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UNIVERSITY OF CALIFORNIA

Radiation Laboratory

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MONTHLY PROGRESS REPORT

No. 98

May 15 to June 15, 1951

July 2, 1951

RESTRICTED DATA

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Berkeley, California

RADIATION LABORATORY, UNIVERSITY OF CALIFORNIA

May 15 to June 15, 1951

MONTHLY PROGRESS REPORT NO. 98

July 2, 1951

1. Bevatron (AEC Program No. 1500)

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Magnet. Coil winding has been proceeding on the second quadrant at a somewhat faster rate than in the first quadrant. Drawings have been completed for pole tips for the small aperture and bids will be requested in such a way that decision between the two apertures (1 x 4 ft. and 2 x 6 ft.) can be made at the time punching the steel starts. This will require completing dies for both the large and small aperture plates. The magnet model tests of the small aperture design showed an effective n value of 0.9 with tips designed for 0.6 and this discrepancy will have to be cleared up before construction starts on the dies. It is tentatively planned to remove the enamel from the inside edge of every second pole plate to provide a conducting surface in the aperture. The exposed edges may be metal sprayed to prevent rusting. The magnet will not be tested until all quadrants are wound and temporary bracing is installed between the quadrant ends.

Vacuum Tanks. The drawings of the tanks for the straight sections of the orbit have been completed and drawings of the curve tank are progressing.

2. 184-inch Cyclotron Operation (AEC Program No. 5741)

UNCLASSIFIED

The cyclotron was used for research experiments approximately 98 percent of the 482 hours that the crew was on duty.

The time distribution is as follows:

Operation for customers	473.75 hrs	98.2 percent
Filament change	1.25	0.3
Mechanical troubles (magnet heating)	3.25	0.7
Electrical troubles	4.50	0.8
	482.75 hrs.	100.0 percent

3. 60-inch Cyclotron Operation (AEC Program No. 903)

UNCLASSIFIED

A bombardment efficiency of about 80 percent was recorded during the month, with the instrument operating comparatively smoothly.

4. Synchrotron Operation (AEC Program No.5731) UNCLASSIFIED

During the last month the synchrotron has been shut down. The initial shutdown occurred because of arcing in the radiofrequency gap. The donut was assembled with a different resonator. This was so different that a good deal of difficulty in getting even a betatron beam was encountered, so a shift was made back to the old resonator which had been cleaned up. As the month closes, the adjustments are being made, though with more difficulty than had been expected.

5. Linear Accelerator and Van de Graaff Operation (AEC Program No. 5751) UNCLASSIFIED

The repair time during this period was used as follows:

1. The belt in the Van de Graaff was replaced.
2. Various causes of sparking in the Van de Graaff were investigated.
3. Experiments were conducted in order to improve the effective transparency of the grids in the linear accelerator.

In one experiment new grids were installed and simultaneously 1/3 of the grids were left out and replaced with dummy rings. This turned out to be unsatisfactory with only 1/3 of the normal beam available. It is not clear whether the cause is due to new grids or to the omission of the 1/3 of the normal number. When a full complement of grids was installed, 1/3 of the old type and 2/3 of the new, 2/3 of the normal beam was obtained. It is, of course not quite clear what conditions might have changed during this time. Investigation of this problem is being continued.

Operating statistics are as follows:

Running time	70 percent
Machine repair	21 percent
Bake-in time	4-1/2 percent
Machine research	4-1/2 percent

6. Experimental Physics (AEC Program No. 5211) UNCLASSIFIED

Film Program. Meson Masses. Further measurements on the π/μ meson mass ratio have been made to reduce the statistical error. This experiment is now nearly completed. Another comparison of π mesons with protons will be made. The improved apparatus is designed to eliminate more completely mesons coming from points other than the target.

Grain Density of C^{12} Tracks. A project which was left uncompleted several months ago has been revived. This consists of comparing the grain density of C^{12} tracks with alpha particle tracks in the same low sensitivity emulsion. The

experiment is also designed to detect the pick-up of electrons by the C^{12} ion as it slows down.

Cloud Chamber. The pantograph cloud chamber is being assembled for a run at the cyclotron. The experiment is neutron induced stars in helium.

The experimental setup for π^- absorption in helium is nearly completed. The Helmholtz coil magnet has been calibrated for an 11 inch gap. The special chamber, described previously, has been installed in the magnet and all associated equipment, wiring, and testing is being done at present.

The synchrotron beam has been rather low, due to technical difficulties, but some preliminary pictures for the photo-disintegration of the deuteron have been taken.

Due to a rather large influx of new graduate students and the limited accelerator time available for experiments some of the equipment and operating precedure are being modified to utilize the available accelerator time to the fullest. With this in mind the camera used with the pantograph cloud chamber has been modified to hold 400 ft. of film instead of the usual 100 ft. A new fast timer and calibrator of a more efficient design is being made.

In order to get the maximum accuracy from film measurements a new projector has been designed and built and is at present in the checking stage.

Production of High Energy Deuterons in Proton Bombardments. By a method indicated briefly in the Summary Report Dec. 15, 1950-Jan. 15, 1951, but using a considerably improved collimator, the pick-up hypothesis of G. Chew and M. L. Goldberg is being investigated. By using deuterium wax polyethylene target differences, the yields of recoil deuterons in the forward direction is obtained. The process is essentially elastic p-d scattering. The width of the observed deuteron "line" is 10 Mev. The resolution of the detecting apparatus is about 1 Mev in energy, 3° in angle.

The distribution-in-radius of the proton flux on a thin glass target may be studied by microphotometer analysis of the blackening produced in the glass by the beam. It is found that for the targets used, a 1/4-in. clipping aperture appears to be sufficient to reduce multiple passage effects to negligible amounts. Thus it might be assumed that the principal broadening effect of the deuteron line is the energy distribution of the protons on their first passage of the target. When the target is placed at a radius so as to receive 110 Mev protons, the deuteron peak is observed at an energy corresponding to 100 Mev protons, thus it would appear that the mean amplitude of the radial oscillations in the circulating beam is about 3 inches. This fact is also supported by blackening studies in the glass targets.

Pick-up deuterons are being investigated in Be, and C targets as well as in p-d scattering. As might be expected on the basis of theory, the upper limit of the Be spectrum at 0° is on the order of 15 Mev high than the C spectrum.

Cerenkov Radiation. The attempt to extend the Cerenkov radiation method of particle velocity measurement to lower velocities by using the high refractive

index of synthetic rutile has proceeded far enough so that the problems are more fully defined. A boule of the material was purchased and with the cooperation of the Mare Island crystal laboratory the material was oriented by x-rays and an attempt made to cut the material in the proper direction with respect to the optic axis. The material was brittle and tended to crack in the sawing process with the saws used. An attempt will be made to demonstrate this method of energy measurement with the material which remains but a precise measurement will probably require a new start.

Measurement of Cross Sections of Products of High Energy Neutron Bombardment of C^{12}. Preparations are being made to measure the cross sections for the production of B^{12}, Li^{8}, and He^{6} from C^{12} by 90 Mev neutrons and 300 Mev protons. A rotating disk of polythene is to be irradiated at one spot on the rim, and the resultant beta activities are to be measured at points along the circumference when the activities reach equilibrium. The C^{11} production cross section is to be used as a monitor for the computation of cross sections of B^{12}, Li^{8}, and He^{6} by comparison of relative beta activities.

Rotating a 20 inch diameter disk at 3450 r.p.m. spreads one half-life of B^{12} (0.022 seconds) out over the circumference of the disk. The major experimental difficulty is that of providing equivalent geometry for the counting of the 12 Mev negatrons from B^{12} and of the 1 Mev positrons from C^{11} because of greater self-absorption and shorter range in the latter case.

Proton Elastic Scattering. In order to obtain more detail in the minima of the diffraction patterns, it is desirable to obtain better angular resolution. In order to do this, 1/2 in. x 1/8 in. rectangular collimators have been made. The scattered deflected beam leaves the snout of the "deuteron tube" concentrated mainly in a plane tilted at about 13° to the horizontal. In order to take full advantage of this in the use of a line source, a new scattering table is being built which may be tilted through a range of angles such that the plane in which the scattering measurements are made is perpendicular to the plane in which most of the beam is concentrated.

High Energy Gamma Ray Experiment. An improved pair spectrometer has been used to measure more precisely the gamma ray spectra arising from bombardment of carbon targets with 340 Mev protons. Four different angles of view with respect to the direction of the incident proton beam were measured (0°, 45°, 135°, and 180°).

The resultant spectra were similar to previously measured spectra but indicated the possible presence of at least 7 percent of gamma radiation not arising from the decay of a neutral meson.

D-p Scattering Using 190 Mev Deuterons. The total d-p scattering cross section has been measured by the method of observing the single counting rate of one counter as a function of angle, and integrating over all solid angles to determine the number of d-p collisions. The carbon subtraction inherent in a method based on a CH_2 sample is fairly difficult at very small angles, but does not seem to be prohibitive. The result obtained in one run was $(88 \pm 9) \times 10^{-27}$ cm^2. This is surprisingly low compared to $(117 \pm 5) \times 10^{-27}$ cm^2 obtained for total n-d cross section at comparable energy by Cook, McMillan, Peterson, and Sewell (Phys. Rev. 75, 7 (1949). If such a difference exists between these two cross sections it would be quite important to know about it. The experimental

work will be considerably restudied and repeated in the future, in an effort to establish a reliable total cross section for the d-p scattering.

Search for New Delayed Alpha Particle Emitters. The three known radioactive nuclei with A = 4n, Z = 2n + 1 have been found in substances bombarded by the linear accelerator beam. These nuclei are B^8, N^{12}, and Na^{20}. Two new members of of this series have been found and are F^{16} and Al^{24}. The series is therefore complete from n = 2 to n = 7. For n = 1 the nucleus is Li^4, which is almost certainly unstable. The period of Al^{24} is 1.9 seconds and its mass (from its (p,n) threshold) is 24.0070. F^{16} has a period of approximately 1/2 second and a mass of 16.0168.

Proton bombardment of three different fluorine compounds has yielded a 4 second period which has not yet been identified. It was at first thought to be Ne^{18}, the one unknown nucleus which could be made by 32 Mev protons on F^{19}. This assignment appears to be incorrect, however, since the (p,n) threshold for this reaction is so low that the mass of the 4 second period, if it were Ne^{18}, would be less than the mass of F^{18}. An investigation of this activity is underway and a search for Ne^{18} is also planned.

Inelastically Scattered Protons from Heavy Elements. When heavy elements such as Au and Pb are bombarded with 32 Mev protons from the linear accelerator, low range particles corresponding to protons of less energy than the barrier of the target element are seen to come off in numbers much larger than can be explained by the Gamow penetration factor. This effect, previously observed, is being further studied. A new collimator has been tested and found very effective. To be sure that no low Z contaminant (e.g. diffusion pump oil) is occluded on the surface of the target, a platinum target is used which is heated practically to incandescence by passing current through it during the bombardment.

In spite of these precautions, the infra-barrier effect is still observed. The possibility that the low range particles are not protons, but rather deuterons or higher mass particles of consequently greater energy will be studied shortly.

Search for an Excited State of the He^4 Nucleus. An excited state of the He^4 nucleus has been sought by the method of inelastic scattering of protons. A chamber filled with helium gas was bombarded with 31.1 Mev protons from the linear accelerator and the spectrum of scattered particles was observed at several angles. Three peaks have been observed. Two of these peaks were readily identified as those of the elastically scattered protons and the recoiling helium nucleus. From the kinematics of the problem and from independent measurements of the range and energy of the particles composing the third peak, they were identified as deuterons from the heretofore unobserved reaction $He^4(p,d)He^3$. Experiments to measure the angular distribution of these deuterons are now in progress.

Although a proton group with energy as low as 4.5 Mev corresponding to an excitation energy of 23 Mev in the target nucleus should have been seen, no low energy proton group has been observed. Hence it may be said that there exists no excited level of the helium nucleus up to 23 Mev above the ground state which has a cross section for formation by this process greater than 1 millibarn per steradian.

7. Theoretical Physics (AEC Program No.5211) SECRET

MTA. The work on the preliminary design of the Mark II front end is essentially completed. The indicated phase acceptance angle is about 200°. The root mean square magnet fields (using the average over the length of the complete units) required were 6000 gauss in the first unit and 4000 gauss in the 11th unit.

A preliminary study of ions lost by phase slippage indicates that if ions are injected at all phase angles there will always be ions peeling off the edge of the phase stable region into bad phases. It appears that a small fraction of these will eventually hit the walls of the drift tubes. This amount of beam hitting the drift tube walls has not been investigated thoroughly as yet. At best this can probably be done only on a statistical basis and thus estimate the radioactivity to be expected from the drift tubes. If ions could be injected only during a time when the phase angles of injection were also phase stable, this situation could possibly be improved.

Some calculation was also done on a method of distributing the beam over the target by using the spherical aberration produced by a magnetic lens at the end of the accelerator. This method of spreading the beam did not appear to be satisfactory.

8. MTA Program (AEC Program No.1500) SECRET

Mark I Vacuum Tests. As of June 13 the vacuum vessel at Livermore had been evacuated to a pressure of 170 microns. It was then let down to air to remove the nitrogen trap. When a pressure of 170 microns was reached, the vessel was shut off and allowed to set for a time. There were no significant changes in pressure, indicating that no serious leaks were present. The strength tests without the drift tube load have been completed satisfactorily. Concrete shielding blocks placed along the top of the vessel were used to simulate the drift tube loading.

There has been a bottleneck in the fabrication of the liner sections. Personnel changes have been made together with one change in the design of the liner sections in order to speed their fabrication. The change was to eliminate the requirements for soldering the return bends of the tubing that covers the liner panels. Authorization has also been given to the fabricator to omit the additional copper reinforcement in the region of the return bend if trouble is encountered with its installation.

The possibility that the spongy aluminum spray coating in the Mark I tank may become contaminated with oil and lead to the contamination of drift tube surfaces under poor vacuum conditions led to the conclusion that vacuum testing should be carried out with only the oil diffusion pumps that are in favorable position with respect to the present liquid air baffle, and that every effort should be made to avoid operating the diffusion pumps in the pressure range in which the backstreaming of oil occurs. It is agreed that aluminum spray test samples would be placed in the tank during vacuum

tests and that a check of oil contamination will be made to determine the effectiveness of the procedure.

Oscillator Design. Plans for the design of cluster oscillators to power Mark II have been dropped. Originally it was thought that the transmission line for a 1 megawatt tube and cluster oscillator would be substantially the same, but that the circuitry would be simpler for a cluster oscillator than for an equivalent number of individual oscillators. However, it has now been determined that a transmission line for a single 1 megawatt oscillator need only be about 6 to 8 inches in diameter instead of the 18 to 24 inches originally thought. Furthermore since the tubes in the cluster oscillator are expensive items, precautions to prevent tube damage result in circuitry requirements that negate any advantage the cluster system was orginally felt to have in this respect. The smaller transmission lines for the 1 megawatt tube is now possible because it has been found that large amounts of circulating power in the transmission line and tube circuit can be eliminated by the use of a 1/2 wave transmission line and flat coupling loop inside the cavity. Furthermore, allowance for a 2 to 1 standing wave ratio is now considered adequate in place of the ratio of 10 to 1 originally considered necessary. Transmission lines of the type being considered have been tested for some time on the B-1 cavity and appear to be completely reliable.

A cost analysis of the alternative oscillator and transmission line designs has shown that use of many smaller transmission lines is less costly than the use of large transmission lines for cluster oscillators. A complete analysis of all parts to be affected by a change from cluster oscillators and large transmission lines to single tube oscillators and small transmission lines has not been made. It is believed that the cost difference between the two alternatives will prove to be small enough so that a decision on which system should be used may be based purely on electrical advantages.

Mark II Development. There has been some change of plans regarding the programing of the Mark II development. An engineering study of the use of a frequency of 20 megacycles will be made as well as a continuation of the studies of the 12 megacycles accelerator. Construction for Mark II will be held in abeyance pending the results on the Mark I machine, which are expected to be available by the end of 1951. A number of investigations carried out so far make it appear that the use of 20 megacycles does not present some of the difficulties originally anticipated. The aperture considerations were such that it did not appear possible to inject high current beams in the largest apertures then considered usable for 20 megacycle operation. It has now been shown that an injection aperture of 6.73 inches at 20 megacycles with 300 kilovolts injection voltage is possible. Furthermore, it has been shown that the x-ray loading can be reduced in the test cavities and it is thought that the same results are applicable to Mark I and Mark II. This reduction in x-ray loading over previous considerations allows higher electric fields to be held, permitting a shorter tank and thus making use of 20 megacycle frequency more promising. These and several other considerations seem to make it advisable to carry on investigations at 20 megacycles.

Some layout studies have been made with a model of Mark II. The particular case studied has involved the large injection aperture required for a gradient of 0.23 Mev per foot. This geometry has been worked out in detail at the injection end up to 30 Mev, which is equivalent to about 170 feet of

length full scale, and contains a total of 28 drift tubes. Operation at 12 megacycles and 94 kv injection energy was assumed.

Target Studies. It has been agreed that the work program on thorium will be carried out jointly by the Ames Laboratory, Battelle Memorial Institute, and the Oak Ridge National Laboratory. At the present time Ames is the main producer of thorium and their production is scheduled to reach 3 tons per month by July of this year. The material will be sent to Battelle Memorial Institute for forging and machining and from there to Oak Ridge for fabrication into tubes, rods, etc. These organizations will investigate the mechanical properties of thorium, the development of uranium-thorium alloys, and all phases of fabrication.

It has been found in the experiments at Oak Ridge that noticeable growth in uranium samples is produced by thermal cycling at peak temperatures in excess of 300 degrees. At these temperatures the growth is noticeable and rapid. For thermal cycling between 0 degrees and 300 the growth is small and difficult to measure. In the case of thorium the thermal growth is not detectable at average temperatures up to 500 degrees. On the basis of present work unclad thorium will be used in the primary target in preference to clad uranium. The present target design will permit the substition of uranium sections for test purposes.

Improved calculations of the neutron leakage from the opening in the lattice reduced the estimated leakage by about 20 percent. On this basis a 16 by 16 foot lattice with a 6 by 6 foot opening gives a total fast leakage of about 5 to 10 percent compared to previous estimates of 10 percent to 12 percent. On the basis of these new estimates it appears significantly less desirable to add a two inch layer of heavy water to reduce the fast flux leakage. At present the total neutron losses both in the resonance and thermal regions is estimated to be 20 percent. If the target loss of three percent is subtracted, the real loss of the system is 17 percent. Whereas the loss of neutrons in the above categories are not difficult to estimate flux distribution is very difficult to calculate. It is apparent, however, that it will be desirable to design a lattice in which the loading distribution can be altered over a wide range in order to permit attainment of the optimum flux distribution. Before it is possible to determine the advantage of reducing the size of the target to permit a reduction in the size of the lattice opening it will be necessary to explore the effects of target size on the efficiency of the primary-secondary target arrangment for converting the incident deuteron beam into neutrons, since the overall efficiency of the machine will be the product of the target efficiency and the lattice efficiency. Because of the rather small size of the target group it is possible for them to study intensively only one target design at a time. It is felt at the present time that the group should place its emphasis on the 100 milliampere 20 megacycle 750 foot machine. The decision as to which type machine is built first will be determined largely by the decision as to whether Mark II construction will be started before or after the testing of Mark I.

Studies have been made of a lattice design which will permit disassembly. These studies have assumed the availibility of a 30 ton crane and has resulted in a lattice of 16 by 16 by 21 feet which involves between $\frac{1}{2}$ and 1 ton of

stainless steel in the lattice support structure. In this target the graphite moderator and reflector are supported from ion thermal shielding at the top of the reactor. The weight of stainless steel required is essentially independent of the method of supporting the lattice. It will be possible to utilize the structural strength of the graphite itself to support the graphite longitudinally and therefore avoid the use of any steel within the lattice in regions of high flux. It has been suggested that the roof of the lattice be built in the form of a self supporting arch in order to reduce the weight of the load which must be supported by the thermal shield.

Layouts have been made of a number of alternative target arrangments for the purpose of evaluating the applicability of NaK cooling to specific designs. For the purpose of this study the graphite lattice and a 100 milliampere 350 Mev deuteron beam and a target of 8 feet in diameter is assumed.

Thomas Cyclotron Development (Mark III). The pole faces of the electron model of the clover leaf cyclotron have been improved by the addition of shims. Measurements of the magnetic field indicated improvement, although accurate evaluation of the field is difficult because of its low average value. The design is such as to give electrons the same velocity at a radius of 15½ inches as is possessed by deuterons of 250 Mev energy. The shape of the external beam has been investigated by the use of probes coated with fluorescent materials. The pattern of the external beam has been changed by the improvement of the magnetic field. By a judicious choice of the currents in the hill and valley trimming coils it is possible to cause the beam to come out essentially completely at any one of the three hills. From this it appears feasible to have a single target and to provide for switching the beam to an alternative target at will. Theoretical work is still in progress looking towards an understanding of the proper magnetic fields for a cyclotron and of this type and it is planned to make new pole faces which involve the refinements discovered in the calculations. It appears that the spaced charge effect will be negligible. Electron currents of the order of 1 microampere are now being obtained. The choice of 250 Mev for the beam energy was based on an estimate of the ultimate value of beta for which correction can be obtained by tailoring the magnetic field. It is estimated that this factor will impose a limit of about 300 Mev for deuterons.

It is planned to redesign the 20 inch injector cyclotron and equip it with three phase dees to experiment with. Three phase operation at somewhat higher power than is possible with the electron model, and to investigate the ion currents that can be started off and captured into reasonable stable orbits with the field configurations one will have at the center. The design conversion work will be completed about the end of July. The cyclotron will accelerate protons.

It has been proposed that work begin immediately on the construction of Mark III at Livermore and that the Mark II engineering studies be carried on at the same time. There are quite a few problems associated with materials in the target end of Mark II and the beam from such a cyclotron would be very valuable for testing these materials. Furthermore, should Mark I prove inoperable much of the power equipment for it could be used for Mark III.

The optimum dee voltage is about 10 percent above the threshold and the present electron model is more efficient at low dee voltage due to the increased vertical oscillation caused by the higher dee voltage. This latter effect would not be noticeable in a full voltage machine. 200 to 300 kilovolts would be required for excitation of the dees to 310 kilovolts to ground. The exciting power would be three or four times that required for the 60-inch cyclotron. In such a cyclotron the beam load would be of the order of 100 times the excitation power.

9. Chemistry

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Part A
(AEC Program No. 5311)

Rare Earth Alpha Emitters. The artifically produced alpha activities of the rare earths now include the following isotopes: Eu^{147}, whose alpha particle energy is 2.98 Mev and half-life is 22 d; Gd^{148}, 3.26 Mev and half-life >35 y; Tb^{149}, 3.95 Mev, and half-life 4.1 h; Tb^{150} or Tb^{151}, 3.44 Mev, and half-life 19 h; Dy (149 to 153), 4.21 Mev, and half-life 7 m; Dy (149 to 153), 4.06 Mev, and half-life 19 m, and Dy (149 to 153), 3.61 Mev, and half-life 2.3 h.

Alpha Decay of Bismuth. A mixture of Bi^{203} and Bi^{204} has been studied for alpha decay by a photographic emulsion technique. A few alpha particles of energy 4.8 to 4.9 Mev (by range measurement) were found. If they are due to alpha decay of bismuth, the branching is of the order of one alpha per 10^7 electron capture events. Since the abundance is near the limit of sensitivity of the method, this may only be an upper limit to the alpha abundance.

Isotopes of Bromine. By excitation curve experiments with As^{75} targets and alpha particles from the 60-inch cyclotron, a 16-hour activity has been assigned to Br^{76}, and the assignment of 57-hour Br^{77} has been confirmed.

Coincidence Studies. Alpha-gamma and alpha-electron coincidences have been measured for Th^{230} and U^{233} as part of the program of determination of decay schemes. The data are not yet sufficient for unique interpretation.

Mass Spectrograph. An electron bombardment source for solid samples has been installed in one of the mass spectrometers and has been used for some analyses of mercury and thallium (as the sulfides). The mass spectrograph used for the heavy isotope abundance work to date has suffered from poor vacuum, and consequently a new pumping system is being installed. The source box will now be pumped out independently of the rest of the system.

Spectrographic analysis. An air filter system has been constructed to prevent the spread of radioactive materials used in the arc spectrograph. In addition to very successful retention of the activity, the device makes available for recovery (in the first filter) 75 to 80 percent of the material used in the analysis.

Fission Recoil Ranges. The ranges in aluminum of particular recoil particles from fission of U^{238} by 18 Mev deuterons and by 335 Mev protons have been measured. The forward and backward recoils (with respect to the beam direction) with 18 Mev deuterons are significantly different. The difference corresponds (to within the rather poor accuracy of conversion of range into energy) to compound nucleus formation, followed by isotropic fission in the center of mass system. The ranges of particular fragments in the 335 Mev proton case are less than those of the same fragments in the 18 Mev deuteron case. The difference is consistent with a model which involves the spallation of from 7 to 20 neutrons, followed by fission of the resulting distribution of excited nuclei.

Chemistry SECRET

Part B
(AEC Program No.5311)

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

1. Oxide phase diagrams.
2. Gaseous hydroxides of Mo and W.
3. High temperature x-ray studies.
4. Refractories.
5. Stability of gaseous CN at high temperatures.
6. Heat transfer in forced convection film boiling.

Basic Chemistry, including Metal Chelates. The following problems are under investigation:

1. Germanium chemistry.
2. Thermodynamics of rhenium.
3. Electron exchange rate between Fe^{2+} and Fe^{3+}.
4. The hydrolytic polymerization of zirconium.

Chemistry UNCLASSIFIED

Part C
(AEC Program No.6400)

Synthetic and Experimental Chemistry. Preparation of the following labeled compounds has been investigated: Hippuric acid (benzoylglycine-2-C^{14}), leucine-3-C^{14}, norleucine-3-C^{14}, valine-4,4'-C_2^{14}, isoamyl-1-C^{14} bromide, cholesterol-23-C^{14}, stearic-T acid, cholesterol-T, vinyl acetic-1-C^{14} acid, aspartic-β or γ-C^{14} acid, guanine-8-C^{14}, codeine-N-methyl-C^{14} morphine-N-methyl-C^{14}, phthalylglycine-2-C^{14} and a number of labeled dipeptides derived from phthalyglycine by reaction with amino acids.

In the study of the effect of high-energy radiation on peptides a 750 mc cobalt-60 source was set up which gave a γ-ray dosage of about 1000 r. per hour. A solution of glycyl-1-C^{14}-glycine-1-C^{14} in twice distilled water was irradiated in this field for seven days. Determination of the activity of aliquots before and after irradiation indicated that five other components were formed. The total activity in these spots amounted to about 10 percent of the original activity. None gave a positive ninhydrin test. It appears that rupture of the diglycine molecule at the peptide bond to give two molecules of glycine does not occur in any appreciable extent. Comparable results have now been obtained with non-labeled glycyl-l-tryptophan, glycyl-l-phenylalanine and triglycine.

Decarboxylation of α-naphthylmalonic acid-1-C^{14} has been carried out. The ratio of the frequency of rupture of C^{12}-C^{12} bonds to the C^{12}-C^{14} bonds was found to average 1.097 ± 0.004 for the liquid acid run. The precision of

the measurements is not great enough to show any significant temperature coefficient for the isotope effect in the solution experiments. However, there is a significant difference between the isotope effect for the liquid acid at 160°C and for the acid in solution.

Biological Chemistry. The metabolism of stilbamidine-amidine-C^{14} in normal and neoplastic tissue-bearing mice has continued. Radioactivity appears to be largely associated with the mitochondrial fraction of the liver. The oxidase activity is believed to be associated with the mitochrondria and thus serves as an indicator for the separation of the mitochondria. Sonic disintegrations of the mitochondria indicate that the activity is associated with the "membrane" of the fragment. Other methods including enzymatic are being used to study the method by which the stilbamidine is bound by the mitochondria.

Other experiments currently being investigated include: (1) metabolism of labeled purines and mode of excretion of these molecules, (2) location of activity incorporated in eggs by hen fed labeled acetate (3) cholesterol metabolism in rats and the products in which radioactive materials are found after feeding this material, (4) metabolism of propionic acid by in vitro liver slices.

Photosynthesis Chemistry. The role of ribulose and sedoheptulose in photosynthesis is being investigated. Kinetic experiments as well as chemical degradation experiments are in progress for the purpose of determining their mode of synthesis and metabolism. Methods for periodate degradation of labeled sugars in tracer amounts are being developed. Preliminary results indicate that the sedoheptulose molecule first becomes labeled in one or more of carbon atoms, 3, 4, 5, and 6, and is later labeled at the terminal carbons.

The fermentative system operating in chlorella is being investigated by feeding labeled sucrose and glucose.

Photosynthetic carbon dioxide fixation by blue-green algae, S. Cedorum, and by Euglena Y is being studied.

Ion exchange resin separation of ribulose diphosphate has been accomplished and larger amounts are being accumulated for classical identification.

10. Medical Physics

UNCLASSIFIED

Part A
(AEC Program No. 6000)

Tracer Studies. Tracer studies on the metabolism in the rat of carrier-free Tm^{170} and $Tl^{200,202}$ are continuing. Completed were studies on the metabolism in the rat of Hg^{197} and $Pt^{191,192}$.

Astatine. Further studies were made of the uptake of iodine and astatine in the same thyroid gland. A monkey was used and a series of autographs on stripping film were made. Photomicrography continued of materials prepared for the astatine paper.

Radiochemistry. A carrier-free procedure has been developed for the preparation and isolation of Hg^{197} from gold. Previously reported methods were used in the production of the following radioisotopes in the carrier-free state: $Tl^{201,202}$, W^{181}, F^{18}, and At^{211}.

The target assembly for the radiation experiments on aqueous solutions has been completed and preliminary tests are being made.

Medical Physics — UNCLASSIFIED

Part B
(AEC Program No.6000)

Double Nucleated Lymphocytes. After a control period of fifteen weeks during which time twenty examinations were made for the presence of abnormal lymphocytes in the blood of two dogs by methods outlined in previous progress reports, the animals were exposed to approximately 10^6 neutrons/cm^2 in a 90 Mev neutron beam from the 184-inch cyclotron. The doses received during the 15 minute exposures were measured, by Victoreen thimble chambers behind 2-1/4 inch paraffin, to be of the order of 0.25 r. Most of the smears taken during the control period have now been examined and no double nucleated cells have been found. An evaluation of these preparations for lymphocytes with bilobed nuclei is under way. In the smears made subsequent to the irradiation, some double nucleated cells, or more accurately, filamented lymphocytes, have been seen. The frequency of their occurrence has not yet been established. However, the evidence so far suggests that the low dose of radiation may have resulted in an increase in these cells in the peripheral blood.

Biological effects of radiation on animals (184-inch Cyclotron). Two more series of animals have now been irradiated in the region of the pituitary glands and sacrificed 30 to 60 days later. The greatest effect in retarded growth occurs between the 10th and 20th day and after this period slow recovery sets in even though the pituitary glands' histology appeared to be greatly damaged at the time recovery was taking place. Even after a single dose of 20,000 r.e.p. to the pituitary, the recovery is significant. The ACTH level is not influenced appreciably by 10,000 and 20,000 r.e.p. after a period of 30 days, but 30,000 r.e.p. caused a depression near the end of that period.

Activation Analysis. Elution characteristics from Dowex-50 have been determined for iridium, yttrium, aluminum, cadmium, tantalum, scandium and europium.

Biological Effects of Irradiation on the Yeast Cells. A defective yeast colony is prepared by pre-irradiation which has the peculiar characteristic that only four out of every five cells in a colony can undergo cell division on the same medium in which the normal unirradiated yeast cells show 100 percent cell division. Survival curves of haploid and diploid yeast colonies have been obtained at dose rates of 10,000 to 50,000 r.e.p. per minute with helium ions accelerated in the 60-inch cyclotron. There is slight if any dependence of the biological effect on dose rate at the rates tested. The helium ion experiments are carried out in parallel with preparation of the 60-inch cyclotron with 6 times

ionized carbon ions. With this latter beam there are difficulties in obtaining consistent data because of the wide distribution in energy of particles and the low beam intensity.

Instrumentation; Localization of the Distribution of Radioactivity In Vivo. A pinhole camera was built of lead for the purpose of obtaining radiographs of the spatial distribution of radioactive gamma sources in the animal and human body. In order to intensify the effects of the gamma rays on the photographic plate, a slab of fluorescent crystal (sodium iodide) was placed in front of the photographic plate. The metastases of a thyroid tumor was photographed in a patient after administration of a therapeutic dose of I^{131}. The tumor was located at one elbow. A picture was obtained after an hour exposure which clearly indicated the outlines of the region where the uptake of the radioactive iodine occurred. The distance of the patient's arm from the camera was about 10 inches and the photographic plate was placed 6 inches from the pinhole which was 1/8 inch in diameter. The initial success of the application of the pinhole camera in localization of radioactivity in the body is encouraging. Further steps are being taken to increase the sensitivity.

Counting equipment for in vivo measurements of gamma rays in human beings has advanced to the stage where mechanical assembly is finished and electrical assembly is beginning.

11. Health Chemistry (AEC Program No.5311) UNCLASSIFIED

Research and Development Group Activities. Work in progress is listed below:

1. Pile-irradiated animal ash samples have been loaded in a new type of capsule and slug assembly and sent to Hanford. Handling equipment for the slugs when they are returned after being bombarded has been completed. Multiple column operation equipment is not yet finished.

2. A box and dolly for americium chemistry was completed.

3. A box to provide proper handling of I^{131} and P^{32} was completed for the Donner Clinic.

4. Improvements on a box for processing Y^{90} in Donner were made.

5. Three boxes for Th-U bombardments were completed.

6. A lithium sample was prepared for bombardment. The box in which the bombardment will take place was made.

7. Improved electrical controls for the spot heater, the cold bath and the automatic stirrer was designed.

8. Equipment used in chemistry in the gloved and lead-shielded boxes, was completed.

9. A target for use in the internal cyclotron beam was completed.

10. An ionization chamber, made of low neutron absorbing material, was made, to be used with neutron-bombarded samples.

11. A case for safely carrying bombarded powder targets in solution was completed. The case is equipped to hold three sizes of Ehrlenmeyer flasks.

12. In the Berkeley Box group, the following jobs were completed: four gloved boxes assembled and fitted. alterations in three boxes, design and construction of three rotary plastic air outlet valves, design and construction of plastic holders for glass fume hoods, reassembly of three centrifuges received from decontamination, assembly of ten induction heating coils, assembly of six Variac type centrifuge speed controllers.

Disposal at sea included 115 drums of active waste in cement.

It has been necessary during this period to set up and take precautions for alpha activity in seven laboratories.

12. Plant and Equipment

OFFICIAL USE ONLY

Bevatron Building and Instrument. (Program No. 1500. 5-424-9001) The first coil has been completely wound and is connected. Coils in quadrant two are being laid now and are 40 percent complete.

M. T. A. - Mark I. (Program No 1500. 5-424-9004) Development and design continuing.

M. T. A. - Mark II. (Program No. 1500. 5-424-1004) Development and design continuing.

Accelerator Design Building. (Program No. 1500. 5-424-1004) Work on this building is substantially complete and final inspection has been scheduled for the afternoon of June 20, 1951.

Miscellaneous Construction. (Program No. 1500. 5-424-1001)

Decontamination Yard Extension. This work was started on March 28, 1951 and was completed May 28, 1951.

Corporation Yard Development. This was started on March 26, 1951 and is 80 percent complete.

Waste Oil Tank. This work was started on May 2, 1951 and is 65 percent complete.

Building 29 and 30 Sprinkler System. This work was started on May 1, 1951 and the sprinkler system in Building 30 is 95 percent complete, and the sprinkler system in Building 29 is 20 percent complete.

OFFICIAL
USE ONLY

North Gate House, Building 65. Plans and specifications were revised and bids are to be taken July 31, 1951.

Slope Stabilization, Bevatron Site Area. The contract has been let and work will start in approximately 10 days.

Wilson Road Repair. This work was started on June 6, 1951 and will take two months.

Animal House. (Program No. 1600. 6-424-9007) Forms for columns and roof are in process of erection. Work is proceeding satisfactorily and approximately 41 percent of the building is considered complete.

Radiological Laboratory at the University of California Medical School. (Program No. 1600. 6-424-9008) The plasterer is finishing his work and the heating and ventilation contractor has a good crew. Finish hardware is being installed. The sliding door to the accelerator room is 75 percent complete. The lift mechanism for the medical synchrotron has been installed and final inspection will be made next week.

LMM/7-3-51
Information Division

MAN-MONTHS EFFORT REPORT

Scientific Personnel

PROGRAM		SUBDIVISION	MAN-MONTHS EFFORT	COMMENTS
Plant and Equipment				
9200	MTA - Mark I	Design and Development	27.9	
9200	MTA - Mark II	Design and Development	30.6	
9300	Weapons	General	-	
9500	Bevatron	Miscellaneous	.2	
Operations				
Physics Research				
3000	Weapons	General	13.2	
5211	Thomas Cyclotron	Electron and X-C Models	12.0	
	Experimental Physics	Cloud Chamber	10.1	
		General Physics Research	34.2	
		Instrument for General Use	2.3	
		Special Development	5.8	
		Magnetic Measuring Equipment	4.6	
	Theoretical Physics	General	10.1	
	Photographic Film Detectors	General	13.6	
	Isotope Separation	General	-	
	Radioactivity Physics	General	1.8	

PROGRAM	SUBDIVISION	MAN-MONTHS EFFORT	COMMENTS
Operations (Continued)			
Chemistry Research			
5311 Basic Chemistry Research, Part A	Chemistry of Heavy Elements	4.5	
	Nuclear Properties of Heavy Element Isotopes	8.5	
	Transmutations with the 184" and 60" Cyclotrons	7.1	
	Analytical and Services	11.8	
	Special Chemistry Development	1.5	
	Mass Spectroscopy, Beta Ray Spectroscopy	2.0	
	Instrument Development and Services	3.1	
	X-ray Crystallographic Measurements	1.9	
	Health Chemistry Research	11.6	
Basic Chemistry Research, Part B	Metals and High Temperature Thermodynamics	4.0	
	Basic Chemistry, including Metal Chelates	2.0	
5361 Applied Chemistry Research,	Process Chemistry	12.7	
Reactor and Accelerator Operation			
5731 Synchrotron	Operation	7.2	
5741 184-inch Cyclotron	Operation	9.5	
5751 Linear Accelerator and Van de Graaff Generator	Operation	10.7	

PROGRAM	SUBDIVISION	MAN MONTHS EFFORT	COMMENTS
6000 Biology and Medicine Part A	Metabolic Properties of Various Materials	11	
	Radiochemistry	4	
	Radioautography	2	
6000 Biology and Medicine Part B	Instrumentation for Qualitative measurements of radiation	2.0	.8 Consultant
	C^{14} Metabolism	3.1	.8 Man-Months
	Use of Radioactive Materials in Human Physiology and Experimental Medicine	5.8	7.0
	Trace Elements and Irradiation Studies	3.4	.9
	Radiation and Mutation Rate	1.6	.3
	Physical Biochemistry	6.9	2.3
	Biochemical Response to Irradiation	2.3	1.0
	Miscellaneous	1.0	.2
	Donner Animal Colony Expense	1.5	2.0
	Metabolism of Lipo Protein and Lipids	4.1	7.7
	Iron Metabolism Hematopoiesis	3.3	.5
	Internal Irradiation and Hematological Response	2.1	-
	Biological Effects of Cosmic Radiation	1.4	-
6400 Biological Research	Synthetic and Experimental Organic Chemistry	5.9	
	Biological Chemistry	6.5	
	Photosynthesis Chemistry	4.4	
	Metabolism of Fission Products	14.0	
6500 Biophysics Research	General	2.7	