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RADIOISOTOPE PROGRAM (8000)
PROGRESS REPORT FOR
FEBRUARY 1973

A. F. Rupp

MASTER

OAK RIDGE NATIONAL LABORATORY

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Contract No. W-7405-eng-26

ISOTOPES DEVELOPMENT CENTER

RADIOISOTOPE PROGRAM (8000) PROGRESS REPORT
FOR FEBRUARY 1973

A. F. Rupp

Work Sponsored by
AEC Division of Applied Technology

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MARCH 1973

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OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
operated by
UNION CARBIDE CORPORATION
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RADIOISOTOPE PROGRAM (8000) PROGRESS REPORT
FOR FEBRUARY 1973

A. F. Rupp

RADIOISOTOPE PRODUCTION AND MATERIALS DEVELOPMENT

REACTOR-PRODUCED ISOTOPES - 08-01-01

Phosphorus-33 (J. K. Poggenburg)

The purpose of this project is to develop methods of preparing hundred-millicurie quantities of carrier-free phosphorus-33 containing $\leq 5\%$ phosphorus-32. The two methods for producing phosphorus-33 being evaluated are based on the irradiation of highly enriched targets of sulfur-33 (>92 at. %) or chlorine-36 (approximately 63 at. %) in a fast neutron flux. Phosphorus-33 (25.2 days; 0.248-MeV β_{max}) has both a longer half-life and a lower energy beta than phosphorus-32 (14.3 days; 1.709-MeV β_{max}), which makes it advantageous for autoradiography, longer ecological and agricultural experiments than with phosphorus-32, synthesis of tagged complex organophosphorus compounds, and double labeling experiments.

Last month it was reported that the solution from a 1.06-g (approximately 65% enriched) $K^{36}Cl$ target gave a low phosphorus-33 yield upon processing and showed upon analysis that it still contained what was thought to be approximately 900 mCi phosphorus-33. The solution was converted to $H^{36}Cl$, and fresh $Fe(OH)_3$ was dissolved in the solution. Reprecipitation of $Fe(OH)_3$ was again carried out using KOH. The phosphorus-33 yield from this procedure was 110 mCi. Since more phosphorus-33 was expected, the procedure was repeated using NH_4OH to effect the precipitation of $Fe(OH)_3$. Another 100 mCi of phosphorus-33 was obtained. At this point the target solution was analyzed by counting Cerenkov and liquid scintillation samples. While the liquid scintillation samples gave significant count rates, the Cerenkov count rate was not consistent with what should be expected from the known fraction of phosphorus-32 in the phosphorus product. The Cerenkov count rate could, in fact, be accounted for by the expected chlorine-36 activity of the target. A beta-absorption sample was prepared; the analysis showed only one beta-component, with a half-thickness consistent with sulfur-35. The quantitative beta analysis indicated 1.3 Ci of sulfur-35 in the target. The sulfur-35 beta end-point energy is 167 keV, which does not excite a Cerenkov count. The liquid scintillation count was also consistent with 1.3 Ci sulfur-35.

The total amount of phosphorus-33 extracted from this target was 500 mCi at discharge. The procedure of converting the $K^{36}Cl$ target to $H^{36}Cl$ and

adding $\text{Fe}(\text{OH})_3$ was adopted as a method to avoid adding sulfate ion and to obviate the need for a BaSO_4 precipitation. It now appears that the original procedure of adding $\text{Fe}_2(\text{SO}_4)_3$ and the subsequent BaSO_4 precipitation is desirable to remove the sulfur-35 which builds up. The recovery of the phosphorus-33 was also more reliable. If greater effort to remove SO_4^{2-} from the target is necessary (natural sulfur also produces phosphorus-32), then excess $\text{Ba}(\text{OH})_2$ can be added for the BaSO_4 precipitation, followed by use of a H^+ cation column and titration with KOH to remove the barium. Also, use of alcohol to precipitate the K^{36}Cl should remove additional traces of sulfate. We have been taking the salt directly to dryness since we were adding no foreign cations except the iron.

Since the target was left in the form of $\text{NH}_4^{36}\text{Cl}$ after the final $\text{Fe}(\text{OH})_3$ precipitation, it was recovered by adding phenolphthalein indicator and boiling down to dryness with addition of KOH to indicator end point as the NH_3 boiled off. The final K^{36}Cl was fired at 450°C , treated with decolorizing charcoal to remove the traces of degraded indicator, and recovered as a pure white salt. It was then loaded into a target capsule for reinsertion at the next reactor cycle. An 0.8-g $\text{K}_2^{33}\text{SO}_4$ target was processed, but the phosphorus-32 content was 28%. This target had only 6% phosphorus-32 at the last processing. A review of the procedures gives no reason to suspect isotopic contamination with sulfur-32. The target was recovered and will be reirradiated.

A target containing 1.13 g of 48% enriched K^{36}Cl was processed. It had been irradiated for six months and had decayed for one month. The phosphorus-32 content at processing was 10%, but the 50 mCi of phosphorus-33 obtained was blended with other material to fill orders for 200 mCi.

Potassium-43 (J. K. Poggenburg)

The objectives of this project are to prepare potassium-43 by the $^{43}\text{Ca}(n,p)^{43}\text{K}$ reaction using isotopically enriched ^{43}CaO targets and to establish cooperative programs with medical institutions to evaluate it. Potassium-43 is potentially useful for metabolic and clinical studies of blood flow, rejection of transplanted organs, and kidney function. The half-life of potassium-43 is 22.5 hr; gamma-rays are 0.373 and 0.617 MeV.

Three batches of potassium-43 were processed this month, and four shipments totaling 16 mCi were made.

Platinum-195m (J. K. Poggenburg)

The objectives of this work are to develop methods for preparing platinum isotopes suitable for whole-body scanning in biological and medical experiments, to characterize the products, and to establish

cooperative programs with medical research groups interested in evaluating their usefulness.

Recent medical research has shown that some platinum compounds act as chemical therapeutic agents towards certain kinds of tumors. Platinum radioisotopes are needed for investigation of the therapeutic mechanism involved. Platinum-195m (4.0 d) has gamma emissions of 99 keV (11%) and 129 keV (2.8%) that make it suitable for whole-body scanning.

A target of 95.95% enriched platinum-194 was irradiated 17.7 hr in a thermal flux of 2.3×10^{15} n/cm²·sec; the platinum-195m specific activity was 1.06 mCi/mg; and the cross section was calculated from these data to be 0.047 barn, which is lower than the reported value of 0.09 barn. A longer irradiation will be made to confirm the previous observation that for long irradiations the apparent cross section decreases, which would imply a large burnup cross section for the platinum-195m nuclide.

This highly enriched target, low in platinum-196 (0.64%) produced only one-third as much 20-hr platinum-197 as platinum-195m and would be suitable for human use studies.

Reactor Products Pilot Production (R. W. Schaich)
(Production and Inventory Accounts)

<u>Processed Units</u>	
<u>Radioisotope</u>	<u>Amount (mCi)</u>
Calcium-47	23.9
Zinc-69m	1635.0
Copper-67	29.0

ACCELERATOR-PRODUCED ISOTOPEs — 08-01-02

Bismuth-206 (L. C. Brown)

The objectives of this program are to evaluate the pertinent production parameters and to provide bismuth-206 (6.24 d) for evaluation as a diagnostic radionuclide in medicine. Bismuth-206 has been used to delineate brain tumors in patients with known brain tumors which are poorly visualized by more common radionuclides. Even though very favorable tumor-to-background activity ratio has been obtained by earlier workers, the lack of an appropriate scanning system suitable for the high-energy emissions of this nuclide has retarded the evaluation of the isotope.

Cooperative programs have been established with Vanderbilt Medical School and the Medical Division of ORAU for the evaluation of bismuth-206 as a diagnostic radionuclide using high-energy photon scanning systems.

Test irradiations of natural isotopic abundance lead have been continued¹ in an attempt to determine the optimal target thickness for bismuth-206 production via the $^{207}\text{Pb}(p,2n)^{206}\text{Bi}$ reaction path. The results of these irradiations for the $^{\text{nat}}\text{Pb}(p,xn)^{205}\text{Bi}$ reaction are shown in Fig. 1 for a target mounted at a 15° angle to the beam. The yield of bismuth-205 was used to determine the (p,2n) reaction path optimization since this isotope can be formed only by the $^{206}\text{Pb}(p,2n)^{205}\text{Bi}$ reaction; whereas, bismuth-206 can be formed by both the $^{206}\text{Pb}(p,n)^{206}\text{Bi}$ and the $^{207}\text{Pb}(p,2n)^{206}\text{Bi}$ reactions. These values are based on a 28% photon intensity for the 703-keV photon of bismuth-205. Assuming comparable cross sections for both the $^{206}\text{Pb}(p,2n)^{205}\text{Bi}$ and $^{207}\text{Pb}(p,2n)^{206}\text{Bi}$ reactions, one can estimate the bismuth-206 machine yield by multiplying the x axis of Fig. 1 by a scale factor of approximately 9.6. This estimate neglects any contribution from the $^{206}\text{Pb}(p,n)^{206}\text{Bi}$ reaction, which should be minimal due to (1) the relatively high coulomb barrier for proton penetration at these high Z's and (2) the reduced lead-206 isotopic abundance in this enriched target (e.g., 2.16 atom % vs 23.6 atom % for natural isotopic abundance lead).

Fig. 1. Effect of Average Natural Lead Plate Thickness on Bismuth-205 Target Yields.

¹A. F. Rupp, *Radioisotope Program (8000) Progress Report for January 1973*, ORNL-TM-4106, Oak Ridge National Laboratory, p. 3.

In order to demonstrate the purity of bismuth-206 possible with this target material, to provide some high-purity bismuth-206 product to the medical collaborators for evaluation, and to obtain enriched lead-207 target yield data points on Fig. 1, irradiations of the enriched target material will be performed at moderate power levels. A 0.005-in.-thick lead-207 target will be irradiated at a power level of approximately 4 kW (i.e., 180- μ A beam of 22-MeV protons). A second irradiation of a 0.006- to 0.007-in.-thick target (near optimal thickness from the data in Fig. 1) will be performed.

Potassium-43 (*J. K. Poggenburg and L. C. Brown*)

The CaO target for the experiment to test production of potassium-43 by the $^{44}\text{Ca}(\gamma, p)^{43}\text{K}$ reaction is ready, and it is hoped the irradiation will be accomplished at the beginning of next month.

Cyclotron Products Pilot Production (*L. O. Love*) (Production and Inventory Accounts)

February 1973 ORNL 86-Inch Cyclotron runs for ORNL and non-ORNL programs are given in Table 1.

Table 1. Cyclotron Irradiations and Runs for February 1973

Date	Customer	Product	Target	Total Time (hr:min)	Total Charges
<u>ORNL Programs</u>					
1-22-73	Isotopes Division	Bismuth-206	Lead	2:15	\$ 221
1-26-73	Isotopes Division	Bismuth-206	Lead	2:10	213
1-30-73	Isotopes Division	Bismuth-206	Lead	1:55	189
2-1-73	ORAU and others	Gallium-67	Zinc-68	8:50	846
2-2-73	Isotopes Division	Bismuth-206	Lead	1:55	189
2-2-73	Isotopes Division	Bismuth-206	Lead	1:55	189
2-12-73	Isotopes Division	Bismuth-206	Lead	2:15	221
2-15-73	ORAU and others	Gallium-67	Zinc-68	9:00	862
<u>Non-ORNL Programs</u>				30:15	\$2930
2-8-73	New England Nuclear Corp.	Copper-67	Nickel-58	51:15	\$7314

FISSION PRODUCTS - 08-01-03

Krypton-85 Enrichment (*R. A. Robinson*)

The leaking tube in the 8-tube section reported last month was found and, as suspected, leakage was the result of overheating due to a thick buildup of scale in the vicinity of the baffles. A more complete inspection of the tubes in this column and in another column that was removed from the cell indicates that many of the tubes in the center of each column bundle have experienced local overheating at points where they pass through the

baffles and are severely distorted. Although there are no other leaks, these tubes are damaged to the extent that they should be replaced. Plans are in progress to dissolve the scale off these two bundles and the four remaining in the cells and to replace the damaged tubes.

Cesium-137 Pilot Production (*R. W. Schaich*)
(Production and Inventory Accounts)

1. Process Status

Attempts to process cesium oxalate by crystallizing in the concentrate crystallizer and jetting the slurry to the filtration system were unsuccessful, probably due to redissolving of the crystals during jetting. The cesium-137 final processing cell was decontaminated and the failed agitator was replaced. During the period that the cell was open, several large pieces of equipment were removed and discarded in preparation for a full decontamination after all cesium-137 has been processed. Since removal of these items would have been a necessary first step in the decontamination, the agitator replacement resulted in little net loss in cesium-137 processing time. After the agitator was replaced, one cycle of cesium oxalate was run with an estimated yield of 50,000 Ci. Accumulation of filtrate and reconcentration for another oxalate cycle is in progress.

During the temporary shutdown of cesium-137 processing, several shipments of solid waste were made. Much of this was old equipment which had accumulated in the manipulator cells over several years' time. All equipment small enough for airlock transfer except that needed to finish up strontium-90 and cesium-137 processing has been discarded.

A routine recheck on a $^{137}\text{CsCl}$ product showed an unusually high variation (+10%) from the previous assay. After some rechecking it was decided that several analyses might be in error, and all available (i.e., unwelded) containers of product-grade material were resampled. Several batches were found to be higher in cesium-137 than had been indicated (none lower), and the cesium-137 product inventory was adjusted accordingly. The current cesium-137 process status is as follows:

<u>Item</u>	<u>Cesium-137 (Ci)</u>
In-process material (estimated)	110,000
$^{137}\text{CsCl}$ products	479,100
Sources in fabrication	0 ^a
Completed sources awaiting shipment	190,600

^aThe 180,000-Ci BNL order noted last month has been canceled.

2. Operational Summary

<u>Item</u>	<u>Feb. 1973</u>		<u>CY 1973</u>		<u>FY 1973</u>	
	<u>No.</u>	<u>Ci</u>	<u>No.</u>	<u>Ci</u>	<u>No.</u>	<u>Ci</u>
HAP0 shipments received	0	0	0	0	0	0
Product batches prepared	0	0	8	150,000	38	457,000
Sources						
Fabricated	0	0	8	22,750	34	48,450
Shipped	6	11,700	7	14,700	33	45,400
Special form cans						
Fabricated	41	5,200	41	5,200	51	5,700
Shipped	5	700	6	950	10	2,450

3. Current Orders

Current orders for cesium-137 as sources or bulk power are listed below:

<u>Customer</u>	<u>Amount (Ci)</u>	<u>Estimated Shipping Date</u>
J. L. Shepherd & Associates, Inc.	21,754	March & May 1973
Radiochemical Centre	1,500	May 1973

An order is on hand from Atomic Energy of Canada, Limited, for ~63 kCi of cesium-137 as CsCl powder. The powder has been canned and stored and is awaiting release by customer.

4. Source Fabrication

Six cesium-137 sources totaling 11,754 Ci were fabricated for J. L. Shepherd and Associates, Inc.. Four sources totaling 200 Ci were fabricated for General Radioisotope. One 500-Ci source was fabricated for 3-M Company.

Strontium-90 Pilot Production (R. W. Schaich)
(Production and Inventory Accounts)

1. Process Status

No strontium-90 processing was done this month. As part of the preparation for manipulator cell decontamination, several containers of assorted strontium-90 materials were removed from in-cell storage to carrier storage. These materials included $^{90}\text{SrSiO}_3$, low-grade $^{90}\text{Sr}_2\text{TiO}_4$, and solid waste high in strontium-90. Weldable containers are being prepared for storage of the present inventory of source-grade $^{90}\text{Sr}_2\text{TiO}_4$ so that it can also be removed from in-cell storage. The current strontium-90 process status is as follows.

<u>Item</u>	<u>Strontium-90 (Ci)</u>
In-process material	805,900
Strontium-90 products	426,200
Sources in fabrication	0
Returned SNAP sources	446,600
Completed sources awaiting shipment	221,000

2. Operational Summary

There were no operational entries for February 1973, CY 1973, or FY 1973 except shipment of one 10-Ci special form can.

3. Current Orders

Current orders for strontium-90 as sources or bulk powder are listed below:

<u>Customer</u>	<u>Amount (Ci)</u>	<u>Estimated Shipping Date</u>
U. S. Navy	221,000	FY 1973
Radiochemical Centre	500	May 1973

Short-Lived Fission Products Pilot Production (*R. W. Schaich*)
(Production and Inventory Accounts)

<u>Isotope</u>	<u>Number of Batches</u>	<u>Amount (Ci)</u>
Xenon-133	1	350.0
Yttrium-91	1	3.1
Zirconium/Niobium-95	1	23.2
		376.3

Promethium-147 Shipments and Current Orders

Donald W. Douglas has placed an order for 200,000 Ci of promethium-147. Shipments of 50,000 Ci will be made in May, July, October, and December 1973. Minnesota Mining & Manufacturing Company will receive a shipment of 5,001 Ci promethium-147 in late February.

SOURCE DEVELOPMENT — 08-01-04

Gadolinium-153 (*F. N. Case*)

Nine separation runs for purification of gadolinium-153 were made using a high-pressure ion-exchange column. Each run consisted of approximately 100 mg of gadolinium-152 target that had been irradiated in the HFIR. This 100-mg quantity is the maximum quantity that can be loaded on the

ion-exchange column for optimum separation of terbium-160 and europium-155 from the irradiated gadolinium-152 target. The yield of product quality gadolinium-153 (<10 ppm total radiochemical impurity) from the nine runs was 7 Ci.

Calculations to determine the optimum irradiation time in the HFIR at a neutron flux of 2×10^{15} n/cm²·sec indicate that maximum production of gadolinium-153 is achieved in 2.5 to 3 days. The yield from the targets irradiated for 1 day and 2 days produced 13 and 16 mCi/mg of target, respectively. Additional targets have been prepared for irradiation to give a projected yield of 15 to 20 Ci of gadolinium-153.

Six sources were prepared from the purified product. These sources, used in process control, have been placed in operation in routine production for control of trace elements and coating thickness.

Sources are being prepared for several different medical groups who plan to carry out brain and organ transmission scanning research using gadolinium-153 as an external source of radiation, bone density measurements to determine changes in bone density of the astronauts involved in Skylab experiments, and determination of lead in children by use of transmission scanning and x-ray fluorescence techniques for thyroid scan. All of these proposed medical uses involve the application of radiation externally with the total radiation dose to the patient being from 100 to 1000 times less than when scans are made by organ uptake of the radionuclide.

A large (20-Ci) source will be prepared for use in the development of single wire position-sensitive detectors under development in the ORNL Instrumentation and Controls Division.

A separation run for recovery of semipurified gadolinium-152 from the HFIR control plates will be made during March.

Ultrahigh Specific Activity Cobalt-60 (*F. N. Case*)

Plans are being made for the preparation of 1000 Ci of cobalt-60 having a specific activity of greater than 1000 Ci/g for use by an AEC facility in radiographic inspection procedures. Feed for this preparation is available from high burnup cobalt-59 prepared approximately three years ago. Nickel will be removed by ion exchange, and the cobalt-60 will be electrolytically reduced to elemental form for pressing into a small pellet. The utility of ultrahigh specific activity cobalt in radiographic procedures has been demonstrated as necessary for high-resolution imaging in AEC production operations.

Iodine-125 (*F. N. Case*)

A method for preparing very small sources of iodine-125 that have minimum self-absorption was developed to fill a need by Brookhaven National Laboratory that could not be met commercially. Iodine-125 (half-life 60 days) decays by electron capture through the 0.035-MeV level of

tellurium-125. The 0.035-MeV gamma is highly converted so that most of the radiation is tellurium x rays within the energy range of 27.2 to 31.7 keV. To prepare a high output source, the fabrication methods require much attention to problems of self-absorption. In the particular application planned, the radiation source is required to be a 1-mm-diam sphere emitting radiation 180° from the surface of the sphere.

Using iodine-131 tracer, a method was developed in which iodine can be reduced to elemental iodine by using sodium iodide as starting feed and extracting the free iodine into a small volume of carbon tetrachloride. A 1-mm-diam copper bead, when exposed to the CCl₄ solution of iodine, will adsorb the iodine present. The copper iodide formed appears to be stable and will provide a useful source of tellurium x rays. Copper samples in various configurations were reacted with 1-ml portions of CCl₄ solution containing 5 µg of iodine. Yields of absorbed iodine are shown in Table 2.

Table 2. Reaction of Iodine with Copper

Form of Copper	% Reacting
4.4-mg Cu foil	91.5
1.0- × 1.0- × 0.02-mm foil	88.0
5.0-mg solid	56.0
5.3-mg Cu foil, rolled into ball	94.6
5.0-mg Cu foil, rolled into ball	68.4

Radioisotope Characterization, Quality Control, and Standards (S. A. Reynolds)

1. Radioisotope Characterization

An inquiry on absorption of beta radiation from nickel-63 was answered by reference to a paper and an old report of ours, ORNL-788 (1950). The half-thickness in aluminum is about 0.6 mg/cm². Information from the "Radioactive Atoms" table (*Nucl. Data*) sufficed for most of the response to an inquiry from the College of American Pathologists for decay-scheme parameters for radiopharmaceuticals. Another inquiry about the half-life of barium-133 led to a review of probable impurities leading to others' low values. Secondary-product cesium-134 seems the most likely candidate.

2. Radioisotope Special Analysis and Quality Control

Our change in basis of assay of gallium-67 (last month) and corresponding change in price was announced in a letter to users and standards groups. The College of American Pathologists asked and received permission to use

our statistical analysis of their intercomparison on chromium-51 assay, which showed a standard deviation of 12-13%. An inquiry on decomposition of water vapor prompted a literature survey of radiolytic, photolytic, and other methods, but none were found that were very efficient. Other inquiries were concerned with analysis of iridium, standards for alpha measurements, and methods for measurements of activities in gaseous and liquid wastes.

RADIOISOTOPE SALES

(J. E. Ratledge)

An inquiry was received from the British Embassy, Washington, D. C., regarding availability of strontium-90 as sources in quantities greater than 100 kCi. A notice of cancellation was received from Brookhaven National Laboratory of their order for cesium-137. Two orders were received from Minnesota Mining and Manufacturing Company for 5676 Ci of promethium-147 as bulk powder.

An order was received from Radiochemical Centre for 1 Ci each of 6% and 93% abundance (enriched) radiosamarium-151. An order was received from International Chemical and Nuclear Corporation for 700 mCi of phosphorus-33 to be shipped at the rate of 100 mCi every 50 days. An order was received from New England Nuclear Corporation for 300 mCi of phosphorus-33 to be shipped at the rate of 100 mCi every month.

Shipments made during the month that may be of interest are listed below:

<u>Customer</u>	<u>Isotope</u>	<u>Amount</u>
<u>Large Quantities</u>		
New England Nuclear Corporation	Tritium	8,000 Ci
KMS Fusion, Inc.	Tritium	2,000 Ci
U. S. Radium Corporation	Tritium	10,000 Ci
Canrad Precision Industries, Inc.	Tritium	1,000 Ci
Schwarz/Mann	Tritium	1,500 Ci
Minnesota Mining & Manufacturing Company	Promethium-147	675 Ci
Minnesota Mining & Manufacturing Company	Cesium-137	500 Ci
Industrial Nucleonics Corporation	Krypton-85, enriched	200 Ci
<u>Withdrawn Items</u>		
Cleveland Metropolitan General Hospital	Iodine-131, FP	400 mCi
Mayo Clinic	Copper-67	~10 mCi
University of Chicago	Copper-67	~10 mCi
McClellan Air Force Base	Copper-67	~10 mCi

<u>Customer</u>	<u>Isotope</u>	<u>Amount</u>
<u>Items Used in Cooperative Programs</u>		
Vanderbilt University	Bismuth-206	~5 mCi
University of Southern California	Platinum-195m	~30 mCi
Oak Ridge Associated Universities	Gallium-67	~400 mCi

Unusual Items

Gamma Industries	Cesium-137 ^a	~5 Ci
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^aImpregnated in glass cones.

A summary of radioisotopes shipped during January 1973 is given in Table 3.

Table 3. Summary of Radioisotopes Shipped During January 1973

<u>Isotope</u>	<u>Number of Shipments</u>	<u>Quantity (mCi)</u>
Barium-140	2	6
Calcium-47	10	6
Cesium-137	8	3,009,351
Cobalt-60	1	25
Copper-67	4	37
Gallium-69	11	475
Iodine-131	4	750
Krypton-85, normal	9	388,000
Krypton-85, enriched ^a	5	1,269,900
Niobium-95	7	28
Phosphorus-33	2	200
Potassium-43	4	16
Promethium-147	6	60,000
Ruthenium-103	1	10
Ruthenium-106	1	2
Strontium-89	4	42
Strontium-90	3	105
Technetium-99	3	12,500 mg
Tritium	19	12,070,000
Xenon-133	51	72,020
Yttrium-91	1	8
Miscellaneous compound preparations	9	5,830
Cyclotron irradiations:		
International Chemical and Nuclear Corporation	Cobalt-57 as target	~2,000
New England Nuclear Corp.	Cobalt-57 as targets	~4,000
International Chemical and Nuclear Corporation	Gold-195 as targets	~40
Total	172	16,882,781 12,500 mg

^aIncludes 973.8 Ci of enriched krypton-85 billed to Measurex Corporation but not shipped.

The radioisotopes sales proceeds and shipments for the first seven months of FY 1972 and FY 1973 are given in Table 4.

Table 4. Radioisotope Sales and Shipments

Item	7-1-71 thru 1-31-72	7-1-72 thru 1-31-73
Inventory items	\$259,622	\$288,519
Major products	37,957	33,281
ORNL 86-Inch Cyclotron	87,361	74,710
Radioisotope services	162,035	100,538
Miscellaneous processed materials	36,892	30,746
Packing and shipping	<u>42,355</u>	<u>39,407</u>
Total	\$626,222	\$567,201
Number of shipments	1,449	1,214

ADMINISTRATIVE

The only travel during February was a trip by J. H. Gillette and E. Lamb to DAT, Washington, D. C., to discuss close-out costs for the 08 Program.

PUBLICATIONS

REPORTS

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