

# OAK RIDGE NATIONAL LABORATORY

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for the

U.S. ATOMIC ENERGY COMMISSION



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ISOTOPES DIVISION  
QUARTERLY REPORT  
APRIL-JUNE 1961

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ORNL-TM-76

ISOTOPES DIVISION

QUARTERLY REPORT

April - June 1961

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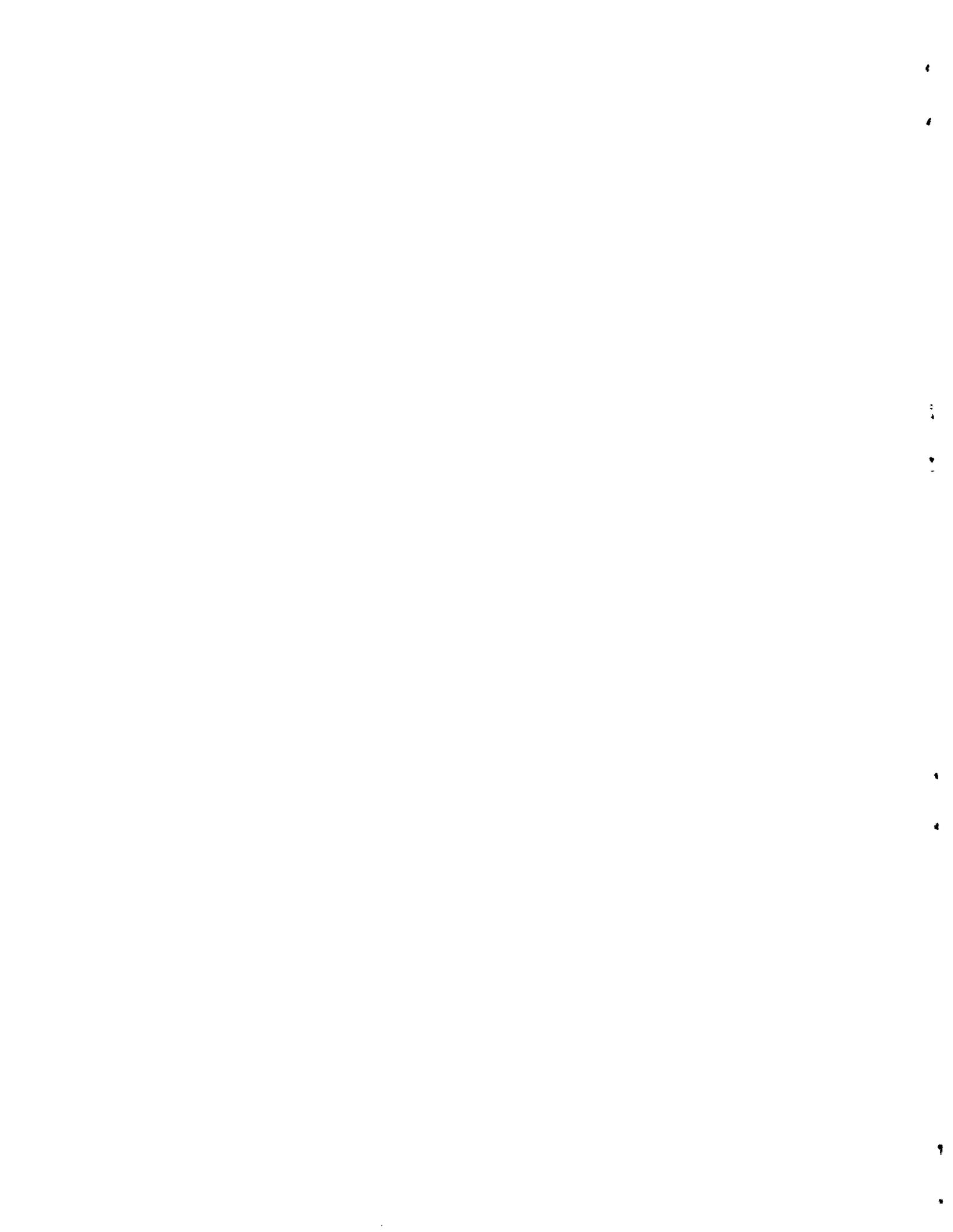
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ABSTRACT

The following abstracts of contributions to the report cover the major activities of the Division. They include abstracted information on Applied Isotopes Development, Fission Products Development Laboratory, Advanced Isotopes Development, Isotope Separations, and Target Preparation.

APPLIED ISOTOPES DEVELOPMENT

Quantities of separated radioisotopes and radioactive sources consisting of liquids and gases as well as solid sources were shipped.

FISSION PRODUCTS DEVELOPMENT LABORATORY

Strontium-90 was separated for use in a Weather Bureau thermoelectric source. The strontium was converted to  $\text{SrTiO}_3$ , pelletized, sintered, and sealed in a capsule by welding.

Cesium-137 chloride powder (36,395 curies) was prepared and the customary cesium alum procedure for purification used.

ADVANCED ISOTOPES DEVELOPMENT

Process Development, Technetium, Radioactive Source Development, Fission Product Chemistry, Engineering Development, and Thermal Diffusion will be discussed briefly in the following abstracts.

Process DevelopmentStrontium-90

Thermal Energy Output of Strontium-90. -- The energy output of  $\text{Sr}^{90}\text{-Y}^{90}$  in the form of powder and pellets was measured to be  $6.3 \times 10^{-3}$  watts per curie in a calibrated thermal conductivity calorimeter.

Solubility Considerations in Strontium-90 Precipitations. -- The FPDL procedure was changed from the precipitation of  $\text{SrC}_2\text{O}_4$  to the precipitation of  $\text{SrCO}_3$  in order to reduce solubility losses. Data from full scale (1.0-1.4 kc)  $\text{Sr}^{90}\text{CO}_3$  precipitations in 3 M  $\text{NH}_4\text{NO}_3$  show the solubility of the  $\text{SrCO}_3$  is  $1 \times 10^{-4}$  m/l (0.6 c/l).

Enrichment by Electromigration

Enrichment of Rubidium-87. -- The separation tube was operated successfully 220 hours and an enrichment factor of 1.067 at the end of the experiment was obtained.

Separation of Promethium and Americium

Americium-241 and promethium-147 were separated by cation exchange system using Dowex-50 resin and 1.0 M  $\text{NH}_4\text{SCN}$ . A separation factor of 13.9 was obtained.

### Preparation of Carrier-Free Thorium-234

By use of clean vessels in which  $\text{Th}^{234}$  was allowed to grow from uranium parent for three months, the amount of inactive thorium in  $\text{Th}^{234}$  has been reduced to  $\sim 3.4 \mu\text{g}$  per mc.

### Solvent Extraction

The distribution coefficients of iron between aqueous solutions containing sulfate and a D2EHPA-TBP-Amsco phase were determined.

In the extraction of mixed  $\text{H}_2\text{SO}_4$  and  $\text{HNO}_3$  with 0.5 M Alamine 336 using four successive contactings, the  $\text{HNO}_3$  was nearly removed before an appreciable amount of  $\text{H}_2\text{SO}_4$  was extracted.

The distribution coefficients of various cations in Alamine 336 in contact with different compositions of aqueous phases were determined.

### Technetium

#### Separation of Technetium

A new extraction unit was put into operation to recover technetium from 10 N  $\text{HNO}_3$  solutions by use of 10 N NaOH for neutralization and 1.0 N NaOH and lutidine for extraction of the technetium.

#### Analysis of Technetium Metal

By precipitation of tetraphenylarsonium pertechnetate, purities of technetium metal ranging from 98.0 to 100% were determined.

### Radioactive Source Development

The physical properties of radioactive sources prepared by adsorbing radioactive cations on Decalso can be modified by adding small quantities of fluxing agents to reduce the surface tension.

### Fission Product Chemistry

#### Separation of Cesium and Rubidium

To recover rubidium from  $\text{Cs}^{137}$ , a column containing attapulgus clay was used. After elution with 0.05 M  $\text{NH}_4\text{NO}_3$ , a sharp separation was observed.

### Engineering Development

#### Fission Products Development Laboratory Equipment Modifications

The following equipment in the Fission Products Development Laboratory was modified: hot off-gas scrubbers, closed loop process water system, cell ventilation filter cask, cask transfer station - Cell 1, STP - gondola unit, Cell 27 -  $\text{Sr}^{90}$  handling cell. Also an investigation was made to determine

the time required to rupture the present and modified versions of the STT when subjected to an instantaneous increase in surface temperature.

#### Slurry Filter Casks

An ultrasonic inspection indicated that bonding of the lead to the stainless steel was not achieved on the second cask; however, on the basis of a heat transfer test showing a temperature difference of 57° across the cask wall, it was accepted.

#### Weather Bureau Source

Eleven sintered pellets of  $\text{Sr}^{90}\text{TiO}_3$  (762.5 g) were encapsulated by welding in a Hastelloy C container and were inserted in a thermoelectric converter. Thermal output due to  $\text{Sr}^{90}$  was 110.1 watts.

#### Technetium-99 Equipment Installation

New equipment for the neutralization, extraction, and steam distillation for the production of  $\text{Tc}^{99}$  has been installed in Bldg. 3026-C.

#### Cask Drop Tests

Several scale model casks have been built to perform drop tests which will aid in determining design characteristics for future carriers and check structural calculations on casks already built.

#### Isotope Area Cell Ventilation Filter Pit

Site preparation has been started for the concrete structure of the filter pit with the installation of a cell ventilation duct by-pass around the construction area.

#### Iodine-131 Filter Pit

A gas-sampling apparatus of the same type used on the 3039 stack was installed in  $\text{I}^{131}$  cell ventilation filter pit to measure iodine activity before and after the filter bank.

#### Containment - Bldg. 3027

Construction of containment facilities for Bldg. 3027 has begun.

#### Displays - Technetium-99, Cesium-137, Neodymium

Displays are being prepared to show separation and purification and/or source fabrication of  $\text{Cs}^{137}$ , Nd, and  $\text{Tc}^{99}$ .

#### Cobalt-60 Irradiator for Solid States

The design and drawings for a shielded irradiator to accommodate 1500 curies of  $\text{Co}^{60}$  are complete.

### Building 3026-C Modifications

Design is 50% complete on a plan for converting the two cell banks into one cell bank with five manipulator cells.

### Radioisotope Development Laboratory

Installation of the following items is complete: cell block sub-floor; cell floor pans; air conditioning ductwork, fans and compressor; interior partitions; hot drain and vacuum system piping; and the monorail hoist.

### Iodine-125 Loop

The production of  $I^{125}$  by irradiating  $Xe^{124}$  in a continuous process is being investigated.

### Dose Rate Calculations

A simple method of calculating the dose rate from a cylindrical gamma source was developed which takes into account self-absorption and source build-up, as well as the contributions made from all points of the source.

### Thermal Diffusion

#### Column Operation

A total of 450 mg of  $Ar^{36}$  (60-65%) was obtained.

#### Development

Krypton-86 enriched to 55% is now being obtained. Development work is continuing on  $Ne^{21}$  and  $C^{13}$  enrichment.

### ISOTOPE SEPARATIONS

This section will discuss calutron operations, charge preparation, chemical refinement, special separations, and isotope receiver studies.

#### Calutron Operations

The isotopes of calcium, potassium, zirconium, magnesium, tin, samarium, nickel, and tungsten were separated. Data are tabulated giving element, series, process efficiency and weight equivalent to monitored ion currents.

#### Charge Preparation

Quantities of Mg metal (compacted),  $NiCl_2$  (fused),  $NiCl_2$  (enriched),  $SmCl_2$  (compacted),  $TiCl_4$  (liquid), Ca metal,  $SnCl_4$  (liquid),  $WCl_6$  (compacted),  $ZrCl_4$ ,  $GdCl_3$ , and  $UF_6$  have been procured for the separation of the isotopes of calcium, magnesium, nickel, samarium, tin, titanium, tungsten, zirconium, and gadolinium. Also some unresolved charge materials are being recovered.

Chemical Refinement

Chemical recovery and refinement were completed on new inventory lots of Cd<sup>106,108,111,113,114,116</sup>, C<sup>13</sup>, Ga<sup>69</sup>, Fe<sup>54,57,58</sup>, Ni<sup>61,64</sup>, Tl<sup>203</sup>, Y<sup>168,171,174,176</sup>, and Zr<sup>96</sup>. Of the 466 isotope collector pockets received, the collected material from 188 was processed.

Special Separations

A total of 300 grams of Np<sup>237</sup> (detector foils) was fabricated and shipped. One thousand grams of uranium (depleted) was converted to UF<sub>4</sub>.

Isotope Receiver Studies

The sputtering program has been continued in the current calcium separation for the purpose of determining the sputtering ratio of carbon atoms per incident Ca<sup>40</sup> ion. Data (estimated weight, percent retention, weights lost, and sputtering ratio) obtained by bombarding five different graphite blocks with calcium are given.

Process Improvement

Preparations necessary for the initial testing of the double-focusing isotope separator are nearing completion. The calculation to find the best contour for the pole tips has been finished and actual fabrication is in progress.

TARGET PREPARATIONDevelopment of Decelerator

Calutron experiments have been continued using the decelerator since practical use of this equipment would be the direct deposition of separated isotopes on specific target backings for use in particle accelerators. Construction of a rotational device has been in progress in order to produce required uniformity of deposited material over the surface of the backing.

Fabrication

The following list consists of the methods of fabrication and number of elements and compounds used by each method.

Evaporated	1 (62 targets)
Rolled	17
Electrodeposited (foils on backed targets)	10
Cast in stainless steel holders	7

ISOTOPE SALES AND DISTRIBUTION

Radioisotope sales and shipments are listed for this quarter and calendar year to date. Stable isotopes sales and loans (AEC, domestic, and foreign) are listed.

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APPLIED ISOTOPE DEVELOPMENTRoutine ProcessingCarbon-14

A large-scale run resulted in a yield of 18 curies of  $C^{14}$ . The factor limiting the capacity of this operation is the solubility of the  $BeSO_4 \cdot 4H_2O$  during the dissolution of the  $Be_3N_2$  in  $H_2SO_4$ . With the currently available irradiated  $Be_3N_2$ , it is now possible to produce 20 curies of carbon in one batch.

The scrubber section contained in a hood in Building 3033 was dismantled for reinstallation in the new  $C^{14}$  hood in Building 3033 Annex. Better containment for the operation will result, since the equipment will be confined to a small room used only for  $C^{14}$  production.

Cesium-137

Seventy-two sources of  $Cs^{137}$  containing a total of 5,974 curies were fabricated, and 19 sources totaling 5,179 curies of  $Cs^{137}$  were shipped.

Cobalt-60

Ten shipments containing a total of 80,600 curies of  $Co^{60}$  were prepared. An irradiator belonging to the Solid States Division was reloaded with 11,000 curies of  $Co^{60}$  in 12 welded capsules.

The fabrication of  $Co^{60}$  sources for three BNL food irradiators is in progress. Each irradiator will consist of approximately 160 doubly encapsulated, weld-sealed tubes which contain 30,000 curies of  $Co^{60}$ .

Iodine-131

A total of 790 curies of  $I^{131}$  was produced.

Iridium-192

A total of 1,185 curies of  $Ir^{192}$  was contained in the 46 sources that were assayed, decontaminated, and prepared for shipment. Twenty-six cans containing decayed iridium sources and three cans containing inactive iridium sources were prepared for irradiation.

The ORR-irradiated iridium sources do not meet the 0.005-microcurie smear tolerance because of the  $Zn^{65}$  produced in the 2S aluminum capsule jackets by the neutron activation in the aluminum alloy. The problem became apparent after the irradiation of iridium was moved from the LITR to the higher flux of the ORR. The transferrable  $Zn^{65}$  activity exists as  $Zn^{65}O$  on the surface of the capsule.

Krypton-85

Because of leaks in the krypton system, a few shipments of Kr<sup>85</sup> were below catalog specifications. One of the major causes of the leaks in the system was metal dust that fouled the valves. Repair of the leaks is in progress. The piping will be revised so that the packaging operation will require only a small portion of the present system. A new carbon trap will be installed and a chemical clean-up will be made on the gas to be packaged by passing gas over heated calcium.

Phosphorus-32

A total of 135 curies of P<sup>32</sup> was produced.

Radioisotope Packaging and Shipping

Type of Containers Loaded	Number	Percent
Returnable	332	9.00
Non-returnable	3,239	87.88
Customer	115	3.12
Total	3,686	100.00

A total of 394 returnable and customer containers were received and prepared for use.

Units Prepared for Irradiation and Processed

Two hundred eighty-two units were prepared for irradiation in the ORR, LIIR, and OGR.

One hundred thirty-three units were opened and the contents were repackaged for shipment.

Miscellaneous Operations

Forty-nine irradiation cans were opened and the contents were repackaged for shipment.

Four Am<sup>241</sup> and three Pa<sup>231</sup> samples were weighed, packaged, and prepared in the alpha handling facility.

Four samples of Tc<sup>99</sup> were weighed, packaged, and prepared for shipment.

Non-Routine ProcessingCarbon-14

Four batches of BaC<sup>14</sup>O<sub>3</sub> were blended using a modified Waring blender. This product has been analyzed by Analytical Chemistry Division and C<sup>14</sup> found of uniform isotopic ratio.

Thirty-two  $\text{Be}_3\text{N}_2$  slugs were dejacketed by using RF heating. The time required to dejacket slugs by this method is  $\sim 30\%$  of that required when a resistance-type electric furnace is used.

#### Cerium-144

A ten-curie source was prepared by diluting the active material with inert  $\text{CeO}_2$  for the production of a 1 cm x 1 cm pellet, which was sealed in a welded stainless steel capsule.

#### Enriched Calcium-46 Recovery

Enriched  $\text{Ca}^{46}$  was recovered for use as a target material from three old product solutions of  $\text{Ca}^{47}$ .

#### Cobalt-60 Irradiator

A  $\text{Co}^{60}$  source containing 25,000 curies was arranged in a manipulator cell on two occasions for use in radiation damage studies on "fast burst detectors."

#### Cobalt-60 Recanning

Two hundred sixty stainless steel cans containing 25 curies of  $\text{Co}^{60}$  in each can were opened and the material was recanned in aluminum.

#### Iodine-125

A ten-millicurie special product of  $\text{I}^{125}$  was prepared in 0.1 cc of 0.001 N NaOH for use in a medical project.

#### Sulfite-Free Iodine-131

Seven products containing a total of 70 millicuries of  $\text{I}^{131}$  were made.

#### Elemental Iodine-131

Two products containing elemental iodine tagged with 100 millicuries of  $\text{I}^{131}$  were prepared.

#### Iron-55 Sources

Eight sources containing a total of 11.6 millicuries of  $\text{Fe}^{55}$  were made.

#### Strontium-90 Sources

Forty-seven sources, each containing 200 microcuries of  $\text{Sr}^{90}$ , were fabricated to be used in checking the ORNL personnel pocket radiation detector devices. Dry  $\text{Sr}^{90}\text{F}$  was sealed in a stainless steel capsule by welding. The radiation reading through the 0.008-inch thick window was 2 r/hr at three inches. The sources were placed in portable shields which reduced

the radiation reading to 2 mr/hr on the surface of the container.

### Yttrium-88

A proton bombarded  $\text{Sr}^{88}$  target was processed for  $\text{Y}^{88}$ , which was used to prepare a doubly encapsulated stainless steel source.

### Foreign Scientists-in-Training

An area in Building 3031 is now being used for traing foreign scientists.

Individual training in radiation safety and radioisotope production is given to each scientist-in-training according to his interests and needs. He prepares radioisotope products having low level or tracer-scale activity using ORNL procedures. Frequently production methods are changed because of special conditions existing in the scientist's own country. Small scale production runs were made by the trainees to produce the following product solutions:

Arsenic-76 from germanium  
 Cadmium-109 (carrier-free) from silver  
 Calcium-45 from  $\text{CaCO}_3$   
 Cobalt-58 from nickel  
 Gold-199 from platinum  
 Iodine-131 from  $\text{TeO}_2$   
 Iron-55-59 from iron  
 Mercury-203 from mercury  
 Phosphorus-32 from sulfur

### FISSION PRODUCTS DEVELOPMENT LABORATORY

### Strontium-90

Redox feed material was processed for part of the  $\text{Sr}^{90}$  required for the Weather Bureau thermoelectric source. The remainder of the  $\text{Sr}^{90}$  was received from Hanford on April 13, 1961, in container HAP0-1A on Decalso. This material was converted to  $\text{SrTiO}_3$  powder, which was pelletized, sintered, and combined with the pellets from the Redox material in a welded capsule. The capsule was then sealed in the Martin Company thermoelectric converter by a welded closure. The following table contains the data concerning the  $\text{Sr}^{90}$  loaded into the source capsule:

Type of Feed Material	Weight (grams)	Sr <sup>90</sup> (Curies/gram)	Total Sr <sup>90</sup> (curies)	Number of Pellets	Total Heat Generation of Sr <sup>90</sup> (Watts)
<u>Arco</u>					
Batch 1	250.30	15.9	3,980	3	25.03
Batch 2	149.05	16.4	2,444	2	15.35
<u>HEW</u>	<u>363.16</u>	30.4	<u>11,401</u>	<u>6</u>	<u>69.73</u>
Totals	762.51		17,825	11	110.11*

\*Sr<sup>89</sup> activity - 9.9 watts; total source wattage - 120.01

### Cesium-137

Four Shielded Transfer Tanks (STT's) containing Cs<sup>137</sup> on Decalso were received from Hanford with the Sr<sup>90</sup> shipment and were eluted with 2 M (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>. The Cs<sup>137</sup> processing was conducted concurrently with the Sr<sup>90</sup> operations. As high as 20% process loss of Cs<sup>137</sup> was encountered in crystallizer operations involving addition of Al(NO<sub>3</sub>)<sub>3</sub> to the (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> eluate for the formation of ammonium alum. These losses were found to be due to the higher-than-normal ammonium ion concentration, which hindered the formation of cesium alum. The losses were reduced to normal by boiling off the ammonia from the neutralized crystallizer feed.

A total of 36,345 curies of Cs<sup>137</sup>Cl powder was produced.

The FPDL inventory on June 30, 1961, was as follows:

### Strontium-90 Inventory

Status	Estimated Curies	Remarks
Powder	22,500	Ready for pelletization
Cell 11	800	Recycle HEW
Cell 9	<u>3,500</u>	Arco
	26,800	

### Cesium-137 Inventory

Location	Estimated Curies	Remarks
Cell 14	15,500	Reserved powder
C-38	31,000	Rb removal completed
C-17	12,500	Crystallized
W-19 and W-20	8,000	Feed
S-122	<u>5,500</u>	Recycle material
	72,500	

ADVANCED ISOTOPES DEVELOPMENTProcess DevelopmentStrontium-90

Thermal Energy Output of Strontium-90. -- The energy output of  $\text{Sr}^{90}\text{-Y}^{90}$  in the form of powder and pellets was measured in a calorimeter which consists of a copper cup mounted on a vertical copper shaft, both insulated by an inverted glass vacuum flask. The heat from a radioactive sample placed in the cup is conducted by the shaft to a water cooled base. At thermal equilibrium, the temperature difference between the top and the bottom of the shaft is proportional to the heat output of the sample, the difference being measured with a four-junction thermopile.

The calorimeter was calibrated by means of an electrical heater. The change in the calorimeter constant with energy input is shown in Table 1, with the changes being caused by variations with temperature of the thermopile sensitivity and the thermal conductivity of copper.

The measured energy outputs of recent samples of  $\text{Sr}^{90}\text{TiO}_3$  processed in FPDL are given in Table 2. The measured energy (gross power) was corrected for a  $\text{Sr}^{89}$  heat contribution by calculation to determine the  $\text{Sr}^{90}\text{-Y}^{90}$  heat values.

Table 1. - Calibration of Thermal Conductivity Calorimeter

<u>Watts</u>	<u>Thermopile Millivolts</u>	<u>Watts per Millivolt</u>
41.555	13.880	2.994
20.292	6.695	3.031
12.602	4.128	3.052
5.410	1.755	3.082

Table 2. - Power Outputs of  $\text{Sr}^{90}$  Titanate Samples

<u>Sample</u>	<u>Gross Power Corrected to 5/12/61 (watts/g)</u>	<u>Power Produced By <math>\text{Sr}^{90}\text{-Y}^{90}</math> (watts/g)</u>
Powder Batch 1-Sr11-P	0.204	0.178
Powder Batch 2-Sr11-P	0.228	0.199
Weighted mean of 1-Sr11-P and 2-Sr11-P	0.217	0.190
Blend of 1 and 2	0.219	0.192

The correction for the  $\text{Sr}^{89}$  heat contribution is believed to be the principal uncertainty in the data. The activity ratio of  $\text{Sr}^{89}$  to  $\text{Sr}^{90}$  which was used in the calculation was a mean value of the average of five routine analyses (0.27), the average of two special analyses (0.28), and a value given by Hanford (0.27), with each given equal weight in the calculation of this mean. Average beta decay energies of 1.10 mev and 0.57 mev per disintegration for  $\text{Sr}^{90}$ - $\text{Y}^{90}$  and  $\text{Sr}^{89}$  respectively were used in the calculation.

The power per curie of  $\text{Sr}^{90}$  was calculated to be  $6.3 \times 10^{-3}$  watts per curie, the measured values of 30.4 curies per gram and 0.1917 watts per gram being used. The average energy per disintegration based on these data is 1.06 mev as compared to the calculated value of 1.10. The difference is less than the uncertainty in the radiochemical analyses used to obtain the specific activity used in this calculation.

Solubility Considerations in  $\text{Sr}^{90}$  Precipitations. -- Strontium-90 for FPDL operations shipped from Hanford is adsorbed on beds of Decalso (an inorganic cation exchanger). A 4 M  $\text{NH}_4\text{NO}_3$  solution is used to elute the activity for subsequent chemical operations. Currently, the  $\text{Sr}^{90}$  is converted to  $\text{Sr}^{90}\text{TiO}_3$  by precipitating  $\text{SrC}_2\text{O}_4$  or  $\text{SrCO}_3$  from the 4 M  $\text{NH}_4\text{NO}_3$  solution to which  $\text{TiO}_2$  has been added as a slurry. The mixed-salt precipitate is then calcined at  $1100^\circ\text{C}$  to form the titanate.

One-liter scale experiments were run to determine the solubility loss of  $\text{SrC}_2\text{O}_4$  as a function of  $\text{NH}_4\text{NO}_3$  concentration. The results are given in Table 3.

Table 3. - Strontium Oxalate Solubility  
as a Function  $\text{NH}_4\text{NO}_3$  concentration

$\text{Sr}^{85}$  tracer     $\text{Sr} = 1.0 \text{ g/l}$     Oxal. Conc. = 0.02 M  
pH = 5 to 6    Temp. =  $20^\circ\text{C}$

<u>Conc. of <math>\text{NH}_4\text{NO}_3</math> (moles/liter)</u>	<u>Sr Solubility (moles/liter)</u>
1.0	$5.1 \times 10^{-4}$
2.0	$8.9 \times 10^{-4}$
3.0	$15.0 \times 10^{-4}$
4.0	$17.0 \times 10^{-4}$

The effect of oxalate concentration and temperature on strontium oxalate solubility in 1.0 M  $\text{NH}_4\text{NO}_3$  is shown in Table 4.

Table 4. - Effect of Oxalate Concentration and Temperature on the Solubility of  $\text{SrC}_2\text{O}_4$

$\text{NH}_4\text{NO}_3 = 1.0 \text{ M}$      $\text{Sr} = 1.0 \text{ g/l}$      $\text{pH} = 5 \text{ to } 6$

	Oxalate (moles/liter)	Sr Solubility (moles/liter)
Temp. = $50^\circ\text{C}$	0.02	$6.4 \times 10^{-4}$
	0.05	$3.3 \times 10^{-4}$
	0.10	$2.4 \times 10^{-4}$
Temp. = $30^\circ\text{C}$	0.02	$5.2 \times 10^{-4}$
	0.05	$2.5 \times 10^{-4}$
	0.10	$2.1 \times 10^{-4}$
Temp. = $21^\circ\text{C}$	0.02	$5.1 \times 10^{-4}$
	0.05	$2.1 \times 10^{-4}$
	0.10	$2.0 \times 10^{-4}$

The solubility loss of strontium oxalate was investigated as a function of ammonium acetate concentrations. The results are presented in Table 5.

Table 5. - Sr Oxalate Solubility as a Function of Ammonium Acetate Concentration

$\text{Sr} = 1 \text{ g/l}$     Excess oxalate =  $0.02 \text{ M}$   
 $\text{pH} = 5 \text{ to } 6$     Temp. =  $20^\circ\text{C}$

$\text{NH}_4\text{OAc}$ (moles/liter)	Solubility (moles/liter)
1.0	$4.2 \times 10^{-4}$
2.0	$6.0 \times 10^{-4}$
3.0	$9.1 \times 10^{-4}$
4.0	$10.8 \times 10^{-4}$
5.0	$15.5 \times 10^{-4}$
6.0	$18.3 \times 10^{-4}$

The increased solubility of strontium with increasing concentration of the neutral salt is evident, but a comparison with Table 3 shows that the loss in acetate solutions is less than in nitrate solutions at comparable concentrations of neutral salt.

The data from  $\text{Sr}^{90}$  precipitations at FPDL are in substantial agreement with the laboratory data given above. Strontium oxalate precipitations from  $\sim 3 \text{ M}$   $\text{NH}_4\text{NO}_3$  solutions containing 0.04 moles/liter of excess oxalate ion at pH 6 have shown the solubility of  $\text{SrC}_2\text{O}_4$  to be  $\sim 2 \times 10^{-3}$  moles/liter at  $30^\circ\text{C}$ . This solubility is equivalent to  $\sim 12$  curies of  $\text{Sr}^{90}$  per liter of the filtrate which makes it necessary to reprocess the solution and recover the activity.

Inactive chemical experiments showed that  $\text{SrCO}_3$  precipitations in a  $\text{TiO}_2$

slurry resulted in  $\text{SrTiO}_3$  preparations which were equivalent to the products obtained from  $\text{SrC}_2\text{O}_4$  precipitations. Therefore the FPD procedure was changed to  $\text{SrCO}_3$  to reduce the excessive solubility losses. Data from full scale (1.0-1.4 kc)  $\text{Sr}^{90}\text{CO}_3$  precipitations in 3 M  $\text{NH}_4\text{NO}_3$  show the solubility of the  $\text{SrCO}_3$  is  $1 \times 10^{-4}$  moles/liter (0.6 curie/liter).

#### Isotope Enrichment by Electromigration

Enrichment of Rubidium-87. -- The  $\text{Rb}^{87}$  isotope enrichment experiment described in the last quarterly report was completed.

This experiment, undertaken to test the enrichment apparatus before attempting to use it for  $\text{Cs}^{137}$  enrichment, was performed in a hood with a large air flow to simulate the turbulent conditions in a hot cell. Small temperature variations in the cooling air caused major variations in the tube operation. Hence the efficiency of the operation of the separation tube might not be as high as it would be under more ideal conditions.

The separation tube operated successfully for 220 hours at which time the experiment was discontinued. Table 6 shows the isotopic composition of the starting solution as well as that of each electrode area at 102 hours and at 220 hours. The enrichment factor ( $\alpha$ ) was 1.063 at the end of 102 hours and 1.067 at the end of 220 hours. Since this  $\alpha$  is for the entire tube with  $\text{Rb}^{87}$  enriched at the anode and  $\text{Rb}^{85}$  enriched at the cathode, the  $\alpha$  for either  $\text{Rb}^{85}$  or  $\text{Rb}^{87}$  enrichment is about 1.03.

Table 6. -  $\text{Rb}^{85}$  and  $\text{Rb}^{87}$  Enrichment Experiment

<u>Time</u>	<u>Cathode</u>		<u>Anode</u>	
	<u><math>\text{Rb}^{85}\%</math></u>	<u><math>\text{Rb}^{87}\%</math></u>	<u><math>\text{Rb}^{85}\%</math></u>	<u><math>\text{Rb}^{87}\%</math></u>
0 hrs.	72.10	27.90	72.10	27.90
102 hrs.	72.71	27.29	71.49	28.51
220 hrs.	72.93	27.07	71.64	28.36

At the end of 102 hours there was a shift in the rubidium concentration toward the cathode, resulting in a smaller rubidium hold-up at the anode area. This caused the anode sample to appear slightly higher in  $\text{Rb}^{87}$  at this time than at the end of 220 hours. However, the overall  $\alpha$  was better at 220 hours. The  $\text{Rb}^{87}$  was enriched from 27.90 to 28.51 in this experiment.

The effective length of the enrichment tube was 70-80 cm. In an experiment by Ramarazi in which  $\text{Rb}^{85}$  was enriched in a 100-cm tube, the  $\alpha$ 's of the tube were 1.071 at 40°C and 1.085 for 85°C. This compares favorably with 1.067 at 65°C for the shorter tube used in this experiment. The average current for this experiment was 175 ma compared with 110 ma for Ramarazi's experiment.

Future work with  $\text{Rb}^{87}$  enrichment will involve the use of rubidium acetate in dilute acetic acid rather than rubidium hydroxide in water. This is

to determine the effect of a larger and less mobile anion on the enrichment factor.

### Special Sources

Cadmium-109 Electroplated Source. -- Cadmium-109 was electroplated onto platinum and encapsulated in an aluminum source holder with a 15-mil window.

At the face of the source, the output was  $4.65 \times 10^8$  gamma counts per second. The 22-keV silver X ray represented approximately one-third of the total output, the balance of the gamma activity being the 87-keV decay of  $\text{Ag}^{109m}$ .

Promethium-147 Sources. -- Two pressed cylindrical sources, 3 mm x 1 mm, each containing about 8 curies of  $\text{Pm}^{147}$  were made and encapsulated in aluminum holders having 15-mil aluminum windows. The output at the face of the source was approximately  $1.0 \times 10^8$  photons per second of the characteristic 38-40 keV promethium X ray.

Yttrium-91 Electrodeposited Source. -- Approximately 0.6 millicurie of carrier-free  $\text{Y}^{91}$  was electrodeposited onto platinum from citrate solution to produce a beta source, after which several layers of nickel were electrodeposited, thereby reducing smears to 30 d/m. The radiation 1-1/2 inches from the face was 5 r/hr and from the back was  $\sim 20$  mr/hr.

### Separation of Promethium and Americium

Recent tracer experiments demonstrate that a cation-exchange system using Dowex 50 resin and 1.0 M  $\text{NH}_4\text{SCN}$  solution can be used for the separation of  $\text{Am}^{241}$  and  $\text{Pm}^{147}$ . A separation factor of 13.9 was obtained with an elution time of 21 hours. However, a better process is the new use of anion exchange with 5.0 M  $\text{NH}_4\text{SCN}$ .

### Preparation of Carrier-Free Thorium-234

Previously prepared products of  $\text{Th}^{234}$  contained inactive thorium which reduced the specific activity. The amount of inactive thorium in  $\text{Th}^{234}$  products has been reduced by the use of clean vessels in which  $\text{Th}^{234}$  was allowed to grow from the uranium parent for three months. The result of these transfers is that the product now contains  $\sim 3.4$  micrograms of inactive thorium per millicurie of  $\text{Th}^{234}$ .

### Solvent Extraction

Experiments on the removal of the gross ionic constituents of fission product waste solutions by solvent extraction were continued. These experiments are directed toward the development of a chemical flowsheet to separate the fission products into chemically related groups. Experiments were concerned with the removal of iron, aluminum, and  $\text{HNO}_3$  without appreciable extraction of the fission product.

Extraction of Iron. -- The distribution coefficients of iron between aqueous solutions containing sulfate and TBP in the organic phase were found to be much lower than those reported for D2EHPA and a HNO<sub>3</sub> system. The results of several experiments using a D2EHPA-TBP-Amsco phase are shown in Table 7. The batch-extraction removal of iron from a synthetic Purex waste solution is shown in Table 8. The aqueous phase contained 0.5 M Fe, 1 M sulfate ion, and 4 M HNO<sub>3</sub>, after one hour contacting of the phases.

Table 7. - The Kd of Iron Between D2EHPA-TBP-Amsco and Mixed Acid Aqueous Phases\*

Exp. No.	O/A	D2EHPA (M)	TBP (M)	SO <sub>4</sub> <sup>--</sup> (M)	H <sup>+</sup> (M)	Fe g/l	Kd
1	1/15	0.5	0.5	~ 1	~ 5	1	2.8
2	1/15	0.5	-	-	~ 5	1	11.0
3	1/15	0.5	0.5	-	~ 5	1	8.7
4	1/15	0.5	-	~ 1	~ 5	1	9.0
5	1/1	0.5	0.5	~ 1	~ 5	1	3.3
6	1/1	0.5	-	~ 1	~ 5	1	43.0

\*Phases contacted to equilibrium, Fe concentration is given before phases were contacted.

Table 8. - Batch Extraction of Fe with D2EHPA-Amsco

Exp. No.	O/A	D2EHPA (M)	Fe (g/l) Starting	Kd Fe
1	1/2	1.66	26.0	5.1
2	1/2	1.66	7.4	87.2

Back Extraction of Iron. -- Since TBP in the presence of sulfate interfered with the extraction of iron, a means of solvent recovery was sought which did not require TBP in the organic phase. The most effective method found was to back extract iron with dilute phosphoric acid with equilibrium conditions reached in about five minutes. The results are shown in Table 9.

Table 9. Kd of Iron Between D2EHPA and H<sub>3</sub>PO<sub>4</sub> Solutions

Exp. No.	D2EHPA (M)	Fe (g/l) in Organic Phase	H <sub>3</sub> PO <sub>4</sub> in Aqueous Phase (%)	Kd
1	1.0	40	8.5	0.77
2	1.0	40	17.0	0.37
3	1.0	40	25.5	0.14
4	1.0	40	34.0	0.05
5	1.0	40	42.5	0.02

Acid Extraction. -- The extraction of nitric acid by Alamine 336 was

found to follow the relationship of Bertocci<sup>(1)</sup> with an average value of  $k = 0.19$  where:

$$Kd_A = k (\underline{M} \text{ of amine nitrate})$$

where

$Kd_A$  = the distribution coefficient of the stoichiometric excess of nitric acid.

In the extraction of mixed sulphuric and nitric acid, the nitric acid was nearly removed before an appreciable amount of sulphuric acid was extracted. The results of four successive contactings of an aqueous phase with equal volumes of 0.5 M Alamine 336 are shown in Table 10.

Table 10. - The Extraction of  $\text{HNO}_3\text{-H}_2\text{SO}_4$  with 0.5 M Alamine 336

	<u>HNO<sub>3</sub></u> <u>(M)</u>	<u>H<sub>2</sub>SO<sub>4</sub></u> <u>(M)</u>
Starting aqueous	1.00	1.00
After 1st contacting	0.43	1.00
After 2nd contacting	0.00	0.93
After 3rd contacting	0.00	0.52

Extraction of Cations by Alamine 336. -- To determine the extent of fission product extraction that would occur during extraction of acid from waste solution, a series of tests were made with 4 N mixed acid and 1 N  $\text{H}_2\text{SO}_4$  aqueous phases. To simulate fission product waste solutions from which iron had been removed, 1 M  $\text{NaNO}_3$  and 0.1 M  $\text{Al}(\text{NO}_3)_3$  were added to the aqueous phases. The organic phase was 50% (1.9 M) Alamine 336 in diethyl benzene. Results are shown in Table 11.

Table 11. -  $Kd$  of Some Fission Products Between Alamine 336 and Aqueous Acid Phases

Element	<u>Kd from 1 M H<sub>2</sub>SO<sub>4</sub>*</u> <u>2 M HNO<sub>3</sub></u>	<u>Kd from</u> <u>1 N H<sub>2</sub>SO<sub>4</sub>*</u>
Mo	5.6900	11.4000
Ru	0.0810	0.1900
Ce	0.0180	0.0097
Eu	0.0037	0.0057
Cs	0.0033	0.0080
Y	0.0026	0.0100
Rb	0.0006	0.0064
Fe	0.0004	0.0044

\*Starting aqueous phase composition,  $O/A = 1$

1. U. Bertocci, Some Observations on the Extraction of Nitric Acid, Uranium, and Plutonium by Tri-isonyl-amine, AERE-R-2933 (May 1959).

## Technetium

### Separation of Technetium

A new extraction unit consisting of three 45-liter countercurrent batch extractors was put into operation to recover Tc from 10 N HNO<sub>3</sub> solutions which are received from Paducah. The feed is neutralized with 10 N NaOH, and the insoluble material is allowed to settle for at least 16 hours. Four drums (100 liters per drum) of Paducah concentrate gave 10 liters (settled volume) of precipitate. Five drums of concentrate can be processed before reworking the precipitate by extracting the technetium with 1.0 N NaOH. The supernatant solution is contacted with lutidine which extracts 99% of the technetium. The feed can be processed at the rate of 170 liters of 1.0 N NaOH - 4 M NaNO<sub>3</sub> solution per four-hour period in the new equipment.

Technetium is concentrated in the final evaporator to 150 to 200 g/l of technetium. The highly colored solution which contains some black organic matter can be filtered readily. The filtered solution is being stored until a glove box is completed for the NH<sub>4</sub>TcO<sub>4</sub> crystallization operations.

A more dense technetium metal product was obtained by extending the reduction time to 16 hours at 760°C in a H<sub>2</sub> atmosphere.

### Analysis of Technetium Metal

Routine analyses of recent technetium metal products have indicated a 90-95% purity in comparison with technetium standards. However, activation, spectrometric, and oxygen analyses did not reveal any impurities. It was decided to analyze the metal by making a tetraphenylarsonium precipitation, a gravimetric analysis which does not depend on a technetium standard. Technetium metal was dissolved by boiling for two hours in 0.1 to 0.2 N NaOH which contained an equal volume of 5% sodium hypochlorite. Powdered technetium metal went into solution smoothly but the fused metal would not dissolve readily. Tetraphenylarsonium pertechnetate was precipitated, dried, and weighed. Solubility losses were determined by using six-hour Tc<sup>99m</sup> tracer and were found to be less than 1%. Hypochlorite did not interfere in the concentrations used here, since excess hypochlorite could be destroyed by H<sub>2</sub>O<sub>2</sub>. The analytical results from several samples of technetium metal are shown in Table 12.

Table 12. - Analyses of Several Batches of Tc Metal  
by Precipitation of Tetraphenylarsonium Pertechnetate

<u>Sample from</u> <u>Run No.</u>	<u>% Tc</u>
24	98.0
25	98.7
26	100.0
27	98.5

The routine analyses are consistently ~ 5% lower than the results shown in Table 12. The analytical laboratory is preparing a new standard from 3.0 grams of  $K_2CO_4$  which is being purified.

### Radioactive Source Development

The physical properties of radioactive sources prepared by adsorbing radioactive cations on Decalso (an aluminosilicate cation exchanger) can be modified by adding small quantities of fluxing agents to reduce the surface tension. It was found that oxides such as  $As_2O_3$ ,  $WO_3$ ,  $MO_3$ ,  $V_2O_5$ , and  $P_2O_5$  will lower the surface tension of the standard CaO-Decalso melt so that it spreads evenly in a thin layer, and that as little as 2%  $MO_3$  was sufficient to lower the surface tension. It was necessary to add ~ 10% by weight of the other oxides to cause the glass to spread evenly, but at these concentrations the glass was not as resistant to chemical leaching. The glass currently being studied is composed of 10% CaO, 2%  $MO_3$  and 88% Decalso.

The volatility of  $Cs^{137}$ ,  $Sr^{89}$ , and  $Ce^{144}$  from Decalso which melts at temperatures up to  $1400^\circ C$  was determined to be between 0.1 and 0.25% in a 24-hour period for cesium, and less than 0.1% in a 4-hour period for strontium and  $Ce^{144}$ . The volatility was determined by scrubbing a stream of  $N_2$  which passed through the furnace and checking the activity of the scrubber solution.

### Source Evaluation

Work has been concentrated on thin  $\alpha$  and  $\beta$  sources to develop a thin-film glass layer which will transmit a high percentage of the particles. The particle-emission efficiency of  $Pm^{147}$   $\beta$  (0.22 Mev),  $Am^{241}$   $\alpha$  (5.8 Mev), and  $U^{233}$   $\alpha$  (4.7 Mev) as a function of the thickness of the glass film is shown in Figure 1. The  $\alpha$  sources gave essentially mono-energetic  $\alpha$  particles at glass thicknesses of 0.05 - 0.6 mg/cm<sup>2</sup> with particle emission efficiencies in the range 90 - 99%.

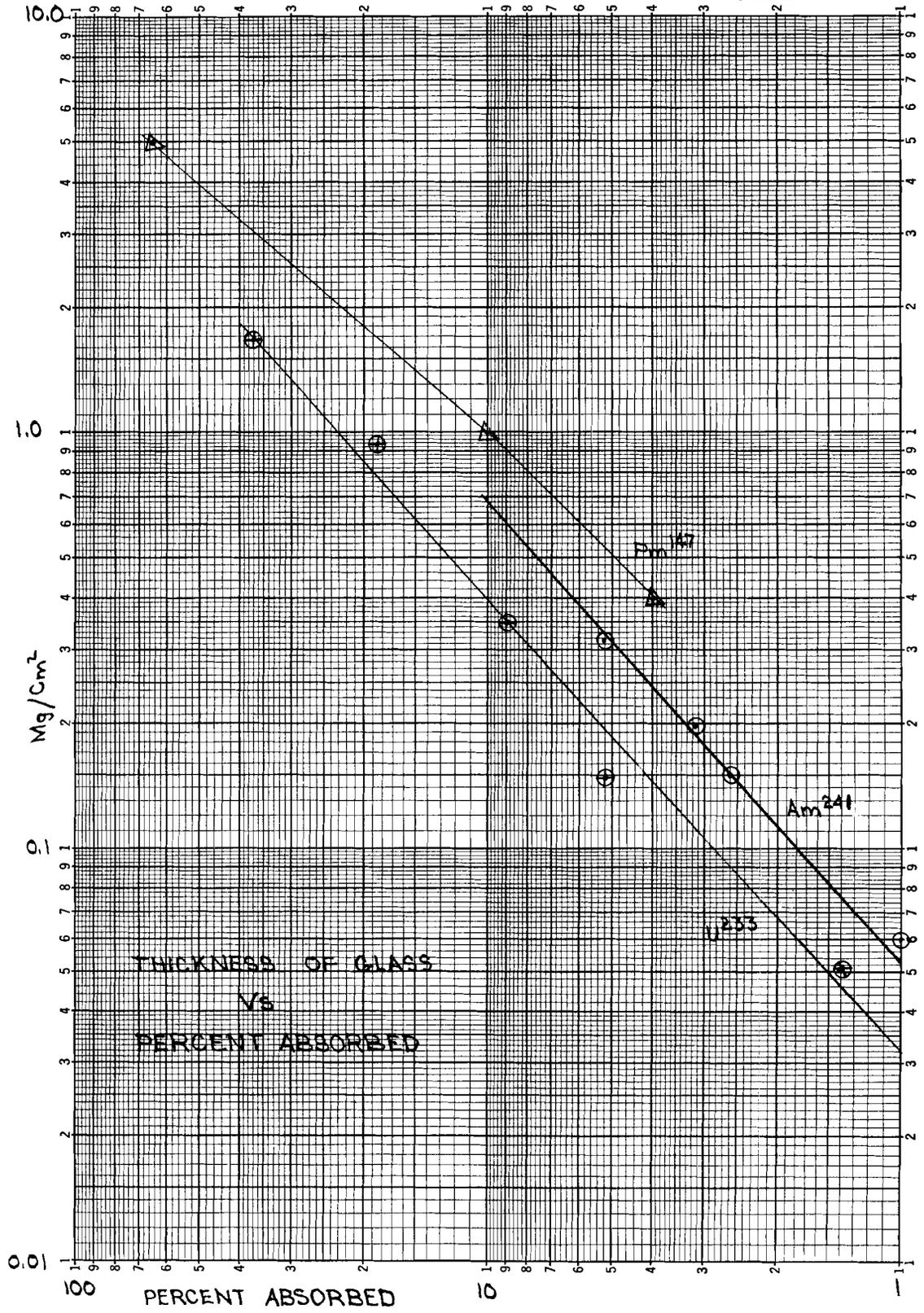
Ten millicuries of  $Pm^{147}$  was adsorbed on 100 mg of Decalso (~ 100-200 mesh), then mixed with 10% CaO and a water slurry hand-painted on 1/4" Berl saddles. These saddles were fired to  $1400^\circ C$  for two hours. The Berl saddles were placed in 0.1 M  $H_2SO_4$  and leached for 24 hours, 48 hours, and one week. Approximately  $7 \times 10^{-4}\%$  of the  $Pm^{147}$  was leached from the glass after one week, which is equivalent to 7 mc/100 curies promethium leached.

### Fission Product Chemistry

#### Separation of Cesium and Rubidium

Cesium and rubidium isotopes occur in fission products in the weight ratio of  $\frac{Cs}{Rb} = \frac{8}{1}$ . The fission rubidium consists of the two isotopes  $Rb^{85}$  and  $Rb^{87}$  which is also the case with the natural element. However, in fission of rubidium the percent abundance of the isotopes is reversed from that of natural rubidium, which makes it a desirable product to recover for

FIGURE 1



further enrichment in calutrons.

Methods for the recovery of rubidium from Cs<sup>137</sup> fractions in FFDL and decontamination from traces of radioactivity (principally Cs<sup>137</sup>) are being investigated. One method involves the use of attapulgus clay which has cation exchange properties. A column 25 cm long and 1 cm in diameter of LVM-30 attapulgus clay with a 0.18 Meq/g capacity was converted to the NH<sub>4</sub> form. Equal weights of cesium and rubidium were adsorbed on the column to load 5% of the capacity of the clay. Cesium-137 and Rb<sup>86</sup> tracers were used to follow the elution. The column was eluted with 0.05 M NH<sub>4</sub>NO<sub>3</sub> at 70°C at a flow rate of 0.5 column vol/hr. The sharp separation of rubidium and cesium is shown in Figure 2. The rubidium was completely removed in seven column volumes without cesium contamination and after thirteen column volumes the cesium was removed. Small amounts of Al(OH)<sub>3</sub> were observed in the solution and the same physical deterioration of the clay was noted after prolonged use at 70°C.

### Engineering Development

#### Fission Product Development Laboratory Equipment Modifications

Hot Off-Gas Scrubbers. -- The coolers on the hot off-gas scrubbers are operating satisfactorily and have eliminated most of the filter plugging that was caused by wet filters. The quantity of liquid condensed from the off-gas stream varies with the plant operation, but liquid build-up rates as high as 50 gallons per day have been observed in the first scrubber. The build up in the second scrubber has been negligible.

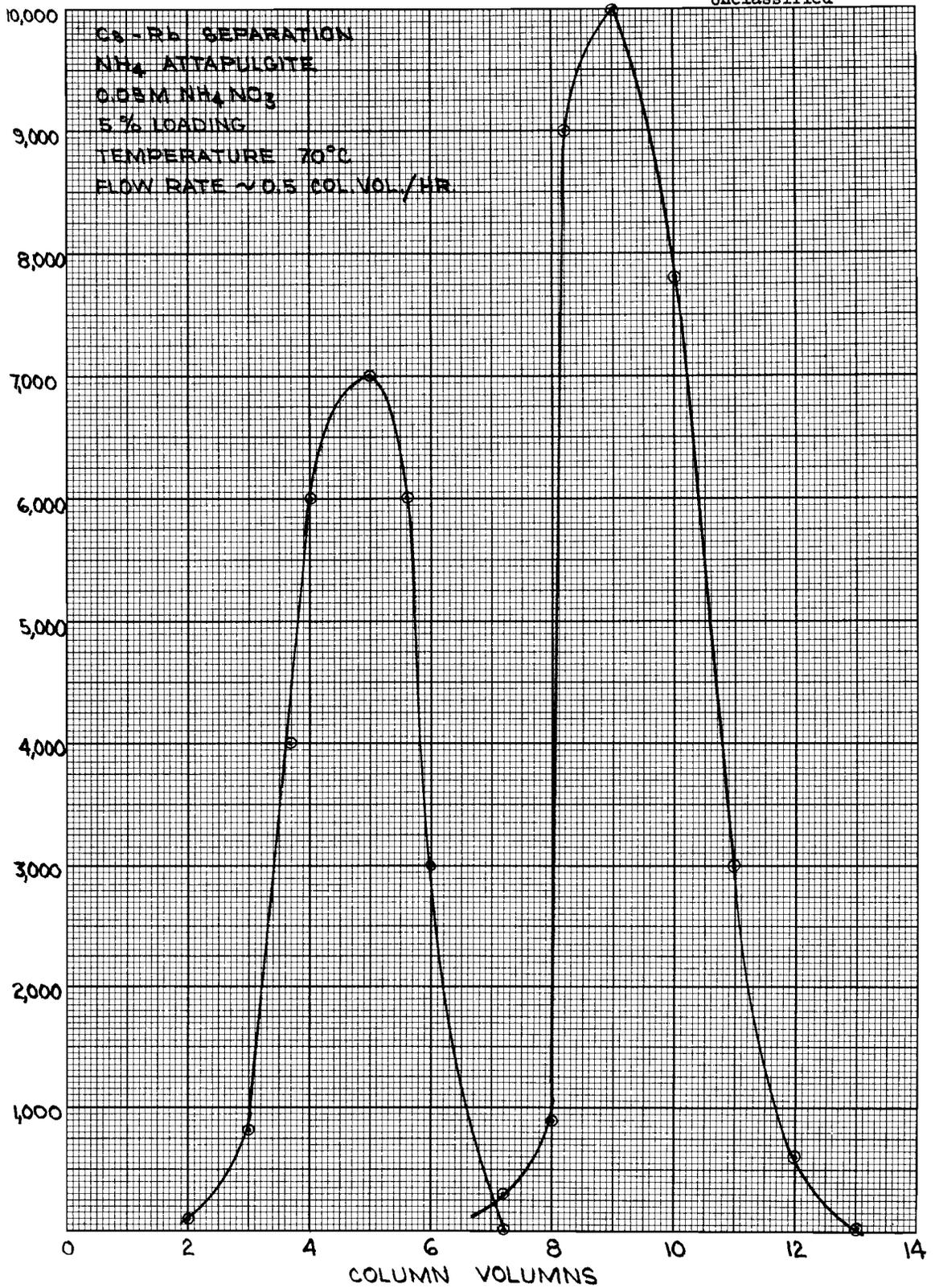
Closed Loop Process Water System. -- Title II design has been completed and remains as described in the previous quarterly report except that the size of the new chiller unit has been reduced from 75-ton capacity to 60-ton.

Cell Ventilation Filter Cask. -- Preliminary design is in progress for a shielded cask which will effect safe removal of contaminated filters from the Fission Products Development Laboratory and the Isotopes Area filter pits. The criteria require that each bank of filters be enclosed inside the cask in metal containers in which these filters will remain and be deposited in the burial ground.

Cask Transfer Station - Cell 1. -- Assembly and installation of the fluid transfer device is complete with piping modifications having been made to allow the slurring of Sr<sup>90</sup>CO<sub>3</sub> from the HAP0-II cask and to air-cool the cask.

Shielded Transfer Tank Hazards Report. -- A revised hazards analysis indicates that the STT-gondola unit conforms to the proposed CFR, Part 72 (Rev. 5-16-61) concerning shipment of radioactive materials with few exceptions requiring only minor modifications. These modifications include removing the positioning pins from the STT walls, replacing asbestos gaskets with Teflon O-rings, and installing fire shields. Modifications to the

FIGURE 2

ORNL-LR-Dwg. 64671  
Unclassified

gondola cars include placing three inches of steel under the area in which the cask sits and installing rubber buffers under each cask.

SST Heat Transfer Calculations. -- The object of this investigation was to determine the time required to rupture the present and modified versions of the SST when subjected to an instantaneous increase in surface temperature. The transfer of heat into the core of the SST would increase the vapor pressure of the water which it contains and reduce the structural strength of the steel portions of the cask. It is estimated that at 500°F the vapor pressure of the water would be sufficient to cause the inner tank to rupture with time calculated as function of the exterior surface temperature.

The SST can be represented as either a hollow sphere or a cylinder whose surface area is the same as the actual cask. If a cylinder is used to represent the SST, an analog computer must be used to simulate the model; if the sphere model is used, the problem can be solved analytically. Three assumptions were made for simplicity and conservatism, as follows:

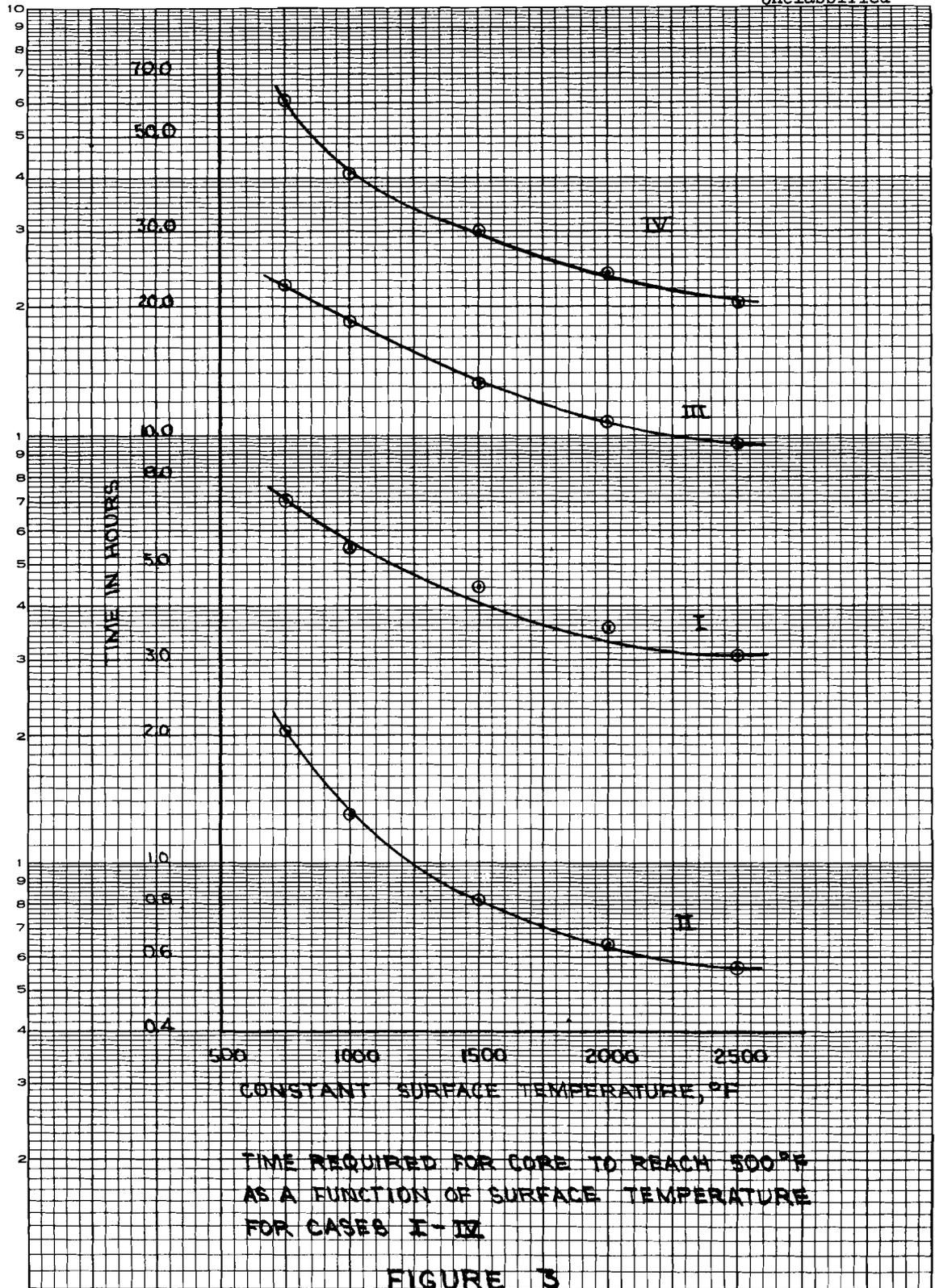
1. The laminated SST wall can be replaced by a homogeneous wall of identical dimensions and average physical and thermal properties.
2. The liquid in the core is perfectly mixed at all times and offers no heat transfer resistance via film boiling.
3. All heat absorbed by the water enters into raising its temperature. No allowance was made for heat absorbed in vaporizing a portion of the water.

Three shielded transfer tank designs were considered and the results of calculations over a range of external temperatures from 750°-2500°F are plotted in Figure 3. Case I, which used the sphere model, represents the SST without a heat shield. Cases II and III, which used the cylinder model, represent the addition of a thermal shield around the SST. The Case II shield was composed of steel and an air gap, while Case III was steel, air, and mineral wool insulation. The rate of heat transfer in all cases was estimated to be approximately  $2 \times 10^6$  Btu per hour.

Cell 27 - Strontium-90 Handling Cell. -- The CPFF portion of the Cell 27 project is complete. ORNL will complete the remaining work which includes the installation of the door seal, manipulator, booting adapter, viewing window, wall surfacing, cell ventilation duct and dampers, and equipment and instrumentation.

### Slurry Filter Casks

After the lead shielding for the second cask (HAPO-1B) was poured, an ultrasonic inspection indicated that bonding of the lead to the stainless steel was not achieved. The Hanford inspection group recommended acceptance on the basis of a heat transfer test in which a 5 Kw heat input



resulted in a temperature difference of 57°F across the cask wall. Although this temperature difference is about twice the design allowance, it is within the cask overload safety factor for heat dissipation.

#### Weather Bureau Source

Eleven sintered pellets of  $\text{Sr}^{90}\text{TiO}_3$  having a total weight of 762.5 grams were encapsulated in a Hastelloy C container which was inserted in a thermoelectric converter. The thermal output of the pellets due to  $\text{Sr}^{90}$  was 110.1 watts, which is converted to approximately 5 watts of electrical power by the thermoelectric elements. Shipment of the completed unit to the Martin Company was made on May 22, 1961.

The capsule closure was made by remote welding in a helium atmosphere at 30 psig pressure. Approximately 0.2% of the inert gas atmosphere was fission product gas containing  $\text{Kr}^{85}$ . After welding, the capsule was placed in a water-cooled evacuated chamber for five hours. The pressure was then raised to atmospheric pressure and two gas samples were checked for  $\text{Kr}^{85}$  activity, indicating a leak rate of less than 1.3 cc/yr.

The capsule containing the  $\text{SrTiO}_3$  pellets was placed then in the 5-watt converter assembly and a closure made by remote welding. A  $\text{Kr}^{85}$  leak test indicated a leak rate into the converter of less than 1.3 cc/yr.

#### Technetium-99 Equipment Installation

New equipment for the neutralization, extraction, and steam distillation for the production of  $\text{Tc}^{99}$  has been installed in Bldg. 3026-C. Tests are being run on ion exchange columns to determine the efficiency and operating characteristics of these columns during the recovery of technetium from waste streams of the purification process.

#### Cask Drop Tests

In cooperation with the Chemical Technology Division several scale-model casks have been built to perform drop tests. The purpose of these tests is to determine design characteristics for future carriers and to check structural calculations on casks already built. The casks will be instrumented to determine areas of maximum strain, accelerations experienced in sudden stops, time of free fall, and height of free fall.

The drop tests will be performed on these casks which vary in weight from 2700 pounds to 11,000 pounds with lead thicknesses from 1.5 inches to 6 inches. Included in these is a scale model of an STT.

#### Isotope Area Cell Ventilation Filter Pit

Site preparation has been started for the concrete structure of the filter pit with the installation of a cell ventilation duct by-pass around the construction area. The scheduled completion date is September 1961.

Iodine-131 Filter Pit

A gas sampling apparatus of the same type used on the 3039 stack was installed in the  $I^{131}$  cell ventilation filter pit to measure iodine activity before and after the filter bank. Each sample loop contains a millipore filter and a charcoal trap in series. Decontamination factors in the order of 1.5 were observed, and the air flow in the filter pit was determined to be 924 cubic feet per minute. After the filter pit was opened and a visual inspection made of the charcoal filter, no damage or deterioration to the filter was observed.

Containment - Building 3027

Construction of containment facilities for Building 3027 has begun. The expected completion date is July 28, 1961.

Displays - Technetium-99, Cesium-137, and Neodymium

Two graphic displays, each 36" x 48" x 4", are being prepared showing the separation and purification of  $Tc^{99}$  and neodymium.

Two displays mounted in attaché cases will show the separation, purification, and source fabrication of  $Cs^{137}$ .

Cobalt-60 Irradiator for Solid States Division

The design and drawings are complete for a shielded irradiator that will accommodate 1500 curies of  $Co^{60}$ . The Isotopes Division will furnish the  $Co^{60}$  source on a loan basis in a cooperative project to determine the fundamental effects of radiation on shielding glass.

Building 3026-C Modifications

Design is 50% complete on a plan for converting the two cell banks into one cell bank with five manipulator cells. A cost estimate will be obtained as soon as the preliminary design is complete.

Radioisotopes Development Laboratory

The cell block sub-floor has been poured and three of the cell floor pans have been grouted into place. Since floor pans as received from the fabricator were distorted by welding so that they did not drain properly, it was necessary to weld two additional screeds to the bottom of each pan to provide the proper slope. The floor pan penetrations have been welded in place. The side plates for three of the liners have been tack welded into position but final welding is being delayed pending a decision on the welding method to be used on those parts of the liners which do not join according to specifications.

Installation of the following items has been completed: air conditioning ductwork, fans and compressor; interior partitions; hot drain and vacuum system piping; and the monorail hoist.

### Iodine-125 Loop

The production of  $I^{125}$  by irradiating  $Xe^{124}$  in a continuous process is being investigated. The  $Xe^{124}$  can be irradiated in a reactor beam-hole of the LITR and then passed into a hold-up vessel, where it can be condensed and the  $I^{125}$  deposited. A prototype in-pile loop and a hold-up vessel have been designed and fabricated for out-of-pile tests.

### Dose Rate Calculations

A simple method of calculating the dose rate from a cylindrical gamma source was developed which takes into account self-absorption and source build-up, as well as the contributions made from all points of the source. The flux at the center of the base of the right cylinder is calculated and is then treated as emitted from a point source. The calculated result is the dose rate at one meter from the assumed point source. In order to make the method generally applicable, no corrections were made for scattering or collimation of the beam in various designs of shielding heads.

The results of this investigation indicate that the build-up factor is important and contributes as much as 33% of the observed dose rate.

Customers who have obtained both  $Cs^{137}$  and  $Co^{60}$  sources have been requested to furnish measurements of the dose rates from these sources for comparison with the calculated results.

### Thermal Diffusion

#### Column Operation

A total of 450 mg of  $Ar^{36}$  in 60-65% enrichment range was obtained. Modifications were made to argon columns and small columns were added to the system which is now operating.

#### Development

Krypton-86 Enrichment. -- The  $Kr^{86}$  operation was continued and enrichment is now ~ 55%.

Neon-21 Enrichment. -- At the maximum  $Ne^{21}$  concentration of 1%, ~ 3900 mg of neon has been withdrawn. This is about one-half the amount required for recycling the operation to obtain higher enhancement of  $Ne^{21}$ .

The differential equation expressing the variation of  $Ne^{21}$  concentration as a function of column length has been written as

$$C_{21} \frac{d^2 C_{21}}{dz^2} - 2 \left( \frac{dC_{21}}{dz} \right)^2 + \left( \frac{H}{K} \right)^2 \left[ \left( 1 + \frac{U_{22} - U_{20}}{H} \right) C_{21} \right] C_{21}^2 =$$

$$\frac{\sigma}{K} \left( \frac{3 U_{21}}{\sigma} - C_{21} \right) \frac{dC_{21}}{dz} + \left( \frac{U_{21}}{K} \right)^2 - \left( \frac{U_{21}\sigma}{K^2} \right) C_{21}$$

where

$C_{21}$  is concentration of neon-21  
 $z$  is column length  
 $\sigma$  is production rate  
 $H$  and  $K$  are constants of the column  
 $\tau_{21}$ ,  $\tau_{22}$ , and  $\tau_{20}$  are internal isotope transports and  
depend upon  $\sigma$  and  $C_{21}$

This equation can be solved completely on an analog computer. A study of various methods of connecting a plant should lead to smaller and more efficient systems. Also this equation is directly applicable to such middle isotope problems as  $\text{Ar}^{38}$ ,  $\text{Cl}^{36}$ , and by extension should include  $\text{Kr}^{85}$  and more complicated systems of isotopes.

Carbon-13 Enrichment. -- A system for the recovery of  $\text{C}^{13}$  as  $\text{BaCO}_3$  is required. The  $\text{C}^{13}\text{H}_4$  will be scrubbed with  $\text{Ba}(\text{OH})_2$  to remove  $\text{CO}_2$  containing low-level  $\text{C}^{13}$ . The  $\text{C}^{13}\text{H}_4$  is then burned in a hot sand-filled tube with excess  $\text{O}_2$  to form  $\text{CO}_2$ . The  $\text{BaCO}_3$  is removed from this  $\text{CO}_2$  by scrubbing through  $\text{Ba}(\text{OH})_2$  and is dried for storage.

The design of a plant to produce one-half gram per day of  $\text{C}^{13}$  enriched to 90% has been completed.

#### Enlarged Facility

The enlarged facilities for thermal diffusion operations should be released by the construction company soon. However, several weeks of additional work will be needed to install local piping and correct errors in the original revision.

### ISOTOPE SEPARATIONS

#### Calutron Operations

Calutron time was allocated to the separation of the isotopes of calcium, potassium, zirconium, magnesium, tin, samarium, nickel, and tungsten. The separations of tin, samarium, nickel, and tungsten are still in progress.

Isotope separations consumed 96.6% of the total available calutron hours. The remaining 3.4% consisted of development and miscellaneous uses. In Table 13 data are tabulated for production separations. The values shown in this tabulation are the summation of the entire separation series to date.

Table 13. - Summary of Isotope Separation - Production Data

<u>Element</u>	<u>Series</u>	<u>Process Efficiency (%)</u>	<u>Weight equivalent to monitored ion currents (g)</u>	
Ca	JW	19.0	Ca-48	11.4496
			46	0.1949
			44	116.8718
			43	8.0440
			42	34.6727
			40	8289.2114
			<u>8460.4444</u>	
K	KI	9.8	K-41	3.7166
			40	0.0775
			39	66.5508
			<u>70.3449</u>	
Zr	KK	4.3	Zr-96	28.2449
			94	171.8596
			92	165.3778
			91	107.4050
			90	509.4173
			<u>982.3046</u>	
Ni*	KT	7.7	Ni-64	0.9268
			62	3.8263
			61	1.1153
			60	26.4012
			58	66.2785
			<u>98.5481</u>	
Mg	KM	13.2	Mg-26	19.2182
			25	16.4634
			24	122.7172
			<u>158.3988</u>	
Sn*	KN	8.7	Sn-124	77.3852
			122	59.9575
			120	302.0053
			119	79.4092
			118	154.6839
			117	60.5957
			116	106.9966
			115	2.7832
			114	5.3760
			112	8.8921
			<u>858.0847</u>	

(continued)

Table 13 - continued

<u>Element</u>	<u>Series</u>	<u>Process Efficiency (%)</u>	<u>Weight equivalent to monitored ion currents (g)</u>	
Sm*	KO	9.39	Sm-154	35.6035
			152	41.5565
			150	11.5165
			149	21.1515
			148	17.1128
			147	22.7358
			144	4.3620
			<u>154.0386</u>	
W*	KQ	4.6	W-186	93.4247
			184	86.2020
			183	6.2506
			182	73.5586
			180	2.3247
				<u>261.7606</u>

\*Series incomplete

As a result of mixing Ni<sup>61</sup> and Ni<sup>64</sup>, second pass separations are in progress. Typical mass analyses which are the highest attained for these isotopes in any separation are as follows:

<u>Nickle-61</u>		<u>Nickle-64</u>	
<u>Isotope</u>	<u>Atom %</u>	<u>Isotope</u>	<u>Atom %</u>
58	~ 0.01	58	0.02
60	~ 0.01	60	0.03
61	99.97	61	0.03
62	~ 0.01	62	<0.01
64	-	64	99.92

Stable Isotopes Separation Schedule for Next Quarter

	<u>Building 9731</u>		<u>Building 9204-3</u>		
	<u>XAX</u>	<u>XBX</u>	<u>Track 1</u>	<u>Track 2</u>	<u>Track 3</u>
July	Lu	Ni	W	Gd	Sn
August	Lu	Ti	W	Ca	Sn
September	Lu	Ti	Ta	Ca	Hf

Special Services

Special service projects conducted by the refinement group are divided into four general groups:

1. Chemical conversion of an inventory form to a particular compound

requested by the customer

2. Conversion of an inventory form to the element
3. Conversion of an inventory form to the element followed by preparation of the metal in a specified form
4. Encapsulation of inventory forms

Table 14 summarizes these special services by groups.

<u>Table 14</u>			
<u>Element and Isotope</u>	<u>Lot Number</u>	<u>Quantity (g) of element desired</u>	<u>Type of Conversion</u>
<u>Group 1</u>			
B-10	SS 1(b)	3.5 total (2 samples)	Elemental boron $\rightarrow$ $H_3BO_3$
B-11	SS 2(ce)	3.0	Elemental boron $\rightarrow$ $H_3BO_3$
Cl-37	KL 1255(c)	3.0	NaCl $\rightarrow$ RbCl
K-41	RS 48(e)	0.050	KCl $\rightarrow$ $KClO_4$
Li-6	SS 5(a)	14.50	Li metal $\rightarrow$ LiF, oxygen content < 0.05%
Li-6	SS 5(h)	602.5 total (7 samples)	Li metal $\rightarrow$ $Li_2CO_3$
Li-6	SS 5(h)	292.132 total (10 samples)	Li metal $\rightarrow$ LiF
Li-6	SS 5(h)	5.0	Li metal $\rightarrow$ LiCl, packaged in 5 1-gram lots as anhydrous chloride
Li-6	SS 5(h)	120.0	Li metal $\rightarrow$ $LiOH \cdot H_2O$
Li-7	SS 7(c)	10.0	$LiOH \cdot H_2O \rightarrow$ LiCl, packaged in 10 1-gram lots as anhydrous chloride
Li-7	SS 7(c)	5.0	$LiOH \cdot H_2O \rightarrow$ LiCl, chloride sealed in quartz for irradiation
Ni-64	KP II-1	0.060	$Ni(C_4H_7N_2O_2)_2 \rightarrow$ $NiSO_4$
Rb-85	HW 963(a)	0.030	RbCl $\rightarrow$ $Rb_2Cr_2O_7$
Rb-87	JE 1099(a-1)	0.030	RbCl $\rightarrow$ $Rb_2Cr_2O_7$
Sr-87	JH 1117(b)	0.2484	$Sr(NO_3)_2 \rightarrow$ SrO
<u>Group 2</u>			
Cd-112	KG 1230(a)	0.150 total (2 samples)	CdO $\rightarrow$ Cd
Cd-113	KG 1231(b)	0.300	CdO $\rightarrow$ Cd
Cd-114	KG 1232(a)	0.100	CdO $\rightarrow$ Cd
Cd-116	KG 1233(a)	0.100	CdO $\rightarrow$ Cd
Cr-50	JR 1171(a)	0.175 total (2 samples)	$Cr_2O_3 \rightarrow$ Cr
Cr-52	GR 837(a)	60.637	$Cr_2O_3 \rightarrow$ Cr
Cr-52	GZ 869(a)	13.845	$Cr_2O_3 \rightarrow$ Cr

(continued)

Table 14 - continued

<u>Element and Isotope</u>	<u>Lot Number</u>	<u>Quantity (g) of element desired</u>	<u>Type of Conversion</u>
Cr-53	IP 1035(a)	0.060 total (2 samples)	Cr <sub>2</sub> O <sub>3</sub> → Cr
Cr-54	JR 1174(a)	0.025	Cr <sub>2</sub> O <sub>3</sub> → Cr
Fe-54	FN 685(b)	0.025	Fe <sub>2</sub> O <sub>3</sub> → Fe
Fe-56	FC 635(a)	19.675	Fe <sub>2</sub> O <sub>3</sub> → Fe
Fe-57	DL 463(z)	0.100 total (2 samples)	Fe <sub>2</sub> O <sub>3</sub> → Fe
Ge-70	JL 1135(a)	0.050	GeO <sub>2</sub> → Ge
In-115	JO 1159(a)	0.200	In <sub>2</sub> O <sub>3</sub> → In
Mo-92	HF 889(a)	0.750 total	MoO <sub>3</sub> → Mo
Mo-94	HF 890(a)	0.040	MoO <sub>3</sub> → Mo
Mo-96	HF 892(a)	0.780 total (2 samples)	MoO <sub>3</sub> → Mo
Mo-98	HF 894(a)	0.800 total (2 samples)	MoO <sub>3</sub> → Mo
Mo-100	HF 895(b)	0.040	MoO <sub>3</sub> → Mo
Mo-100	HF 895(d)	0.600	MoO <sub>3</sub> → Mo
Pb-208	RS 124(a)	0.050	PbO → Pb
Pb-208	JU 1185(a)	0.582	Pb(NO <sub>3</sub> ) <sub>2</sub> → PbCO <sub>3</sub>
Pb-208	JU 1185(a)	0.200	PbCO <sub>3</sub> → PbO
Sn-116	RS 184(b)	0.260	SnO <sub>2</sub> → Sn
Sn-117	IJ 1003(a)	0.040	SnO <sub>2</sub> → Sn
Sn-118	RS 186(b)	0.500 total (2 samples)	SnO <sub>2</sub> → Sn
Sn-118	IJ 1004(fp)	19.912	SnO <sub>2</sub> → Sn
Sn-119	EC 533(a)	2.57	SnO <sub>2</sub> → Sn
Sn-120	IJ 1006(a)	49.996	SnO <sub>2</sub> → Sn
Sn-124	IJ 1008(a)	0.050	SnO <sub>2</sub> → Sn
Zn-64	HR 951(b)	14.712	ZnO → Zn
Zn-64	JN 1148(a)	0.100	ZnO → Zn
Zn-66	HR 952(c)	0.050	ZnO → Zn
Zn-66	JN 1150(a)	0.750	ZnO → Zn
<u>Group 3</u>			
Pb-208	JU 1185(a)	139.551	Melted Pb; cast in cylinder 1-1/8" x 3/4"
Sn-112	IJ 999(a)	0.005	SnO <sub>2</sub> → Sn; sealed in quartz ampoule for irradiation
Sn-116	IJ 1002(a)	0.010	SnO <sub>2</sub> → Sn; sealed in quartz ampoule for irradiation
Sn-118	FS 715(a)	0.010	SnO <sub>2</sub> → Sn; sealed in quartz ampoule for irradiation
Sn-118	IJ 1004(fp)	1.0	SnO <sub>2</sub> → Sn; prepared in single bead and sealed in quartz ampoule

(continued)

Table 14 - continued

<u>Element and Isotope</u>	<u>Lot Number</u>	<u>Quantity (g) of element desired</u>	<u>Type of Conversion</u>
Sn-122	IJ 1007(a)	0.010	SnO <sub>2</sub> → Sn; sealed in quartz ampoule for irradiation
Sn-124	IJ 1008(a)	0.010	SnO <sub>2</sub> → Sn; sealed in quartz ampoule for irradiation
Zr-96	KK 1253(a)	0.982	ZrO <sub>2</sub> → Zr; Zr deposited on 7-mil tungsten filament
<u>Group 4</u>			
Hg-196	JG 1108(a)	0.002	Encapsulate Hg(NO <sub>3</sub> ) <sub>2</sub> in Pyrex
Hg-199	DR 487(a)	0.0059	Encapsulate Hg(NO <sub>3</sub> ) <sub>2</sub> in Pyrex
Hg-204	JG 1114(c)	0.010	Encapsulate Hg(NO <sub>3</sub> ) <sub>2</sub> in Pyrex

#### Charge Preparation

The following chemical forms have been procured from commercial vendors or synthesized in the laboratory for the separation of the isotopes of calcium, magnesium, nickel, samarium, tin, titanium, tungsten, zirconium, and gadolinium:

Mg metal (compacted)	1,082 g
NiCl <sub>2</sub> (fused)	2,508 g
NiCl <sub>2</sub> (enriched)	266 g
SnCl <sub>2</sub> (compacted)	7,564 g
TiCl <sub>4</sub> (liquid)	3,130 g
Ca metal	13,348 g
SnCl <sub>4</sub> (liquid)	30,124 g
WCl <sub>6</sub> (compacted)	19,802 g
ZrCl <sub>4</sub>	42,971 g
GdCl <sub>3</sub>	1,614 g
UF <sub>6</sub>	120 g

In addition, some 1,200 g of anhydrous lutetium chloride and 1,800 g of anhydrous gadolinium chloride have been prepared from their respective oxides in anticipation of forthcoming isotope separations.

Chemical recovery of the unresolved charge materials used in recent isotope separations of dysprosium, samarium, osmium, and enriched potassium is in progress. Approximately seven kilograms of ytterbium oxide has been recovered and refined in a similar charge recovery program. This quantity accounts for 95% of the charge material used in the collection. Nine hundred thirty grams, representing 94% of the total europium charge material, was also recovered and purified.

### Chemical Refinement

Chemical recovery and refinement was completed on new inventory lots of Cd<sup>106,108,111,113,114,116</sup>, Cl<sup>3</sup>, Ga<sup>69</sup>, Fe<sup>54,57,58</sup>, Ni<sup>61,64</sup>, Tl<sup>203</sup>, Yb<sup>188,-171,174,176</sup>, and Zr<sup>96</sup>. Refinement was also completed on "old loan agreement" samples of Pb<sup>204,207</sup> and current returns of Cr<sup>54</sup>, Fe<sup>57</sup>, Tl<sup>50</sup>, and W<sup>186</sup>. The lots mentioned above, with the exception of Ni<sup>61</sup> and Ni<sup>64</sup>, were prepared and placed in inventory following spectrochemical and mass analyses.

A total of 466 isotope collector pockets was received for recovery of separated isotopes or for studies connected with operation control and calutron development projects. Of this total, the collected material from 188 pockets was processed in order to obtain a sufficiently pure sample for mass analysis. Material from most of the remaining pockets has been removed and is in various stages of chemical refinement.

### Special Separations

A total of 300 Np<sup>237</sup> detector foils was fabricated and shipped. One thousand ten grams of depleted uranium were converted to UF<sub>4</sub> and reduced to metal. A total of 50.6 grams of highly depleted uranium was converted to UF<sub>4</sub> and reduced to metal for shipment.

Decontamination work was completed in preparation of the area for the new plutonium containment facility.

The following shipments were made during the quarter:

Uranium	21
Plutonium	3
Np <sup>237</sup>	9

### Isotope Receiver Studies

The sputtering program has been continued in the current calcium separation for the purpose of determining the sputtering ratio of carbon atoms per incident Ca<sup>40</sup> ion. Calcium-40 was collected on a weighed triangular block of graphite for a period of time sufficient to deposit several grams of the separated isotope. Table 15 gives the data obtained by bombarding five different graphite blocks with calcium, each in a different Ca<sup>40</sup> collector pocket. The estimated weight is the amount of calcium calculated to have struck the target surface as determined from the integrated current readings. The percentage retention indicates the struck surface. The sputtering ratio of carbon to calcium given here was obtained by weighing the graphite pad before and after use, followed by a chemical determination of the calcium remaining with the pad.

Table 15. - Sputtering Data - 35 Kev Ca<sup>+</sup> Ions on C

Est. Wt.(g) of Ca <sup>40</sup> Collected (Monitored)	Wt. of C(g) lost from Striking Pad	Wt. of Ca(g) Retained on Striking Pad	Retention (%)	Sputtering Ratio C atoms/Ca atoms
96.5012	96.129	0.053	0.055	3.32
95.9728	97.150	0.047	0.049	3.38
128.4675	129.081	0.057	0.044	3.35
103.6717	99.949	0.062	0.060	3.22
95.5076	102.850	0.080	0.084	3.59

#### Process Improvement

Preparations necessary for the initial testing of the double-focusing isotope separator are nearing completion. The calculation to find the best contour for the pole tips has been finished and actual fabrication of these parts is now in progress.

In order to accomplish this computation, a program which would evaluate the potential distribution produced by an approximate shim contour was prepared for the IBM 7090 computer. Since the iron used will have a relative permeability of 1000 to 5000 at operational flux levels, the surfaces of the shims were considered to be magnetic equipotentials. The computer calculated the magnetic intensity distribution produced by this approximate surface and compared it with the desired theoretical intensity distribution. This calculation also resulted in pole pieces which will produce the maximum volume of usable field with the restrictions imposed on them by the physical dimensions of a beta calutron tank.

Because of the 255° focal angle of this magnetic system, a new source was constructed by modification of the existing calutron source. It was necessary to relocate the high-voltage bushings and to redesign the ionization chamber and ion accelerating system. The ion beam will now leave the source at an angle of 32-1/2° downward with respect to the horizontal. (See Figure 4) This source has been tested in a calutron with a magnesium charge and was found to operate satisfactorily with respect to ion output, high voltage discharge, and electron drain.

A new receiver has also been built for this separator by modifying the adjusting mechanism and other components of a regular calutron receiver. This includes the design and fabrication of receiver pockets and face plates, properly shaped for the image curvature characteristic of this system.

An electronic data handling system has been acquired and is now being tested. This instrumentation will be used to measure the voltages developed by a Hall generator in the magnetic field of the new separator. The digital data system will record data concerning the magnetic field on punched paper tape, thus providing access to a computer. This information will provide

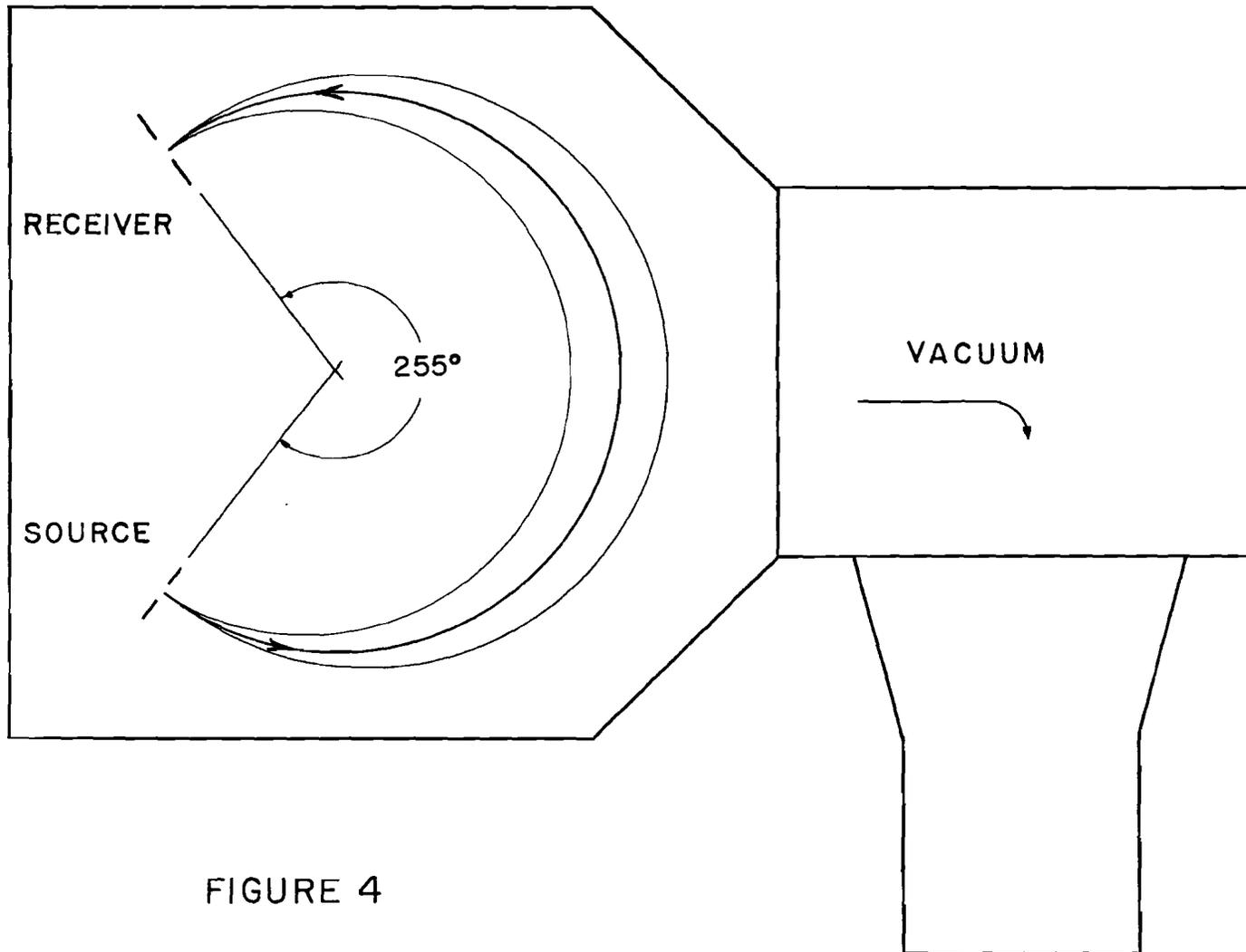


FIGURE 4

a means of accurately measuring the magnetic field generated, comparing it with the final field shape desired, and determining the changes to the pole tips that will be necessary to produce the correct field.

### Construction Progress

Bids for the subcontract construction work covering the installation of the Radioactive Containment Improvements job, Building 9204-3, were opened by UCNC Purchasing Division on May 23, 1961. The low bid was \$393,890, or approximately \$153,000 more than the estimate of UCNC as authorized by Modification 4 of Directive Y-22-222. On the basis of this overage, all five bids were rejected.

The scope of this job is presently being revised and necessary revisions made to drawings and specifications in order that work can be accomplished within GPP subproject limitations. When this phase is completed, the job will be re-advertised.

The present schedule of job phases is outlined below:

<u>Description</u>	<u>Date</u>
Drawing and specifications submitted for re-advertising	8-1-61
Bids completed	9-1-61
LSSC construction start-up	9-11-61
Beneficial occupancy of area	Mid-Jan. 1962
Job completion	Mid-Feb. 1962

### TARGET PREPARATION

#### Development of Decelerator

Calutron experiments using the decelerator have been continued. Practical use of this equipment would be the direct deposition of separated isotopes on specific target backings for use in particle accelerators. In this application, it is necessary to move or rotate the target in the ion beam to produce the required uniformity of deposited material over the surface of the backing. In an attempt to accomplish this uniformity and desired thickness, two mechanical devices, which utilize rotational and oscillatory motions respectively, have been constructed. They are powered by a synchronous motor geared to provide 33 rpm.

The rotational device is a disc which is used as a mounting for the target backing material. This disc is offset from the center of the receiver so that a series of targets mounted on it may be rotated through the center of the impinging, low energy, ion beam. With such motion, deposited material is expected to be uniform within 10% over a target diameter of 2.5 cm.

Experimental runs with this device have been made to work out mechanical difficulties and permit examination of the resulting targets. The following

table shows the results of these runs using Ni<sup>58</sup>.

<u>Target</u>	<u>Backing Material</u>	<u>Size of Target</u>	<u>Time of Deposition</u>	<u>Density</u>
Ni-58	Ta	3/4" dia.	3 hr.	.2 mg/cm <sup>2</sup>
Ni-58	Ta	1-1/2" dia.	8 hr.	.3 mg/cm <sup>2</sup>

(Uniformity determinations have not yet been made.)

The oscillatory device moves harmonically through the beam with a period of ~ 0.5 sec. Backing material is attached to the moving plate and provides a target for the direct deposition of a given isotope from the ion beam. The travel in one direction is 2", so the overall size of the target in this direction is presently limited to this value.

### Fabrication

Two high vacuum evaporators were installed making a total of six evaporators ranging from bell jar sizes of 12 inches to 24 inches producing pressures of less than  $5 \times 10^{-6}$  torr. Sixty-two 4-inch diameter targets of UF<sub>4</sub> on 5-mil magnesium backing were produced by evaporation.

A power driven four high roll mill was installed and targets rolled included Li, Mg, Al, Ca, Fe, Co, Ni, Cu, Zr, Zn, Pd, Ag, Cd, Sn, Pt, Pb, and Ti.

Thin self-supported foils of Co, Ni, Cu, Zn, Cd, and backed targets of Cr, Zn, Ni, Co, and Cd were prepared by electrodeposition.

Targets of Na, K, Rb, P, Se, Te, CBr<sub>4</sub> have been cast in stainless steel targets holders. Also, a 30-ton hydraulic press was acquired and has been used considerably in the preparation of targets.

Orders have been routinely filled for tritium-zirconium and tritium-titanium targets.

### ISOTOPES SALES AND DISTRIBUTION

#### Radioisotopes

Table 16. - Radioisotope Sales

	<u>This Quarter</u>	<u>CY to Date</u>
Processed Material	19,703 c	28,971 c
Service irradiations	205	393
Targets	70	96
Cesium sources	5,395 c	7,677 c
Cobalt sources	81,344 c	161,199 c
Iridium	1,185 c	3,161 c
Strontium	17,523 c	17,577 c

Table 17. - Radioisotope Shipments

	<u>2nd Qtr.</u> <u>CY-61</u>	<u>1st Qtr.</u> <u>CY-61</u>	<u>2nd Qtr.</u> <u>CY-60</u>	<u>Since</u> <u>August 1946</u>
Processed Material	3,430	3,099	3,036	126,012
Irradiation Units	<u>196</u>	<u>291</u>	<u>268</u>	<u>25,886</u>
Total	3,626	3,390	3,304	151,898
Domestic	1,857	1,924	1,759	
Foreign	210	184	178	
AEC	<u>1,559</u>	<u>1,282</u>	<u>1,367</u>	
Total	3,626	3,390	3,304	

Stable Isotopes

Table 18. - Stable Isotope Shipments

	<u>AEC</u>		<u>Domestic</u>		<u>Foreign</u>		<u>Total</u>	
	<u>2nd Qtr.</u>		<u>2nd Qtr.</u>		<u>2nd Qtr.</u>		<u>2nd Qtr.</u>	
	<u>1961</u>	<u>1960</u>	<u>1961</u>	<u>1960</u>	<u>1961</u>	<u>1960</u>	<u>1961</u>	<u>1960</u>
<u>SALES</u>								
EM Shipments*	101	86	156	120	114	119	371	325
Lithium	<u>6</u>	<u>6</u>	<u>24</u>	<u>12</u>	<u>16</u>	<u>6</u>	<u>46</u>	<u>24</u>
Total	107	92	180	132	130	125	417	349
Special Orders**	28	13	47	25	26	3	101	41
Uranium	0		0		4		4	
<u>LOANS</u>								
EM Shipments*	19	13	12	10	2	0	33	23
Special Orders	6	9	1	5	0	0	7	14
			<u>AEC</u>	<u>Domestic</u>	<u>Foreign</u>		<u>Total</u>	
Total loans under new policy			285	112	38		435	
Total returns of new loans			117	89	27		233	

\*Electromagnetically separated isotopes.

\*\*Included in total shipments.

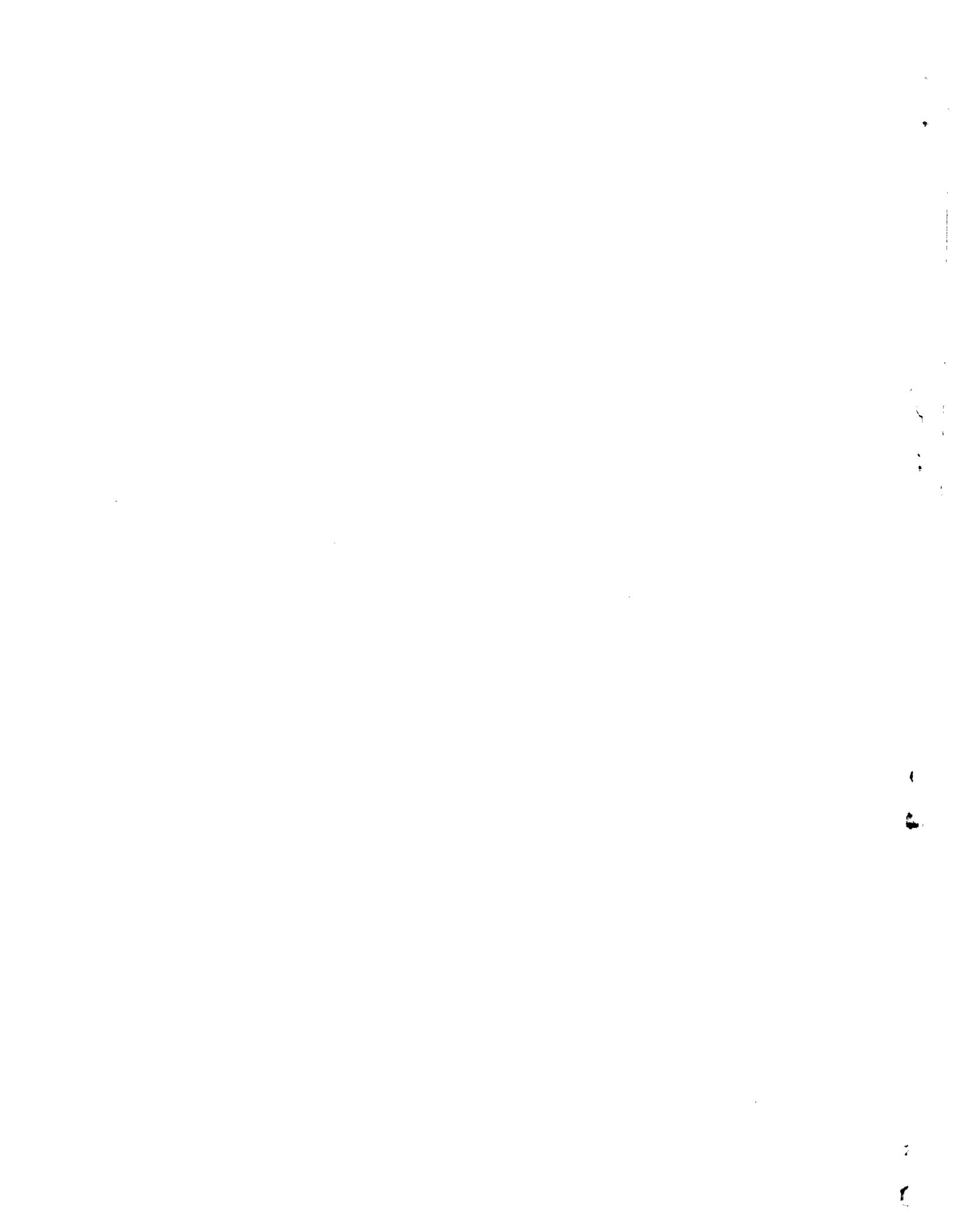
There are 2 unfilled orders of Dy.

MISCELLANEOUSTable 19. - Activation Analyses - SS Accounting

	<u>This</u> <u>Qtr.</u>	<u>Last</u> <u>Qtr.</u>	<u>CY</u> <u>to date</u>	<u>Total</u> <u>Last CY</u>
Activation Analyses completed	176	32	208	292
SS and Special Material:				
Receipts, number of lots	136	118	254	506
Shipments, number of lots	78	88	166	353
Material requests issued	31	63	94	197
Reports issued	35	41	76	172
Internal audits and surveys	15	19	34	55

Table 20. - Cobalt Inventory

<u>Grade</u> <u>c/g</u>	<u>Storage Inventory</u> <u>Curies</u>
0 - 25	30,083
26 - 40	70,404
41 - 55	74,398
> 55	<u>11,793</u>
	186,678



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