2-

(13)

**USER'S MANUAL
FOR THE
BATTELLE-NORTHWEST
ISOTOPIC DATA TAPE**

R. L. REYNOLDS

NOVEMBER, 1967

**AEC RESEARCH &
DEVELOPMENT REPORT**

TO: <i>H. C. Roesch</i>	FILE NO: <i>30562-529</i>	DATE: <i>JAN 22 1968</i>

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

PACIFIC NORTHWEST LABORATORY

RICHLAND, WASHINGTON

operated by

BATTELLE MEMORIAL INSTITUTE

for the

UNITED STATES ATOMIC ENERGY COMMISSION UNDER CONTRACT AT(45-1)-1830

3 3679 00060 6899

BNWL-551

UC-23, Isotopes - Industrial Technology
(TID-4500)

USER'S MANUAL
FOR THE
BATTELLE-NORTHWEST
ISOTOPIC DATA TAPE

by

R. L. Reynolds

Advanced Concepts and Analysis
Mathematics Department

November 1967

BNWL-551
UC-23, Isotopes - Industrial Technology
(TID-4500)

PACIFIC NORTHWEST LABORATORY
RICHLAND, WASHINGTON

Printed in USA. Price \$3.00. Available from the Clearinghouse for Federal
Scientific and Technical Information, National Bureau of Standards
U.S. Department of Commerce, Springfield, Virginia

ABSTRACT

A computer program has been prepared that provides an efficient means of using a data tape to survey selected aspects of isotopes, to identify isotopes by property, and to determine chains of nuclear processes.

CONTENTS

	<u>Page</u>
Computer Input Card Decks	3
Using the ISOTAB Program	4
Input Data for the ISOTAB Program	10
Use with Other Programs	16
Example Program DECAY	19
Symbolic Listings	28
Appendix - Program DECAY	29

ISOTOPIC DATA TAPE

Survey calculations in nuclear physics and related fields often require limited basic data on properties and reactions of many isotopes. Battelle-Northwest's Isotopic Data Tape provides this type of information in a readily usable form. The tape contains both the data library and the program to process it. This program loads the library for reference by other Univac-1107 programs, maintains the library, and prints out values for review.

No attempt has been made to provide the detailed data required by many calculations which are not of the survey type. This data is available from existing library tapes, such as the Battelle-Northwest Cross-Section Library tape. The Isotopic Data Tape provides an efficient means of surveying selected aspects of the various isotopes, of identifying isotopes which meet specified criteria, and of determining chains of nuclear processes.

FOR EACH OF THE ELEMENTS, the isotopic data tape provides the following values:

Identification

- Chemical symbol
- Chemical name
- Atomic number

Occurrence

- Abundance in the Earth's crust

Cross-sections

- Thermal neutron cross-section of the natural element
- Fission cross-section of the natural element in a fission neutron spectrum
- Capture cross-section of the natural element in a fission neutron spectrum

FOR SELECTED ISOTOPES, the tape provides:

Identification

- Chemical symbol
- Atomic number
- Mass number

Occurrence

- Fraction of the natural element
- Fraction of U^{233} fission products
- Fraction of U^{235} fission products
- Fraction of Pu^{239} fission products
- Fraction of Pu^{241} fission products

Characteristics

- Measured mass
- Magnetic moment
- Spin states
- Half-life
- Specific power of decay

Cross-sections

- 2200 m capture cross-section
- 2200 m fission cross-section
- Resonance integral cross-section
- Pile spectrum cross-section

Radioactive decay

- Alpha decay
- Beta decay
- Gamma decay
- Positron decay
- K-capture decay
- Isomeric transition decay

Nuclear reactions

- Types of reactions
- Cross-sections in a fission spectrum
- Threshold energies
- Simplified cross-section versus energy curves

The demonstration program DECAY (described on page 19) uses data from the tape to calculate radioactive decay chains. It is stored on the same magnetic tape.

COMPUTER INPUT CARD DECKS

When the programs stored with the Isotopic Data Tape are processed through the Battelle-Northwest Univac-1004 remote terminal, the first part of the card deck will consist of the following system cards (the symbol ▽ represents a 7-8 punch, in Column 1):

```
▽ TEL BNW JØB          TAPES U0594
▽ RUN          5, CUSxxx, xxx, xx      xxxxx
▽ R  ASG A=U0594
▽ XQT CUR
IN A
TRW A
```

These cards will be indicated in the following sections as system cards, and any variations will be noted.

Tape U0594 contains data for isotopes of general interest. Additional tapes have been prepared for isotopes included in specific areas of interest. If one of these tapes is used, the tape numbers will be changed on the TEL and ASG cards.

USING THE ISOTAB PROGRAM

Values entered on the data tape may be changed, new values entered, or printouts made by means of the ISOTAB program. Although the print-out feature was intended to permit verification of the entered values, it is adequate for reference listings of selected variables.

Control actions and the input data card formats are described on the pink sheets at the end of this section. Each control card operates independently, and the cards should be entered in the sequence in which operations are to take place. Diagnostic messages for improper input cards are self-explanatory.

For use with the Battelle-Northwest remote terminal, the card deck should appear as follows when no changes or entries are to be made on the tape:

system cards

```
7 DAT ITAPE/BIN,0
7N XQT ISOTAB
```

control cards

```
7 FIN
```

Additions to the isotopic data tape will be made by the Advanced Concepts and Analysis Section, and entered values will be modified as additional data become available. If changes are to be made to the tape, the deck should appear as follows:

system cards (TAPES U0594RI)

```

▽ DAT ITAPE/BIN, 0
▽N XQT ISOTAB

```

control cards and data entry cards

```

7 XQT CUR
OUT A, 1, 2, 3
TEF A
TRI A
▽ FIN

```

As an example, the following card deck would be used to print out all of the values which have been entered on the tape for the chemical elements.

```

▽ TEL BNW JOB          TAPES U0594
▽ RUN 5          ,CUS999, 05, 50          J SMITH
▽R ASG A=U0594
▽XQT CUR
IN A
TRW A
▽ DAT ITAPE/BIN, 0
▽N XQT ISOTAB
NEW PAGE
PRINT          ELEMENTS
NEW PAGE
ENDJOB
▽ FIN

```

A portion of the print-out which results is shown in Table I.

Tables II, III, and IV show print-outs from the control cards.

PRINT ISOTØPE	PU238		
PRINT HALF		H 003	ZN064
PRINT HALF	RANGE	0.1	1.0

A negative zero on the print-out indicates data which have not been entered on the tape.

TABLE I. VALUES FOR ELEMENTS FROM ISOTOPIC DATA TAPE, REVISED 05/04/66

SYMBOL	NAME	ABUNDANCE	THERMAL NEUTRON CROSS-SECTION	FISSION SPECTRUM FISSION C-S	FISSION SPECTRUM CAPTURE C-S
1	H	HYDROGEN	1.40000-03	3.30000-01	-0.00000
2	HE	HELIUM	3.00000-09	7.00000-03	-0.00000
3	LI	LITHIUM	6.50000-05	7.10000+01	-0.00000
4	BE	BERYLLIUM	6.00000-06	1.00000-02	-0.00000
5	B	BORON	3.00000-06	7.59000+02	-0.00000
6	C	CARBON	3.20000-04	3.70000-03	-0.00000
7	N	NITROGEN	4.60000-05	1.90000+00	-0.00000
8	O	OXYGEN	4.66000-01	2.00000-04	-0.00000
9	F	FLUORINE	3.00000-04	9.00000-03	-0.00000
10	NE	NEON	-0.00000	3.50000-02	-0.00000
11	NA	SODIUM	2.83000-02	5.30000-01	-0.00000
12	MG	MAGNESIUM	2.09000+02	6.30000-02	-0.00000
13	AL	ALUMINUM	8.13000-02	2.30000-01	-0.00000
14	SI	SILICON	2.77000-01	1.60000-01	-0.00000
15	P	PHOSPHORUS	1.18000-03	2.00000-01	-0.00000
16	S	SULPHUR	5.20000-04	5.20000-01	-0.00000
17	CL	CHLORINE	3.14000-04	3.40000+01	-0.00000
18	AR	ARGON	4.00000-08	6.30000-01	-0.00000
19	K	POTASSIUM	2.59000-02	2.10000+00	-0.00000
20	CA	CALCIUM	3.63000-02	4.30000-01	-0.00000
21	SC	SCANDIUM	5.00000-06	2.30000+01	-0.00000
22	TI	TITANIUM	4.40000-03	5.80000+00	-0.00000
23	V	VANADIUM	1.50000-04	4.90000+00	-0.00000
24	CR	CHROMIUM	2.00000-04	3.10000+00	-0.00000
25	MN	MANGANESE	1.00000-03	1.33000+01	-0.00000
26	FE	IRON	5.00000-02	2.60000+00	-0.00000
27	CO	COBALT	2.30000-05	3.70000+01	-0.00000
28	NI	NICKEL	8.00000-05	4.60000+00	-0.00000
29	CU	COPPER	7.00000-05	3.80000+00	-0.00000
30	ZN	ZINC	1.32000-04	1.10000+00	-0.00000
31	GA	GALLIUM	1.50000-05	3.00000+00	-0.00000
32	GE	GERMANIUM	7.00000-06	2.40000+00	-0.00000
33	AS	ARSENIC	5.00000-06	4.30000+00	-0.00000
34	SE	SELENIUM	9.00000-08	1.20000+01	-0.00000
35	BR	BROMINE	1.60000-06	6.70000+00	-0.00000
36	KR	KRYPTON	-0.00000	3.10000+01	-0.00000
37	RB	RUBIDIUM	3.10000-04	7.30000-01	-0.00000
38	SR	STRONTIUM	3.00000-04	1.30000+00	-0.00000
39	Y	YTTRIUM	2.80000-05	1.30000+00	-0.00000
40	ZR	ZIRCONIUM	2.20000-04	1.80000-01	-0.00000
41	NB	NIOBIUM	2.40000-05	1.10000+00	-0.00000

TABLE II. VALUES FOR ISOTOPES FROM ISOTOPIC DATA TAPE, REVISED 05/04/66

COL ISOTOPE	MEAS MASS	FRACTION	U-233 FP	U-235 FP	PU-239 FP	PU-241 FP	HALF-LIFE	SP POWER	MAG MOMENT
208 PU-238	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	3.28720+04	5.60000-01	-0.00000

COL ISOTOPE	SPIN STATES		BASIC L	1 L	2 L	3 L	4 L	5 L	6 L	7 L	8 L	9 L	10 L	11
208 PU-238			0/2	0/2	16/2	12/2	8/2	4/2	0/2	-0/2	-0/2	-0/2	-0/2	-0/2

COL ISOTOPE	2200 M CAP. C-S OR PILE C-S	RESONANCE C-S OR (+ZERO)	K CAPTURE DECAY FRACTION	ENERGY	ISOMERIC TRANSITION DECAY FRACTION	ENERGY
208 PU-238	4.030000+02	3.260000+03	-0.000000	-0.000000	-0.000000	-0.000000

COL ISOTOPE	ALPHA DECAY		POSITRON DECAY		BETA DECAY	
	FRACTION	ENERGY	FRACTION	ENERGY	FRACTION	ENERGY
208 PU-238	7.200000-01	5.491000+00	-0.000000	-0.000000	-0.000000	-0.000000
	2.800000-01	5.448000+00	-0.000000	-0.000000	-0.000000	-0.000000
	1.000000-03	5.348000+00	-0.000000	-0.000000	-0.000000	-0.000000
	5.000000-05	5.195000+00			-0.000000	-0.000000
	-0.000000	4.992000+00			-0.000000	-0.000000

GAMMA DECAY									
FRACTION	ENERGY	FRACTION	ENERGY	FRACTION	ENERGY	FRACTION	ENERGY	FRACTION	ENERGY
COL 208, ISOTOPE PU-238									
2.80000-01	4.30000-02	3.80000-04	4.36000-02	8.00000-05	9.96000-02	1.00000-05	1.52000-01	4.00000-08	2.03000-01
2.50000-06	7.60000-01	2.00000-07	8.10000-01	1.00000-03	1.00000-01	5.00000-05	1.53000-01	-0.00000	7.60000-01

TABLE III. VALUE OF THE VARIABLE HALF FROM ISOTOPIC DATA TAPE, REVISED 05/04/66

1	H -003	4.47800+03
2	F -019	0.00000
3	NA-022	9.42000+02
4	NA-023	0.00000
5	MG-025	0.00000
6	SI-030	0.00000
7	SI-031	1.08000-01
8	SI-032	2.55675+05
9	P -032	1.45000+01
10	S -032	0.00000
11	AR-038	0.00000
12	AR-039	9.67912+04
13	AR-040	0.00000
14	AR-041	7.62000-02
15	AR-042	1.27830+03
16	K -039	0.00000
17	K -042	5.20800-01
18	CA-044	-0.00000
19	CA-045	1.65000+02
20	SC-045	-0.00000
21	TI-049	-0.00000
22	V -049	3.30000+02
23	V -051	-0.00000
24	CR-050	-0.00000
25	CR-052	-0.00000
26	CR-054	-0.00000
27	MN-054	2.78000+02
28	MN-055	-0.00000
29	FE-054	-0.00000
30	FE-055	9.49650+02
31	FE-056	-0.00000
32	CO-057	2.70000+02
33	CO-059	-0.00000
34	CO-060	1.92500+03
35	NI-058	-0.00000
36	NI-062	-0.00000
37	NI-063	3.10462+05
38	NI-064	-0.00000
39	CU-065	-0.00000
40	ZN-064	-0.00000

TABLE IV. VALUES OF THE VARIABLE HALF BETWEEN 1.00000-1 AND 1.00000+00 ON ISOTOPIC DATA TAPE,
REVISED 05/04/66

<u>COL</u> 7	<u>SI-031</u>	ENTRY 1	<u>1.08000-01</u>
COL 65	RU-105	ENTRY 1	2.25000-01
COL 200	AC-228	ENTRY 1	2.55400-01
COL 148	ER-171	ENTRY 1	3.12500-01
COL 213	AM-244	ENTRY 1	4.16700-01
COL 184	PB-212	ENTRY 1	4.43000-01
COL 17	K -042	ENTRY 1	5.20800-01
COL 211	AM-242	ENTRY 1	6.66700-01
COL 169	IR-194	ENTRY 1	7.96600-01

INPUT DATA FOR THE ISOTAB PROGRAM

Control Cards

(Specify sequential operations. Only columns within boxes are significant.)

Card Column

<div>16</div>	<div>1116</div>	<div>2125</div>	<div>3135</div>	<div>4145</div>	
<u>Operation</u>	<u>Subject</u>	<u>Modifier</u>	<u>Lower Limit</u>	<u>Upper Limit</u>	<u>(notes)</u>
NEW TAPE	code				(1)
ELEMENTS	code				(2)
READ	TAPE	tape unit			(3)
PRINT	ELEMENT	symbol			(4)
PRINT	ELEMENTS		symbol	symbol	(5)
PRINT	ELEMENTS				(6)
PRINT	ISOTØPE	sym, mass			(7)
PRINT	ISOTØPES		sym, mass	sym, mass	(8)
PRINT	ISOTØPES				(9)
PRINT	variable	symbol			(10)
PRINT	variable	sym, mass			(11)
PRINT	variable		symbol	symbol	(12)
PRINT	variable		sym, mass	sym, mass	(13)
PRINT	variable				(14)
PRINT	variable	RANGE	value	value	(15)
PRINT	variable	RANGES	value	value	(16)
NEW PAGE					(17)
ERASE	ELEMENT	symbol			(18)
ERASE	ISOTØPE	sym, mass			(19)
ERASE	variable	symbol			(20)
ERASE	variable	sym, mass			(21)
ERASE	variable				(22)
DELETE	ISOTØPE	sym, mass			(23)
RECOPY	TAPE				(24)
RECOPY	TAPE	tape unit			(25)
SUPPRESS	TAPE COPY				(26)
ENTRIES	code				(27)
ENDATA					(28)
LOAD					(29)
END JOB					(30)

Control Cards (notes)

- (1) First card when a tape is being created for the first time ("code" is any 6-character data entry code word, established when a new tape is created, and required when changes are made to that tape). Input tape must be on logical unit 1 (tape A) and output tape must be on another unit.
- (2) First card if a new tape is to be created, using data for chemical elements only from an existing tape on logical unit 1 (tape A).
- (3) Read data matrices in from the specified logical numerical tape unit (not 7), instead of from the Isotopic Data Tape on the drum (must be the first card).
- (4) Print all values for this chemical element.
- (5) Print all values for elements from the lower limit to the upper limit.
- (6) Print all values for all chemical elements.
- (7) Print all values for this isotope.
- (8) Print all values for isotopes from the lower limit to the upper limit.
- (9) Print all values for all isotopes.
- (10) Print the value of the specified variable for this chemical element.
- (11) Print the value of the specified variable for this isotope.
- (12) Print the value of the specified variable for elements from the lower limit to the upper limit.
- (13) Print value of specified variable for isotopes from lower to upper limit.
- (14) Print value of specified variable for all elements or isotopes.
- (15) Print identification and values for all entries of this variable falling within the specified range, from the lower to the upper limit (E, F, or I format).
- (16) Print identification and values for all entries of this variable falling within the specified range, from the lower to the upper limit, for isotopes which are also included in the limits of all RANGES cards immediately preceding this one (E, F, or I format; a NEW PAGE card will not interrupt the sequence of RANGES cards).
- (17) Start the next print-out at the top of a new page.
- (18) Convert all values for this element except SYMBOL to -0 (a -0 indicates missing data).
- (19) Convert all values for this isotope except ID to -0.
- (20) Convert the entry for this variable, for this element, to -0.
- (21) Convert the entry for this variable, for this isotope, to -0.
- (22) Convert all entries for this variable to -0.
- (23) Eliminate this isotope from the data tape.
- (24) Recopy matrices on the drum at the end of this run (this will be done automatically whenever new isotopes are entered or deleted, or changes made, unless SUPPRESS TAPE COPY is entered).
- (25) Recopy matrices on the specified logical numerical tape unit (tape unit must be indicated on ▽ ASG and ▽ TEL cards), but not symbolic or object programs.
- (26) Do not recopy matrices on the drum, or retain on the drum any changes made during this run.
- (27) All data entry cards are placed between an ENTRIES card and
- (28) an ENDATA card.
- (29) Load data matrices for use by another program, when ENDJOB is read.
- (30) Last card. All operations have been requested; complete housekeeping.

Data Entry Cards

(Batched between ENTRIES and ENDATA cards)

Entries for a specified element or isotope

An entry will replace any previous entry for single-entry variables; previous entries for multiple-entry variables will be retained.

Values may be entered as exponentials (eg., 1.4E1 or 1.4+1), floating point (14.0), or integers (14); blank columns are equivalent to zeroes.

Card Column

1	67	11	22	33	33	44	55	66	66	7777	8
		56	12	01	67	56	12	01	67	5678	0

(name)(value)(name)(value)(name)(value)(name)(value)(name)(value) ssmmm

name is an accessible variable name, not including special variables

ss is the chemical symbol of an element (with mmm blank)

ssmmm is the symbol and mass of an isotope

(1 to 5 entries per card. For double-word variables, enter name of variable, first value, (blank), second value)

Entries for a specified variable

(Values will be entered in sequential element or isotope columns)

Card Column

1										67	7777	8
										90	5678	0

(columns 1-69 blank)

(name)ssmmm

name is an accessible variable name, not including special variables

ss is the element symbol of the first entry on the next card

ssmmm is the isotope symbol and mass of the first entry on the next card

..... followed by any number of data cards with sequential data,

Card Column

1												80
---	--	--	--	--	--	--	--	--	--	--	--	----

(Any number of sequential values, each value except the last on each card followed by a comma. All nonblank fields must include a decimal point. A value may not be split between two cards, and all cards after the first data card must include at least one comma. Blank fields will be entered as -0, to indicate missing data.)

Entries for special variables

DATE	col 70-73 1- 2 3- 4 5- 6	DATE mm dd yy for mm/dd/yy
INDEX	col 70-74 79-80 1-60	INDEX Sequence number of first entry 10 fields, 6 columns each, for alphanumerics A blank field does not make or delete an entry, but is counted in sequencing ERASE deletes all entries
SYMBOL	col 70-75 1-60	SYMBOL 10 fields, 6 columns each, for entry of two- column chemical symbol, three-digit atomic number, blank column. May be in any order Blank fields are ignored
NAME	col 70-73 76-77 1-60	NAME Symbol of first entry 5 fields, 12 columns each, for alphanumerics A blank field does not make or delete an entry, but is counted in sequencing
SPIN	col 70-73 76-80 1-36	SPIN Isotope symbol and mass 12 fields, 3 columns each, for right-adjusted numerators of $x/2$ spin states Blank fields are entered as -0. ERASE deletes all entries for this isotope
Isotopic reaction data		
	col 70-74 76-80 68-69 1-10 11-20 21-35 36-50 51-65 66-67	REACT Isotope symbol and mass Sequence number, for this isotope, of this reaction Value of FISPEC Value of THRESH First CURVE values (starting energy, inter- cept, slope), 5 columns each Second CURVE values (energy, intercept, slope), 5 columns each Third CURVE values (energy, intercept, slope), 5 columns each Value of NOR (sequence number of reaction in INDEX)

Names of Accessible Variables(multiple entries)

DATE	*Date last changes were entered	
INDEX	*Table of isotopic reactions, e. g. (N, P), 20 max	
Elements	(103 max)	
SYMBOL	*Chemical symbol and atomic number	
NAME	*Chemical name (12 characters max)	
CRUST	Abundance in Earth's crust	
THERM	Thermal neutron cross-section	
FISNAT	Fission spectrum fission cross-section	
CAPNAT	Fission spectrum capture cross-section	
Isotopes	(400 max)	
ID	Column number index of isotopes entered on the tape (not for data entry)	
WEIGHT	Measured mass	
PCT	Fraction of natural element	
FP233	Fraction of U ²³³ fission product	
FP235	Fraction of U ²³⁵ fission product	
FP239	Fraction of Pu ²³⁹ fission product	
FP241	Fraction of Pu ²⁴¹ fission product	
HALF	Half-life (days)	
POWER	Specific power	
COMPAS	Magnetic moment	
SPIN	*Spin state (basic and 11 excited levels, $\pm 3 \frac{1}{2}$ max)	
SIGMAC	2200 m capture cross-section and resonance integral cross-section, or pile section cross-section and +0	
CAPK	K-capture decay fraction and energy	
TRANS	Isomeric transition decay fraction and energy	
ALPHA	Alpha decay fraction and energy	(5 max)
POSIT	Positron decay fraction and energy	(3 max)
BETA	Beta decay fraction and energy	(5 max)
GAMMA	Gamma decay fraction and energy	(10 max for 380, 15 max for 20)
SIGMAF	2200 m fission cross-section and resonance integral cross-section, or pile spectrum cross-section and positive zero. (40 isotopes max)	
*Isotopic reaction data		(3 max for 380, 18 max for 20)
NOR	*Sequence number of reaction in INDEX	
FISPEC	*Fission spectrum cross-section value	
THRESH	*Threshold energy	
CURVE	*Starting energy, intercept, and slope for three cross-section curve sections	

*Indicates special format is required for entry of data

Example of an Input Deck

```

( 1) ENTRIES
( 2) CRUS T      1. 2 E- 7 FIS NAT      . 0 0 0 1      XE
( 3)                                     HALF XE124
( 4) 1. 4, 2 0 7 8. , 5. 0 - 3 ,      1 1 1. , 1. 0
( 5) 0 3 1 1 6 6      DATE
( 6) ENDDATA
( 7) PRINT      ELEMENT      XE
( 8) NEW PAGE
( 9) PRINT      HALF      XE124 U 235
(10) PRINT      ID
(11) PRINT      INDEX
(12) ENDJØB

```

- (1) The following cards contain values to be entered into the data matrix.
- (2) Insert 1.2×10^{-7} as the abundance of xenon, and 0.001 as the fission spectrum fission cross-section of xenon.
- (3) The following cards insert values of half-lives for isotopes starting with Xe¹²⁴.
- (4) Insert 1.4, 2078, 0.005, 111, and 1 as half-life values for Xe¹²⁴ and the next four isotopes listed in the tabular variable ID.
- (5) Label this tape with the date 3/11/66.
- (6) That was the last data entry card.
- (7) Print all values entered for the element xenon.
- (8) Start a new page on the print-out.
- (9) Print half-life values for isotopes Xe¹²⁴ through U²³⁵ (isotopes are stored in ascending atomic number, mass number order).
- (10) Print the index of isotopes entered on the tape.
- (11) Print the table of isotopic reactions.
- (12) This is the end of the input data deck.

Note: If the matrix is just to be loaded from tape, the input deck will consist of

```

LOAD
ENDJØB

```

A list of the isotopes which are currently stored on the tape may be obtained by the control card

```

PRINT ID

```


USE WITH OTHER PROGRAMS

The primary purpose of the Isotopic Data Tape is as a source of physics data in the computer high-speed internal memory, accessible to programs which will utilize the data.

A program to be applied in this manner must be compiled with the C option and must include the following statement ahead of any executable statements:

```
INCLUDE COMDIM
```

The program also must include the following statement to load the data tape matrices:

```
CALL NTRAN (25, 2, 43663, NUMBER, LTEST)
```

The sequence of data on the Isotopic Data Tape is described at the start of the ISOTAB program symbolic listing, along with a description of the variables. Entered values are stored on the tape in sections, with sequential entries for all values within a section which apply to a given isotope. As stored in the computer memory for use by other programs, sequential entries for all of the isotopes are stored for each variable in the data matrices. Elements are stored by ascending atomic number. Isotopes are stored in ascending atomic number and mass number.

Programs which use data from the data tape do not depend on the arrangement of the data on the tape or in memory. Program statements reference the data by the variable names listed on page 14 of the pink sheets, with subscripts as indicated in the DIMENSION statement which is shown on page 29.

The variables SYMBOL, NAME, INDEX, ID, and DATE store data in BCD form.

SYMBOL has two characters for the chemical symbol, three characters for the atomic number, and one blank character. ID has three characters for the atomic number and three characters for the mass number.

A search which compares the first three characters of ID with characters three to five of SYMBOL is necessary when isotopes are specified by symbol and mass number, and the Univac-1107 function FLD is useful for this manipulation.

DATE has two BCD characters each for the month, day, and year. The FLD function can be used to split this word for printing in a more familiar form. DATE will be all blanks if changes were made to the data tape without the entry of a new date.

GAMMA2 contains additional entries of GAMMA values for any twenty isotopes. The last entries in GAMMA for these isotopes are the negative of the row number in GAMMA2 which has the additional values.

Each row in SIGMAF has three entries. The third of these is the isotope number which the row applies to.

NOR contains three integer numbers, in bits 6 - 11, 12 - 17, and 18 - 23 (where a word has 0 - 35 bits). Each of the three words in NOR2 contains five integer numbers, in bits 6 - 11, 12 - 17, 18 - 23, 24 - 29, and 30 - 35. These numbers are subscripts for the variable INDEX. Corresponding values of INDEX are BCD symbols for the reactions described by FISPEC, THRESH, and CURVE. If NOR is negative, then additional reaction entries for that isotope are entered in the supplementary tables, and the integer number in bits 2 - 5 is the row of NOR2, FISPE2, THRES2, and CURVE2 with the additional entries.

A card input deck to provide the contents of the isotopic data tape for the use of another program (called "NAME" in this example) will look like this:

```

[system cards]
▽IC FRN NAME, NAME
[symbolic program "NAME" to use data]
▽ DAT ITAPE/BIN, 0
▽N XQT ISOTAB
LOAD
ENDJOB
▽ XQT NAME
[input data cards for the program "NAME"]
▽FIN

```

If the new program is to be saved on tape, for subsequent runs, the deck will have changed ▽TEL and ▽ASG cards, and will have additional system cards after the compilation.

```

[system cards (TAPES U0594, TITLE and ASG A=U0594, B=TITLE)]
▽IC FRN NAME, NAME
[symbolic program "NAME"]
▽ XQT CUR
OUT B, 1, 2, 3
TEF B
TRI B
▽ DAT ITAPE/BIN, 0
▽N XQT ISOTAB
LOAD
ENDJOB
▽ XQT NAME
[input data cards for "NAME"]
▽ FIN

```

Subsequent runs will use tape B only, and will not include the compilation or the second ▽XQT CUR operations.

EXAMPLE PROGRAM

The program DECAY, which is stored on the same tape as the isotopic data library and the program ISOTAB, is an example of a program using information on the Isotopic Data Tape. It calculates quantities of the isotopes present in radioactive decay chains after a specified time interval.

The input data cards for this program follow the format below, with one card for the parent isotope of each chain to be calculated.

col	1-8	Initial weight of parent isotope
	10-11	Units of weight
	16-20	Symbol and mass number of parent isotope
	28-35	Elapsed time
	37-	Units of time (YEARS, DAYS, HOURS, MINUTES, or SECONDS)

Output of the program is printed in the format of the familiar isotopic charts, and Figure 5 corresponds to the section of chart shown.

Po 210 RaF 138.40d α 5.30, γ .80 σ (.0005+.03) 209.9829	Po 211 25s AcC' α 7.1, 0.52s 8.7, α 7.44, γ .89, γ .89, .57 (11, 57) 210.9866	Po 212 46s ThC' α 11.7, 0.30 μ s γ .88, α 8.78 211.9889	Po 213 4 μ s α 8.37 212.9928	Po 214 RaC' 164 μ s α 7.68 213.9952
Bi 209 100 σ (.019+.015) 208.9804	Bi 210 2.6x10 ⁶ y RaE α 4.93, 5.0d 4.89, β 1.16 4.59, α 4.7, γ .e- no γ E 1.39	Bi 211 AcC 2.15m α 6.62, 6.27, (9) β .35 e- E .60, 210.9873	Bi 212 ThC 60.6m β 2.25 α 6.05, 6.09, (9.5-10.5) 7.040-2.20 E 2.25	Bi 213 47m β 1.39, .96 γ .44 α 5.9 E 1.39
Pb 208 52.3 σ .0005 207.9766	Pb 209 3.3h β .635 no γ E 635	Pb 210 RaD 21y β .015, .061 γ .047 E .061	Pb 211 AcB 36.1m β 1.39, .56, γ .83, .41, .06-1.1 E 1.39	Pb 212 ThB 10.64h β .34, .58, γ .239, .30, .11-.41 E .58
Tl 207 AcC'' 4.78m β 1.44, γ .89 E 1.44	Tl 208 ThC'' 3.1m β 1.80, 1.0-2.36 γ 2.61, .58, .51, .040-1.09 E 4.95	Tl 209 2.2m β 1.8, 2.3 γ 11-1.6, 12D E 3.9	Tl 210 RaC'' 1.32m β 1.96 (n) γ .8, .2-2.4 E 5.4	

Figure 1 shows the resulting output when an input card is

```
1.0      KG      PB212          1.0 DAYS
```

Figures 1 through 6, which show the buildup of Pb^{208} with time, are produced by the deck

System Cards			
▽ DAT ITAPE/BIN,0			
VN XQT ISCTAB			
LOAD			
ENDJOB			
VN XQT DECAY			
1.0	KG	PB212	1.0 DAYS
1.0	KG	PB212	2.0 DAYS
1.0	KG	PB212	4.0 DAYS
1.0	KG	PB212	8.0 DAYS
1.0	KG	PB212	1.6E+1 DAYS
1.0	KG	OF PB212 AFTER	3.2+1 DAYS
▽ FIN			

In the print-outs from this program, the parent isotope is enclosed in a box. Half-lives are shown in days. Half-life will be replaced by "(STABLE)" for isotopes with an entry of zero half-life, and by a blank line for isotopes which are not present on the data tape. Weights will be indicated as "TRACE" for those isotopes with a weight/(initial weight of the parent) ratio less than 10^{-14} , because the limitations on significant figures within the computer make these values meaningless.

In this program, the weights of isotopes in a decay chain are calculated by a modification of the classical Bateman equation

$$(\text{weight})_n = (\text{weight})_1 \frac{(\text{isotopic mass})_n}{(\text{isotopic mass})_1} \sum_{i=1}^n C_i e^{-\lambda_i(\text{time})}$$

where

$$C_i = \frac{\prod_{j=1}^{n-1} \lambda_j^*}{\prod_{\substack{k=1 \\ k \neq i}}^n (\lambda_k - \lambda_i)}$$

and

$$\lambda_j^* = \lambda_j \cdot (\text{fraction of total decay for this path})$$

The term $\frac{1}{2^{t/T_{1/2}}}$ is equivalent to $e^{-\lambda t}$, and is used in its place

to increase computational accuracy.

The appendix contains a listing of the program DECAY.

1.150-12 KG OF
PO-212
(3.47-12 HALFLIFE)

ALPHA DECAY
TO PB-208

2.191-02 KG OF
BI-212
(4.20-02 HALFLIFE)

ALPHA DECAY
TO TL-208

BETA DECAY
TO PO-212

7.539-01 KG OF
PB-208
(STABLE)

4.029-04 KG OF
TL-208
(2.15-03 HALFLIFE)

BETA DECAY
TO PB-208

* 2.092-01 KG OF *
* PB-212 *
(4.43-01 HALFLIFE)

* BETA DECAY *
* TO BI-212 *

Figure 1. RADIOACTIVE DECAY PRODUCTS OF 1.0000+00 KG OF PB212 AFTER 1.0000+00 DAYS

2.406-13 KG OF
PO-212
(3.47-12 HALFLIFE)

ALPHA DECAY
TO PB-208

4.582-03 KG OF
BI-212
(4.20-02 HALFLIFE)

ALPHA DECAY
TO TL-208

BETA DECAY
TO PO-212

9.335-01 KG OF
PB-208
(STABLE)

8.427-05 KG OF
TL-208
(2.15-03 HALFLIFE)

BETA DECAY
TO PB-208

* 4.375-02 KG OF *
* PB-212 *
(4.43-01 HALFLIFE)

* BETA DECAY *
* TO BI-212 *

Figure 2: RADIOACTIVE DECAY PRODUCTS OF 1.0000+00 KG OF PB212 AFTER 2.0000+00 DAYS

1.053-14 KG OF
PO-212
(3.47-12 HALFLIFE)

ALPHA DECAY
TO PB-208

2.004-04 KG OF
BI-212
(4.20-02 HALFLIFE)

ALPHA DECAY
TO TL-208

BETA DECAY
TO PO-212

9.789-01 KG OF
PB-208
(STABLE)

3.686-06 KG OF
TL-208
(2.15-03 HALFLIFE)

BETA DECAY
TO PB-208

* 1.914-03 KG OF *
* PB-212 *
(4.43-01 HALFLIFE)

* BETA DECAY *
* TO BI-212 *

Figure 3. RADIOACTIVE DECAY PRODUCTS OF 1.0000+00 KG OF PB212 AFTER 4.0000+00 DAYS

TRACE OF
PO-212
(3.47-12 HALFLIFE)

ALPHA DECAY
TO PB-208

3.836-07 KG OF
BI-212
(4.20-02 HALFLIFE)

ALPHA DECAY
TO TL-208

BETA DECAY
TO PO-212

9.810-01 KG OF
PB-208
(STABLE)

7.055-09 KG OF
TL-208
(2.15-03 HALFLIFE)

BETA DECAY
TO PB-208

* 3.663-06 KG OF *
* PB-212 *
(4.43-01 HALFLIFE)

* BETA DECAY *
* TO BI-212 *

Figure 4. RADIOACTIVE DECAY PRODUCTS OF 1.0000+00 KG OF PB212 AFTER 8.0000+00 DAYS

TRACE OF
PO-212
(3.47-12 HALFLIFE)

ALPHA DECAY
TO PB-208

1.405-12 KG OF
BI-212
(4.20-02 HALFLIFE)

ALPHA DECAY
TO TL-208

BETA DECAY
TO PO-212

9.810-01 KG OF
PB-208
(STABLE)

2.584-14 KG OF
TL-208
(2.15-03 HALFLIFE)

BETA DECAY
TO PB-208

```
*****
* 1.341-11 KG OF *
*      PB-212      *
* (4.43-01 HALFLIFE)*
*
*   BETA DECAY   *
*   TO BI-212   *
*****
```

Figure 5. RADIOACTIVE DECAY PRODUCTS OF 1.0000+00 KG OF PB212 AFTER 1.6000+01 DAYS

TRACE OF
PO-212
(3.47-12 HALFLIFE)

ALPHA DECAY
TO PB-208

TRACE OF
BI-212
(4.20-02 HALFLIFE)

ALPHA DECAY
TO TL-208

BETA DECAY
TO PO-212

9.810-01 KG OF
PB-208
(STABLE)

TRACE OF
TL-208
(2.15-03 HALFLIFE)

BETA DECAY
TO PB-208

* TRACE OF *
* PB-212 *
(4.43-01 HALFLIFE)

* BETA DECAY *
* TO BI-212 *

Figure 6. RADIOACTIVE DECAY PRODUCTS OF 1.0000+00 KG OF PB212 AFTER 3.2000+01 DAYS

SYMBOLIC LISTINGS

A listing of the symbolic program ISOTAB can be obtained by submitting the following deck:

```


system cards

  
LIST ISOTAB  
▽ FIN
```

A listing of the program DECAY can be obtained by substituting the card

```
LIST DECAY
```

These list cards can also be inserted immediately after the system cards in any run which uses the Isotopic Data Tape.

APPENDIX

Program DECAY

@ ELT DECAY,1,670425, 62206

```

000001      C   DEMONSTRATION PROGRAM FOR THE APPLICATION OF ISOTOPIC DATA TAPE
000002      C   - RADIOACTIVE DECAY PRODUCTS -
000003      C
000004      C
000005      C   - R L REYNOLDS
000006      C
000007      C   INCLUDE COMDIM, LIST
000008      C
000009      C   DOUBLE PRECISION COEF,DECAY
000010      C   DIMENSION FLTBL(7)
000011      C   DIMENSION TIMU(5),LINE(2),KECAY(3,4),MOTHER(55,55,4),DURAT2(2), DIMENSION
000012      C   1 ISOTOP(55,55),WEIGHS(55,55),FRAC(3),DECAY(200,2) DIMENSION
000013      C   DIMENSION FMT(6,6),FMTFLD(4,7),FMT4(4,2),FMTB(4),PO(6),IPO(6),
000014      C   1 IPO3(3,6),INOW(6)
000015      C   EQUIVALENCE (MOTHER,S(26704)),(WEIGHS,S(39904))
000016      C   DATA TIMU/3HYEA,3HDAY,3HHOU,3HMIN,3HSEC/
000017      C   1 ,LINE/ 6H*****, 1H /
000018      C   3 ,KECAY/6H ALP,6HHA DE,3HCAY,6H BE,6HTA DEC,2HAY,
000019      C   4 6HPOSITR,6HON+EC ,5HDECAY,6HPOSITR,6HON+EC ,5HDECAY/
000020      C   5 ,BLANK/1H /,MINUS/3H -/,NULL/6H000000/
000021      C   DATA FMT1/4H(1X,/,FMT36/3H1X)/,FMTS/3H1X,/,FMTISI/4H1H*,/
000022      C   1 , FMTB/4H18X,,3*1H /,FMT4/6H5X,1H(,6H,A6,1H,5H),5X,,1H ,
000023      C   2 6H1H(,1P,6HE7.2,1,6H0H HAL,6HFLIFE)/,FMT4B/6HSTABLE/
000024      C   3 ,FMTFLD/4H3A6,,3*1H ,
000025      C   4 6H1PE10,,6H3,1X,A,6H2,5H 0,4HF ,
000026      C   5 6H6X,A6,,3H6X,,2*1H ,
000027      C   6 4*1H ,
000028      C   7 4H3A6,,3*1H ,
000029      C   8 6H4X,4HT,6H0 ,A6,4H,4X,,1H ,
000030      C   9 3H5X,,6H8HTRAC,5HE OF,,3H5X,/
000031      C   900 FORMAT (2I3)
000032      C   920 FORMAT (A6)
000033      C   940 FORMAT (E8.0,1X,A2,4X,A5,7X,E8.0,1X,A3)
000034      C   960 FORMAT (17X,I3,16X,A6,A1)
000035      C   999 FORMAT (1H1/20(1H0/),1X,43(1H.),23H START OF VERTICAL SET ,12,
000036      C   1 4H OF ,12,44(1H.))
000037      C   1000 FORMAT (1H1,22X,29HRADIOACTIVE DECAY PRODUCTS OF,1PE10.4,1X,A2,
000038      C   1 4H OF ,A6,6H AFTER,E10.4,1X,A6,A1/1H0)
000039      C   1001 FORMAT (1H1/1H0)
000040      C   1009 FORMAT (1H )
000041      C   1100 FORMAT (25H1AN ENTRY OF THE ISOTOPE ,A6,18H IS UNRECOGNIZABLE)
000042      C   1101 FORMAT (21H0THE ISOTOPE WITH Z =,I4,11H AND MASS =,I4,67H FALLS OU
000043      C   1TSIDE OF DIMENSIONED ARRAYS. THE CHAIN HAS BEEN CUT HERE.)
000044      C   1102 FORMAT (40H1ERROR IN READING THE ISOTOPIC DATA TAPE/1H1)
000045      C   CALL SETDR(10,600000,100,FLTBL)

```

000045		LV=-4	
000046		LTIME=1	
000047	2	CALL NTRAN (25,10,2,43663,NUMBER,LTEST)	
000048		GO TO (3,30), LTIME	
000049	3	MDIM=55	DIMENSION
000050		M=(4*MDIM)/5	
000051		DO 4 I=2,6	
000052		FMT(1,I)=FMTS	
000053	4	FMT(6,I-1)=FMTS	
000054		FMT(1,1)=FMT1	
000055		FMT(6,6)=FMT36	
000056	10	DO 15 I=1,MDIM	
000057		DO 15 J=1,MDIM	
000058		ISOTOP(I,J)=0	
000059		WEIGHS(I,J)=0.0	
000060		DO 15 K=1,4	
000061	15	MOTHER(I,J,K)=0	
000062	C	ISOTOP(2+INCZ,M+INCM)=ISOTOPE COLUMN (-A6 IF NOT ON TAPE)	
000063	C	MOTHER(2+INCZ,M+INCM,1-3)=PARENTZ,M,NN WHEN LEFT	
000064	C	MOTHER(2+INCZ,M+INCM,4)=RECORD OF DECAY PATHS (. . . PBA)	
000065		READ(5,940) POUNDS,UNITS,ISI,ELAPSE,DURAT	
000066	C	STARTING WEIGHT,UNITS OF WEIGHT,STARTING ISOTOPE,TIME INTERVAL,	
000067	C	TIME UNITS	
000068		ISO=ISI	
000069		READ(LV,960) INITM,DURAT2	
000070		NEXT=1	
000071		DO 20 J=1,5	
000072		IF (DURAT-TIMU(J)) 20,21,20	
000073	20	CONTINUE	
000074		DURAT=TIMU(2)	
000075		J=2	
000076	21	GO TO (22,23,24,25,26), J	
000077	22	TIME=ELAPSE*365.25	
000078		GO TO 30	
000079	23	TIME=ELAPSE	
000080		GO TO 30	
000081	24	TIME=ELAPSE/24.0	
000082		GO TO 30	
000083	25	TIME=ELAPSE/1440.0	
000084		GO TO 30	
000085	26	TIME=ELAPSE/86400.0	
000086	30	LTEST=LTEST	
000087		IF (LTEST+1) 31,30,40	
000088	31	GO TO (32,33), LTIME	
000089	32	LTIME=2	
000090		CALL NTRAN (25,22)	
000091		GO TO 2	
000092	33	WRITE(6,1102)	
000093	40	DO 42 IE=1,103	

```

000094      IF (FLD(0,12,ISO)-FLD(0,12,SYMBOL(IE))) 42,46,42
000095      42 CONTINUE
000096      44 WRITE(6,1100) ISO
000097      GO TO 10
000098      46 INITZ=IE
000099      IZP=IE
000100      FLD(18,18,ISO)=FLD(12,18,ISO)
000101      FLD(0,18,ISO)=FLD(12,18,SYMBOL(IE))
000102      INCZ= M-INITZ
000103      INCM= M-INITM
000104      IZ=M
000105      IM=M
000106      MAXZ=M
000107      MINZ=M
000108      MAXM=M
000109      MINM=M
000110
000111      C      50 DO 54 I=1,6
000112      IF (FLD(6*(I-1),6,ISO)-FLD(6,6,BLANK)) 54,52,54
000113      52      FLD(6*(I-1),6,ISO)=FLD(6,6,NULL)
000114      54 CONTINUE
000115      NNOW=MAX0(40,NUMBER/8)
000116      I1=NUMBER+1
000117      80 I2=I1-1
000118      IF (I2) 103,103,90
000119      90 I1=MAX0(1,I2-NNOW)
000120      DO 100 IC=I1,I2
000121      IF (ISO-ID(IC)) 80,104,100
000122      100 CONTINUE
000123      103 FLD(12,6,ISO)=FLD(12,6,MINUS)
000124      FLD(0,12,ISO)=FLD(0,12,SYMBOL(IZP))
000125      8104 IC=-ISO
000126      GO TO (44,105), NEXT
000127      104 GO TO (9105,105,8104), NEXT
000128      9105 ISS=IC
000129      NO=1
000130      WINIT=WEIGHT(IC)
000131      IF (WINIT) 8105,8105,105
000132      8105 WINIT=INITM
000133      105 ISOTOP(IZ,IM)=IC
000134      NEXT=2
000135      NN=1
000136      200 DECAY(NO,1)=DLOG(2.0D0)/HALF(IC)
000137      DECAY(NO,2)=HALF(IC)
000138      IF (WEIGHT(IC)) 202,202,9202
000139      202 WEIGHT(IC)=IM-INCM-M+IZ
000140      9202 DO 203 J=1,NO
000141      COEF=1.0D0
000142      DO 9203 K=1,NO

```

```

000143      IF (K=NO) 6203,7203,6203
000144      6203 COEF=COEF*DECAY(K+100,1)
000145      7203 IF (K=J) 8203,9203,8203
000146      8203 COEF=COEF/(DECAY(K,1)-DECAY(J,1))
000147      9203 CONTINUE
000148      203 WEIGHS(IZ,IM)=WEIGHS(IZ,IM)+POUNDS*WEIGHT(IC)/WINIT
000149      1 *COEF*2.D0**(-TIME/DECAY(J,2))
000150      IF (ISOTOP(IZ,IM)) 500,500,204
000151      204 IF (HALF(IC)) 500,500,205
000152      205 DO 206 I=1,3
000153      206 FRAC(I)=0.0
000154      DO 210 I=1,5
000155      FRAC(1)=FRAC(1)+ALPHA(IC,1,I)
000156      210 FRAC(2)=FRAC(2)+BETA(IC,1,I)
000157      DO 220 I=1,3
000158      220 FRAC(3)=FRAC(3)+POSIT(IC,1,I)
000159      FRAC(3)=FRAC(3)+CAPK(IC,1)
000160      TFRAC=FRAC(1)+FRAC(2)+FRAC(3)
000161      DO 230 I=1,3
000162      230 FRAC(I)=FRAC(I)/TFRAC
000163      300 IF (FRAC(NN)) 400,400,305
000164      305 FLD(36=NN,1,MOTHER(IZ,IM,4))=FLD(35,1,BLANK)
000165      GO TO (306,307,308), NN
000166      306 NEXTZ=IZ-2
000167      NEXTM=IM-2
000168      GO TO 310
000169      307 NEXTZ=IZ+1
000170      NEXTM=IM-1
000171      GO TO 310
000172      308 NEXTZ=IZ-1
000173      NEXTM=IM+1
000174      310 IF (NEXTZ*(MDIM+1-NEXTZ)) 312,312,311
000175      311 IF (NEXTM*(MDIM+1-NEXTM)) 313,313,315
000176      312 NOw=2
000177      N=IZ
000178      IF (NEXTZ) 6312,6312,4312
000179      4312 IF (MINZ-1) 314,314,5312
000180      5312 MOVEZ=1
000181      GO TO 9614
000182      6312 IF (MAXZ-MDIM) 314,314,7312
000183      7312 MOVEZ=MAXZ-MDIM
000184      I1=MAXZ
000185      I2=MINZ
000186      I3=-1
000187      GO TO 615
000188      9312 INITZ=INITZ-MOVEZ
000189      MINZ=MINZ-MOVEZ
000190      MAXZ=MAXZ-MOVEZ
000191      NEXTZ=NEXTZ-MOVEZ

```

```

000192      INCZ=INCZ+MOVEZ
000193      IZ=N-MOVEZ
000194      GO TO 310
000195 313 NOW=2
000196      N=IM
000197      IF (NEXTM) 6313,6313,4313
000198 4313 IF (MINM-1) 314,314,5313
000199 5313 MOVEM=1
000200      GO TO 604
000201 6313 IF (MAXM-MDIM) 314,314,7313
000202 7313 MOVEM=MAXM-MDIM
000203      J1=MAXM
000204      J2=MINM
000205      J3=-1
000206      GO TO 605
000207 9313 INITM=INITM-MOVEM
000208      MINM=MINM-MOVEM
000209      MAXM=MAXM-MOVEM
000210      NEXTM=NEXTM-MOVEM
000211      INCM=INCM+MOVEM
000212      IM=N-MOVEM
000213      GO TO 310
000214 314 IZI=NEXTZ-INCZ
000215      IMI=NEXTM-INCM-M+NEXTZ
000216      WRITE(6,1101) IZI,IMI
000217      GO TO 400
000218 315 MOTHER(NEXTZ,NEXTM,1)=IZ
000219      MOTHER(NEXTZ,NEXTM,2)=IM
000220      MOTHER(NEXTZ,NEXTM,3)=NN
000221      DECAY(NO+100,1)=DECAY(NO,1)*FRAC(NN)
000222      NO=NO+1
000223 320 IZ=NEXTZ
000224      IM=NEXTM
000225      MAXZ=MAX0(MAXZ,IZ)
000226      MAXM=MAX0(MAXM,IM)
000227      MINZ=MIN0(MINZ,IZ)
000228      MINM=MIN0(MINM,IM)
000229      NN=1
000230      IC=ISOTOP(IZ,IM)
000231      IF (IC) 500,330,200
000232 330 IZP=IZ-INCZ
000233      IMP=IM-INCM-M+IZ
000234      REWIND 10
000235      WRITE(10,900) IZP,IMP
000236      REWIND 10
000237      READ(10,920) ISO
000238      GO TO 50
000239 400 NN=NN+1
000240      IF (NN-3) 300,300,500

```

```

000241      500 IF (MOTHER(IZ,IM,1)) 502,502,501
000242      501 NEXTZ=MOTHER(IZ,IM,1)
000243      NEXTM=MOTHER(IZ,IM,2)
000244      NN =MOTHER(IZ,IM,3)
000245      NO=NO-1
000246      IZ=NEXTZ
000247      IM=NEXTM
000248      IC=ISOTOP(IZ,IM)
000249      NN=NN+1
000250      IF (NN-3) 205,205,500
000251      502 NN=NN+1
000252      IF (HALF(IC)) 600,600,503
000253      503 IF (NN-3) 300,300,600
000254      C PRINT-OUT
000255      600 NTOTAL=MAXZ-MINZ+1
000256      MTOTAL=MAXM-MINM+1
000257      603 MOVEZ=MINZ-1
000258      IPT=(MTOTAL-1)/6+1
000259      MBLANK=MAX(0,(6*IPT-MTOTAL)/2)
000260      MOVEM=MINM-1-MBLANK
000261      MTOTAL=MTOTAL+MBLANK
000262      NOW=1
000263      604 J1=MINM
000264      J2=MAXM
000265      J3=1
000266      IF (MOVEM) 614,614,605
000267      605 DO 610 I=MINZ,MAXZ
000268      DO 610 J=J1,J2,J3
000269      IM=J-MOVEM
000270      ISOTOP(I,IM)=ISOTOP(I,J)
000271      ISOTOP(I,J)=0
000272      MOTHER(I,IM,4)=MOTHER(I,J,4)
000273      MOTHER(I,J,4)=0
000274      GO TO (609,606), NOW
000275      606 MOTHER(I,IM,2)=MOTHER(I,J,2)-MOVEM
000276      MOTHER(I,IM,1)=MOTHER(I,J,1)
000277      MOTHER(I,IM,3)=MOTHER(I,J,3)
000278      DO 608 K=1,3
000279      608 MOTHER(I,J,K)=0
000280      609 WEIGHS(I,IM)=WEIGHS(I,J)
000281      610 WEIGHS(I,J)=0,0
000282      GO TO (613,9313), NOW
000283      613 MINM=1
000284      MAXM=MTOTAL
000285      9614 I1=MINZ
000286      I2=MAXZ
000287      I3=1
000288      614 IF (MOVEZ) 625,625,615
000289      615 DO 620 I=I1,I2,I3

```

```

000290      DO 620 J=MINM,MAXM
000291      IZ=I-MOVEZ
000292      ISOTOP(IZ,J)=ISOTOP(I,J)
000293      ISOTOP(I,J)=0
000294      MOTHER(IZ,J,4)=MOTHER(I,J,4)
000295      MOTHER(I,J,4)=0
000296      GO TO (619,616), NOW
000297 616 MOTHER(I,IZ,1)=MOTHER(I,J,1)-MOVEZ
000298      MOTHER(I,IZ,2)=MOTHER(I,J,2)
000299      MOTHER(I,IZ,3)=MOTHER(I,J,3)
000300      DO 618 K=1,3
000301 618 MOTHER(I,J,K)=0
000302 619 WEIGHS(IZ,J)=WEIGHS(I,J)
000303 620 WEIGHS(I,J)=0.0
000304      GO TO (625,9312), NOW
000305 625 DO 628 IZ=1,NTOTAL
000306      DO 628 IM=1,MTOTAL
000307      IF (MOTHER(IZ,IM,4)) 626,628,626
000308 626 NOPATH=0
000309      DO 627 I=1,3
000310      K=0
000311      FLD(35,1,K)=FLD(36-I,1,MOTHER(IZ,IM,4))
000312 627 NOPATH=NOPATH+K
000313      MOTHER(IZ,IM,4)=NOPATH
000314 C      (MOTHER(IZ,IM,4) NOW IS NUMBER OF DECAY PATHS FOR THIS ISOTOPE)
000315 628 CONTINUE
000316      IM1=1
000317      IM2=MIN0(MTOTAL,6)
000318      IP=1
000319      IPS=(INITM+INCM-MOVEM-1)/6+1
000320      IS=0
000321 634 IF (IM2-MTOTAL) 635,640,640
000322 635 WRITE(6,999) IP,IPT
000323      IF (IP-IPS) 642,640,642
000324 640 WRITE(6,1000) POUNDS,UNITS,ISI,ELAPSE,DURAT2
000325      GO TO 650
000326 642 WRITE(6,1001)
000327 C 650 DO 699 IZ=NTOTAL,1
000328 650 IZ=NTOTAL
000329 651 NEXT=1
000330      MAXMOM=0
000331      DO 652 J=1,MTOTAL
000332 652 MAXMOM=MAX0(MAXMOM,MOTHER(IZ,J,4))
000333      MAXMOM=3*MAXMOM+5
000334 C      (MAXMOM=MAX P.O. LINES FOR THIS Z)
000335      NOCAY=0
000336 C      DO 9698 IL=1,7
000337      IL=1
000338 653 ILL=IL-6*(IL/7)

```

```

000339      DO 654 I=2,5
000340      DO 654 J=1,6
000341      654 FMT(I,J)=FMTB(I-1)
000342          IN=0
000343          IS=0
000344          NOWMOM=0
000345      C      DO 697 IM=IM1,IM2
000346      656 IM=IM1
000347      657 IF=IM-IM1+1
000348          IDECAY=1
000349          IF (IM=MTOTAL) 660,660,680
000350      660 NOWMOM=MAX0(NOWMOM,MOTHER(IZ,IM,4))
000351      C      (NOWMOM=MAX NUMBER OF DECAY PATHS ON THIS PAGE FOR THIS Z)
000352          ISO=ISOTOP(IZ,IM)
000353          IF (ISO) 9660,680,9661
000354      9660 ISO=-ISO
000355          IDECAY=2
000356      9661 ISTAR=2
000357          IF (ISO=ISS) 662,661,662
000358      661 ISTAR=1
000359          IS=IF
000360          IF (IF=1) 8662,8662,7662
000361      7662 FMT(1,IF)=FMTISI
000362      8662 IF (IF=6) 9662,662,662
000363      9662 FMT(6,IF)=FMTISI
000364          662 DO 663 I=2,5
000365          663 FMT(I,IF)=FMTFLD(I-1,ILL)
000366          IN=IN+1
000367          665 GO TO (671,672,673,674,675,676,671), IL
000368          671 DO 9671 I=1,3
000369      9671 IPO3(I,IN)=LINE(ISTAR)
000370          GO TO 697
000371          672 IF (WEIGHS(IZ,IM)) 6672,9672,6672
000372      6672 IF (WEIGHS(IZ,IM)/POUNDS-1.E-14) 7672,9672,9672
000373      7672 IN=IN-1
000374          DO 8672 I=2,5
000375      8672 FMT(I,IF)=FMTFLD(I-1,7)
000376          GO TO 697
000377      9672 PO(IN)=WEIGHS(IZ,IM)
000378          GO TO 697
000379          673 GO TO (9673,8673), IDECAY
000380      8673 IPO(IN)=ISO
000381          GO TO 697
000382      9673 ICOL=ISO
000383          GO TO 759
000384          674 GO TO (6674,5674), IDECAY
000385      4674 PO(IN)=FMT4B
000386          GO TO 8674
000387      5674 IN=IN-1

```


000388	GO TO 680
000389	6674 IF (HALF(ISO)) 4674,4674,7674
000390	7674 PO(IN)=HALF(ISO)
000391	IDECAF=2
000392	NOCAY=NOCAY+1
000393	8674 DO 9674 I=1,4
000394	9674 FMT(I+1,IF)=FMT4(I,IDECAF)
000395	GO TO 697
000396	675 IN=IN-1
000397	DECAY(IF,1)=0.0
000398	IF (HALF(ISO)) 680,680,7700
000399	7700 GO TO (8700,680), IDECAF
000400	8700 GO TO (9700,700), NEXT
000401	9700 INOW(IF)=0
000402	700 INOW(IF)=INOW(IF)+1
000403	NOW=MIN0(INOW(IF),5)
000404	720 GO TO (721,722,723,724, 680), NOW
000405	721 INIT=5
000406	GO TO 730
000407	722 INIT=21
000408	GO TO 730
000409	723 INIT=15
000410	GO TO 730
000411	724 INIT=1
000412	730 IF (CAPK(ISO,INIT)) 700,700,731
000413	731 IN=IN+1
000414	DECAY(IF,1)=1.0
000415	DO 732 I=1,3
000416	732 IPO3(I,IN)=KECAF(I,NOW)
000417	GO TO 678
000418	676 IF (DECAY(IF,1)) 677,677,697
000419	677 IN=IN-1
000420	GO TO 680
000421	678 NEXTM=IM-2/NOW+NOW/3
000422	GO TO (754,755,756,756), NOW
000423	754 NEXTZ=IZ-2
000424	GO TO 757
000425	755 NEXTZ=IZ+1
000426	GO TO 757
000427	756 NEXTZ=IZ-1
000428	757 ICOL=ISOTOP(NEXTZ,NEXTM)
000429	IF (ICOL) 758,758,759
000430	758 IPO(IN)=-ICOL
000431	GO TO 697
000432	759 FLD(18,18,MINUS)=FLD(18,18,ID(ICOL))
000433	I1=104
000434	8760 I2=I1-1
000435	IF (I2) 9761,9761,9760
000436	9760 I1=MAX0(1,I2-26)

```

000437      DO 760 IE=I1,I2
000438      IF (FLD(0,18,ID(ICOL))-FLD(12,18,SYMBOL(IE))) 8760,761,760
000439      760 CONTINUE
000440      9761 FLD(0,12,MINUS)=FLD(0,12,BLANK)
000441      GO TO 762
000442      761 FLD(0,12,MINUS)=FLD(0,12,SYMBOL(IE))
000443      762 IPO(IN)=MINUS
000444      GO TO 697
000445      780 IL=5
000446      DO 8780 J=1,6
000447      IF ((INOW(J) .GT. 0) .AND. (INOW(J) .LT. 5)) GO TO 9780
000448      8780 CONTINUE
000449      GO TO 9697
000450      9780 IF (NOCAY) 9697,9697,653
000451      800 NEXT=2
000452      IF (IL=5) 8800,805,8800
000453      8800 IF (IN) 890,890,9800
000454      9800 GO TO (801,802,803,804,805,806,9801), IL
000455      801 WRITE(6,1009)
000456      9801 WRITE(6,FMT) ((IPO3(K,J),K=1,3),J=1,IN)
000457      IF (IL=5) 698,9698,698
000458      802 WRITE(6,FMT) (PO(J),UNITS,J=1,IN)
000459      GO TO 698
000460      803 WRITE(6,FMT) (IPO(J),J=1,IN)
000461      GO TO 698
000462      804 WRITE(6,FMT) (PO(J),J=1,IN)
000463      GO TO 698
000464      805 IF (IN) 780,780,801
000465      806 WRITE(6,FMT) (IPO(J),J=1,IN)
000466      GO TO 780
000467      890 IF (IL=2) 9890,8890,9890
000468      8890 WRITE (6,FMT)
000469      GO TO 698
000470      9890 WRITE(6,1009)
000471      I1=1
000472      IF (IL=1) 698,891,698
000473      891 DO 892 I=I1,MAXMOM
000474      892 WRITE(6,1009)
000475      GO TO 9699
000476      680 DO 681 I=2,5
000477      681 FMT(I,IF)=FMTB(I-1)
000478      697 IM=IM+1
000479      IF (IM=IM2) 657,657,800
000480      9697 IL=6
000481      698 NEXT=1
000482      IF (IS) 9698,9698,5698
000483      5698 IF (IS=1) 7698,7698,6698
000484      6698 FMT(1,IS)=FMTS
000485      7698 IF (IS=6) 8698,9698,9698

```

000486	8698	FMT(6,IS)=FMTS
000487	9698	IL=IL+1
000488		IF (IL-7) 653,653,699
000489	699	NOWMOM=3*NOWMOM+5
000490		IF (MAXMOM-NOWMOM) 9699,9699,8699
000491	8699	I1=NOWMOM+1
000492		GO TO 891
000493	9699	IZ=IZ-1
000494		IF (1-IZ) 651,651,9999
000495	9999	IM1=IM2+1
000496		IM2=MIN0(MTOTAL,IM2+6)
000497		IP=IP+1
000498		IF (IM1-MTOTAL) 635,635,10
000499		END

END CUR

DISTRIBUTION

10 Atomic Energy Commission - Washington, D. C.
 Division of Operations Analysis and Forecasting
 R. W. Ramsey

 Division of Reactor Development and Technology
 J. Whitman, Assistant Director for Program
 Analysis (9)

8 Atomic Energy Commission - Richland, Washington
 P. G. Holsted (2)
 C. L. Robinson (5)
 Technical Information Library

237 Division of Technical Information Extension (UC-23)

7 Douglas United Nuclear, Inc.
 R. Nilson
 Files (6)

6 Isochem Inc.
 A. E. Smith
 Document Classification and Custody (5)

248 Battelle-Northwest
 F. W. Albaugh
 J. M. Batch
 C. A. Bennett
 T. K. Bierlein
 C. H. Bloomster
 G. M. Dalen
 F. G. Dawson, Jr.
 R. F. Dickerson
 D. E. Deonigi
 R. L. Engel
 E. A. Eschbach (100)
 E. A. Evans
 D. P. Granquist
 D. R. Haffner
 J. J. Hauth (2)
 P. L. Hofmann
 P. A. Horton
 L. D. Jacobson
 R. A. R. Kent
 D. P. Konichek
 B. B. Lane
 R. C. Liikala

C. W. Lindenmeier
E. T. Merrill
F. T. Miles
J. H. Nail
W. I. Neef
S. E. Nunn
R. S. Paul
R. G. Rau
W. A. Reardon
R. L. Reynolds (100)
C. A. Rohrmann
L. C. Schmid
E. A. Schnaible
A. M. Schneider
R. E. Shaver
R. E. Shippert
R. I. Smith
C. R. Tipton, Jr.
H. H. Van Tuyl
E. E. Voiland
G. L. Wilfert
K. E. Yandon
Technical Information Files (5)