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RADIOISOTOPE PROGRAM (8000) PROGRESS REPORT FOR MAY 1973

A. F. Rupp

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ISOTOPES DEVELOPMENT CENTER

RADIOISOTOPE PROGRAM (8000) PROGRESS REPORT FOR MAY 1973

A. F. Rupp

Work Sponsored by
AEC Division of Applied Technology

JUNE 1973

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OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
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RADIOISOTOPE PROGRAM (8000) PROGRESS REPORT FOR MAY 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 ≤ 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.

The targets which were reported in processing last month were completed, and the $K^{36}Cl$ was recovered and reinserted in the reactor. One target was 44% enriched chlorine-36 irradiated for 9 months in HFIR for further enrichment. While the reactor position used is more suited to thermal enrichment than the fast neutron phosphorus-33 production reaction, a discharge activity of 440 mCi phosphorus-33 was obtained from 3.67 g of $K^{36}Cl$, with 300 mCi contained in 1.16 g $K^{36}Cl$ in the center ampul of the three irradiated. The phosphorus-32 activity was ∿9% at processing. The second target processed yielded discharge activities of 436 mCi in the primary target of 1.05 g ∿65% enriched $K^{36}Cl$ and 684 mCi in the satellite targets of 2.61 g ∿48% enriched $K^{36}Cl$. At processing time the phosphorus-32 contents were 15% in the more enriched target and 28% in the others. These products were combined with past product remnants to fill a 100-mCi phosphorus-33 order with <5% phosphorus-32 and a larger order of 500 mCi phosphorus-33 with 15% phosphorus-32.

Another target containing 0.54 g >90% enriched $K_2{}^{33}SO_4$ was discharged this month after irradiation for three cycles in HFIR. The yield at discharge was 372 mCi phosphorus-33, and at processing the phosphorus-32 content was 9.5%. The target K_2SO_4 had been recovered by an alcohol precipitation after it had contained 28% phosphorus-32 when last processed. The decrease in phosphorus-32 impurity indicates that the phosphorus-32 in the preceding process of this target had arisen from chemical impurities in the target

and not from reduction of isotope purity of sulfur-33. This product will be used to fill an order for 100 mCi of phosphorus-33 next month when the phosphorus-32 content will be less than 5%. The $K_2{}^{33}SO_4$ was again recovered by alcohol precipitation and the amount recovered was ~99% of the original material. The alcoholic filtrate is always retained for further recovery of $K_2{}^{33}SO_4$ at the next processing.

Potassium-43 *(J. K. Poggenburg)*

> *The objectives of this project are to prepare potassium-43 by the $^{43}Ca(n,p)^{43}K$ 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 six shipments totaling 21 mCi were made. Other progress in potassium-43 is reported under Accelerator-Produced Isotopes.

Platinum-195m *(J. K. Poggenburg)*

> *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.*

Seventeen millicuries of platinum-195m was shipped to University of Southern California under our medical cooperative program.

Two local interdisciplinary meetings were held on platinum-195m, including persons in the ORNL Biology Division, ORAU, University of Tennessee, and UT Memorial Research Hospital. The participants are members of a newly formed local organization known as the Associated Researchers in Cancer. At the first meeting invited guests were Drs. Milan Slavik and Michael Goldsmith from the Cancer Therapy Evaluation Branch, NCI; Dr. Philip J. Stone, Boston University Medical School; and Dr. Barnett Rosenberg, Michigan State University, who is one of our medical cooperative researchers in platinum-195m studies. Dr. Rosenberg gave a seminar presenting his results. The UT Memorial Research Hospital is already participating in a grant from NCI to the Southern Cancer Screening Group in the evaluation of therapy with cis-dichlorodiammine Pt(II), DDP. The purpose of the meetings was to explore what type of proposal our local group might submit to NCI for research in platinum antitumor compounds. At the second meeting it was agreed that we should focus our attention

on the platinum compounds of DDP and a uracil compound. Isotopes Division will plan to synthesize these compounds with platinum-195m tracer. Initially the DDP compound will be made following the protocol received from USC.

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

Processed Units	
Radioisotope	Amount (mCi)
Calcium-47	32.7
Copper-67	46.65
Zinc-69m	423.9

ACCELERATOR-PRODUCED ISOTOPES — 08-01-02

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

Potassium-43 has been shown to be an excellent tool for studying blood perfusion in the heart and for diagnosing myocardial infarctions. Potassium-43 is currently produced in millicurie quantities in the HFIR by the $^{43}Ca(n,p)^{43}K$ reaction. The objective of this project is to investigate the large-scale photonuclear production of this radionuclide using the Oak Ridge Electron Linear Accelerator (ORELA). The ultimate goal is to develop the technology required to produce curie quantities of potassium-43 at costs that will allow its widespread clinical application as a primary agent for the early detection and diagnosis of heart disease.

The previously described[1] experiment to test the feasibility of the $^{44}Ca(\gamma,p)^{43}K$ photonuclear reaction for the large-scale production of potassium-43 was performed at the ORELA during this period with very encouraging results. A stainless steel 55-gal drum filled with CaO (bulk density ~34% of theoretical density) was irradiated at a low power level (~2.7 watts of electron beam power) for 4 hr with 130-MeV electrons. After completion of the irradiation, the target drum was disassembled, and pre-weighed, sealed cans of CaO — which had been strategically located throughout the drum volume — were retrieved for direct counting with a calibrated Ge(Li) detector. After the contents were counted, the can containing the greatest amount of potassium-43 was opened and the CaO was dissolved, sampled, and recounted to determine a reliable normalization factor for the direct determination of the potassium-43 content of each can. The yield and distribution of potassium-43 in the

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[1]A. F. Rupp, *Radioisotope Program (8000) Progress Report for November 1972*, ORNL-TM-4067, Oak Ridge National Laboratory, pp. 3-5.

drum volume were then estimated from these data. A small background correction was also measured in a subsequent experiment and applied to the data to compensate for the extra-target photon flux originating from the main beam tube and its collimators. These data were then extrapolated to a full power "saturation" production rate for potassium-43 of ∿8.8 Ci for this target configuration. This encouraging result confirms within a factor of 2 the value estimated earlier from Barbier's work.[2] As was expected, significant potassium-43 production was confined to a much smaller volume than the 55-gal drum used for this experiment, e.g., it is estimated that ∿65% of the total potassium-43 produced by the direct electron beam was produced within <6% (∿14 liters at ∿34% bulk density) of the CaO volume. This result implies two important considerations in future experiment design: (1) smaller targets, with the possibility of reduced fabrication, handling, and processing costs, can be considered for the full power target design and (2) isotopically enriched calcium-44 or other high cost target materials can be considered. With regard to this latter item, two different approaches will be investigated. The first will be the use of an ∿80-g sample of 98.5% enriched calcium-44 for the target material. If this enriched calcium-44 were placed in the region of maximum potassium-43 production, say 5-10% of the total production rate observed in this experiment, then the approximately 50-fold increase in calcium-44 composition might result in a 2-1/2- to 5-fold increase in potassium-43 yield. A second alternative photonuclear production path using a natural mononuclidic scandium-45 target might also prove practical. The ORELA personnel theorize that a conservative estimate of the $^{45}Sc(\gamma,2p)^{43}K$ cross section (threshold energy = 19.06 MeV) would be ≥1/10 the $^{44}Ca(\gamma,p)^{43}K$ cross section. If this is correct, then the 50-fold increase in target atom concentration would again offer a 5-fold or greater increase in potassium-43 production. Both of these production paths will be investigated next fiscal year. Assuming either or both will work, the approximately 5-fold increase in the potassium-43 production rate would suggest a "saturation" production rate on the order of 25-30 Ci.

Obviously, the estimates mentioned above are based on one initial feasibility experiment and need to be confirmed by additional work. In order to obtain these additional data and to investigate the distribution of potassium-43 within the target volume more accurately, i.e., determine iso-production contour profiles, an experiment involving the irradiation of a stack of thin marble ($CaCO_3$) slabs at low power levels with ∿140-MeV electrons will be performed. After completion of the irradiation, these slabs will first be autoradiographed and then scanned with a rectilinear scanner in both the x and y direction in an attempt to determine a three-dimensional representation of the potassium-43 production.

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

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[2]M. Barbier, Appendix D in *Induced Radioactivity*, Wiley, New York, 1969, p. 355.

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 appropriate scanning systems suitable for the high-energy emissions of this nuclide has retarded the evaluation of the isotope. Cooperative programs have been established for the evaluation of bismuth-206 as a diagnostic radionuclide using high-energy photon scanning systems.

Test irradiation of a high-yield, electrodeposited lead-207—on—copper target design was continued in order to optimize irradiation parameters and target integrity and to provide high-purity bismuth-206 to medical cooperative participants for evaluation. A target of 6.1-mil average lead-207 plate thickness (92.4 atom % lead-207) was irradiated with a 22-MeV proton beam at an average current of 200 μA without failure. An earlier target[3] of similar design and thickness, and which had been irradiated under similar conditions, showed no outwardly visible signs of target degradation, but upon dissolution of the lead-207 plate for chemical processing, a "hot-spot" abnormality was observed at the copper substrate surface in the region of maximum beam energy deposition. This "hot-spot" did not resemble intermetallic alloy formation as experienced during the zinc-68—on—copper target development for large-scale gallium-67 production, so a second target was irradiated under similar conditions to determine whether it represented the onset of the Pb-Cu interface degradation or whether it may have been just an imperfection in the copper substrate material. This second target showed no signs of beam damage or irregularities at either the lead-207 outer surface or the polished copper substrate surface after dissolution of the lead-207 plate. It was concluded, therefore, that the "hot-spot" observed earlier did not represent incipient target failure and that development of this target design should be extended to thicker lead plates and higher power levels to obtain the maximum production levels consistent with reliable operation.

The measured cyclotron yield agreed very well with the earlier target run under similar conditions, indicating that the yield values estimated from natural lead targets[4] are approximately 15% too high. No attempt will be made to rationalize this discrepancy until additional yield data have been obtained for the enriched lead-207 targets as a function of plate thickness. The losses of bismuth-206 during chemical processing mentioned earlier[3] have been reduced to ∿15% with the major loss, ∿7-10%, still attributed to surface adsorption during product finishing. The reason for this loss will be investigated during the next reporting period in an attempt to assure reliable chemical processing yields of ≥90% in the future.

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[3]L. C. Brown, "Bismuth-206," in *Radioisotope Program (8000) Progress Report for April 1973*, ORNL-TM-4229, Oak Ridge National Laboratory, p. 3.
[4]L. C. Brown, "Bismuth-206," in *Radioisotope Program (8000) Progress Report for February 1973*, ORNL-TM-4161, Oak Ridge National Laboratory, p. 3.

Rare-Earth Radionuclides *(L. C. Brown)*

Ytterbium-169 has been found to exhibit high tumor-to-nontumor uptake ratios, comparable to the uptake ratios of gallium-67. A cooperative project has begun with the Medical Division of ORAU to determine whether all the rare earths show this tumor localization, or whether it is limited to either the light (La-Gd) or heavy (Tb-Lu) members of this series, and to evaluate the most promising radionuclides for tumor localization in humans.

A preliminary test irradiation was performed to produce thulium-167 via the $^{167}Er(p,n)^{167}Tm$ reaction path using a plugged aluminum capsule target configuration[5] and the ORNL 86-Inch Cyclotron. A 60-mil deep by 1.25-in.-long void volume plug was used to minimize the amount of enriched $^{167}Er_2O_3$ target material required.* The target assembly was irradiated for 2 hr at an average beam current of 189 μA with 22-MeV protons (tubing walls and cooling water layer reduce the proton energy to ∿15 MeV at the surface of the target material). The irradiated target was dissolved approximately 16 hr after end-of-bombardment (EOB) and found to contain large amounts of short-lived, high radiation dose rate thulium-167 (30 hr) and thulium-166 (7.7 hr). The concomitant production of these short-lived radiocontaminants will require use of a "hot cell" for shielding purposes during chemical separation. Scale-up of the high-pressure ion-exchange separation to be used for the adjacent Tm-Er rare-earth separation has been started with 100-mg rare-earth oxide samples being separated successfully. Future work will be directed toward additional scale-up of this separation and checking out the equipment for hot-cell operation. Three millicuries of separated thulium-167 was distributed to ORAU for initial counting and animal experiments.

Lead-203 *(L. C. Brown)*

Lead-203 (52.1 hr) has been suggested as a possible bone-scanning agent, chelated as a cisternographic agent, and possibly as a tumor-localizing agent. The radioisotope has an acceptable half-life for production and shipment and low radiation dose decay characteristics (i.e., it decays solely by electron capture with the emission of two main gamma rays of 279 and 401 keV with intensities of 81 and 5%, respectively).

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[5] J. A. Martin and F. L. Green, *Nucl. Sci. Eng.* 1, 185 (1956).

*908 mg of $^{167}Er_2O_3$ of the following isotopic composition was used (values given in atom %): $^{162}Er \leq 0.03$; $^{164}Er = 0.06$; $^{166}Er = 2.93$; $^{167}Er = 91.54$; $^{168}Er = 5.14$; and $^{170}Er = 0.33$.

Two irradiations of natural Tl_2O_3 targets (3-in.-void-length vented aluminum capsules containing ∿6 g of Tl_2O_3) have been performed in the ORNL 86-Inch Cyclotron since this item was last reported.[6] The chemical processing procedure employed for the first target included dissolution of the entire aluminum capsule in HBr in an attempt to minimize the handling required to open the capsule and to allow the start of chemical processing as soon as possible after end-of-bombardment (EOB) even though appreciable amounts of short-lived lead-202m (3.61 hr), produced concomitantly with the lead-203, were present. The presence of macro amounts of aluminum in the process was found to lengthen the chemical separation procedure so much that the time savings achieved by starting early were lost. As a result, the second target was irradiated late on the first day, allowed to decay overnight in the cyclotron, and then processed early on the second day with shipment in early afternoon of the same day. The chemical process employed was similar to one employed earlier,[7] with the target material being removed manually from the aluminum capsule before dissolution. In the absence of large amounts of aluminum, the entire chemical processing and product finishing required less than 3 hr and exhibited >90% chemical yield. The purified product was shipped to a cooperative participant for application in animal tumor uptake studies.

Cyclotron Products Pilot Production *(M. R. Skidmore)* (Production and Inventory Accounts)

May 1963 ORNL 86-Inch Cyclotron runs for ORNL and non-ORNL programs are given in Table 1.

Table 1. Cyclotron Irradiations and Runs for May 1973

Date	Customer	Product	Target	Total Time (hr:min)	Total Charges
		ORNL Programs			
4-25-73	ORAU and Others	Gallium-67	Zinc-68	9:00	$ 862
4-30-73	ORAU and Others	Gallium-67	Zinc-68	3:45	363
5-7-73	Isotopes Division	Bismuth-206	Lead-207	2:05	205
5-10-73	ORAU and Others	Gallium-67	Zinc-68	9:35	917
5-15-73	Isotopes Division	Lead-203	Thallium Oxide	3:00	317
5-15-73	Isotopes Division	Thulium-167	Erbium-167 Oxide	3:05	325
5-16-73	ORAU and Others	Gallium-67	Zinc-68	3:35	348
	Totals			34:05	$3337
		Non-ORNL Programs			
5-4-73	New England Nuclear	Cobalt-57	Nickel-58	51:15	$8480
5-17-73	Vanderbilt University and Chemistry Division	Europium-150	Samarium-150 Oxide	2:50	415
	Totals			54:05	$8895

[6]A. F. Rupp, ORNL-TM-4067, p. 5.
[7]A. F. Rupp, *Radioisotope Program (8000) Progress Report for May 1973* ORNL-TM-3461, Oak Ridge National Laboratory, p. 5.

FISSION PRODUCTS — 08-01-03

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

1. Process Status

Cesium processing has been discontinued. The last of the cesium chloride product stored in six Type-IV liners was loaded out of the cells in two uranium-shielded carriers. At present there is no cesium in-process material and no cesium chloride product material in FPDL, but there is solid waste still to be discarded. The current cesium-137 process status is shown below.

Item	Cesium-137 (Ci)[a]
In-process material	0
$^{137}CsCl$ products	594,200
Returned sources (including canceled orders)	134,700
Completed sources awaiting shipment	133,300
	862,200

[a]All values based on physical inventory May 1, 1973.

2. Operational Summary

Item	May 1973		CY 1973		FY 1973	
	No.	Ci	No.	Ci	No.	Ci
HAPO shipments received	0	0	0	0	0	0
Product batches prepared	0	0	17	225,000	47	532,000
Sources						
Fabricated	0	0	10	22,800	36	48,500
Shipped	0	0	9	14,700	35	40,400
Special Form Cans						
Fabricated	0	0	41	5,200	51	5,700
Shipped	0	0	6	950	10	2,400

3. Current Orders

Current orders for cesium-137 as sources or bulk powder are as follows:

Customer	Amount (Ci)	Estimated Shipping Date
J. L. Shepherd Associates	10,000	June 1973
Radiochemical Centre	1,500	June 1973
3M Company	500	June 1973
White Sands Missile Base	14,221	July 1973

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

1. Process Status

A total of 1285 Ci of strontium-90 as calcined strontium carbonate was loaded into 54 special-form cans. One can contained 10 Ci; each of 10 cans contained 20 Ci (a total of 200 Ci of strontium-90), and each of 43 cans contained 25 Ci (a total of 1,075 Ci of strontium-90). The current strontium-90 process status is shown below; this was revised in accord with the annual physical inventory of May 1, 1973.

Item	Strontium-90 (Ci)
In-process material	766,800
Strontium-90 products	430,800[a]
Sources in fabrication	0
Returned sources	435,200
Completed sources awaiting shipment	216,000

[a]Includes 30,500 Ci of $^{90}SrSiO_3$

2. Operational Summary

Item	May 1973		CY 1973		FY 1973	
	No.	Ci	No.	Ci	No.	Ci
HAPO shipments received	0	0	0	0	0	0
Product batches prepared	0	0	0	0	0	0
Sources						
Fabricated	0	0	0	0	0	0
Shipped	0	0	0	0	0	0
Special Form Cans						
Fabricated	54	1285	54	1285	54	1285
Shipped	4	100	5	110	5	110

3. Current Orders

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

Customer	Amount (Ci)	Estimated Shipping Date
U. S. Navy	221,000	FY 1973
Radiochemical Centre	1,500	June 1973
General Radioisotope Products	210	June 1973

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

Isotope	Number of Batches	Amount (Ci)
Xenon-133	2	700
Iodine-131	1	28

Promethium-147 Shipments and Current Orders

Donald W. Douglas has an outstanding order for 150,000 Ci of promethium-147 with shipment to be made in 50,000 Ci quantities in July, October, and December; W. Maier K.G., Germany, has an outstanding order for 100 Ci to be shipped in July; and Radium Chemie, Switzerland, has placed an order for 300 Ci to be shipped in July.

SOURCE DEVELOPMENT — 08-01-04

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

The Department of Radiology at the University of Wisconsin has indicated their desire to study the use of gadolinium-153 in bone adsorption measurements. The very high radiochemical purity of gadolinium-153 now being prepared appears to be useful in spine scanning for a matched bone pair study of osteoporotics versus normals and in the study of leg-bone mineralization.

This work is a continuation of earlier work carried out by the University of Wisconsin Medical Physics and Engineering Center using gadolinium-153 for bone density measurements. Two sources will be made available under the medical cooperative program: a 1.5-Ci and a 200-mCi point source. Reports will be issued as the work progresses.

A 2-Ci gadolinium-153 source was prepared, placed in a collimator, and shipped to the University of California at Los Angeles for use in transmission brain scanning.

RADIOISOTOPE SALES

J. E. Ratledge

A request for quotation was received from Teledyne Isotopes, Inc., for five strontium-90 sources each containing 620 W (∿456 kCi strontium-90 total). A revised request for quotation was received from Sulzer Brothers, Ltd., Switzerland, for up to 60 cesium-137 sources, each containing 8600 Ci with an indication that ∿700 sources might be needed in 1974. An order was received from 3M Company for 500 Ci cesium-137 as bulk powder.

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

Customer	Isotope	Amount
Large Quantities		
Donald W. Douglas Laboratory[a]	Promethium-147	50,000 Ci
IAEA	Phosphorus-33	500 mCi
New England Nuclear Corporation	Tritium	8,000 Ci
U. S. Radium Corporation	Tritium	10,000 Ci
Withdrawn Items		
University of Chicago	Copper-67	∿6.5 mCi
George Washington Medical Center	Copper-67	∿6.5 mCi
Mayo Clinic	Copper-67	∿13 mCi
University of Rochester	Iodine-131	300 mCi
University of Pittsburgh	Iodine-131	50 mCi
Cleveland Metropolitan General Hospital	Iodine-131	50 mCi
Items Used in Cooperative Programs		
Oak Ridge Associated Universities	Gallium-67	520 mCi
	Bismuth-206	1 mCi
VA Hospital, Palo Alto, Calif.	Lead-203	5 mCi
Georgia Institute of Technology	Nickel-59	1.6 mCi
Vanderbilt University	Bismuth-206	10 mCi
University of California, Los Angeles	Gadolinium-153	2,000 mCi
University of Southern California	Platinum-195m	20 mCi

[a]Shipped directly from PNL, Richland, Washington.

The radioisotopes sales proceeds and shipments for the first ten months of FY 1972 and FY 1973 are given in Table 2.

Table 2. Radioisotope Sales and Shipments

Item	7-1-71 thru 4-30-72	7-1-72 thru 4-30-73
Inventory items	$446,426	$391,227
Major products	52,238	46,176
Radioisotope services	257,302	181,863
Cyclotron irradiations	103,250	92,872
Miscellaneous processed materials	50,052	50,158
Packing and shipping	59,255	56,688
Total	$968,523	$818,984
Number of shipments	2,004	1,766

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

Table 3. Summary of Radioisotopes Shipped During April 1973

Isotope	Number of Shipments	Quantity (mCi)
Barium-140	2	11
Calcium-47	6	5
Cesium-137	8	77,600
Copper-67	3	23
Gadolinium-153	3	7,000
Gallium-67	20	11,129
Hafnium-181	1	10
Iodine-129	1	510 mg
Iodine-131	1	50
Krypton-85 normal	13	390,000
Krypton-85 enriched	4	136,710
Neodymium-147	1	50
Niobium-95	1	10
Phosphorus-33	4	610
Potassium-43	2	10
Samarium-151	1	30 mg
Strontium-89	2	67
Technetium-99	3	12,000 mg
Tritium	13	18,306,000
Xenon-133	38	41,100
Yttrium-71	1	3
Zirconium-Niobium-95	3	64
Miscellaneous preparations and targets	9	60
Cyclotron irradiations:		
International Chemical	1[a]	100
and Nuclear Corporation	1[b]	30
Pacific Northwest Laboratories	1[c]	0.25
Totals	143	18,970,642.25 12,540 mg

[a]Cobalt-56
[b]Yttrium-88
[c]Promethium-143 as solution

ADMINISTRATIVE

Visitors to the IDC and travel by IDC personnel are given in Tables 4 and 5, respectively.

Table 4. Visitors to IDC

Visitor	Affiliation	Subject Discussed
D. Schwarzendruber	Oak Ridge Associated Universities	
Alan Solomon	UT Memorial Hospital	
Walter Farkas	UT Memorial Hospital	
P. J. Stone	Boston University Medical School	Medical isotopes and tour IDC
Bernard Rosenberg	Michigan State University	
Michael Goldsmith	National Cancer Institute	
Milan Slavik	National Cancer Institute	
Stuart Hawkinson	University of Tennessee	
Carlos Gaveria	Memorial Hospital, Worcester, MA	Medical isotopes and tour IDC

Table 3. Travel by IDC Personnel

Traveler	Site Visited	Purpose of Visit
F. N. Case R. S. Pressly	Bureau of Mines, Pittsburgh, PA	Discuss source development
J. E. Ratledge	Washington, DC	Attend First National Symposium on Hazardous Materials Transportation
E. E. Ketchen	Washington, DC	Present paper at AATCC Symposium on the Textile Industry and the Environment

PUBLICATIONS

REPORTS

E. Lamb, *Isotopic Power Fuels Monthly Status Report for April 1973*, ORNL-TM-4230, Oak Ridge National Laboratory.

A. F. Rupp, *Radioisotope Program (8000) Progress Report for April 1973*, ORNL-TM-4229, Oak Ridge National Laboratory.

JOURNAL ARTICLES

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