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# RADIOISOTOPE PROGRAM (8000) PROGRESS REPORT FOR JANUARY 1973

A. F. Rupp

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ISOTOPES DEVELOPMENT CENTER

# RADIOISOTOPE PROGRAM (8000) PROGRESS REPORT FOR JANUARY 1973

A. F. Rupp

Work Sponsored by
AEC Division of Applied Technology

FEBRUARY 1973

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# RADIOISOTOPE PROGRAM (8000) PROGRESS REPORT FOR JANUARY 1973

*A. F. Rupp*

## RADIOISOTOPE PRODUCTION AND MATERIALS DEVELOPMENT

### REACTOR-PRODUCED ISOTOPES — 08-01-01

#### Phosphorus-33 *(T. A. Butler)*

*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 $\beta^-_{max}$) has both a longer half-life and a lower energy beta than phosphorus-32 (14.3 days; 1.709-MeV $\beta^-_{max}$), 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.*

A 1.06-g $K^{36}Cl$ target which had been irradiated for two cycles in HFIR was processed. It was dissolved in water and converted by ion exchange to $H^{36}Cl$; freshly precipitated $Fe(OH)_3$ was dissolved in the acid solution and then cesium-free KOH was added to adjust the pH to 9. As experienced in the preceding target processing, a low-product yield was obtained, in this case only 80 mCi or ∿10% of what was expected. The phosphorus-32 content was 6% at time of processing, and it was combined with product remaining from a previous batch to provide an acceptable product to fill a 100-mCi order.

A beta-absorption study of the dissolved target solution revealed that about 900 mCi phosphorus-33 remained in solution. The changed processing procedure uses a KOH precipitation of $Fe(OH)_3$ instead of the $NH_4OH$ previously used. The erratic yields have occurred since this change. A tracer level experiment with phosphorus-32 was performed to test whether the ability of $Fe(OH)_3$ to carry $PO_4^{3-}$ was sensitive to this. In the single experiment performed, however, both the KOH and $NH_4OH$ precipitations carried ∿95% of the $PO_4^{3-}$. There was a slight indication that the KOH procedure was less efficient, but more experiments are required. The target solution will be reprocessed to recover the additional phosphorus-33.

Potassium-43 *(T. A. Butler)*

*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.*

Two batches of potassium-43 were processed this month, and four shipments totaling 15.5 mCi were made.

The Society of Nuclear Medicine sponsored a symposium on cardiac imaging in nuclear medicine in Chicago. A clinician reviewed the clinical needs for reproducible techniques applicable to critically ill patients for quantifying infarcts and defining salvageable ischemic areas amenable to surgery. He illustrated the significant risk involved in the invasive techniques, which are in current practice, and their inadequacy when applied to hearts with gross physical abnormalities. An interesting report from a Harvard group was the fact that acute infarct areas could be selectively labeled by technetium-99m-labeled tetracycline provided there was still some vascular blood supply to the infarcted area. Cesium-129 appears to have little or no advantage over potassium-43 and suffers a disadvantage in its slower uptake and clearance rates. While the 1.25-min rubidium-82, which could be readily available from a 25-day strontium-82 generator, most nearly resembles potassium physiologically and gave promising results with animals, it has been somewhat disappointing in the few human studies.

The Johns Hopkins group presented studies defining ischemic areas by scanning with potassium-43 given at rest and then given subsequent to strenuous exercise. In this application potassium-43 probably has a distinct advantage because potassium is physiological, whereas other agents may be just as adequate for studies of infarction.

The general conclusions drawn are that much progress has been made, but the wide variation in quality of images underscores how much needs to be done, especially in this area. It appears that potassium-43 has a significant place in cardiac imaging, but it must be more available and at lower cost.

In pursuit of both objectives of quantity and economy we have begun assembling the calcium oxide target to test the production yield via the $^{43}Ca(\gamma,p)^{43}K$ photonuclear reaction.[1] The experiment itself requires a large (>600 lb CaO) target from which selective samples will be taken.

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

Production of potassium-43 by this mechanism would involve costly processing of large quantities of target materials, but the deliverable product would be in the decicurie range with net reduction in unit costs. Expanded production at reduced cost is a prerequisite to any widespread clinical role for potassium-43.

Platinum-195m *(T. A. Butler)*

*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.*

Two shipments of platinum-195m, totaling ∿60 mCi, were made to the University of Southern California under our cooperative program.

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

| Processed Units | |
|---|---|
| Radioisotope | Amount (mCi) |
| Copper-67 | 58 |
| Calcium-47 | 4.3 |
| Zinc-69m | 163 |

ACCELERATOR-PRODUCED ISOTOPES — 08-01-02

Bismuth-206 *(T. A. Butler)*

*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.*

Development of an electrodeposited lead-on-copper cyclotron target suitable for use with highly enriched lead-207 target material has been resumed.[2] Use of an approximately 1.5 *M* fluoboric acid ($HBF_4$) electrolyte, containing 2 to 3 g lead [added as $PbCO_3$ or 2 $PbCO_3 \cdot Pb(OH)_2$], a small amount of bone glue additive, and an inert platinum screen anode have yielded targets with smooth, tightly adherent lead plates ranging in thickness from 3.3 to 7.9 mils average. Test irradiation of these targets, prepared from natural isotopic abundance lead, has begun and will be continued to determine the effect of target thickness on yield and the effect of proton beam power levels on target integrity before starting an extensive production effort with highly enriched lead-207. The low-purity bismuth-206 produced during the testing of the natural lead targets (∿35% bismuth-205, 15.3 d, at end of bombardment, EOB) will be distributed to collaborative investigators for preliminary animal distribution studies, which will not require the lower dose, higher purity bismuth-206 (estimated to be ≤ 5% bismuth-205 EOB) to be prepared from the enriched lead-207 for human studies. In order to confirm the estimated purity of a bismuth-206 product prepared via the $^{207}Pb(p,2n)^{206}Bi$ reaction using enriched lead-207, a 2.7-mil-thick lead-207 electrodeposited target (92.4 at. % isotopically enriched lead-207, 2.16 at. % lead-206) was irradiated in the ORNL 86-Inch Cyclotron at low beam current (∿140 μA) with 22-MeV protons, the carrier-free bismuth was recovered and purified, and the product radionuclidic purity was characterized. The EOB composition of the bismuth was found to be >98% bismuth-206 and ∿1.5% bismuth-205 (15.3 d), well within the earlier estimates.

The irradiated lead is electrostripped into ∿1.5 *M* $HNO_3$, the aqueous phase is then diluted to ∿0.3 *M* $HNO_3$, and then the $Bi^{3+}$ is extracted from the aqueous phase using a 0.3 *M* solution of di(2-ethylhexyl)-phosphoric acid (HDEHP) in n-heptane as developed by Neirinckx.[3] Preliminary experiments using this chemical process indicate that it is more efficient than processes used earlier.[2] The distribution coefficients for Cu(II), Pb(II), and Zn(II) [zinc-62 (9.15 h) and zinc-65 (243 d) are formed by (p,*x*n) reaction on the copper target substrate] are all ≤ 0.1 under these extraction conditions; whereas, the distribution coefficient for Bi(III) is approximately 40. Total process chemical yields >90% would seem possible using this basic separation and purification procedure. Additional work will be done on process testing and optimization and on product characterization in the future, with the products being distributed to collaborative investigators for evaluation.

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[2]A. F. Rupp, *Radioisotope Program (8000) Progress Report for April 1971*, ORNL-TM-3414, Oak Ridge National Laboratory, p. 17.
[3]R. D. Neirinckx, *Radiochem. Radioanal. Letters* 8, 59 (1971).

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

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

Table 1. Cyclotron Irradiations and Runs for January 1973

| Date | Customer | Product | Target | Time (hr:min) | Total Charges |
|---|---|---|---|---|---|
| | | ORNL Programs | | | |
| 1-4-73 | ORAU and others | Gallium-67 | Zinc-68 | 9:15 | $ 886 |
| 1-18-73 | ORAU and others | Gallium-67 | Zinc-68 | 8:45 | 838 |
| 1-19-73 | Isotopes Division | Bismuth-206 | Lead | 1:50 | 181 |
| | | | | 19:50 | $ 1,905 |
| | | Non-ORNL Programs | | | |
| 12-22-72 | New England Nuclear Corporation | Cobalt-57 | Nickel-58 | 51:15 | $ 8,540 |
| 1-8-73 | International Chemical & Nuclear Corp. | Gold-195 | Platinum | 6:15 | 1,447 |
| 1-11-73 | International Chemical & Nuclear Corp. | Cobalt-57 | Nickel-58 | 49:15 | 8,260 |
| | | | | 106:45 | $18,247 |

In addition to routine maintenance, the oscillator tube was replaced, and a preset current meter was installed in the bias circuit to deenergize the high-voltage system during periods of excessive radio frequency. We are now using rebuilt oscillator tubes guaranteed to operate 1000 hr, and the cost is approximately 20% of a new tube. The tube removed was a rebuilt tube which had operated 1679 hr. Occasionally it was necessary to replace a radio-frequency cable in the bias system which was damaged by surges. This would interrupt operation of the cyclotron for periods up to 3 hr. Installation of the preset current meter in the bias circuit has reduced the occurrence of the radio-frequency cable failures.

Cyclotron operational cost for December was $12,555.

# FISSION PRODUCTS — 08-01-03

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

The thermal diffusion unit with a cooling water leak into the gas annulus was removed from the cell. A pressure test confirmed the existence of a leak somewhere in the eight tubes of the light end section. The tube bundle was pulled out of the outer shell, and an inspection showed the tubes to be in good condition generally, but heavy deposits, apparently of dust in the cooling water, had accumulated around the outside of the tubes in spots on the downstream side of the internal cooling water baffles.

The individual tubes have not yet been removed for inspection, but it appears likely that the leak will be found to be due to overheating and burnout in the regions covered by the deposits.

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

### 1. Process Status

Eight batches of $^{137}CsCl$ totaling approximately 150,000 Ci were processed from "cesium carbonate" intermediate product prepared in November and December. At present the crystallizer inventory is approximately 110,000 Ci; this material is being purified for another oxalate cycle. The agitators in both the oxalate precipitators (in manipulator cells) are inoperable; so an attempt will be made to crystallize the oxalate in the cesium-137 purification crystallizers and then transfer the slurry to the manipulator cell equipment for filtration. Since there are so few oxalate batches (probably four) remaining to be run, it is not considered worthwhile to repair the agitators.

Water rinsing and long-term soaking (with 1.0 *M* $HNO_3$) of the cesium-137 storage tank did not result in the removal of any additional cesium-137. Preliminary decontamination of the cesium-137 storage and transfer system has begun. The remaining in-process cesium-137 consists of the crystallizer inventory (∿110,000 Ci), the cesium-137 glass residue (estimated at 35,000 Ci), and about 5,000 Ci of miscellaneous items such as returned analytical samples and reserved carbonate for special shipments. It is expected that routine cesium-137 process operations will be terminated in late February or early March. The current cesium-137 process status is as follows.

| Item | Cesium-137 (Ci) |
|---|---|
| In-process material | 150,000 |
| $^{137}CsCl$ products | 450,000 |
| Sources in fabrication | a |
| Completed sources awaiting shipment | 202,250 |

[a]A campaign for preparation of 40 "BNL strips" containing a total of approximately 180,000 Ci is in progress.

### 2. Operational Summary

| Item | Jan. 1973 | | CY 1973 | | FY 1973 | |
|---|---|---|---|---|---|---|
| | No. | Ci | No. | Ci | No. | Ci |
| HAPO shipments received | 0 | 0 | 0 | 0 | 0 | 0 |
| Product batches prepared | 8 | 150,000 | 8 | 150,000 | 38 | 457,000 |
| Sources | | | | | | |
| Fabricated | 8 | 22,750 | 8 | 22,750 | 34 | 48,450 |
| Shipped | 1 | 3,000 | 1 | 3,000 | 27 | 33,700 |
| Special form cans | | | | | | |
| Fabricated | 0 | 0 | 0 | 0 | 10 | 500 |
| Shipped | 1 | 250 | 1 | 250 | 5 | 1,750 |

## 3. Current Orders

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

| Customer | Amount (Ci) | Estimated Shipping Date |
|---|---|---|
| Brookhaven National Laboratory | ∿180,000 | FY 1973 |
| J. L. Shepherd and Associates | 21,754 | a |
| Radiochemical Centre | 1,500 | May 1973 |
| General Radioisotope Products | 200 | March 1973 |

[a]Sources have been fabricated and are awaiting receipt of customer's container.

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, awaiting release by customer.

## 4. Source Fabrication

A 3,000-Ci source was shipped to J. L. Shepherd and Associates.

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

## 1. Process Status

No strontium-90 titanate processing was done this month. A special strontium-90 product batch for a customer was made by diluting strontium-90 feed. Since cesium-137 processing should be completed in the near future, plans are being made to begin strontium-90 processing in March. There are no present or expected orders for strontium-90 sources, so the strontium-90 (as the distrontium titanate) will be canned in doubly welded storage cans. The current strontium-90 process status is as follows:

| 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 | Jan. 1973 No. | Jan. 1973 Ci | CY 1973 No. | CY 1973 Ci | FY 1973 No. | FY 1973 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 | 0 | 0 | 0 | 0 | 0 | 0 |
| Shipped | 0 | 0 | 0 | 0 | 1 | 10 |

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 | 221,000 | FY 1973 |
| Radiochemical Centre | 500 | May 1973 |

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

| Isotope | Number of Batches | Amount (Ci) |
|---|---|---|
| Xenon-133 | 2 | 700 |
| Iodine-131 | 2 | 55.5 |
| Strontium-89 | 1 | 17.3 |
| Barium-140 | 1 | 54.4 |

Promethium-147 Shipments and Current Orders

Donald W. Douglas Laboratories has placed an order for 200,000 Ci. Shipments of 50,000 Ci will be made in May, July, October, and December 1973.

SOURCE DEVELOPMENT — 08-01-04

Americium-241 *(F. N. Case)*

A ring source containing approximately 16 Ci americium-241 was returned by Vanderbilt University Medical Center for re-encapsulation into 16 cylindrical sources. An inactive prototype source was first prepared and tested under the ORNL standard source classification procedure to a III-C rating which is equal to the ring source and adequate for

Vanderbilt's requirements. The sources will be placed in an array around a collimator and used for secondary x-ray scanning of thyroid and brain.

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

Interest in the use of gadolinium-153 for medical diagnosis continues to increase. Another group at the University of California, Los Angeles, AEC Medical Center, has joined the program to evaluate gadolinium-153 in the form of sealed sources for various diagnostic procedures.

Two targets made from gadolinium-152 recovered from HFIR control plates were irradiated for the preparation of gadolinium-153. The product from this irradiation has been processed to solution, and a high-pressure ion-exchange column has been placed in operation for removal of terbium-160. Tracer runs using this column were made during the last week in January. Several in-process control devices utilizing gadolinium-153 have been developed by an AEC facility, and a paper describing their use is in preparation.

## Prototype Source Testing *(R. A. Robinson)*

Two doubly encapsulated sources and one singly encapsulated cylindrical source were tested and found to meet the requirements for ORNL Class III-C. The first source was designed as a replacement for a previously tested[4] $^{241}AmO_2$ ring-shaped source. It was designed to contain about 1 Ci of $^{241}AmO_2$ which was doubly encapsulated in stainless steel. Both inner and outer capsules had 0.020-in. walls and 0.008-in. windows. The second source was essentially the same design as a previously tested[5] stainless steel californium-252 neutron source except that the encapsulation material was 0.050-in. Zircaloy instead of 0.050-in. stainless steel. The third source was the same as the second except that it was singly encapsulated rather than doubly encapsulated in 0.050-in. Zircaloy. The two Zircaloy sources were limited to Class III-C because they failed to pass the Class IV shear test and the Class D maximum temperature test. The americium-241 source was not tested for Class IV-D.

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

### 1. Radioisotope Characterization

Values were selected for neutron cross sections for production of 90 common radionuclides. Adoptions by KAPL personnel for the new *Chart of*

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[4]A. F. Rupp, *Radioisotope Program (8000) Progress Report for August 1971*, ORNL-TM-3558, Oak Ridge National Laboratory.
[5]A. F. Rupp, *Radioisotope Program (8000) Progress Report for March 1971*, ORNL-TM-3380, Oak Ridge National Laboratory.

*the Nuclides* were found to be in essentially complete agreement with our own selections. Product cross sections, i.e., for "burn-up" of the desired nuclides, were included where known. Representation from the U. S. Nuclear Data Committee was secured for the panel discussion during the special session being arranged by ANS-16 for the national ANS meeting in June.

## 2. Radioisotope Special Analysis and Quality Control

In connection with the assay of uranium-235 in special samples, specific activities were confirmed, methods and precisions were reviewed, and an additional measurement was recommended and interpreted. Gallium-67 preparations were obtained from the British Radiochemical Centre (RCC) and from a domestic supplier. Our measurements, using two independently calibrated instruments in each of two laboratories, were 0.8% below RCC and 1.6% above the domestic supplier. The RCC value was obtained by coincidence counting[6] and was therefore little affected by assumptions about the decay scheme, but our measurements required utilization of data we selected from the literature which are quite different from those in the 1967 *Table of Isotopes*. In particular, a 30% error in assay would have resulted from use of the old percentage for the 0.300-MeV gamma radiation. Details of this study will be made available to domestic suppliers and users, NBS, and other standards groups and may contribute to resolution of discrepancies some have reported.

Our study of the measurement of xenon-133 has continued. The ionization chamber used for assay of whole shipments was recalibrated by use of mass-analyzed samples. The overall precision was about 6%, and the previous calibration was confirmed within 0 to 7%. According to data received from a commercial supplier, taking an NBS measurement as unity, ours would be 1.07, the supplier's 1.19, and a foreign source 1.73. It must be emphasized that the NBS measurement was made on a small sample, and the above comparison is tentative. Final resolution of the discrepancies awaits issuance of an NBS standard of appropriate level later this year.

It appears that the problem of tritium in heavy water has disappeared. A major commercial vendor reported that low-tritium material has been available all the time, when requested, and that all their supply is now low-tritium material. ASTM Committee D-19 declined to add tritium level to its specifications for heavy water, and members of ANS-16 advised against our attempting to set such a specification. Finally, there is no mention of tritium in the NRC specifications (*Specifications and Criteria for Biochemical Compounds*, 3rd., National Academy of Sciences, Washington, DC, 1972).

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[6]V. E. Lewis *et al.*, *Int. J. Appl. Radiat. Isotopes* 23, 279 (1972).

## RADIOISOTOPE SALES

*(J. E. Ratledge)*

Orders were received from U. S. Radium Corporation for 10,000 Ci of tritium gas, Industrial Nucleonics Corporation for 200 Ci krypton-85 (11.2% enriched), and Sumitomo Shoji America, Inc., for 100 Ci normal krypton-85. An order was received from Radiochemical Centre, England, for 150 Ci krypton-85 (50 Ci ∿15% enriched and 100 Ci normal gas), 1500 Ci cesium-137 as calcined oxalate (30 cans of 50 Ci each), and 500 Ci strontium-90 as oxide (20 cans of 25 Ci each).

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

| Customer | Isotope | Quantity |
|---|---|---|
| | Large Quantities | |
| J. L. Shepherd and Associates | Cesium-137 | 3,000 Ci |
| Schwarz-Mann | Tritium | 1,000 Ci |
| Canrad Precision Industries | Tritium | 1,000 Ci |
| New England Nuclear Corporation | Tritium | 5,000 Ci |
| Radiochemical Centre | Krypton-85, normal | 100 Ci |
| American Atomics Corporation | Krypton-85, enriched | 43.6 Ci |
| Radiochemical Centre | Krypton-85, enriched | 50 Ci |
| Sumitomo Shoji America, Inc. | Krypton-85, normal | 100 Ci |
| Measurex Corporation[a] | Krypton-85, enriched | 973.8 Ci |
| | Withdrawn Items | |
| University of Pittsburgh | Iodine-131, FP | 50 mCi |
| Cleveland Metropolitan General Hospital | Iodine-131, FP | 50 mCi |
| University of Rochester | Iodine-131, FP | 450 mCi |
| University of Chicago | Copper-67 | ∿13 mCi |
| Mayo Clinic | Copper-67 | ∿13 mCi |
| University of California, Livermore | Cadmium-115m | 0.9 Ci |
| | Items Used in Cooperative Programs | |
| University of California, Livermore | Erbium-171-172 | ∿4.65 Ci |
| Vanderbilt University | Bismuth-206 | ∿5 mCi |
| Oak Ridge Associated Universities | Gallium-67 | ∿300 mCi |
| University of Southern California | Platinum-195m | ∿35 mCi |
| | Unusual Items | |
| U. S. Army Corps of Engineers | Sand tagged with gold-198-199 | ∿40 Ci |

[a]Billing for material has been made; shipment is to be made at a later date.

A summary of the radioisotopes shipped during December 1972 is given in Table 2.

Table 2. Summary of Radioisotopes Shipped During December 1972

| Isotope | Number of Shipments | Quantity (mCi) |
|---|---|---|
| Calcium-47 | 6 | 4 |
| Cerium-144 | 1 | 2 |
| Cesium-137 | 9 | 660,900 |
| Cobalt-60 | 2 | 50 |
| Copper-67 | 3 | 20 |
| Europium-152-154 | 1 | 2 |
| Gallium-67 | 11 | 443 |
| Hafnium-181 | 1 | 8 |
| Iodine-131, fission product | 3 | 200 |
| Krypton-85, normal | 12 | 430,000 |
| Krypton-85, enriched | 2 | 302,950 |
| Niobium-95 | 2 | 6 |
| Phosphorus-33 | 3 | 202 |
| Potassium-43 | 6 | 20 |
| Promethium-147 | 5 | 51,040,050 |
| Ruthenium-103 | 1 | 3 |
| Strontium-90 | 6 | 10,250 |
| Tritium | 18 | 10,609,600 |
| Xenon-133 | 53 | 75,020 |
| Zirconium-95 | 1 | 1 |
| Misc. compound preparations | 15 | 150 |
| Cyclotron irradiations | | |
| New England Nuclear Corp. | Cobalt-57 as target | ∿2,000 |
| N. V. Philips-Duphar | Cobalt-57 as solution | 400 |
| Total | | 63,132,281 |

Radioisotope sales proceeds and shipments for the first six months of FY 1972 and FY 1973 are shown in Table 3.

Table 3. Radioisotope Sales and Shipments

| Item | 7-1-71 thru 12-31-71 | 7-1-72 thru 12-31-72 |
|---|---|---|
| Inventory items | $234,141 | $200,635 |
| Major products | 30,122 | 28,341 |
| Radioisotope services | 133,600 | 87,763 |
| 86-Inch Cyclotron irradiations | 78,231 | 49,149 |
| Miscellaneous processed materials | 32,279 | 26,013 |
| Packing and shipping | 36,340 | 33,770 |
| Total | $544,713 | $425,671 |
| Number of shipments | 1,256 | 1,036 |

## ADMINISTRATIVE

Travel of IDC personnel is given in Table 4.

Table 4. Travel by IDC Personnel

| Traveler | Site Visited | Purpose of Visit |
|---|---|---|
| P. S. Baker | Washington, DC | Attend Highway Research Board Nuclear Principles and Applications Committee meeting |
| E. E. Beauchamp | Washington, DC | Attend ANSI N-14 Committee meeting on packaging and transportation of fissile and radioactive materials |
| J. K. Poggenburg | Chicago, IL | Attend Society of Nuclear Medicine Symposium on Cardiac Imaging in Nuclear Medicine |
| A. F. Rupp | Kansas City, MO | Give talk at ANS meeting |

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