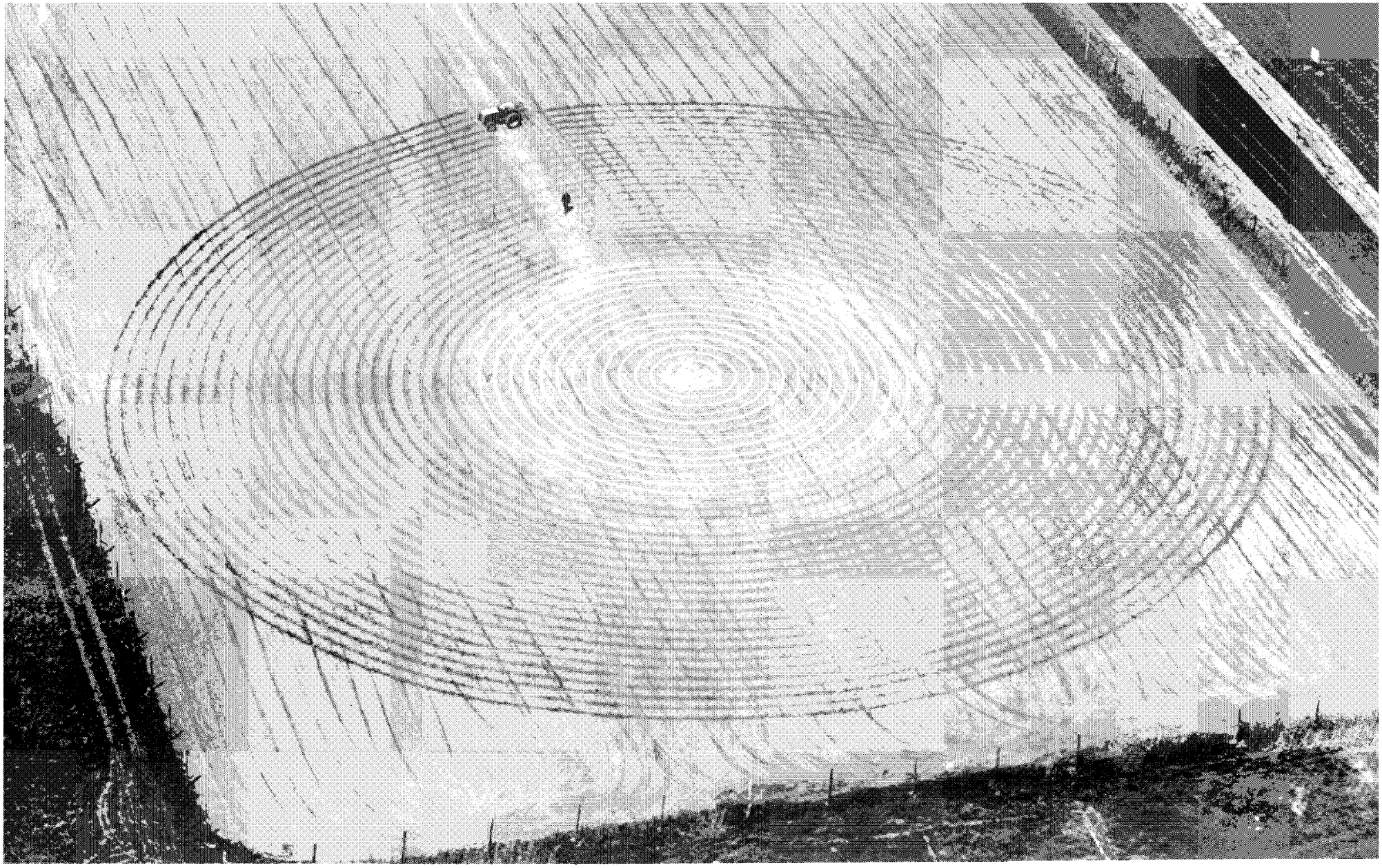
The accompanying diagram illustrates the sigma pile structure. The lead cube was constructed from bricks which were fabricated at the Laboratory, of dimensions

*Obtained through Stable Isotopes Division, Atomic Energy Commission, Oak Ridge, Tennessee.

# Indicates publication. See Appendix for complete reference.

1-1/2" x 3" x 6", with a minimum lead content of 99.9% by weight. The magnesium used was obtained from a commercial source, in the form of bars 1" x 2" x 24" and 2" x 4" x 24", composed of 99.85% pure magnesium.

The sigma pile method is based upon the fact that if there exists a flux of thermals through an extended homogeneous medium, one of the factors which will determine the neutron density distribution will be the absorption cross section of the medium. To determine the neutron densities, thin foils of indium, which exhibits a resonance absorption of thermals, were irradiated within the medium. The isotope of indium thus formed later decayed by beta emission, so that the beta intensity, as determined by counting with a Geiger tube served as a measure of the neutron density at the point where the foil was irradiated. Using this technique, it was determined that σ_a (Mg) = 0.15 ± 0.02 barns, and σ_a (Pb) = 0.12 ± 0.03 barns (S. Wallack).



Gamma-ray field being prepared for planting. A 20-curie cobalt source is housed in the center of the field, with controls so arranged that the source can be dropped into a lead cave when the field is entered. The planting will follow the circles, so that a variety of dose rates and total dosage can be obtained with practically continuous gamma irradiation.

LIFE SCIENCES

BIOLOGY

The Biology Department now has 16 scientists, 17 technicians, and 4 administrative and clerical employees. In addition, 8 visiting scientists have spent or are spending various lengths of time working in the Department. The length of stay has varied from as little as one week to as long as a year. Three other scientists are expected in the next few weeks.

Part of a barracks building at 14 Humboldt Lane has been modified to provide two laboratories for cytochemical work and a fairly large darkroom which will be used primarily for radioautography. These laboratories are essentially complete and are in use. Completion of the darkroom has been delayed, but is expected within a few weeks.

Modification of the cinder block building at 46 Bell Avenue is about 60% completed; it is expected that it will be ready for occupancy by early fall.

Biological Effects of Radiation

1. Animals

Further studies on the effects of whole body irradiation have demonstrated that many of the biochemical changes produced in selected tissues are similar to those seen in other types of stress. After exposure to dosages of 500 to 2000 r, the glycogen of the fasted rat livers becomes elevated, and the cholesterol and ascorbic acid contents of the rat livers are reduced. The large dose required to bring about these changes attests to the relative insensitivity of this aspect of the pituitary-adrenal protective mechanisms to the stress of irradiation. However, the data obtained will provide a basis for comparisons with rats receiving either neutron irradiation in the nuclear reactor or internal irradiation by ingested radioactive sodium or phosphorus. The latter experiments will be carried on during the coming year.#

It has been found that fasted control rats have the same weight losses, whether by individual organs or total body weight, as the irradiated rats. This is strong presumptive evidence that weight losses in the irradiated animals are due to a loss of appetite, and are not to be attributed specifically to the irradiation.

The disturbances in salt and water metabolism in rats following X-ray exposure are still under study. It has been observed that, for the first 24 hours after

# Indicates publication. See Appendix for complete reference.

exposure, the uptake of fluid ad lib. is directly proportional to the dose over the range of 75 to 600 r. It appears likely that dosages as low as 50 r may be detected by this simple measure of radiation response. The concomitant disturbances in Na, K, Cl metabolism are also being studied, but further experiments are needed to clarify the data. An attempt is being made to determine whether the polydipsia is caused by the associated polyuria. The results to date indicate that the polyuria precedes the polydipsia. Experiments are being carried out to see whether anti-diuretic factors in the blood are lowered in the irradiated animal. The parts which the kidney and the posterior lobe of the pituitary gland play in the observed water disturbances are also being examined. The mechanism by which a second wave of polyuria and polydipsia is produced five to six days after exposure still eludes detection.#

After a hemorrhage, the hemoglobin of an animal's blood rapidly returns to normal. Experiments are under way to determine whether the rate of formation of new hemoglobin following hemorrhage is seriously interfered with by irradiation. It is thought that the response might serve as a sensitive indicator of radiation damage to the hemopoietic system, and might be useful for the comparison of biological effectiveness of different modalities of ionizing rays (A. Edelmann, F. Summers, H.E. Abritis, N. North, L.F. Nims).

2. Plants

A 20-curie cobalt source has been placed near the center of a plot of land which is about three acres in extent. This source makes possible the study of the effects of continuous gamma radiation upon plants grown under field conditions. The radiation levels employed will vary from over 100 r per day to less than 0.5 r per day. Arrangements have been made to provide irrigation for the plants, since long spells of dry weather could seriously interfere with the success of some of the experiments now under way. The circular geometry obtained from a single source is almost ideally suited for genetic experiments; but, in addition to genetic experiments, information will be obtained concerning the growth, development, and yields of some of the species under observation. A variety of plants will be under investigation this summer. The particular observations which will be made on the different species are described below.

A study of the effect of continuous gamma irradiation in inhibiting the growth and development of Katahdin and Green Mountain varieties of potatoes is being made. The interest in these experiments has been intensified because of unexpected data obtained from experiments begun last year. It was found that the seeds from Katahdin tubers which received a single exposure of X-rays before planting have at least a 50% increase in germination, and that the resulting plants are unusually vigorous. If this phenomenon can be generalized to other varieties, the means will be at hand for a very practical application of irradiation techniques to a potato improvement breeding program -- a procedure which has been almost impossible in the past because certain potato varieties, like the Green Mountain, set viable seed with great difficulty. Experiments designed to give yield data are being continued on the X-rayed potatoes. These results will give interesting comparative data for the single exposures to X-rays and the continuous exposure to gamma-rays. Diploid and tetraploid Tradescantia plants are being grown in the gamma field to determine the chromosome aberrations at various intensity and dose levels. These will be

The effect of continuous gamma radiation on growing Tradescantia. Left, control, unirradiated Tradescantia. Center, plant received approximately 42 r per day of gamma radiation for 90 days (total 3,780 r). Right, plant received approximately 120 r per day of gamma radiation for 90 days (total 10,800 r).

examined by cytological techniques. Also, preliminary experiments are under way on the effects of gamma irradiation upon the fertility of tetraploid snapdragons, marigolds, and phlox (A.H. Sparrow, E. Christensen).

Genetic studies on corn are in progress in the gamma field. Four varieties of maize of known genetic constitution are being grown. The corn will receive continuous gamma radiation at levels from 200 r per day on down. An excellent estimate of the mutation rate as a function of dose should be obtainable from these plantings. Millet and sunflower plants are also under observation and, in collaboration with the Plant Pathology Department of the Connecticut Agriculture Experiment Station, the effects of continuous gamma irradiation on tomato plants and fusarium cultures will be studied. The lethal doses for dry and germinating seed corn are being obtained from potted material which is in immediate proximity to the gamma source. In this way, it is possible to achieve exposure levels of over 100 r per hour.

Sweet corn is now growing on 13 of the Laboratory's 16 third-acre plots located about the site. Three of the other plots are being used to increase inbred and genetic stocks. Two other larger plots have also been brought into operation. The spontaneous mutation rates observed this summer will be compared with those obtained

next summer when the reactor is in operation. While no increase in mutation rate due to the Laboratory operations is expected, this experiment in genetic monitoring should establish whether any change in the rate is produced. These stocks are similar to those under study at Peoria, Illinois, in a region far from any reactors; mutation values at the Laboratory will be compared with values obtained there (W.R. Singleton, F. German).

3. Cells

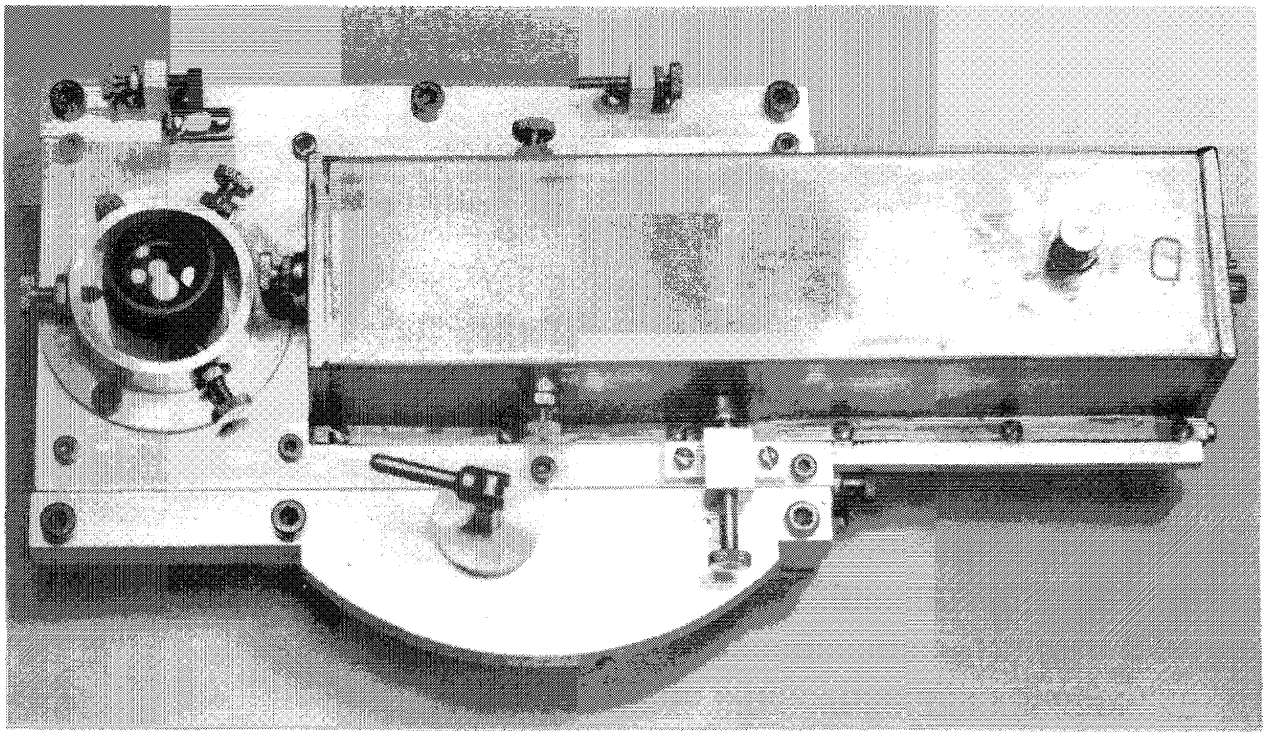
Study of X-ray induced aberrations in Trillium erectum is continuing. During the past six months, some 6000 slides from irradiated material and 1200 slides from control plants were prepared for analysis, which will continue during the summer and fall months. Particular attention is being paid to the sensitivity curve, the response to dosage as a function of the stage of development, the changes in relative proportion of different types of aberrations produced by the irradiation of different stages, and the relation between radiation effect and degree of polyploidy# (A.H. Sparrow, R.C. Sparrow, L. Ottolenghi, E. Christensen, G.R. Davison, V. Pond).

Preliminary observations on Tradescantia indicate that it is possible, by appropriate chemical treatment, to modify the sensitivity of the material to radiation as determined by the number of broken chromosomes (A.H. Sparrow, L. Ottolenghi).

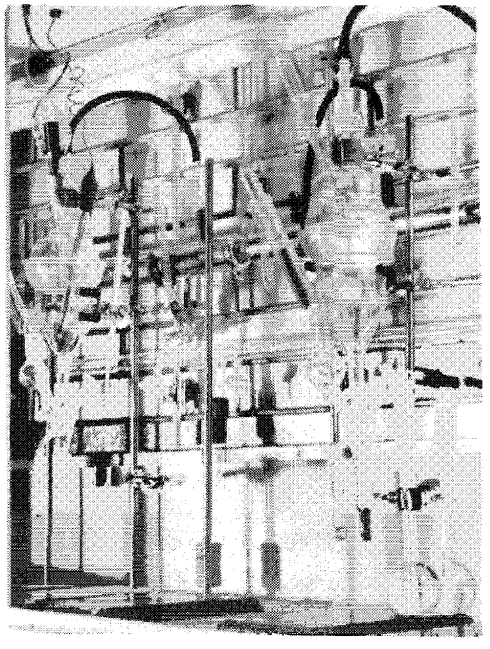
An examination of irradiated and control material is being made by cytochemical techniques in an effort to determine by qualitative and quantitative techniques the chemical changes produced in cells by ionizing irradiation. Particular attention is being focused on the nucleic acids and proteins in the cell; the concentrations of these materials in situ are being obtained by appropriate optical techniques. New apparatus now almost assembled will permit photometric determinations of quantities of the order of 10^{-12} grams in either the nucleus or selected portions of the chromosomes. The apparatus will allow photometric or spectrophotometric measurements to be made in either the visible or ultraviolet regions (M.J. Moses, A.H. Sparrow).

Work is continuing on Allomyces arbusculus. Crosses of two different amino acids requiring biochemical mutants produced by ultraviolet irradiation have given strains which grow on minimal media. Irradiation of the zoospores of these strains has given preliminary results which indicate that the diploid spores have the same sensitivity to lethal levels of irradiation as the haploid spores. The significance of these results is not clear, and further work is under way. Irradiation by X-rays will be done on the biochemical mutants in an attempt to disrupt differentiation, so as to produce heterothallic strains, block the formation of γ-carotene in the male gametangium, and block the formation of the male or female gametangia on the gametophyte thallus (K. Yaw).

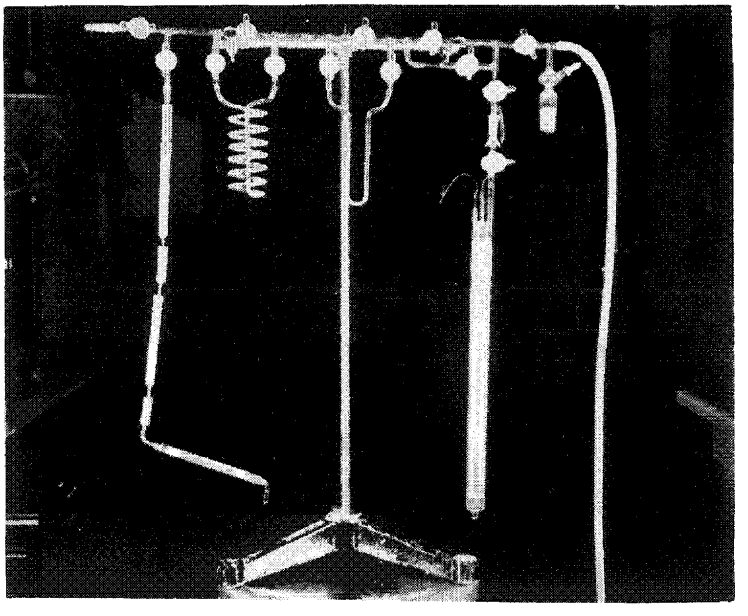
E. coli has been grown in concentrations of P^{32} as high as 8 millicuries per cc. Mutations with different degrees of streptomycin resistance have been obtained. The results to date indicate that the effects of radioactive phosphorus absorbed in the cells is greater than can be accounted for by the calculated ionization produced in the cells. The genetic details of streptomycin resistance are quite complex; consequently it will be several months before the experiments are complete. Variation of the media on which the organism grows, by increasing the glucose content, or



Phototube head for photometric apparatus used in quantitative cytochemical analyses. Top view showing phototube in place for measuring light passing through microscope system. This device takes the position normally occupied by the plate holder of an ordinary photomicrographic camera. The phototube "sees" a microscopic image of, for example, a nucleus, from which the surrounding areas have been excluded by a diaphragm in the optical axis. The apparatus is essentially a microscopic colorimeter.



All-glass mouse metabolism cage assembly for C^{14} work.



The chain used to fill a counter tube, the long glass tube on the right, with gaseous CO_2 for counting with a proportional counter.

increasing the oxygen content, has been shown to respectively decrease and increase the sensitivity of the organism to the beta irradiation of the radioactive phosphorus# (B.A. Rubin, P. Steinglass, L. Jasewicz).

Tracer Studies of Biochemical Problems

Studies of the phosphorus metabolism of liver are continuing. Findings to date indicate a clear-cut strain difference between the livers of the Sprague-Dawley rat and the Carworth rat maintained under the same nutritional conditions. The Sprague-Dawley rat not only has a higher level of acid-soluble phosphorus in the liver than the Carworth rat, but also shows a marked difference in the rate at which radioactive phosphorus in the plasma reaches equilibrium with the various tissue depots and the extracellular spaces. These differences serve to point out the necessity of having available standardized genetic strains for precise studies of problems of intermediary metabolism. The phosphorus fractionation scheme being used in these studies has been improved to the point where 80% of the acid-soluble phosphorus compounds of the liver are accounted for by ten fractions of more or less distinct chemical entities. In an hour and a half after the subcutaneous injection of radioactive phosphate, the labile phosphorus of the adenosine di- and triphosphates reaches its maximum isotope concentration in both strains. The level reached in the Carworth Farm animals is appreciably higher, probably due to the fact that the plasma levels in the Carworth rat are also higher at this time# (J. Sacks, B. Damast).

Although sensitivity of the hemopoietic centers to radiation is well known, quantitative studies of this aspect of radiation damage have been few. The use of radioactive iron to follow some of the changes should give much more detailed information of the events in this type of radiation damage. Therefore, radioactive iron is being used to assay radiation damage. Other studies in iron metabolism being pursued at the present time include the uptake of iron in the cytochrome of duck muscle. As part of this study, it was demonstrated that during the first few days after intraperitoneal administration of radioactive iron, the rate of increase in specific activity was highest for muscle iron and lowest for that of cytochrome C; erythrocyte iron was intermediate. It is probable that the avidity of muscle for iron is due to its myoglobin. Equilibration of injected iron in the duck is reached in about a month. Determination of the relative specific activity of the iron at that time indicates that the duck contained 1300 micromoles per kg body weight, a figure which has been checked by direct chemical examination. Other studies under way include the equilibration time of iron in the rat, the metabolic components responsible for the transfer of iron across the erythrocyte *in vivo*, determination of the life span of the erythrocyte in the dog, and a detailed study of myoglobin# (J.R. Klein, L.M. Sharpe, B.P. Baldwin, M. Kern).

Analysis of the uptake of manganese and barium in hornets is continuing. A study of the uptake of manganese by white and lilac varieties of *Syringa vulgaris* is also under way. Under study also are methods for the determination of barium at concentration levels of barium below 0.002% by the flame photometer. It has been found possible to determine fluorine throughout the range of 50 to 2000 micrograms by the bleaching of color produced with iron and the organic reagent 7-iodo-8-hydroxyquinoline-5-sulfuric acid, even in the presence of considerable quantities of phosphate# (V.T. Bowen, A. Carbone, D. Sutton).

The methods used in the biosynthetic production of C^{14}-tagged glucose, fructose, and starch from the leaves of selected plants have been standardized, and will be published soon. When the sunflower leaves assimilate $C^{14}O_2$ in the light, the heaviest concentration of labeled carbon appears in 1,6 positions of photosynthetically produced glucose. In contrast, sunflower leaves exposed to $C^{14}O_2$ in the dark contain glucose in which the 3,4 positions contain the greatest activity# (M. Gibbs, R. Dumrose, F. Acher, M. Bubeck).

It has been found that 80% of the administered radioactive carbon is eliminated by mice in eight hours when fed tagged sucrose along with large amounts of carrier sugar, a condition which should favor the retention of the tagged carbon. There is an early rapid oxidation of the administered glucose lasting four or five hours, followed by a period of lower excretion at a slow, steady rate. The levels of activity per mouse will be increased to above 500 microcuries to see whether it is possible to produce radiation damage. Attempts will also be made to ascertain the amounts of activity which must be administered in order to have adequately tagged tissues for study six months after sucrose feeding# (R. Steele).

The conditions for the successful counting of C^{14}, S^{35}, and H^3 in the methane flow proportional counter have been established, and the results will soon be published. It has been found that the exchange reaction $HT + HOH \rightleftarrows TOH + H_2$ goes quite rapidly in the mouse. Tritium gas does not behave like an inert gas in the body, and the tolerance will have to be adjusted accordingly# (R. Ballentine).

The visiting scientists in the Biology Department, with the help of certain members of the staff, are carrying out problems primarily in the field of tracer applications. Dr. J. Sokal of the Yale School of Medicine is studying the phosphorus metabolism of a transplanted tumor in mice. Prof. A. Gorbman of Columbia University is studying iodine metabolism of the local invertebrates. Prof. S.A. Matthews of Williams College is using radioactive iodine to investigate thyroid function in the frog. Dr. S. Udenfriend of Washington University is using radioactive phosphorus and carbon to study the formation of the phosphorylated sugars in plants. Dr. M. Holt of New England Deaconess Hospital will assist in the hematological observations of hemorrhaged irradiated rats; and Dr. G. Culbreth of Johns Hopkins will investigate certain aspects of brain metabolism with C^{14}.

MEDICINE

As of June 30, personnel in the Medical Department numbered 46, including 5 physicians,* 10 registered nurses, 4 medical laboratory technicians, 3 laboratory technicians (research), 1 X-ray technician, 2 dietitians, 1 pharmacist, 1 medical records librarian, 4 orderlies, 3 matrons, 3 kitchen staff, 1 animal caretaker, 8 administrative and clerical.

Organization, Physical Plant, and Equipment

A plan for the permanent organization of the Medical Department was endorsed on January 28, 1949, by the ad hoc Committee on Clinical Investigation, under the chairmanship of Dr. David P. Barr of the New York Hospital, and was approved by the Director of the Laboratory. Five divisions were established as follows:

Division of Medical Practice
Division of Pathology
Division of Bacteriology
Division of Biochemistry
Division of Physiology

The four hospital buildings, equipped with 42 beds, the out-patient clinic, the out-patient clinical laboratory, and the X-ray unit were completed and put into operation just prior to January 1, 1949. Since that date, the hospital has been expanded to include a kitchen with full facilities for the feeding of 42 patients and members of the medical staff who are immediately and specifically engaged in the treatment of patients. Adequate provision has been made for the service of such special diets as may be required. Two operating rooms are complete and fully equipped with the exception of anesthesia apparatus and basic surgical instruments. These are presently on order, with delivery expected during the month of July.

The building which will house temporarily the Division of Pathology is being modified; the contractor's completion deadline is August 15. Indications are, however, that work will be completed some time prior to this date. About 90% of the laboratory equipment, both major and minor, has been received, with the balance expected by the time the laboratory is ready for occupancy.

Plans and full specifications for remodeling another building to house temporarily the bacteriology laboratory are complete and ready to go out for bids. Work under this contract will begin by July 15. All basic equipment has been ordered, and approximately 70% of it has been received.

Preliminary plans for the temporary biochemistry laboratory are complete, but specifications have not yet been written. Experience with the pathology and bacteriology laboratories suggests that plans and specifications for biochemistry will be completed by August 1, which will permit remodeling to start during the month. Major equipment has been ordered.

* Does not include Dr. Farr, Chairman of the Department, who is still listed as a consultant, and who will not assume full-time status until September 1, nor Dr. Hale, Head of the Division of Bacteriology, who will report for duty on July 1.

Completion of plans for the physiology laboratory awaits appointment of the division head.

Medical Practice Division

The Division of Medical Practice is charged with the care of Laboratory personnel and their dependents, and is now responsible for the operation of the hospital and out-patient clinic. For personnel exposed to specific hazards, special examinations have been developed. These include the ophthalmological examination of persons who at any time have been exposed to neutron beams, and the analysis of urine of workers using plutonium, so that body contamination, if it should occur, may be kept at safe levels. X-ray apparatus in the hospital has been calibrated for dosage delivered in the various roentgenographic procedures. This data has been reported to the Health Physics Division in order that each individual's radiation exposure from all sources may be tabulated and held readily available. Special tests are being planned and developed to insure proper care and protection of personnel who will be concerned with work at the reactor.

The census of patients hospitalized for medical care, but not for research, has proved to be much lower than was anticipated. During the six months period covered by this report, the number of patients hospitalized for medical care has varied between one and seven per day. This low incidence of hospitalization is due, in part, to the facts that maternity care is not provided, and that no surgery has been done.

Liaison has been established with the Suffolk County Medical Society, which has appointed a five-man committee to represent its members in dealings with the hospital. Plans for the appointment of a courtesy medical staff comprised of local practitioners have been developed. Under this arrangement, personnel of the Laboratory and their dependents may, at their discretion, retain the services of their family physicians while hospitalized in the Laboratory hospital. The committee is cooperating closely with the Medical Department in the preparation of a list of suitable physicians for this courtesy staff. Adequate safeguards have been established to insure that the medical care under this arrangement will meet the high standards set for the hospital.

The clinical research program was initiated in April, with the admission of the first patient with thyroid carcinoma. At present, six such patients are hospitalized, and a seventh is expected in the near future. These patients have come from Memorial Hospital in New York City, under a program of cooperation between that hospital and the Laboratory, which was gradually developed during the spring. These arrangements will serve as a model for association with other New York institutions wishing to establish such a cooperative enterprise. Details have been worked out to permit ready transfer of patients without interruption of medical care. Continuity of their medical programs has been achieved by appointing as consultants Drs. Rulon W. Rawson and J.B. Trunnell of the Memorial Hospital staff, who will make weekly visits to the Laboratory until satisfactory coordination has been effected. Direct medical responsibility for the research patients rests, at present, on the staff members of the Medical Practice Division, since no clinicians appointed to the research service have as yet assumed full-time duties. Radioactive iodine used on these patients is being obtained presently from Oak Ridge by Memorial Hospital.

There will be no increase in the census of research patients until early fall, when senior members of the research staff will be on duty and the supporting Laboratory facilities are complete.

In May, a program was initiated whereby members of the nursing staff receive special instructions in procedures relating to the care of cancer patients. Teams of two nurses each are sent to Memorial Hospital in New York for periods of six weeks. Insofar as possible, this rotating assignment will continue until each member of the nursing staff has received the benefits of this specialized training.

Division of Pathology

Research work in pathology has been begun by Dr. S.C. Madden and his technicians in improvised quarters. They are studying the influence of certain injuries upon the synthesis of tissue protein and blood proteins. The effects of radiation injury and of sterile inflammatory processes will be among the first studied. The methods involve labeling of diet nitrogen or sulfur with amino acids containing N^{15} or S^{35}. The rates and extents of incorporation of labeled material into specific proteins of the injured animals will be compared with those of normal controls. Cell particle fractions separated by high speed centrifugation as well as homogenous cell protein fractions obtained by alcohol precipitation in the cold may be analyzed when indicated.

Division of Bacteriology

Dr. William M. Hale, Professor of Bacteriology and Head of the Department at the State University of Iowa College of Medicine, has accepted appointment as senior physician and head of the Division of Bacteriology. Dr. Hale will assume his new duties on July 1. Dr. John B. Nelson, at present an associate member of the Rockefeller Institute for Medical Research at Princeton, New Jersey, has been appointed as epidemiologist, and is to be in charge of animal colonies and facilities at the Laboratory. Although Dr. Nelson will actually be attached to the Laboratory's Assistant Director for Biology and Medicine, it is planned that he will carry out much of his investigative work in the Division of Bacteriology; laboratory space for such work is being provided for him by Dr. Hale. Approval has been received from the New York State Department of Health to maintain quarters for animals for experimental purposes.

Division of Biochemistry

Dr. Donald D. Van Slyke and Dr. Lee E. Farr will jointly head the Division of Biochemistry; they are at present screening various applicants for junior positions in the Division. Dr. Van Slyke and Dr. Farr will assume full-time duties at the Laboratory on September 1.

Division of Physiology

Several candidates are being considered for appointment as head of the Division of Physiology. No attempt will be made to fill other positions in the division until this appointment has been made.

RADIATION PROTECTION

Although the Laboratory is organized along the more or less traditional lines of major departments representing broad subject fields, many activities require the concerted efforts of "task forces" drawn from the various scientific disciplines. This is well illustrated in the so-called projects which were established for the design of the major facilities, and in the group of activities which together constitute the program of radiation protection and environmental studies. The units engaged in these latter activities come from different parts of the Laboratory organization, but their work is so closely related to the central theme of achieving safety for personnel and surroundings that it is natural to consider their progress and plans in the same section of this report, as has been done in previous reports.

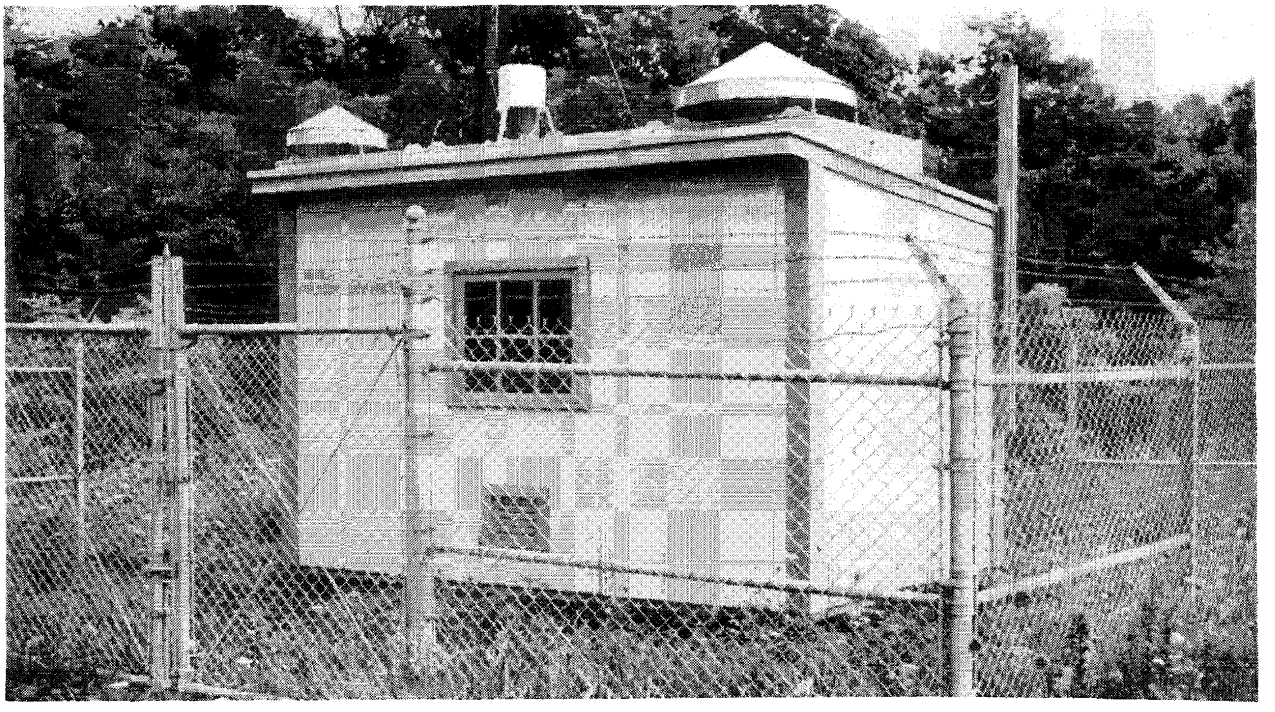
While delays in starting up the reactor are distressing to the scientists who are eager to use it in their research, the additional months have permitted longer baselines of information about natural background radiation, meteorological conditions, crops, and ground water, against which to monitor the effects, if any, of reactor operations. The extra time has meant a larger, better trained, and more fully equipped group in health physics. It has provided an opportunity for analysis of numerous smoke experiments and for more thorough training of meteorology personnel, has permitted virtual completion of the test-well drilling program, and collection of data in the first phase of the economic crop survey. As a result, use of the reactor will be initiated with more completely organized radiation protection services than had been expected in earlier planning.

Health Physics

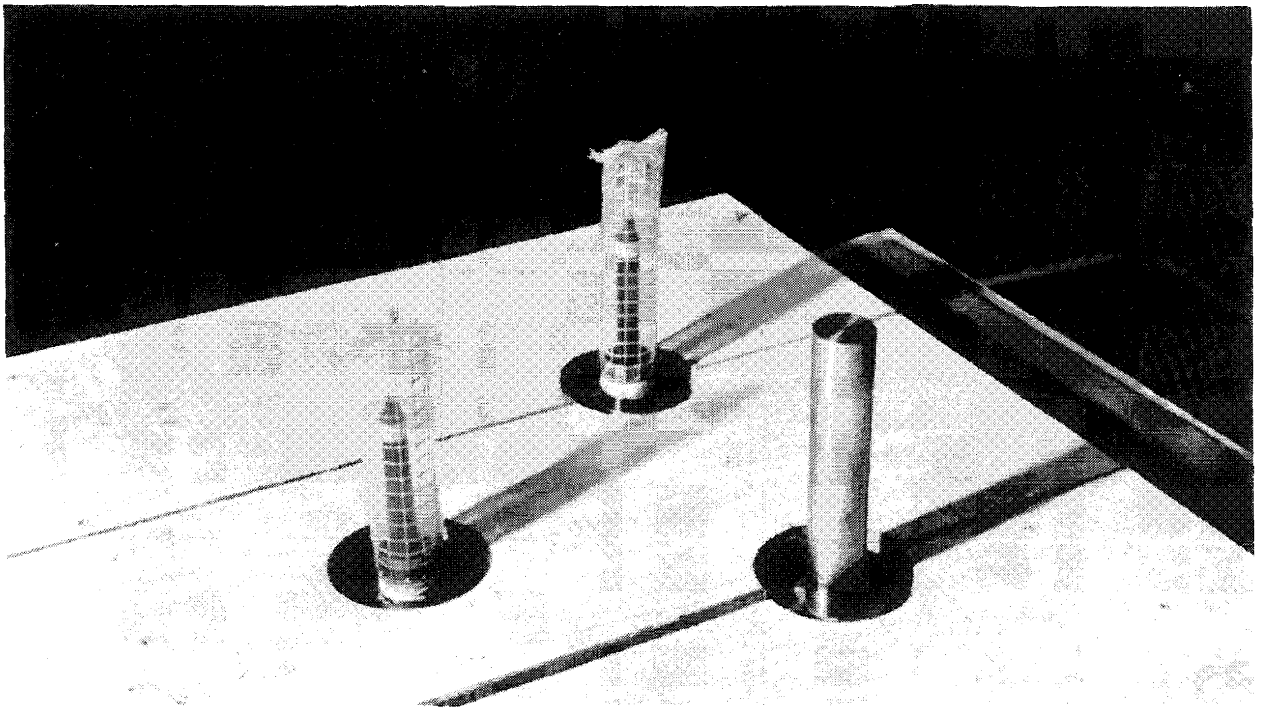
The close correlation between the magnitude of the radiation protection program and the scale of experimental work has continued. The Health Physics Division staff has grown from 29 to 36, with a considerable further expansion anticipated next fall and winter as the reactor, hot laboratory, 60-inch cyclotron, and new biology building go into operation. The work of the Source Custodian, reported below, is being transferred to the Reactor Science and Engineering Department.

With the establishment of a small testing laboratory for special projects involving radioactive substances (and therefore not suitable for the Electronics Division laboratories), the central facilities of Health Physics Division are essentially complete. Survey headquarters rooms are planned for several of the more important operating areas; the one in the chemistry complex is already set up.

Arrangements have been made for an experienced health physics surveyor to be available on the site 24 hours a day for emergency calls. This supplements the detailed operating procedure outlined for the Police and Fire Departments, and the current information on conditions in radiation areas maintained by the Building Survey Group.



Exterior of a background monitoring station. Visible on the roof are two conical shelters for protection of Geiger-Mueller counter tubes and the ionization chamber and electrometer head of a dynamic condenser electrometer between these shelters.



Close-up of three Geiger-Mueller counter tubes on roof of monitoring shack, with protecting cover removed. The counter on the right is provided with a brass shield to exclude beta-rays.

Training

Training of staff, particularly for the building survey program, is still a major activity. A considerable backlog of operating experience with low and medium level survey responsibilities has been accumulated. Several new men have had tutorial and on-the-job training this spring. During June and July, six surveyors not previously experienced in hot operations are visiting Oak Ridge National Laboratory for brief tours of duty at the reactor and in the hot laboratory. This summer, the Laboratory expects to conduct a series of recitation and discussion periods on a variety of subjects, and to give the newer employees on-the-job training of one week in each of 8 subdivisions of Health Physics Division activities.

The need for a general indoctrination pamphlet on radiation and radiation protection has been recognized for some time. It is being met by a booklet, The ABC's of Radiation, currently being distributed to all Laboratory employees and available upon request to others who are interested.

All of the reactor operating staff have now received a reasonable amount of training in health physics. This will be supplemented on the job as reactor operations are begun. After completing course work at the University of Rochester, a group of Atomic Energy Commission fellows in health physics will visit the Laboratory during September and October for field experience in all aspects of the Laboratory program.

Waste Disposal

Disposal of radioactive waste is as yet a minor problem, but will soon increase rapidly in magnitude. The broad outline of proposed operating policy in regard to liquid wastes has been established by the Radiation Safety Committee, but the Atomic Energy Commission has not yet replied to the proposal. Hold-up tanks and proportional sampling arrangements are to be provided at many Laboratory locations, so that the projected low activity levels in waste released to the environment may be maintained. All but extremely dilute liquid wastes will be stored until such time as a satisfactory concentration process is developed. At present, the activity appearing in the effluent from the sewage processing plant is undetectable most of the time, with occasional days when concentrations of the order of 10^{-13} curies per cc are noted. A hold-up tank and sampling arrangement for the Chemistry Department's semi-hot laboratory is being constructed. Proportional samplers at the sewage disposal plant are in the design stage.

Solid waste is at present being stored in some small buildings located in what was formerly the Ordnance Area. Plans have been made for developing this area, which is well isolated from the rest of the Laboratory, for waste storage and processing. Storage and burial trenches are to be provided; and carefully controlled small-scale incineration, particularly of biological waste, will be undertaken.

An extensive area monitoring program is primarily concerned with the control of gaseous waste. This has been supplemented in recent months by a program for the study of the gaseous effluents from hoods and ventilators. Emphasis has been placed on providing equipment for the detection of radioactive particles or aerosols. No such particulates exist at present, but a close watch is kept so that the present cleanliness of the site may be preserved for experimental, as well as health, reasons.

Building Survey

The detailed arrangements for survey coverage of the whole Laboratory have now been well elaborated. Health Physics Division instruction sheets for the guidance of maintenance and operating personnel are in use, and a system has been established for maintaining an up-to-date summary of special hazards for the benefit of fire, police, maintenance, and health physics emergency people. Periodic contamination surveys of all parts of the Laboratory have been instituted. Procedures for the guidance of telephone company employees have been worked out.

The setting up of a 20-curie cobalt^{60} source by the Biology Department was an operation requiring careful planning from the point of view of safety. Other "hot" operations were the dissolving of activated uranium, and numerous machining operations on uranium and activated graphite.

There has been a small but steady succession of health physics problems in connection with the activities of the metallurgy, waste concentration, biology, chemistry, and physics laboratories.

Plans have been made for equipping the various health physics survey headquarters in the operating areas. Most of the equipment needed has been purchased. Projects for development of the remainder have been set up in the Electronics Division. Work is progressing on BF_3 neutron counters, laundry monitors, and doorway alarm monitors ("friskers"). Plans have been made for a detailed survey of the nuclear reactor shield at the time of start-up.

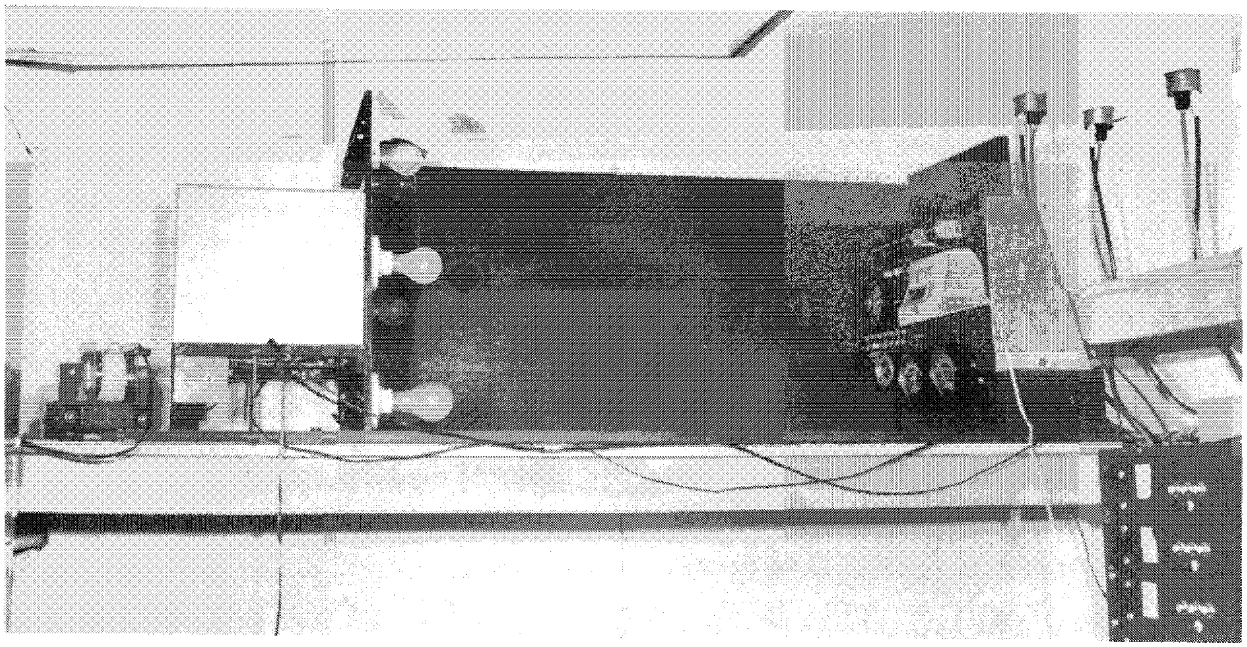
Area Survey

Considerable progress has been made toward completing the equipment of the area monitoring stations. The G-M tube installations are all in operation; troubles due to photosensitivity and moisture have been largely overcome. Numerous weaknesses in the equipment, which developed in use, have been remedied. Engineering development of dynamic condenser type electrometers and ionization chambers has been completed after persistent difficulties with earlier models, particularly due to thermal effects on the insulators. Background values of 0.2 mr per day radium equivalent are recorded, with 7 stations equipped, and the rest to be equipped soon.

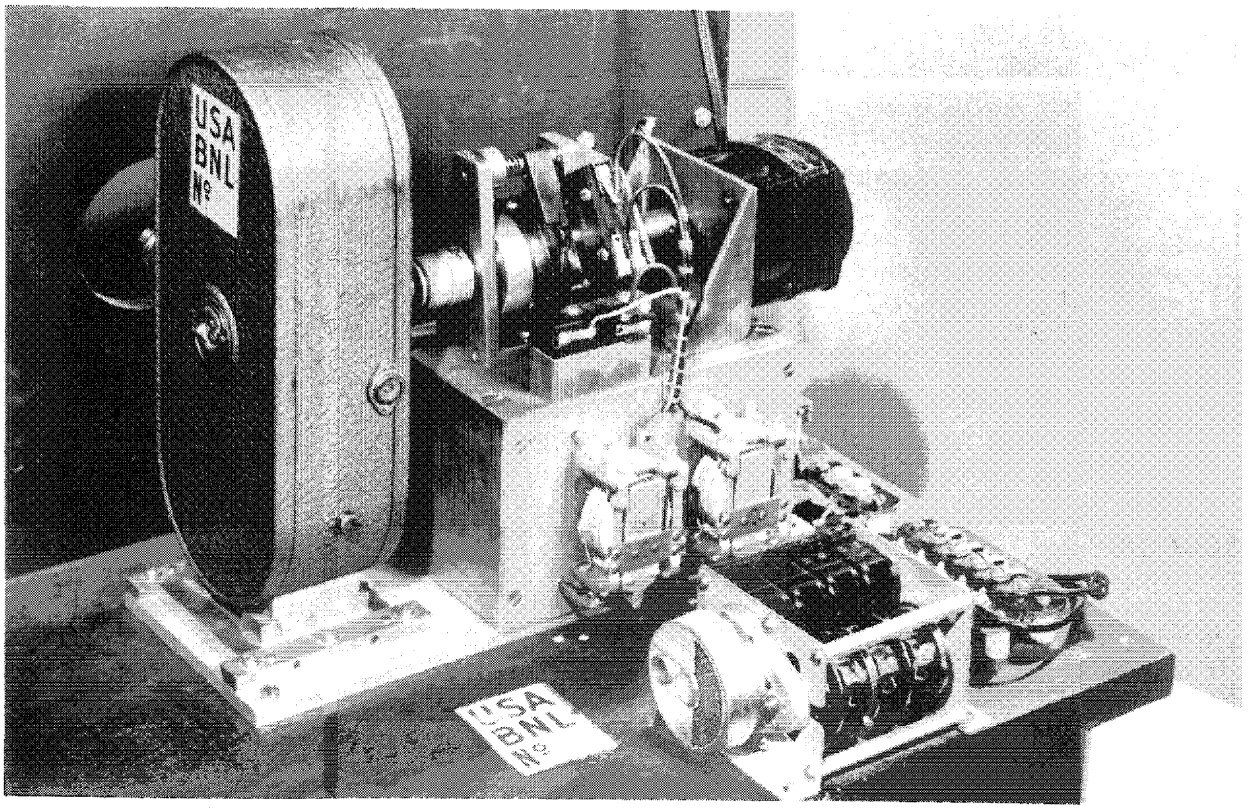
Equipment for continuous collection of dust samples and analysis for alpha and beta-gamma activities has been developed; it will be procured for all the stations. Monitoring equipment is now operating on the taller meteorology tower, and a mobile station is ready for use.

The equipment and operating procedures of the area monitoring counting room have been considerably elaborated. The Electronics Division has developed a scintillation type alpha counter with a low background and high geometry. Difficulties with line noise and switching transients have been overcome, and predetermined count attachments have been procured for several counting set-ups.

Adequate data on the background activity at a nearby photographic plant have been accumulated, and tests on radiosensitivity of its products have been completed.



Part of the equipment in a monitoring shack. Leads from three preamplifiers associated with Geiger-Mueller counter tubes come through the ceiling and go to the scalers partly visible at the lower right. At the upper left is the photographic recording setup. All the data obtained in the shack are displayed on the instrument board at the right.



Close-up of camera drive with cover removed. The instrument panel is photographed every six minutes.

Personnel Monitoring

The volume of routine personnel monitoring service has remained rather low -- about 350 film badges and 350 pairs of pocket chambers per week. Average exposures measured have been near zero in most cases, with one or two individuals receiving isolated doses of slightly more than the 250 mr per week operating limit. Special services have included the processing of films used in wrist badges, radioautographic studies, and dosage measurements on plants. The equipment and the record system of the Personnel Monitoring Group have been essentially completed. Arrangements have been made for coordination of the records with those of the Medical Department.

A technique for calibrating and monitoring films for beta sensitivity by means of U_3O_8 plaques has been developed to avoid the use of metallic uranium. Special studies have been made of film response in the high and low exposure regions. The drying of film has been greatly accelerated and improved by the use of wetting agent.

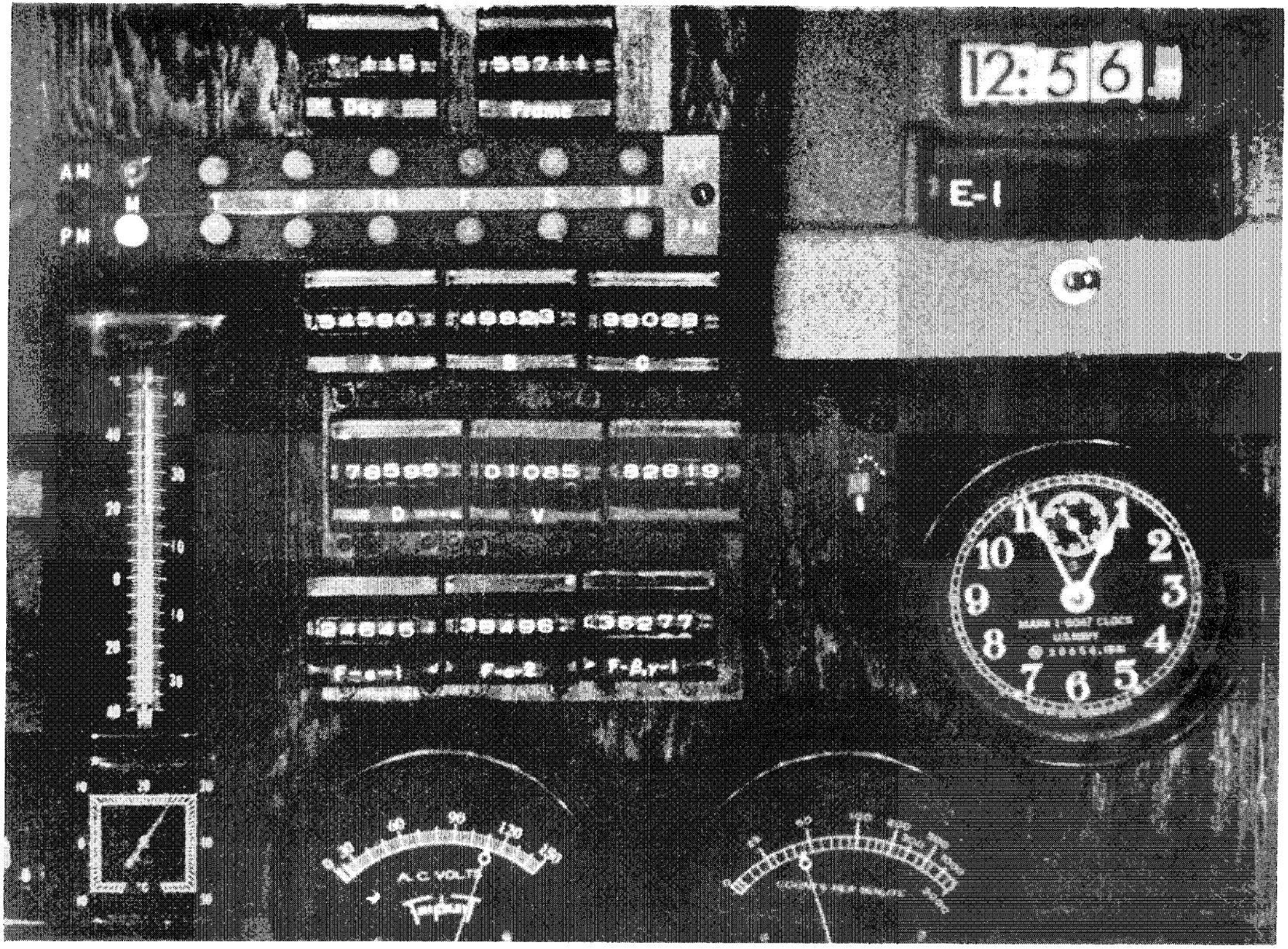
Source Custodian

Isotope procurement from the Atomic Energy Commission at Oak Ridge has increased considerably. About 5 curies of 28 types of radioactive isotopes were received in addition to the 20-curie cobalt^{60} source, as well as a number of radium sources and four irradiated slugs. Various quantities of 11 varieties of stable isotopes have been received. Major items were 2.7 curies of tritium, 710 mc of P^{32}, 160 mc of G^{198}, 100 mc of Cu^{64}, 95 mc of Y^{91}, and 84 mc of Ce^{141}.

A number of shipments of C^{14}-labeled compounds have been made to experimenters at other laboratories. The facilities at the source warehouse have been elaborated by addition of a loading ramp, electromagnetic tongs, and additional storage facilities.

Meteorology

The Meteorology Group has devoted the major portion of its effort during the past six months directly to the effluent dispersion problem. Emphasis has been centered on the accumulation and analysis of reliable data, such that the characteristic dispersion patterns of the predominating meteorological situations could be determined. Some twenty "smoke runs" have been completed, and the significance of the various meteorological regimes which will influence activity at the Laboratory has begun to emerge. That these first segments of data agree remarkably well with prior expectations is most encouraging, since the persistent weakness in all early estimates concerning the problem has been the dearth of reliable data relating meteorological variables with effluent dispersion from tall stacks. Firm conclusions regarding the fine details of the atmospheric diffusion processes in this area await the completion of a large number of smoke runs. It would be premature to assign precedence to a particular theoretical approach, since many of the differences which are significant from the theoretical point of view can be disclosed only by a very complete observational record. Minor deficiencies not evident in the design stage have required some effort to improve the instrumentation and equipment. With the beginning of actual operations of the reactor, the forecast program will come into



Sample frame of the record obtained from a background monitoring station.

somewhat greater prominence, and a number of new aspects of the instrumentation program will be investigated in order to make the most effective use of available facilities.

The data now being collected fall into three broad categories: general climatological and snyoptic weather data, micrometeorological data, and smoke dispersion data. A full report containing outlines and analysis is being prepared for publication. Plans for the immediate future involve the completion of the final phase of the forecast program and the conversion of micrometeorological variables in terms of effluent concentrations. Continuing smoke runs will define the relationships more closely.

The U.S. Weather Bureau office continues to cooperate with the Meteorology Group in its operational and research activities. A measure of the ratio of vertical to lateral gustiness in the surface layers of the atmosphere is being obtained through the use of tethered balloons whose motions are observed and recorded by an observer downwind. The variation of the gustiness ratio with height and meteorological parameters will be derived from observations taken from the meteorological towers. A published paper estimates the degree of past exposure to atmospheric contamination in the neighborhood of an industrial plant, using primarily as a basis production figures and atmospheric diffusion theory ("Non-Occupational Berylliosis", by M. Eisenbud, R.C. Wanta, C. Dustan, L.T. Steadman, W.B. Harris, B.S. Wolf, NYOO-53, March 16, 1949).

Geological Studies

Completion of a 10-inch well to bedrock north of the reactor complex furnished additional evidence that the Lloyd sand aquifer in this area has a considerably higher clay content than in the western part of Long Island, and that water can be obtained from it only with difficulty. Pumping tests show a specific capacity of the Lloyd to be approximately 2.7, compared with 10-14 in Nassau County and 50-150 for wells in the glacial sands.

Considerable difficulty was encountered in setting screen and developing the well in the uppermost aquifer of the Magothy. This added an unexpected factor to the cost of the 10-inch well. But that was offset by a decision to abandon plans for development at about 1100 feet in the Magothy. This decision was not made on the basis of cost, however, but on the ground that core samples did not reveal a distinct aquifer at the level as had been the case in the first deep well. Lateral changes in lithology of the Magothy beds are such that at this point the entire Magothy would probably function virtually as a single hydrologic unit.

In order to test tightness of the Raritan clay seal over the Lloyd, a 4-inch well was drilled 1000 feet adjacent to the 10-inch well. Observations during pumping of the larger well seem to show that there is no direct communication between the Lloyd and the overlying aquifers at this point.

Fifteen small diameter wells were driven to fill in some of the blank areas in the water level program. Drilling of five cored wells through the Pleistocene sands during the summer, and of a few monitoring wells in the vicinity of waste storage

facilities, will practically complete the pattern of wells and test holes originally laid out.

Sixty-two observation wells are now being measured every two weeks; and five continuous recorders are in operation. Details of the local water table are beginning to emerge. Complete chemical analyses of sixty-two water samples have now been received from Washington. Results from measurements of gross natural radioactivity in eleven samples have been received, and more are being submitted. As had been expected, the activity is very low, with one exception at some distance from the Laboratory, which is being investigated further. Thus, before reactor operations begin, the geologists have assembled a good deal of information about the general chemical composition of both surface and ground waters in this vicinity.

Now that the well drilling becomes less of a preoccupation, the geologic staff can begin to concentrate on experimental work and the gathering of data on underflow, adsorption, ion exchange, and water level fluctuations, and on monitoring of the more strategically located wells. Two small scale pumping tests were run to take advantage of temporary installations, and some preliminary work was done with direct measurements of the rate of flow. In one locality, results gave a rate of movement of only four inches per day. The main progress has been in the development of methods, where the principal advance has been the addition of methanol to the concentrated ammonium chloride solution used as a tracer to bring the specific gravity of the mixture back to that of pure water. In this way, the tracer shows no tendency to sink, and can be followed over much longer periods of time than was previously possible.

In June, the Assistant Director of the U.S. Geological Survey and the Chief of the Ground Water Division visited the Laboratory in company with representatives of the Atomic Energy Commission Engineering Division. After reviewing the geologic work accomplished thus far, they entered negotiations with Associated Universities and the Laboratory to arrange for continuing use of the Laboratory's geologic facilities for work of interest primarily to, and to be financed by, the Survey. It was agreed that a "pact of mutual cooperation" would be drawn up between the parties similar to the one already in operation with the Weather Bureau. In this way, again, the exceptional network of special facilities (wells and test holes) required by the Laboratory will be made available to another Government agency for the advancement of collateral science.

During the ensuing fiscal year, it is expected that the drilling and leveling programs will be completed. Hydrologic studies will be vigorously pursued, including pumping tests, recharging experiments, studies to determine indices of dilution, and direct flow measurements using tracers. The water sampling and monitoring programs will be routinized. It is also hoped that further resistivity work can be undertaken and some seismic studies begun to extend data obtained from the two deep wells regarding the configuration of the bedrock beneath the Lloyd sand.

Economic Crop Survey

Brookhaven National Laboratory lies in a farming region where the principal crop is potatoes. There are 629 farms with a total of 29,000 acres devoted to this

crop within 13 miles of the reactor. The next most important crop, cauliflower, is raised on only 3,400 acres in the same area. Data from earlier years indicate the sensitivity of the potato yields per acre to reduced precipitation and high temperatures in the spring and early summer. During a dry period which may occur as often as every five years, the yields per acre may be halved. Because of the somewhat poorer soil immediately surrounding the Laboratory site, the average potato yield was 284 bushels per acre in 1948, compared to yields of 312 bushels per acre 10 and 13 miles away (J.S. White).

DIRECT SERVICES

Information and Publications

The staff of the Information and Publications Division, which numbered 40 at the start of the 1948-49 fiscal year, now stands at 36. This reduction by no means indicates a downward trend in the work load of the Division as a whole, or in any one of its various operating units. In fact, in most cases statistics show that the volume of work is on the increase; and in some fields it has doubled during the past six months.

The Publications and Information Groups have moved into more spacious quarters which were formerly occupied by the Accelerator Project, with a resultant improvement in working conditions. The Research Library has reached the point where more stack space is required. Rather than adopt the temporary solution of converting an adjacent building to accommodate the overflow, it has been decided to make additions to the existing stacks in the hope that a permanent, somewhat larger library building can be planned before long.

The Classified Library will also be able to expand now that Reactor Science and Engineering Department personnel, who occupied adjacent space, are moving into the new reactor building. This Library now has over 7200 classified report titles, 790 of which were added during the last six months. The index to these reports is being revised. In addition, an inventory of all the classified documents at the Laboratory is being made; this is expected to require some three months for completion. Over 3000 classified memoranda and letters, 600 photographs, 1000 prints, and 152 classified notebooks have been recorded to date. Including duplicate copies of reports, this brings the total of individual classified units over which the Library has accountability control close to 20,000. The effectiveness of this control is indicated by the fact that, at the most recent count, only two items could not be located, one of them a letter which was erroneously classified in the first place, but which cannot be declassified by the Atomic Energy Commission, and the other a one-page report which is apparently misplaced temporarily -- perhaps attached to other material in the classified files.

In the Research Library, the rate of acquisition of books and bound periodicals is now approximately 300 per month; at this rate, the added stack space will be adequate for two more years. However, while the work of assembling the basic material for the Library can be considered as virtually complete, with a total of some 20,000 books and bound periodicals now assembled, other functions of the Library staff are receiving increasing emphasis. A sufficient number of books has been cataloged to allow a permanent arrangement of volumes on the shelves by subject rather than by author, as was done in the past. At the same time, the card catalog in its final form has been made available to Library users. The reference desk is handling an average of 140 questions per month. The Library staff has increased its contribution toward the Weekly Selected Reading List by making the selections for the biology and medicine sections. A complete specialized reference service for the Biology Department has been initiated. This includes, among other items, work on a punched-card index system for literature in the fields of biological applications of nuclear energy. The central repository

of translated Russian scientific documents has now been established; over 130 translations have been received from industrial laboratories and other research organizations in the United States, Canada, and the United Kingdom. Since lists of the available translations were published in recent issues of the Guide to Russian Scientific Periodical Literature, some 35 requests for loans, or photostat copies (at a small service charge), have come in. The translation from the Russian scientific literature of outstanding articles in the field of nuclear physics has continued; in particular, mention should be made of the article, "The Existence in Cosmic Rays of Positive and Negative Particles with Masses Greater than that of a Meson," by A.I. Alikhanyan, A.I. Alikhanov, and A. Vaisenberg, for which Alikhanyan received one of the two Stalin prizes in physics in 1947. Such translated articles, together with translated abstracts and titles from the most important Russian scientific journals, are published in the Russian Guide, eleven issues of which have so far been distributed.

The Publications Group has edited and otherwise processed 40 major documents, not including the Russian Guide, the Weekly Bulletin, and the Weekly Selected Reading List, during the past six months. Most of these documents cover technical phases of the Laboratory's work. Twenty-six of them are unclassified, and are therefore available for wide distribution. Nominal charges were placed on many such documents, to be paid by requestors who were not included in the free distribution of individual personal copies to Laboratory staff members, consultants, trustees, and members of advisory committees, and to libraries, organizations, and individuals provided for in the Standard Distribution Lists of the Atomic Energy Commission. Such charges, while covering production costs to some extent, served as a valuable check on unnecessary distribution. In about seven months, approximately fifteen hundred dollars was collected in this manner. A recent policy decision of the Atomic Energy Commission will henceforth concentrate the distribution and sale of documents to non-Project recipients at the Commission's own document sales agency in Oak Ridge.

In addition to the publication of reports, the Division has been responsible for the publication review processing of approximately 70 manuscripts prepared by staff members for publication in the professional journals; it is expected that the volume will increase as the Laboratory's research facilities develop further. Such manuscripts must be submitted for clearance in regard to security and patent significance before they can be forwarded for publication. This publication review procedure, and the highly varied requirements of the journals with regard to manuscripts and to the ordering of reprints, has made it desirable to assemble information on these matters. Accordingly, all the journals with which the Laboratory has dealings are now furnishing information regarding their requirements or preferences in the preparation and submittal of papers, the ordering of reprints, and the presentation of technical papers at scientific meetings.

Laboratory scientists are cooperating with the Division in the compilation of data on the properties of the atomic nuclei. In addition to the first in the series, Spins, Magnetic Moments, and Electrical Quadrupole Moments, which is now being revised, a second, Range-Energy Curves for Alpha-Particles, Protons, and Mesons, BNL-T-7, was recently issued. Additional compilations on neutron cross sections, and energy levels, are in preparation.

The Division is also responsible for a library of films and other audio-visual aids. During the period under review, more than 50 film showings were arranged, most of them serving to familiarize the civic organizations and groups in surrounding communities with the fundamentals of atomic energy. A collection of unclassified photographs dealing with various phases of the atomic energy program, both here and abroad, will be completed shortly as an aid in the education of staff members, visitors, and the general public.

Photography and Graphic Arts

Personnel of the Photography and Graphic Arts Group now numbers 18, an increase of one during the period under review. This reflects a steadily rising volume of work for this service unit as the construction program reached its peak and the research activities expanded. Emphasis in photography is now shifting from the recording of construction to photographic documentation of research techniques and apparatus, and to the development of photographic techniques for taking data.

Increasing publications activities and participation of the scientists in colloquia, conferences, and professional society meetings has stepped up the demand for illustrative aids of all sorts. Although production figures show a percentage rise in prints, photostats, and lantern slides, the number of negatives required dropped 9%, and the number of offset pages fell 6%. The latter was occasioned by the Laboratory's effort to reduce publication costs by using mimeographed text wherever appropriate, rather than more expensive and "fancier" reproduction processes.

Significant additions to equipment include phase contrast equipment for the photomicrographic apparatus, and a high speed 16 mm motion picture camera now in use with metallographic and other studies.

To aid the Speaker's Bureau and the lecturers for more technical audiences, the Group has prepared a visual catalog of some 500 available lantern slides. During the last six months, this catalog was consulted in connection with almost a hundred popularized talks and other presentations.

During the ensuing fiscal year, the Group is expected to expand slightly to an authorized strength of 20, at which point stabilization may occur, according to present plans. The Group's most urgent need is for additional space. It is hoped that this can be provided within a few months to improve morale and efficiency by eliminating the exceptionally crowded working conditions which characterize present operations.

Drafting and Shops

Drafting. The general character of the work done in the past six months is reflected in the work of each section of the Drafting Group, and reflects in turn the progress of the entire Laboratory program.

The section which handles drafting and design for the Reactor Science and Engineering Department has seen a shift of emphasis from apparatus and equipment needed during the reactor construction phase to experimental apparatus which will

be used when the pile is completed and available for research. Examples of the latter which are currently under design are a two-mirror collimator and a remotely controlled crystal table, both to be used in conjunction with studies of neutron beam energies. A water tank for installation in the reactor roof is being designed, and preliminary studies are being made of an apparatus for running high temperature creep tests of metals under radioactive bombardment.

Work for the Accelerator Project has emerged from the design-study phase and, with the impact of building construction and the progress of the procurement program for Cosmotron magnet blocks, is entering the final design stage relating to assembly procedures and final arrangements of facilities for the machine and the building. Work has also been going forward on model testing. The progress of the cyclotron building and the assembly of the cyclotron and related facilities have required the full time assignment of a designer.

Research work in the Biology Department requiring the assistance of the Drafting Group has been covered by both the Tool Design Section in the Shops Division and the Drafting Headquarters Section. The Biology Department's expanding program has resulted in the strengthening of the Tool Design Section to a group of four. This section is now actively engaged in laboratory and apparatus design for the biology, chemistry, reactor, and accelerator programs, in addition to its own shop program work on tooling and special purpose machines. Special tooling problems of the Accelerator Project and Reactor Science and Engineering Departments have been handled here.

The Drafting Headquarters Section has been engaged on three long-term apparatus design projects for the Physics Department. Two of these pieces of apparatus will be used for experimental work connected with the reactor; the third will be used with the electrostatic generator of the Accelerator Project. Several other general designs were prepared for the Biology and the Reactor Science and Engineering Departments, and for the Particle Physics Group. The Drafting Headquarters Section also handles a large volume of work which subsequently goes to the Photography and Graphic Arts Group for reproduction. This material includes graphs, charts, and pictorial representations for intra-departmental reports and Laboratory publications.

Shops. The organization of the shops at the Laboratory has been decentralized to a considerable degree. In addition to the two central shops, there are now six staff shops, with a total personnel of 22, under the direct supervision of the scientific departments. Since the last report, Machine Shop B, known as the Heavy Machine Shop, has been set up for all-around machine operation. A 74-inch Bullard lathe will be installed and ready for operation by September 1. A Machine Maintenance Group has been set up in Shops to service, oil, and make minor repairs on all machines, including those of the staff shops. The Shops Standards Section is fully equipped and able to handle any work required of it by the scientific departments and by Shops itself. This section is especially valuable in the thorough inspection by the Shops Standards Inspector of all work which has been subcontracted to outside machine shops.

The following table is a schedule of "completed" and "in process" work orders handled by Shops in the last three six-month periods. It is to be especially noted that, beyond the steady increase of work orders, there have been these changes:

1. Hours per work order increased from 38.6 (6/30/48) to 56.7 (12/31/48) to 59.5 (6/30/49).
2. Work orders subcontracted to outside fabricators decreased more than 50%.
3. This steady increase in work took place in the past six months without any increase in Shops personnel.

	Period Ending		
	6/30/48	12/31/48	6/30/49
No. jobs completed	444	742	851
No. hours	17,124	42,037	50,580
Average hours per job	38.6	56.7	59.5
No. jobs in process	121	124	128
Estimated hours	21,455	16,550	26,305
No. jobs subcontracted	32	26	9
No. completed	27	22	2

ADMINISTRATION AND MAINTENANCE

Architectural Planning and Plant Maintenance

Personnel of the Architectural Planning and Plant Maintenance Department now numbers 411, indicating a net increase of 5 over the December 31 total. This increase arises from better staffing of the maintenance shops to meet growing demands for operation and maintenance of new facilities.

During the past six months, more than 80,000 square feet of new laboratory facilities were placed in operation, as is seen in the accompanying table.

New Facilities Added -- January 1 to June 30, 1949			
	Area in Square Feet		
Facility	Added by New Construction		Added by Modification
Meteorology	3,000		3,000
Accelerator laboratories	-		13,100
Waste disposal laboratory	-		4,700
Surgery	-		5,800
Isolation ward	-		4,100
Hospital kitchen	-		4,100
Chemistry complex	13,500		10,300
Accelerator offices	6,300		-
Physics laboratory	-		2,400
Fluorine laboratory	600		-
Biology laboratory	-		4,700
Boiler house	4,900		-
Totals, January 1 to June 30	28,300		52,200
December 31 totals	16,500		384,100
Percent increase	171.52%		13.59%
	Dec. 31	Increment	% Increase
Total area in active use	825,400	80,500	9.75%
Area in use by modification or new construction	400,600	80,500	20.09%

With the exception of the boiler house, fluorine laboratory, and meteorology building (which account for 11,500 square feet), complete architect-engineer services for these modifications and new construction projects were furnished by the Architectural Design Group. Modification of over 50,000 square feet, new construction amounting to 25,500 square feet, and 6 utility additions, all designed, supervised

and administered by this Group, were started during the report period. In addition, members of the Group spent considerable time in supervising the completion of parts of the reactor complex and the cyclotron - electrostatic accelerator building.

The Group is now working on modifications or new construction involving 20 buildings and 6 utility additions and modifications, and has just completed the design stages of the Cosmotron building and auxiliary services, working in conjunction with the architect-engineer firm of Skidmore, Owings, and Merrill. This major new facility presented a complex design problem, further complicated by the need for speed in its execution. In order to gain time, every opportunity has been exploited to complete portions of the actual work during the design stage. The magnet foundation was completed in January by the H.K. Ferguson Company; rough excavation for the building was completed by Elmhurst Contracting Company during May. Orders were placed for the elevator, cranes, wall panels, structural steel, unit substation, and main station breakers during the period from late February to the middle of April -- as soon as the various portions of the design were sufficiently defined. In the meantime, test buildings to provide space and services for coil winding and the testing of the magnet blocks are being built, and are scheduled for completion prior to the arrival of the magnet sections. Bids for the construction of the building, which will incorporate the erection and installation of the previously ordered building components, are due on July 1. Completion of the building is scheduled for April 1950.

The Department's routine maintenance functions are being carried on by the Buildings and Grounds Division, as outlined in previous reports. No new maintenance facilities have been added. Personnel of the maintenance forces have been gaining familiarity with the operating problems of the complex mechanical and electrical equipment which the reactor complex and accelerator buildings contain.

Economies in operation of the Transportation Group have been continued by increased use of self-driver vehicles. Self-driver mileage increased from 39,363 miles in the first half of fiscal year 1949 to 79,517 miles in the second half.

The Fire Department has been reorganized in such a way that the chain-of-command is better defined. Four captains were appointed as monthly employees and placed in nominal charge of the shifts, under the direction of the Chief. Five lieutenants were designated. All firefighters are on a rotating shift. Round-the-clock inspection has been inaugurated. Training emphasis is placed on familiarizing all firefighters with all aspects of the Laboratory. Personnel has been reduced from 66 to 64; further reduction may be possible during the coming six months.

Business Management

The trend of employment in the Business Department during the past fiscal year and the projected employment for the coming year are indicated in the chart below.

Budget

Since January 1, 1949, the Budget Office has participated in several activities

Employment -- June 30, 1948 - June 30, 1950					
Subdivision	Actual			Projected	
	6/30/48	12/31/48	6/30/49	6/30/49	6/30/50
Shops	99	88	86	88	92
Drafting	22	25	28	25	27
Business management (Planning and administration)	14	11	8	8	8
Fiscal	48	44	49	53	53
Purchasing	23	23	23	23	20
Receiving, warehousing, and distribution	84	75	71	71	60
Office services	44	41	33	37	33
Total	334	307	298	305	293

Decrease, 6/30/48 - 6/30/49: 36
Decrease, 6/30/48 - 6/30/50: 41
Percentage of total Laboratory employment, 6/30/48: 25.2%
Percentage of total Laboratory employment, 6/30/49: 21.0%
Percentage of total Laboratory employment, 6/30/50: 18.3%

which have resulted in transferring from current operating budgets (including Associated Universities overhead and the Public Education Office) a total of $1,080,000 to help meet the increased facilities costs -- principally of the nuclear reactor and the cyclotron - electrostatic accelerator building. At the same time, adjustments were made in the facilities budgets for the fiscal years 1948 and 1949 amounting to $354,000; this sum was reallocated to the increased facilities costs noted above. The total adjustments, therefore, amount to $1,434,000.

During the six-month report period, budget estimates for the fiscal years 1950, 1951, and 1952 were also prepared. The final detailed functional Laboratory operating budget, Associated Universities overhead budget, and Public Education Office budget, together with budgets for facilities and capital equipment for fiscal 1950, were prepared and submitted. The Budget Office is currently preparing preliminary detailed functional operating, capital equipment, and facilities budgets for fiscal 1951 for submission in July. It is also developing detailed construction data on individual projects of $100,000 or more. In addition, the Office has prepared manpower estimates for Laboratory operations, as well as for construction projects through the calendar year 1952, and it maintains current price trend indices to help guide the management in its planning.

Contract Negotiation

The Subcontract Negotiations Section has participated in the negotiation of an additional 318 contractual instruments, valued at $3,124,613, bringing the year's totals to 541 and $5,887,613, respectively. The same diversity of contract content noted in the preceding progress report has continued, with contracts ranging from the purchase of a $400,000 electrostatic machine to the leasing of airport space for $1000.

Purchasing

Purchasing activities continue at the relatively high level established during the previous six months. It is anticipated, however, that, by the end of fiscal 1950, improved efficiency will make it possible to handle the present work load with a staff reduced slightly in number through the normal process of attrition.

To keep abreast of changing prices more effectively, the Purchasing Group has set up, and is maintaining without an increase in employment, a card catalog of items which indicates vendors and prices. This catalog already contains close to four thousand cards and several times that number in posting.

Receiving, Warehousing, and Distribution

The Receiving, Warehousing, and Distribution Group (formerly Materials Control Group) is responsible for goods handling and inventory control. As of June 30, its personnel numbered 71 -- a decrease of 4 in the last six months. The volume of stores issue and receiving reports which were processed, however, increased approximately 35%.

Laboratory property handled by the Warehouse Section of the Group is made up of both unissued and surplus items. It is housed in 27 buildings; seven contain the bulk of the active usable property, while the remaining 20 buildings house items held for future use, property taken over on the site pending decisions on future usefulness, and property in the process of being declared surplus. The Group also contains a section for the disposal of salvage material taken over originally from the Government and items of no further value to the Laboratory. The value of such salvage processed during the report period was approximately $600,000.

Fiscal

The Administrative Group of the Fiscal Division comprises the Controller, Chief Accountant, Internal Auditor, and an administrative aide who serves as secretary for these three. All fiscal functions except the budget preparation are in the charge of the Controller. He supervises all fiscal personnel, designs and operates fiscal procedures, and directs internal audits of Associated Universities, Laboratory, and subcontractors' accounts.

During fiscal 1949, accounting classifications and procedures necessary to record the transactions of the Laboratory were aligned with budget categories, so that commitments were routinely recorded against the appropriate budget classification at the time funds were committed. The inventory of unissued materials and supplies in Central Stores was set up and priced at a standard cost, and was controlled in total amounts by the general ledger. Categories of supplies of insignificant unit value were removed from inventory and charged directly against expense accounts. The Controller's office instituted a new system of reimbursement, changing from "voucher to voucher" submission to a one voucher per month basis; this office also worked out the necessary record keeping and auditing procedure with the Atomic Energy Commission and the General Accounting Office.

The Fiscal Division supplied information on, and explanations of, Laboratory transactions for two audits by public accountants, two audits by the General Accounting Office, and continuing audits by the Atomic Energy Commission. The Division prepared complete monthly reports of transactions and budget status for the Laboratory management, for the officers and the Executive Committee of Associated Universities, and for the Commission. It planned, in cooperation with the Commission, the institution of fixed asset accounting which will be started in part during fiscal 1949. The Division maintained current audits of all cost subcontracts, including the examination and review of overhead rates, and also carried on current internal audit checks throughout Laboratory operations. The Controller participated in the accounting aspects of contract negotiations, and established reimbursement and reporting procedure for cost contractors.

The Payroll Section of the Fiscal Division prepares salaries and wage checks, and makes authorized deductions for taxes, both State and Federal, and for group insurance, retirement, safety equipment, bond purchases, and union checkoffs. It also prepares monthly payroll and personnel force reports, quarterly and annual tax reports, and other Federal Government reports, including the employee's record of earnings and taxes withheld. Overtime and shift differentials are computed, as well as vacation and sick leave allowances. Commitments of wages and salaries are prepared monthly for the monthly financial report. Monthly and weekly payrolls involve approximately 4700 checks, 21,000 deduction entries, and 4500 time cards.

The Bookkeeping Section is responsible for recording manually the complete permanent summary of information pertaining to all the fiscal affairs of the Laboratory and Corporation.

The Accounts Payable Section processes all vendors' invoices. It also prepares the entry by which the commitment is relieved when the expenditure is made, the writing and verification of checks in payment for the invoices, and the adjustment of disputed invoices. These functions result in check payments averaging approximately $1,500,000 a month. In a sample month, 1500 checks to vendors were issued.

The Fixed Assets Section is a new group which has started to prepare fixed asset records to form the basis for fixed asset accounting in conformity with the Commission's new accounting policies. The work will involve the preparation of priced cards for all existing equipment and other property, and the development of appropriate depreciation rates and charges for the property. It will also, on a continuing basis, pick up and add to its records newly acquired property which is appropriate for capitalization purposes. On an estimated basis, the section will handle some 15,000 to 20,000 property cards.

The general functions of the Internal Audit Section were described above, in connection with the responsibilities of the Controller's Office.

The Contract Records Section maintains complete and detailed records on all contractual obligations of Associated Universities and the Laboratory, from the inception of negotiations for a contract to the last payment and the verification of the subcontractor's audit. A historical file is maintained for each separate contract; and payments and vouchers for payment are processed through this Section for scrutiny and verification before payments are made by the Accounts Payable Section. A monthly report on the status of all subcontracts is prepared, in substantially more

detail than is presented in the monthly accounting report, for the information of the management and the officers of Associated Universities; the report includes details of any contractual obligations which are in process or being negotiated. In addition, this Section maintains custody, for a period of five years, of the contracts of employees with the Teacher's Insurance and Annuity Association.

Summary of Subcontract Status

January 1, 1947 - June 30, 1949				
	No. Contracts		Total Value* of Commitments, 6/30/49	Expenditures* to 6/30/49
	Initiated	Completed		
Construction (except housing)	115	71	$26,078,112**	$24,891,898
Housing:				
On-site housing	9	9	564,905	564,905
Bellport	3	2	26,600	26,050
Equipment facilities	43	14	3,270,926	1,261,858
Equipment operation	6	2	68,019	53,359
Research	26	10	403,455	309,664
Personal services	5	1	21,854	10,691
Totals	207†	109	$30,433,871	$27,118,425

*Cents omitted.

**Advance to H.K. Ferguson Company not carried as an expenditure in this summary.

†Not counted in this total are numerous small purchase orders. The dollar value of such purchase orders is included, however, in the commitment and expenditure figures.

In addition to the above listing, there are numerous miscellaneous service contracts, such as: telephone and power services; reciprocal firefighting agreements with surrounding communities; operation of the cafeteria, gasoline station, vending machines; insurance for workmen's compensation, group life, retirement, and other miscellaneous policies; operation of branch bank; use of property for monitoring stations.

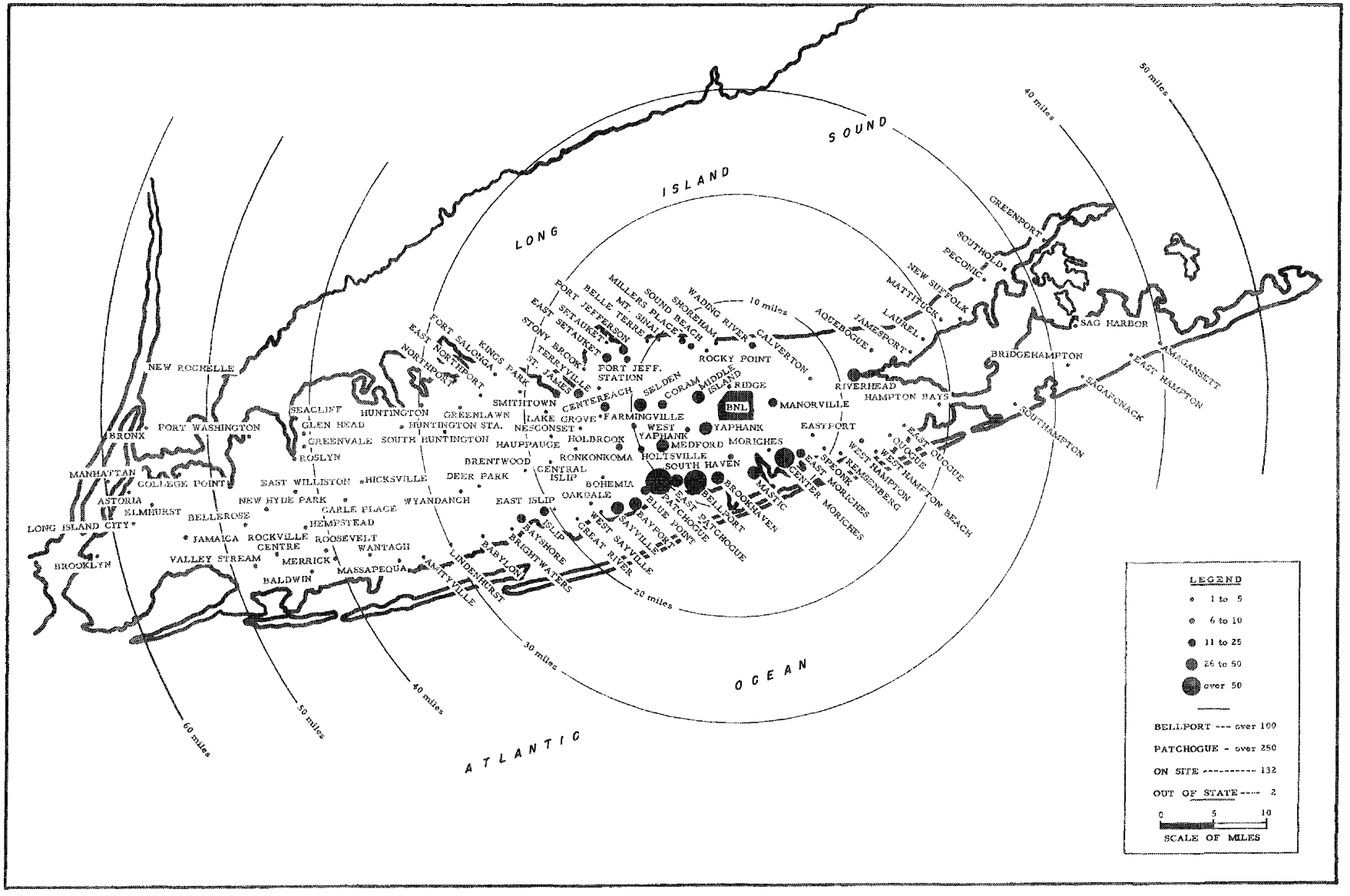
Office Services

During the past six months, personnel in the Office Services Group was reduced from 41 to 33.

The Group carries on the following functions: mail delivery, messenger service, duplicating, office machine repair, stenographic pool, telephone service, and file control (temporarily unstaffed). Pertinent statistics for the period January 1 through June 30, 1949, are listed below.

Mail Delivery and Messenger Service:

450,000 pieces of mail delivered



RESIDENCE DISTRIBUTION OF BROOKHAVEN STAFF — JUNE 1949

5,400 deliveries by special messenger
400 postings on 108 separate bulletin boards
7,500 information calls answered
2,500 telegrams received and dispatched
300 parcels wrapped for special handling.

Duplicating:

1,800 separate mimeograph jobs, involving over one million sheets of paper, and resulting in 12,000 copies
2,000 stencils prepared
500 jobs collated, consisting of some 3000 pages, and resulting in approximately 65,000 copies
350 addressograph jobs of approximately 50,000 impressions
3,500 scratch pads made from scrap paper and turned over to Central Stores for issue
250 dictaphone cylinders shaved for reuse.

Office Machine Repair:

900 repair jobs on 50 different types of office machines.

Stenographic Pool:

900 typing and stenographic assignments for all sections of the Laboratory.

Telephone Service:

158,000 outgoing calls
106,000 incoming calls
3,000 personal calls billed to employees
200 new phones installed.

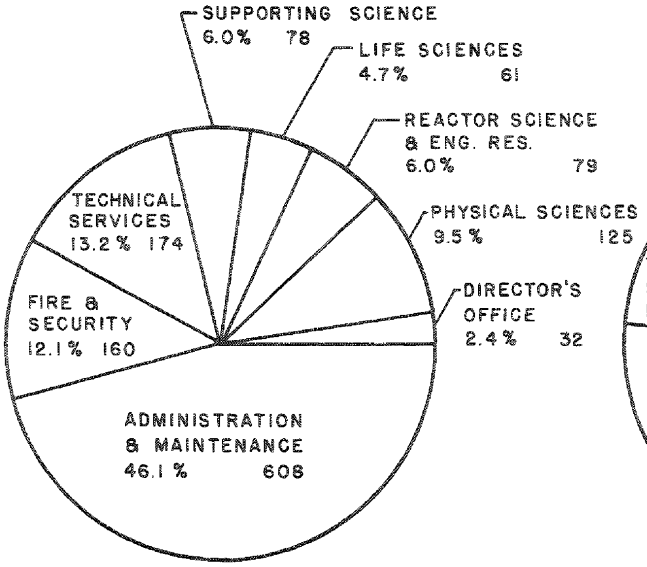
Personnel

The number of Laboratory employees on June 30, 1949 was 1411, not including 27 temporary appointments and 4 employees of the Public Education Office. This is a net gain of 69 over the total employed on December 31, 1948. It compares with a net gain of 25 during the last six months of 1948, and a net gain of 177 during the first six months of 1948. The increased net gain in the first six months of 1949, as in the first six months of 1948, reflects the seasonal recruitment of scientific personnel who during that period make commitments for the beginning of the new academic year, and the corresponding recruitment of personnel in support of the scientific staff. The average monthly rate of net accessions for the first half of 1949 was 1.1%. This can be compared with a rate of 0.3% for the last six months of 1948, and a rate of 2.4% for the first six months of 1948.

The average monthly turnover rate declined during the first six months of this year to 1.4%. During the last six months of 1948, the rate was 2.2% -- the same as for the first six months of that year.

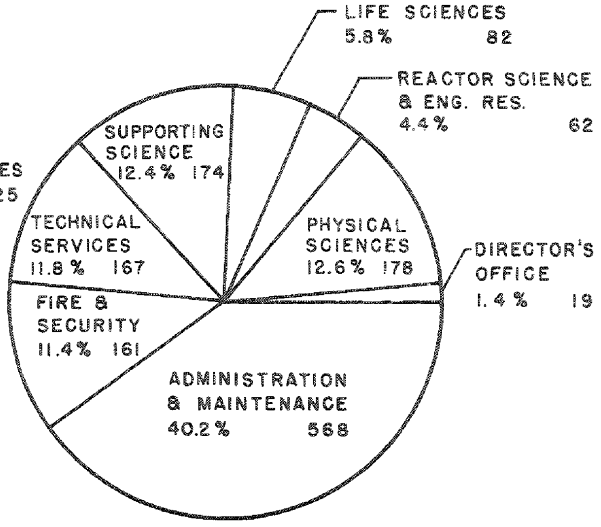
The ratio of scientists to nonscientists, as of June 30, 1949, was 1 to 5.4, exclud-

1948



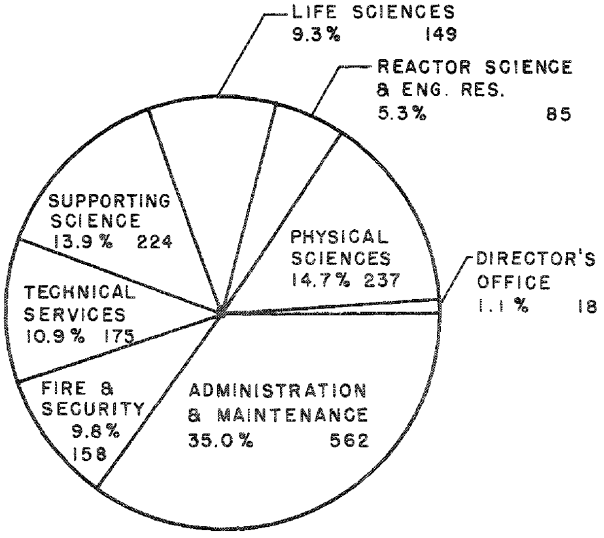
TOTAL– 1317

1949



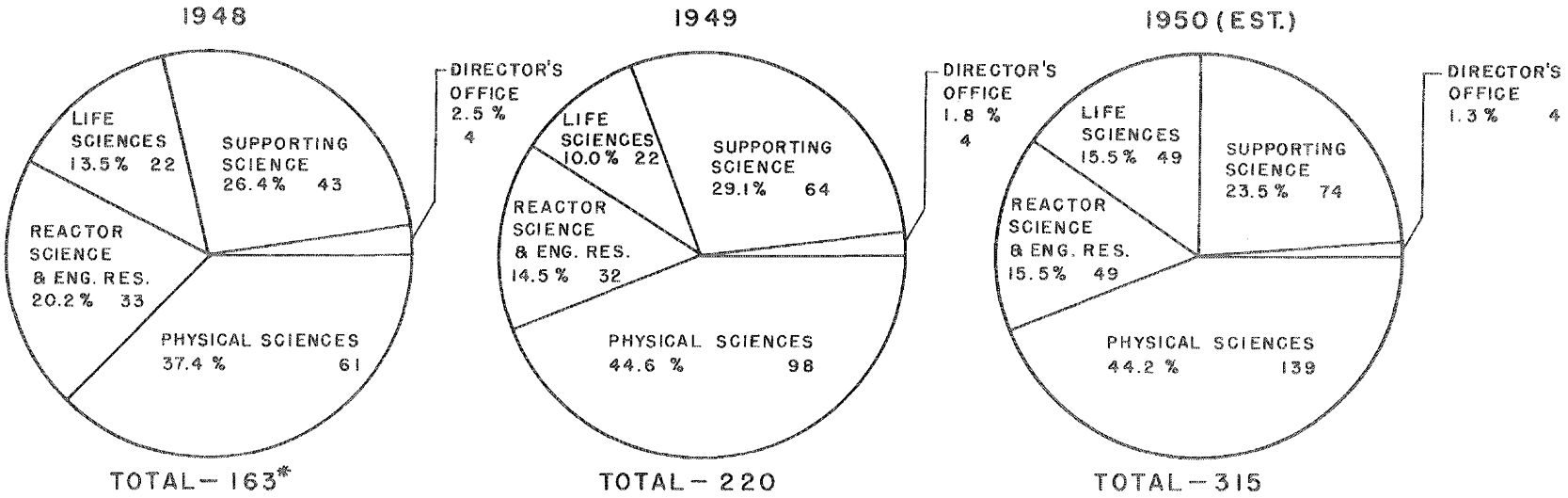
TOTAL–1411

1950 (EST.)



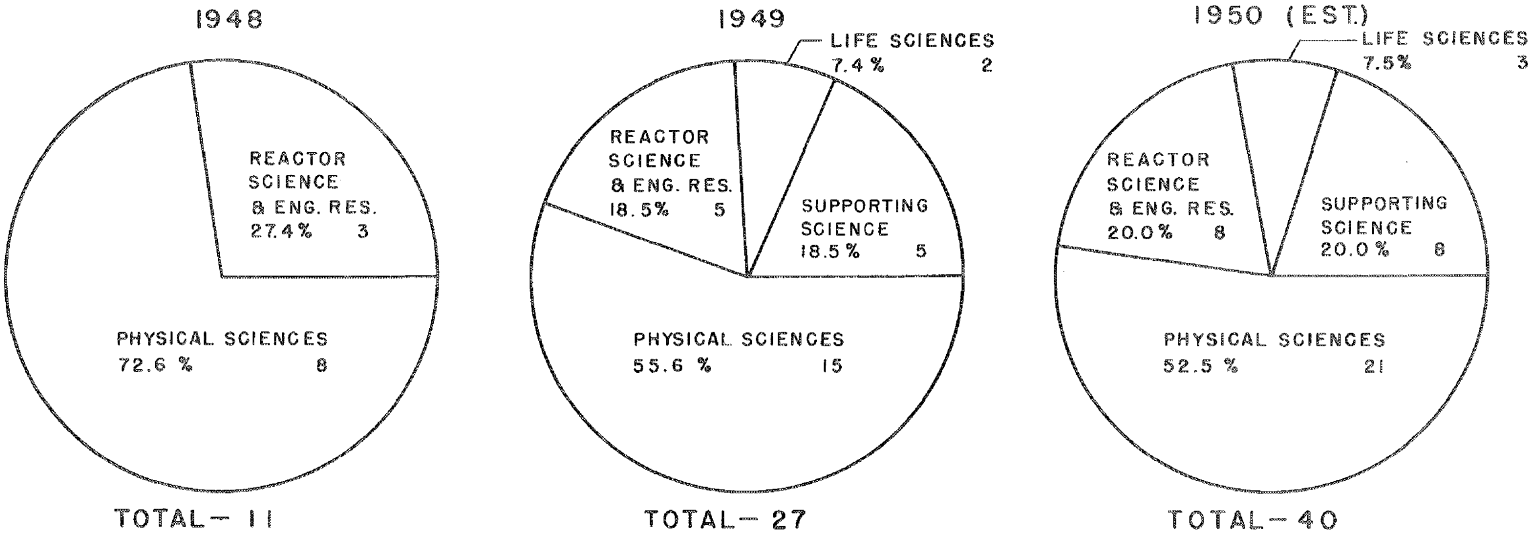
TOTAL–1608

PERSONNEL BY MAJOR OPERATING SUBDIVISIONS
(END OF FISCAL YEAR)



DISTRIBUTION OF SCIENTIFIC STAFF – END OF FISCAL YEAR

*(Since June 1948, changes have taken place in classification of personnel, reducing by 21 the total included in scientific staff.)



TEMPORARY SUMMER APPOINTMENTS to SCIENTIFIC STAFF

ing temporary appointments. This compares with ratios of 1 to 7.3 as of June 30, 1948, and 1 to 13.6 as of June 30, 1947.

During the last six months, the Personnel Division evaluated a number of new jobs for which need had become apparent. Re-evaluations were made of an additional group of jobs in which the duties have changed materially since they were originally evaluated. Investigation of systems for the evaluation of monthly paid jobs is going forward. An evaluation method suitable for use at the Laboratory is being developed for testing during the next six months.

The Housing Office assisted employees in arranging for 17 purchases of houses and 52 leases of houses, apartments, and rooms. Receipts for properties controlled by the Laboratory amounted to $37,209, which compares with $36,396 received during the first six months of 1948. Requests for the assistance of the Housing Office in securing off-site housing continued at virtually the same rate as before. In view of the considerably smaller number of new employees, this continued activity reflects the search for satisfactory housing, as compared to the previous search for merely a place to live. During the past six months, a major activity of the Housing Office has been the investigation of alternative methods for housing temporary and on-leave members of the scientific staff.

Emphasis of the Safety Group has been shifting to the scientific, operating, and research activities of the Laboratory. The results of the program of the past two years which was directed primarily at maintenance and service activities may be appreciated in terms of the 50% reduction in the frequency rate of disabling injuries for 1948 and a 40% further reduction during the first half of 1949. Since the first of the year, the Safety Group has accomplished standardization in the handling of compensation insurance claims through liaison with the carrier and the Workmen's Compensation Board. The development of the Laboratory's Medical Department has made it possibly to apply to the Workmen's Compensation Board for an employer's medical bureau permit, under which an employer may treat employees for other than first aid cases. Research in the effectiveness of dry chemical as a fire extinguishing agent and research in the control of uranium fires have increased the probability of improved fire protection. A major project for the Safety Engineer has been the development and coordination of an emergency plan for the Laboratory.

The activities and entertainments sponsored by the Brookhaven Employees Recreation Association have been accomplished without direct subsidy from the Laboratory during the complete fiscal year ending June 30, 1949. Approximately 60% of the employees participate in one or more of the individual, team, and group activities.

On March 23, 1949, negotiations between the Laboratory and Federal Labor Union No. 24426, American Federation of Labor, were completed; an agreement extending to June 30, 1950, was signed by both parties. Relations between the Union and the Laboratory during the bargaining period and since the signing of the agreement have been marked by a joint desire to work cooperatively in the interest of both the Laboratory and the employees.

Despite a 25% increase in premium charges, the number of employees subscribing to the group Blue Cross hospitalization plan increased from 76% to 80% of those eligible. The Laboratory's retirement plan, which was put into effect last August,

numbers 625 participants -- approximately 50% of those eligible. Participants in the group insurance plan continued to exceed 90% of the total staff.

Security and Plant Protection

Remote as it is from normal municipal services of police and fire protection, the Laboratory must always carry a complement of nonscientific manpower to cover these functions. As the Laboratory grows, so also do the problems of security, police, and plant protection. In meeting them with efficiency and economy, emphasis is placed on developing standardized, yet flexible, procedures, on improving morale and effectiveness through training, and on tighter scheduling of existing manpower, rather than on a growing roster of protection personnel. The objective is, of course, to provide the kind of security and plant protection consistent with the requirements of the Commission, without undue drain on the budget, and with minimum impact on academic freedom.

That is not an easy goal to achieve. Consequently, during the past six months, considerable time was given to repeated evaluation of needs, with a view to finding less expensive ways of meeting them adequately. Reduction of the Fire Department to 64 (with further reduction to 53 in July) was accomplished; and a reduction of about 20% in earlier budget estimates for Police Group manpower appears possible, even though the duties of this Group are notably increasing.

Personnel of the Security Office itself remains at six; no increase in this number is expected. The Police Group, not yet up to authorized strength, has remained more constant than before because of wage readjustments and more careful screening of applicants. Thorough indoctrination in the police school has also helped to stabilize the Group, by increasing the officers' comprehension of their duties, and by developing the concept of Laboratory police work as a career. Some increase in the force is expected as the Laboratory takes over from the H.K. Ferguson Company full responsibility for security and protection of the reactor complex area.

Present budgeted police manpower figures are, of course, based on the assumption that no major changes of procedure will be required by the Commission as a result of recent discussions with Congressional committees.

During the period under review, there were on the average almost 2700 vehicles entering and leaving the site per day. The number of visitors fluctuated from about 1500 in January to over 2000 in June, as the period of summer conferences began. Although the number of subcontractor personnel is decreasing markedly with completion of the major facilities, the total of transients is expected to remain at a high level because of increases in scientific staff and visitors. Proper recordkeeping for this volume of mobile persons is a substantial job in itself.

In addition to the transients, there are some 2300 employees, consultants, and contractor personnel who are at the site five days a week. Several hundred of them, including whole families, are in residence in the dormitories, guest houses, and apartments on the site. It is not surprising, therefore, that, during the report period, the Security Office and Police Group were drawn into a monthly average of 88 investigations. These involved problems arising from fire, pilfering and theft, minor

or potential breaches of security, traffic hazards or accidents, personnel clearances, transportation of classified materials, loss of possessions, misplaced keys, disorderly conduct, and a host of causes occasioned by the vagaries of human nature.

On several occasions, both the Police Group and the Fire Department were called, or voluntarily responded, to fires and traffic accidents occurring near the Laboratory. The immediate and efficient cooperation of these units has established cordial reciprocal working relations with county and local authorities in the Brookhaven area, and has developed considerable good will for the Laboratory.

Former Atomic Energy Commissioner Robert F. Bacher pointed out in a talk to the Laboratory staff several months ago that the Laboratory is in a very real sense pioneering for the Commission in many matters of security administration. This arises from the fact that this laboratory has such a preponderant amount of unclassified work and is largely an unrestricted area, yet necessarily has elements of classified activity also, which must be isolated in some respects without divorcing them completely from the whole. Operating such a "mixed" laboratory without jeopardizing the national interest on the one hand, nor interfering with individual freedom and the dissemination of scientific results on the other, is a difficult assignment. Consequently, it can be expected that the Laboratory will strive for ever clearer definitions in matters of security, will experiment with procedures and with training techniques, and will repeatedly require modification and interpretation of the standard regulations to adapt them to its unique operating conditions. It should be emphasized, however, that the basic policy underlying security administration at the Laboratory calls for rigidity in restricted matters, whereas unrestricted ones are handled quite openly. This contrast serves to keep the staff always aware that not everything at the Laboratory can be treated with equal freedom and informality.

APPENDIX

UNCLASSIFIED PUBLICATIONS, JANUARY 1 - JUNE 30, 1949

This list includes official Laboratory publications, publications by staff members and consultants, which resulted from work done at the Laboratory, and abstracts, submitted during the report period, of papers which were or will be presented at scientific meetings. In addition, publications listed as "in press" in the previous Progress Report (BNL-AS-1), are listed again in cases where complete publication information is now available. (A) indicates abstract; (L) letter to the editor. (In press.) indicates definite acceptance for future publication.

General Publications

Progress Report, July-December, 1948 (BNL-AS-1)

A B C's of Radiation

Guide to Russian Scientific Periodical Literature 1, #7; 2, #1, 2, 3 (BNL-L-57,58,59,60)

Weekly Bulletin 2, #23-48

Weekly Selected Reading List 1, #43-52; 2, #1-16

Staff Publications and Abstracts

Accelerator Project

Blewett, M.H.
Effects of eddy currents on the field of the cosmotron magnet (A)
Physical Review 75, 1288 (1949)

Blewett, J. (Co-author, M. Plotkin)
Ferromagnetic ferrites for a cosmotron accelerating unit (A)
Physical Review 75, 1288 (1949)

Blewett, J.
Propagation of electromagnetic waves guided by magnetic materials (A)
Physical Review 75, 1288 (1949)

Courant, E.D.
A resonance effect in the synchrotron
Journal of Applied Physics 20, 611-6 (1949)

Green, G.K. (Co-authors, H.S. Snyder and L.W. Smith)
Dynamic magnetic measurements on cosmotron magnet model (A)
Physical Review 75, 1289 (1949)

Plotkin, M. (Co-author, J. Blewett)
Ferromagnetic ferrites for a cosmotron accelerating unit (A)
Physical Review 75, 1288 (1949)

Smith, L.W. (Co-authors, G.K. Green and H.S. Snyder)
Dynamic magnetic measurements on cosmotron magnet model (A)
Physical Review 75, 1289 (1949)

Snyder, H.S. (Co-authors, G.K. Green and L.W. Smith)
Dynamic magnetic measurements on cosmotron magnet model (A)
Physical Review 75, 1289 (1949)

White, M.G.
Design of the Brookhaven high energy proton synchrotron (A)
Physical Review 75, 1288 (1949)

Biology Department

Acher, F. (Co-authors, M. Gibbs and R. Dumrose)
C^{14} uniformly labeled starch and glucose
Book - "Biochemical Preparations" (In press.)

Acher, F. (Co-authors, R. Dumrose and M. Gibbs)
C^{14} uniformly labeled sucrose
Book - "Biochemical Preparations" (In press.)

Ballentine, R. (Co-author, W. Bernstein)
A methane flow beta proportional counter
Review of Scientific Instruments 20, 347-9 (1949)

Bernstein, W. (Co-author, R. Ballentine)
A methane flow beta proportional counter
Review of Scientific Instruments 20, 347-9 (1949)

Bowen, V.T.
Barium metabolism in hornets by means of radioisotopes (A)
Transactions of the New York Academy of Science, [2] 11, 68-72 (1949)

Brookhaven conference report:
Biological applications of nuclear physics, July 12-27, 1948 (BNL-C-4)

Dumrose, R. (Co-authors, M. Gibbs and F. Acher)
C^{14} uniformly labeled starch and glucose
Book - "Biochemical Preparations" (In press.)

Dumrose, R. (Co-authors, M. Gibbs and F. Acher)
C^{14} uniformly labeled sucrose
Book - "Biochemical Preparations" (In press.)

Edelmann, A.
Some effects of X radiation on water and electrolyte metabolism in the rat (A)
Federation Proceedings 8, #1, Part I, 39 (1949)

Gibbs, M. (Co-authors, R. Dumrose and F. Acher)
C^{14} uniformly labeled starch and glucose
Book - "Biochemical Preparations" (In press.)

Gibbs, M. (Co-authors, R. Dumrose and F. Acher)
C^{14} uniformly labeled sucrose
Book - "Biochemical Preparations" (In press.)

Gibbs, M.
Distribution of labeled carbon in plant sugars after a short period of photosynthesis in $C^{14}O_2$
Journal of Biological Chemistry 179, #1, 499-500 (1949)

Gibbs, M.
The use of tracers in plant physiology
The Teaching Scientist (In press.)

Nims, L.F.
Radiation (section)
Annual Review of Physiology 11, 527-44 (1949)

Nims, L.F. (Co-author, N. North)
Time-dose study of biochemical responses of rats to X radiation (A)
Federation Proceedings 8, #1, Part I, 119 (1949)

North, N. (Co-author, L.F. Nims)
Time-dose study of biochemical responses of rats to X radiation (A)
Federation Proceedings 8, #1, Part I, 119 (1949)

Sacks, J. (Co-author, S. Stigman)
The turnover rates of the acid-soluble phosphorus compounds of liver (A)
Federation Proceedings 8, #1, Part I, 136 (1949)

Sfortunato, T. (Co-author, R. Steele)
Techniques in the use of carbon 14, February 25, 1949 (BNL-T-6)

Singleton, W.R.
Items for maize genetics cooperation
Cornell University News Letter, #23, 5-11, March 10, 1949

Sparrow, A.H.
Some factors affecting sensitivity of chromosomes to X-ray breakage and subsequent recombination (A)
Proceedings of the Eighth International Congress of Genetics, 668, July, 1948

Sparrow, A.H. (Co-author, R.C. Sparrow)
Treatment of Trillium erectum prior to and during mass production of permanent smear preparations
Stain Technology 24, 47-55 (1949)

Sparrow, R.C. (Co-author, A.H. Sparrow)
Treatment of Trillium erectum prior to and during mass production of permanent smear preparations
Stain Technology 24, 47-55 (1949)

Steele, R. (Co-author, T. Sfortunato)
Techniques in the use of carbon 14, February 25, 1949 (BNL-T-6)

Stigman, S. (Co-author, J. Sacks)
The turnover rates of the acid-soluble phosphorus compounds of liver (A)
Federation Proceedings 8, #1, Part I, 136 (1949)

Chemistry Department

Bigeleisen, J.
Isotope effect in the decarboxylation of labeled malonic acids (L)
Journal of Chemical Physics 17, 425-6 (1949)

Bigeleisen, J.
Isotope effect in the rupture of carbon-carbon bonds in propane-1-C^{13} (L)
Journal of Chemical Physics 17, 344-5 (1949)

Bigeleisen, J.
The validity of the use of tracers to follow chemical reactions
Science 110, 14-6 (1949)

Brookhaven conference report:
Isotopic exchange reactions and chemical kinetics, December 1-3, 1948 (BNL-C-8)

Burtt, B.P.
Standardization and use of RaE sources for absolute beta-counting
Nucleonics (In press.)

Dodson, R.W. (Co-author, J.W. Gryder)
The exchange reaction between the two oxidation states of cerium in nitric acid solutions
Journal of the American Chemical Society 71, 1894-5 (1949)

Dodson, R.W. (Co-authors, J.M. Miller and J.W. Gryder)
Reactions of recoil atoms in liquids
Journal of Chemical Physics (In press.)

Elliott, N.
Magnetic susceptibilities of some tetravalent uranium fluorides
Physical Review (In press.)

Gryder, J.W. (Co-author, R.W. Dodson)
The exchange reaction between the two oxidation states of cerium in nitric acid solutions
Journal of the American Chemical Society 71, 1894-5 (1949)

Gryder, J.W. (Co-authors, J.M. Miller and R.W. Dodson)
Reactions of recoil atoms in liquids
Journal of Chemical Physics (In press.)

Miller, J.M. (Co-authors, J.W. Gryder and R.W. Dodson)
Reactions of recoil atoms in liquids
Journal of Chemical Physics (In press.)

Rubinson, W.
Half-life determinations and the establishment of genetic relationships
Handbook of Radiochemical Techniques (In press.)

Rubinson, W.
The equations of radioactive transformation in a neutron flux
Journal of Chemical Physics 17, 542-7 (1949)

Samos, G.
Some observations on exchange of CO_2 between $BaCO_3$ and CO_2 gas
Science (In press.)

Turkevich, J., McKenzie, H.A., Friedman, L., and Spurr, R.
Infrared spectra of ortho-, meta-, para-, and omega- mono deutero toluenes in the 2 to 16 micron region
Journal of the American Chemical Society (In press.)

Electronics and Instrumentation Division

Pidd, R.W. (Co-author, L. Madansky)
Recovery problem in spark counters (BNL-I-11)

Pidd, R.W. (Co-author, L. Madansky)
The general properties of the parallel plate spark counter
Physical Review 75, 1175 (1949)

Madansky, L. (Co-author, R.W. Pidd)
Recovery problem in spark counters (BNL-I-11)

Madansky, L. (Co-author, R.W. Pidd)
The general properties of the parallel plate spark counter
Physical Review 75, 1175 (1949)

Health Physics Division

Balber, D.
Health physics
Nucleonics 4, #5, 112-23 (1949)

Harris, S.J.
Handbook of health physics (BNL-I-9) (In press.)

Weiss, M.
Area survey manual (BNL-I-8) (In press.)

Information and Publications Division

Goldsmith, H.H.
Bibliography on radiation detection
Nucleonics 4, #5, 142-50 (1949); #6, 62-9 (1949)

Goldsmith, H.H.
The literature of atomic energy of the past decade
Scientific Monthly 68, 291-8 (1949)

Physics Department

Alburger, D.E.
Beta-ray spectrum of K^{40} (L)
Physical Review 75, 1442-3 (1949)

Alburger, D.E.
Gamma-radiation from Na^{22} and Co^{60}
Physical Review (In press.)

Alburger, D.E. (Co-author, E.M. Hafner)
Properties of atomic nuclei. III. Nuclear energy levels: Z = 11-20 (BNL-T-9) (In press.)

Bethe, H.A. (Consultant)
Properties of atomic nuclei. II. Range-energe curves: Alpha-particles, protons, mesons (BNL-T-7)

Cohen, V.W. (Co-authors, W.S. Koski and T. Wentink, Jr.)
Nuclear spin and quadrupole coupling of S^{35} (L)
Physical Review (In press.)

Donoghue, W.F. (Co-authors, E.M. Hafner and M. Snyder)
A new proton spectrometer (A)
Physical Review 75, 331 (1949)

Goudsmit, S.A. (Co-authors, P.I. Richards and E.E. Hays)
Magnetic time-of-flight mass spectrometer (A)
American Physical Society Meeting, Washington, March 28-30, 1949

Hafner, E.M. (Co-authors, W.F. Donoghue and H.S. Snyder)
A new proton spectrometer (A)
Physical Review 75, 331 (1949)

Hafner, E.M. (Co-author, D.E. Alburger)
Properties of atomic nuclei. III. Nuclear Energy levels: Z = 11-20 (BNL-T-9) (In press.)

Hays, E.E. (Co-authors, P.I. Richards and S.A. Goudsmit)
Magnetic time-of-flight mass spectrometer (A)
American Physical Society Meeting, Washington, March 28-30, 1949

Hoke, G.R. (Co-authors, R.P. Shutt, W.A. Tuttle, and G.F. O'Neill)
Some cloud chamber photographs obtained with a high pressure cloud chamber (A)
Physical Review 75, 1329 (1949)

Hornbostel, J. (Co-author, E.O. Salant)
High energy events at high altitude (A)
American Physical Society Meeting, Cambridge, June, 1949

Johnson, A.L. (Co-authors, R.P. Shutt and A.M. Thorndike)
A cloud chamber of light weight for balloon flights
Review of Scientific Instruments 20, 398-400 (1949)

Johnson, T.H.
Photographic neutron detector of high sensitivity (A)
Physical Review 75, 1301-2 (1949)

Koski, W.S. (Co-authors, T. Wentink, Jr. and V.W. Cohen)
Nuclear spin and quadrupole coupling of S^{35} (L)
Physical Review (In press.)

O'Neill, G.F. (Co-authors, W.A. Tuttle, G.R. Hoke, and R.P. Shutt)
Some cloud chamber photographs obtained with a high pressure cloud chamber (A)
Physical Review 75, 1329 (1949)

Richards, P.I. (Co-authors, E.E. Hays and S.A. Goudsmit)
Magnetic time-of-flight mass spectrometer (A)
American Physical Society Meeting, Washington, March 28-30, 1949

Rossi, B.
Cosmic ray phenomena (BNL-T-8)

Safford, R.W. (Co-author, A.M. Thorndike)
A cosmic ray particle of charge two or greater
Physical Review 75, 903-4 (1949)

Salant, E.O. (Co-author, J. Hornbostel)
High energy events at high altitude (A)
American Physical Society Meeting, Cambridge, June, 1949

Schwartz, H.M.
Basic electromagnetic theory and the correspondence principle (A)
American Physical Society Meeting, Washington, March 28-30, 1949

Schwartz, H.M.
Contributions to existence theory of ordinary differential equations in the real domain. I (A)
Bulletin of American Mathematical Society 55, 518 (1949)

Schwartz, H.M.
Contributions to existence theory of ordinary differential equations in the real domain. II (A)
American Mathematical Society Meeting, Durham, N.C., April 1-2, 1949

Schwartz, H.M.
Notes on the differential equation $Y^{11}(x) + h(x,\lambda)Y = 0,1$. Preliminary report
Bulletin of American Mathematical Society 55, 290 (1949)

Scott, W.T.
The distribution of arc-chord differences in scattered particle tracks (L)
Physical Review (In press.)

Scott, W.T. (Co-author, H.S. Snyder)
Multiple scattering of fast charged particles
Physical Review (In press.)

Scott, W.T. (Co-author, H. Snyder)
New calculations of multiple scattering (A)
Physical Review 75, 1296 (1949)

Scott, W.T.
Notes on cosmic ray conference, September 10-12, 1947 (BNL-I-4)

Scott, W.T.
The statistical distribution of arc-chord differences in scattered particle tracks (A)
Physical Review 75, 1327-8 (1949)

Shutt, R.P. (Co-authors, A.L. Johnson and A.M. Thorndike)
A cloud chamber of light weight for balloon flights
Review of Scientific Instruments 20, 398-400 (1949)

Shutt, R.P. (Co-authors, G.R. Hoke, W.A. Tuttle, and G.F. O'Neill)
Some cloud chamber photographs obtained with a high pressure cloud chamber (A)
Physical Review 75, 1329 (1949)

Snyder, H.S.
Cascade theory (L)
Physical Review 75, 906-7 (1949)

Snyder, H.S. (Co-author, W.T. Scott)
Multiple scattering of fast charged particles
Physical Review (In press.)

Snyder, H.S. (Co-author, W. Scott)
New calculations of multiple scattering (A)
Physical Review 75, 1296 (1949)

Snyder, H.S. (Co-authors, W.F. Donoghue, E.M. Hafner)
A new proton spectrometer (A)
Physical Review 75, 331 (1949)

Snyder, H.S.
On the external polarization of the vacuum (L)
Physical Review 75, 1623 (1949)

Thorndike, A.M. (Co-authors, R.P. Shutt and A.L. Johnson)
A cloud chamber of light weight for balloon flights
Review of Scientific Instruments 20, 398-400 (1949)

Thorndike, A.M. (Co-author, R.W. Safford)
A cosmic ray particle of charge two or greater
Physical Review 75, 903-4 (1949)

Tuttle, W.A. (Co-authors, G.F. O'Neill, G.R. Hoke, and R.P. Shutt)
Some cloud chamber photographs obtained with a high pressure cloud chamber (A)
Physical Review 75, 1329 (1949)

Wentink, T., Jr. (Co-authors, V.W. Cohen and W.S. Koski)
Nuclear spin and quadrupole coupling of S^{35} (L)
Physical Review (In press.)

Reactor Science and Engineering Department

Beers, N.R.
Stack meteorology and atmospheric disposal of radioactive waste
Nucleonics 4, #4, 28-38 (1949)

Borst, L.B.
Atomic energy -- benefits. II. The new power address
The Teacher's In-Service Training Course, April 28, 1949

Borst, L.B. (Co-author, J.J. Floyd)
Energy of beta-rays from K^{40} (L)
Physical Review 75, 1106 (1949)

Borst, L.B.
Nuclear reactor at Brookhaven National Laboratory (A)
Physical Review 75, 330 (1949)

Borst, L.B. (Co-authors, J.J. Floyd and C.D. Coryell)
The radioactive decay of K^{40} (A)
Physical Review 75, 328 (1949)

Coryell, C.D. (Co-authors, J.J. Floyd and L.B. Borst)
The radioactive decay of K^{40} (A)
Physical Review 75, 328 (1949)

Floyd, J.J. (Co-author, L.B. Borst)
Energy of beta-rays from K^{40} (L)
Physical Review 75, 1106 (1949)

Floyd, J.J. (Co-authors, L.B. Borst and C.D. Coryell)
The radioactive decay of K^{40} (A)
Physical Review 75, 328 (1949)

Manowitz, B. (Co-authors, R.W. Southworth and T.S. van Winkle)
Progress report on waste concentration studies, March 1, 1949 (BNL-I-10)

Southworth, R.W. (Co-authors, B. Manowitz and T.S. van Winkle)
Progress report on waste concentration studies, March 1, 1949 (BNL-I-10)

Williams, C.
Experimental facilities to be available at Brookhaven Nuclear Reactor (A)
Physical Review 75, 1289 (1949)

Van Winkle, T.S. (Co-authors, B. Manowitz and R.W. Southworth)
Progress report on waste concentration studies, March 1, 1949 (BNL-I-10)