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Radiation Laboratory

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PROGRESS REPORT No. 70

January 15 to February 15, 1949

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Berkeley, California

UNIVERSITY OF CALIFORNIA, RADIATION LABORATORY

January 15 to February 15, 1949

PROGRESS REPORT No. 70

1. Bevatron

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The question of charge neutralization of the accelerated particles by electrons picked up from the residual gas has been the subject of experiments on the cyclotron. A considerable amount of neutral radiation had been observed, and it was felt that an experimental check on the cross section for neutralization of the ions should be made. The results of the experiment indicate that most of the neutral atoms observed in the cyclotron arise from negative hydrogen atoms accelerated in a direction opposite to that of the protons. However, neutral radiation from protons was also observed. These experiments showed a decay half-life of .3 seconds for neutral radiation coming from a radius of 12 ± 3 inches and .62 seconds for a 24 ± 3 inch radius. It seems reasonable to conclude from these studies that no trouble from this source should be expected in the full-size bevatron.

Work on the quarter-scale model has continued with vacuum tests on two half quadrants of the vacuum tank. It has been found that without liquid nitrogen traps the pressure is higher by a factor of five after about one day's outgassing. This indicates the value of a liquid nitrogen tube running through the vacuum tank. One quadrant of curved tanks has been set in place in the magnet together with one tangent tank and the pumping system. These are now undergoing tests in place. The cyclotron injector magnet to be used with the model is being assembled in the shops, and the cyclotron vacuum chamber is under construction.

Tests of the one-twelfth scale a.c. magnet model have continued with concentration on improvements in the reliability of the measuring instruments. A new method of obtaining magnetization curves is being tried in which the magnet is compared with an air core solenoid in the same circuit, using the oscilloscope as a null indicator only. Comparison of the pulses obtained by peaking strips in the operating model gap and peaking transformers on the magnet leads shows less than 10 microseconds jitter, indicating that timing signals can be obtained from these transformers.

The order for two 30-ton-5 ton auxiliary rotating cranes for the magnet room of the bevatron building have been placed, and bids for the magnet cable are under consideration. Preliminary drawings have been given to the architects covering the requirements for the foundation of the building. The specification for the sample quantity of steel for one magnet sector has been held up pending further magnet test results. Grading work on the site has been held up by the weather.

2. 184 inch Cyclotron Operation

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The cyclotron was used for research experiments approximately seventy-nine percent of the 480 hours that the crew was on duty.

This was the first month of steady operation of the cyclotron after the proton conversion so that an appreciable part of the time was still devoted to making adjustments in the new unit. In addition to this, time had to be spent in development of rf bypass condensers that would not fail during operation.

3. 60 inch Cyclotron Operation

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The termination of the long micro-interceptor target run for Doctor Seaborg's group occurred during this period. In the last eight days, 30 microamperes were put on this target which intercepted approximately 1/25 of the entire beam. The magnet current resonance value has experienced a drop of 20 amps over the last month. Checks to determine the cause or causes of this phenomena have been numerous but negative. At present, a beam energy determination is contemplated to ascertain the effect of this shift on the accelerated particles.

4. Synchrotron Operation

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Continued adjustment of the magnetic field shape, small changes in the value of n , and timing adjustments have resulted in increasing the out-put of the machine to a peak value of 1200 mr per hour, as measured by standard RL Zeus meter located behind 1/8" lead, 10 feet from the target.

Measurements of the out-put as a function of injection time indicate that it will be necessary to reduce timing jitter to about .02 microseconds. This also necessitates improving the voltage regulation of the injector high voltage supply. These changes are being designed, and it is hoped that when they are complete, it will be possible to maintain the out-put at the above stated high level which can now be observed only as a flash performance. At the present time, it is necessary for the operator continually to adjust the injector timing to take care of drift and jitter.

Similar tests designed to measure the required precision of the oscillator timing circuits indicate that a tolerance of 5 microseconds is permissible in turning on the oscillator. Since this tolerance is in range of the present triggering equipment, it will not be necessary for these circuits to be re-designed. Tests have been made of the effect of oscillator rise time on performance. To date, no very important improvements have resulted from changing this shape. The machine appears to operate equally well on a pulse which rises sharply and on one which has a gradual rise for a period of 200 microseconds.

Some minor troubles have been encountered during the past month, such as failure of the internal photomultiplier assembly to function properly, and open circuits in the conducting surface of the quartz donut.

A considerable portion of the machine operation has been with nuclear plates located on each side of the x-ray beam and on targets of various materials located in the beam. Mesons have been observed in these plates, but no quantitative data are yet available. The large cloud chamber is being adjusted to observe phenomena caused by the x-ray beam, and it should be possible in the near future to perform cloud chamber experiments with the synchrotron.

5. Linear Accelerator and Van de Graaff Operation

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The machines were used for bombardments a total of 212 hours. Four minor shutdowns on the Van de Graaff totaled 4-1/2 days. A major shutdown of 3 days was caused by bearing failure of the motor driving a hypervac pump inside the Van de Graaff. A check of Van de Graaff failures shows that the machine now runs for periods

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of 3 weeks without being opened for any reason at all and the curve shows steadily decreasing outage time.

Proton-proton scattering experiments are taking the major part of the linear accelerator time. Be⁷ decay experiments account for most of the spare Van de Graaff beam time.

6. Experimental Physics

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Film Program. The primary effort of the film program during the past month has been the reduction of background in the cyclotron for the study of mesons produced by 350 Mev protons. By contouring a clipper to conform with the beam profile and by placing lead bricks within the dee at a radius beyond the beam orbit, it has been possible to obtain plates with approximately one track out of ten a meson or a star prong associated with a meson.

Cloud Chamber. The pantagraph cloud chamber and magnet at the cyclotron have been reassembled. It has been possible to make only one run because of some trouble with the magnet generator, but from this run approximately 230 mesons have been observed.

A cloud chamber without magnetic field has been operated at the synchrotron. The chamber contained a series of lead plates. The pictures demonstrate the multiplicative nature of fast electrons, and the depth to which the showers penetrate indicate that the synchrotron is producing 300 Mev γ -ray.

Energy Distribution of Neutrons from 350 Mev Protons. An experimental determination of the energy distribution of the proton-produced neutron beam from the 184 inch cyclotron has been started. The method of neutron-proton scattering was used, with the energies of the scattered protons being determined by a magnet and slit system rather than by absorbers. First results show a maximum in the distribution at 255 ± 15 Mev.

High Energy Gamma Rays Emitted by Cyclotron Target. The integrated cross section for the production by 350 Mev protons of the high energy photons being studied has been evaluated as:

$$\int_{30 \text{ mev}}^{105 \text{ mev}} \sigma(E) dE = 7 \times 10^{-28} \text{ cm}^2 \text{ mev}$$

per Be target nucleus. Measurements of photon beam attenuation in Pb at 30 Mev and 78 Mev gave values about 10 percent lower than the Heitler values.

Application of Scintillation Counting to γ Detection. A scintillation counter using a coincidence circuit operating at room temperature and arranged to detect β or γ rays was delivered to Dr. C. Tobias at Donner Laboratory. Stability measurements using a Co⁶⁰ sample showed a difference between the maximum and minimum count in numerous trials of 6 percent. The overall efficiency for detecting Co⁶⁰ gammas was found to be about 3.7 percent, which is about ten times the efficiency obtained with the Geiger counters used at Donner. At present there seems to be no point in trying to use this counter for β rays. Lack of large clear anthracene crystals is one of

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the major factors standing in the way of increasing the efficiency for gamma rays.

Work has commenced on a counter arranged for liquid samples.

Mass Spectrograph. Automatic Scale Changer. A simple scale changing mechanism has been incorporated into the Leeds & Northrup Speedomax circuit. A step relay is operated by a micro switch, which is in turn operated by the Speedomax recorder mechanism when full scale deflections occur. This allows rapid changes to less sensitive scales to take place until a signal less than full scale is attained on the recorder. On the removal of the signal, the release solenoid of the step relay is energized by another micro switch set at the lower end of the recorder scale, which resets the recorder to maximum sensitivity where it will remain until a new signal is received. The scale changer is limited to the signals of 5 seconds or more duration due to the speed of the recorder mechanism.

Germanium Fluxmeter. The magnetic field measuring device described in the previous report has been modified by introducing a new holder for the germanium crystal. Both the current carrying leads and the e.m.f. leads are soldered to the germanium crystal, and the entire assembly has been dipped in clear glyptal varnish. All indications of instability in the output of the e.m.f. from Hall Effect has disappeared, with no apparent reduction in sensitivity or linearity. Further tests are now being made.

Enriched Fe^{58} has been analyzed by heating FeCl_3 in sample furnace. Sample did not last long enough to give satisfactory results and will be repeated in the future.

A remote control unit has been constructed for the 100 percent feedback d.c. amplifier but has not yet been installed.

7. Theoretical Physics

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The 90 Mev n-p scattering calculations have been completed and a paper is being written on the results. The p-p scattering calculations await the experimental results. In the meantime, relativistic effects are being investigated.

The meson production by 350 Mev protons is being calculated. Estimates are also being made of the x-ray production of mesons.

The x-ray production to be expected from high energy protons, due to nuclear encounters, has been determined. Both ordinary bremsstrahlung, and the radiation due to the magnetic moments was taken into account. The expected radiation is an order of magnitude smaller than that found by Moyer and York.

A paper on the operation of the cyclotron has been completed. Work is being done on various bevatron problems.

8. Chemistry

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Part A

Yields of Mn⁵² and Mn⁵⁶ from Various Targets. Data have been obtained for the yields of Mn⁵² and Mn⁵⁶ induced by 190 Mev deuterons from the following elements: ²⁴Cr, ²⁵Mn, ²⁶Fe, ²⁷Co, ²⁸Ni, ²⁹Cu, ³⁰Zn, ³¹Ga, ³²Ge, ³³As, ³⁴Se, ³⁵Br, and ³⁸Sr. The maximum yields were obtained from Co and Ni. For greater Z, the yields fall off, the decrease being sharper for Mn⁵² than Mn⁵⁶. The two isotopes were detected in targets as far away as Br and Sr respectively, but with yields of the order of 10⁻⁴ of the maximum value. An attempt is being made to account for certain alterations of yield as a function of Z. The preferential emission of alpha particles in spallation in certain cases may be connected with this effect.

Mass Assignment of Po²⁰⁴. An alpha-active polonium with a 4-hour half-life has been observed previously in bismuth bombarded with high energy deuterons, helium ions, and protons, and in lead bombarded with high energy helium ions. It has now been assigned to Po²⁰⁴ by periodic milking of the bismuth daughter of electron-capture decay. It was found that the yield of 12-hour Bi²⁰⁴ fell off with a 4-hour half-life. A crude estimate of the K/α branching ratio of Po²⁰⁴ is of the order of 10³. There is some evidence that the daughter of the alpha decay is 18-hour Pb²⁰⁰ decaying to 27-hour Tl²⁰⁰, but these facts have not been demonstrated conclusively.

Decay Energy of Th²³³. The old value of 1.6 Mev for the beta decay energy of Th²³³ is inconsistent with the prediction based on alpha decay systematics for the heavy isotopes. Recent measurements give a preliminary result of 1.0, in good agreement with the expected value. A better measurement on a more active sample will be undertaken.

New Beta-stable Isotopes. Data have been obtained which indicate that the following isotopes decay in part by β⁻ emission: Tm¹⁶⁶, Ta¹⁷⁸, Re¹⁸², Ir¹⁹⁰, and Au¹⁹⁴. This means that the daughters Yb¹⁶⁶, W¹⁷⁸, Os¹⁸², Pt¹⁹⁰, Hg¹⁹⁴, previously unknown, are beta-stable. In other cases less complete evidence of the same kind can be interpreted as implying the beta-stability of Dy¹⁵⁴, Hf¹⁷⁰, Hf¹⁷², W¹⁷⁶, and Hg¹⁹². That these species are not found in nature may be due to low abundance, below the present limit of detection of mass spectrographs, or to decay by alpha emission at a rate rapid with respect to the age of the earth.

Heat of Solution of Praseodymium Metal. Some recent measurements of the heat of solution of praseodymium metal in 1.5 M hydrochloric acid have given results ranging from 173 to 178 kcal/mole. These results are higher than expected, and better precision should be obtained. The divergence has been attributed to barium and beryllium impurities in the praseodymium metal. For this reason, reduction of praseodymium by lithium in a tantalum crucible will be undertaken.

Chemistry

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Part B

Synthetic and Experimental Chemistry. Satisfactory progress has been made in all the preparations of C⁻¹⁴ labeled compounds to be distributed by the Isotopes Division of the Atomic Energy Commission except in that of the propyl alcohols and halides.

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High pressure hydrogenation has been used in the preparation of the methyl iodide for these syntheses since some contamination with ethyl iodide (inactive) generally seems to take place when lithium aluminum hydride is used.

The preparation of I^{131} -diiodotyrosine has been studied on both a semi-micro (100 mg) and a micro (100 μ g) scale. In the semi-micro preparation the product was crystallized but in the micro the material was separated by paper chromatography and eluted to give a pure product.

The work on the preparation of Demerol, a synthetic analgesic, is being continued. Low activity preparations of alanine-3- C^{14} have been made in about 50 percent yield; a high activity run will probably be made shortly. The study of the decomposition of acetyl peroxide in labeled acetic acid is continuing; the various products from this reaction are being carefully isolated and degraded to study the distribution of the activity. The purification of labeled glucose and mannose by the use of chromatographic columns packed with shredded paper is being attempted. It is desired to develop a good method for the purification of synthetically prepared sugars.

Biological Chemistry. A study has been made of the utilization of C^{14} methylene-labeled glycine in normal and starved mice. Mice maintained for 72 hours on a normal, on a glucose, and on a water diet were injected with radioactive glycine and sacrificed at 2, 4 and 6 hours after injection. It was definitely shown that the presence of glucose in the diet of protein depleted animals results in a higher conversion of amino acids to proteins.

The studies on the rate of metabolic oxidation to $C^{14}O_2$ of labeled organic compounds have continued. In these studies it is found that the elimination curve of the activity can usually be broken into a fast, a medium and a slow component.

The studies of the difference in the rate of metabolism of sodium propionate-1- C^{14} in normal and tumor mice are continuing. The results seem to indicate that the difference is not as large or as consistent as was found in the first batch of mice. The difficulty has not been resolved.

Photosynthetic Chemistry. A series of carbon dioxide fixation experiments with the algae *Scenedesmus* and *Chlorella* have been performed to determine the chemical relationship of respiration to photosynthesis. Since both processes occur simultaneously in the light it is important to recognize respiration intermediates. By allowing algae to photosynthesize with $C^{14}O_2$ in order to build up a reservoir of radioactive intermediates it has been possible to examine the action of fermentation (anaerobic) and respiration (aerobic) on these compounds.

Preliminary short photosynthetic experiments (60, 15 and 8 seconds) have been performed with leaves of higher plants. The radioactive products are being separated by paper chromatography.

It has been possible to produce radioactive sucrose in the dark by pre-illuminating the algae *Chlorella* in the absence of carbon dioxide followed by 2 minutes in the dark with radioactive $C^{14}O_2$. The intermediates and their relative amounts are identical with the photosynthetic intermediates produced in a similar length of time.

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An experiment has been carried out to determine the effect of malonate inhibition on the reactions involved in carbon dioxide reduction in photosynthesis.

Work on the identification of phosphorylated compounds formed during photosynthesis is continuing. The location of hexose-diphosphate, fructose-6-phosphate, phosphoglyceric acid and phosphoglyceraldehyde on paper chromatograms has been determined.

Chemistry

Part C. Project 48B

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

1. Thermodynamics of CN and N₂.
2. Absorption coefficients of CN and C₂.
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.

9. Medical Physics

Part A

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Tracer Studies. The entire activities of the tracer group were involved in the study of the metabolism of Nd¹⁴⁷. Rats were given this rare earth and were or will be sacrificed 1, 4, 16, and 32 days after administration. Studies were set up as follows:

1. Nd¹⁴⁷ as carrier-free neodymium.
2. Nd¹⁴⁷ complexed with citrate.
3. Nd¹⁴⁷ complexed with oxalate.
4. Nd¹⁴⁷ given with 1/2 milligram of carrier isotopic neodymium.
5. Nd¹⁴⁷ given with 1/2 milligram of praseodymium carrier.
6. One 4 day intravenous study.
7. One intravenous study in a rat bearing a fibrosarcoma.
8. One stomach tube group.

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The data are complete up to one day after administration. With carrier-free neodymium, 70 percent of the material administered remained in the injection site. That which was absorbed was deposited primarily in the liver and the skeleton, deposition being 13 percent and 6 percent respectively of the administered dose. At four days after administration, 54 percent of the dose remained in the injection site, 15 percent in the liver and 9 percent in the skeleton. When neodymium was complexed with citrate, the uptake was enhanced ten fold after intramuscular administration, there remaining but 7 percent in the left leg and 23 percent in the skeleton. Of the total dose given, 37 percent was found in liver. Attempts to complex Nd^{147} with oxalate gave totally dissimilar results and complexing with this material altered very little the uptake of neodymium from the injection site. These results resembled those obtained on the carrier-free uncomplexed material. The addition of isotopic neodymium or carrier praseodymium to the carrier-free Nd^{147} completely inhibited any uptake from the administration site at 1 day. Nd^{147} is not absorbed from the intestinal track and the largest organ, which was the balance of the animal, contained but .005 percent of the dose.

Neodymium in the carrier-free state is not particularly deposited in tumors such as fibrosarcoma in the rat. The physical description of the Nd^{147} furnished us by Oak Ridge originally checked with the data available in the literature having an 11 day half-life. However, at this date, or approximately two half-lives later, it is now 13 days and it would appear now that the material possibly contains small amounts of element 61 as a contaminant.

Radioautographic studies of the uptake of neodymium by the femur and the costochondral junction have been initiated. Experiments are underway to study the uptake of radio-strontium at the costochondral junction at very short time intervals, i.e. 5, 10, 20, and 40 minutes after administration of strontium. Experiments are continuing with element 61.

Decontamination Studies. Owing to counter difficulty, there is little progress to report this month. Study of the mechanism of zirconium citrate decontamination is being continued, as well as investigations of endocrine factors affecting bone metabolism. Acute experiments are being made to study the rate of uptake of certain radioactive elements and fission products by bone, both by direct measurement and by radioautographs.

Radiochemistry. During the past month, astatine has been made twice from alpha bombardments of bismuth. The first astatine obtained was used for animal injection. The results of the first experiments indicated that improved recovery techniques were necessary and the product of the second bombardment was used for the purpose of improving the recovery processes. Confirmation of a neodymium shipment from Oak Ridge was made by column separation with carrier. A separate peak indicated a small amount of impurity. An attempt was made to obtain copper of very high specific activity, but the specific activity of the Cu^{64} has not yet been made high enough for animal injection. Columbium in carrier-free form was obtained from a Zr-Cb shipment from Oak Ridge.

Medical Physics

Part B

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As of January 20, 1949, the U. S. Navy contract N6ori-111, Task Order 3,

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Project NR 171-138, entitled "Immediate and Delayed Biochemical and Biological Effects of Irradiation on Animal Tissues" has been transferred to the auspices of the Atomic Energy Commission. Progress on the above will be reported under the following new headings:

- (A) Effect of specific irradiation of liver, spleen, bone marrow, and lymphatic tissue on the circulating plasma proteins.
- (B) Metabolic studies on normal and leukemic cells.
- (C) Physical chemistry. Physical and chemical methods in dealing with large molecules in biological systems.

In carrying on a study of radiation effects on iron metabolism, the distribution of intravenously administered Fe^{59} in normal rats, and rats receiving 250 r of total body irradiation, was determined. The studies show that in rats the concentration of Fe^{59} rises most rapidly in the bone marrow, reaching a maximum in eight hours. In the radiated animals the marrow reaches only half the concentration of that in the normal animals and the maximum is reached in a period of 20 hours after the administration. In a period of 5 days the liver concentration in the radiated animal has a value twice that of the normal animal. In general this seems to be a shift of iron to the storage depots following radiation in contrast to the normal condition when there is immediate production of red cells from the available iron.

Biological work with the 184 inch cyclotron was temporarily suspended because of alterations on the cyclotron.

In the course of study of nucleic acid metabolism preliminary experiments indicate an increased turnover of desoxyribose nucleic acid in liver slightly irradiated with external x-radiation (60 r).

The study of the nature of radio resistance and radio sensitivity of bacteria has been continued. A definite recovery phenomenon from the effects of ultra-violet on E. coli, as first described by A. Kelner in unpublished data, has been observed when the bacteria are illuminated with a strong source of visible light after the ultra-violet irradiation. In addition, however, indications have been found that a degree of radio resistance can be induced by exposing the bacteria to visible light previous to the ultra-violet irradiation. Ultra-violet ray studies of protection and recovery phenomena on bacteria are being extended to ionizing radiations. Recovery from ultra-violet effects by subjecting the bacteria to cold irradiation has been described by Roberts in unpublished data. This effect has been observed in our radio-sensitive "B" strain.

10. Health Physics and Chemistry

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Radiation Field Studies. Various measurements of the components of the radiation fields of cyclotron and linear accelerator are continuing. The installation of concrete mazes in the shielding door apertures of the cyclotron has improved the radiation field level markedly in locations near the doors.

Surveys on the linear accelerator show the following general features:

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- (1) Slow neutron production is sufficiently small to be negligible in hazard.
- (2) Fast neutron flux is usually sufficiently low outside the target-area fences, but the situation is marginal under high intensity operation.
- (3) X-ray levels are higher than is desirable. Further Pb shielding measures are in progress, as well as studies aimed at lowering X-ray production.

Research and Development. The projects in progress in the Research and Development Section of the Health Chemistry Division are as follows:

1. Lead glass brick window and frame for mounting in 1-in. lead manipulator panel: 80 percent completed; ready for assembly.
2. Automatic air sampler for detection of presence of alpha emitters: sampler completed and awaiting testing.
3. Alpha survey meter: improved alpha survey meter with preamplification in the probe completed and delivered.
4. Separation, storing and metering of tracer samples for Medical Physics Group: advice on planning for the separation, storing and metering of approximately 1000 tracer samples given by the Health Chemistry group; job completed.
5. Hanford slug 12B (May 1949): plans for opening and handling under way.
6. Preparation for Pa²³² detection from a 60 inch cyclotron bombardment: designs for chemical unit for Hot Cave, Building 5, and for box for target assembly under way.
7. Preparation for Pa²³³ detection from a Clinton slug: chemical unit for processing slug in Hot Cave, Building 5, under development.
8. Liquid target holder shield box and transportation facilities: shielding box and dolly for transportation of target holder from 60 inch cyclotron to Building 4 being designed.
9. Special hood for vacuum system containing plutonium: adjustable hood with glove ports for enclosing vacuum system being designed.
10. Decontamination room annex to Building 5: bids let for construction of room.
11. Improved platinum interceptor for 60 inch cyclotron targets: fabrication 50 percent complete.
12. Gloved boxes completed: box assembly for microbalance reflector beam arm; three recessed centrifuge and automatic sampler type boxes; two centrifuge well type boxes with dolly.
13. Jiffy probe target equipment: target holder completed; special tons for jiffy probe 50 percent completed.

14. Work on the baffling of hoods for streamlining hood air flow: 70 percent complete.

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Information Division
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SUMMARY OF RESEARCH ACTIVITIES

January 15 to February 15, 1949

60 inch Cyclotron

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

The development is proceeding on the theoretical level with practical applications materializing. Problems of main import are: 1) Counting rate metering system for beams of 10^{-12} amps. 2) Resolving mechanism to differentiate between $C^6 + He^{24}$.

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

Suspended temporarily due to pressing needs of other assignments.

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

Work done on the 184 inch group model of the 60 inch magnet indicates a 1-1/4 percent decrease in fall-off due to removing of taper of present pole face, ie: extension of 60 inch pole face to 72 inches.

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

Work progressing in conjunction with the Health Chemistry Division.

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

Design completed, fabrication and assembly assignments being made.

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

Suspended temporarily due to pressing needs of other assignments.

184 inch Cyclotron

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

No progress. Awaiting delivery of the motor.

2. Development of improved beam monitoring equipment.

Design and construction work in progress.

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184 inch Cyclotron (Continued)

3. Construction of proton beam deflector.

Equipment still undergoing tests; not yet installed.

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

Auxiliary probe equipment constructed; installation not yet completed. A new large probe is being designed.

300 Mev Synchrotron

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

Measurements of output as a function of injection time indicate that it will be necessary to reduce timing jitter to about .02 microseconds. Effects of oscillator rise time on performance have been measured.

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.

Cross sectional area of the vacuum chamber being used by the beam was observed to be 1 inch high and 3 inches wide in the radial direction.

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

Mesons have been found in nuclear plates exposed on both sides of the beam. No quantitative data is available as yet.

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

Preliminary measurements of the transition thickness of lead show it to be approximately 3/8 inch. This test made use of a multiple sandwich of lead plates and type K x-ray film. The energy spectra are not known yet.

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

No work done during the month.

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Linear Accelerator

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

There have been no changes with the rf half of the linear accelerator for several months.

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

No changes in the Van de Graaff generator for two months. Preparations are being made to install a new ion source.

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

The PIG ion source has been made into a model suitable for use in the Van de Graaff and is now being given final bench tests prior to installation.

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

Proton-proton scattering experiments using both counter and photographic emulsion techniques are in progress. The two methods agree within statistical errors.

Bevatron

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

Magnet tests completed. The vacuum tanks are being installed. Cyclotron injector is under construction.

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

The cranes have been ordered. Magnet design and model testing is in progress. (Note: Last month's report should have read - core and coil design proceeding.)

PHYSICS RESEARCHGeneral

UNCLASSIFIED

1. Range measurements for fast particles.

No work currently in progress.

Fundamental Properties of Nucleons.

UNCLASSIFIED

1. Neutron-proton scattering.

Experiments have been started with neutrons from the 184-inch cyclotron. The runs thus far have been preliminary to learn the techniques at the higher energies. A ten channel analyzer is being tested. A theoretical study of neutron-proton scattering is being written for publication.

2. Proton-proton scattering.

See item 4 under Linear Accelerator. Theoretical work is being done in an effort to explain the shape of the scattering curves.

3. Scattering of protons and neutrons on deuterons.

Ten channel pulse analyzer is being tested.

4. Other scattering experiments.

The energy spectrum of inelastically scattered protons from carbon has been obtained covering the range from 0 to 32 Mev.

5. Life time of neutron.

All equipment is now on hand and has been tested piece by piece. The first overall check will be made shortly.

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

230 mesons produced in the neutron beam of the 184-inch cyclotron have been observed. With the synchrotron the production of mesons by 335 Mev x-rays has been observed. Now engaged in getting quantitative data on yields under various conditions. Study continues on high energy photons from the cyclotron target. Calculations of meson production by 350 Mev protons are in progress. The cross section for x-ray production has been calculated and numerical applications are being made.

Nuclear Reactions.

UNCLASSIFIED

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

Work has continued on the development of a theoretical explanation for the production of deuterons. x-ray production of proton bremsstrahlung and by radiation from proton and neutron magnetic moments have been calculated.

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Nuclear Reactions (Continued)

2. Energy dependence of reactions.

A paper on the N^{12} excitation curve is in press. The work on Bi + d excitation has been completed and a new isotope of Po found. Theoretical work on the production of high energy neutrons by 350 Mev protons is in progress.

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

See the section on Nuclear Chemistry.

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

A very tentative value of $0.03 \pm .005$ b for the total n-p cross section has been found. Preliminary results on the study of the energy distribution of neutrons produced by 350 Mev protons have been obtained. Preliminary interpretation has been made of high energy (~ 300 Mev) neutron cross sections.

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

Cancellation ionization chambers for use in measurements of fission cross sections under changed particle bombardments have been built and are being tested.

Instrumentation

UNCLASSIFIED

1. Instrumentation in support of cloud chamber development.

The magnet for the cloud chamber used with the 184-inch cyclotron was reassembled following an accident in which the top pole piece was pulled down.

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

Work in progress.

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

Work continues on crystal counter development.

4. General development of electronic counting equipment.

See item 1 under Fundamental properties of nucleons. General development work has continued. Improved counting equipment has been in-

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Instrumentation (Continued)

stalled to measure radioactive deposits on the photographic plates after a mass spectrograph run.

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

Various types are being developed and built as needed.

6. Development of radiation survey instruments.

See item 4 under Health Physics.

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

The Nier spectrometer is operating satisfactorily on isotopic carbon samples and on calutron produced samples. Mass identification of four radioactive isotopes of rubidium has been completed.

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.

The sensitivity of Ilford Q plates over Eastman III-O spectroscopic plates for positive ions has been determined. The Ilford plates are more sensitive by a factor of 10^5 for mass spectrograph work.

Electromagnetic Isotope Separation

SECRET

1. Design and construction of experimental units.

No progress.

2. Development of r.f. source units.

No progress.

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

No progress.

Nuclear Chemistry

CONFIDENTIAL

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

Work is continuing on isotopes of a large number of elements.

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Nuclear Chemistry (Continued)

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

Additional measurements are being made using the 350 Mev protons.

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

Experiments on the fission products of tantalum are in progress.

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.

No progress.

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

There is some evidence that the 18-hour Pb, K-daughter of the 1-hour bismuth alpha emitter and assigned to Pb²⁰⁰, is also the α -daughter of 4-hour Po²⁰⁴.

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.

No progress.

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.

Bombardment of U²³³ on the 60-inch cyclotron is continuing.

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

No progress.

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Nuclear Chemistry (Continued)

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

Studies are underway on targets of uranium, thorium, bismuth, lead, antimony, copper and potassium.

12. Study of meson reactions by chemical means.

Lead, bismuth, and copper have been bombarded with 350-Mev protons in a continuation of the search for abnormal charge increase.

13. Development of chemical analysis techniques utilizing radioactive tracers.

No progress.

Chemistry of Heavy Elements

CONFIDENTIAL

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.

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

The study of the Pr-O system is continuing.

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

No progress.

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

No progress.

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Chemistry of Heavy Elements (Continued)

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

Measurements of the heat of solution of Pr metal in HCl solutions have been made, but they must be repeated because of impurities in the metal.

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

No progress to report.

High Temperature and Pile Chemistry

SECRET

1. Metals and high temperature thermodynamics.

Work is in progress on the thermodynamics of CN and N₂, the absorption coefficients of CN and C₂, the thermodynamics of molybdenum halides and oxides, the thermodynamics of gaseous aluminum oxides, low melting metal systems, and on the structure of solids and 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.

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

UNCLASSIFIED

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

Wet and freezing weather has prohibited extensive work on this project. Also, the subcontractor's delivery of pipe has been behind schedule so that the percentages for this month are: Clearing, 90 percent; preparation of the 48 inch drain line, 80 percent. Architects are involved in problems of getting out final work drawings for the foundation and building. The 1/4 scale Bevatron has been retarded somewhat by the testing of vacuum tanks--this proving to be a long and tedious process to insure freedom from leaks. Design of full scale equipment continuing as fast as possible.

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Program Class 530 - Plant and Equipment (Continued)

2. Complete equipping of Central Research Laboratory Building.

The ground floor is nearly completely poured, as are most of the columns. The pouring of the second floor in some sections is ready to proceed.

3. Construction of Animal House and Cafeteria.

As stated in last month's report, these projects are being studied by the architects, Hertzka and Knowles.

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

Tentative plans have been submitted to combine the shop buildings with the building for maintenance machinists forces. These plans are now being studied and final comments will be given to the architects, *Hertzka and Knowles* (~~Master and Hurd~~), in the near future. The second building is not as yet on the drawing board, since funds do not permit its erection until next year.

5. Miscellaneous Small Construction.

Warehouse grading, 27 percent complete.

Paint Shop - Steel frame erected. Windows, doors, sides and roofing ready for installation.

A small building was constructed to protect the cloud chamber that will be operated outside the synchrotron building.

MEDICAL RESEARCH

Biological and Medical Studies at Crocker Laboratory

UNCLASSIFIED

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

As explained more fully in an earlier section of this report, the entire efforts of the group were concerned with studying the fate of Nd¹⁴⁷ in rats.

2. Decontamination Studies.

Owing to counter difficulty, there is little progress to report for the period. Study of the mechanism of zirconium citrate decontamination is being continued, as well as investigations of endocrine factors affecting bone metabolism.

Biological and Medical Studies at Crocker Laboratory (Continued)

3. Radioautographic Studies.

Work is in progress studying the uptake of Nd^{147} in the femur and the costochondral junction of rats. Studies with strontium at short term intervals have been initiated. Projected studies include the uptake of plutonium in healing tissue and in the costochondral junction.

Medical Research at Donner Laboratory and Elsewhere

UNCLASSIFIED

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

The work is being continued.

2. Biological effects of fission.

Inactive at the present time.

3. Biological effects of high energy neutrons.

Inactive at the present time.

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

The animal house has not been built as yet.

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

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

Preliminary experiments indicate an increased turnover of desoxy-ribose nucleic acid in livers slightly irradiated with external x-radiation (60 r).

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

Transferred to the Hunters Point Navy Laboratory.

8. Microchemical assay of tissue components by induced radioactivity.

The distribution of trace elements in blood components from normal humans and patients with blood dyscrasias is being continued with samples activated at the Hanford pile.

Medical Research at Donner Laboratory and Elsewhere (Continued)

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

(A) Fe metabolism in animals exposed to x-radiation. Distribution of intravenously administered Fe⁵⁹ in normal rats and rats receiving 250 r total body irradiation was determined.

(B) Further studies were carried out on the effect of x-radiation on the blood serum of rabbits. The serum is found to be opaque after lethal dose of irradiation, the opaqueness being caused by fat particles being liberated in the blood stream. The rate of appearance of this phenomenon is being studied. It seems to have a definite correlation with the lethal effects.

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

The work is being continued.

11. Study of genetic effects of radiation.

The work is being continued.

12. Radiation effects on micro-organisms and studies on the nature of radio-sensitivity and radioresistance.

A definite recovery from the effects of ultra-violet light has been observed when the bacteria are illuminated with visible light. Light seems to be effective when it is applied before and after the ultra-violet irradiation.

New Projects Added:

13. Effect of specific irradiation of liver, spleen, bone marrow, and lymphatic tissue on the circulating plasma proteins.
14. Metabolic studies on normal and leukemic cells.
15. Physical chemistry. Physical and chemical methods in dealing with large molecules in biological systems.

Navy Contract.

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

UNCLASSIFIED

1. Effects of external irradiation of the whole body.

5 blood counts done on patients treated before or during 1946.

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

7 blood counts done on patients treated with P^{32} prior to May 24, 1948. 13 blood counts done on patients treated with I^{131} ; of these 13, four are new patients.

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

26 uptake studies with 14 treatments following these studies; currently, analysis of all surgical and ~~chemical~~ ^{clinical} cases to date with reference to the type of disease and percentage of iodine absorbed and effects of thyroid medication.

4. Study of skin reaction to radiation from x-rays, gamma rays, beta particles, alpha particles, 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. Investigations into the cause and cure of radiation sickness.

No work being done under this title.

Biochemistry

UNCLASSIFIED

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.

Study of free radical decomposition of acetyl peroxide is continuing. Some presumed isotope effects in chemical reactions were investigated, but not substantiated. Some paper work has continued.

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.

The following compounds have been sent out: Sodium propionate- $l-C^{14}$, 5 mc run; Sodium Butrate- $l-C^{14}$, 5 mc; Sodium Valerate- $l-C^{14}$, 5 mc; Sodium Caproate- $l-C^{14}$, 5 mc; Sodium Heptanoate- $l-C^{14}$, 5 mc;

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Biochemistry (Continued)

Sodium Acetate-2-C¹⁴, 60 mc; Calcium Glycolate-1-C¹⁴, 10 mc; Benzoic Acid, 17 mc, Alanine-1-C¹⁴, 10 mc. Work is continuing on a number of other compounds.

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

Work is continuing on a number of projects including lactic acid, demerol alanine, diiodotyrosine, alanine-3-C¹⁴, glucose-1-C¹⁴, mannose-1-C¹⁴, succinic acid, maleic acid etc. An active field of work.

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

Metabolism work of Dopa, and tyrosine is being concluded. Work on rate of metabolism of simple compounds is continuing. Some distribution and rate studies have been instigated.

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

A series of CO₂ fixation experiments have been made to study respiration and fermentation in plants. Rate studies have also been made. A very active field of investigation.

Health Physics

UNCLASSIFIED

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.

An extensive study is being made of the numbers and energies of protons, deuterons, H³ls, He³ls, and alpha-particles produced in the neutron irradiation of various materials.

3. Controlled exposure of animals in neutron beam.

No work during this period.

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Health Physics (Continued)

4. Applications of new types of counters to dosimetry.

Further development and use of recoil proportional counters in evaluating fast neutron fields. A program of adapting scintillation counting methods to problem being worked on in Donner Laboratory has continued with some promise of useful results in γ counting.

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

Over 900 film badges are being processed weekly.

6. Shielding materials.

Attenuation measurements on neutrons produced by 350 Mev protons have been carried out for concrete, lead, and copper.

Health Chemistry

UNCLASSIFIED

1. Shielding - materials, stopping power, geometry.

Continued study of the appropriate material and design to be used in containers with maximum efficiency in shielding, especially for economy of shipping weight.

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

Heavy liquids, including thallium formate: optical properties and density studied. Even with a density of 3.7 a liquid cannot compete with lead glass for shielding from present indication.

3. Plutonium slug design for use in piles.

No special design for Pu slug; pile slug and capsule setup already developed satisfactorily for all pile work.

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

Permanent container completed.

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

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

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Health Chemistry (Continued)

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

CWS filters received for test and work continuing on blowers and filters. Special filter designs being employed for use with larger volumes of acids being evaporated in the boxes.

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

Decontamination annex approved for construction.

8. Design of special target holders for active material.

Design of special target holder is progressing with special emphasis on speed of removal of target for detection of short-lived isotopes.

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; any further statement on the progress therein beyond the scope of these comments.

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

Continuous attacks on these problems being made, details of which would require too lengthy a description to be suitable for this report.

RESTRICTED

APPROXIMATE DISTRIBUTION OF EFFORT

PROGRAM	SUBDIVISION	MAN MONTHS	COMMENTS
184-inch Cyclotron	Operation	10.4	
	Proton Conversion	-	
60-inch Cyclotron	-	-	Non-Project
Synchrotron	R.f. System	.7	
	General	.7	
	Injection	3.6	
	Miscellaneous	-	
	Magnet Tests and Operation	6.5	
	Vacuum Chamber	-	
Linear Accelerator	Linear Accelerator - General	2.0	
	Van de Graaff - General	4.4	
	Development	2.5	
Bevatron	Injector	3.3	
	Magnet	1.2	
	1/4 Scale Model	3.8	
Experimental Physics	Cloud Chamber	5.5	
	Film Program	6.2	
	Ionization Chamber and Crystal Counter	3.2	
	Neutron-proton Scattering	1.2	
	Proton-proton Scattering	1.8	
	Neutron Diffraction	.4	
	Meson Range and Decay Measurement	2.2	
	Absolute Cross Section Measurements	2.0	
	Neutron Half Life	.5	
	General Physics Research	7.6	
	Magnetic Measuring Equipment	.4	
	Instruments for General Use	1.8	
Theoretical Physics	Synchrotron	-	
	Bevatron	1.5	
	Cyclotron	.5	
	Linear Accelerator	-	
	General Physics Research	12.3	
Isotope Separation	Nier Spectrometer	2.0	
	Low Mass Spectrograph	.2	
	XC Isotope Separation Program	3.0	

PROGRAM	SUBDIVISION	MAN-MONTHS	COMMENTS
Chemistry, Part A	Chemistry of Transuranic Elements	6.5	
	Nuclear Properties of Transuranium Elements	3.3	
	Transmutations with the 184-inch Cyclotron	7.0	
	Analytical and Service	13.0	
Chemistry, Part B	Synthetic and Experimental Organic Chemistry	7.3	
	Biological Chemistry	4.8	
	Photosynthetic Chemistry	5.4	
Chemistry, Part C	Metals and High Temperature Thermodynamics	3.0	
	Basic Chemistry, Including Metal Chelates	1.5	
	Engineering Development of Plutonium Separation	2.0	
	Ore Reduction	2.5	
	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	1.0	1.5 Man-Months
	Special x-ray Studies, Radioactive Measurements, etc.	3.9	3.6
	Radioactive Carbon Studies	2.1	.7
	Fundamental Medical Research	3.3	2.8
	Hematology	.7	1.4
	Medical Work with 184-inch Cyclotron	2.6	1.1
	Fly Genetics	1.0	.3
	60-inch Cyclotron Bombardments	.4	-
Health Physics and Chemistry	Monitoring and Disposal	6.3	
	Salvage, Decontamination, etc.	-	
	Research and Development	14.7	
	Film Badge Program	4.6	

DECLASSIFIED

~~SECRET~~