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RADIOISOTOPE PROGRAM (8000)
PROGRESS REPORT FOR SEPTEMBER 1972

A. F. Rupp

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ORNL-TM-4002

Contract No. W-7405-eng-26

ISOTOPES DEVELOPMENT CENTER

RADIOISOTOPE PROGRAM (8000) PROGRESS REPORT FOR SEPTEMBER 1972

A. F. Rupp

Work Sponsored by
AEC Division of Applied Technology

OCTOBER 1972

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OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
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CONTENTS

Page

RADIOISOTOPE PRODUCTION AND MATERIALS DEVELOPMENT 1

REACTOR-PRODUCED ISOTOPES 1

A. Biomedical Radioisotopes 1

1. Potassium-43 1
2. Platinum-195m 1
3. Silicon-32 2

B. Reactor Products Pilot Production 3

ACCELERATOR-PRODUCED ISOTOPES 3

A. Biomedical Radioisotopes 3

1. Gallium-67 3
2. Lead-203 4

B. Cyclotron Products Pilot Production 5

FISSION PRODUCTS 6

A. Krypton-85 Enrichment 6

B. Cesium-137 Pilot Production 6

1. Processing and Process Status 6
2. Operational Summary 7
3. Current Orders 7
4. Source Fabrication 7

C. Strontium-90 Pilot Production 7

1. Processing and Process Status 7
2. Operational Summary 8
3. Current Orders 8
4. URIPS-8 Generators 8

D. Short-Lived Fission Products Pilot Production 9

E. Promethium-147 Shipments and Current Orders 9

SOURCE DEVELOPMENT 9

A. Radioisotope Characterization, Quality Control, and Standards 9

1. Radioisotope Characterization 9
2. Radioisotope Special Analysis and Quality Control . . 10

Page

RADIOISOTOPE SALES 10

ITEMS OF INTEREST 10

ADMINISTRATIVE 12

PUBLICATIONS 13

REPORTS 13

JOURNALS 14

BOOKS 14

ABSTRACTS 14

RADIOISOTOPE PROGRAM (8000) PROGRESS REPORT FOR SEPTEMBER 1972

A. F. Rupp

RADIOISOTOPE PRODUCTION AND MATERIALS DEVELOPMENT

REACTOR-PRODUCED ISOTOPES — 08-01-01

A. Biomedical Radioisotopes

1. Potassium-43

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 22.3 hr; gamma-rays are 0.373 and 0.617 MeV.

Two small batches of potassium-43 were processed and shipped this month. The unassigned activity was used in a continuing cooperative development effort with the ORNL Medical Instrumentation Group (Dr. P. R. Bell) to improve imaging techniques. The current studies are being performed with a heart phantom, using lead and gold collimators and various computer processing techniques to study the effects on image resolution. Substitution of a new resin batch in the ion-exchange process has corrected the problem of poor column resolution of the sodium-24 and potassium-43 alluded to in last month's report.

We participated in a meeting on potassium-43 at the National Heart and Lung Institute (NHLI) of NIH which was attended by representatives from Division of Applied Technology and Division of Biomedical and Environmental Research. The purpose was to explore the mutual interest of NHLI and AEC in increasing support for evaluation of the myocardial applications of potassium-43. The outcome of the meeting was an expression of interest by NHLI in participating in some type of symposium which would bring together the many researchers in the field to evaluate the current status of potassium-43 trials.

2. Platinum-195m

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.

Two more shipments totaling 60 mCi of platinum-195m were shipped to the University of Southern California under our medical cooperative program to study the pharmacokinetics of cis-dichlorodiammine-platinum(II).

3. Silicon-32

Silicon-32 (∿650 year) exhibits many desirable physical decay characteristics that make it an interesting and attractive radionuclide for a variety of uses: (1) the only long-lived radionuclide of silicon for use in agriculture, geology, solid-state physics, etc., (2) as a parent for a ^{32}Si-^{32}P *generator system which would offer a constant supply of phosphorus-32 for medical and scientific application, and (3) as a long-lived Cerenkov counting standard for phosphorus-32 determinations. Reactor production of silicon-32, which will be investigated initially, can occur via three completely different reaction paths: (1)* $^{30}Si(n,\gamma)^{31}Si(n,\gamma)^{32}Si$, *(2)* $^{31}P(n,\gamma)^{32}P(n,p)^{32}Si$, *and (3)* $^{34}S(n,\gamma)^{35}S(n,\alpha)^{32}Si$. *Silicon-32 can also be prepared in large quantities via the spallation reaction using high-energy (>100 MeV) protons and will be investigated in collaborative efforts with other AEC laboratories as high currents of these high energy protons become available.*

Earlier calculations,[1] based on the systematics of fast neutron capture, have indicated that paths (2) and (3) shown above should offer higher reactor production rates and higher specific activities of silicon-32 than the more direct double neutron capture path, path (1) above. In order to test the validity of these estimates, three target assemblies (two $AlPO_4$ and one $K_2{}^{34}SO_4$ targets) were inserted in the HFIR for extended irradiation.[2] One of the $AlPO_4$ targets was withdrawn after three cycles (estimated $nvt_{th} \approx 5 \times 10^{22}$ n/cm^2) and has been held in storage to allow complete decay of all phosphorus-32 formed directly from neutron capture by phosphorus-31 during irradiation (target decay time about one year). Any phosphorus-32 now present in this target material should be in secular equilibrium with its silicon-32 parent, and should be representative of the amount of silicon-32 formed during the irradiation. This "long-cooled" target will be used for both yield determination and chemical process development and testing.

Preliminary to opening this three-cycle target, chemical process development using carrier-free silicon-31 (2.62 hr) and phosphorus-32 (14.31 d)

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[1]A. F. Rupp, *Radioisotope Program (8000) Progress Report for October 1970*, ORNL-TM-3228, Oak Ridge National Laboratory, p. 4.
[2]A. F. Rupp, *Radioisotope Program (8000) Progress Report for July 1971*, ORNL-TM-3526, Oak Ridge National Laboratory, p. 6.

has been started. Initial experiments using a weakly basic anion-exchange column (Bio-Rad AG3) to separate $^{31}SiO_3^{2-}$ and $^{32}PO_4^{3-}$ have been most encouraging. Tracer quantities of silicon-31 and phosphorus-32 were prepared by irradiating 100-mg samples of $AlPO_4$ in the ORNL Analytical Chemistry Division's pneumatic transfer tube at the ORR. After decay of the short-lived aluminum-28 (2.27 min), the sample was dissolved in 10 ml of 10% NaOH (∿2.75 *M*). This "dissolver" solution was then heated for 30 min on a hot plate to ensure complete conversion of silicon-31 to the α-silicate, which will not adsorb on a cation-exchange column. After conversion to α-silicate, the solution was passed through a Dowex 50-X8, H^+ form cation column to remove the macro amounts of Al^{3+} and Na^+ ions. At present, the major chemical losses, ∿10-12%, have occurred during the cation column phase of the procedure. After elution of the anions from the cation column, the acid solution is then neutralized to a methyl orange end point, pH ∿3-4, and passed through a weakly basic anion-exchange column (Bio-Rad AG3, Cl^- form). The silicon-31 passed directly through the column with >98% recovery achieved within the first 10 column volumes when dilute 0.005 *N* HCl was used to wash the column. The phosphate anion, on the other hand, was not eluted by dilute HCl and was not detected in the eluate until 6 *N* H_2SO_4 was used as an eluent. Preliminary experiments with K_2SO_4 indicate that this weakly basic anion-exchange column is suitable for targets containing macro amounts of phosphate, e.g., $AlPO_4$, and for targets containing only carrier-free amounts of phosphate, e.g., K_2SO_4 and NaCl, the latter being the spallation production path target proposed by BNL. Additional process development will be undertaken to identify and remedy the causes of silicate losses on the cation column for $AlPO_4$ targets. Additional work will be done to determine if these losses also occur with other targets such as K_2SO_4 and NaCl.

B. Reactor Products Pilot Production
(Production and Inventory Accounts)

Processed Units		Service Irradiations	
Radioisotope	Amount (mCi)	Type	Number
Calcium-47	11	None	
Copper-67	49		
Hafnium-181	4550		
Indium-114	1105		

ACCELERATOR-PRODUCED ISOTOPES — 08-01-02

A. Biomedical Radioisotopes

1. Gallium-67

The objectives of this program are to determine the optimal target configuration for gallium-67 (78.2 hr) production by the $^{68}Zn(p,2n)^{67}Ga$ reaction in acceptable purity and quantity and to provide gallium-67

for clinical applications research and development. Gallium-67 decays by electron capture with the emission of four main gamma rays of 93, 185, 300, and 394 keV with intensities of 42, 24, 17, and 5%, respectively.

Since gallium-67 work was last reported two months ago, eight 100-mCi batches of pharmaceutical-grade gallium-67 citrate have been supplied to ORAU as part of the project of the Cooperative Group to Study Localization of Radiopharmaceuticals. Additional fractions were packaged as either the citrate or the chloride for sale to other medical researchers. Additional testing of the electrodeposited zinc-68 on nickel on copper target design discussed earlier[3] was continued without problems. No signs of loss of target integrity, e.g., loose machine contamination or apparent change in the plated zinc surface, were encountered at integrated proton beam currents approaching 3 mA-hr. Preparation of an open literature publication describing this high-yield target design has been started.

Personnel were trained during this reporting period for routine gallium-67 processing; therefore, gallium-67 will no longer be reported as a separate item unless some additional development work is required. The majority of the technology relating to the large-scale preparation, separation, and purification of carrier-free gallium-67 has either already appeared or will appear soon (upon completion of the article mentioned above) in the open literature; but in order to draw any loose ends together, a summary ORNL report will be published.

2. Lead-203

Lead-203 (52.1 hr) has been suggested as a possible bone-scanning agent with an acceptable half-life for production and shipment and with 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). Three medical cooperative programs have been established to perform the applications evaluation of this nuclide.

Preliminary experiments utilizing the direct formation reaction path have been undertaken for the initial investigation of this radionuclide due to the ready availability of a cyclotron target holder design suitable for (p,n) production and the relatively low cost of enriched lead-203 target material. A 3-in. void aluminum capsule containing 5.7 g of natural isotopic abundance Tl_2SO_4 was irradiated in the ORNL 86-Inch Cyclotron. Thallium(I) sulfate was chosen as the target material in an attempt to use a water-soluble target and thereby avoid the dilute HNO_3 leaching of the aluminum capsule required in an earlier experiment[4] which later

[3]A. F. Rupp, *Radioisotope Program (8000) Progress Report for June 1972*, ORNL-TM-3905, Oak Ridge National Laboratory, p. 3.
[4]A. F. Rupp, *Radioisotope Program (8000) Progress Report for May 1971*, ORNL-TM-3461, Oak Ridge National Laboratory, p. 5.

complicated the separations chemistry. Upon opening the aluminum capsule, it was observed that the white Tl_2SO_4 was a dark gray in color and that part of it was water insoluble. As a result, the aluminum capsule had to be acid leached to ensure complete removal of the target material. A large fraction (>80%) of the initial "dissolver" solution was separated by coprecipitation of carrier-free lead-203 with $Fe(OH)_3$ as described by Neirinckx.[5] This procedure seemed to work adequately, but it required handling procedures too complicated for efficient hot-cell operations required for large amounts of radioactivity. The purified product from this separation was divided into two portions and shipped to cooperating participants for evaluation.

An attempt was made to separate Tl(I) and ^{203}Pb(II) using a hydrous zirconium oxide (HZO) inorganic anion-exchange column based on the work of Maeck *et al.*[6] The pH of the remaining 20% of the "dissolver" solution was adjusted to approximately 3 with 1 *M* NaOH, then the solution was passed through a 0.7-cm-ID by 8-cm-long HZO column (100-200 mesh, preconditioned to pH 3 with dilute HNO_3). Fractions were collected and analyzed separately. The ^{203}Pb(II) was retained by the column, whereas the Tl(I) was only slightly adsorbed. These species did not separate as well as the data of Maeck *et al.* would indicate. Extensive Tl(I) tailing into the ^{203}Pb(II) fractions was observed, and the removal of ^{203}Pb(II) at higher acids was incomplete and seemed to be elution rate dependent. The large differences in distribution coefficient for Pb(II) ($D>500$ at pH $\simeq 3$) and Tl(I) ($D<5$ at pH $\simeq 3$) make this approach look very interesting for rapid, convenient hot-cell operation. As a result, additional separations development work will be undertaken to determine whether this separation of carrier-free lead-203 from macro amounts of Tl(I) can be improved to correspond to that indicated by the measured distribution coefficients.

B. Cyclotron Products Pilot Production (Production and Inventory Accounts)

September 1972 ORNL 86-Inch Cyclotron runs for ORNL and non-ORNL programs are given in Table 1.

Table 1. Cyclotron Irradiations and Runs for September 1972

Product	No. of Runs	Time (hr:min)	Total Charges
	ORNL Programs		
Cobalt-61	2	6:00	$ 587
Gallium-67	2	13:30	1297
Lead-203	1	2:45	293
		22:15	$2177

[5]R. D. Neirinckx, *Radiochem. Radioanal. Letters* 5, 201 (1970).
[6]W. J. Maeck, M. E. Kussy, and J. E. Rein, *Anal. Chem.* 35, 2086 (1963).

Table 1. continued

Product	No. of Runs	Time (hr:min)	Total Charges
	Non-ORNL Programs		
Aluminum-26	1	Septum tubes	$2000
Germanium-68	1	9:15	1533
Rhodium-102	1	4:15	613
Yttrium-88	1	11:15	1660
		24:45	$5806

FISSION PRODUCTS — 08-01-03

A. Krypton-85 Enrichment

The three thermal diffusion units operating with krypton appear to be very close to equilibrium. The product from the two low-level units will be removed and used as feed for the high-level run, boosting the product concentration in this unit. The readings from the two count-rate meters installed near the center of the system indicate that the product concentrations should be in the range of 45 to 50% krypton-85.

B. Cesium-137 Pilot Production
(Production and Inventory Accounts)

1. Processing and Process Status

A cycle of cesium oxalate/carbonate conversion was run, but the yield was 30% of normal conversion. The calcined oxalate was reserved while another alum/oxalate/carbonate cycle was run. The combined carbonates (∿100,000 Ci) will be processed to the chloride product during October. The current cesium-137 process status is shown below.

Item	Cesium-137 (Ci)
In-process material	732,000
$^{137}CsCl$ products	192,000
Sources in fabrication	0
Completed sources awaiting shipment	182,500

2. Operational Summary

Item	Sept. 1972 No.	Sept. 1972 Ci	CY 1972 No.	CY 1972 Ci	FY 1973 No.	FY 1973 Ci
HAPO shipments received	0	0	0	0	0	0
Product batches prepared	0	0	16	148,300	15	141,300
Sources						
Fabricated	0	0	23	55,300	0	0
Shipped	0	0	23	55,300	0	0
Special Form Cans						
Fabricated	0	0	20	114,400	10	500
Shipped	1	500	8	1,900	3	1,000

3. Current Orders

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

Customer	Amount (Ci)	Estimated Shipping Date
Brookhaven National Laboratory	203,000	FY 1973
Lockheed Georgia Company	∿35,000	a
Atomic Energy of Canada Limited	25,200	December 1972
Gamma Industries	30	December 1972
Technical Operations, Inc.	8	October 1972
Technical Operations, Inc.	100	December 1972
J. L. Shepherd Associates, Inc.	50,001	To be scheduled

[a]Sources are in storage awaiting receipt of customer's container.

An order is on hand from Atomic Energy of Canada Limited for 88,000 Ci of cesium-137 as CsCl powder. The powder has been canned and stored awaiting release by the customer.

4. Source Fabrication

Five hundred curies of cesium-137 was shipped to 3M Company.

C. Strontium-90 Pilot Production
(Production and Inventory Accounts)

1. Processing and Process Status

No strontium-90 processing was done. The current strontium-90 process status is shown below.

Item	Strontium-90 (Ci)
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

Item	Sept. 1972		CY 1972		FY 1973	
	No.	Ci	No.	Ci	No.	Ci
HAPO shipments received	0	0	0	0	0	0
Product batches prepared	0	0	13	510,000	0	0
Sources						
Fabricated	0	0	9	581,000	0	0
Shipped	0	0	5	360,000	0	0
Special Form Cans						
Fabricated	0	0	39	5,600	0	0
Shipped	0	0	13	900	0	0

3. Current Orders

Current orders for strontium-90 as sources or bulk powder are shown below.

Customer	Amount (Ci)	Estimated Shipping Date
U.S. Navy (ORNL)	221,000	FY 1973
U.S. Navy	278,675	a

[a]To be released by customer.

4. URIPS-8 Generators

Load test readings of the URIPS-8 generators were completed on September 29. The four generators had operated 52 days at temperature at that time. Typical readings for the generators are given in Table 2.

Table 2. URIPS-8 Generator Test Data

Generator No.	Load		Shorted		Temperature (°F)	
	Volts	Amps	Volts	Amps	Fin	Hot Shoe
25	5.29	1.92	0.04	3.43	125	515
26	5.16	1.89	0.04	3.33	123	520
27	5.19	1.87	0.03	3.40	125	509
28	5.18	1.88	0.02	3.50	118	485

D. Short-Lived Fission Products Pilot Production (Production and Inventory Accounts)

Isotope	Number of Batches	Amount (Ci)
Xenon-133	3	∿1100
Iodine-131	2	38
Zirconium/niobium-95[a]	1	48

[a]Run made and reported during August; analysis has now been reported.

E. Promethium-147 Shipments and Current Orders

Current orders for promethium-147 are from Donald W. Douglas Laboratories for 51,000 Ci and from Radiochemical Centre, England, for 2000 Ci. These orders will be shipped in October.

SOURCE DEVELOPMENT — 08-01-04

A. Radioisotope Characterization, Quality Control, and Standards

1. Radioisotope Characterization

An investigator has recently made the following assignments for barium-133: half-life 10.4 years, K x rays 120%, 0.356-MeV gamma 62%. This agrees with values accepted by the Nuclear Data Group and Isotopes Development Center. Our published value for the half-life of beryllium-10, 1.6 ± 0.2 million years, is lower than the accepted value of 2.5×10^6 years. Another determination has just been reported[7] as 1.5 ± 0.3 million years, and two old values have been recalculated; all of these are now in the range 1.3-1.9, averaging 1.6. A new value for iridium-194, 19.15 hr, roughly confirms our 19.41-hr value and indicates that the previously accepted 17.4-hr value should be discarded.

Two more inquiries about the half-life of plutonium-241 were answered by quoting 14.8 years.[8] Such inquiries indicate the need for a generally accepted source of authoritative information for widely used nuclides. It is hoped that the newly formed U.S. Nuclear Data Committee will undertake such a project, but if it does not, an attempt will be made through ANS-16 and the ANS Information Center on Nuclear Standards to provide the information and secure its acceptance. Obviously we would generate and compile little of the data outselves, but would depend on the Nuclear Data Group, for example. However, our contribution would be putting it in a form usable by nonspecialists and vigorously publicizing its availability.

[7]F. Yiou and G. M. Raisbeck, *Phys. Rev. Letters* 29, 372-5 (1972).
[8]*Nuclear Data* B6, 630 (1971).

Other inquiries were concerned with the decay schemes of cobalt-57, cerium-144—praseodymium, barium-133, and such schemes in general, plus a request for actual counting data for each of the nuclides in three-member chains (none were found).

2. Radioisotope Special Analysis and Quality Control

Users of liquid scintillation counting are gradually realizing that the technique is subject to interferences, such as quenching, chemiluminescence, and sorption, which are poorly understood and may not be anticipated in a particular case. In investigating discrepancies in the assay of phosphorus-33 (reported last month), for which a substitute standard of calcium-45 is used, it was found that the "carrier-free" phosphorus-33 was lost from the scintillator mixture in a period of hours to days. Addition of microgram quantities of phosphate eliminated the losses. Standards of calcium-45 and phosphorus-32 (a by-product of phosphorus-33) were obtained, and local measurements agreed exactly with the supplier's on calcium-45 and were 3.8% above on phosphorus-32 (certified to 2.7%). In the past year, eleven standards of ten nuclides were obtained, mostly from NBS, and agreement was adequate for all.

Recent papers have contained information that deuterium compounds, including D_2O, contain variable concentrations of ^3H. Of course, D_2O is used as starting material for the prepartion of many other compounds. It was found that a local supply contained 3.8 μCi/ml. Our postulate is that small quantities of neutron-irradiated D_2O, which may contain over 10 mCi/ml, have been inadvertently introduced into some D_2O stocks. Inquiries were received on availability and quality of standards, including those for radium-226.

RADIOISOTOPE SALES

ITEMS OF INTEREST

A request for quotation was received from California Institute of Technology for 10- and 100-kCi promethium-147 sources. An order was received from Radiochemical Centre for 2 kCi of promethium-147 as bulk powder. An order was received from Atomic Energy of Canada Limited for 14 cesium-137 sources, each containing 1800 Ci.

Shipments of interest made during the month are listed below:

Customer	Isotope	Amount
Large Quantities		
New England Nuclear Corporation	Tritium	7000 Ci
Minnesota Mining & Manufacturing Company	Cesium-137	502 Ci
Radiochemical Centre, England	Cesium-137	512 Ci
General Motors, Frigidaire Division	Krypton-85	100 Ci
Western Electric Company, Massachusetts	Krypton-85	130 Ci

Customer	Isotope	Amount
Items Used in Cooperative Programs		
Oak Ridge Associated Universities	Gallium-67	
Oak Ridge Associated Universities	Lead-203	
State University of New York	Lead-203	
University of Southern California	Platinum-195m	
Vanderbilt University	Xenon-133	
Specially Approved Withdrawn Items		
Mayo Clinic	Copper-67	3 lots
George Washington University	Copper-67	1 lot
University of Pittsburgh	Iodine-131	100 mCi
University of Rochester	Iodine-131	200 mCi
University of California, Berkeley	Iodine-131	30 mCi

Unusual Items

A set of septum tubes from the ORNL 86-Inch Cyclotron was sold to International Chemical and Nuclear Corporation for recovery of aluminum-26.

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

Table 3. Summary of Radioisotopes Shipped During August 1972

Radioisotope	Number of Shipments	Quantity (mCi)
Argon-37	2	30
Barium-140	9	60
Calcium-47	9	7
Cesium-137	2	10,010
Copper-67	4	26[a]
Gallium-67	11	447[a]
Iodine-131	4	280
Krypton-85, enriched	4	90,520
Krypton-85, normal	18	705,500
Niobium-95	3	18
Phosphorus-33	3	101
Potassium-43	7	18[a]
Promethium-147	32	57,308,050
Ruthenium-103	2	6
Ruthenium-106	2	22
Samarium oxide	1	1[a]
Strontium-89	5	63
Strontium-90	1	5
Technetium-99	2	7,000[a]
Tritium	15	28,706,000
Xenon-133	57	73,870
Yttrium-91	1	11
Zirconium-95	4	50

Table 3. continued

Radioisotope	Number of Shipments	Quantity (mCi)
Service irradiations — cyclotron	3	2
Misc. compound preparations	2	
Special services	1	
	204	86,894,605 7,492[a]

[a]Milligrams.

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

Table 4. Radioisotope Sales and Shipments

Item	7-1-71 thru 8-31-71	7-1-72 thru 8-31-72
Inventory items	$ 72,839	$ 73,917
Major products	8,665	10,002
Radioisotope services	40,102	21,258
Cyclotron irradiations	18,742	20,074
Miscellaneous processed material	15,804	12,203
Packing and shipping	12,847	11,590
Total	$168,999	$149,044
Number of Shipments	464	362

ADMINISTRATIVE

Travel of IDC members and visitors to the IDC are given in Tables 5 and 6, respectively.

Table 5. Travel by IDC Personnel

Site Visited	Purpose
National Institutes of Health Bethesda, Maryland	Discuss potassium-43 for myocardial scanning
NASA Huntsville, Alabama	Discuss preparation of samples for Skylab

Table 5. continued

Site Visited	Purpose
AEC, Atlantic Richfield, and Pacific Northwest Laboratory Richland, Washington	Discuss large-scale fission product program
Wilmington, Delaware	Attend American Standards Institute meeting on leakage tests for radioactive material packaging
Battelle Memorial Institute Columbus, Ohio	Discuss Skylab experiment
U. S. Atomic Energy Commission Washington, D. C.	Preliminary safety analysis review and discuss source testing program
Wilmington, Delaware	Attend ANSI N-14 Advisory Committee meeting on packaging and transportation

Table 6. IDC Visitors

Visitor (affiliation)	Purpose of Visit
Boris Kidric Institute of Nuclear Science Belgrade, Yugoslavia	Discuss radioisotope production and tour the IDC
Georgia Institute of Technology School of Chemistry Atlanta, Georgia	Discuss fluorescence yields and Coster-Kronig transitions
IAEA, Turkey	Discuss radioisotope and radiopharmaceutical production

PUBLICATIONS

REPORTS

J. H. Hamilton, E. Collins, P. E. Little, N. R. Johnson, A. V. Ramayya, J. J. Pinajian, and A. F. Kluk, "M1 Admixtures of Transitions in ^{156}Gd," *Chemistry Division Annual Progress Report for Period Ending May 20, 1972*, ORNL-4791, Oak Ridge National Laboratory (August 1972).

Eugene Lamb, *Isotopic Power Fuels Monthly Status Report for August 1972*, ORNL-TM-3982, Oak Ridge National Laboratory.

A. F. Rupp, *Radioisotope Program (8000) Progress Report for August 1972*, ORNL-TM-3980, Oak Ridge National Laboratory.

JOURNALS

L. C. Brown, "A New Determination of the Half-Life of ^{83}Rb," *J. Inorg. Nucl. Chem.* 34, 2974-78 (1972).

BOOKS

H. K. Carter, W. H. Brantley, J. C. Manthuruthil, and J. J. Pinajian, "Search for 0^+ and 3^- Levels in ^{132}Xe," p. 1381 in *Radioactivity in Nuclear Spectroscopy: Modern Techniques and Applications*, vol. II, ed. by Joseph H. Hamilton and Jose C. Manthuruthil, Gordon and Breach, New York, 1972.

J. C. Manthuruthil, H. J. Hennecke, and J. J. Pinajian, "L-Subshell Conversion Line Intensity Ratios for the 82.45-keV Pure M1 Transition in Ho^{166}," p. 1357, *ibid.*

ABSTRACTS

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