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UNIVERSITY OF CALIFORNIA

Radiation Laboratory

Contract No. W-7405-eng-48

PROGRESS REPORT No.69

December 15, 1948 to January 15, 1949

Berkeley, California

UNIVERSITY OF CALIFORNIA, RADIATION LABORATORY

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1. Bevatron

Operating Model. The magnet connections were completed and the entire magnet was energized January 14, 1949. Magnetic field measurements show azimuthal variations of about half of one percent, not including end effects, for the two quadrants so far tested. Vacuum testing has disclosed an unusually large number of leaks in the welded (magnetic) steel tangent tanks. This has delayed testing the first half quadrant. However, considerable manpower is now available since the 184 inch cyclotron proton conversion is now installed and running so that no delay in the completion date is yet indicated. The injector cyclotron core and coil drawings are in the shop.

Full Scale. Sizes for the magnet core plates have been determined and the plates required for a sample sector have been requisitioned. These are to be rolled in April and assembled in the cyclotron building. It is hoped that these plates can be cut and punched by the shop which will fabricate the full order. This will require placing the fabrication order by April. It has been decided to request an overhead wire gallery surrounding the magnet room just inside the crane columns with an extension running through the fan and pump rooms. Connection to the control room would be made overhead to a "pull room" above the relay racks. It was also decided that one bay of the shop and control section could be eliminated and that the control desk should be made most convenient for a single operator.

2. 184-inch Cyclotron Operation

This past month was devoted to the installation and testing of the proton unit.

The new unit produced deuterons of 160 Mev and protons of 300 Mev on December 22, 1948.

Protons of 350 Mev and deuterons of 195 Mev, which constitute the maximum energy of the cyclotron, were obtained by the end of the month.

3. 60-inch Cyclotron Operation

Two-thirds of the operating time of the 60-inch cyclotron was spent on bombardments requiring the use of alpha particles. Coincident with this operation, there developed a siege of short filament life, that is 2.3 hour average life, as compared with a normal of 6 - 8 hours. This condition is usually corrected by replacement of components that might have developed small water leaks, such as the filament holder. However, to date this remedy has not been effective. Within the last two weeks a decline in magnet field resonance has occurred, slowly changing from 289 amps to 275 amps on alphas. Check-ups of oscillator frequency and magnet coil resistance has provided no reason for this decline in magnet field resonance. Investigation of this problem is being continued.

4. Synchrotron Operation

Following the first production of a synchrotron beam, mentioned in the preceding report, the energy was worked up to 220 Mev by careful adjustment of the magnet. The machine was then disassembled and several improvements were made in the design of the compensating circuits, the flux bar bias windings, and other equipment which had been originally installed in a temporary manner. The direction of rotation of the beam was reversed in order to bring the x-ray beam out in a more desirable location.

Following reassembly, considerable time was spent in studying the effects of various combinations of adjustments on betatron beam intensity. Subsequent to turning on the oscillator a synchrotron beam of 300 Mev was obtained on January 17th. Following is a table of intensities at various energies as measured by an ionization chamber (standard RL Zeus meter) covered by 1/8" of lead and located 10 feet from the target. An additional 1/2" of lead was located in the beam about three feet from the target.

130 Mev	30 mr/hr
270 Mev	7 mr/hr
300 Mev	1 mr/hr

A flash performance under the above conditions at 280 Mev was obtained giving 15 mr/hr.

Two sets of nuclear plates have been exposed in the synchrotron beam. The exposures are not accurately known, but are believed to be greater than 10 mr. at 280 Mev for the second set. In this second set of plates a number of stars were observed. Additional exposures are planned using the least sensitive plates, for it was found that those having greater sensitivity were blackened by electrons.

5. Linear Accelerator and Van de Graaff Operation

The linear accelerator was returned to operation on the 21st of December, and has been used for thirty-two million volt bombardments daily since then. The machine was in operation a total of 214 hours or 88 percent of the available time. The beam current has been several times larger than before, the improvement due in part to changes in the Van de Graaff machine, and in part to the higher transparency focusing grids now used in the accelerator. Peak currents during the pulse of more than 1 μa (average beam 4 x 10^{-9} amp) are now common.

The Van de Graaff is operating very nicely as a steady-running machine. There were three minor shutdowns during the month, costing a total of 2-1/2 shifts. The accelerating tube is baked in to a degree where operation is possible without ice water on cool days. During the period December 21 to January 15, the beam was in use during 31-1/2 of the 33 shifts.

6. Experimental Physics

Film Program. Immediately upon completion of the cyclotron conversion to protons, mesons were found in photographic plates placed within the cyclotron tank, when a carbon target was bombarded with 300 Mev protons. Subsequent exposures have shown that the threshold for meson production by protons lies below 220 Mev; further investigation of the excitation function and the energy distribution has, however, been postponed, pending reduction of background tracks in the plates. A program is

underway to determine the origin of the background and the method of its reduction. Photographic emulsions suspended in the full energy neutron beam have yielded four events of actual meson creation within the emulsion itself. Two of the meson tracks (one of which ends in a star) are observed to originate from stars; the remaining two show no accompanying visible tracks at their origin.

Cloud Chamber. The efforts of the cloud chamber group have been divided among three main problems. Firstly, some photographs taken last month are being analyzed. From the analysis the energy and angular distributions of the protons and deuterons emitted by a carbon target in the neutron beam will be obtained. Secondly, an attempt has been made to operate a cloud chamber with the synchrotron, but it was found that the cloud chamber magnet disturbs the synchrotron so the magnet cannot be used, even with low counts, while the synchrotron is in operation. It is planned to move the cloud chamber magnet out into a tent about fifty feet from the synchrotron. Without the use of the magnet, however, some cloud chamber pictures of fast electrons were obtained. Thirdly, a cloud chamber has been operated in the neutron beam of the 184-inch cyclotron. This beam is produced when the 350 Mev protons strike a 2-inch copper target. Presumably there are neutrons having energies up to the full energy of the protons. With this arrangement the first cloud chamber pictures of artificial mesons were obtained. One meson track was found ending in a star.

High Energy Gamma Rays Emitted by Cyclotron Target During Bombardment. The gamma radiation in the region 20-105 Mev has been investigated by means of a pair counter. In the backward direction (relative to the direction of the bombarding particles) the yield per second in the region of 70 Mev has been found to be about 500 times greater in the case of 350 Mev protons than for 190 Mev deuterons. Assuming a proton current of .5 microamperes and spherical symmetry, the cross section for producing gammas between 30 and 105 Mev is about $3 \times 10^{-28} cm^2$ for Be, the target material used thus far. The distributions have the following general properties:

1. 190 Mev deuterons, backward direction: Yield decreases with energy of gamma, somewhat faster than 1/E.

2. 350 Mev protons, backward direction: Yield increases rapidly with energy from 20 to 60 or 70 Mev, then falls.

3. 350 Mev protons, forward direction: Yield increases slowly with energy from 45 Mev to 105 Mev, the highest energy yet investigated.

At present an attempt is being made to determine the corrections for scattering losses in the radiator and counters. Preliminary results indicate rough agreement with a single scattering process (as opposed to multiple scattering) in the Ta radiator (usually .02 radiation units thick).

Neutron Scattering by Nuclei. The results of the neutron elastic scattering experiments have been analyzed. Corrections to the angular distribution measurements for self absorption and multiple scattering in the scatterers have been made. The angular distributions as measured are not in disagreement with the theoretical angular distributions based on the partially transparent model of the nucleus worked out by Fernbach and Taylor of the theoretical group.

Application of Scintillation Counting to γ Detection. A new coincidence circuit was completed and tested but did not reduce the background count as expected from a decrease in resolution time. The reason for this failure is not yet known. A counter

has been assembled using a thin aluminum window so that it can be used to detect β's as well as γ's and is now ready for delivery to Donner Laboratory. It is well known that there is a wide variation in the signal to noise ratio of photo-multiplier tubes. Equipment is being assembled to test signal to noise ratio so that the most efficient tubes can be selected for this work.

Miscellaneous Experiments. Work has continued on the p-p scattering experiments with the linear accelerator. The existence of N^{12}, with a half-life of 12.5 milliseconds, has been proved. It emits 16.6 Mev positrons. Po^{209} has been discovered. It is an α emitter (5 Mev) of many years half life. Several new short life alpha activities have been detected in the alpha bombardment of lead. Other experiments in progress involve the three second period from Ni, the Ca^{38} activity, the inelastic scattering of protons on carbon, and the excitation of the $C^{12}(p,pn)$ reaction.

7. Theoretical Physics

New approximation methods have been developed for scattering calculations, which can be used, for example, for n-p scattering below 30 Mev, or for p-p scattering at high or low energy. A paper on this subject has been sent to the Physical Review. An explanation of the scattering cross sections of 90 Mev neutrons has been completed. The data can be fitted supposing a neutron potential energy in the nucleus of 30 Mev, and a mean free path in nuclear matter between 3 and 5 x 10^{-13} cm. A paper on this has also been sent to the Physical Review. Numerous calculations on scattering, meson production, etc. of the 350 Mev particles are in progress. The bremstrahlung due to the proton and neutron magnetic moments has been estimated, and is thought to be the origin of x-rays which have been observed. Work on the requirements for bevatron injection is continuing.

8. Isotope Separation

Cyclorator Development. It has been previously reported that Z modulation of the beam was accompanied by undesirable energy modulation, the effect of which was to introduce phase discrepancies and increase the energy width of the beam at the receiver. Work during this period has been principally to devise a system for Z modulation for which the associated energy modulation was acceptably small. These efforts have resulted in a tentative conclusion that with the present arc symmetry this may not be accomplished. A ladder type of electrode was placed in the C slits with alternate rungs at the same potential. It proved unsuccessful because of beam plasma. A similar ladder in the G slit failed because of severe scattering of the beam in the Z direction. Efforts were made to modify the split G system. As the angle of the split is increased the relative amount of energy modulation decreases, of course. In the extreme a saw-tooth split was tried for which the angle of the split was 45°. The effect was to Z scatter the beam, apparently because the equipotential surfaces instead of following the tooth structure were actually well rounded surfaces. In the best system which was tried the C slit was baffled to give a beam 1-1/2 inches in the Z direction. The G was split with an angle of 14°. Here the energy modulation was sufficiently small that the Z modulation was substantially that predicted. In this situation the total beam was less than 6 ma and the modulation of the beam to the side collectors was .5 ma or less. The principle question in this work is whether intense beams can be modulated at high frequency without disturbing the condition of space charge neutralization or some other equilibrium of the beam plasma. Since it was found impossible to dissociate

the Z modulation from energy modulation for beams sufficiently large to apply to the above problem it was decided to return to the method of energy modulation.

Nier Spectrometer. The last month has been spent in attempting to adjust the spectrometer tube, magnet, high voltage, etc. for the best possible resolution in preparation for running at very high masses. The results have been quite favorable. For example, the mercury spectrum has been completely resolved and at higher masses (above 300) the peak height is approximately 5000 times the valley height between 2 peaks 3 mass units apart and whose relative abundance is about 100 to 1. Indications are that this is mostly due to high background pressures from the sample and it is believed that this can be improved by better preparation of samples. Some time has been spent in trying to get rid of a small amount of a.c. pickup in our collector current amplifier.

9. Chemistry

Part A

Spallation Reactions with 350 Mev Protons. Bombardments with the high energy protons on copper and arsenic have yielded plentiful quantities of radioactivities. Preliminary yield distribution data seem to indicate that spallation reactions involving large decrease of A and Z are more favored relative to small change of A and Z than is the case with 190 Mev deuterons and 380 Mev helium ions.

Cross-sections for (α,xn) and (α,pxn) Reactions on Heavy Nuclei. It is known that for lead and bismuth with 38 Mev helium ions the cross section for the $(\alpha,3n)$ reaction is of the order of one barn. The cross section for the (α,n) is much less. Likewise, the (α,pxn) reactions have low yields. For uranium and plutonium we have found the case to be quite different. For example, for plutonium (α,n) and $(\alpha,3n)$ the cross sections are both of the order of 10^{-4} barn. In the case of uranium, (α,pxn) reactions actually exceed (α,xn) reactions. In these cases, fission is the predominant process. An explanation for this behavior has been formulated.

Assignment of Am^{238}. A 90-minute electron capture americium activity has been observed previously in bombardments of plutonium with high energy deuterons on the 184-inch cyclotron. It has now been found in plutonium irradiated with 16-18 Mev deuterons on the 60-inch cyclotron. Since the (d,4n) reaction is unlikely at this energy, and since Am^{239} and Am^{240} are already known, the activity is assigned to Am^{238}.

Neutron Deficient Neptunium Isotopes. The irradiation of U^{233} with 15 Mev deuterons has been repeated, followed by more rapid chemistry. The neptunium fraction showed an x-ray activity with a half-life of the order of 10 minutes, plus the 30 minute activity previously reported. The 10 minute activity is presumed to be Np^{232}, and the 30 minute activity Np^{233}.

Demonstration of Nd^{140} Decay to Pr^{140}. A rapid separation method was devised to establish that a 3.3 day neodymium isotope is the parent of a 3.5 minute Pr^{140}.

Mass Spectrographic Assignment of Cs^{131}. The 10 day electron capture cesium activity, daughter of the 12 day barium, has been identified with the mass spectrograph as Cs^{131}, in agreement with the assignment deduced elsewhere from its properties and mode of formation. The sample used came from normal barium (0.1% Ba^{130}) exposed to neutrons

in the Clinton pile. Chemical separation with an ion exchange column yielded sufficient carrier free cesium activity for the experiment, whereas the barium specific activity was much too low for direct identification of the Ba^{131}.

High Temperature Hydrolysis of $LaCl_3$. The equilibrium constant for the reaction $LaCl_3 + H_2O = LaOCl + 2HCl$ is being studied by a flow method. A preliminary value at 500°C is $0.9 < K < 1.6$ atm.

Intermediate Praseodymium Oxides. The oxides of praseodymium are being investigated by observation of the pressure of oxygen in equilibrium with oxides of various compositions at various temperatures. The samples investigated have had compositions in the range from Pr_2O_3 to Pr_6O_{11} ($PrO_{1.5}$ and $PrO_{1.83}$). A sample of Pr_6O_{11} if heated gives off oxygen discontinuously. The most definite break in the curve corresponds to $PrO_{1.75}$. Other less obvious breaks correspond to $PrO_{1.67}$ and $PrO_{1.80}$.

X-ray diffraction examination of some of these samples have shown cubic phases closely related to the PrO_2 and Pr_2O_3 structures. The $PrO_{1.67}$ is isomorphous with cubic Pr_2O_3, which has a unit cell closely related to 8 units of PrO_2 forming a cell twice as big on an edge. Another sample of $PrO_{1.67}$ was found to be a mixture of the $PrO_{1.75}$ material plus some hexagonal Pr_2O_3.

The explanation of these phenomena is not clear. The structures of the various phases are so similar that one would expect a continuous range of solid solutions, but many attempts to form solutions intermediate between PrO_2 and $PrO_{1.83}$ have failed. Additional work is in progress.

Preparation of Beryllium Fluoride. Beryllium fluoride has been prepared by hydrofluorination of beryllium hydroxide at 200 - 225°C followed by sintering and aging for 5 hours at 500°C. X-ray diffraction studies have shown the preparation to be beryllium fluoride and not an oxyfluoride mixture. It has a crystalline hexagonal structure with the dimensions A = 7.42Å and C = 5.18Å identical with that described by Novoselova (J. Gen. Chem. U.S.S.R. 14, 385 (1944).

Preparation of Thin Polonium Samples. A satisfactory method has been devised for the separation of weightless polonium samples from bismuth and lead for use in the alpha pulse analyzer.

Chemistry

Part B

Synthetic and Experimental Chemistry. During the past month most of the effort of the synthesis group has been directed toward the preparation of C^{14} labeled compounds to be distributed by the Isotopes Division of the Atomic Energy Commission. Of the 180 mc of C^{14} received for this purpose, 130 mc have been processed through at least one step and a portion through two or more steps. An additional 60 mc of barium carbonate will be converted to methyl-labeled acetic acid for Oak Ridge National Laboratory.

The preparation of I^{131} labeled diiodofluorescein has been studied by Moore's method (ICl) and by the use of iodine in ammonia solution (hypoiodite). The yield obtained by Moore's method was considerably the greater, but an analysis of the products showed that the material produced by the second method was probably more pure.

The preparation of I^{131} labeled diiodotyrosine using ICl has proved unsatisfactory due to reduction of the iodine. The hypoiodite method did prove satisfactory; product yields of 55 percent have been obtained and work is in progress in an attempt to increase this figure.

The study of the free radical decomposition of acetyl peroxide to succinic acid is continuing. The purification of synthetic C^{14} labeled glucose is being investigated using paper chromatography. The studies of the synthesis of C^{14} labeled morphine and codeine are continuing.

Biological Chemistry. In the investigation of melanin metabolism, the conversion of C^{14} labeled dihydroxyphenylalanine and tyrosine to melanin is being studied on the Warburg apparatus. Several melanoma (a type of cancer) homogenates are being tested in poisoned and non-poisoned systems. This conversion is also being studied by pancreatin hydrolysis of melanoma tumor proteins from mice injected with radioactive tyrosine.

Workis beginning on a series of experiments to study in detail the metabolism in mice of C^{14} labeled stilbamidine. Work is also continuing on the rate studies of the metabolism of simple C^{14} labeled compounds as measured by the expiration rate of radioactive carbon dioxide in normal and tumor-bearing mice.

Photosynthetic Chemistry. The role of respiration in photosynthesis has been investigated by two independent methods, the chemical and physical approach. In the chemical approach the radioactive products formed during respiration after photosynthesis have been determined using paper chromatography. The results confirm previous arguments that the tricarboxylic acid respiration cycle functions in algae (Chlorella and Scenedesmus).

The identity of the early products of photosynthesis have been questioned by a number of investigators in this country. In an attempt to determine the nature of these compounds, barium phosphoglycerate has been isolated by classical methods from Scenedesmus that have been photosynthesizing 5 seconds. This isolated material had the correct physical properties for phosphoglycerate such as percent phosphorus, specific rotation and solubility, and when analyzed on paper chromatograms it corresponded to the same position as that previously observed from 5-second photosynthesis and assumed to be phosphoglyceric acid.

The physical approach to the problem involves measurement of $[C^{14}O_2]$, $[CO_2]$, and $[O_2]$ during photosynthesis in order to determine the rate of CO_2 evolution from respiration.

Chemistry

Part C. Project 48B

Metals and High Temperature Thermodynamics. Work is in progress on the following problems.

1. Thermodynamics of CN and N_2.
2. Absorption coefficients of CN and C_2.
3. Thermodynamics of molybdenum halides and oxides.

4. Thermodynamics of gaseous aluminum oxides.
5. Low melting metal systems.
6. Structure of solids and gas-solid surface interactions.

Basic Chemistry. Solvent Extraction. The following problems are under investigation.

1. The exchange of iodine atoms between iodate ion and iodine.
2. The chelate complex of lanthanum with TTA.

Engineering Development of Plutonium Separation. The following subjects are being investigated.

1. Solvent extraction using chelate process.
2. Pilot-scale synthesis of TTA.

Ore Reduction. A micro titration method for U(VI) is being developed.

10. Medical Physics

Part A

Preliminary observations on the uptake of element 61 in the tissues adjacent to the costochondral junction, 4 days after administration, have shown the following. The radioactivity in the bony portion of the rib is apparently limited to the periosteal and endosteal regions, with no activity seen in the older cortical bone of the rib. The spotty distribution previously reported in cortical bone, and seen again in the tibias of this experiment, was not seen in the cortical bone of the rib. The darkest part of the radioautograph was seen at the terminus of the cartilage bar where calcification of both cartilage (vesicular zone) and bone (primary spongiosa) are taking place. The cartilage portion of the rib has a central calcified area, which in the strontium experiments showed a definite accumulation of the radioactive element. In the experiment with 61, there was radioactivity present on the peripheral surface of this central calcified area. There was probably none in the calcified cartilage, with one exception, the uncalcified cartilage near the marrow junction (and the region of endochondral ossification) was faintly positive.

The studies with Sr and element 61 are continuing and it is expected that Pu studies will be initiated shortly.

Metabolic tracer studies are being set up with Nd^{147}. This material is going to be studied in rats as the carrier-free substance as it is produced by Oak Ridge. In addition to this, the effect of citrate and oxalate complexes upon the metabolism of Nd will be studied. The addition of inactive isotopic Nd in carrier amounts will be studied as well as the effect of other rare earths in milligram amounts, such as cerium.

Studies are being continued on the metabolism of radio-tin which is now complete to 32 days following intramuscular administration. Further studies with radio-arsenic and its use in detecting red blood cells is being continued. Developmental work with crystal counters is being continued.

In order to determine something of the mechanism involved in zirconium citrate decontamination, a study is being made of the kinetics of skeletal uptake and

excretion of radio-yttrium in treated and untreated rats. Similar studies are being made with therapeutic levels of zirconium labelled with radio-zirconium. Endocrine factors affecting bone metabolism are also being investigated to determine how these may modify the therapeutic action of zirconium, as well as their possible application to therapeutic overlayering of deposited plutonium.

10.7 millicuries of Cu^{64} were prepared from a deuteron bombarded copper target; the sample had a specific activity of 18.2 millicuries per gram of copper. A method was worked out for the separation of carrier-free selenium activity made by the reaction $As^{75}(d,2n)Se^{75}$; the process involves the use of a tellurium carrier which is separated from the Se^{75} by a hydrogen bromide-bromine distillation. Work on At^{211} was continued; a new target was designed to obtain maximum beam efficiency. One millicurie of carrier-free As^{74} was separated from a germanium target.

Medical Physics

Part B

The research effort of Donner Laboratory is divided into eleven different fields as indicated in the last monthly progress report. Below is presented a summary of the new results obtained during the past month.

Biological Effect of Cyclotron Radiations Using 190 Mev Deuterons and 380 Mev Alpha Particles. Because of construction work on the 184 inch cyclotron, no biological experiments were carried out. A new control board is being constructed for instrumentation in biological experiments and dose integrators are being installed.

Data were obtained in collaboration with Dr. N. Giles on the effect of deuteron and alpha beams on chromosomal rearrangements in Tradescantia pollen. Preliminary summary of the results to date may be stated as follows:

1. 190 Mev deuterons cause about as many isochromatic breaks and exchanges as 50 kev x-rays. The specific ionization of the 190 Mev particles is also about the same as 50 kev electrons.

2. Low energy deuterons having specific ionization of about 3.8 times that of 190 Mev deuterons produce about 6-1/2 times as many isochromatic breaks and about 6 times as many exchanges as 50 kev x-rays for the same total ionization per gram plant tissue.

3. 380 Mev alpha particles produce about as many isochromatic changes as 190 Mev deuterons for the same ionization in spite of the fact that each alpha particle has four times the specific ionization of each deuteron.

4. Experiments with low energy alpha particles that ionize on the average six times higher than the 380 Mev are inconclusive. The work will be continued and expanded to study the effects induced as a function of temperature.

The yield of H_2O_2, O_2, and H_2 in water subjected to radiation is being studied in function of the specific ionization of protons, deuterons and alpha particles.

Studies on Blood Coagulation. Using 1000 cycle a.c. and the conductivity apparatus described previously, blood conductivity changes during and following blood clotting

have been measured in a group of normal subjects, polycythemics and leukemics. Blood resistance increases almost linearly during clot retraction as a function of time and this increase may be followed for periods up to four hours. Normals and patients with different blood dyscrasias exhibit different rates of resistance change on their clot retraction curve and it appears that the slope correlates with the platelet counts.

Basic Studies on the Metabolism of C^{14} Labelled Compounds. Each carbon position in each molecule studied has a different pattern of conversion to carbon dioxide. The rates of conversion to carbon dioxide of methyl labelled carbon in pyruvate and carboxyl labelled carbon in propionate are different in normal mice and mice bearing neoplastic transplants. Other positions in these same molecules are indistinguishable in normal and cancer animals.

A paper is being prepared on retention of carbon in bone from methyl labelled glycine. There is no more retention in bone than in other tissues and the biological half life of C^{14} atoms is something around 12 days - after the first few days, indicating that carbon does not remain in the animal body.

Radiation Effects on Bacteria. In the course of some work with E. coli it has been found that radiation sensitivity of strain B increases during the first few hours of incubation, while the sensitivity of the strain B/r decreases. There seems to be some correlation between the number of nuclear bodies in the bacterial cell and the sensitivity of the cell to ultraviolet light. A somewhat more detailed report has been submitted.

Genetic Effects of Irradiation on Drosophilia. Investigation of the frequency of sex linked lethals produced in Drosophilia by low doses of gamma ray irradiation has now been completed. The findings are essentially in agreement with previously reported results, namely that low doses of irradiation produce a significant number of mutations. These results are discussed in the Quarterly Progress Report.

11. Health Physics and Chemistry

Radiation Field of Cyclotron. Surveys of the radiation field outside the shielding of the 184 inch cyclotron while developing 350 Mev protons has given the following information.

Conditions:

Approx. 1/2 μa proton beam, normal direction. 1/2" Be target.
10 ft. walls (except upper tier on south side, which is temporarily on 5 ft. thick).
4 ft. roof
Neutron port open

Observations:

(a) Fast neutrons - 5 ft. from floor

1. Along east and west sides of shielding the energy flux is 4 to 8 Mev/cm^2 sec.

2. Along north wall: 30 - 60 Mev/cm^2sec. This is due to protons striking dee, and this effect is accentuated by the scattering of protons by the thin 1/2" Be target.

3. Along south wall: Very low behind cave; up to 95 Mev/cm^2 in region near neutron beam port. But this high level is not due to the emerging beam, but rather to the missing blocks on the upper tier in this region.

(b) Slow neutrons

The slow neutron flux at 5 ft. from the floor varies from 10 to 30 neuts/cm^{2}sec. At 12 ft. the values are about the same. At 30 ft. the flux is almost uniform at 20/cm^{2}sec.

(c) Total radiation (Plastic-wall ionization chamber)

The level at 5 ft. elevation is everywhere less than 0.4 m rep/hr, except near the five-foot shielding doors. At the north door region it is as high as 5 m rep/hr, and along the south side as high as 1 m rep/hr in the region near portion of shielding irradiated by primary fast neutrons.

At 30 ft. the level ranges from 0.5 to 2.5 m rep/hr.

All the readings mentioned above apply to positions roughly 20 ft. out from the outside face of the vertical walls of the shielding.

Research and Development. The projects in progress in the Research and Development Section of Health Chemistry during the period December 15 to January 15 are as follows:

1. S. G. Thompson interceptor run: the three-months' 60 inch cyclotron bombardment of a curium sample is still in progress. No operational difficulties developed during this period.

2. Specially equipped box for Dr. Gofman's yttrium and strontium processing: the equipment has been completed and put in use.

3. Controlled atmosphere arc stand for Dr. John Conway's spectrum analysis of radioisotopes: the equipment has been completed and delivered.

4. S. G. Thompson hood for processing U^{233} bombardments: the hood has been completed and satisfactorily used. A new target holder for this work has been designed and is awaiting delivery of the platinum from which it is to be constructed.

5. Special alpha source for use by Dr. Panofsky: completed and delivered.

6. Special tongs to facilitate removal of 60 inch cyclotron targets: completed.

7. S. G. Thompson Hanford slug operations for May, 1949: preliminary plans for handling have been made; a new survey of the shielding power of the straight-type cave in Room 107, Bldg. 5, has been made.

8. Lead glass bricks and windows: three lead glass bricks have been polished on four faces, very satisfactorily from a viewing standpoint. Drawings are completed for a window frame and mounting bracket in a 1 inch lead manipulator panel

9. Separation, storing and metering of tracer samples for R. Wolfe and R. Dunn: advice on planning for the separation, storing and metering of approximately 1000 tracer samples has been given by the Health Chemistry group; the job is about 50 percent complete.

10. Electronics: the automatic air sampler for the presence of alpha emitters is about 75 percent complete. An improved alpha survey meter with preamplification in the probe is completed and ready for test.

11. Flexible shaft manipulators: three units are now in stock; formal drawings have been completed.

12. "Jiffy" probe holder for short-lived targets: work 70 percent completed.

13. Gloved boxes: boxes completed and delivered during this period include 1 box to the XC area and one specially equipped box to S. G. Thompson, Bldg. 5; a standard centrifuge well-type box for L. Magnussen was delivered to Crocker Laboratory. Four boxes are in preparation for the Seaborg group.

LMB/1-27-49
Information Division

SUMMARY OF RESEARCH

Activities for the Period December 15, 1948 to January 15, 1949

60 inch Cyclotron

1. Development of ion sources for carbon and oxygen ion beams.

   Completely hooded ion source found to be as good as open type ion source. An electron gun type of source is under fabrication.

2. General studies aimed at increasing power output, and probably replacement of dees, dee supports and grounding spiders with new design.

   Beam envelope equipment is nearly complete and should be used this next month. The oscillator tube characteristics have been obtained to enable us to increase our oscillator efficiency.

3. Application of studies of magnetic shimming for the reduction of dee and deflector voltage requirements and increase in energy.

   The model for the 60-inch has been designed and tested, and designs have been completed shaping the poles on the model in view of re-shaping the 60-inch pole tips to give an improved field shape.

4. Improvement of handling equipment for targets and ion source to reduce exposure of personnel.

   The area for handling hot targets has been isolated and the spread of contamination reduced. The techniques for handling the hot targets and ion sources have been improved. The use of long handled screw drivers and tongs in handling ion sources has been inaugurated and a shield for the cone devised for use when it is removed from the cyclotron. A high voltage filament holder has been tested and will be used to reduce breakdowns.

5. Application of remote control to filament depth and other adjustments.

   The designs are complete for a remote control filament. The oscillator booster has had remote tuning installed by means of Selsyn units so that it can be tuned from the control room.

6. Development of hydraulic motor for remote control of adjustments inside the vacuum.

   The initial model has been designed and tested, but it needs further work done on it.

184 inch Cyclotron

1. Installation of new, higher-power magnet generator.

   No work. Awaiting delivery of the motor.

2. Development of improved beam monitoring equipment.

   Design work started.

3. Construction of proton beam deflector.

   Construction of pulsing equipment complete. Equipment being tested, but not yet installed.

4. Design and construction of improved targets and target handling equipment to meet continuing experimental requirements.

   Design of additional equipment started.

300 Mev Synchrotron

1. Studies of influence of operating parameters on synchrotron output.

   Adjustments of various operating parameters have increased the beam energy to 300 Mev.

2. Operational studies, related to bevatron problems, such as studies of effect on beam current of (a) magnetic field variations, (b) vacuum chamber cross sectional area, (c) beam scattering; study of catching conditions for pulling ions into synchronous orbit.

   It appears likely that detailed compensation of the azimuthal variations of magnetic field are unnecessary as long as the sum of the products of each Fourier component and its proper weighting factor is kept within tolerable limits.

   Studies are in progress of the effect of changing the shape of the RF envelope on catching the betatron beam into a synchronous orbit. A rough check has also been made of the effect of gas scattering on beam intensity. Preliminary results indicate that attenuation starts when the pressure reaches 10^{-4} mm.

3. Search for mesons using 300 Mev x-rays.

   Two groups of nuclear plates have been exposed. The integrated radiation is not accurately known, but in the second exposure it was 15 mr as measured at the Zeus meter.

300 Mev Synchrotron (Continued)

4. Determining absorption coefficients of various materials for high energy x-rays.

No work.

5. Study of nuclear reactions produced by fast electrons and x-rays.

No work.

Linear Accelerator

1. General replacement of temporary construction and changes indicated by operational experience.

No changes during the month.

2. Redesign and replacement of component parts of Van de Graaff generator as required in light of continuing operation.

Electric generator in the high potential electrode was replaced. Operation was thereby markedly improved.

3. Development of ion sources for Van de Graaff generator and bevatron.

New ion source for the Van de Graaff has been given extensive bench tests; it gives 2 ma of protons, pulsed.

4. Use of 32 Mev proton beam for proton-proton scattering and other experiments exploring the fundamental properties of nucleons.

Two experiments underway. Results indicate that there is no p-wave interaction between protons. Both methods give the same results.

Bevatron

1. Operational studies using low-power one-quarter scale operating model.

Magnet assembly complete; now being tested. Vacuum testing on individual tanks in progress. A cyclotron will be used for injection; the design is underway.

2. Erection of crane and magnet. Construct and install magnet coils, vacuum system, controls and accessory equipment.

Coil winding is proceeding. Bids for the crane have been received.

PHYSICS RESEARCH

General

1. Range measurements for fast particles.

No progress to report.

Fundamental Properties of Nucleons.

1. Neutron-proton scattering.

Theoretical work with a Yukawa well completed. A search for a well shape that will give better agreement with experiment is being made. An orientation run was made to survey the intensity and energy distribution of the 350 Mev proton beam. Pulse selector built but not tested.

2. Proton-proton scattering.

See item 4 under Linear Accelerator. Calculations progressing with the use of central forces. Tensor force calculation being made.

3. Scattering of protons and neutrons on deuterons.

Pulse selector built; ready to be tested.

4. Other scattering experiments.

An experiment is in progress on the inelastic scattering of 32 Mev protons on carbon.

5. Life time of neutron.

All equipment in working order. Vacuum chamber has been redesigned. Anthracene crystal detectors will be used in place of Geiger counters.

6. Production of mesons by 390 Mev alpha particles, 350 Mev protons, and 300 Mev x-rays.

Studies in progress on high energy γ's possibly due to decay of neutral π mesons. Calculations on the production of mesons by α particles have been repeated. Good agreement with the observed cross section was obtained. The cross sections for 350 Mev protons and for x-rays have been made and are being extended.

Nuclear Reactions

1. Types of reactions produced by particles and x-rays at various energies.

   Good progress has been made in developing a theoretical explanation for the production of deuterons.

2. Energy dependence of reactions.

   Excitation function for the reaction $C^{12}(p,pn)$ is being measured.

3. Study of radioactive isotopes formed and their decay properties.

   New radioisotope N^{12}. T 1/2 = 12.5 milliseconds. E = 16.6 Mev positrons. Formed in $C^{12}(p,n)$ N^{12} $N^{12} \rightarrow C^{12} + \beta^+$. Po^{209} has been discovered; emits 5 Mev d's with a long half life. Several new short life α activities detected in α bombardments of lead.

4. Total cross sections for neutrons and charged particles for various elements.

   Calculations in progress with data gathered earlier on total and elastic scattering cross sections for various elements for 90 Mev neutrons. A paper completed on 90 Mev neutron cross sections. Calculations for higher energies in progress.

5. Study of the characteristics of fission and fission product yields produced by high energy particles.

   Cancellation ionization chambers have been built, but not tested, for use in the measurement of fission cross sections under charged particle bombardments and possibly for the measurement of the fission fragment energy distribution.

Instrumentation

1. Instrumentation in support of cloud chamber development.

   Work on the replacement glass and plastic chamber for the cloud chamber is being continued.

2. Development of ionization chambers and Lindeman or vibrating reed electrometers for specific purposes, such as hydrogen 3 analysis for use in medical physics.

   Two new chambers were made for survey work with the Lindemann electrometer.

3. Continuing development of solid counters, and studies of suitable materials, including naphthalene, anthracene, etc.

   A β-γ scintillation counter for routine use in medical physics was constructed. Work continues on general crystal counter development.

Instrumentation (Continued)

4. General development of electronic counting equipment.

   Nine, four-channel coincidence mixers are under development for use with a γ-ray spectrometer for high energy γ studies.

5. Development of gas-filled counters in various forms to meet specific research requirements, such as n-p scattering, neutral meson detection, etc.

   Eight counters were fabricated for neutral meson γ detection - to be used in the γ-ray spectrometer - pair counting system. Other counters are being developed for high energy proton scattering experiments.

6. Development of radiation survey instruments.

   Two types of proton-recoil counters were made and are under study. They are for use in neutron energy spectrum studies in the general radiation field.

7. Applications of Nier spectrometer and development of low-mass spectrometer.

   The Nier spectrometer was applied to problems of the isotope separation program.

8. Instrumentation in support of chemistry program, including special mass-spectrograph for assigning mass numbers, x-ray spectrograph, beta-ray spectrograph, spontaneous fission counters and special counters for measurements in accelerator beams.

   No work done.

Electromagnetic Isotope Separation.

1. Design and construction of experimental units.

   Work is continuing.

2. Development of r.f. source units.

   Z - modulation and energy-modulation experimental units tested with some success.

3. Investigation into neutralization of space charge, including r.f. photo-electric and thermionic emission methods.

   No progress.

Nuclear Chemistry

1. Preparation and properties of all neutron-deficient isotopes that can be reached with the 60-inch and 184-inch cyclotrons.

   Some additional facts have been learned concerning isotopes of calcium, germanium, arsenic, praseodymium, neodymium, thulium and lutecium. Experiments have been done with the "rabbit" at the 60-inch cyclotron searching for short-lived activities produced from fluorine, lead, and bismuth, but the data are not complete.

2. Determination of cross sections for the many spallation reactions at high energies.

   Some preliminary data have been obtained for spallation yields from copper and arsenic with 350 Mev protons.

3. Characteristics of bismuth, lead, and other light element fission. Theory for process.

   Little progress, but a study of tantalum fission yields with 380 Mev helium ions and 350 Mev protons is being started.

4. Extension of fissionability measurements below tantalum into the rare earth elements.

   No progress.

5. Characterization of fission of uranium and thorium induced by high energy particles.

   Some additional data on the fission yield distribution of uranium plus 380 Mev helium ions have been obtained, mostly for longer-lived isotopes.

6. Identification of the interesting new bismuth alpha-emitters.

   No progress.

7. Attempt preparation of elements 97 and 98.

   No progress.

8. Preparation of larger amounts of americium 241 and curium 242 for chemical and nuclear studies.

   About 16 mg of americium were milked from the plutonium cow.

Nuclear Chemistry (Continued)

9. Preparation and determination of properties of those isotopes of americium and curium (also neptunium and plutonium) which have not yet been prepared, including spontaneous fission rate and slow neutron fissionability.

   Three activities, 10-minute, 30-minute, and 90-minute, have been assigned to Np^{232}, Np^{233} and Am^{238} respectively. Work is continuing on a spontaneous fission rate counter.

10. Determination of amounts and properties of transplutonium isotopes produced by the intense neutron irradiation of plutonium and americium.

    No progress.

11. Chemical identification of the products from nuclear reactions with 350 Mev protons.

    Work is in progress on bombardments of copper, arsenic and thorium with 350 Mev protons.

12. Study of meson reactions by chemical means.

    Lead, bismuth and thorium are being bombarded with 350 Mev protons to give additional evidence concerning meson and secondary particle mechanisms for the abnormal charge increase reactions.

13. Development of chemical analysis techniques utilizing radioactive tracers.

    No progress.

Chemistry of Heavy Elements

1. Microchemical studies of curium with pure curium to determine its chemical properties.

   No progress.

2. Further studies of americium including its oxidation states and other basic chemical and metallurgical problems.

   No progress.

3. Chemistry of protoactinium and neptunium, elements about which little is known (including metallurgy).

   No progress.

Chemistry of Heavy Elements (Continued)

4. Chemical properties of the rare earth elements for comparison with the actinide elements.

   Preliminary data have been obtained on the equilibrium pressures of oxygen obtained in the thermal decomposition of praseodymium oxides. The equilibrium constant of the hydrolysis of $LaCl_3$ at high temperatures is being studied. Gadolinium metal was prepared and was found by x-ray diffraction to be in the hexagonal closest packing structure reported in the literature.

5. Methods of separating americium, curium, and higher elements from each other and from the rare earths.

   Elution of americium, curium and 61 from Dowex 50 columns is being studied using acetylacetonate, thiocyanate, and cyanide as complexing agents, to see if the behavior found with hydrochloric acid can be duplicated.

6. X-ray diffraction determination of crystal structure of compounds of neptunium, americium and curium.

   Several samples of rare earth and actinide compounds have been identified as known structures.

7. Thermochemical studies of compounds and metals of heavy elements.

   A solvent, 0.1 M HBF_4 in 6 M HNO_3 has been found to be suitable for the solution of AmO_2 for calorimetric runs.

8. Investigation of the chemistry of astatine (element 85) on a tracer scale. Formation and study of new isotopes of astatine.

   No progress.

High Temperature and Pile Chemistry

1. Metals and high temperature thermodynamics.

   Work is in progress on the thermodynamics of CN, N_2, the molybdenum halides and oxides, and the gaseous aluminum oxides. Studies are also being made of the absorption coefficients of CN and C_2, of the structure of solids, of low melting metal systems, and of gas-solid surface interactions.

2. Basic chemistry. Solvent extraction.

   Experiments are continuing on the exchange of iodine atoms between iodate ion and iodine, and on the chelate complex of lanthanum with TTA.

High Temperature and Pile Chemistry (Continued)

3. Engineering development of plutonium separation.

The solvent extraction using chelate process and the pilot scale synthesis of TTA are under investigation.

4. Ore reduction.

A micro titration method for U(VI) is being developed.

Program Class 530 - Plant and Equipment

1. Completion of Bevatron building; continuation of Bevatron construction.

Subcontract work for building site grading is continuing. Clearing is approximately 75 percent done and preparation the the 48" drain line is about 50 percent done. Architects are continuing with building layout problems. The 1/4 scale model of the bevatron is to the point where the winding of the magnet is complete and the vacuum tanks are being tested. Since design of the model is nearly complete, design of the full scale equipment has been resumed.

2. Complete equipping of Central Research Laboratory Building.

The floor slab of the ground floor is being poured after some delay due to lack of steel and to freezing weather.

3. Construct Animal House and Cafeteria.

A contract is being let to Architects Hertzka and Knowles to study these projects. It is anticipated that these projects will have to be delayed until after July 1, 1949, as funds are not available to contract for buildings at this time.

4. Construct Shops - plumbing, electrical, sheetmetal and salvage.

Architects contract has been let for these buildings in conjunction with projects under 3 above. It is planned that the first of these buildings will be built as soon as plans are completed and bids solicited.

5. Miscellaneous small construction.

Warehouse grading 15 percent complete.
Paint shop foundation completed. Steel frame ready to be erected.

MEDICAL RESEARCH

Biological and Medical Studies at Crocker Laboratory

1. Evaluation of the metabolic properties of fissionable elements, fission products, and other materials of project interest.

   Tin is currently being investigated as are germanium, strontium and element 61. The study of samarium will be continued when more of the material is available. Experiments with Nd^{147} are being set up.

2. Decontamination studies.

   Work is continuing on the mechanism of zirconium citrate decontamination of plutonium.

3. Radioautographic studies.

   A series of radioautographic experiments have been conducted using the costrochondral junction of the rat.

Medical Research at Donner Laboratory and Elsewhere

1. Selective tissue irradiation involving radioactive colloids of phosphorus, yttrium zirconium, lanthanum and uranium.

   Irradiation of liver and bone marrow of animals is being continued.

2. Biological effects of fission.

   No work is being done on this problem at the present time.

3. Biological effects of high energy neutrons.

   The 184-inch cyclotron was not in operation during the past month.

4. Use of large animals in long range studies of item (3) with particular interest centered in carcinogenic and longevity aspects.

   We do not have facilities for maintaining large animals as yet, but they will be shortly under construction.

5. Biological effects of high energy particles (other than neutrons -see item (3) above.

   A new control table was constructed for biological dose measurement with the cyclotron and results of data on chromosomal rearrangements in Tradescantia pollen were obtained.

6. Biological effects of radiation on nucleoprotein metabolism and protein metabolism.

   This study is being continued.

Medical Research at Donner Laboratory and Elsewhere (Continued)

7. Effects of radiation on the reticuloendothelial system and related effects with regard to immunity mechanisms.

   The work is being continued.

8. Microchemical assay of tissue components by induced radioactivity.

   An ion exchange method is under develpment for rapid radiochemistry of the irradiated tissue ash. So far we have succeeded in separating simultaneously P, Na, K, Zn, Fe, Co, Ca and the rare earth in one group from the tissue ash.

9. Study of the mechanism of radiation injury and possible prophylactic and therapeutic management of such injury.

   Correlation between the blood platelet count and the rate of change of blood resistance during clot retraction was established.

10. Study of metabolism measured by the utilization of simple organic compounds labelled with radioactive carbon.

    It has been found that the rates of conversion to CO_2 of methyl labelled carbon in pyruvate and carboxyl labelled carbon in propionate are different in normal mice and mice bearing neoplastic transplants.

11. Study of genetic effects of radiation.

    A long range study has been completed on sex linked lethal mutations in Drosophila.

12. Radiation effects on micro-organisms and studies on the nature of radiotion sensitivity studies of E. coli with ultra-violet light have been completed.

    Radiation sensitivity studies of E. coli with ultra-violet light have been completed.

Cancer and Medical Research at U. C. Hospital (48-C)

1. Effects of external irradiation of the whole body.

   a. Clinical: Some patients treated before 1946 are still being followed.
   b. Animal: No work started.

2. Hematological effects of irradiating the body from within, principally P^{32} and I^{131}

   a. Clinical: The blood studies are being done on patients treated with P^{32} prior to May 24, 1948 and I^{131} currently being treated.
   b. Animal: No work being done.

Cancer and Medical Research at U. C. Hospital (48-C) (Continued)

3. Studies on the metabolism of I^{131} together with tests of its usefulness as a diagnostic and therapeutic agent.

   Work in progress.

4. Study of skin to radiation from x-rays of all energies, gamma rays, beta rays, alpha rays and neutrons.

   No work being done under this title.

5. Investigations in (4) extended to plants and animals.

   No work being done under this title.

6. Investigation into the cause and cure of radiation sickness.

   No work being done under this title.

Biochemistry

1. Use of carbon 14 in study of organic reaction mechanisms and physical-chemical phenomena, such as the mechanisms of molecular rearrangements, cracking of hydrocarbons, etc.

   We have worked on the mechanism of the free radical decomposition of acetyl peroxide in acetic acid.

2. Production for shipment of various carbon 14 labelled compounds, such as methyl-labelled sodium acetate, methylene and carboxyl-labelled glycine, carbonyl-labelled sodium pyruvate and glucose.

   Of the 180 millicuries of C^{14} received from Oak Ridge, 130 millicuries have been processed through one or more steps. A number of the compounds have already been completed and will be sent to Oak Ridge shortly.

3. Production for experimental use of compounds and as phenylalanine (either beta or ring labelled), complicated amino acids, drugs, hormones, carcinogens, etc.

   The preparation of the following compounds has been studied: phenylalanine-beta-C^{14}, glucose-1-C^{14} mannose-1-C^{14}, iodine-labeled diiodo tyrosine, C^{14} labeled morphine, codeine, succinic acid and fumuric acid.

4. Studies of the mode of action and distribution of the compounds in (3) above in animal and plant metabolism.

   Work is in progress on the metabolism of C^{14} labeled stilbamidine. The study of the rate of metabolism of the simple metabolic intermediates is continuing.

Biochemistry (Continued)

5. Isolation of the intermediates of photosynthesis and study of the mechanism of this process.

The identity of phosphoglyceric acid as one of the first products of photosynthesis has been re-checked and found to be correct. A number of the products of both short and long periods of photosynthesis have been more completely identified and the previously formulated metabolic cycle confirmed. The physical approach to the problem of photosynthesis using measurement of the rates of absorption and evolution of radioactive carbon dioxide and oxygen has received further study.

Health Physics

1. Dosimetry in high energy neutron beams; evaluation of energy absorption coefficients for hydrogen, carbon and oxygen; application to tissue.

No progress.

2. Study of ranges and relative numbers of ionizing secondaries from materials irradiated with high energy neutrons.

No progress.

3. Controlled exposure of animals in neutron beam.

No progress.

4. Applications of new types of counters to dosimetry.

A calibrated hydrogen recoil counter for fast neutron survey work has been developed. Work in progress on coincidence recoil counter application to the measurement of the neutron energy spectrum outside the shielding.

5. Extension of Health protection program, involving use of film badges and pocket chambers by all personnel.

Film badge coverage extended to include 900 persons.

Health Chemistry

1. Shielding - materials, stopping power, geometry.

Equipment is available to test shielding properties of various materials against calibrated samples, and tests are made as occasion requires.

Health Chemistry (Continued)

2. Problems in optics for caves and dry boxes, involving mirrors, lenses, and liquids.

   Satisfactory mirror arrangements in movable cylinder with 6" lead protection in use. Laminated lead glass windows in use. Solid lead glass windows under construction. Dry boxes being adapted and used for all problems. Liquids being tested, both for optical and shielding properties.

3. Plutonium slug design for use in piles.

   Satisfactory containers for various products being bombarded in piles have been designed and in use. No special consideration being given to plutonium.

4. A "Cow" for milking americium from plutonium.

   After initial encouraging results work was discontinued pending more permanent additions to Bldg. 5.

5. Instruments including G. M. tubes, tongs, and particle detecting rings.

   Satisfactory alpha meter created; air alarm counter being developed; numerous flexible tongs and manipulators created; developments being continued in all of the above fields.

6. Decontamination of the air expelled from an area such as the "hot cave".

   Filtering being accomplished but there is much room for improvement and research is under way to accomplish this.

7. Surface decontamination for working areas; studies of decontamination technique for large equipment, and development of special equipment for this purpose.

   Extensive strip coating study completed and successful coatings in use; decontamination chamber with motorized dolly, electrolytic decontamination sump and other features under construction.

8. Design of special target holders for active material.

   Probe for extremely short-lived targets developed and in use; further designs for other target problems under research and development.

Health Chemistry (Continued)

9. Continuing improvement in dry-box design, construction and associated mechanical equipment for remotely handling and performing specialized manipulations with active materials.

   Work on the above activities constitutes a major portion of the time spent by the Research and Development group.

10. Receival, storage, monitoring and waste disposal of all radioactive material in Laboratory, and health monitoring for exposure to such activity.

    Continuous attacks on these problems are being made.

APPROXIMATE DISTRIBUTION OF EFFORT

PROGRAM	SUBDIVISION	MAN-MONTHS EFFORT	COMMENTS
184 inch Cyclotron	Operation	5.4	
	Proton Coversion	4.8	
60 inch Cyclotron	-	-	Non-Project
Synchrotron	R.f. System	2.6	
	General	.4	
	Injection	2.4	
	Miscellaneous	.3	
	Magnet Tests and Operation	4.0	
	Vacuum Chamber	1.7	
Linear Accelerator	Linear Accelerator - General	4.5	
	Van de Graaff - General	4.7	
Experimental Physics	Cloud Chamber	4.4	
	Film Program	9.6	
	Ionization Chamber and Crystal Counter	3.6	
	Neutron-proton Scattering	.6	
	Proton-proton Scattering	1.8	
	Neutron Diffraction	.5	
	Meson Range and Decay Measurement	1.3	
	Absolute Cross Section Measurements	1.1	
	Neutron Half Life	.5	
	Bevatron Design Studies	.6	
	General Physics Research	2.5	
	Magnetic Measuring Equipment	.6	
	Bevatron Magnet	.5	
Theoretical Physics	Synchrotron	-	
	Bevatron	1.4	
	Cyclotron	.5	
	Linear Accelerator	-	
	General Physics Research	11.7	
Isotope Separation	JA Conversion	-	
	Nier Spectrometer	2.1	
	Low Mass Spectrograph	.2	
	XC Isotope Separation Program	6.2	

PROGRAM	SUBDIVISION	MAN-MONTHS EFFORT		COMMENTS
Chemistry, Part A	Chemistry of Transuranic Elements	5.5		
	Nuclear Properties of Transuranium Elements	3.5		
	Transmutations with the 184-inch Cyclotron	7.2		
	Transmutations with the 60-inch Cyclotron	.4		
	Analytical and Service	13.0		
Chemistry, Part B	Synthetic and Experimental Chemistry	7.8		
	Biological Chemistry	3.9		
	Photosynthetic Chemistry	4.6		
Chemistry, Part C	Metals and High Temperature Thermodynamics	3.0		
	Basic Chemistry, including Metal Chelates	1.5		
	Engineering Development of Plutonium Separation	1.5		
	Ore Reduction	1.0		
	General	1.0		
Medical Physics, Part A, Div.I	Metabolism of Fission Products	11.0		
	Decontamination Studies	7.0		
	Radio-Chemistry	2.0		
	Radioautography	2.0		
Medical Physics Part B, Div.II	Uranium Research	1.0	.2	Consultant
	Tumor Metabolism	.8	.9	Man-Months
	Special x-ray Studies, Radioactive Measurements, etc.	3.8	3.3	
	Radioactive Carbon Studies	3.1	.7	
	Fundamental Medical Research	2.0	2.3	
	Hematology	.7	1.1	
	Medical Work with 184-inch Cyclotron	2.8	1.1	
	Fly Genetics	1.0	.3	
	60-inch Cyclotron Bombardments	.4	-	
Health Physics and Chemistry	Monitoring and Special Problems	6.8		
	Salvage, Decontamination, Disposal, etc.	5.0		
	Research and Development	8.9		