BROOKHAVEN NATIONAL LABORATORY

Associated Universities, Inc.

Progress Report
July 1, - December 31, 1948

Upton, New York

Administrative and Scientific Progress Report
July 1, through December 31, 1948

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Upton, New York

This report of progress achieved by Associated Universities, Inc. and Brookhaven National Laboratory during the period June 30-December 31, 1948, is submitted under the terms of Contract #AT-30-2-GEN-16 between Associated Universities, Inc. and the Atomic Energy Commission.

This report initiates a new series that will combine material formerly given separately in Administrative Progress and Scientific Progress Reports. Issuance of these two separate series will be discontinued. Present plans are that a combined report will be issued semiannually, and that the one which appears in July will contain the year-end fiscal statistics. Each report in the series will be designated by the reference symbol BNL-AS-, followed by the number which indicates its position in the chronological sequence.

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REACTOR COMPLEX
January 1949

PART ONE

REPORT OF ASSOCIATED UNIVERSITIES, INC.

As Brookhaven National Laboratory comes closer to the time of full utilization of its major research facilities, it is appropriate that the spotlight in any report of progress move toward the scientists and their plans and achievements, rather than toward the administrative achievements of Associated Universities, Inc., the parent organization. Most of the information in this volume concerns the progress and plans of the scientific departments and projects of the Laboratory. This introductory section outlines the more significant aspects of the Corporation's activities since June 30, 1948.

Organization and Personnel

Since Dr. Leland J. Haworth became Director on October 13, several basic changes have been made in the Laboratory's chart of organization. They are described elsewhere in this report. Changes since June 30 which affect the Corporation are as follows:

Dean Thomas K. Sherwood has been nominated a Trustee by M.I.T. to replace Mr. James R. Killian, who has become President of M.I.T.

At the annual meeting of the Trustees on August 14, 1948, the membership of the Executive Committee was revised as provided in the By-Laws. It now consists of the President and

Dr. I.I. Rabi, Columbia University,
Dr. Franklin A. Long, Cornell University,
Dr. A. Baird Hastings, Harvard University,
Mr. Peter Stewart Macaulay, The Johns Hopkins University,
Mr. William H. DuBarry, University of Pennsylvania,
Dr. Edmund W. Sinnott, Yale University.

Although his term of office had already been extended for one year beyond its stipulated term, Mr. Edward Reynolds, President of the Corporation, consented to continue in that post until his successor was appointed. Associated Universities, Inc. and Brookhaven National Laboratory are most fortunate that Dr. Frank D. Fackenthal, formerly Secretary and Provost, later Acting President of Columbia University, and now intimately associated with both Columbia and the Carnegie Corporation for the Advancement of Teaching, accepted appointment as President of the Corporation to succeed Mr. Reynolds. The debt of gratitude that all friends of Brookhaven National Laboratory owe to Mr. Reynolds can hardly be stated in words and can never be paid. Suffice it to say that his influence contributed immeasurably to the soundness of the major decisions upon which the institution's future rests so securely.

On January 22, 1949 Mr. Charles F. Dunbar, hitherto resident Legal Counsel for the Laboratory, will assume the duties of Secretary of the Corporation in place of Mr. Malcolm R. Warnock.

Advisory Committees

On November 29 a meeting of the Engineering Advisory Committee was held to permit careful consideration of

- a) The program of the new Department of Reactor Science and Engineering;
- b) Brookhaven's needs for senior engineering personnel;
- c) Plans for an early meeting of engineering school representatives.

In cooperation with the Advisory Committee for Biology and Medicine, the plans and program of the Medical Department were completed by the Laboratory and approved by the Board of Trustees. A regular meeting of the committee was held on November 23, 1948.

A new ad hoc Advisory Committee for Clinical Investigation was authorized by the Trustees to serve as a source of information and advice to the Medical Department in the development of the clinical aspects of a program of medical research. The committee has been appointed, and its first meeting will be held toward the end of January 1949. Its members are.

Dr. Robert F. Loeb, Columbia University,
 Dr. David P. Barr, Cornell University, Chairman
 Dr. George W. Thorn, Harvard University,
 Dr. A. McGehee Harvey, The Johns Hopkins University,
 Dr. Francis G. Wood, University of Pennsylvania,
 Dr. William S. McCann, University of Rochester,
 Dr. Francis G. Blake, Yale University.

Visit of University Presidents

On October 13, the Laboratory was host to the following presidents of the nine sponsoring universities or their representatives:

General Dwight D. Eisenhower, President, Columbia University,
 Dr. Frank D. Fackenthal, formerly Acting President, Columbia University,
 Dr. Edmund E. Day, President, Cornell University,
 Dr. James B. Conant, President, Harvard University,
 Dr. Isaiah Bowman President, Johns Hopkins University,
 Dr. Karl T. Compton, President, Massachusetts Institute of Technology,
 Dr. George W. McClelland, Chairman, University of Pennsylvania,

Dr. Harold W. Dodds, President, Princeton University,
Dr. Donald W. Gilbert, Provost, University of Rochester,
Dr. Charles Seymour, President, Yale University.

Mr. Alfred Loomis, consultant to the Atomic Energy Commission at Berkeley, was invited as an additional member of the group at the request of Dr. Karl Compton of M.I.T. Following a tour of the Laboratory site and other appropriate ceremonies, the visitors and the Trustees of the Corporation met with Laboratory and Corporation officials and the scientific staff. There followed a very useful exchange of views between the Presidents and the Trustees concerning the plans for the development of the Laboratory and for effective cooperation between the Laboratory and its sponsoring universities and other educational institutions in the Northeast.

Fiscal

The principal concern of those responsible for the Corporation's fiscal affairs was to negotiate a satisfactory agreement with the Atomic Energy Commission regarding the Commission's request that the method of seeking reimbursement be altered to resemble industrial practice more closely, and that a modified form of accrual accounting be instituted to record depreciation for major categories of fixed assets. The Commission has a very real interest in making these changes which are intended to improve the fiscal relationships between the Commission, its contractors, and Congress. It is difficult for most large government enterprises to provide Congress with adequate information about their complicated operations. The Atomic Energy Commission, with its novel and rapidly growing responsibilities, found the task even more difficult.

During the last week of December, final steps were taken to introduce the first of the accounting changes requested, considerably modified to suit the special circumstances in which Associated Universities, Inc. finds itself. A new reimbursement system has now been instituted whereby the Corporation will seek reimbursement once a month, rather than currently as heretofore. This will considerably reduce the routine clerical work required for preparation of reimbursement vouchers. The necessary additional working capital has been provided by the Commission.

In deciding how far Associated Universities, Inc. should go in acceding to the Commission's requests, a principal criterion was whether the proposed change would serve the needs of the Corporation for additional information without undue cost and without placing an extra administrative burden upon scientists. The agreements reached so far satisfy these tests and appear to provide a satisfactory beginning in the Commission's move to provide Congress with more complete and useful information about its activities.

Public Education

A principal objective of the public education program of the Corporation is to maintain a satisfactory relationship between the Laboratory and its neighbors in the surrounding communities on Long Island. Efforts in this direction have apparently

been successful thus far. A Laboratory devoted to the nuclear sciences might all too easily become an object of fear and suspicion. The indications are that the Laboratory is rather generally regarded as an asset by neighbors of all degrees. The job of dealing with the normal crop of rumors is considerably easier; those whom rumor might arouse in other circumstances fail to react when a rumor concerns the Laboratory. Fortunately, they seem to believe that all necessary, and perhaps some unnecessary, precautions are being taken to assure that no employee, nor any resident in a nearby community, will suffer by reason of the Laboratory's existence or operation. Important factors in achieving this result have been carefully prepared press releases, which received wide circulation, concerning the purposes and operations of the Meteorology Group, the activation of its weather observation towers, and the smoke tests which are part of their function. Also important have been visits to the Laboratory by the Long Island Park Commission, the Long Island Association, the Brookhaven Town Board, the Riverhead Planning Board, representatives of the state, county and local American Legion organizations, and many other public and private groups.

During the period under review, the Corporation's exhibit program was augmented by the completion of a mobile exhibit which had its first showing in New York City at Grand Central Palace during the Jubilee Exposition of the Golden Anniversary of the City of New York. Following the showing in New York City, the mobile exhibit has appeared in Norwalk, Bridgeport, and Hartford, Connecticut, and Kingston, New York. The larger exhibit moved, after its initial appearance in Boston, to a three months' stand in Buffalo, and thence to Philadelphia, where it will be on display until January 31. Experience of a year and a half in the management of exhibits has suggested the need for a careful re-examination of the program, which is currently under way.

An effort has been made to say less about what is expected to be done at the Laboratory, in order to place greater emphasis later upon what has been done. Several noteworthy magazine articles about the Laboratory have appeared, with good effect; but it has been the intention of the Public Education Office itself to keep promotional material to a minimum and to a low key.

In cooperation with the New York Operations Office of the Atomic Energy Commission, efforts were made to assist the New York City Board of Education in introducing atomic energy components into the curricula of the city's schools. Promising progress is being made with this project, which may become a model for other cities to adapt to their own uses.

Housing Procurement

Plans previously reported for development of off-site housing have been further delayed, in part, by a reduction in the rate of recruitment of new employees, and also by a reappraisal of the Laboratory's basic needs for additional housing. No new construction has yet been undertaken; but in order to accomodate larger numbers of visiting scientists, as the pile and other facilities become available in 1949, it will be necessary to construct rental houses.

ASSOCIATED UNIVERSITIES INC.
ORGANIZATION
JANUARY 1, 1949

PART TWO

REPORT OF BROOKHAVEN NATIONAL LABORATORY

INTRODUCTION

Organization, Personnel, and Policies

The last half of 1948 witnessed organizational developments of major importance in the history of the Laboratory. On July 17, Dr. Leland J. Haworth, who had been an Assistant Director since August 1, 1947, was named Acting Director to succeed Dr. Philip M. Morse, who returned to teaching and research at Massachusetts Institute of Technology. On October 13, the Trustees announced selection of Dr. Haworth as Director.

Other significant senior appointments have included the naming of Dr. Donald D. Van Slyke as Assistant Director for Biology and Medicine, Dr. Milton G. White as Chairman of the Accelerator Project to succeed Dr. M. Stanley Livingston who also returned to M.I.T., and Dr. Lee E. Farr as Chairman of the Medical Department effective in July 1949.

Since August, two major organizational changes have been effected. In November, an Instrumentation and Health Physics Department was established under the chairmanship of Dr. J.B.H. Kuper. This new Department combined the Electronics and Instrumentation Division, formerly a part of the Physics Department, with the Health Physics Group, previously attached to the Director's Office for administrative purposes.

Late in November, the Director also announced establishment, on January 1, 1949, of a Reactor Science and Engineering Department under the chairmanship of Dr. Lyle B. Borst. This new Department represents a consolidation of the Nuclear Reactor Project with the Engineering Department, both of which will cease to exist as separate organizational entities. The Reactor Science and Engineering Department will effectively continue the life of the Nuclear Reactor Project in the period of initial reactor operation. Its scope will, however, exceed that of the Project, and will incorporate the program proposed for the Engineering Department. The new Department's functions will comprise four categories of activity and responsibility:

1. Reactor operation and services, including Meteorological Services.
2. Hot chemistry laboratory operation and services, including liquid waste disposal.
3. Engineering and applied science studies particularly pertinent to the reactor

and hot laboratory, including the problems covered in the Second Planning and Program Report for the Engineering Department, dated November 15, 1948. (Classified)

4. Fundamental research involving use of the reactor and its associated facilities.

It is not yet possible to determine the relative emphasis to be given to each of these, since a careful survey must be made of the manpower and facilities each will require.

Major outlines of the scientific departments and projects are now rather well fixed, but some consolidation in administrative and service units remains to be accomplished before the Laboratory organization is stabilized. During the fall several specific delegations of authority were made and minor rearrangements of function effected, in order to reduce the number of individuals who report directly to the Director. A new organization chart incorporating these changes and others described elsewhere in this report is in preparation.

Day-by-day operations are now largely accomplished through decisions by individuals with duly delegated authority, rather than through decisions made by committees. Standing committees have been reduced in number, and the frequency of their meetings has fallen off considerably. Committees still have their place as advisory bodies, but they are not needed as frequently as they were in the early history of the Laboratory, when individuals were becoming acquainted and were learning to function as a team, and when many of the basic policies which are now established guides to operations had to be formulated.

The total staff of the Laboratory is now 1,347; in July it was 1,322. This represents a net gain of only 25 during the six months. Decreases in the administrative staff have been more than offset by recruitment of technical staff, so that the ratio of nonscientists to scientists now stands at 5.8 to 1. The sizeable increase in scientific and technical staff (including technicians, laboratory assistants, and shop personnel) had been predicted; it was achieved as laboratories were activated and more housing became available, as the unique nuclear machines came closer to reality, and as the Laboratory became in other respects a "going concern."

A total apparent reduction of forty-eight in administrative, maintenance, and service personnel has come about partly through organizational readjustments and partly through a policy of nonreplacement as vacancies occurred. Openings in secretarial and clerical categories are now being filled by internal transfer wherever possible. A total reduction of about 30 in these grades has thus been achieved without involuntary terminations.

Marked additional slowing down in the rate of recruiting has occurred since June. This can be attributed to a number of causes, among which are: a) construction delays in completing the reactor complex, the accelerators, and the other major facilities; b) considered reappraisal of the program and a realization that it would be unhealthy to continue the rate of expansion in program and personnel achieved during the first eighteen months; c) voluntary deferment of some work to offset the increasing spiral of construction costs on the major facilities; d) virtual

completion of the administrative organization, which had to be developed first, and which is now becoming stabilized; e) difficulties in securing personnel for certain key positions -- which introduced delays in launching several new programs and securing personnel to carry them out; f) difficulties also in recruiting certain grades of skilled and semiskilled personnel from the neighborhood, both because the Laboratory had nearly drained the supply, and because renewed activity at the Long Island aircraft plants introduced strong competition; g) a slight lag in response of the Laboratory's salary and wage schedules to the changing economic situation, so that a few existing openings in technical and skilled labor grades are difficult to fill, even though rates of pay have been adjusted upward somewhat; h) improved orientation of personnel through on-the-job training -- which has made for greater efficiency, so that individuals can carry increased work loads; i) relaxation by the Atomic Energy Commission of the rigid compartmentation of information that was necessary during the war, and the opening up of substantial unclassified fields or topics of research -- which has meant fewer personnel for security administration than would otherwise have been necessary; j) steps taken by the Commission to streamline its contract requirements and administration -- which made unnecessary some hiring of staff merely to handle the many paper routines that would have been necessary under earlier requirements regarding property, security, fiscal accounting, and reporting.

Of even greater significance than the factors enumerated above, because of its long-term implications, has been a concerted effort to eliminate plans and activities not essential to the major purposes of the Laboratory. This has already brought about significant reduction of "frills and fanciness" in items whose individual costs are not great, but whose aggregate cost over a long period can be substantial. Closer scrutiny of every phase of the Laboratory's operation, in order to effect appropriate economies, will probably characterize the next few months, and will set the tone for future activities.

Policy with regard to the tenure of appointments was revised September 1. Essentials of the new policy are: 1) to develop a more or less permanent staff of senior research scientists; 2) to encourage a continuous flow of younger scientists through the Laboratory on appointments of from one to six years; and 3) to establish a service and operating staff with appointments, the length of which will presumably depend upon the continuing need for their services. In essence, the Laboratory strongly encourages rotation of staff, especially in the junior grades, through its new appointment policy and its ready consideration of on-leave appointments.

During the past half year, the Laboratory was host to a guest scientist and a guest fellow who lived on the site for short periods of time at their own expense, and who used, without charge, facilities not available to them at their home institutions. These two research visits marked the beginning of a new aspect of the Laboratory's services to research institutions in the Northeast. It is anticipated that such spontaneous utilization of facilities by guest scientists will increase as the major nuclear machines and laboratories are placed in operation.

Activation of Scientific Departments and Facilities

Although some individual schedules have been distressingly slow, there has been considerable overall achievement since July in completion of laboratories,

acquisition and installation of equipment, and construction of special experimental facilities. The exterior building of the pile is practically finished; a good start has been made on the laboratory wings; the foundations for the hot laboratory are completed and the building itself begun; the stack has been completed and painted; the cooling towers are finished; the fan house is nearing completion, and some of the fans have been installed; the meteorology towers and the area monitoring stations are in operation; the drilling of test wells is about half completed; the new boiler plant is nearly finished; and the new transformer station has been taking part of the Laboratory power load for about three months.

The new high pressure cloud chamber is expected to be ready for operation by next summer; completion of the chemistry complex is in prospect; the greenhouse was completed and experimental farm plots were under cultivation this summer; laboratories for sanitary engineering, metallurgy, and fluorine chemistry have been built. A 42-bed hospital, approved for use under the Blue Cross Plan, was activated in December.

The 3.5 Mev electrostatic accelerator is nearly finished, and is undergoing tests at General Electric Company; assembly of the 60-inch cyclotron is under way at Collins Radio Company. The building which will house these machines is partly finished. Rapid progress has been made in the design of the Cosmotron (proton synchrotron); construction of the foundation and of the special building to house that massive machine is under way.

The beginning of a change of emphasis from organization and construction to research is reflected in the fact that, in the interval from June to December, the Laboratory published some 25 technical and internal reports and processed for security and patent review 50 manuscripts submitted for publication in the journals of scientific and professional societies. Moreover, the number of papers presented at scientific meetings is now increasing rapidly. Thus, the Laboratory is beginning to produce the chief product for which it was created -- new knowledge.

Summer Sessions

As had been forecast, the summer proved to be exceptionally worthwhile in the program of the Laboratory. Altogether there were over 500 visitors, including not only eminent scientists whose advice and participation in conferences and in informal discussions was of inestimable value, but also a large number of junior men and women who had come for the stimulation and training they could receive. Numerous requests for the published reports of special conferences on Biological Applications of Nuclear Physics, Gas Discharge, and Hot Atom Chemistry have come in from all over the country, and from several foreign nations. This alone testifies to widespread interest and confirms the conviction that the Laboratory should include numerous conferences in its plans, provided their subject contents fall within the scope of the Atomic Energy Commission's purposes.

The value to this summer program of the furnished on-site apartments and of Lindenmere, a bayside hotel leased by the Laboratory, cannot be overstated. Additional on-site furnished apartments may well be needed as succeeding summer sessions attract larger numbers of high-quality scientists in disciplines other than physics, which was best represented this past summer. Visitors remained in

residence for periods varying from a few weeks to three months.

Training Programs

At the request of the Atomic Energy Commission, the Biology Department conducted a short training course during the summer for faculty members of certain colleges and universities. At these institutions, research fellows sponsored by the Commission were, in turn, to be trained under a cooperative fellowship program administered by the National Research Council. The course was held in conjunction with the biology conference above.

During the fall, a training program in health physics was instituted, primarily for the education of members of the Laboratory staff. Interest in the possibility of participating in such a training program when the growth of the Health Physics staff necessitates that it be repeated is already evident among industrial and research organizations in the Northeast.

Formalized training of Laboratory police officers was instituted by the Security Office. Somewhat less formalized programs of indoctrination in many fields of work have been underway throughout the Laboratory.

There are now twelve graduate students at the Laboratory; it is expected that their number will increase substantially during the next eighteen months as a larger group of colleges and universities begin to participate more actively in the use of the nuclear reactor and the particle accelerators.

Speakers' Bureau

Although public education and public relations are functions for which the staff of Associated Universities, Inc. is primarily responsible, one phase of such work necessarily and especially requires the active participation of Laboratory staff members. This is the furnishing to schools, civic organizations, church groups, and various other requestors of people who will speak, in general or in particular, on the Laboratory's program. This activity is coordinated in the Director's Office through a Speakers' Bureau. During the two years of its existence, the Bureau has furnished speakers, on request and at no cost, to more than a hundred organizations, most of them within a radius of 50 miles. Forty-eight Laboratory people, thirty-five of them scientists, have been the principals in this educational venture. The speaking has been done entirely on a voluntary basis, and chiefly after working hours, in the evening or on weekends.

The intangible values of this "extracurricular" participation of Laboratory personnel in the life of the surrounding communities are probably far out of proportion to the expenditure of effort. And tangible results can be seen in the lack of any general local fear of the Laboratory, criticism of its methods, or hostile treatment of its staff. Ready cooperation of local agencies and people can be a decided asset in the furtherance of the whole scientific program. As the scientific program has been accelerated, there have been more requests for speakers to explain it, just as in the vicinity of a university.

Relations with the Atomic Energy Commission

The extent of progress reported herein, could, of course, not have been accomplished without the cordial cooperation of local representatives of the Atomic Energy Commission. Mr. Wilbur E. Kelley, Manager of New York Operations, Mr. E.L. Van Horn, Area Manager of the Brookhaven Area, and members of their staffs have maintained a sympathetic attitude toward the Laboratory and have frequently reduced time-consuming, costly, and irritating red-tape through their intelligent and liberal interpretations of administrative matters.

DESIGN AND CONSTRUCTION OF MAJOR FACILITIES

NUCLEAR REACTOR

At the close of 1948, the Nuclear Reactor Project staff included 51 scientists, 32 technicians, and 18 administrative and clerical personnel. Two of the Project scientists, temporarily assigned to other Atomic Energy Commission installations, have returned to their work at the Laboratory. No change has occurred in the Project administrative organization since the previous Administrative Progress Report, BNL-A-4.

The Reactor Operation Division has rounded out the staff required to operate the reactor. A training program for operating personnel included a one-month course in reactor operation at Oak Ridge, a week of study on control equipment at Massachusetts Institute of Technology, special training on instruments at their places of manufacture, and a course in electrical engineering, given by H.B. Hansteen, one of the visiting engineers on the Project staff.

To meet a need for additional laboratory space, two more barracks buildings have been attached to the Project building at 29 Cornell Avenue. These are being converted to form four laboratories. Of those planned, only the one provided for waste disposal studies has been completed. Another, which will provide approximately 600 square feet, is currently being modified for engineering research. Approximately 25 % of the floor space in the main engineering laboratory, recently occupied by the Project's Engineering Division, is once more available and will be assigned for use by the Metallurgy Group.

The engineering design of the reactor complex (consisting of the reactor, reactor building, reactor laboratories, fan house, stack, cooling towers, pump house, and boiler house) is substantially complete. Construction progress is estimated approximately as follows:

Reactor	97%
Reactor building, fan house, stack, cooling towers, pump house, and boiler house	95%
Air ducts and coolers	75%
Laboratory wings	50%

Design of the hot chemistry laboratory is approximately 80 % complete. Overall construction of this unit is 25 % complete. The excavation and foundations are finished; all future construction will be above ground. Design of the waste field is estimated to be 20 % complete.

Construction of the various units of the reactor complex has proceeded without interruption during the year, but at a pace which, at this time, places it about six months

Artist's sketch of reactor complex from the north.

Reactor complex from the northwest. Laboratory wings are seen in the left foreground; hot laboratory foundations at the left center.

behind the original schedule. Each of the units, except the hot chemistry laboratory and the reactor laboratories, has reached final stages of construction; and it now appears that the reactor can be brought into initial operation during the spring of 1949. The Metallurgy Group has almost finished the fabrication of fuel elements required for start-up.

The reactor building is entirely enclosed. Internal details, such as stairs, elevators, air conditioning and heating, installation of service equipment, and finishing operations have yet to be completed. The shield for the reactor is nearly ready. There are, of course, small portions which cannot be added until the graphite structure is finished. The major portion of the work in this building during the next few months will involve completion of the control system and of the reactor itself. About 75% of the graphite has been laid up, and the remainder should be in place some time in January. The control system is being installed simultaneously; it will be the factor which determines the actual start-up date. New features have been incorporated in this system; hence, a considerable task study will be required to adjust and prove each of the component elements under actual operating conditions.

The fan building is nearly finished. Installation of equipment is proceeding rapidly. One of the fans has been installed, and installation work on two additional fans is well along. The wiring, instrumentation, and duct work in the building is almost complete. The stack and cooling towers are practically ready for operation. Much remains to be done on the duct work between the reactor and the fans, but this part of the system will be tied together long before the start-up date.

The exterior of the reactor laboratory wings will soon be finished. Various services and equipment for the reactor room have been installed, but laboratory equipment and furniture will probably not be in place by the time the reactor goes into initial operation. It is expected, however, that research can be carried on in these wings during the early summer.

On August 8, 1948, the following design features of the Brookhaven reactor were declassified and approved for release:

1. The maximum thermal neutron flux is expected to be about 5×10^{12} n/cm²-sec.
2. The shield is perforated by one hole 12 inches square, which is provided for large experimental equipment, and by a number of holes 4 inches square, which permit the insertion of small experimental equipment into the body of the reactor, or are capable of releasing collimated neutron beams.
3. The top shield of the reactor consists of removable blocks, 4 feet square, to accommodate thermal columns, and large equipment designed to utilize the leakage of thermal neutron flux (in excess of 10^{11} n/cm²-sec).
4. Facilities will be available for irradiating samples for short or long time intervals. The dimensions of the container will depend upon the nature of the sample and the exposure required.
5. The overall dimension of the reactor, including shields, in the direction of the experimental holes will be approximately 38 feet.

Construction of the hot laboratory was begun August 13, 1948. The foundations, grade beams, and interior walls to the main floor level have been poured. The foundations of the hot and semi-hot cells have also been poured. The slabs over the basement area are scheduled to be poured next; backfilling is proceeding wherever possible. The estimated completion date is June 1, 1949.

As outlined extensively in Report BNL-S-4, the hot laboratory building will be divided essentially into two sections: a "hot" section measuring 150 ft x 70 ft, and a "cold" section about 200 ft x 70 ft. The "hot" section, which required considerable development work to reach its present stage of design, will consist of specialized laboratories for the handling of highly radioactive materials. The most complex of these will be the hot cells, for activity levels varying from 1 to 50 curies of 2 Mev gamma-rays, and the semi-hot cells, for activities of from 1 millicurie to 1 curie. Of no less importance in this section will be the semi-works area, in which large scale engineering projects may be undertaken. These main research areas will be supplemented by appropriate dismantling, decontamination, and storage areas. In the cold area there will be analytical laboratories, a counting room, a physical measurements room, offices, shops, lockers, and an area for equipment assembly and testing with nonradioactive materials. All traffic is to be routed through guard and monitoring stations to meet requirements of security and health physics.

Mock-ups of both the hot and semi-hot cells are undergoing tests. Development work has also been done on smaller equipment and accessories essential to satisfactory operation. A pneumatic tube system connecting the hot laboratory with the reactor has been designed. An investigation to improve the design of existing remote-handling devices and to design new ones is under way. Replicas of most of the remote control apparatus in use at the University of California Radiation Laboratory have been constructed in Brookhaven National Laboratory's shops, and will be tested in the near future.

Initial study of waste disposal problems at the Laboratory early indicated the need for an extensive waste handling, treatment, and storage system. It was apparent that high standards would have to be set for the liquid waste effluent from the reactor and its associated facilities. It would, therefore, be necessary to 1) develop a concentration process that would minimize the volume of accumulated wastes, and 2) store all liquid wastes above a set operating level until a satisfactory concentration process could be developed. Further studies resulted in delimiting the scope of a system for present and future requirements, in defining the classes of liquid waste to be handled, and in estimating beforehand the quantities involved.

A layout scheme of the system was then designed and made the basis of study and discussions between the Laboratory and the H.K. Ferguson Company. Two important results have been achieved:

1. The volume requirements for interim storage have been reduced as a consequence of initial studies of concentration processes performed by the Engineering Department.
2. To further reduce the overall cost, in line with more exacting studies of the facilities required, the system has also been consolidated.

It is believed that the design is now fixed. The H.K. Ferguson Company is proceeding with detailed engineering.

The Metallurgy Group is proceeding with plans for modification of the present Project building to house some of its equipment. The metallographic apparatus and the X-ray machine will be in operation within a few weeks. Work has started on setting up vacuum melting and vacuum thermoanalysis furnaces. The design of the first single crystal furnace is practically complete, and it is planned to design other furnaces for growing single crystals of inorganic and organic materials. Tentative arrangements have been made to supply such crystals to other departments of the Laboratory. Research on inert atmosphere welding processes will start in the next few months.

The major portion of the effort of the Project's Theoretical Group has been devoted to a reworking and extension of design calculations for the reactor. In collaboration with other groups in the Project, considerable attention has been given to a variety of engineering problems. In addition, the Group has been studying problems which will arise during the period of initial operation, when the properties of the reactor will be studied and careful comparisons made between theoretical predictions and experimental behavior. Some work has been done on certain basic problems in reactor theory and in fields in which research will be undertaken when the reactor goes into operation; e.g., solid state and nuclear physics.

ACCELERATORS

The production of high speed particles at Brookhaven National Laboratory may be considered in three distinct categories, in accordance with the types of research to be done. Nuclear energy levels from 0 to 3.5 Mev for protons, and from 6 to 12 Mev for neutrons, are most conveniently studied by means of an electrostatic (Van de Graaff) accelerator. For higher energy nuclear levels, and for the production of certain radioisotopes, a large (60-inch) cyclotron is most suited. Finally, for the study of elementary particles such as protons, neutrons, mesons, etc., it is necessary to attain particle energies in the billion electron volt range. The Accelerator Project has the responsibility of providing all three types of accelerators.

In order to avoid burdening the scientific personnel with unnecessary engineering detail, it was early decided to let out on contract the design and construction of the 60-inch cyclotron and the electrostatic accelerator, since their designs are fairly straightforward. However, the 2-3 Bev proton synchrotron involves many elements of considerable novelty. While some heavy items have been let out on contract to commercial concerns, the primary calculations, designs, and model testing have all been carried out by members of the Accelerator Project.

With the return of Dr. M.S. Livingston to Massachusetts Institute of Technology, the Project has suffered a severe loss, for he had been initially responsible for the organization and general direction, as well as for much of the mechanical and electrical design. The new Project chairman, Dr. M.G. White of Princeton University, is spending three days a week at the Laboratory, the remainder of his time being devoted to research work at Princeton. Dr. White assumed the chairmanship in September, after having spent the summer at the Laboratory. Because of the general shortage of qualified experimental physicists, it has not been possible to build up the staff as rapidly as desired. The Project needs several experimental physicists trained in electronic techniques, and at least one mature construction engineer. Delays in procuring properly qualified manpower will prove a handicap; but building construction will almost certainly be the slowest factor in the completion and early operation of the several accelerators.

3.5 Mev Electrostatic Accelerator

This machine, originally ordered by the Atomic Energy Commission from General Electric Company for the Knolls Laboratory, is nearing completion and appears to be adequately designed for its original purpose. In many respects, the design follows the practices of Professor Herb of Wisconsin. It is a horizontal machine, employing dry nitrogen at high pressure, and has an 8-foot accelerator tube and differential pumping tube. A single high voltage terminal is used, in contrast to the double shell technique which is rapidly growing in favor. After its delivery to Brookhaven sometime in the spring, it will be used for a few months to study Cosmotron injection problems. After this first priority call is met, the generator will be used by the Physics Department for nuclear studies. A second electrostatic machine, to be used with the Cosmotron, is on order from High Voltage Engineering Corporation for delivery in the fall. The characteristics of this machine are described below in connection with the Cosmotron. (G.J. Hoey)

3.5 Mev electrostatic accelerator, under construction at General Electric Co. View of belts and supporting structure.

Outside of face plate.

Inside of sphere.

60-Inch Cyclotron

Good progress has been made on the construction and installation of the 60-inch cyclotron under the contract with Collins Radio Company.

The cyclotron magnet iron from Carnegie-Illinois Steel Company was received in the middle of October; it was erected by American Bridge Company on October 22 and 23. Placement of the two 2-ton chamber lids in position for a magnetic measurements check has been completed.

Several large components of power equipment, including the 200 kw motor-generator set, amplidyne, switchgear, and water pumps have been received from subcontractors and are in storage, awaiting completion of the building. Progress on the ion source filament supply and transmission line is ahead of schedule at Collins Radio Company Research Department.

Oscillator design is nearly finalized, with much of the material now in the Collins plant. Complete assembly of the vacuum system acceleration chamber, dee tanks, manifold, and diffusion pumping units is planned for January 1949 at the Collins main plant. The working units, except for the magnet, which has already been received and set up, will be shipped in two freight cars during April 1949, installed during May and June, and tested and tuned up for maximum beam output during the summer months.

Some delays have been encountered in the construction of the building to house the 60-inch cyclotron and the electrostatic generator. Present estimates are that the building will be completed by March 1949. If this date is realized, both machines may be in operation by late summer (W.W. Merkle).

Cosmotron (Proton Synchrotron)

The Cosmotron is now entering upon what might be described as the third stage of its progress toward completion. The first, or conception, stage was completed by the end of 1947. By then, the method for accelerating protons to the billion electron volt range had been chosen, the fundamental problems had been solved on paper, and the basic design parameters had been approximated for machines to operate at 2.5 and at 10 Bev. Early in 1948, 2-3 Bev was chosen as the goal for the first machine, and the second, or design, stage was actively entered. This has involved elaborate laboratory tests, extensive computations, and frequent consultations with manufacturers. Although the design stage will continue for some time, the work has now entered upon the third, or construction, stage. Steel for the magnet is on order; the power equipment is being built by Westinghouse; construction of the Cosmotron office building is just beginning; and the magnet foundation is complete.

The present schedule calls for installation of all major components by the end of 1949. The fourth, or testing, stage will then begin; and, after a period which cannot be predicted accurately, the machine will enter upon its final operating stage. It is hoped that this culmination of efforts will occur before the end of 1950.

Lowering the 65-ton top member of the cyclotron magnet assembly.

Winding the cyclotron magnet at Collins Radio Corporation.

In this project, the Laboratory has received active and enthusiastic support from industrial concerns, including Bethlehem Steel, General Electric, Westinghouse, Allis-Chalmers, Philips, R.C.A., General Ceramics, Bell Telephone Laboratories, High Voltage Engineering, and many others. The Accelerator Project staff is in continuous communication with the University of California group at Berkeley, with the accelerator group in Birmingham, England, and with various university groups building smaller accelerators in America. Several of the member universities of Associated Universities, Inc. have supplied manpower and technical assistance. The staff has benefited in many ways from the assistance of associates in other divisions of the Laboratory.

In the sections which follow, some of the problems which have been solved or are in the process of solution are discussed briefly.

Magnet

The magnet, 73 feet in diameter, is the largest single component of the Cosmotron, and has, thus far, received more attention than any other part of the machine. Before the 1600 tons of steel which it includes could be ordered, it was essential that experimental tests be made to establish accurately the design parameters (R.A. Meyer). Three scaled-down models have been operated under conditions which simulate, as closely as possible, the operation of the final magnet. It has been necessary to measure the magnetic field accurately, and to observe changes in field occurring in periods as short as one ten-thousandth of a second. Though very difficult, it must be accomplished before operation of the machine can be predicted with any degree of assurance. These measurements were made by using very careful and complex instrumentation # (G.K. Green, H. Snyder, L.W. Smith, R. Kassner).

A detailed theoretical study of the magnet has been carried out, and reasonable agreement has been found between experiment and theory # (J.P. Blewett, M.H. Blewett).

Work has also been done on the design characteristics of a digital computer which is needed to solve problems involving the synchronization of radio frequency oscillation and the varying magnetic field in the Cosmotron (H. Snyder).

On the basis of these results, the magnet design is now frozen.

The magnet will be constructed of 3456 half-inch plates, welded together in blocks of twelve. Except at the welds, there must be no short circuits between one plate and the next. Many tests have been made on a variety of lamination insulating materials capable of standing the high pressure that will be set up when the plates are welded. A special type of impregnated paper is the final choice. The paper will probably be a 3-ply lamination of fish paper and metal foil, the foil being used to detect the presence of shorts between the half-inch steel plates.

With these problems solved, detailed specifications have been drawn up and submitted to the steel companies. Bids have been received and a contract has been let to Bethlehem Steel Company for complete delivery of the steel by August 1949.

Indicates publication. See Appendix for complete reference.

Five hundred gallons of water per minute will be used to carry away the 800 kw of power dissipated in the magnet winding. All physical turns of the coil are to be cooled in parallel. Water will be supplied to each of two manifolds at each magnet quadrant at a pressure of 40 psig. There will be a closed water system, cooled by evaporative coolers and maintaining purification by a Permutit demineralizing system with a vacuum deaerator.

The magnet windings will be insulated from the magnet by a 3/8" molded insulation form slipped on each magnet section or block. The return windings are to be insulated from ground by 17/32" of laminated plastic. The maximum turn-to-ground potential will be 3500 volts. The coil will be fabricated and installed by a contractor yet to be selected. It will be protected from open circuits in the connecting lines by a spark gap. A generator resistor to ground will short the coil if a ground short occurs (J.A. Kosh).

Power Supply

The magnet power supply is also a major item, involving a 40,000 kva generator coupled to a 40-ton flywheel. After extensive consultation with manufacturers of power machinery, it was decided to abandon early ideas of using d.c. machinery in favor of a.c. machinery and mercury arc rectifiers. An incidental gain from this change has been the doubling of the expected rate of cycling of the magnet from 6 to 12 pulses per minute. Specifications have been assembled for machinery to draw the magnet energy from the flywheel and, after the accelerating cycle is over, to return most of the magnet energy to the flywheel. This will permit operation without undue transient loading of the Long Island power lines. After a study of competitive bids, the contract has been let to Westinghouse Electric Company, which promises delivery late in 1949 (G.K. Green, A.N. Wise).

Radio Frequency

The three primary problems in the design of the radio frequency accelerating system are:

1. The source of varying frequency (0.3 to 4.1 megacycles).
2. The amplification of this varying frequency to a high power level.
3. The coupling of this power into the protons which are to be accelerated.

The first problem has been met by beating together two klystrons. Exhaustive tests of this device indicate that it will have satisfactory frequency stability. Voltage control of frequency (easily achieved with klystrons) is particularly desirable, since it is important that the frequency be very accurately controlled by a signal derived from the ions themselves. These correcting signals will shift the frequency so that the ion beam is maintained in the desired orbit (A.I. Pressman).

The second problem, that of developing a wide-band power amplifier, remains to be studied.

The third item, the radio frequency accelerating unit, will consist of a large r.f. transformer whose secondary "winding" is the ion beam itself. About a ton of

View of the concrete foundation for the Cosmotron magnet.

Testing a model Cosmotron magnet section.

magnetic material suitable for use at high frequencies will be needed for the transformer core. The best available core material is a ferrite, developed by Philips Lamp Works in Eindhoven, Holland, which is just now coming on the market. Other manufacturers in this country are initiating programs for development of similar materials. The Accelerator Project staff has been able to assist in and to profit from the various development programs. Numerous studies of the properties of these materials have been made. The Laboratory is now in the process of requesting bids for a quantity of material which will meet specifications for use with the Cosmotron (J.P. Blewett, M. Plotkin).

Vacuum System

Members of the staff have published theoretical predictions of the degree of the vacuum necessary in order that the proton beam will not be unduly scattered by residual gas atoms # (E.D. Courant, N.M. Blachman). These predictions have been roughly confirmed by data obtained on a cyclotron at the University of California. The vacuum requirements are fairly severe, but can be met satisfactorily by sound design of the vacuum tube in which the beam circulates, and by providing very high speed pumping systems.

The vacuum envelope will probably be constructed of ceramic sections. Samples of the proposed material have been tested for vacuum tightness and found satisfactory. Sections of the same size as the final tube have been fabricated by The General Ceramics Company and will shortly be tested for ability to stand up mechanically under evacuation (W. Liben).

Injection System

A second electrostatic accelerator, designed specifically for high pulse current injection, has been ordered from High Voltage Engineering Corporation. The accelerating and differential pumping tubes will be twelve feet long, and a double-shell high voltage structure will be employed. Special ion source studies have been started by this company in the hope of achieving pulse currents in the milliamperere range. No effort will be spared to attain reliable operation at 4 Mev and above, even in the presence of the high pulse currents. High voltage injection is desired in order to escape gas scattering and to minimize the magnetic field irregularities which are expected to be more severe at low injection fields. Delivery of this electrostatic accelerator is promised by January 1950 (M.G. White).

Other Problems

Numerous other investigations are in progress or have been completed. For examples, studies have been made of ion sources suitable for providing the proton beam, and an experimental ion source has been set up and tested. A method has been evolved for injecting ions into the desired orbit from an external electrostatic machine. Ejection techniques have been proposed for bringing the high speed ions clear of the magnet structure. Shielding of personnel from dangerous radiation has been studied and considered in the building design. Theoretical studies have been made of the effects of many possible defects in the magnet, of small errors in radio frequency,# and of other contingencies (E.D. Courant, W.H. Moore, Jr.).

Cosmotron Building

The basic building design has been completed in collaboration with the architectural firm of Skidmore, Owings, and Merrill. To house the Cosmotron itself, a rectangular structure about 120' x 200' x 25' high will be built. Because of the penetrating nature of the radiation emitted by high energy machines, it is necessary to establish the level of the machine about 10 feet below ground level. Space will be provided for generators, control equipment, research areas, preparation docks, and research staff offices. The necessary shop, stock, and office space will be provided by converting an existing concrete-block building into a shop, and by constructing a new wing for offices. These two units will be contiguous with the new building.

The massive reinforced concrete foundation for the Cosmotron was completed in December and should be well settled by spring, when building construction and magnet erection will begin (L.D. Stoughton, A.N. Wise).

PHYSICAL SCIENCES AND ENGINEERING

PHYSICS

The Physics Department now has thirty scientists, seven additional scientists on leave from other institutions, six technical specialists, an executive aide, and four secretaries. During the summer months, six additional scientists and two technicians joined the staff temporarily. Since July 1, twenty-three consultants have contributed over 450 man days to the Department's program.

The personnel of the Department is now organized into eight scientific groups -- Theory, Nuclear Interaction, Cloud Chamber, Cosmic Radiation, Moments, Reactor Experiments, Van de Graaff Experiments, and Solid State Physics. The latter group was activated in September, under Dr. A. McReynolds. On September 2 the Electronics Division was detached from the Physics Department and was joined with the Health Physics Group to form the new Instrumentation and Health Physics Department.

The Physics Department is housed in seven buildings. Architectural drawings have been completed to provide additional space, consisting of part of the building at 55 Brookhaven Avenue and also a new generator building, which is to be located behind the Cloud Chamber Laboratory at 51 Brookhaven Avenue. No plans exist for the overall consolidation of the research space of the Physics Department. Effective consolidation in the near future is prevented by the dispersion of the major experimental facilities which the Department will use, i.e., reactor, accelerators, and cloud chambers.

A number of other institutions are cooperating in the program of the Department. The Johns Hopkins University is collaborating with the Moments Group in the study of chemical reactions connected with the microsynthesis of carbonyl sulfide, COS. Arrangements were made with the Department of the Navy for carrying emulsions in special balloon flights in the temperate latitudes. Other balloon flights carrying emulsions were made in conjunction with the Office of Naval Research and Princeton University. The betatron at the Naval Research Laboratory and the cyclotron at the Department of Terrestrial Magnetism have been made available for use by the Department. Special mass spectrometer analyses were made by the Bureau of Standards. Negotiations with the United States Air Force for the use of a B-29 airplane for cosmic ray research were completed near the end of the summer. The Air Force has made the plane available to the Laboratory for use by the research institutions of the Northeast, and has completed a number of structural modifications of the airplane which are necessary for the installation of scientific equipment. First flights are to begin in late January.

Nine of the twelve balloon cloud chamber flights, for which the Laboratory contracted with the Office of Naval Research, were completed in Minnesota. Contracts covering various phases of construction of the large high pressure cloud chamber are progressing favorably, and delivery is expected in the spring. The last contract

Left: A 7-prong star produced inside the cloud chamber, close to the front glass plate. Total energy involved in this star is of the order of at least 10^9 ev. It is produced by a neutral particle. The large angles indicate the conversion of large amounts of energy into mass.

Right: Cloud chamber photograph of positive meson decaying by emission of a positron. The track of interest is in the upper left quadrant of the chamber. The photograph was made under a pressure of 150 atmospheres of argon.

Finished steel yoke for the new large high pressure cloud chamber constructed by Bethlehem Steel Company. The movable cross member in the foreground weighs 20 tons, and is attached to the remaining assembly by the two cylindrical nuts and bolts at extreme left and right. The cloud chamber will be located within the hollow tube in the center of the yoke. Magnet coils will surround the tube.

covering the necessary rigging for installation has been let. A contract was awarded to the Polaroid Corporation to develop new techniques for the scanning of photographic emulsions. The Airborne Instruments Company was awarded a contract for the construction of a neutron velocity selector for use with the reactor, and it has completed the development of a radio-controlled parachute release, for use in connection with the balloon cloud chamber program. Under a contract with Columbia University, M. Blau of that institution made significant contributions to the technique of handling and preparing nuclear emulsions.

Since one of the functions of the Laboratory is the training of personnel in the several fields of nucleonics, the Physics Department is sponsoring three courses in physics. Two of these are in theoretical physics, on the junior and senior levels; the third provides a background in nuclear physics at a graduate level.

The Department conducts bi-weekly journal club meetings and research conferences. Additional colloquia are held from time to time, chiefly during the summer, at which the speakers include consultants and visitors from other research institutions as well as staff members. During the past summer, 29 colloquia were held at the Laboratory under the sponsorship of the Physics Department. They were addressed by 18 consulting scientists from other institutions.

Cosmic Ray Studies Involving Cloud Chambers

Continuing the program for studying cosmic rays at high altitudes by means of balloon-borne cloud chambers, a series of seven flights were made at Camp Ripley, Minnesota, during August and September, in connection with Project Skyhook of the Office of Naval Research. Although considerable difficulty was experienced with both balloons and apparatus, fairly successful, but limited, results were obtained on four flights. These flights yielded approximately 200 photographs, at altitudes up to 100,000 ft. One photograph of special interest showed a heavily ionizing particle with sufficient energy to pass through 1.25 cm of lead. This behavior is not consistent with the charge and mass of a meson or of a proton, and it may be inferred that the particle was multiply charged, and may have been an alpha particle or a still heavier nucleus of primary origin. A survey of the collection of photographs as a whole gives a picture which is entirely consistent with present concepts. The frequency of occurrence of heavily ionizing particles and stars due to nuclear disruption increased continuously to the highest altitudes, while electron tracks and electron showers reached a maximum frequency at about 50,000 ft.

A thermostatically-controlled heater which burns butane with oxygen has been built to improve the quality of the photographs on future flights. A contract with the Airborne Instruments Laboratory has resulted in the development and availability of a parachute release for balloon-borne apparatus, which may be actuated by a specially coded radio signal sent from a following airplane. This device will permit longer flights, and will facilitate the recovery of the apparatus and the films# (A.M. Thorndike, R.W. Safford, R.P. Shutt, A. Wotring).

The small high pressure cloud chamber was operated for approximately 1000 photographs in September, with a pressure of 140 atmospheres of argon and a magnetic field of 4000 gauss. Several μ -mesons were observed stopping in the gas. While the

Indicates publication. See Appendix for complete reference.

positive mesons always showed the characteristic decay process, the negatives appear to have stopped without further consequences. Two low energy nuclear disruptions induced by neutral particles, presumably neutrons, resulted, respectively, in two and three particles of approximately 1 cm range. One high energy disruption occurring in the gas, also from a neutral particle, resulted in seven particles of total energy in excess of a billion electron volts. The least energetic of these could be identified as a 70 million volt proton. The cloud chamber is now being equipped with improved temperature control, which should improve the quality of the photographs and extend the time of sensitivity for undistorted tracks# (R.P. Shutt, G.R. Hoke, G. O'Neill, W. Tuttle).

Construction has started on an apparatus for studying the scattering of cosmic rays of high, but well determined, energy. It is expected that one will be able to distinguish, in this way, between μ -mesons, π -mesons, and protons, and, at the same time, measure the cross sections for nuclear scattering as a function of the energies of these particles for each type of radiation. The apparatus will consist of two cloud chambers, located above and below the air gap of a permanent magnet which will yield a field of 8000 gauss over a rectangular volume 11" x 11" x 1 1/2". Experiments will be conducted at sea level and at higher elevations (W.L. Whittemore, R.P. Shutt).

Cosmic Ray Studies Involving Counters

The study of the β -decay of mesons, referred to in Scientific Progress Report BNL-S-4, has proceeded according to plan. Work was begun in November at an elevation of 11,300 ft above sea level, at Berthoud Pass, Colorado. It is still too early to report results on the range of electrons resulting from μ -meson decay; on the other hand, the results of experiments on the association of mesons with penetrating showers have established that a large percentage of these showers result in delayed coincidences, with delay times corresponding to the half-life of μ -mesons. It has also been shown, however, that the negative mesons associated with penetrating showers are captured without decay in absorbers of both high (sulfur) and low (carbon) atomic number, a characteristic which distinguishes these mesons from those not associated with penetrating showers. This permits the conclusion that the shower-associated μ -mesons have been produced locally in the absorber by the decay of π -mesons, the negatives of which are known to be captured by all nuclei. This work derives considerable importance from the fact that now, for the first time, π -mesons, which were previously found only in photographic emulsions, can be distinguished by an apparatus which utilizes G-M counters# (O. Piccioni).

In another experiment being prepared for airplane flights in a B-29, a number of G-M counters have been arranged to give coincidences only when traversed by penetrating showers. The experiment will attempt to determine the variations, with latitude and elevation, in the frequency of occurrence of this type of shower. Interest derives from the presumption that these showers are local effects caused by high energy protons and neutrons which survive the primary cosmic rays (O. Piccioni, T. Walsh).

An apparatus, based on the Bridge design, for recording the type of charged cosmic rays, presumably primary protons, which produce nuclear disruptions has been constructed for operation in the B-29 airplane. It will be used to study the

Left: The tracks on the photographic plate in the direction of the arrow are proton recoils from an aluminum target bombarded by 16 Mev deuterons. The arrow also indicates the direction of the incident deuterons. This plate, located at 90° with respect to the beam and 7.5 cm from the target, was from a hemispherical shell of plates centered on the target.

Right: This eighteen-prong nuclear disruption (star), recorded on a photographic plate, was caused by cosmic radiation during a balloon flight to 100,000 ft. One of the prongs, which has been identified as a slow negative meson, produced another star.

Above: Apparatus to be carried in a B-29 airplane for determining the latitude effect and the east-west asymmetry of the component of the cosmic radiation which produces nuclear disruptions. The counters and pulse ionization chambers are incorporated in the assembly at the right. Oscillograph traces and lamps indicating which of the five counter trays has discharged are in the central assembly.

latitude dependence and angular dependence of these rays at various elevations. The apparatus comprises a pulse ionization chamber, surrounded by lead, outside of which five groups of Geiger-Mueller counters are arranged; a sixth group is placed beneath the chamber. A coincidence between any one of the five groups and the sixth group establishes the direction of the primary ray. At the same time it initiates the horizontal sweep of a cathode ray beam whose vertical deflection indicates the current in the ionization chamber. From the shape of the trace of the cathode ray beam, which is recorded on film, one can distinguish ionization bursts produced by heavy particles in a nuclear disruption from those produced more uniformly throughout the chamber by electron showers. This apparatus is performing satisfactorily and will be ready when the airplane experiments begin in February (B. Rossi, A. McMahon, W. Burditt).

Cosmic Ray Studies Involving Photographic Emulsions

Cosmic ray experiments utilizing nuclear emulsions have involved airplane and balloon flights. Nuclear emulsions sent aloft to 90,000 ft while enclosed in a metal gondola containing other heavy materials have been found to contain many more tracks of π -mesons than were found in earlier exposures made in the open. This confirms the belief that π -mesons are produced locally by impact of cosmic rays upon matter. Nuclei in these photographic emulsions split into more fragments, on the average, when disrupted by primary cosmic rays at the top of the atmosphere than by those at mountaintop or sea level elevations. Disruptions involving the emission of many fragments are more asymmetric in angular distribution than those resulting in fewer fragments, indicating a larger amount of momentum transferred to the struck nucleus by the incident particle# (E.O. Salant, J. Hornbostel, E. Dollman).

After an investigation of research in English and French laboratories, the program of the Nuclear Interaction Group was modified considerably. Cosmic ray work with emulsions at terrestrial altitudes was abandoned for high altitude studies, and photodisintegration work (see next section) was shifted from low to high energies (E.O. Salant).

Other Studies in Nuclear Physics Involving Photographic Emulsions

With a camera designed to record neutron-induced recoil protons in emulsions, the distribution in energy and angle of neutrons from targets bombarded by deuterons was investigated. Deuterons of 16 Mev and 3 Mev, from the cyclotron and the electrostatic accelerator at the Department of Terrestrial Magnetism in Washington, were used. Gold, beryllium, indium, magnesium, zinc, zirconium, lead, copper, silver, carbon, and aluminum were bombarded at 16 Mev; the last four elements were also bombarded at 3 Mev. Plates from all bombardments, except copper at 3 Mev, showed copious tracks. About 800 tracks each for copper, gold, aluminum, carbon, beryllium, silver, and indium at 16 Mev have been measured; the results are being compiled so as to indicate the distributions with respect to the desired parameters. It is already clear that neutrons are generally emitted predominantly forward to the bombarding beam, and that their energies extend as high as 14 Mev. Protons are also emitted during the bombardments of some elements (E. Dollman).

In another camera, protons emitted by nuclei irradiated with high energy gamma-rays have been measured. The betatron at the Naval Research Laboratory was used for gamma-rays with energies up to 20 Mev. Initial difficulties in shielding the photographic plates from gamma radiation and neutrons were finally overcome, so that protons from photodisintegration of ruthenium were successfully observed in the photographic plates. Work is being continued with other elements (D. Lee).

Under a research subcontract, scientists at Polaroid Corporation developed a rotating substage illumination for the scanning microscope, which reduced, by 50% on first trial, the time required for scanning a nuclear emulsion.

Nuclear emulsions 200 microns thick can now be developed uniformly by a new process. The plate is first soaked in a nonalkaline solution of developer until the chemicals have thoroughly diffused throughout the emulsion; then a strongly alkaline sugar solution is added** (M. Blau, J.A. DeFelice). Still greater uniformity in the development can be realized if the usual acetic acid short stop bath is replaced by one of citric acid. The latent image in these emulsions can be eradicated, according to present indications, by soaking the plates in hydrogen peroxide (J. Hornbostel, S. Millman).

Miscellaneous Nuclear Physics

An attempt has been made to determine the life, before annihilation, of positrons stopped in hydrogenous crystals of phenanthrene. With an expected lifetime of the order of 10^{-8} sec, the entrance of the positron into the crystal, and its subsequent annihilation into two photons with conversion of one or both into an electron, should appear as a double step pulse on the oscillograph record of the scintillation. No effect of the type expected has been found in the first experiments. Conditions are being improved for a second attempt (E.M. Hafner).

When radioactive (2.7 year) Sb^{125} decays, a long-lived (2 month) metastable state of Te^{125} is formed which decays to Te^{125} by the emission of a 150 kev gamma-ray. The latter is at least 99% internally converted to electron emission from the K-shell. This is by far the longest lived known isomeric state of a stable nucleus# (M. Goldhaber).

A design has been found for a magnetic spectrograph which will focus protons inelastically scattered, with a given Q-value, from a unidirectional monoergic beam by a recoiling nucleus. The instrument will bring protons scattered over a range of angles to a point focus; different Q-values will appear on a flat plate as spectral lines, the positions of which depend upon the mass of the scattering nucleus. Thus, isotopic mixtures of light nuclei can be studied unambiguously. A plan view of this spectrograph is shown in an accompanying figure# (E.M. Hafner).

While the Nuclear Reactor Project's first function has been to develop, construct, and place in operation the reactor and associated facilities, a limited amount of pure research has been carried on by members of the Project. During the present six-month period, the principal endeavor in this respect has been to evaluate the decay of the natural radioactive isotope of potassium, K^{40} .

*Under subcontract with Columbia University.

Plan of the proton spectrometer vacuum system. The uppermost focal line corresponds to particles which are emitted by infinitely heavy nuclei and which are, therefore, homogeneous in energy. The lower focal lines indicate shifts of the focal position that are due to recoil of a target nucleus of low mass.

For this purpose, a sample of potassium, enriched fourteenfold, was obtained from the Stable Isotopes Division of Oak Ridge National Laboratory. A beta-ray absorption spectrum of this enriched sample was measured, using a thin mica window beta counter. A Feather analysis was made of the absorption curve, indicating a maximum beta-ray energy of $1.9 \pm .2$ Mev. The disintegration constant for beta emission was found to be $3.9 \pm 4 \times 10^{-10} \text{ yr}^{-1}$. The shape of the absorption curve for K^{40} is very similar to that of RaE . K^{40} shows much less curvature than do the absorption curves for UX_2 , P^{32} , and Na^{24} , even when normalized at 50% of the reported range. The present best characterization of the radiations is given in the accompanying table.

Characteristics of Radiation			
	λ (yr^{-1})	E (Mev)	Source
Beta emission	$3.9 \pm .4 \times 10^{-10}$	$1.9 \pm .2$	Present work
Gamma emission	$0.62 \pm .02 \times 10^{-10}$	> 1.5	R.D. Evans
K capture	$0.6 \pm .2 \times 10^{-10}$		A.O. Nier

Assuming these data to be correct, two alternative decay schemes are possible. At the present time, it is not possible to distinguish with certainty between the two.

Because of the unusual stability of Ca^{40} , it is probable that A^{40} is sufficiently unstable with respect to Ca^{40} to exclude the first scheme from the standpoint of energy. On the other hand, the near equality of the branch ratios in scheme (2), of K capture and gamma emission, would give increased credence to scheme (1).

A more highly enriched sample is being prepared at Oak Ridge and will soon be available for further studies** (L.B. Borst, J.J. Floyd).

Nuclear Moments

In the experiment to determine the nuclear spin and quadrupole interaction of the radioactive isotope S^{35} , efforts are being concentrated on the chemical production and separation of carbonyl sulfide, COS, in micromole quantities from active samples of sulfuric acid obtained from Oak Ridge. It has already been reported that this molecule has an absorption line in the K-band of the microwave spectrum. Yields of this compound, containing as high as 30% of the original sulfur, have been obtained. It is now necessary to concentrate the COS and separate it from other products of the reaction, including CO_2 and H_2S . Before such separation can be accomplished, it will be necessary to obtain additional data on the vapor pressure of COS at temperatures between -100 and -140°C . A search is also being made for a tellurium-containing molecule which has an absorption line in the K-band and can be used for a study of the spin of the 30-day isotope Te^{125} (V.W. Cohen, T. Wentink).

The microwave spectrographs used in this work have undergone a number of improvements, including a) the installation of a stabilized microwave oscillator which will permit fairly accurate measurements of frequency differences over a limited region of the spectrum, and b) the replacement of a 6 kc oscillator by a 100 kc square wave generator to provide voltage for the Stark cell. A better ratio of signal to noise is expected at the higher frequency.

A nuclear magnetic resonance absorption has been found for antimony; but a precise value for the gyromagnetic ratio g cannot be stated until after the magnetic field has been calibrated against the well-known neighboring resonances in Na and Br. In order to facilitate magnetic field stabilization in the magnetic resonance apparatus, a photoelectrically controlled source of direct current is being provided to excite the magnet. In addition, a circuit is being constructed for stabilizing the field against the proton magnetic resonance and against a standard frequency, which should hold the field constant to one part in 20,000 over a long period (V.W. Cohen, W. Knight, J. Muller).

Time-of-Flight Mass Spectrometer

An instrument has been proposed for determining the masses of atomic nuclei by measuring their times of flight for an integral number of revolutions along helical paths in a uniform magnetic field. The method seems especially suitable for heavy

* See "Preparations for Experiments Using the Nuclear Reactor."

POSSIBLE DECAY SCHEMES OF K^{40}

$$T_{\frac{1}{2}} = 1.5 \pm .2 \times 10^9 \text{ yr}$$

$$T_{\frac{1}{2}} = 1.4 \pm .2 \times 10^9 \text{ yr}$$

atoms which have long times of flight. Work on a prototype instrument for testing the principle has progressed to the point where ion pulses of one quarter of a microsecond duration have been expelled from a rubidium ion source and have been detected by a cage connected to a broad band amplifier and oscilloscope. The next steps will be to place these components in the field of a fifteen-inch magnet and then, if pulses may still be detected, to proceed with the timing and a study of the errors inherent in the system# (S.A. Goudsmit, V.W. Cohen, P.I. Richards, E. Hays, L.G. Smith).

A proposed design for a possible future model has been successfully investigated on the basis of computations of S. Pasternack and preliminary work by M.H. Blewett. The results lead to the planning of a field produced by two concentric solenoids, at least 50 inches long, having a mean radius of 15 inches and a spacing of about 2 inches. The field will be 200 gauss (L.G. Smith).

Preparations for Experiments Using the Nuclear Reactor

Work has progressed on the mechanical chopper for slow neutrons referred to in Scientific Progress Report BNL-S-4. Some changes have been made in the design. It now appears that the slots between the cadmium foils in the rotating chopper will have a slightly spiral shape and will be transparent only to neutrons within a limited velocity range, the mean velocity depending upon rotational speed. Overlapping orders will thus be eliminated and pulses will occur at each complete revolution, rather than at each half revolution as is the case with straight slots. Timing for the counter gates will be performed electronically.

Under construction on the same contract with Airborne Instruments Laboratory is a rotor containing spiral grooves. It will act as a slow neutron velocity selector (or monergator), and will pass only those neutrons which lie within an energy band ΔE . The design provides for a considerable range of adjustment. As a typical example, at a rotational speed of 275 radians per sec, the monergator will pass neutrons in the energy range $(0.01 \pm .0006)$ ev with an efficiency of 30% (F.G.P. Seidl).

A new type of photographic detector for neutrons, which promises to have application to neutron diffraction studies and other experiments requiring high detection sensitivity, has been tried successfully. The neutron pattern to be photographed is allowed to fall upon a surface of indium, or other material, which is thus made radioactive. After exposure to neutrons, this surface is mounted as a cathode in a parallel-plate Geiger counter, the anode of which is a plate of transparent, but conducting, NESAG glass. When the cell is filled with argon and an organic quenching vapor such as acetone, and the voltage across it is raised above the counting threshold, each discharge initiated by the beta radiation from a decaying nucleus in the cathode takes the form of a minute spark. A time exposure of the counter, taken with an ordinary camera focused through the NESAG plate upon the cathode, shows a pattern of sparks which reproduces the primary pattern of neutrons # (T.H. Johnson).

The thin-lens magnetic spectrometer for electrons, referred to in Scientific Progress Report BNL-S-4 is nearing completion in the main machine shop of the Laboratory. It has been designed to operate over the electron energy range from 0.05 to 10 Mev, and it will have an energy resolving power $\frac{\Delta E}{E}$ which can be adjusted

Left: Arrangement for photography. The brass platten is mounted as shown after it has been exposed to neutrons.

Right: A ten minute exposure of the platten after having been irradiated for one hour by neutrons from a 1 gm Ra-Be source through a cross-shaped mask of indium foil.

Left: Oscilloscope trace of the absorption in OCS of microwaves at 24,326 megacycles due to transitions between rotational states $J = 1 \rightarrow J = 2$. The oscillograph beam and the microwave frequency were swept at 10 cps, and the pattern shows the envelope of oscillations occurring at 6 kc with the Stark modulation voltage. The large peak at the center is the unmodulated absorption line, while the low peaks on either side represent the absorption frequencies modulated by about 2 and 3 mc, respectively, by the Stark voltage. The peak at the extreme left is instrumental.

Right: "Thin lens" spectrometer for measuring energies of beta-rays up to 10 Mev. Electrons emitted from a source on the axis at the right end of the four foot tube are brought to a focus on a Geiger counter, shown on the axis at the left end. Focusing at a particular energy depends upon the strength of magnetic field produced by the large coaxial coil.

between 1% and 10%, with corresponding solid angular apertures ranging from $4\pi/500$ to $4\pi/50$. The instrument will be mounted horizontally with either Helmholtz coil or iron ring compensators. The field coils will be excited by a generator stabilized by means of a photoelectric amplifier operating from a galvanometer and potentiometer. With this device, the maximum error in the field can be held to one part in 10^3 . As a first use of this instrument, in advance of the operation of the nuclear reactor, it is planned to study the β -spectrum of K^{40} , making use of an enriched sample prepared at Oak Ridge* (D. Alburger).

Theoretical Physics

A large portion of the time of the Theoretical Physics Group has been devoted to questions arising from the experimental program. Such problems include the design theory of newly planned apparatus, as well as the interpretation of observational data.

Studies have been made of the relative merits of various schemes for producing highly monochromatic neutron beams for use in neutron diffraction experiments. The methods studied were the curved crystal arrangement, the critical energy cut-off for neutrons in grazing angle reflection from mirrors of Ni^{58} , and the sharp resonance in indium (S. Pasternack).

Several papers of a purely theoretical nature have been published. These cover various subjects, such as cosmic ray theory# (H.S. Snyder), quantum mechanics perturbation theory# (P. Richards), and scattering of charged particles by thin foils and along tracks in cloud chambers and emulsions# (H.S. Snyder, W.T. Scott, S.A. Goudsmit).

The problem of multiple scattering has finally been solved in a form lending itself to extensive numerical computations which are valid for small angles. Tables have been compiled which give data for a wide range of experimental conditions. One feature of the results is that they show clearly that, even for thin foils, it is very difficult to approach the conditions for single scattering.

*See "Miscellaneous Nuclear Physics."

ELECTRONICS AND INSTRUMENTATION

An Instrumentation and Health Physics Department was established under the chairmanship of Dr. J.B.H. Kuper on September 1. This was brought about by transferring the Electronics and Instrumentation Division from the Physics Department and merging it with the Health Physics Office, which had been temporarily attached to the Director's Office. The new Department consists of an Electronics and Instrumentation Division, headed by Dr. Kuper, with W.A. Higinbotham as Associate Division Head, and a Health Physics Division* headed by Dr. F.P. Cowan. Total personnel of the Department at the end of 1948 was 74, including two on assignment from other parts of the Laboratory.

The Electronics and Instrumentation Division retains its main headquarters office and laboratories at 51 Bell Avenue. For the past few months this building has been crowded to such an extent that additions to the staff have been held up pending availability of the contiguous space now occupied by the Accelerator Project Laboratory. During the past six months there has been a net increase of only two in personnel of the Division. Repair and calibration of radiation equipment is handled by this Division in a separate building equipped primarily for gamma-ray calibration. Facilities for alpha and beta calibrations will be added later.

The Health Physics Division occupies two converted barracks buildings which have been connected by a corridor. Except for some laboratory facilities, such as dust collectors for the evaluation of area survey instruments, the equipment of the two buildings is essentially complete.

Aside from minor rearrangements which will be required when the Department fully occupies its headquarters building, and the provision of several additional laboratory rooms in the Health Physics buildings, no building modifications are planned by the Department for the near future.

The Electronics and Instrumentation Division continues to render substantial services to the entire Laboratory, as well as to conduct independent research. The service activities include procurement of equipment, design, testing, calibration, repair, and maintenance of instruments of many kinds -- from simple thermostats to vacuum leak finders. As the amount of electronics equipment in use increases, more repair and service work becomes necessary. In the period under review, for example, more than a hundred repairs were made on forty scalars, and numerous oscilloscopes and meters have been fixed. Some 150 calibrations have been made. The machine shop has rendered material assistance to the cosmic ray experiments, as well as to the regular electronics assignments. The glass shop has filled about 200 requisitions for the Laboratory, 40% for the Chemistry Department, and 20% each for the Biology Department, Physics Department, and Electronics Division. A BF_3 filling system is complete; G-M tube production proceeds. Vacuum testing facilities have been improved. Glass shop and vacuum facilities have been able to take care of all requests. In addition, halogen-quenched G-M tubes have been studied, and some work has been done on photosensitivity of the glass type tubes.

It is the continuing policy of the Division to purchase electronic circuits wherever this is practicable. Quantities of scaler circuits and other radiation

* Progress of the Health Physics Division is described in the section of this report which deals with the radiation protection program.

Calibration room of the Electronics Division. Standard radium sources, usually stored in the concrete floor vault, are blown to the tops of the plastic tubes for calibrating. The instrument to be calibrated is run out a measured distance on the movable platform, and its readings are observed through the telescope.

measuring devices have been purchased for use by this Division and by other units. In many cases, advice has been given to other departments on procurement of special equipment. Special test equipment has been developed to check new units and to determine which commercial components are more satisfactory. The test equipment has been considerably augmented in the last six months, and the accumulated data on scalars will be available shortly in a Laboratory report.

Most of the effort of the Division has been concentrated on production of special electronic equipment which was needed by the rest of the Laboratory but which could not be bought. When instruments are not yet available commercially, they are built by the Division or by subcontract. In the last six months, a number of items were built which are fairly standard but not on the market, such as certain laboratory sweep circuits and a number of high voltage supplies.

The Division has also designed a number of special circuits for other divisions. These include a current stabilizer for a mass spectrometer, a high power pulser for the Nuclear Moments Group, an automatic Geiger tube plateau runner for the Chemistry Department, a "Gooch crucible" proportional counter for the Biology Department, test equipment used in checking construction of the reactor, and two sets consisting of amplifiers, oscilloscope, and camera, for cosmic ray studies. The current stabilizer is similar to previous designs. The pulser gives a square pulse at a high rate, and will drive a very high capacity load. The automatic plateau runner is a new design and should be a very useful circuit. The proportional counter is primarily a new geometrical design with high counting efficiency, which is especially convenient for biological and chemical analysis. Electronics staff members have cooperated with the Nuclear Interaction Group in the design, construction, and testing of two elaborate projects for cosmic ray studies.

Summer visitors carried on much of the research undertaken by the Division. Work was continued on parallel plate counters. Fast oscilloscopes were constructed to measure pulse shape, and studies of cathode materials and of other factors affecting efficiency and recovery time were undertaken # (R. Pidd, L. Madansky).

Numerous phosphors were examined to improve their responses as scintillation counters for neutrons. These efforts have been handicapped by sensitivity to gamma-rays (R. Hofstadter). The microoscillograph has been used to measure the speed of response of anthracene and similar phosphors. The pulse rise was shown to be of the order of 10^{-8} seconds, and the pulse shape was accurately recorded # (G. Collins). A video amplifier has been developed with a rise time of 1.5×10^{-8} seconds (W.C. Elmore). The analysis of scintillation pulse shapes in various crystals and the study of the effect of temperature on pulse shape have been cooperative projects # (W.C. Elmore, G. Collins, R. Hofstadter).

Additional equipment has been completed for the background monitoring stations; many of the original circuits have been improved in reliability. The vibrating-reed electrometers, described in Scientific Progress Report BNL-S-4, have required more study than had been anticipated, but they are finally being installed. A zinc sulphide photomultiplier continuous alpha monitor has been built,

Indicates publication. See Appendix for complete reference.

and is now under test in the laboratory. Geiger tubes in lead pigs were installed. Power supply and measuring equipment for a trailer-mounted portable station have been assembled.

Some attention is now being given also to the corollary problem of monitoring the ground water and liquid waste. Measurements of the ground water activity are presently being made in the Electronics Laboratory, preparatory to design of final monitoring equipment.

CHEMISTRY

On December 31, 1948, the staff of the Chemistry Department comprised 29 persons, of whom 23 were scientists. The net increment (2) of scientists added since July has been held small to accord with the slow rate of completion of the chemistry laboratories. Completion of the entire chemistry laboratory ensemble is expected within the next few months. Use of the building at 59G Bell Avenue as a laboratory has continued. Emergency use has also been made of wooden barracks at 11 Humboldt Lane. The latter building has served during this period as a laboratory for ten staff members. The radiochemistry laboratory at 59A Bell Avenue is still not ready for use, but its completion is believed to be imminent.

The Department is sponsoring a series of informal conferences on subjects connected with its research program. The first of these, on "The Chemical Effects of Nuclear Transformations," was held August 19-29. The papers given are available in Report BNL-C-7.# The second conference of the series, on "Isotopic Exchange Reactions and Chemical Kinetics," was held December 1-3; a report will be available soon.

Electronic States of the Heavy Elements

The magnetic susceptibilities of KUF_5 , K_2UF_6 , and K_3UF_7 have been measured in the temperature range 74-293°K. KUF_5 and K_3UF_7 obey the Weiss-Curie law over the entire temperature range; K_2UF_6 deviates slightly at the bottom of the temperature range. Magnetic moments calculated from the data are:

Compound	Moment (Bohr Magnetons)
KUF_5	3.2 β
K_2UF_6	3.5 β
K_3UF_7	4.0 β

The theoretical moments are 2.84 β if only the electron spins are involved, 3.58 β if the full orbital contribution is also present.

A new magnet has been received from Consolidated Engineering Corporation, and has been put into working order. It is equipped with 2" diameter pole faces, and will give fields up to 15,000 gauss with a 1" pole gap (N. Elliott).

Provision for additional studies of the electronic states of the heavy elements as they exist in various solid compounds has also been made. Some desirable design changes have been incorporated in the spectrographic laboratory. Preparations have been made for the delivery of the helium liquefier being built by Arthur D. Little Company. (It will be necessary to install this machine in temporary quarters for about six months.) This apparatus will be equipped with explosion-proof fittings, in

Indicates publication. See Appendix for complete reference.

order to permit its safe use as a hydrogen liquefier. Among the uses to which the equipment will be put is the provision of low temperatures for magnetic and spectroscopic measurements. Some equipment is being set up for growing single crystals from solution and from the melt (J. Bigeleisen).

Radiation Chemistry

For the study of the chemical changes brought about by ionizing radiations, it is hoped to obtain a 2 Mev electrostatic accelerator for electrons. The cathode rays produced by such a machine provide a source of intense radiation which should greatly facilitate radiation chemical studies. At present, the X-ray machine of the Biology Department is available, but long exposures are required to produce even small chemical effects. It is intended to make use of this machine until a stronger source is available.

For the present, it appears most profitable to confine attention to certain reactions in aqueous solution. The initial studies will be concerned with the kinetics of the radiation-induced reaction between hydrogen and hydrogen peroxide, and the effect of the addition of reducing agents such as bromide. Previous work suggests that, in these systems, the reaction mechanism can be worked out in detail, although more complex systems will probably have to be studied before the absolute number of primary radicals formed can be determined (A.O. Allen).

It was hoped that it would be possible to investigate the radiation-induced gas phase reaction between HCl and O₂ by using a sensitive radiochemical method of analysis for the chlorine formed. This method was based on the stoichiometric oxidation of solid KI containing I¹³¹, the iodine formed being separated and counted. The problem has been discontinued, however, since it was found that the blanks were too high and irreproducible for dependable analyses on the necessary scale of 10⁻¹⁰ - 10⁻⁹ moles (E. Shapiro, T.W. Davis, I. Greenberg).

Study of the methyl iodide photolysis in the presence of silver (thesis problem) has been continued. The reaction products are being analyzed by infrared absorption. The purity of the starting material was also established by this method. An apparatus has been constructed in which the reaction gas is stirred by a rapidly rotating silver vane, the purpose of which is to fix the iodine atoms produced in the primary step. Several runs have already been made (R. Schultz).

Recoil Atoms and the Chemical Effects of Nuclear Transformations

Some preparations have been made for determining the various states of combination into which "hot" bromine atoms enter when formed in hydrocarbons. This work is not active at present (L. Friedman, R. Dodson).

The apparatus for measuring the energy distribution of Ag¹⁰⁷ recoils (resulting from Cd¹⁰⁷ electron capture) has been completed. It was tested with inactive cadmium. A second apparatus is being assembled for studying K-capture recoils in

Chemistry complex from the southwest.

Be7. An electron multiplier furnished by the RCA Laboratory will be used for detecting the recoil particles (R. Davis).

The possibilities that molecular integrity may be preserved in the beta decay of Cl^{14} , and that this nuclear process may, thus, lead to the synthesis of organic nitrogen compounds, is being investigated. A technique of double isotopic labeling is being employed. For this purpose, a Cl^{14} sample of high specific activity (about 25% Cl^{14}) has been used to synthesize acetylene. A sample containing one millicurie has been synthesized, in good yield, from barium carbonate through barium carbide as an intermediate. The nonoccurrence of bond rupture in the beta decay will be determined by measuring the amount of Cl^{14} -labeled cyanide present in the system after standing (W. Miller, R. Dodson).

Chemical Studies with Isotopes

This subject includes investigations of the synthesis of isotopically labeled compounds, of the spectroscopic and other properties of such compounds, and of the use of isotopic tracers in studying the kinetics of chemical reactions.

The Fischer-Tropsch recycle unit has been operated for several months with CO and H_2 over a cobalt-thoria-kieselguhr catalyst. The gaseous products were separated by low temperature distillation and identified by their infrared spectra. Selective pressure hydrogenation, coupled with infrared measurements, has been used to study the distribution of double bonds in the unsaturated compounds present in the liquid fraction. After charging with fresh catalyst, the system has been operated with CO and D_2 input. The rate of formation of deuterocarbons is less than that of hydrocarbons. The gaseous and liquid products are substantially free of protium. The infrared spectra of these products have been examined. The spectra of the liquid deuterocarbons are markedly different from the corresponding spectra of liquid hydrocarbon products. Catalytic pressure deuterization is being carried out in order to facilitate interpretation of the spectra and isolation of individual pure deuterocarbons. It is planned to use protium and Cl^{13} as tracers in the deuterium system for the study of the mechanism of the Fischer-Tropsch reaction. This combination of isotopes offers marked advantages from the mass spectrometric standpoint, in that odd masses in the mass spectrum can be directly associated with the tracer isotope (S. Thompson, J. Turkevich).

Propane-1- d_1 and propane-2- d_1 have been synthesized, and their infrared spectra have been examined in the range from 2 to 16 microns. The positions of the primary and secondary C-D bands are different by 45 cm^{-1} . This measurement leads to some reassignments of the fundamental vibration frequencies of the propane molecule# (L. Friedman, J. Turkevich).

The infrared spectra of a number of derivatives of methane and benzene have been measured in order to prepare a catalogue of such spectra for future analytical work, and also to determine the effect of substituents on the intensities of infrared bands. In particular, the spectra of ortho-, meta-, and paradeuterotoluenes have been determined (P. Stevenson, J. Turkevich).

The study of the interaction between CO_2 and charcoal, using C^{14} as tracer, has led to the following results: At 500°C , CO_2 is reduced to CO with no change in pressure or specific activity of the off gas. Measurements with several pressures of CO_2 at temperatures from 700 - 800°C indicate very rapid reduction of CO_2 , the CO produced having the same specific activity as the initial CO_2 , followed by a slow increase in pressure and drop in specific activity. The data are interpreted in terms of two successive first order decomposition reactions of the oxygen-carbon surface (F. Bonner, J. Turkevich).

A preliminary study has been made of exchanges between deuterium and methanol. Over a Raney nickel catalyst, only the OH group exchanges. No exchange between the C-H bonds and D_2 occurred over a synthetic ammonia catalyst of copper on alumina at 200°C and 100 atm pressure. It is planned to determine how close one must approach methanol synthesis conditions to effect carbon exchanges between CO and methanol, and hydrogen exchange with the C-H bonds (P. Stevenson, J. Turkevich).

Two problems in organic chemistry are being investigated. The aim of the first is to develop new synthetic procedures for the incorporation of carbon tracer into complex organic molecules. The alkali carbonyls may be useful for this purpose. A possible synthesis of mesoinositol from potassium carbonyl is being investigated. Secondly, various possibilities for the incorporation of cobalt into biochemically active substances similar to vitamin B_{12} and to hemin are being considered. Such substances would be of tracer interest and possible therapeutic value (R.C. Anderson).

Work on the gas phase exchange of bromine between Br_2 and HBr has been continued. A kinetic method leading to very short contact times has been used. The two components are separated by condensation in cold traps. The data indicate rapid exchange, with half-times of the order of half a second at 1 mm total pressure and room temperature. Complete exchange is observed when the total pressure is raised to 30 mm and the contact time to 15 seconds (H. Jacobson).

Study of the exchange between CO_2 and BaCO_3 has been continued, with particular reference to the effects of moisture, particle size, and heat treatment of the barium carbonate (G. Samos).

It is known that the exchange of bromine between aluminum bromide and ethyl bromide in carbon disulfide solution is markedly inhibited by the addition of nitrobenzene. Since it is also known that aluminum bromide forms complexes with nitrocompounds, it appears that there is in these complexes a marked effect on the reactivity of the aluminum-bromine bond. This effect may have a bearing on the mechanism of some Friedel-Crafts reactions; and it is being investigated quantitatively for various complexing agents. Preparation for this work has been completed. Preliminary runs have confirmed that exchange between aluminum bromide and ethyl bromide is complete after several hours at room temperature; at ice temperature, the half-time is approximately twenty minutes (H.C. Thomas).

An increasing body of experimental evidence indicates that the exchange of electrons between different oxidation states of an element in aqueous solution is, in many cases, a slow process. In this connection, experiments have been undertaken to measure the rates of exchange between cerous and ceric ions in perchloric and sulfuric acid solutions (thesis problem). Using diffusion through sintered glass and

spectrophotometric analysis, evidence has been obtained for a measurably slow rate of exchange in solutions which contain sulfuric acid. Further refinement of the methods of separation and analysis is necessary, however, before quantitative results can be given (J. Gryder).

In the use of isotopic tracers, it is important to know the magnitudes of chemical differences between isotopic molecules. The theory of the differences in the thermodynamic properties is now well developed. Since isotopic tracers are extensively used to follow the rates of chemical reactions, it is also desirable to know the effect of the isotopic constitution on reaction rate constants. To this end, a development of the theory of the relative reaction velocities of isotopic molecules has been undertaken. A set of upper limits to the ratios of rate constants at 25°C for molecules containing the common tracers has been calculated. The largest effects occur, of course, in compounds containing isotopes of hydrogen. It also appears that the effects with compounds containing C^{14} may be sufficiently different from those containing C^{12} to warrant special attention in quantitative work.

Detailed application of the theory has been made to the rupture of C-C bonds in propane containing C^{13} and C^{12} . The results are applicable to the process of electron bombardment in mass spectroscopy. Detailed consideration has also been given to the decarboxylation of labeled malonic acid. The theory indicates that $C^{14}O_2$ should be evolved with a rate constant which is 96% of that for the evolution of $C^{12}O_2$ from the normal acid. The reason for the discrepancy between this result and the recent experiments at Berkeley is not yet clear# (J. Bigeleisen).

In addition to the above work of the resident staff, work involving Laboratory facilities has been done from time to time by visitors. Thus, measurements have been made in connection with a study of the properties of some complexes of nickel and exchange reactions of nickel (F.A. Long, Cornell University). An experimental study of the Gibbs absorption theorem has also been undertaken, with the use of radioactive tracers to measure the concentration of surface active agents at interfaces (E. Hutchinson, Fordham University).

Nuclear Problems

A search is being made for the occurrence of Se^{79} among the fission products of uranium. The radiations from this isotope have never been detected, probably because of its extremely long half-life. Experiments have been started with the aim of isolating this isotope, carrier-free, from intensely irradiated uranium, and measuring its half-life and radiations. The chemical separations have been tested with 127 day Se^{75} tracer. Tellurium appears to be an unsatisfactory carrier. When uranium metal is dissolved in concentrated hydrochloric acid in the presence of selenite, it appears that selenium is reduced to hydrogen selenide which can be boiled out (S. Katcoff).

Preparations have been essentially completed for the search for fission products outside the known mass range. Possible products for which search will be made include isotopes of argon, phosphorus, beryllium, as well as H^3 and He^3 (W. Rubinson, B. Burt, G. Samos). Attention has been given to the general question of the equations

of radioactive transformation in a neutron flux; the appropriate equations have been derived. The treatment is useful in predicting the products of sustained high neutron dosage# (W. Robinson).

In a search for a metastable state of Te^{125} with a measurable lifetime, tellurium was chemically separated from two different samples of Sb^{125} obtained from the Isotopes Branch of the Atomic Energy Commission. An activity was found to be associated with the Te fraction. It was shown that the tellurium activity grows from the Sb^{125} and has a half-life of (58 ± 1) days. Absorption measurements indicated the presence of conversion electrons of about 120 kev, and of characteristic tellurium X-rays. No unconverted γ -rays have been observed, and a lower limit of 100 can be set for the conversion coefficient. A source containing about 0.2 rd of Te^{125} , with about 0.1 mg of tellurium carrier, was prepared for introduction into an electron spectrography at the University of Illinois, where the K, L, and M conversion lines of a 109.3 kev γ -ray, and a fourth weak line of 30.4 kev energy, have been found. A source of about 0.2 rd of Sb^{125} has also been prepared for the spectrograph# (G. Friedlander, M. Goldhaber, G.S. Goldhaber, R.D. Hill).

Since the 58-day Te^{125} is the longest-lived isomer of a stable nuclide which is now known, and since it appears feasible to obtain it carrier-free, it is planned to attempt a measurement of the spins of both the ground state and the excited state by microwave absorption methods. This will be done in cooperation with the Nuclear Moments Group. A search for suitable compounds has been started, and a sample of tin is being irradiated at Oak Ridge to obtain a sufficiently strong Te^{125} source.

The radiations emitted by a sample of long-lived nickel obtained from the Isotopes Branch have been investigated after thorough chemical purification. No evidence was obtained for the previously reported positrons (or their associated annihilation radiation) attributed to a 15-year Ni^{59} . Neither was any appreciable intensity of X-rays (associated with K-capture) observed. Instead, a negative β -ray, of 50 kev maximum energy, was found by absorption measurements. (This phase of the work was done in cooperation with G.S. Goldhaber.) It seems likely that this is associated with Ni^{63} , and that Ni^{59} has a half-life of at least 10^3 or 10^4 years. For further study of the assignments and radiations of the long-lived nickel activities, samples of the five separated nickel isotopes were irradiated for two months in the Oak Ridge reactor. These are now being subjected to careful chemical purification (G. Friedlander).

Other Topics

The Nier type mass spectrometer has been put into operation. Good resolution has been obtained over the mass range 1-210. The instrument is being adapted for appearance potential measurements. A sample handling system using a nonfractionating leak is being constructed (O. Schaeffer, J. Hastings).

An experimental study (thesis problem) is being carried out on the mechanisms of the reactions which occur in the flowing systems encountered in chromatographic and ion exchange separations. A simplification of these systems has been sought in the ordinary Jones reductor, operated under conditions of incomplete reduction. Preliminary results indicate that, in this system, the reaction is diffusion-controlled. The effects of flow rate, temperature, length of column, and other pertinent experimental variables will be determined (K. Knox).

ENGINEERING

As of January 1, 1949, the funds, personnel, facilities, and program of the Engineering Department, established January 8, 1948, under the acting chairmanship of Assistant Director Captain R.D. Conrad, U.S.N. (Ret), will be merged with the Nuclear Reactor Project to form the new Department of Reactor Science and Engineering, under the chairmanship of Dr. L.B. Borst. Of the operating budget for the Engineering Department of \$407,000, \$102,000 was expended or committed to December 31, 1948. An additional amount of \$110,000 was expended or committed for building modifications and major facilities. Fifteen staff members will be transferred to the new Department.

During the eleven months of the Department's existence, much of permanent value was achieved. The plans and accomplishments are described in detail in two classified Planning and Program Reports, one dated April 15, 1948, and the second dated November 15, 1948. The policies established and followed by the Department were approved by the Scientific Steering and the Policy and Program Committees of the Laboratory. The plans and general policies of the Department, described briefly in Reports BNL-A-4 and BNL-S-4, will continue in substantial effect after January 1.

Considerable progress was made in planning and constructing facilities. Headquarters for the Department were moved from the Administration Building to the Reactor Project building at 29 Cornell Avenue, where two new additions were provided for a waste concentration laboratory and a fluorine laboratory. The former is in a wing formed from a two-story barracks building which has now been converted into five laboratories. The ground floor has a single large laboratory with a storage room at one end and a clear two-story space at the other. The upper floor contains four small two-man laboratories, furnished for research in waste concentration and soil chemistry. A small fractionating column (20' x 14" diam) has been installed and tested in the first-floor laboratory; it is being used in waste concentration research. To supply this column with process steam, a 125 psi, 1000 lb per hr, oil fired, "packaged" boiler has been provided.

The fluorine laboratory has been turned over to the Department by the H.K. Ferguson Company, and most of the furniture and equipment is now in place. The laboratory will be virtually fireproof. Elaborate precautions--periscopes, remote control devices, cinderblock separation walls--insure that the fluorine will be processed with maximum safety. The fluorine tanks will be housed at one end, outside the building proper. The other end will serve as a balance room. A relative positive air pressure will be maintained continually in the laboratory to eliminate the danger of a blowback, should a fluorine tank rupture.

Half of the main engineering room at 29 Cornell Avenue is being converted into a temporary metallurgical laboratory containing ovens, three resistance vacuum furnaces, an induction heating unit, and allied equipment. The building already contains a metallography laboratory which, with minor alterations, will be suitable for a time. The existing chemistry laboratory in the south end of the building will be converted into a temporary phase diagram laboratory, and will also house single-crystal furnaces.

Another projected metallurgical laboratory, a former gymnasium of cinderblock construction, has been used by the Nuclear Reactor Project as a shop for machining graphite and canning fuel. Funds for the complete conversion of the building will not become available until fiscal 1950. However, after the building has served its present purpose and is cleared of graphite dust, the heavy equipment on hand, or on order, for metallurgical work will be installed there. At present, the heavy machinery consists of a 120,000 lb testing machine and a small rolling mill. Final plans for this building call for its conversion into a complete metallurgical laboratory, with all components under one roof. The eastern end will eventually become a foundry and a mixing shop for experimental work in shielding.

Through the hiring of personnel, the planning of facilities, the ordering of equipment, the establishment of valuable external contacts, and the development of policy with regard to its proper functions, the Engineering Department has made significant forward steps in setting the stage for a broad program of applied science. As long as engineering personnel was engaged in design and construction of facilities associated with the reactor complex, little of the program specifically envisaged for the Department could be implemented.

LIFE SCIENCES

BIOLOGY

The Biology Department now has 16 scientists, 21 technicians, and 4 administrative and clerical employees. Departmental organization remains unchanged.

Although no new buildings have been occupied, most of the changes predicted in the last report have been effected. The animal quarters, the staff shop, and the glassblowing equipment have all been moved from the laboratory building to the stockroom building. This move has resulted in an appreciable increase in the amount of laboratory space available to the Department. In addition, a small part of the stockroom building is being converted into a laboratory and darkroom for cytochemistry and radioautography.

The detailed design for the alterations and additions to the new biology building at 46 Bell Avenue has been completed, and specifications have been sent out for bids. No firm completion date has been set, but it is expected that the building will be ready for occupancy late in the summer. The greenhouse has been completed and is now in full operation. A supplementary lighting system is being installed which will permit control of the light cycle. The Arthur D. Little Company has submitted a draft of recommendations on the proposed animal quarters. Preliminary design has been started.

In July, the Department sponsored a three weeks conference on biological applications of nuclear physics. Results of the Conference are contained in reports BNL-C-4 and BNL-C-5.

Biological Effects of Radiation

1. Animals

Studies are continuing on the physiological and biochemical responses observable in rats following exposure to whole body X irradiation.

The cholesterol ester, ascorbic acid, and glycogen contents of selected tissues. The change in concentrations of various constituents in the adrenals, liver, testes, and plasma of fasted rats has been determined 3, 24, and 48 hours after exposure to 1000 r of X-rays. An initial rapid fall in ascorbic acid content of the adrenal immediately after exposure, with a return to normal within 24 hours, has been observed. The glycogen content of the liver continues to increase up to 48 hours following exposure. Cholesterol ester contents of the plasma, adrenal gland, and liver are lower than normal for at least 48 hours after exposure# (N. North, H.E. Abritis, L.F. Nims).

#Indicates publication. See Appendix for complete reference.

A potato field showing potatoes, exposed in tuber stage to various dosages of radiation, 33 days after planting. Growth inhibition is greater at higher dosage levels.

Corn grass, a dominant mutant, ancestral type of corn, and normal corn plants in the same progeny.

Shielded adrenals. Rats whose adrenal glands have been protected from radiation by internally placed lead shields have a significantly increased survival time, following exposures to 800 r of X-rays, over rats not so protected (A. Edelmänn, M.J. Rock).

Water and salt metabolism. Both a polydipsia and a polyuria occur in rats during the first and fifth 24-hour period following exposure to X-rays. The reason for the second period of increased water imbibition is not known; it is a completely unexpected finding. The urinary excretion of Na, K, and Cl varies proportionately with the total urine volume# (A. Edelmänn, M.J. Rock).

2. Plants

Corn. Several genetic lines of corn are under study. Stocks are being built up for investigations of the effects of radiation on the genetics of corn. Segregating progeny of crosses between lines of high sugar content were grown and sampled for sucrose. The amount of sucrose in the stalk juice of present stocks ranges from 2 to 10%. An attempt was made to induce mutations of the corn grass line by treating seeds with X-rays and sprouts with radioactive phosphorus. No mutations were found in the limited number of plants grown this year# (W.R. Singleton, F.K. German).

Potatoes. Potato "seed" tubers of the Katahdin variety were irradiated with X-rays at dosage levels ranging from 75 to 38,400 r. These tubers were then planted and allowed to grow under field conditions. It was found that moderate inhibition of growth and yield occurred at levels up to 2400 r, above which level a rapid falling off of growth and yield occurred. The lethal level for potato tubers lies between 20,000 and 40,000 r. No stimulation of growth occurred at any level. In those potatoes which did not grow, a state of suspended development was apparently produced, so that the seed tubers remained in soil all summer without rotting (A.H. Sparrow, E. Christensen, F.K. German).

3. Cells

E. coli. E. coli has been grown in solutions of radioactive phosphorus varying from 0.1 to 3.5 mc/cc of media. Increasing concentrations of radioactive phosphorus caused successive decreases in growth, except for the lowest concentrations tried, in which there may have been a slight increase in growth. No morphological changes were noticed, except at the highest concentrations used, in which a pronounced elongation of the bacterial cells occurred without detectable change in the diameter of the cell.

Subcultures of the cultures exposed to radiation showed a decided increase in the forward (loss) mutation rate. Fractional killing of the radiation-treated cultures also brought to light significant increases of the forward mutation rate. No change in back mutation rate has been demonstrated by any of the techniques employed. The results of the various experiments seem to imply that the E. coli cells are either polyploid or have heterocaryotic nuclear organization# (B.A. Rubin, P. Steinglass, G.A. Snyder, W.E. Culver).

Above: Normal microspore of Trillium erectum. The normal cell in division (first meiotic anaphase).

Below: Irradiated microspore of Trillium erectum. Dividing cell shows chromosome abnormality induced by irradiation with X-rays 14 days previously at the pachytene stage. This cell is now in the same stage of development as the normal cell.

Radioautographs of barium¹⁴⁰ in sections of male hornets. D is a specimen 7 days after feeding; E, 14 days; and F, 28 days. In each case the barium is seen to be mainly in the cells of mid-intestine. The legend is: MG - mid-intestine, HG - hind-intestine, FB - fat body, MT - Malpighian tubules, and G - genital organs.

A young queen of the large European hornet, Vespa crabro, being fed honey from an ordinary medicine dropper. These insects are being used to study the uptake and metabolism of barium and manganese, since they concentrate large amounts of such metals in some organs. This specimen is about 2" long.

Trillium chromosomes. Studies on sensitivity of Trillium chromosomes to X-ray breakage at stages of the nuclear cycle are continuing. Sensitivity curves at 50 r, 25 r, and 12.5 r are nearly complete. The highest sensitivity appears to be in the early diplotene stage, and lowest sensitivity in the interphase stage. Published details concerning these experiments can be found in an article in *Nature* 162, 651 (1948), and in a forthcoming article in the *Annals of the New York Academy of Science*# (A.H. Sparrow, R.C. Sparrow, E. Christensen, G.B. Davison, V. Pond).

Nucleoprotein changes in chromosomes. Apparatus is being assembled and tested which will permit study, by cytochemical and direct microphotometric procedures, of the changes produced in the nucleic acid and protein contents of nuclei or chromosomes after irradiation (M.J. Moses, A.H. Sparrow).

Physiological basis for differentiation in Allomyces. The growth factor requirements of four species of Allomyces intended for use in further radiation studies have been determined# (K.E. Yaw).

Radiation and constituents of cells. X irradiation oxidizes hemoglobin to methemoglobin in vitro. Broken cell preparations of kidney and liver exhibit no change in activity of D-amino acid oxidase following intensive X irradiation of either the whole animal or isolated tissues, a result somewhat at variance with previous work (J.R. Klein, B.P. Baldwin).

Tracer Studies of Biochemical Problems

Phosphorus metabolism of the liver. The data necessary for the determination of the relative turnover rates of various phosphorus compounds in the livers of rats in the post absorptive state have been determined. The readily hydrolyzable phosphate groups of adenosine di- and triphosphate have the highest turnover, followed in order by glucose-1-phosphate, ribose-5-phosphate, and glucose-6-phosphate. Other compounds examined have much lower turnovers. The compounds specifically named above appear to be formed independently. The evidence at hand indicates, however, that glycerophosphoric acid is the precursor of phosphoglyceric acid and that ribose-5-phosphate is the precursor of the stable phosphate group in adenosine di- and triphosphates.

These data, together with information previously obtained on striated and heart muscle, clarify the significance of the phosphorylating mechanisms in the metabolism of various tissues. It is now quite clear that the phosphorylation cycle, as derived from study of isolated enzyme systems, is of major importance in the metabolism of liver tissue, of lesser significance in the metabolism of heart muscle, and least significant in the metabolism of striated muscle# (J. Sacks, S. Stigman, N. North).

Iron metabolism. The rates of incorporation of iron in cytochrome C of muscle and in the erythrocyte are being studied in the duck, and appear to take place at approximately the same rate. No exchange of iron appears to take place between plasma and the human erythrocyte. However, the dog and rat red cells show a slow exchange; the exchange is comparatively rapid in the nucleated duck and pigeon erythrocytes (J.R. Klein, L.M. Sharpe, B.P. Baldwin, A.T. Davis).

Mineral metabolism of hornets. The distribution of ingested barium¹⁴⁰ is being determined, by both counter and radioautographic techniques, in hornets indigenous to this area of Long Island. The work provides evidence of a cycle involving only 10^6 atoms of barium per insect. This cycle includes the movement of barium from the intestine to the gonads and the male accessory glands of the hornets. Analytical studies have also been continued on manganese. Quantitative analyses for iron and copper have been carried out to provide comparative data on the metabolism of metallic elements in the hornet (V.T. Bowen, A. Carbone, G.M. Keefe).

Biological fate of tagged carbon compounds in mice. The construction of all-glass-enclosed mouse metabolism cages is being completed. This apparatus will be used to determine the fate and distribution of C^{14} following the ingestion of selected tagged compounds. Radioactive starch and glucose have been prepared and will be the first compounds used (R. Steele, T. Sfortunato).

Biosynthesis. C^{14} tagged sucrose, fructose, and glucose have been prepared biosynthetically from carbon dioxide and the leaves of sunflower plants. Tagged starch has been prepared from the leaves of bean plants. The methods employed yield material of adequate specific activity with good recoveries of radioactive carbon. Although these products tend to be uniformly tagged in all the carbon positions, they can be used in other tracer experiments. Small amounts of these materials have been supplied to outside investigators, but the major amount of the prepared compounds will be used in experiments to be carried out at the Laboratory (M. Gibbs, R. Dumrose, F. Acher).

Methodology. Continuous improvement is being made in laboratory techniques and methods of handling radioactive materials. This is commonly the result of excellent cooperation among individuals in the various subdivisions of the Laboratory. A free interchange of ideas always makes for rapid development.

Two adaptations of the methane proportional counter for the counting of solid and gaseous samples of radioactive materials are examples of these cooperative efforts. The solid counter uses a standard Gooch crucible as both a sample holder and a chamber to confine the gas. This arrangement gives the advantages of a windowless counter. It is not only generally useful for all radioactive precipitates, but is particularly valuable in the estimation of precipitates of alkaline earth carbonates containing C^{14} . The counting of gaseous C^{14} in a methane proportional counter with a gas pressure of one atmosphere has also proved eminently satisfactory. A procedure has been developed for monitoring $C^{14}O_2$ contamination in air, which shows definite promise of giving adequate control over this potential hazard. Details of these procedures will be published soon (R. Ballentine, W. Bernstein of the Electronics Division).

MEDICINE

A number of important steps have been taken in the Laboratory's medical program in the last six months. Dr. Donald D. Van Slyke, a member of the Rockefeller Institute for Medical Research, who formerly served the Laboratory as Consultant on Life Sciences, has accepted an appointment as Assistant Director of the Laboratory for Medicine and Biology. In December, Dr. Lee E. Farr, Director of Research of the Alfred I. Dupont Institute of the Nemours Foundation at Wilmington, Delaware, accepted appointment as Chairman of the Medical Department; he is expected to take up his duties at the Laboratory on a full time basis in July. Professor S.C. Madden, who will head the work in pathology, will take up residence about the first of February. Joining him in this work will be Dr. Louis Zeldis and several technicians. Other appointments are anticipated shortly.

Plans for the organization of the Department have matured rapidly. Under Dr. Farr's leadership, responsibility for the operations of the Medical Department will be divided among five senior staff members: a senior physician in charge of the hospital, a pathologist, a physiologist, a bacteriologist, and a biochemist. Except for the first, each will be in charge of a research laboratory. It is anticipated that the personnel of these laboratories will carry on research in their respective fields, cooperate with the clinical research of the Laboratory's hospital, support the regular medical service, as needed, and assist in cooperative work with the associated universities by accepting, as working associates, scientists on leave from these and other institutions.

The Atomic Energy Commission has authorized the Laboratory hospital to accept nonpaying patients for the study of cancer. Exploratory discussions are under way with other institutions in this region to develop effective means of cooperation in undertaking cancer research at the Laboratory.

The present staff of the Department comprises a hospital administrator, four physicians, eight registered nurses, four clinical laboratory technicians, an X-ray technician, a registered dietician, a pharmacist, a clerical and administrative staff of five, and a janitorial staff of four.

The 42-bed hospital referred to in Administrative Progress Report BNL-A-4 is now adequately staffed and equipped, and is receiving patients. An out-patient clinic is operating on a twenty-four-hour, seven-day-week basis to provide medical care for Laboratory employees and their dependents. The program of comprehensive and repeated physical examinations of all employees is continuing.

Under present policy, those who may be admitted to the hospital include: 1) employees of the Laboratory and dependents* living with them, 2) employees of the local Atomic Energy Commission staff and dependents* living with them, 3) research patients, 4) official visitors, 5) employees of subcontractors, living on the site, or 6) employees of contractors, requiring emergency care while on the site. Charges for hospitalization and out-patient treatment are based upon rates currently in effect in nearby hospitals and in New York City. Persons insured under the Blue Cross Plan may receive the financial benefits provided for under the terms of their contracts. The present staff is adequate to meet the probable demands upon it for

*On approval of the Laboratory Hospital, and when the other facilities of the region are unavailable or inadequate.

nonspecialist medical services to the groups eligible for hospital and out-patient treatment. For specialist services in surgery, ophthalmology, urology, and other fields, consultants are being appointed, partly from the Long Island region and partly from New York City.

Current plans call for using the present temporary hospital buildings for several years. Existing wooden structures are to be remodeled to house, temporarily, the laboratories of pathology, physiology, bacteriology, and biochemistry. As far as possible, equipment will be planned so that it can be transferred later to permanent laboratories. The location of the permanent medical laboratories on the southern edge of the main center of the Laboratory, in conjunction with those scheduled for the Biology Department, is being considered. Tentative floor plans for permanent laboratories of pathology, physiology, biochemistry, and bacteriology were prepared in August. Preparation of final plans will follow appointment of the heads of the four laboratories, and can be more realistic after some experience has been gained in the temporary structures.

From the beginning, it has been urged that the Medical Department include clinical research in its program. Authorization to do so on a small scale, consistent with the available staff and facilities, has been given, but the details remain to be worked out. Initially, much of the research effort will be concentrated on preclinical investigations, carried out where appropriate, in collaboration with the Biology Department or other research units of the Laboratory.

RADIATION PROTECTION

Much of the equipment for the health physics program has now been procured, and the training of personnel is proceeding rapidly. Forecasting of weather conditions for the Upton area has become a routine matter. The Meteorology Group has begun collecting data from oil-fog smoke runs. Recording equipment on both meteorological towers is operating smoothly. The well-drilling program of the Geology Survey Group is approximately 50% complete. An experienced agricultural economist has joined the staff to conduct the Economic Crop Survey under the general supervision of the Chairman of the Biology Department.

Health Physics

Expansion in the staff and duties of the Health Physics Division has kept pace with increased requirements for radiation protection services. The staff of the Division now numbers 29; it will continue to grow during the next six months.

Since experienced health physicists are few and in considerable demand, the Laboratory must continue to rely for increases in personnel upon its program of in-service training. During the fall, members of the Division offered a course of 19 training lectures on phases of health physics to new members of its Building Survey Section, as well as to members of the Pile Operation Division of the Nuclear Reactor Project. Individuals from other groups in the Laboratory and representatives of the New York State Department of Health also attended.

Many Laboratory policies on various aspects of health physics operations have been established and implemented. After review by the Radiation Protection Committee and the Central Safety Committee, appropriate statements of policy and operating instructions were added to the safety manual. The new material included detailed procedures for personnel monitoring operations, arrangements for procuring and distributing protective clothing, a health physics instruction sheet, procedures for maintenance operations that would involve radiation hazards, and arrangements for small-scale laundering of protective clothing which may be contaminated.

In anticipation of large-scale research activities, limits for the disposal of radioactive liquid wastes via the Laboratory sewer system have been proposed. The proposed limits are 3×10^{-12} curies per cc, averaged over 30 days, for the maximum concentration to be released from the sewer system, and 3×10^{-11} curies per cc, for the allowable peak concentration. Of course, even lower concentrations will be the preferred operating goal.

Additional facilities for storage and control of a steadily mounting volume of sources, isotopes, and fissionable materials are continually being provided by the Source Custodian. The receipt of uranium for the reactor has required the institution of rigid accountability procedures. Monthly inventories of sources and isotopes have been made, and basic quotas of source and fissionable materials have been established

with the Commission. Orders for isotopes are increasing gradually; total procurement to date amounts to approximately 2 1/2 curies, distributed among 25 isotopes.

The gradual increase of experimental activities in the Chemistry and Biology Departments, and of various testing and production activities in the Nuclear Reactor Project, has added steadily to the duties of the Building Survey Section. The largest single task arose in connection with the machining of uranium by an outside contractor. Protection arrangements during the run, and decontamination activities upon completion of the work, required full time supervision by a health physicist for several months. Periodic surveys have been made of the operating scientific laboratories; special studies of X-ray activities in the Medical Department, and of a dilution room in one of the biology buildings, have been undertaken. Surveyors have also designed and procured suitable warning signs, waste receptacles, and special instruments. An arrangement for spot checking the calibration of survey instruments has been worked out jointly with personnel from the Electronics and Instrumentation Division.

The Electronics Division has converted the probes of several Raytheon alpha-particle detectors ("poppy") into methane flow probes for use in detecting C^{14} contamination. An apparatus for assaying $C^{14}O_2$ contamination of the air has been developed, and is ready for operational tests. Several "process monitors" have been adapted for use as hand and foot counters until commercial models become available.

The Area Survey Section has completed its facilities and has accumulated important background data. The chain of 16 area monitoring stations is now operating routinely with a variety of automatic recording counters for detection of beta-gamma radiation. Additional equipment is under construction. A maintenance and operation manual for the stations is ready for publication.

The general nature of the beta-gamma background has been fairly well established by data accumulated during the past nine months. Counting rates with standard Eck and Krebs type G-M tubes vary considerably with changes in the weather and, to a lesser extent, with geographical location. The following averages are typical:

Unshielded tube	35-43 counts/min
Through beta-ray shield of 35 mil brass	26-30 counts/min
Through 1 1/2" lead shield	18-22 counts/min

Routine tests for nonvolatile radioactive contamination in the effluent of the Laboratory sewer system have yielded negative results with equipment sensitive enough to detect approximately 3×10^{-13} curies per cc. Negative results have likewise been obtained from tests of the Laboratory's water supply and of water samples from nearby wells and streams. Use of a five-gallon sample in these tests indicates an extremely low natural background. The beta-gamma activity is estimated to be less than 10^{-14} curies per cc. Alpha and very soft beta-gamma components are strongly masked, for this size of sample, by the considerable quantity of solid residue.

The area monitoring counting room is now equipped. It provides service for both the building and area survey programs. Difficulties have been experienced with various types of alpha counters.

In addition to counting samples of sewage and water, the area monitoring laboratory is beginning to mount vegetation samples. Background measurements of water and dust and of the sensitivity of photographic products to radiation are being made at a nearby photographic plant.

Since the scale of personnel monitoring services remains small -- approximately 300 film badges and 250 pairs of pocket chambers per week -- the Personnel Monitoring Group has been able to devote most of its time to completing operational equipment, setting up record systems, developing operating procedures, and training personnel. The film processing unit and associated equipment and the requisite air conditioning units have now been installed. X-ray equipment for marking badges has been installed, and contamination checking apparatus procured. Operators are being trained to use a high-power microscope for neutron monitoring. Equipment is in operation for calibrating film badges and pocket chambers. There have been no verified cases of exposure beyond the tolerance limit of 250 mrep per week.

Meteorology

As of December 31, 1948, the Meteorology Group of the Nuclear Reactor Project numbered 18. The new towers building is fully occupied and approximately 95% equipped. The major part of the work is still concerned with design and installation of the Laboratory's unique meteorological facility. The towers, recorder building, and micronek are essentially complete, and are undergoing a series of tests.

As described in previous reports, the Special Station of the U.S. Weather Bureau continues to cooperate with and participate in the Laboratory's meteorological work. During the fall, the Station and the Meteorology Group were joint hosts for a visit from Professor O.G. Sutton of the Military College of Science at Shrivenham, England, an expert of long experience in the study of dispersion phenomena.

The actual observation of dispersion of the effluent and its final correlation with meteorological variables await regular routine production of oil-fog smoke from the 350-foot meteorology stack located in the 420-foot tower. Trial smoke runs have been made. Minor changes will be made in the installation after the contractor has turned it over to the Laboratory.

Data resulting from the smoke tests are expected merely to confirm, at first, within a factor of two or three, at most, the results deduced from theoretical considerations. From a practical and operational point of view, there is effort wasted in pushing observation of dispersion to great accuracy unless one learns at the same time how to predetermine, i.e., forecast, the meteorological conditions which (with a given effluent source) determine what the dispersion will be.

As instruments are installed and calibrated, their data become part of the growing microclimatology of Upton. In addition to the accumulation of data reported in previous reports, a master weather summary is now prepared which contains daily values of forty meteorological variables. This summary transcends the usual climatological summaries, since reports are available from several levels of observation on two towers, 420 and 160 feet high; the towers are connected 100 feet above the ground by an aerial cableway designed to carry instruments.

Forecasting experience and synoptic weather data, consisting largely of carefully analyzed maps and charts, are accumulating for correlation with Upton's microclimatology. The mere accumulation of either microclimatological or synoptic weather data is of little value without personnel experienced in their interpretation under stress of actual application. In the period prior to start-up of the reactor, this stress is supplied by the preparation and dissemination (to the Laboratory) of general and special weather forecasts. While these forecasts are of value in themselves, their primary worth is in the training of personnel for the forthcoming operations of the reactor.

First publication of unclassified research papers from the Meteorology Group* will follow shortly after their presentation at the Winter meetings of the American Meteorological Society in New York, January, 1949. These will include a new statistical approach to the theoretical problem of effluent dispersion in and by the atmosphere (P.H. Lowry), and a study of a new nonlinear partial differential equation applicable to the unsteady state when the property under discussion (temperature or matter) depends on time and one space coordinate (N.R. Beers).

A complete library research project, and the subsequent application to the Laboratory reactor of compiled meteorological data observed and computed for Upton, culminated in the approval by the Atomic Energy Commission's Reactor Safeguard Committee of the Laboratory's proposal for meteorological control of the operations of the air-cooled reactor on the Upton site.

Geological Studies**

During the period under review, much of the energy of the Geology Survey Group was devoted to planning and supervising the installation of a network of test holes and wells. These wells are not an end in themselves, but are necessary tools for the water level measurements, pumping tests, underflow and adsorption studies, and other geologic investigations essential to a detailed knowledge of subsurface conditions in the central part of Long Island.

The drilling program is approximately half completed. Twenty-five wells four inches in diameter and from 55 to 160 feet deep, and one 8-inch well that penetrates 1560 feet to bedrock, have been finished. Drilling of a second deep well ten inches in diameter has begun. During the next few months about two dozen shallower wells of varying depths and diameters will be added to the network.

Water level measurements are being taken weekly at some fifty wells on or near the Laboratory grounds, and three automatic, continuous water level recorders are in operation. Collection of this type of data will be expanded as additional wells become available. A crew from the Topographic Branch of the U.S. Geological Survey is expected to begin accurate determination of surface elevations at the well locations within a few weeks.

*See Appendix for full reference.

**Comprehensive statements of the reasons for geologic work at the Laboratory and an outline of the studies proposed were given in the Program Report, March 1948, and in Administrative Progress Report BNL-A-4.

Pumping tests and special wells for underflow measurements are an important part of the program, but these have been deferred until supervision of the drilling is less of a preoccupation for the staff of four geologists who are on detail to the Laboratory.

Sampling of surface and subsurface waters is proceeding slowly. About sixty samples have been sent to the Geological Survey laboratory in Washington for chemical analysis, including eight samples for determination of natural radioactivity content. Plans for conducting a substantial part of the sampling program as a routine at the Laboratory are under discussion.

Study of cores from the first deep well is proceeding. The discovery of several species of fossil Foraminifera may prove to be the long-needed key to establish a factual correlation of certain underground formations on Long Island, and, thereby, to replace the "educated guesswork" of the past. This would be of great value, not only to the geologic work at the Laboratory, but also in facilitating more positive conclusions regarding the stratigraphy of the central Atlantic littoral. Detailed study of these Foraminifera is being carried out as a possible thesis problem by a junior member of the Geology Survey Group. Micropaleontologists at the Woods Hole Oceanographic Institute and paleobotanists at Harvard University have indicated keen interest in procuring samples from the well cores. It is thus already evident that the network of wells will also be a significant aid to progress in collateral fields of science.

Economic Crop Survey

A start has been made in the program to secure data on the yield of the significant economic crops of the region before operation of the reactor begins. The broad aspects of the survey will provide basic crop yield data over a period of approximately five years within an area extending from Riverhead, approximately 15 miles east of the reactor, to Sayville, about the same distance west, and including the entire width of Long Island.

The Bureau of Agricultural Economics of the United States Department of Agriculture began, in November, a potato and vegetable survey of all farms in Suffolk County that produced, for sale during 1948, potatoes, melons, other vegetables, and strawberries. The Laboratory will have access to this data, which will furnish detailed information for the year 1948. To supplement data supplied by this survey, yield data are to be procured from the New York State Department of Agriculture and Markets, and also from local surveys made by the Suffolk County Agricultural Extension Service and the Department of Agricultural Economics of the New York State College of Agriculture. In addition, continuous crop yield estimates will be obtained from selected farms throughout the area, the locations of which are coordinated with the Laboratory's meteorological and radiation monitoring stations (J.S. White, R. Singleton, L.F. Nims, W. Jacobs, consultant).

DIRECT SERVICES

Completion of laboratories, growth of the scientific staff, and increase in research have had the expected impact upon those parts of the organization whose work is largely determined by requests from the scientific departments and projects, rather than being self-initiated. The work loads of the central and staff shops, of the central drafting room, and of the photography and graphic arts units have risen sharply. Yet, except for moderate expansion in order to staff the newly-activated heavy shop (Machine Shop B), the increase has been carried with only small additions of personnel. Productivity of the Laboratory in technical reports and in papers submitted to professional journals has taxed heavily the facilities for publication and distribution. Filling of intra-laboratory requisitions, to provide direct aid in the setting up of facilities or in the conduct of research, represents a continuing burden on the Carpenter and Cabinet Shops and the Electrical and Plumbing Sections, and also on the grounds crews which operate agricultural machinery for experimental work of the Biology Department. Such preoccupation with the scientific program has caused the Architectural Planning and Plant Maintenance Department to set aside until later some of its less critical routine maintenance functions.

Information and Publications

Personnel of the Information and Publications Division has increased by four, and now stands at 40. The Division occupies the same space as in June, but additional space for the Library will be needed soon. An adjacent vacant building is already in use for the storage of reports which are not in general demand. The Publications and Information Groups will likewise require additional working room. A small branch office of the Classified Library will be established in the Nuclear Reactor Building.

The basic collection of books and bound periodicals in the Research Library, totaling some 18,000 volumes, is now virtually complete. About 650 current periodicals have been procured. The Classified Library now has over 6,000 classified report titles. During the last half of the year, the number of loans from the Library increased to approximately 3500; more than a thousand questions were received by the reference desk since July 1.

Work on the translation of outstanding articles from the Russian scientific literature has begun; these translations are published in the Guide to Russian Scientific Periodical Literature. The Library is establishing a central repository of translated Russian documents, and other research organizations have demonstrated an interest in contributing to it. Lists of the titles of such translations will be circulated, so that photostat copies can be made available to interested parties on request.

The Weekly Selected Reading List now includes selections contributed by the Technical Information Branch of the Atomic Energy Commission at Oak Ridge, in addition to those made by scientists and Library personnel at the Laboratory. Sections covering electronics and engineering have recently been added to the list.

The Publications Group has processed 25 major reports and other documents during the period under review, not including the Russian Guide, the Weekly Bulletin, and the Reading List. In addition, approximately 50 manuscripts of papers for professional journals have been processed through the Publication Review Panel, the mechanics of which is centralized in this Division. The addition, during the summer, of an editor experienced in handling scientific manuscripts has considerably improved the quality and efficiency of these operations.

In accordance with policy worked out by the Technical Information Panel of the Commission, nominal charges are now placed on many of the documents produced by the Laboratory. This charge does not affect the free distribution of individual personal copies to 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. It does, however, cover production costs, to some extent, and serves as a check on unnecessary distribution. Early results indicate that in excess of a thousand dollars will be recovered in this way by the end of the fiscal year.

The Information Group has established a reference library of organization manuals and charts, personnel rosters, catalogues, and telephone directories of the Atomic Energy Commission laboratories and offices, of colleges and universities, and of other industrial and Government organizations throughout the country.

During the summer, the Division was an active participant in arrangements for colloquia and conferences, and it has been responsible for publishing compendia of the papers and discussions. (See Appendix.)

A project for the compilation of data on the properties of the atomic nuclei is attracting wide interest. This is being carried out with the assistance of scientists of the Chemistry and Physics Departments. The first compilation in the series, Spins, Magnetic Moments, and Electrical Quadrupole Moments, BNL-I-5, has already been issued. Future issues will include data on neutron cross sections, energy levels, properties of radioactive isotopes, and range-energy ionizations. A revised compilation, List of High Energy Particle Accelerators, which includes data on foreign installations, was published during the summer.

Bibliographic and reference services, abstracting and translating, and the compilation of technical data, in addition to the routine service functions of cataloging and circulation, are expected to represent increasingly important aspects of the work of the Research Library.

The increase in publications activities is reflected in the operations of the Patent Engineer's office. The manuscripts of approximately 100 papers submitted for publication review have been examined during the calendar year, to determine whether possibly patentable items were disclosed therein, and to insure proper reporting of such items to the Atomic Energy Commission. The Patent Engineer has maintained continuing close touch with the scientific program in order to identify items for which the Laboratory may have a patent responsibility under the terms of its contract, and to report these to the Commission insofar as possible, at least in brief, in advance of publication. A large number of the items were found to lack novelty; but 95 were deemed to possess sufficient novelty to warrant further action,

and were set up as preliminary cases. Four of these developed directly into formal reports to the Commission; 33 others have been reported in brief. The Commission has carried two cases through to the stage of filing patent application and assignment by the inventors, and has decided to file applications on four additional cases.

Photography and Graphic Arts

In the interest of developing closer integration of related activities, the Photography and Graphic Arts Group was transferred from the Technical Services Division of the Business Department to direct administrative supervision of the Executive Assistant to the Director, who is also responsible for coordination of information and publications activities. Increased activity and the procurement of additional equipment have made the problem of space for this Group even more critical than it was in July. The new facilities include a process camera, offset plate-making equipment, microfilm equipment which is now in operation, and an additional one-page offset press.

The Group is now doing considerable service work of a "drug store" type. In the period under review, it processed approximately four and a half miles of recording film from the area monitoring stations, from the meteorology operations, and from cameras set to record oscilloscope studies. The requirements for photographic documenting of construction progress, and of the development of new equipment, have been heavy. There has been an 80% increase in the number of photographic prints, so that the average production of these is in excess of 2,000 per month. A short classified motion picture film was produced for the Nuclear Reactor Project.

Requirements for lantern slides and projection services, in connection with the presentation of scientific papers at colloquia, conferences, and professional meetings, and in connection with activities of the Speakers Bureau, show a marked increase. During the last half of the year, the Photography and Graphic Arts Group produced nearly a thousand lantern slides and handled over a hundred requests for projection service.

Increased publications activities have resulted in an increase of more than 50% in the number of offset pages. For the last half of 1948, the number was 891,002, and the prospects are that, for a comparable period, the total will soon be well in excess of a million. The staff artists have prepared illustrations and layouts for 17 major reports, as well as material for lantern slides, posters, and other miscellaneous uses.

Shops and Drafting

The work load of the shops has increased approximately 66%, but there was a net increase of only five in personnel since June. A contaminated materials shop is in full operation. The special materials shop was tooled for peculiar requirements of the Nuclear Reactor Project, and is producing work that involves thousands of pieces. During the last six months, the shops have been asked to do more instrument

General Machine Shop B (heavy shop).

and machine design work, in addition to tool designing. The backlog of shop work has more than doubled, and additional personnel will be needed.

Personnel in the Drafting Group now numbers 24, representing an increase of 2. A total of approximately 14,340 man-hours were expended in the production of 781 detail and assembly drawings which were released to the shops for production. This represents an average of 19.5 hours per drawing, as compared with 16 hours reported for the previous six months. These figures indicate the growing demand on the central drafting facilities for original design work of increasing complexity. Drafting by personnel on detail to the Accelerator and Nuclear Reactor Projects and to the Electronics Division accounts for more than half of the total figures.

ADMINISTRATION AND MAINTENANCE

Architectural Planning and Plant Maintenance

Personnel of the Architectural Planning and Plant Maintenance Department now numbers 406, indicating a net decrease of 22 from the June 30 total. This decrease is partly accounted for by organizational changes, such as the transfer of the Telephone Section to the Office Services Group of the Business Department, and by reduction in personnel of the Fire Department and the Motor Pool. Other organizational changes have resulted in the elimination of one of the two divisions of the Department and the inclusion of the Transportation Group in the Building and Grounds Division. The Fire Department and the Alarms Maintenance Sections now report directly to the Department Manager, as does the Architectural Design Group, which remains as previously constituted.

During the last half of the year, the Architectural Design Group furnished complete architectural and engineering services for thirteen buildings, and acted as consultant for two others. Fifteen buildings or building additions were placed in actual operation. Of these, one was new and the remainder were modified existing buildings. Total area provided by these additional facilities constitutes an 8.5% increase in space actively used by the Laboratory. In addition to facilities placed in operation, the Department, through its own Architectural Design Group, is working on modifications for new construction involving nineteen buildings and thirty-six utilities installations; through outside architect-engineers, it is working on nine more new buildings and three utilities installations.

The Department's routine maintenance functions are being carried on as outlined in Reports BNL-A-2 and BNL-A-4. No new maintenance facilities have been added, and the over-all strength of the Buildings and Grounds Division has undergone little change.

An analysis of 1,495 intra-laboratory requisitions processed by the Buildings and Grounds Division during the last six months indicates some change in the type of work requested. Of the 1,276 requisitions handled in the previous six months, the largest single group of requests were for such things as installation of partitions and attendant utilities, or for fabrication and installation of benches, fume hoods, and other necessary adjuncts to research. The last six months have shown a refinement of this work. Many requests now are for extensions of utilities already installed, or the fabrication of experimental apparatus. The magnitude of the average work order has decreased, so that the total man-days devoted to intra-laboratory requests have been fewer than in the first half of the year. In contrast to the general trend, however, requests for service by the Riggers and Movers Section have nearly tripled. This increase was mainly in the removal and storage of radioactive waste, but it does not yet involve a large number of man-days.

An over-all decrease, from 4,945 to 3,488, in man-days devoted to intra-laboratory requests allowed the Buildings and Grounds Division to pay increased attention to deferred maintenance on important buildings, and to pick up the maintenance load from

new facilities and from the Apartment Area. The rise in the maintenance load is reflected by an increase in the number of man-days spent on maintenance -- 4,798 for the January-June period, 5,663 for the July-December period. This trend may be expected to continue as the number of buildings in use continues to rise, and with it the number of utilities installations required. Reduction of staff to such a level that routine maintenance and some preventive maintenance cannot be accomplished would be false economy.

One of the Division's principal maintenance problems will soon develop in connection with the new facilities in the Rutherford Hill area. Studies now being made indicate that additional personnel will be required as soon as the reactor complex, the cyclotron building, the new high pressure heating plant, and the new transformer station are activated.

Another problem to which serious study is being given is that of the necessary maintenance procedures for areas of possible radioactive contamination, so that equipment and tools can be properly checked and action taken to prevent the spread of contamination to other parts of the Laboratory.

Conspicuous economies have been effected in the operations of the Transportation Group. Substantial savings have been made through increased use of self-driver cars. Prior to July 1, three sedans were available for self-driver purposes. By the end of the year, continued scanning of passenger car use had resulted in increasing to nine the number of cars available to self-drivers. Self-driver mileage increased from 14,573 miles in the first half of 1948 to 39,363 miles in the second half.

A corresponding reduction has been effected in the number of drivers -- from 22 on January 1, 1948, to 14 on December 31, 1948. Although this is an apparent reduction of 26%, the actual reduction is much sharper. Since 7 of these drivers are constantly employed on the movement of material for the Materials Control Group, there has been an actual reduction of drivers available for general purposes from 15 to 7, or more than 50%. The 7 drivers currently used cover courier trips to New York, daily bus trips to Patchogue, and other fixed and necessary runs. This leaves but three to four drivers available for special dispatches. By consolidation in scheduling, and by assignment of cars to frequent users, passenger vehicle dispatches have been reduced from 2,703 for the first six months of 1948 to 1,289 for the last six months -- a reduction of 52.3%.

Since July 1, 1948, a total of 25 new sedans and station wagons have been received as replacements for similar worn-out vehicles. Largely as a result of this, the cost of repair parts has dropped 17.5%. A decreased work load resulting from the acquisition of the new vehicles, together with minor administrative changes, have also made possible a reduction in personnel of the Motor Vehicle Maintenance Section from 25 to 18.

The Fire Department's activities are as last reported. Personnel has been reduced from 72 to 66; further reduction to 61, through transfer of ambulance operations to the Police Group, is expected.

In addition to its normal functions, the Radio and Alarms Maintenance Section has spent a good deal of time on the installation of a new radio transmitter, with 11 mobile

units, for use by the Police and Fire Departments. The transmitter formerly used by these groups has been relocated in the meteorology building; mobile units have been installed in two vehicles for the Meteorology Group, and in one vehicle for the Health Physics Group.

Business Management

The Business Department has a staff of 307. There was a net decrease of 43, or 12.8%, from the June 30 total.* This is accounted for in part by organizational changes, in part by nonreplacement of employees who left the Department. Work done by former employees has been distributed among those who remained. However, the increasing amount of work in the Fiscal Division, Central Shops Group, and Drafting Group will soon require additional staff at these points.

The past six months constituted the first reporting period in which the major functions of the Department -- contract negotiation, budget preparation, contract supervision, record keeping, purchasing, materials control, drafting, management of the central shops, fiscal and accounting operations, and office services -- were fully established. Consequently, steady concentration on the training of personnel and improvement of methods is now possible.

During the report period, the Department negotiated 233 contractual instruments. These instruments included such diverse items as research subcontracts for balloon flights, aerodynamic tests, equipment design and manufacture, and test well drillings; material supply subcontracts for steel fabrication, magnet coil winding, building of mass spectrometers, velocity selectors, and periscopes; and service agreements covering the use of railroad sidings, or private property and facilities, and the installation of a dial telephone system.

Development and reworking of budgets for the current fiscal year, and projection of budgets for the next few years, are continuing tasks. During the past six months, budget estimates for the fiscal years 1950 and 1951, and preliminary statements of program for the same years, were prepared and submitted at the request of the Atomic Energy Commission.

At the end of November, the Commission's approval was received to complete the entire reactor complex at a figure approximately 15% above previous estimates. To cover this increase, \$500,000 was contributed by the Laboratory from its current operating budget. Such a reduction in the 1949 operating budget was made possible by delays in the scheduled availability of certain facilities. This delay, in turn, slowed up recruitment activities, and thereby reduced the volume of contemplated expenditures for salaries and wages, consultant subcontracts, insurance, power, and other expenses. Since January 1947, the Laboratory has placed thousands of small purchase orders in addition to the aforementioned subcontracts. Together they represent a total value of commitments in excess of twenty-seven million dollars. The monthly rate of expenditures against these is now well above two million dollars.

During the period under consideration, numerous physical and methodological changes have been initiated by the Fiscal Division. The Payroll Section was moved to

*Since staff shops were placed under the direct supervision of the scientific departments and projects in June, and the Photography and Graphic Arts Group was later placed under administrative supervision of the Director's Office, manpower figures for these units are not included in the December 31 figures.

larger quarters in the same building to provide vital space and soundproofing for its machine work. The initiation of the retirement plan increased the work load, but this addition was absorbed without additional personnel. On July 1, the General Ledger Section began to post to the general ledger, on the basis of commitments and expenditures against budgeted amounts. The management is thus provided with a consolidated group of books combining fiscal and budgetary data. In addition, this Section prepares the monthly Fiscal Budgetary Report and processes contract payments and stores issues.

The Internal Audit Section, inaugurated before June 30, has grown appreciably. The main audit work involves payments on contracts and subcontracts and examination of overhead charges of subcontractors. Audits are also made of cash receipts and other Laboratory fiscal operations; and some of the concessions, such as the Cafeteria, are also audited.

No change has occurred in the size of the Purchasing Group. The level of purchase orders remains rather high, averaging about 1100 per month, and representing a dollar volume of close to half a million per month. It is expected that this dollar rate will decrease slightly during the coming year, but that it will continue at a fairly high level until all of the facilities are in operation and the laboratories are fully equipped.

The work load of the Materials Control Group has not changed appreciably. This unit has been assigned the task of pricing stores issues, a function previously performed by the Fiscal Division. Deliveries of stores issues to requisitioning departments represent approximately 80% of all stores issues processed.

The Office Services Group, with a staff of 41, continues to perform a variety of essential functions. The mail and messenger service renders 23 distinct services -- from mail handling and pickup to parcel wrapping and dictaphone cylinder shaving. Although mail deliveries throughout the Laboratory have been reduced 50%, the volume of mail handled has increased appreciably to a monthly average of approximately 130,000 pieces. Thousands of additional items were handled by special messenger.

Other services rendered by the Group include 2000 repairs on 52 different types of machines, cutting 2800 duplicator stencils, collating and stapling 124,000 sheets, cutting 4500 new graphotype plates, and running 500 jobs on the Addressograph machine. The stenographic pool averages 300 assignments of varying duration per month, and continues to serve as a training school for some of the incoming secretaries and stenographers.

On December 1, the Office Services Group assumed direction of all details of the telephone services. Late in November, a dial system was installed and placed in operation. Since October 1947, the number of telephone operators has been reduced from 12 to 8; yet during the last six months alone, the daily number of calls has increased from 4000 to 5500.

More detailed discussion of the operations of the Business Department, including summary statistics for the entire fiscal year 1948-49, will be given in the Progress Report to be issued in July 1949.

Personnel

The number of Laboratory employees at the end of 1948 was 1347 -- a net gain of 25 over the total as of June 30, 1948, and a net gain of 202 over the total as of December 31, 1947. The average monthly rate of net accessions during the last half of 1948 was 0.3%, compared to 3.7% for the same period in 1947 and 2.4% for the first half of 1948. The slower rate of accessions reflects the stabilization of the administrative and service staffs, as well as the postponement in hiring of supporting personnel for the scientific staff, pending completion of planned Laboratory facilities.

The average monthly turnover rate for the year 1948 was 2.2%. The rate for the past six months was also 2.2%, which compares with a rate of 3.9% for the last six months of 1947.

The ratio of scientists to nonscientists at the end of 1948 was 1 to 5.8, reflecting a continuation of the trend shown by ratios of 1 to 6.2 on June 30, 1948, 1 to 7.3 on December 31, 1947, and 1 to 13.6 on June 30, 1947.

With the decrease in accessions, there was an increase in the percentage of locally-recruited new employees. This minimized the effect of the housing shortage on employment of technicians and skilled tradesmen. As additional Laboratory facilities are completed, however, the number of persons required to staff those facilities is expected to be such that the shortage of housing may well become a controlling factor in recruitment.

The services rendered by the Housing Office during the past six months continued at relatively the same level as during the first six months of the year. Fifteen members of the staff were assisted in purchasing homes, and 57 in arranging leases of houses and apartments. These totals compare with 26 purchases, 55 leases, and 6 room rentals arranged during the first six months of 1948, and 38 purchases, 70 leases, and 20 room rentals arranged during the last half of 1947. Receipts from properties controlled by the Laboratory (apartments, dormitories, guest house, and Lindenmere) were \$44,323 for the past six months, compared to \$35,352 for the same period of 1947, and \$36,396 for the first six months of 1948.

As of December 1, 1948, the total scientific staff numbered over 200. It comprised 19 senior members with tenure, 94 scientists on term appointment, 60 members in the service and operating staff, and 13 appointees on leave from other institutions, including 7 senior staff members, and 12 research fellows, 11 of whom are carrying out doctoral investigations. More than a dozen additional appointments have been committed.

Acquisition of scientific personnel was slowed appreciably during this period because of unavoidable delays in the provision of both laboratory space and laboratory facilities. Active interest on the part of scientists in exploring possibilities for working at the Laboratory has, however, continued. During the last half of 1948, the scientific personnel office received approximately 400 new applications, and interviewed more than 300 individuals for employment. In appointing scientific personnel, the Laboratory is giving primary consideration to scientists who, through experience and interest, are attracted by the opportunities for research which will be afforded by the major facilities.

During the six months period, 63 offers of appointments to the scientific staff were made. Twenty of these were in the form of consultant contracts to scientists from 14 different institutions. Thirty-three of the remaining 43 offers have been accepted, distributed as follows: 6 senior scientists, 10 term appointments to the rotating staff, 8 indefinite appointments to the operating staff, 7 research fellows, and 2 visiting engineers.

The contracts of 92 consultants expired at the end of the year, but 62 of them have been renewed; these represent affiliations with 21 different institutions. During the summer, temporary appointments were arranged for 33 scientists from 19 different institutions.

A job evaluation program, begun early in 1948, was completed for all hourly and weekly paid employees. The objectives of this program are: 1) to review all job classifications in use, 2) to obtain job descriptions based on duties actually performed, 3) to determine the relative values of these duties in terms of accepted job measurements, and 4) by survey of wages and salaries for jobs of like content, to establish a schedule which is in line with the going rates in this area for similar occupations. The evaluation of some monthly jobs will be carried on during 1949, along with a continuing program to insure that the wage and salary schedules will reflect changing conditions.

The Laboratory's retirement plan was approved and announced during July. This is a contributory plan, available to all employees, which provides for individual annuity contracts with the Teachers Insurance and Annuity Association. As of the end of 1948, approximately one third of the Laboratory staff was participating. The number is expected to increase considerably during 1949. Over 93% of the staff were participating in the group life insurance plan; individual membership in the Blue Cross hospitalization plan continued at over 75%.

Efforts on the part of all supervisors and employees, in cooperation with the Safety Group, reduced the frequency of disabling accidents in 1948 by approximately 50%. The rate for 1948 was 7.64 hours lost per million man-hours worked, compared to a rate of 14.82 for 1947. Likewise, the severity rate was reduced approximately 50%. During 1948, three periods of more than one month each were free from disabling accidents. The longest period was for 50 days. Doubling this period is a minimum goal for 1949. Equipment for the establishment of an industrial hygiene laboratory has been procured. Agreement was reached on the Laboratory's fire control program in conference with representatives of the Atomic Energy Commission. The review of construction and alteration plans by the Safety Engineer continued to provide for improvements in safety measures at a time when costs are minimal; this review procedure is considered to have been a main factor in the low 1948 fire loss ratio of .00033.

As a result of the collective bargaining election held by the National Labor Relations Board on November 19, Federal Labor Union #24426, American Federation of Labor, was certified as the collective bargaining agent of all weekly and hourly employees in the Architectural Planning and Plant Maintenance Department and the Technical Services Division, excluding employees of the Purchasing, Design, and Drafting Groups. Tabulation of results showed that 478 of the 529 eligible voters had cast ballots -- 288 for the union and 190 against it. Contract negotiation is expected to start early in 1949.

The Brookhaven Employee's Recreation Association completed its first full year of operation with outstanding achievement. The activities originally sponsored by the Personnel Division were taken over and directed by the trustee representatives of the Association, under the general supervision of the Personnel Division, and were expanded to provide for all types of interests. Proceeds from the operation of concessions granted by the Laboratory, and from individual events sponsored by the Association, made it possible for the Association to carry out its program since the beginning of the current fiscal year without direct subsidy from the Laboratory.

On September 13 and 14, a conference of personnel representatives of the Commission and its major contractors was held at the Laboratory. This followed an earlier conference, at Los Alamos, attended by personnel representatives of university contractors. The purpose of these conferences was to work toward development and use of more effective personnel policies and methods through interchange and discussion of personnel information.

Security and Plant Protection

The Laboratory site has 28 miles of roads and more than 300 buildings, most of which are now in use. Including the employees of subcontractors, it has a daily average of several thousand persons at work. From 50 to 200 transient visitors go through its gates every day. It has colonies of dormitories and apartments that provide on-site residences for hundreds of people. The Laboratory has, therefore, fully as many normal problems of law and order, and the protection of life and property, as can be found in a large town, or in an industrial plant of comparable size. Additional complications arise because millions of dollars worth of Government property, for which the Laboratory is accountable, are stored in the warehouses or installed in the buildings. Moreover, the many problems entailed in safeguarding restricted data and other classified material create a whole set of special requirements for security personnel. In such a community, the hazards of traffic, accidents, fires, thefts, espionage, or sabotage are out of all proportion to the geographic size of the area.

If the entire Laboratory site had been declared a more restricted area and surrounded by a fence, with only one or two points of entrance, the number of security guards could have been substantially reduced. It has been the firm intention of Associated Universities, Inc. and of the Atomic Energy Commission, however, that insofar as possible, the major part of the site should remain an open area, like a university, within which appropriate security measures would be rigidly enforced at those places where classified information, facilities, or project operations are necessarily located. Although there has been a conscious effort to hold to a minimum the number of separate localities which must become "exclusion" areas, it is apparently inevitable at this stage in the Laboratory's history that they should have multiplied. This has required continuing expansion in the force of security and plant protection officers. That trend cannot be reversed, without jeopardizing both national security and the protection of Government property, until the Laboratory can consolidate into a few large new buildings the scientific and administrative activities now distributed among many buildings, extending over an area more than two miles in diameter.

During the past six months, personnel of the Security Office remained constant at 6. There was an increase of 17 in the Police Group. This represents a rise of 15%;

but the number of detailed assignments required of the Police has increased about 40%. The force is not yet up to authorized strength because of the difficulty of procuring and retaining properly qualified individuals. Consequently, in order to cover the many situations which are the responsibility of this Group, there has been a greater use of overtime than is desirable. Completion of the reactor complex, now almost entirely under guard by the subcontractor's special security police, may necessitate a further personnel increase of 15 or 20% in the Police Group -- unless consolidation of activities, which does not appear possible at present, can somehow be accomplished. The problem of preventing the growth of security manpower from becoming a drain on funds which should be devoted to scientific work, and of simultaneously providing adequate security and protection, as required by regulations of the Commission, is one which receives continual study.

The security and police program of the Laboratory involves four major, closely interrelated aspects: a) personnel clearances and security indoctrination, b) protection of classified information and materials, c) control of visitors, and d) plant protection against theft, misuse or destruction of property, and public nuisance.

Late in the year, the Atomic Energy Commission delegated greater responsibility for the processing of personnel clearances to its major Operations Offices. This has already noticeably speeded up the handling of clearances requested by the Laboratory. The time limits for normal processing remain at 14 days for "P" clearance approval and 60 days for "Q" clearance; but there are now fewer cases which extend beyond those limits.

Security indoctrination of Laboratory employees has continued on a personalized basis. Results of such a program cannot be measured entirely by material facts. However, the number of minor infractions of the rules for handling files and documents has decreased about 50% during the past six months.

Measures are continually being taken to improve the physical security of restricted areas. Physical devices have their function in discouraging vandalism and misguided curiosity, and possibly in preventing some low-level efforts at espionage or sabotage, but it is axiomatic that the real protection of national security depends to a far greater extent on the enlightened cooperation and continual vigilance of the scores of employees who have classified items entrusted to them. Care in establishing clearances and the continuous security indoctrination of new personnel are more difficult, yet more effective, means of insuring national interest. It should be stressed here, as it has been elsewhere, that rapid and sustained scientific progress may in the long run be far more significant in retaining an advantage over potential enemies than are all the means for concealing what is already known. Consequently, intelligent administration of security measures must be based on realistic evaluation of risks, rather than on application of rule-of-thumb techniques.

Methods for controlling visitors to the site are generally not apparent to a casual visitor or investigator, but they exist and will continue to be exercised. There were approximately twice as many visitors during the busy summer conference period as during the winter. In July, a peak of over 2600 visitors was recorded. Conferees, persons seeking employment, salesmen, and visitors to subcontractors constitute the major groups of these transients.

A Police Group School was instituted late in the fall. This involved a series of classroom sessions which provided 20 hours of special training for everyone on the force. Final examinations, the results of which will be taken into account in promotions and salary increases, are in progress. It is expected that refresher courses will be required from time to time.

The Security Office and the Police Group have spent many man-hours in investigative work, in connection with accidents, petty thefts, infractions of security regulations, traffic violations, small fires, and other situations which commonly develop in a community of this size. Ninety-nine such investigations were conducted during the month of December alone. Experience at the Laboratory shows, as is true elsewhere, that insufficient staff to carry out ordinary functions of a municipal police force, or relaxation of effort in investigating petty offenses, is soon followed by an increase in minor violations that can quickly lead to major ones.

Two thefts that occurred in the fall have been completely solved. Both culprits were apprehended, tried, and sentenced in the Federal Court.

APPENDIX

UNCLASSIFIED PUBLICATIONS, JULY 1 - DECEMBER 31, 1948*

General Publications

Administrative Progress Report, January-July, 1948 (BNL-A-4)

Scientific Progress Report, January-July, 1948 (BNL-S-4)

Brookhaven Conference Reports:

Biology Conference, July 12-30, 1948 (In press.) (BNL-C-4)

Symposium on Radioiodine, July 28-30, 1948 (BNL-C-5)

Gas Discharge Conference, October 27-29, 1948 (BNL-C-6)

Conference on the Chemical Effects of Nuclear Transformations (Hot Atom Chemistry) (Chemistry Conference #1), August 19-20, 1948 (BNL-C-7)

Guide to Russian Scientific Periodical Literature 1, #4, 5, 6; (BNL-L-54, 55, 56)

Weekly Bulletin 1, #48-51; 2, #1-22

Weekly Selected Reading List 1, #17-42

Staff Publications and Abstracts

Ballentine, R. (Co-author, W. Bernstein)

Method for monitoring $C^{14}O_2$ air contamination (BNL-T-5)

Beers, N.R. (Co-author, P.H. Lowry)

Summary of current operations of the Meteorology Group, Nuclear Reactor Project (BNL-I-2)

Beers, N.R.

Some practical and theoretical aspects of meteorological control and atmospheric eddy transfer (A)
American Meteorological Society Meeting, New York, January 27, 1949

Bernstein, W. (Co-author, R. Ballentine)

Method for monitoring $C^{14}O_2$ air contamination (BNL-T-5)

Bernstein, W.

Proportional counter equipment for beta detection (A)
Session on Nuclear Instrumentation, I.R.E. Convention, New York, March 10, 1949

Bigeleisen, J.

Isotope effect in the decarboxylation of labeled malonic acids (L)
Journal of Chemical Physics (In press.)

Bigeleisen, J.

Isotope effect in the rupture of carbon-carbon bonds in propane-1- C^{13} (L)
Journal of Chemical Physics (In press.)

*This list includes official Laboratory publications, publications by staff members 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. (A) indicates abstract; (L) letter to the editor; and (N) note.

- Bigeleisen, J.
The validity of the use of tracers to follow chemical reactions
Science (In press.)
- Bigeleisen, J.
The relative reaction velocities of isotopic molecules
Journal of Chemical Physics (In press.)
- Blachman, N.M. (Co-author, E.D. Courant)
Correction and addendum: Scattering of particles by the gas in a synchrotron (L)
Physical Review 75, 315 (1949)
- Blau, M. (Co-author, J.A. De Felice)
Development of thick emulsions by a two-bath method
Physical Review 74, 1198 (1948)
- Blewett, J. (Co-author, M. Plotkin)
Ferromagnetic ferrites for a cosmotron accelerating unit (A)
American Physical Society Meeting, New York, January 26-29, 1949
- Blewett, J.
Propagation of electromagnetic waves guided by magnetic materials (A)
American Physical Society Meeting, New York, January 26-29, 1949
- Blewett, M.H.
Effects of eddy currents on the field of the cosmotron magnet
American Physical Society Meeting, New York, January 26-29, 1949
- Borst, L.B. (Co-author, J.J. Floyd)
The radioactive decay of K^{40} (L)
Physical Review 74, 989 (1948)
- Borst, L.B., et al.
Nuclear reactor at Brookhaven National Laboratory (L)
Physical Review 74, 1883 (1948)
- Borst, L.B.
Nuclear reactor at Brookhaven National Laboratory (A)
American Physical Society Meeting, Chicago, November 26-27, 1948
- Borst, L.B. (Co-authors, J.J. Floyd and C.D. Coryell)
The radioactive decay of K^{40} (A)
American Physical Society Meeting, Chicago, November 26-27, 1948
- Bowen, V.
Barium metabolism in hornets by means of radioisotopes (A)
Transactions of the New York Academy of Science (In press.)
- Collins, G.B.
Decay times of scintillations
Physical Review 74, 1543 (1948)
- Coryell, C.D. (Co-authors, J.J. Floyd and L.B. Borst)
The radioactive decay of K^{40} (A)
American Physical Society Meeting, Chicago, November 26-27, 1948
- Courant, E.D. (Co-author, N.M. Blachman)
Correction and addendum: Scattering of particles by the gas in a synchrotron (L)
Physical Review 75, 315 (1949)
- Courant, E.D.
A resonance effect in the synchrotron
Journal of Applied Physics, April, 1949 (In press.)

- De Felice, J.A. (Co-author, M. Blau)
Development of thick emulsions by a two-bath method
Physical Review 74, 1198 (1948)
- Dollman, E.M. (Co-authors, E.O. Salant and J. Hornbostel)
Tracks in emulsions at 100,000 feet (L)
Physical Review 74, 694 (1948)
- Donoghue, W.F. (Co-authors, E.M. Hafner and H.S. Snyder)
A new proton spectrometer (A)
American Physical Society Meeting, Chicago, November 26-27, 1948
- Edelmann, A.
Some effects of X radiation on water and electrolyte metabolism in the rat (A)
Proceedings of the Federation of Experimental Biologists, Detroit, April 18-22, 1949
- Elmore, W.C. (Co-author, R. Hofstadter)
Temperature dependence of scintillations in sodium iodide crystals
Physical Review 75, 203 (1949)
- Feshbach, H.
On Feenberg's perturbation formula
Physical Review 74, 1548 (1948)
- Floyd, J.J. (Co-author, L.B. Borst)
The radioactive decay of K^{40} (L)
Physical Review 74, 989 (1948)
- Floyd, J.J. (Co-authors, L.B. Borst and C.D. Coryell)
The radioactive decay of K^{40} (A)
American Physical Society Meeting, Chicago, November 26-27, 1948
- Friedlander, F. (Co-authors, M. Goldhaber and G.S. Goldhaber)
Long-lived metastable state of Te^{125}
Physical Review 74, 981 (1948)
- Friedlander, G. (Co-authors, R.D. Hill and G.S. Goldhaber)
Internal conversion electrons from metastable Te^{125} (L)
Physical Review 75, 324 (1949)
- Friedman, L. (Co-author, J. Turkevich)
The infrared absorption spectra of propane-D-1 and propane-D-2
Journal of Chemical Physics (In press.)
- Goldhaber, G.S.
Energy dependence of photoneutrons from deuterium as a function of angle and gamma-ray energy
(BNL-I-3)
- Goldhaber, G.S. (Co-authors, G. Friedlander and M. Goldhaber)
Long-lived metastable state of Te^{125}
Physical Review 74, 981 (1948)
- Goldhaber, G.S. (Co-authors, R.D. Hill and G. Friedlander)
Internal conversion electrons from metastable Te^{125} (L)
Physical Review 75, 324 (1949)
- Goldhaber, M. (Co-authors, G. Friedlander and G.S. Goldhaber)
Long-lived metastable state of Te^{125}
Physical Review 74, 981 (1948)
- Goldhaber, M.
Note on the spins of nuclei of mass number ten
Physical Review 74, 1194 (1948)

- Goldsmith, H.H. (Co-author, D.R. Inglis)
The properties of atomic nuclei. I. Spins, magnetic moments, and electrical quadrupole moments,
October 1, 1948 (BNL-I-5)
- Goudsmit, S.A.
A time of flight mass spectrometer (L)
Physical Review 74, 622 (1948)
- Goudsmit, S.A. (Co-author, W.T. Scott)
Proposed method for measuring scattering of particle tracks
Physical Review 74, 1537 (1948)
- Green, G.K. (Co-authors, H.S. Snyder and L.W. Smith)
Dynamic magnetic measurements on cosmotron magnet model (A)
American Physical Society Meeting, New York, January 26-29, 1949
- Hafner, E.M. (Co-authors, W.F. Donoghue and H.S. Snyder)
A new proton spectrometer (A)
American Physical Society Meeting, Chicago, November 26-27, 1948
- Higinbotham, W.
Stabilized high voltage supplies for chambers and counters
Proceedings of the Institute of Radio Engineers (In press.)
- Hofstadter, R.
Detection of neutrons with scintillation counters, November 1, 1948 (BNL-I-7)
- Hofstadter, R. (Co-author, W.C. Elmore)
Temperature dependence of scintillations in sodium iodide crystals
Physical Review 75, 203 (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)
American Physical Society Meeting, New York, January 26-29, 1949
- Hornbostel, J. (Co-authors, E.O. Salant and E.M. Dollman)
Tracks in emulsions at 100,000 feet (L)
Physical Review 74, 694 (1948)
- Inglis, D.R. (Co-author, H.H. Goldsmith)
The properties of atomic nuclei. I. Spins, magnetic moments, and electrical quadrupole moments,
October 1, 1948 (BNL-I-5)
- Johnson, T.H.
Photographic neutron detector of high sensitivity (A)
American Physical Society Meeting, New York, January 26-29, 1949
- Kragt, P.E.
Some wind and weather systems relevant to elevated source effluents at Brookhaven National Laboratory (A)
American Meteorological Society Meeting, New York, January 27, 1949
- Livingston, M.S.
High energy accelerator design (BNL-T-1)
- Lowry, P.H. (Co-author, N.R. Beers)
Summary of current operations of the Meteorology Group, Nuclear Reactor Project (BNL-I-2)
- Lowry, P.H.
Statistical analysis of data in the field of atmospheric diffusion (A)
American Meteorological Society Meeting, New York, January 27, 1949
- Madansky, L. (Co-author, R.W. Pidd)
The general properties of the parallel plate spark counter
Physical Review (In press.)

Mazzarella, D.A.

Observations and instrumentation of the Meteorology Group, Brookhaven National Laboratory (A)
American Meteorological Society Meeting, New York, January 27, 1949

Miller, W.W. (Co-authors, N. Zwiebel and J. Turkevich)

Preparation of radioactive CO_2 from BaCO_3 (N)
Journal of the American Chemical Society 71, 376-7 (1948)

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)
American Physical Society Meeting, New York, January 26-29, 1949

Ottolenghi, L.A. (Co-authors, R. Steele, and T. Sfortunato)

A micro method for the determination of the nucleic acids, August 15, 1948 (BNL-T-3)
Journal of Biological Chemistry 177, #1, 231-5 (1949)

Piccioni, O.

π - μ meson distinction by G-M counters
American Physical Society Meeting, New York, January 26-29, 1949

Pidd, R.W. (Co-author, L. Madansky)

The general properties of the parallel plate spark counter
Physical Review (In press.)

Plotkin, M. (Co-author, J. Blewett)

Ferromagnetic ferrites for a cosmotron accelerating unit (A)
American Physical Society Meeting, New York, January 26-29, 1949

Richards, P.I.

Notes on Feenberg's series -- rearrangements (L)
Physical Review 74, 835 (1948)

Rubin, B.A.

Detection of the mutagenic effect of transmutation (A)
Genetics 33, 626-7 (1948)

Rubin, B.A.

Detection of the mutagenic effect of transmutation
Records of the Genetic Society of America, #17, 55-6 (1948)

Rubinson, W.

The equations of radioactive transformation in a neutron flux
Journal of Chemical Physics (In press.)

Sacks, J. (Co-author, S. Stigman)

The turnover rates of the acid-soluble phosphorus compounds of liver (A)
Proceedings of the Federation of Experimental Biologists, Detroit, April 18-22, 1949

Sacks, J.

An all-glass filtration apparatus for radioactive tracer experiments (BNL-T-4)
Analytical Chemistry (In press.)

Safford, R.W.

Path of mesons in high pressure cloud chamber with intense magnetic field, June, 1948 (BNL-I-1)

Safford, R.W. (Co-author, A.M. Thorndike)

A cosmic ray particle of charge two or greater
Physical Review (In press.)

Salant, E.O. (Co-authors, J. Hornbostel and E.M. Dollman)

Tracks in emulsions at 100,000 feet (L)
Physical Review 74, 694 (1948)

Schwartz, H.M.

Notes on the differential equation $Y^{11}(x) + h(x, \lambda)Y = 0, 1$. Preliminary report
American Mathematical Society Meeting, Columbus, Ohio, December 28-31, 1948

- Scott, W.T. (Co-author, S.A. Goudsmit)
Proposed method for measuring scattering of particle tracks
Physical Review 74, 1537 (1948)
- Scott, W.T. (Co-author, H.S. Snyder)
New calculations of multiple scattering (A)
American Physical Society Meeting, New York, January 26-29, 1949
- Scott, W.T.
The statistical distribution of arc-chord difference in scattered particle tracks (A)
American Physical Society Meeting, New York, January 26-29, 1949
- Sfortunato, R. (Co-authors, L.A. Ottolenghi, R. Steele)
A micro method for the determination of the nucleic acids, August 15, 1948 (BNL-T-3)
Journal of Biological Chemistry 177, #1, 231-5 (1949)
- Shutt, R.P. (Co-authors, G.R. Hoke, W.A. Tuttle, G.F. O'Neill)
Some cloud chamber photographs obtained with a high pressure cloud chamber (A)
American Physical Society Meeting, New York, January 26-29, 1949
- Smith, L.W. (Co-authors, G.K. Green and H.S. Snyder)
Dynamic magnetic measurements on cosmotron magnet model (A)
American Physical Society Meeting, New York, January 26-29, 1949
- Smith, M.E.
General and micrometeorological forecasting (A)
American Meteorological Society Meeting, New York, January 27, 1949
- Snyder, H.S. (Co-authors, G.K. Green and L.W. Smith)
Dynamic magnetic measurements on cosmotron magnet model (A)
American Physical Society Meeting, New York, January 26-29, 1949
- Snyder, H.S. (Co-author, W.T. Scott)
New calculations of multiple scattering (A)
American Physical Society Meeting, New York, January 26-29, 1949
- Snyder, H.S. (Co-authors, W.F. Donoghue and E.M. Hafner)
A new proton spectrometer (A)
American Physical Society Meeting, Chicago, November 26-27, 1948
- Snyder, H.S.
Cascade theory
Physical Review (In press.)
- Stanford, S.C.
Problems involved in establishing and operating a technical library in a large research laboratory (A)
Presented at meetings of the Division of Chemical Education, American Chemical Society, Washington, August 31, 1948
- Sparrow, A.H.
Radiation sensitivity of cells during mitotic and meiotic cycles with emphasis on possible cytochemical changes
Annals of the New York Academy of Sciences (In press.)
- Steele, R. (Co-authors, L.A. Ottolenghi and T. Sfortunato)
A micro method for the determination of the nucleic acids, August 15, 1948 (BNL-T-3)
Journal of Biological Chemistry 177, #1, 231-5 (1949)
- Stigman, S. (Co-author, J. Sacks)
The turnover rates of the acid-soluble phosphorus compounds of liver (A)
Proceedings of the Federation of Experimental Biologists, Detroit, April 18-22, 1949
- Thorndike, A.M. (Co-author, R.W. Safford)
A cosmic ray particle of charge two or greater
Physical Review (In press.)

- Turkevich, J. (Co-author, L. Friedman)
The infrared absorption spectra of propane-D-1 and propane-D-2
Journal of Chemical Physics (In press.)
- Turkevich, J. (Co-authors, N. Zwiebel and W.W. Miller)
Preparation of radioactive CO_2 from BaCO_3 (N)
Journal of the American Chemical Society 71, 376-7 (1948)
- 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)
American Physical Society Meeting, New York, January 26-29, 1949
- Wanta, R.C.
Ground concentrations of pollution in an urban area from a known source (A)
American Meteorological Society Meeting, New York, January 27, 1949
- White, M.G.
Design of the Brookhaven high energy proton synchrotron (A)
American Physical Society Meeting, New York, January 26-29, 1949
- Williams, C.
Experimental facilities to be available at Brookhaven nuclear reactor (A)
American Physical Society Meeting, New York, January 26-29, 1949
- Zwiebel, N. (Co-authors, J. Turkevich and W.W. Miller)
Preparation of radioactive CO_2 from BaCO_3 (N)
Journal of the American Chemical Society 71, 376-7 (1948)