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HEU Drum Monitor Manual (for Confirmatory Measurements)

J. K. Sprinkle, Jr.
L. A. Stovall

Los Alamos National Laboratory
Los Alamos, New Mexico 87545

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HEU DRUM MONITOR MANUAL
(FOR CONFIRMATORY MEASUREMENTS)

by

J. K. Sprinkle, Jr., and L. A. Stovall

ABSTRACT

This manual describes the operation of the highly enriched uranium (HEU) drum monitor. The drum monitor measures the passive gamma-ray emissions from a sealed shipping container of HEU. These emissions are from ^{235}U and from daughters of ^{238}U and ^{232}U. These radiations span a wide range of energy; consequently, each is susceptible to attenuation and shielding to a different degree. The combination of these measured gamma-ray rates with a weight measurement provides a unique signature for each item. These unique signatures can be determined with similar instruments at both ends of a material transfer between Department of Energy facilities. A consistent result from the two instruments indicates material control has been achieved, specifically that no material was lost or diverted. An additional objective of this instrument is to separate the material control issue from the measurement control issue. This is achieved by not calibrating the instrument and by reporting count rates instead of masses. Consequently, the results do not include calibration uncertainties, and therefore they are more precise. In addition, there are no sampling errors. A signal unique to the special nuclear material (SNM) is obtained nondestructively from the entire item. This instrument complements traditional containment and surveillance techniques by providing a precise measurement of an attribute unique to the SNM in the sample.

GENERAL

This manual describes the operation of the highly enriched uranium (HEU) drum monitor. The drum monitor provides a confirmatory measurement result that can help resolve shipper/receiver differences between Department of Energy (DOE) facilities.[1] The special nuclear material (SNM) items to be transferred are measured at both facilities with similar instruments while they are sealed in the shipping containers (typically a 30- or 55-gal. drum). Consistent measurement results demonstrate that the same SNM was in the shipping container for both measurements. However, these results do not accurately quantify how much SNM was in the container. That issue is addressed by traditional materials accounting measurements, which have much better accuracy, but can not be cost-effectively performed in such a timely fashion. This concept has been described as separating the materials control function (performed by this drum monitor) from the measurement control function (the most accurate materials accounting measurement).

AUDIENCE

This manual is intended for the instrument custodian who will be the resident expert for the HEU confirmatory measurement instrument. The subsections on routine use may be extracted for the instrument operators.

OTHER DOCUMENTATION

Several other documents might be useful:

- RT-11* system manuals
- DEC* FORTRAN manual
- Canberra FTXX73 software manual
- Canberra Series 35+ manual
- Assorted manufacturer's nuclear instrument module (NIM) unit manuals
- File Y12.DOC on the system disk

PURPOSE

This instrument measures the distinctive gamma-ray emissions from a shipping container of HEU. If the material is being received, the instrument will then compare the measured count rates with the values determined before shipment. If any statisti ally significant differences are found, the item is identified as requiring further investigation. This comparison will provide a high degree of confidence that an item was unchanged during shipment by measuring an attribute unique to the HEU. It should complement the various physical security measures that are also applied to each shipping container.

MEASUREMENT TECHNIQUE

Gamma rays from four isotopes are measured.[2] The instrument determines the emission rate of the 185.7-keV gamma ray of ^{235}U, the 413.7-keV gamma

*Digital Equipment Corporation, Maynard, Massachusetts.

MEASUREMENT TECHNIQUE (cont)

ray of ^{239}Pu, the 1001-keV gamma ray emitted by a daughter of ^{238}U, and the 2614-keV gamma ray emitted by a daughter of ^{232}U. These radiations span a wide range of energy; consequently, they are each susceptible to attenuation and shielding to a different degree. The combination of these four measured intensities with the gross weight of the shipping container creates a signature that is unique to each item and is virtually impossible to duplicate with a bogus sample.

GENERAL

The measurement head resides in a heavily shielded counting room. The 2-ft-thick concrete walls attenuate the 2614-keV gamma ray by 2 orders of magnitude. The 4-in.-lead collimators reduce the 2614 keV by another 2 orders of magnitude. The gamma rays of lower energy are attenuated more severely than the 2614-keV gamma ray by this shielding. Consequently, the HEU drum monitor is not affected by SNM movement in the neighboring facility.

The electronics rack may be located up to 50 ft away from the detectors in the measurement head. (Longer distances require new cables for the detector hv and signals.) The system console terminal will reside with the electronics rack. The user console(s) may be placed up to 200 ft away from the rack in a location convenient for the operator.

BLOCK DIAGRAMS

Figure 1 shows the analog-signal processing connections.

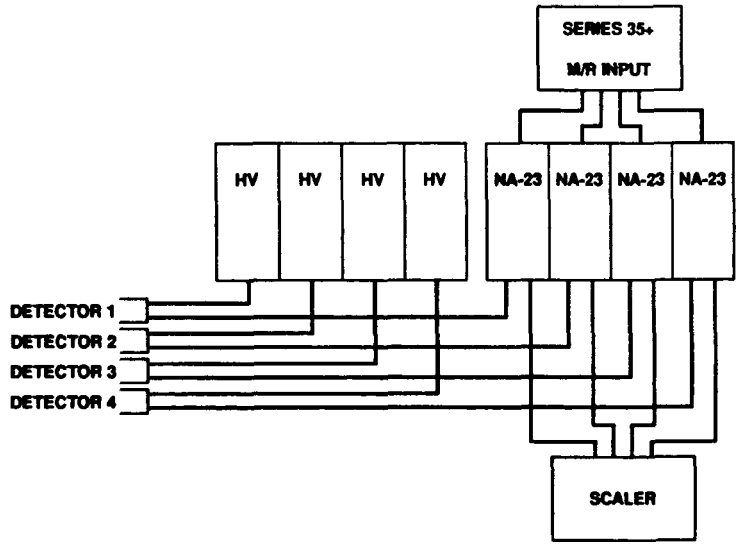

Fig. 1. The analog-signal processing connections.

PHOTOS

Figure 2 shows the measurement head with the side covers on before painting. Figure 3 shows the measurement head with the side covers removed. The four lead collimators are on their shelves. Figure 4 shows the third collimator in position on its shelf. Notice the two lifting eyes in the 1000-lb collimator. Figure 5 shows the third collimator being placed in position on its shelf.

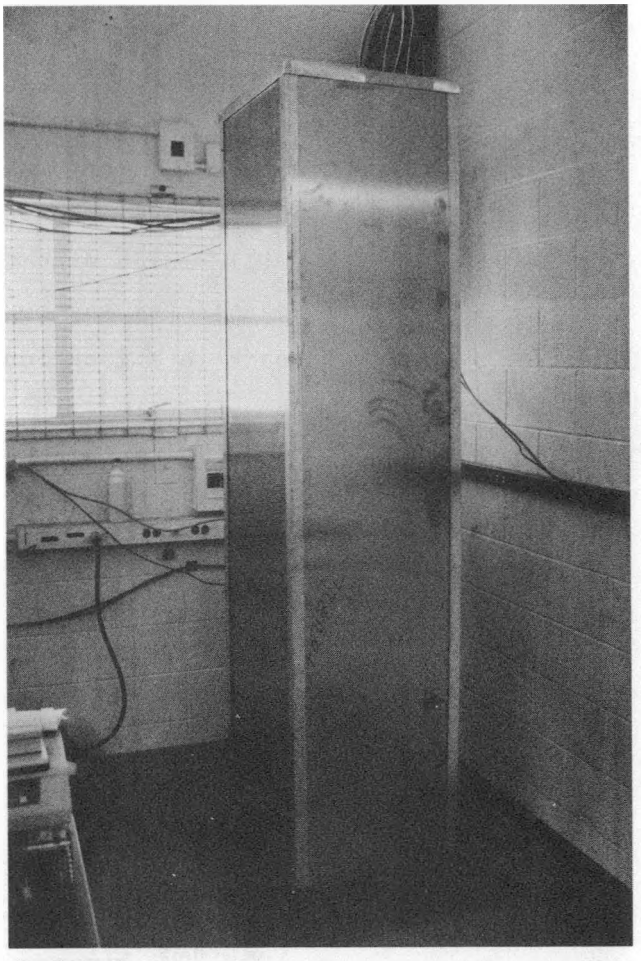

Fig. 2. The measurement head with unpainted side covers.

PHOTOS

(cont)

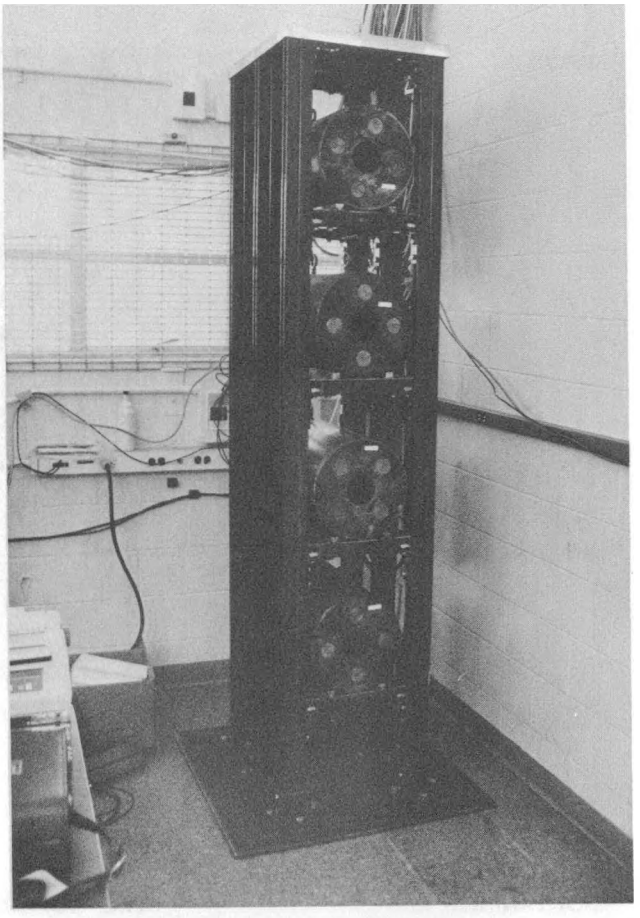

Fig. 3. The measurement head without side covers. Note the four collimators.

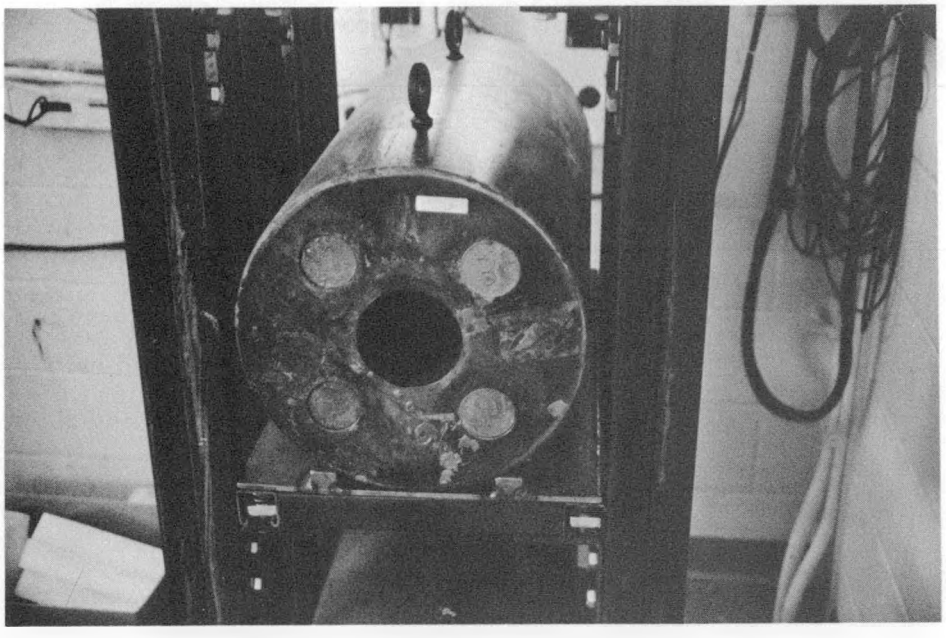

Fig. 4. A single lead collimator in place in the measurement head.

PHOTOS (cont)

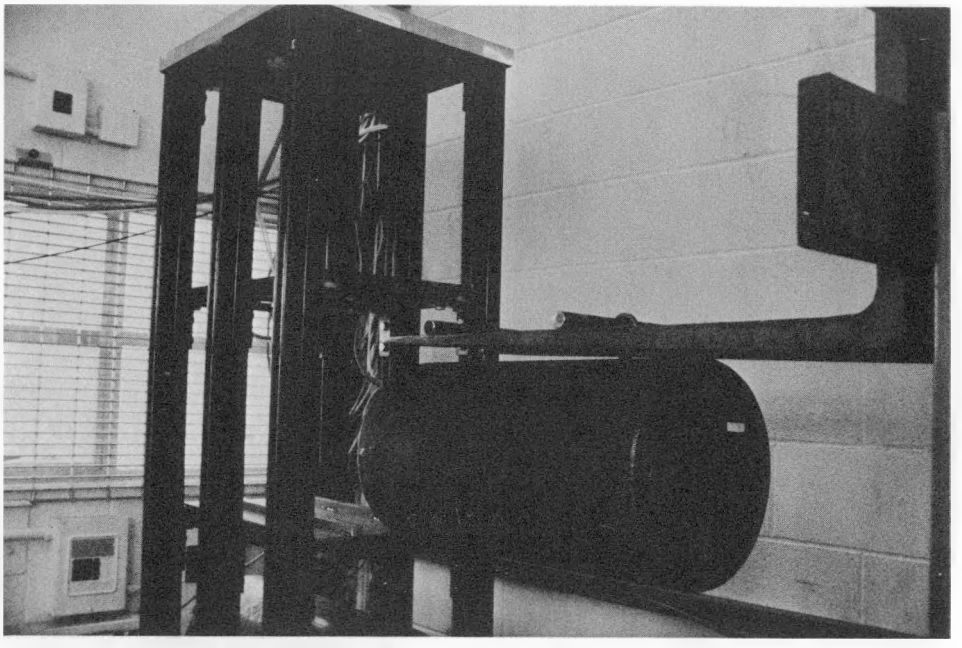

Fig. 5. A lead collimator being placed into the measurement head.

SOFTWARE

The software for the HEU drum monitor runs under the Digital Equipment Corporation (DEC) RT-11, Version 5.02, operating system in the extended memory (XM) environment. The overlaid and structured software package, Y12, written in FORTRAN and MACRO software routines, is menu driven. The operator selects an option from a menu of available options that is presented on the terminal. Each option is a subroutine that calls the routines needed to execute the option. In addition to performing assays, there are options to assay data from disk files or to review log files of the instrument's activity. Routine operation requires the use of only four options.

The Micro-11 contains 128 16-bit words, with each task limited to a 32-k word boundary. The software

SOFTWARE (cont)

to run the HEU drum monitor resides on a 10-Mbyte disk, as do the data and log files. The Micro-11 also contains dual 8-in. floppy disk drives that can be used for data transfer.

There is a separate program for the HEU drum monitor named CHNY12, which is run to change the default parameters used in the main software package. This parameter change routine can only be executed by the instrument supervisor. It is typically run from the main console. The parameters accessed by this program can greatly influence the operation of the system and should only be changed by a knowledgeable person.

POWER UP

1. If the unit was shipped,
   a. Release the RL02 disk head protection and remove the floppy disk head protection.
   b. Connect an hv cable and a signal cable to each detector.
2. Turn on electronics rack power.
3. Turn on each electronics module, with the computer being last. (The RL02 fault light will come on until the computer is on.) Once the Series 35+ multichannel analyzer (MCA) is on, the operator must answer a date/time question at the MCA before the MCA will communicate correctly with the computer.
4. The NIM units should not require adjustment. Up to 24 h may be required for temperature stabilization of the detectors in the lead shields.
5. The computer should boot from the RL02. If it is necessary to boot from the 8-in. floppy, leave the RL02 off-line, place the BOOTABLE floppy in drive 0, and type "P" when the boot process halts (indicated by an "@" at the console).
6. The start-up file "STARTX.COM" will end with @Y12, which is a command file to start the main program at user terminal 1.

POWER DOWN

1. In case of an emergency, the main power cord to the wall can be pulled for a complete shutdown. We do not recommend this practice except for emergencies such as fire or life-threatening situations. (It could destroy the system disk.)

POWER DOWN (cont)

2. A more relaxed shutdown starts when the user program is idle (waiting at the "Enter Option" point) or when the user program X (exit) option has been exercised.
   a. Turn off the computer, NIM bin, RL02, and MCA.

      (Do NOT turn down the hv to zero.)

   b. Turn off the terminals and line printer.
   c. Turn off the electronics rack.

INITIAL SETTINGS

NIM Units

The hv settings for the NaI detectors are quite sensitive. A small change will probably remove the pulser peak from stabilization.

	Det 1	Det 2	Det 3	Det 4
High voltage	670	705	694	674
Amp CG	40	40	40	40
Amp FG	0.60	0.60	0.55	0.56
Delta E	1.0	1.0	1.0	1.0
E	6.40	6.41	5.14	6.23

Regions of Interest

All four detectors have similar regions of interest. The optimal region of interest for the 185.7-keV gamma ray is 161-211 keV for the peak region. The next region is used for both the ^{133}Ba measurement control source and ^{239}Pu. The optimal peak region is 300-485 keV, with background regions of 230-265 keV and 490-510 keV. Strong ^{228}Th sources with very little self-absorption have peaks that interfere with these

Regions of Interest (cont)

background regions (at 238 keV and 511 keV). The americium seed peak is positioned at approximately 1700 keV so as not to interfere with either the 1001 keV or the 2614 keV.

Parameters

A recent listing of the CHNY12 parameter file follows:

5-MAR-88 09:12:23 PARAMETER FILE

SY:PARMTR.HEU JUL 1 1987
Written 10-MAR-88 14:41:53 by SPRINKLE

Peak	Isotope	Energy	Windows....		
	Detector #1				
1	PULSER	1700.0	480 - 500	563 - 735	740 - 750
2	U-235	185.7	59 - 62	63 - 79	80 - 83
3	PU-239	413.7	100 - 108	110 - 171	173 - 181
4	U-238	1001.0	328 - 345	348 - 399	405 - 420
5	U-232	2614.0	880 - 895	901 - 1005	1010 - 1023
	Detector #2				
6	PULSER	1700.0	2530 - 2545	2616 - 2776	2780 - 2790
7	U-235	185.7	2105 - 2108	2109 - 2125	2126 - 2129
8	PU-239	413.7	2148 - 2156	2158 - 2219	2221 - 2229
9	U-238	1001.0	2370 - 2385	2389 - 2438	2443 - 2458
10	U-232	2614.0	2913 - 2928	2933 - 3033	3043 - 3058
	Detector #3				
11	PULSER	1700.0	4545 - 4555	4560 - 4680	4744 - 4760
12	U-235	185.7	4153 - 4156	4157 - 4173	4174 - 4177
13	PU-239	413.7	4196 - 4204	4206 - 4267	4269 - 4277
14	U-238	1001.0	4416 - 4426	4436 - 4482	4492 - 4502
15	U-232	2614.0	4959 - 4969	4979 - 5059	5069 - 5079
	Detector #4				
16	PULSER	1700.0	6631 - 6641	6703 - 6863	6868 - 6878
17	U-235	185.7	6202 - 6205	6206 - 6222	6223 - 6226
18	PU-239	413.7	6244 - 6252	6254 - 6315	6317 - 6325
19	U-238	1001.0	6469 - 6479	6489 - 6536	6546 - 6556
20	U-232	2614.0	7009 - 7019	7029 - 7120	7130 - 7140

SY:BACKGR.HEU
Written 26-FEB-88 11:57:26 by 88267 200. Secs.

Peak	Isotope	Energy	Area	% Err
	Detector #1			
1	PULSER	1700.0	214441.7500	0.23
2	U-235	185.7	233.2500	72.35
3	PU-239	413.7	-1359.5557	-15.35
4	U-238	1001.0	-135.2822	-58.51
5	U-232	2614.0	182.1555	13.97

Parameters

(cont)

	Detector #2			
6	PULSER	1700.0	203569.2344	0.23
7	U-235	185.7	-56.1250	-234.14
8	PU-239	413.7	-1624.6621	-12.00
9	U-238	1001.0	-149.3953	-49.79
10	U-232	2614.0	84.1837	28.91
	Detector #3			
11	PULSER	1700.0	225281.4219	0.23
12	U-235	185.7	-59.5918	-284.88
13	PU-239	413.7	-1911.6924	-11.15
14	U-238	1001.0	-109.5916	-85.90
15	U-232	2614.0	36.4090	73.12
	Detector #4			
16	PULSER	1700.0	222969.7656	0.22
17	U-235	185.7	-274.3750	-50.00
18	PU-239	413.7	-1882.4814	-10.39
19	U-238	1001.0	-194.5454	-42.78
20	U-232	2614.0	81.5455	33.17

ENERGY CALIBRATION - for each detector

E-Slope =	2.800	E-Offset =	-37.600
Energy keV =	185.700	Centroid =	71.000
Energy keV =	1700.000	Centroid =	850.000

MEASUREMENT CONTROL -	Bias	Precision		
Interval(DAYS) =	7.00000	30.0000		
Cycles =		15		
Sample ID =	MCBIAS	MCPREC		
	det #1	det #2	det #3	det #4
Reference Value for Bias =	415.000	218.000	211.000	301.000
Standard Dev. =	25.0000	25.0000	25.0000	25.0000

BACKGROUND -

Interval(DAYS)= 1.0 Preset time = 200.0 sec

lower limit	---------- Upper limits ---------- >			
Area(rateloss)	Norm(186)	Norm(414)	Norm(1001)	Norm(2614)
0.20000E+06	0.20000E-02	0.20000E-02	0.00000	0.20000E-02
0.20000E+06	0.20000E-02	0.20000E-02	0.00000	0.20000E-02
0.20000E+06	0.20000E-02	0.20000E-02	0.00000	0.20000E-02
0.20000E+06	0.20000E-02	0.20000E-02	0.00000	0.20000E-02

DEFAULT CALIBRATION IS # 1, OXIDE

Calibration Constants - Material type: OXIDE

Pulser	185-keV	414-keV	1001-keV	2614-keV
0.54430E-05	1.5000	0.28000E-01	87.660	1.0000
0.10000E-02	1.5000	0.28000E-01	87.660	1.0000
0.18872E-27	1.5000	0.28000E-01	87.660	1.0000
0.00006	1.5000	0.28000E-01	87.660	1.0000

Calibration Constants - Material type: METAL

Pulser	185-keV	414-keV	1001-keV	2614-keV
0.00006	2.0800	0.38000E-01	114.40	1.0000
0.00000	2.0800	0.38000E-01	114.40	1.0000
0.00000	2.0800	0.38000E-01	114.40	1.0000
0.00000	2.0800	0.38000E-01	114.40	1.0000

Parameters

(cont)

Calibration Constants - Material type: NOT-USED

Pulser	185-keV	414-keV	1001-keV	2614-keV
0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000

PRESET TIME for each VERIFICATION = 200.0

Number of sigma allowed in S/R Verification Comparison

	Warning limit	Action limit	
for each peak	3.42000	4.25000	
for each item	2.14000	3.50000	(N = 16)
for each item	2.14000	3.50000	(stat signif peaks)

Systematic error component for S/R comparison = 0.490 %

Conveyor status is T
Timeout is 20 seconds
Instrument # 1 status is - F
2 is - F
3 is - T

DIAGNOSTICS ARE FOR 186 KEV AND PULSER

Diagnostic max = 16

	Value		Limit
Detector #1			
Centroid	71.000	+/-	3.000
FWHM	22.000	+	2.000
Centroid	655.500	+/-	5.000
FWHM	69.000	+	2.000
Detector #2			
Centroid	2117.000	+/-	3.000
FWHM	22.000	+	3.000
Centroid	2705.000	+/-	5.000
FWHM	73.000	+	2.000
Detector #3			
Centroid	4166.000	+/-	3.000
FWHM	20.000	+	2.000
Centroid	4629.000	+/-	5.000
FWHM	66.000	+	2.000
Detector #4			
Centroid	6214.000	+/-	3.000
FWHM	21.000	+	2.000
Centroid	6784.000	+/-	5.000
FWHM	68.000	+	2.000

OVERVIEW

The HEU drum monitor has two modes of operation, routine and supervisor. Routine operation includes the usual verification and measurement control (MC) options. In this context, MC refers to a regular demonstration that the instrument response has not drifted.[4] (Not to be confused with MC of the materials accounting system referred to on pp. 1 and 2.) It is expected that the regular operators will become familiar with four options available in the routine mode, which includes performing the prompted MC. Supervisor mode requires the use of a password to perform additional options. The instrument was shipped with the password disabled. It is expected that the supervisor mode will not be needed very often. When it is, the resident expert will use this mode to gain more control of the instrument. The supervisor has one more level of control over the instrument--the parameter change program CHNY12. This program can be run from the system console and allows access to all parameters used in the Y12 program. CHNY12 is described in the PARAMETER CHANGE section on p. 24.

If the HEU drum monitor is ready for use, the prompt

```
ENTER OPTION ->
```

will be displayed as the last line of output. If the drum monitor is executing an option, it will print out its status or activities on the user cathode-ray tube (CRT) display.

NOMENCLATURE

If the monitor is idle, the "ENTER OPTION" prompt is displayed as the last line of text on the user terminal. Otherwise, the last line gives some indication of what the instrument is doing or it is a user prompt that needs a response. The response may be to follow an instruction or it may be to type an answer on the terminal. Four types of input may be required. Integer input is indicated by (I) at the end of the prompt. Real numbers need a decimal point and are indicated by (F) at the end of the prompt. Alphanumeric input is indicated by (A), and Boolean variables are indicated by (Y/N).

OPERATOR OPTIONS

The four options used in routine operation are

V - Perform a confirmatory measurement as a shipper or as a receiver.

B - Run a background (no sample) count (daily).

MB - Measurement control for bias (daily/weekly).
This is a periodic check that tests the stability of the instrument's response. A known item is remeasured, and the result is compared to a historical value. Two thresholds are used in this test. A warning limit is set at 2σ and an action limit is set at 3σ.
The first action that is suggested for a failed comparison is to check the instrument and parameters carefully and then repeat the measurement. The instrument was supplied with four ^{133}Ba sources for use with this option.

OPERATOR OPTIONS
(cont)

MP - Measurement control for precision (monthly).
This is a statistical check that tests whether the random error is correctly predicted by counting statistics. This test is accomplished by counting a sample 5 or 15 times. Then the observed and predicted variances are compared. Any item (including background) can be the sample. Two thresholds are used in this test. A warning limit is set at 2σ and an action limit is set at 3σ. The first action that is suggested for a failed comparison is to check the instrument and parameters carefully and then try to repeat the failure.

One other option may be useful:

RC - Read confirmatory data file.
This option has a different format depending on whether short, medium, or long printout is the default. Three are shown for a short file.

Los Alamos recommends that the B, MP, and MB options be performed on a regular basis to verify the proper operation of the instrument. Reasonable repetition rates are noted parenthetically above.

You can be reminded of your possibilities at any time by using

H - Help (list the available options).

OPERATOR OPTIONS (cont)

During a data acquisition, three options are available:

Q - Quit the data acquisition without calculating a result.

S - Suspend the data acquisition temporarily. Acquisition is restarted when the operator answers the prompt at the terminal.

T - Terminate the assay or autocycle early, but compute the results anyway.

OUTPUT

The main program has three levels of detail in the output. Short printout gives only the final result, unless an error condition is detected. Medium printout gives some intermediate results, and the long printout is primarily a developmental or diagnostic tool.

Short Output from V Option

```
**************************************************************************

 Y12 - HEU Confirmatory Measurement - Run Type:  Receiver

Sample ID:      BAU             Current Date:   18-FEB-88  07:23:58
Operator ID:    JIM             Backgrd. Date:  17-FEB-88  09:49:28
Data file:    OUT:BAU.Y00
Constants File: SY:PARMTR.HEU   Constants Date: 17-FEB-88  15:34:32
Live time (sec):    200.        Clock time (sec):    235.

*  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *

This comparison is for :
Shipper  : BAU                : 12-FEB-88 : 10:35:56
Receiver : BAU                : 18-FEB-88 : 07:19:59


   **** ERROR #  95
     ***  Shipper / Receiver comparison failed  ***
     Single Peak
Peak #  8  268.14     &   321.09     differ by   -7.8 sigma (  6.76    )

   **** ERROR #  95
     ***  Shipper / Receiver comparison failed  ***
     Single Peak
Peak # 14  89.552     &   101.17     differ by   -5.8 sigma (  1.99    )

Reduced Chisquare (N=16) =   9.63     (exceeds   3.50    , the action limit)

Red Chisquare (N <= 16) =   12.7     (exceeds   3.50    , the action limit)

   **** ERROR #  95
     ***  Shipper / Receiver comparison failed  ***
     BAU
Reduced Chisq =   9.634     (N=16) &   12.74     (N=12)
```

Medium Output from V Option

```
********************************************************************************

 Y12 - HEU Confirmatory Measurement - Run Type:  Receiver

Sample ID:       FBA              Current Date:   17-FEB-88  16:42:01
Operator ID:     JIM              Backgrd. Date:  17-FEB-88  09:49:28
Data file:     OUT:FBA.Y00
Constants File: SY:PARMTR.HEU     Constants Date: 17-FEB-88  15:34:32
Live time (sec):    200.          Clock time (sec):    222.

*  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
Spectrum retrieval completed --  4096 channels written to OUT:FBA.Y00
 Detector          Energy            Norm Count Rate

    1              pulser      0.21383E+06 +/-    489.89
                    185.7       -6.6383     +/-    1.6647
                    413.7        463.26     +/-    3.7729
                   1001.0       0.24059     +/-   0.57577
                   2614.0      0.44544E-01  +/-   0.17649

    2              pulser      0.20312E+06 +/-    478.08
                    185.7       -2.5308     +/-    1.4977
                    413.7        276.42     +/-    3.5667
                   1001.0      -0.53666     +/-   0.53429
                   2614.0      -0.28394     +/-   0.18196

    3              pulser      0.22527E+06 +/-    526.69
                    185.7        1.0471     +/-    1.6165
                    413.7        264.70     +/-    3.5138
                   1001.0      -0.96697     +/-   0.67494
                   2614.0     -0.51556E-01  +/-   0.17694

    4              pulser      0.22203E+06 +/-    499.92
                    185.7       -8.3796     +/-    1.4338
                    413.7        341.35     +/-    3.3350
                   1001.0      -0.28751     +/-   0.58736
                   2614.0     -0.34823E-01  +/-   0.19396

********************************************************************************

This comparison is for :
Shipper  : FBA                 : 17-FEB-88 : 14:26:46
Receiver : FBA                 : 17-FEB-88 : 16:38:15

      Number of standard deviations
    -20       -10        0        +10       +20       Rat:   +/-
 1 :                     *                              1.00003    0.00324
 2 :                   *                                2.16194   -0.76566
 3 :                   *                                0.97796    0.01127
 4 :                    *                               0.50224    1.69604
 5 :                   *                                0.13965    0.77218
 6 :                      *                             1.00527    0.00334
 7 :                    *                               1.53219   -1.28534
 8 :                   *                                0.98384    0.01799
 9 :                    *                               0.60111   -0.84620
10 :                    *                               1.55996   -1.42308
11 :                    *                               1.00141    0.00332
12 :                    *                               0.85070    1.85830
13 :                     *                              1.01493    0.01906
14 :                    *                               0.78979   -0.77676
15 :                    *                               0.51839   -2.52073
16 :                      *                             1.00628    0.00319
17 :                   *                                1.63262   -0.39573
18 :                     *                              1.01084    0.01399
19 :                   *                               -1.01301    2.91612
20 :                     *                              0.18592   -1.48576


Reduced Chisq =  0.8418     (N=16) &  0.9335     (N=13)
Verification successful for FBA
```

Long Output from V Option

```
Y12 - HEU Confirmatory Measurement - Run Type:  Receiver

Sample ID:       BAU              Current Date:   16-FEB-88  11:26:29
Operator ID:     JAMES            Backgrd. Date:  16-FEB-88  09:18:33
Constants File:  SY:PARMTR.HEU    Constants Date: 12-FEB-88  10:23:08
Live time (sec):     20.          Clock time (sec):     23.

* * * * * * * * * * * * * * * * * * * * *
```

Energy	Centroid	FWHM	Net Area	Background	Norm Count Rate
pulser	656.4	63.0	21261.7 +/- 158.2	215789.0 +/- 486.0	
185.7	0.0	0.0	-138.3 +/- 133.5	99.9 +/- 132.8	-7.515+/- 6.809
413.7	137.4	34.5	9526.1 +/- 291.9	-1078.6 +/- 208.7	488.805+/- 15.317
1001.0	373.0	46.7	1356.1 +/- 66.7	-209.8 +/- 81.3	69.366+/- 3.451
2614.0	0.0	0.0	13.5 +/- 10.0	94.8 +/- 26.4	0.213+/- 0.525
pulser	2707.5	68.9	19892.3 +/- 153.7	203076.7 +/- 473.1	
185.7	0.0	0.0	147.6 +/- 122.2	-6.3 +/- 120.5	7.567+/- 6.258
413.7	2180.0	29.7	6305.2 +/- 281.8	-1012.9 +/- 189.6	326.909+/- 14.645
1001.0	2408.3	48.2	1282.2 +/- 91.4	-294.1 +/- 75.6	66.921+/- 3.202
2614.0	0.0	0.0	14.7 +/- 6.4	63.1 +/- 26.7	0.434+/- 0.353
pulser	4630.2	65.7	22070.2 +/- 177.3	225559.5 +/- 526.6	
185.7	0.0	0.0	33.1 +/- 141.2	48.1 +/- 134.2	1.452+/- 7.248
413.7	4228.6	32.6	5628.8 +/- 309.7	-882.2 +/- 205.7	292.043+/- 16.041
1001.0	4457.4	40.3	1820.5 +/- 81.3	-307.9 +/- 97.0	94.567+/- 4.255
2614.0	0.0	0.0	-5.1 +/- 9.9	94.9 +/- 25.1	-0.734+/- 0.522
pulser	6785.2	67.6	21995.6 +/- 160.8	221555.4 +/- 495.2	
185.7	0.0	0.0	-55.2 +/- 118.9	78.6 +/- 118.6	-3.178+/- 6.819
413.7	6279.8	31.8	6816.3 +/- 270.8	-620.1 +/- 185.3	346.393+/- 13.918
1001.0	6514.1	55.0	1425.6 +/- 68.7	-214.7 +/- 83.6	72.874+/- 3.529
2614.0	0.0	0.0	25.8 +/- 6.9	100.7 +/- 27.0	0.797+/- 0.373

185.7 keV :	-2.5330	+/-	20.0
413.7 keV :	2203.3	+/-	45.5
1001.0 keV :	20282.	+/-	484.
2614.0 keV :	0.70926	+/-	0.901

```
This comparison is for :
Shipper  : BAU                 : 12-FEB-88 : 10:35:56
Receiver : BAU                 : 16-FEB-88 : 11:25:55
```

Peak #	Receiver Result	Shipper Result	Combined Sigma	Diff (# sig)	Ratio
1	0.2126E+05	0.2127E+05	524.6	-365.0	0.9995E-01
2	-7.515	3.044	7.194	-1.468	-2.469
3	488.8	492.3	16.14	-0.2170	0.9929
4	69.87	77.86	3.654	-2.188	0.8973
5	0.2127	-0.1012	0.5680	0.5527	-2.102
6	0.1989E+05	0.2006E+05	510.3	-354.1	0.9918E-01
7	7.567	11.35	6.627	-0.5713	0.6665
8	326.9	321.1	15.41	0.3778	1.018
9	66.92	63.71	3.388	0.9483	1.050
10	0.4343	-0.2748	0.4062	1.748	-1.581
11	0.2207E+05	0.2210E+05	589.6	-337.5	0.9986E-01
12	1.452	14.73	7.647	-1.737	0.9857E-01
13	292.0	271.8	16.89	1.196	1.074
14	94.57	101.2	4.493	-1.469	0.9347
15	-0.7345	-0.9664E-01	0.5594	-1.140	7.600
16	0.2200E+05	0.2190E+05	536.4	-367.4	0.1004
17	-3.176	4.434	6.376	-1.194	-0.7161
18	346.4	354.5	14.69	-0.5536	0.9771
19	72.87	73.28	3.743	-0.1077	0.9945
20	0.7987	-0.3972	0.4391	2.719	-2.006

	Shipper	Receiver	Combined Sigma
Peak # 1 sums to	0.8534E+06	0.8522E+05	+/- 0.11E+04
Peak # 2 sums to	33.56	-1.872	+/- 14.
Peak # 3 sums to	1440.	1454.	+/- 32.
Peak # 4 sums to	316.0	304.2	+/- 7.7
Peak # 5 sums to	-0.8698	0.7093	+/- 1.0

```
    Number of standard deviations
   -20       -10        0        +10       +20       Ratio   +/-
 1 : <-                                                0.09995   0.00247
 2 :                  *                               -2.46861   2.36307
 3 :                  *                                0.99289   0.03278
 4 :                 *                                 0.89731   0.04693
 5 :                   *                              -2.10250  -5.61383
 6 : <-                                                0.09918   0.00254
 7 :                  *                                0.66650   0.58373
 8 :                  *                                1.01813   0.04901
 9 :                   *                               1.05044   0.05319
10 :                    *                              -1.58075  -1.47830
11 : <-                                                0.09986   0.00267
12 :                 *                                 0.09857   0.51904
13 :                   *                               1.07430   0.06213
14 :                  *                                0.93474   0.04441
15 :                  *                                7.60014  -5.78821
16 : <-                                                0.10042   0.00245
17 :                  *                               -0.71611   1.43772
18 :                  *                                0.97707   0.04143
19 :                  *                                0.99450   0.05108
20 :                     *                            -2.00581  -1.10555

Reduced Chisq =  1.797    (N=16) &  1.333    (N=11)
Verification successful for BAU
```

Short Output from RC Option

Filename : DAT:12FEB.DAT

Entry # 2 ID: BAU Date: 12-FEB-88 Time: 10:35:56

Entry # 3 ID: BA Date: 16-FEB-88 Time: 11:36:48

Medium Output from RC Option

Filename : DAT:12FEB.DAT

	186 kev	414 kev	1001 kev	2614 kev	Pulser
Entry # 2 ID: BAU			Date: 12-FEB-88 Time: 10:35:56		
Detector #1	3.044	492.306	77.861	-0.101	212725.
Detector #2	11.353	321.086	63.707	-0.275	200575.
Detector #3	14.733	271.846	101.170	-0.097	221021.
Detector #4	4.434	354.523	73.277	-0.397	219039.
Entry # 3 ID: BA			Date: 16-FEB-88 Time: 11:36:48		
Detector #1	9.730	11.868	76.132	0.380	213407.
Detector #2	8.965	12.596	63.604	0.224	201228.
Detector #3	11.315	7.036	97.437	0.001	223781.
Detector #4	6.161	1.900	72.563	-0.015	221925.

Long Output from RC Option

Filename : DAT:12FEB.DAT

	186 kev	414 kev	1001 kev	2614 kev	Pulser
Entry # 2 ID: BAU			Date: 12-FEB-88 Time: 10:35:56		
Detector #1	3.044	492.306	77.861	-0.101	212725.
+/-	2.321	5.078	1.200	0.216	500.
Detector #2	11.353	321.086	63.707	-0.275	200575.
+/-	2.152	4.807	1.109	0.201	487.
Detector #3	14.733	271.846	101.170	-0.097	221021.
+/-	2.436	5.283	1.443	0.201	562.
Detector #4	4.434	354.523	73.277	-0.397	219039.
+/-	2.103	6.035	1.247	0.232	512.
Entry # 3 ID: BA			Date: 16-FEB-88 Time: 11:36:48		
Detector #1	9.730	11.868	76.132	0.380	213407.
+/-	1.743	3.551	1.161	0.198	496.
Detector #2	8.965	12.596	63.604	0.224	201228.
+/-	1.627	3.309	1.075	0.191	486.
Detector #3	11.315	7.036	97.437	0.001	223781.
+/-	1.947	3.991	1.390	0.188	562.
Detector #4	6.161	1.900	72.563	-0.015	221925.
+/-	1.601	0.031	1.197	0.218	509.

SUPERVISOR OPTIONS

The supervisor mode can be password protected. If it is, knowledge of the password is required to gain access to these options.

- A - The assay option gives the same results as the V option. In addition, it gives a mass result using a calibration summed over the four detectors.
- AC - Assay current data - generate results using the current data in the MCA.
- AD - Assay from disk - use a disk file to compute results.
- AU - Autocycle - perform repeated assays on a single sample.
- AUD - Autocycle from disk - use disk files to compute results.
- BD - Background from disk - use a disk file to compute results.
- D - Change a few default parameters:
  1. Long, medium, or short printout,
  2. Whether to write raw data to disk,
  3. Turn the terminal beep on/off,
  4. Change the preset assay time,
  5. Choose which calibration to use,
  6. Change the conveyor status, and
  7. Read another parameter file.
- LA - List the assay log file (contains the last 99 A, AU, and V results).
- LM - List the MC log file (contains the last 99 MC results).
- OU - Change the output device (terminal or line printer).
- R - Read a disk data file to the MCA.
- ST - Test the status of the conveyor interface.

SUPERVISOR OPTIONS (cont)

W - Write the MCA data to a disk file.

X - Exit the program.

CHANGING PARAMETERS

The use of the parameter change program CHNLAS is a supervisory procedure requiring a password. Up to five parameter files are easily accessed within the Y12 and CHNY12 programs. We strongly recommend that changes in the parameter file be considered carefully and evaluated before the original file is altered. First, the supervisor must start the program at the system console.

```
@CHN
```

will run the program at the console. If the supervisor prefers to run the program at the user terminal, first abort the Y12 program with the X option at the user terminal, then at the system console type

```
UNL Y12
SRUN CHNY12/TERM:1.
```

The CHNLAS prompts the user with the present value of a parameter, then allows the user to enter the new value. A RETURN leaves the old value unchanged. It is important to enter integers or real numbers according to the prompt. Integers are indicated by (I) and real numbers are indicated by (F) in the prompt.

The CHNY12 options are

HE - Help (list all options)

IS - Isotope names and indices

CHANGING PARAMETERS (cont)

EN - Peak energies (one for each index)
WI - Regions of interest (three for each index)
CC - Calibration constants
DD - Data diagnostic parameters (peak centroids and widths)
EC - Energy calibration (keV for each channel)
HL - Half-life for MC sources
MC - Measurement control and background parameters
MB - Measurement control - bias
MP - Measurement control - precision
BG - Background parameters
PT - Preset count time
PW - Up to three different passwords can be used
RD - Read parameter file
LI - Output parameters
OU - Change output device (need an LP on system)
WR - Write parameter file
CO - Conveyor status
SR - Shipper/receiver comparison
EX - Exit from CHNLAS (with choice of writing a new file)

CALIBRATION

The primary purpose of the drum monitor is for shipper/receiver comparisons. These comparisons are performed between the two sets of uncorrected count rates obtained by the shipper and receiver respectively. The advantage of this method is that the comparison of two sets of results does not have the additional uncertainties associated with two independent calibrations.

A second potential use that we are exploring is inventory verification. Preliminary results indicate

CALIBRATION (cont)

that this is a technique with the potential to provide rapid results of sufficient quality to assist the facility inspector.[3] SNM of high value is often packaged in standard containers with similar loadings. Consequently, these samples have similar gamma-ray emission levels and attenuation properties. Careful segregation into appropriate material types allows the use of representative standards to derive the corresponding nonlinear calibration curve. In addition, once an inventory item has been verified the first time (or even received), this technique can omit the calibration exercise and verify with an extremely high confidence level whether the item has been altered while it resided in the SNM vault.

The program does not have a calibration option. The operator must invert the equation by hand and calculate the appropriate constant(s) and then use the parameter change program to enter the calibration constants in the parameter file. The main program reads the new values on start-up or by exercising a feature under the D (default) parameter option.

MEASUREMENT CONTROL

The measurement control procedures for this instrument have been used successfully for many applications.[4] Each spectrum is checked to ensure that the system gain and resolution are suitable. This check is primarily applied to the pulser peak from the ^{241}Am seed that is used for gain stabilization. In addition, three specific types of data acquisition are required on a regular basis. A

MEASUREMENT CONTROL (cont)

daily background count verifies that the drum monitor is adequately shielded from other sources of gamma radiation. A periodic bias check demonstrates that the system response to a known item is consistent with the historical value. A less frequent precision check verifies that the random error in repeated measurements of any item is consistent with counting statistics. The frequency of each MC check can be adjusted to meet the facility-specific conditions.

HARDWARE

The oscilloscope is indispensable in diagnosing trouble in the analog electronics. When a defective module is located, it should be removed for repair and replaced. Several test programs are described in the SOFTWARE section that can test the Series 35+, the conveyor interface, and the scale interface separately. If the Canberra test routine UTL73 is aborted in the middle of a test, it may corrupt the battery-backed-up, random-access memory (RAM) on the (Central Processing Unit) CPU/RAM board. See page 131 in the Series 35+ Operator's Manual, Version 2, or contact a Canberra engineer for more information.*

SOFTWARE

The main program Y12 and the parameter change program CHNY12 have both been tested extensively. If either one does not run or function properly, it is an indication of a problem that lies elsewhere, typically in the hardware.

ERROR MESSAGES

RT-11 and FORTRAN

These error messages are explained in the DEC manuals. If a system error occurs, it usually indicates a hardware problem. FORTRAN error messages can arise from both operator error and hardware problems.

Program

The following error messages are printed by the subroutine ERRMSG, which is called when a problem is diagnosed. These messages are self-explanatory, when read in the context of what the program was doing.

---

*Canberra Industries, Meridian, Connecticut.

Program

(cont)

```
100A  THIS IS A JUNK MESSAGE
  1A  ***  ERROR IN OPENING FILE ***
  2A  ***  ERROR IN READING FILE ***
  3A  ***  ERROR IN WRITING FILE ***
  5A  ***  RECORD POINTER INVALID ***
  6A  ***  Decode Error in   ***
  7A  ***  Verification output file already has 99 entries (FULL) ***
  8A  ***  CLOSE error in  ***
 10   consequently we will create a new file
 20   ***  INPUT MUST BE A LETTER  ***
 22A  ***  Invalid Enrichment or Material Type  ***
 25   ***  Can't turn S-90 keyboard ON/OFF  ?  ***
 30A  ***  185.7-keV Position Problem  ***
 31A  ***  pulser Position Problem  ***
 32A  ***  185.7-keV Resolution Problem  ***
 33A  ***  pulser Resolution Problem  ***
 35   ***  Maximum of 25 peaks allowed  ***
 36   ***  Index greater than maximum index  ***
 37   ***  Index 2 is less than Index 1 OR more than 128 channels ***
 40   ***  Background Pulser Rate is Wrong  ***
 41   ***  Background (186) is too large  ***
 42   ***  Background (1001) is too large  ***
 43   ***  Background (2614) is too large  ***
 50   ***  Precision Check Failed (Measurement Control)  ***
 51   ***  Bias Check Failed (Measurement Control)  ***
 60   ***  Invalid Choice ... must be 1, 2 or 3  ***
 61   ***  Put Series 35+ into remote, switch on rear  ***
 62   ***  Series 35+ init failed 3 times, check AN handler  ***
 63A  ***  Answer date/time question at Series 35+  ***
 70   ***  Background result not within limits  ***
 72   ***  Randomness test in MP outside warning limits  ***
 73   ***  Randomness test in MP failed  ***
 74   ***  Reduced Chisquare = 0.0  ***
 75   ***  PRECISION CHECK WARNING LIMITS EXCEEDED  ***
 76   ***  PRECISION CHECK ACTION LIMITS EXCEEDED  ***
 77   ***  BIAS CHECK WARNING LIMITS EXCEEDED  ***
 78   ***  BIAS CHECK ACTION LIMITS EXCEEDED  ***
 80A  ***  Invalid instrument status, active = idle  ***
 81A  ***  Invalid conveyor status, moving = rotating  ***
 82A  ***  All rotaters out of service  ***
 83A  ***  All instruments out of service  ***
 85A  ***  Can not start count if not rotating  ***
 87A  ***  Invalid conveyor status  ***
 88A  ***  Rotater station #1 is not OK  ***
 90A  ***  No match with sample ID  ***
 95A  ***  Shipper / Receiver comparison failed  ***
 101  ***  assay RESULT is SUSPECT, notify your supervisor now  ***
 102  ***  SUPERVISOR NEEDS TO CORRECT PROBLEM  ***
-999
```

RT-11 OPERATING SYSTEM

The drum monitor uses the XM version of RT-11. This version allows the programs to be slightly larger and multiple programs to run on a priority-based CPU sharing convention.

Under normal conditions, the hard disk will hold the last background spectral file, the last 99 assay/autocycle/calibration files, and the last MC bias file. To archive more than this, use the floppy diskettes. Each floppy diskette can hold 24 4-k data files and must be initialized before being used for the first time. Insert the new diskette into the drive (left drive is DY0:, right drive is DY1:). Then at the console type

INI/BAD DYn: (where n is the drive number).

RT-11 will prompt you to confirm the drive, then initialize the diskette and perform a bad-block check. Now define DYn: as the user device DK

ASS DYn: DK: .

The Y12 code writes spectral data to DK, but stores its other files on SY. The usual assignment for writing raw spectral data to disk is

ASS DL0: DK: .

It is also possible to use the RT-11 COPY command to copy files to a floppy diskette from the hard disk for archival storage. The copy command is described briefly below and in detail in the

RT-11 OPERATING SYSTEM (cont)

RT-11 manuals. These commands are valid only at the system console and are provided here as a brief reminder. Detailed descriptions are in the RT-11 manuals. In the following, n refers to the drive number.

To perform a bad-block check on a disk:

```
DIR/BAD DUn:
```

To list the files on a disk (this is lengthy for the hard disk):

```
DIR DUn:
```

To list a single file (a check to see if it exists):

```
DIR DUn:LAS.SAV
```

To initialize a new disk (this could be hazardous for the system disk):

```
INI DUn:
```

We recommend that all disk initializations include a bad-block scan:

```
INI/BAD DUn:
```

To copy a file from file1 on drive #n to file2 on drive #m:

```
COP DUn:file1.ext DUm:file2.ext
```

RT-11 OPERATING SYSTEM (cont)

To perform a fast copy of everything on a floppy diskette from DUn to DUm (the two devices must be identical):

```
COP/DEV DUn: DUm:
```

To delete a file:

```
DEL DUn:file.ext
```

To rename a file from input to output:

```
REN input.ext output.ext
```

To type an ASCII file on the terminal:

```
TYPE file.src
```

To assign a logical name DK to a physical device DUn:

```
ASS DUn: DK:
```

To deassign a logical name:

```
DEASS DK:
```

The show command displays several system characteristics:

```
SHO JOBS      Job status and priority
SHO MEM       Memory partitioning
SHO CONF      System configuration
```

RT-11 OPERATING SYSTEM (cont)

To set the system date and time:

```
DATE 12-OCT-85
TIME 9:10:15          or          TIME 9:10
```

To mount a logical disk:

```
MOU LD2:
files?  LAS.DSK
```

To dismount a logical disk:

```
DISM LD2:
```

To protect a file:

```
PRO file.ext
```

To unprotect a file:

```
UNPR file.ext
```

To run a program:

```
R file.sav              file.sav is on SY:
RUN file.sav            file.sav is on DK:
or
RUN DUn:file.sav        file.sav is on DUn:
SRUN file.sav/TERM:1    Background job using
                        terminal 1.

SRUN VBGEXE.SAV/NAME:LAS/TERM:1
                        Background job LAS.SAV
```

RT-11 OPERATING SYSTEM (cont)

running under virtual executive at terminal 1.

System Rebuild

Read this section completely before starting. If the hard disk crashes and needs to be rebuilt, first copy any irreplaceable files to a floppy diskette, if possible. These files include:

SY:PARMTR.HEU
SY:BACKGR.HEU
SY:MCLOGF.HEU
SY:ASYLOG.HEU.

A set of four floppy diskettes labeled RT11XM system is available. The first diskette is bootable and can execute the copy command. Copy all four diskettes (with the /SYS option) to the new hard disk after it is initialized with a bad-block scan. Next, copy the two diskettes that contain the backup source code. Now rebuild the codes with BLDY12.COM (edit as necessary). Finally, copy the irreplaceable files (if they exist) back to the new hard disk, otherwise you will need to update the parameters.

Necessary Files

Several files are used by the HEU drum monitor programs. The parameter file must exist in order to run the programs. The other files can be created by an editor or by the codes if they do not exist. These files reside on the system device SY:.

Necessary Files
(cont)

ASYLOG.HEU - Contains last 99 assay results in a circular file.
- If not found, the program will create it.
- lslog.src and writlg.src read and write this file.

MCLOGF.HEU - Contains last 99 MC results in a circular file.
- If not found, B option will create it.
- lmclog.src and wtmclg.src read and write this file.

BACKGR.HEU - Most recent background results.
- Written (created) by B option.
- readb.src and writb.src read and write this file.

CONSTA.HEU - ASCII list of five possible parameter files.
- readnm.src reads this file.
- Create it with an editor.

ERRMSG.HEU - ASCII list of error messages.
- errmsg.src reads this file.
- Create or modify it with an editor.

PARMTR.HEU - Parameter storage file.
- readc.src and writc.src read and write this file.

OUTPUT FILES

Examples of the output from the log files follow.

Assay log as of 15-MAR-88 15:01:42

Entry	Date	Time	Sample Id	Operator Id	Filename:	Cycles	Result	Asy Typ	Err Flg
1.	26-FEB	12:10	PUPU	88267	None	1/1	1.6731	R	T
2.	26-FEB	11:58	PUPU	88267	None	1/1	2.0081	R	T
3.	26-FEB	11:47	PUPU	88267	None	1/1	0.92250	R	T
4.	26-FEB	11:30	PUPU	88267	OUT:PUPU.Y00	1/1	0.76848	R	T
5.	26-FEB	11:20	PUPU	88267	OUT:PUPU.Y00	1/1	-377.35	S	T
6.	26-FEB	11:12	PUMETAL	JIM	OUT:PUMETA.Y00	1/1	3.7687	R	T
7.	26-FEB	10:48	PUMETAL	JIM	OUT:PUMETA.Y00	1/1	4.7551	R	T
8.	26-FEB	09:15	PUMETAL	SPRINKLE	OUT:PUMETA.Y00	1/1	0.92198	R	T
9.	26-FEB	08:20	PUMETAL	SPRINKLE	OUT:PUMETA.Y00	1/1	-279.33	S	T
10.	26-FEB	07:42	PUMETAL	88267	OUT:PUMETA.Y00	1/1	182.72	R	T
11.	25-FEB	16:29	MT	SPRINKLE	OUT:MT.Y05	5/5	-136.67	A	F
12.	25-FEB	16:25	MT	SPRINKLE	OUT:MT.Y04	4/5	-216.92	A	F
13.	25-FEB	16:20	MT	SPRINKLE	OUT:MT.Y03	3/5	-82.038	A	F
14.	25-FEB	16:16	MT	SPRINKLE	OUT:MT.Y02	2/5	-266.19	A	F
15.	25-FEB	16:12	MT	SPRINKLE	OUT:MT.Y01	1/5	-218.80	A	F
16.	25-FEB	16:04	MT	SPRINKLE	OUT:MT.Y01	1/5	-161.00	A	F
17.	25-FEB	15:45	MT	SPRINKLE	OUT:MT.Y00	1/1	-160.32	S	F
18.	25-FEB	14:31	PUMET	SPRINKLE	OUT:PUMET.Y09	9/10	-381.72	A	T
19.	25-FEB	14:26	PUMET	SPRINKLE	OUT:PUMET.Y08	8/10	-297.97	A	T
20.	25-FEB	14:20	PUMET	SPRINKLE	OUT:PUMET.Y07	7/10	-166.05	A	T
21.	25-FEB	14:14	PUMET	SPRINKLE	OUT:PUMET.Y06	6/10	-272.71	A	T
22.	25-FEB	14:07	PUMET	SPRINKLE	OUT:PUMET.Y05	5/10	-303.51	A	T
23.	25-FEB	14:01	PUMET	SPRINKLE	OUT:PUMET.Y04	4/10	-250.21	A	T
24.	25-FEB	13:55	PUMET	SPRINKLE	OUT:PUMET.Y03	3/10	-244.25	A	T
25.	25-FEB	13:49	PUMET	SPRINKLE	OUT:PUMET.Y02	2/10	-84.033	A	T
26.	25-FEB	13:43	PUMET	SPRINKLE	OUT:PUMET.Y01	1/10	-496.29	A	T
27.	25-FEB	08:48	BA	SPRINKLE	OUT:BA.Y10	10/10	-119.85	A	F
28.	25-FEB	08:44	BA	SPRINKLE	OUT:BA.Y09	9/10	-221.89	A	F
29.	25-FEB	08:39	BA	SPRINKLE	OUT:BA.Y08	8/10	-100.75	A	F
30.	25-FEB	08:35	BA	SPRINKLE	OUT:BA.Y07	7/10	-211.60	A	F
31.	25-FEB	08:30	BA	SPRINKLE	OUT:BA.Y06	6/10	-191.37	A	F
32.	25-FEB	08:26	BA	SPRINKLE	OUT:BA.Y05	5/10	-224.14	A	F
33.	25-FEB	08:21	BA	SPRINKLE	OUT:BA.Y04	4/10	-208.94	A	F
34.	25-FEB	08:17	BA	SPRINKLE	OUT:BA.Y03	3/10	-138.23	A	F
35.	25-FEB	08:12	BA	SPRINKLE	OUT:BA.Y02	2/10	-93.977	A	F
36.	25-FEB	08:08	BA	SPRINKLE	OUT:BA.Y01	1/10	-232.02	A	F
37.	25-FEB	07:48	BA	SPRINKLE	OUT:BA.Y00	1/1	-296.62	S	F
38.	24-FEB	17:11	MTMT	88267	OUT:MTMT.Y10	10/10	-229.11	A	T
39.	24-FEB	17:06	MTMT	88267	OUT:MTMT.Y09	9/10	-238.61	A	T
40.	24-FEB	17:02	MTMT	88267	OUT:MTMT.Y08	8/10	-226.62	A	T
41.	24-FEB	16:58	MTMT	88267	OUT:MTMT.Y07	7/10	-163.43	A	T
42.	24-FEB	16:53	MTMT	88267	OUT:MTMT.Y06	6/10	-352.31	A	T
43.	24-FEB	16:49	MTMT	88267	OUT:MTMT.Y05	5/10	-157.27	A	T
44.	24-FEB	16:45	MTMT	88267	OUT:MTMT.Y04	4/10	-202.88	A	T
45.	24-FEB	16:40	MTMT	88267	OUT:MTMT.Y03	3/10	-355.29	A	T
46.	24-FEB	16:36	MTMT	88267	OUT:MTMT.Y02	2/10	-288.26	A	T
47.	24-FEB	16:31	MTMT	88267	OUT:MTMT.Y01	1/10	-273.24	A	T
48.	23-FEB	07:39	MT	88267	OUT:MT.Y05	5/10	-512.28	A	F
49.	23-FEB	07:35	MT	88267	OUT:MT.Y04	4/10	-305.96	A	F
50.	23-FEB	07:31	MT	88267	OUT:MT.Y03	3/10	-220.67	A	F

OUTPUT FILES

(cont)

Measurement control log as of 15-MAR-88 15:02:14

Ent	Date	Time	Operator	Ty	MB-Result MP-Chisq B -Result	-Frac Error -Mn Sq Suc Diff -Frac Error	-Std Value -- --	# Run	VX Fg	Er Fg	Live Time
1.	26-FEB	11:53	88267	BG	-588.814	-0.282		1	F	F	200.
2.	25-FEB	07:59	SPRINKLE	MB	1132.554	0.006	1145.000	1	F	F	200.
3.	25-FEB	07:53	SPRINKLE	MB	1146.000	0.006	1439.000	1	F	T	200.
4.	25-FEB	07:20	SPRINKLE	BG	-850.654	-0.195		1	F	F	200.
5.	25-FEB	07:11	SPRINKLE	BG	-441.877	-0.369		1	F	T	200.
6.	25-FEB	06:46	SPRINKLE	BG	-409.289	-0.400		1	F	T	200.
7.	24-FEB	16:26	SPRINKLE	BG	-755.436	-0.220		1	F	T	200.
9.	23-FEB	06:56	SPRINKLE	BG	-931.027	-0.180		1	F	F	200.
10.	19-FEB	09:28	SPRINKLE	BG	-559.525	-0.297		1	F	F	200.
11.	18-FEB	15:38	SPRINKLE	BG	-224.758	-0.741		1	F	T	200.
12.	18-FEB	09:59	SPRINKLE	BG	-665.412	-0.254		1	F	F	200.
13.	17-FEB	17:15	JIM	MP	0.936	-1.299		5	F	F	200.
14.	17-FEB	09:45	JIM	BG	-354.040	-0.472		1	F	F	200.
15.	16-FEB	09:14	JIM	BG	-1026.416	-0.165		1	F	F	200.
16.	12-FEB	14:13	JIM	MB	1413.941	0.007	1439.000	1	F	F	200.
17.	12-FEB	10:26	JIM	MB	1409.478	0.007	1439.000	1	F	T	200.
18.	12-FEB	10:17	JIM	MB	1417.663	0.007	1439.000	1	F	T	200.
19.	12-FEB	09:54	JIM	MB	-1375.697	-0.043	1439.000	1	F	T	200.
20.	12-FEB	09:05	JAMES	MB	1396.176	0.007	1439.000	1	F	T	200.
21.	12-FEB	08:29	JIM	MB	1414.555	0.007	1439.000	1	F	T	200.
22.	12-FEB	08:12	JIM	MB	1418.748	0.007	1439.000	1	F	T	200.
23.	12-FEB	08:01	JIM	MB	1440.202	0.007	1270.000	1	F	T	200.
24.	12-FEB	07:48	JIM	BG	-1063.356	-0.176		1	F	F	200.
25.	12-FEB	07:40	JIM	BG	-760.495	-0.243		1	F	T	200.
26.	12-FEB	06:49	JIM	BG	-1108.887	-0.169		1	F	T	200.
27.	11-FEB	17:17	JIM	BG	-710.373	-0.261		1	F	T	200.
28.	25-JAN	07:25	JAMES	BG	-1458.263	-0.128		1	F	F	200.
29.	25-JAN	07:18	JAMES	BG	-1078.429	-0.170		1	F	T	200.
30.	25-JAN	07:02	JAMES	BG	-906.675	-0.203		1	F	T	200.
31.	25-JAN	06:54	JAMES	BG	-790.408	-0.233		1	F	T	200.
32.	25-JAN	06:47	JAMES	BG	-1094.153	-0.170		1	F	T	200.
33.	20-JAN	15:11	SPRINKLE	MP	1.093	-0.941		5	F	F	200.
34.	20-JAN	14:40	SPRINKLE	MB	1309.241	0.008	1270.000	1	F	F	200.
35.	20-JAN	14:10	SPRINKLE	BG	-776.152	-0.241		1	F	F	200.
36.	20-JAN	14:04	SPRINKLE	BG	-446.936	-0.415		1	F	T	200.
37.	20-JAN	13:58	SPRINKLE	BG	-908.262	-0.204		1	F	T	200.
38.	19-JAN	17:10	JIM	MB	1322.211	0.023	1270.000	1	F	T	20.
39.	19-JAN	14:57	SPRINKLE	MB	1275.408	0.022	1270.000	1	F	T	0.
40.	19-JAN	14:55	SPRINKLE	MB	1283.412	0.022	1270.000	1	F	T	0.
41.	19-JAN	14:53	SPRINKLE	MB	1251.258	0.022	1270.000	1	F	T	0.
42.	19-JAN	14:50	JIM	BG	-74.512	-0.866		1	F	T	0.
43.	19-JAN	14:49	JIM	BG	6165.171	0.024		1	F	T	0.
44.	19-JAN	14:16	JIM	MP	0.932	0.146		5	F	F	0.
45.	19-JAN	14:11	JIM	MB	1326.780	27.616	460.000	1	F	F	0.
46.	19-JAN	11:21	JIM	MB17474024.000		0.000	460.000	1	F	T	0.
47.	19-JAN	11:00	SPRINKLE	MB17614832.000		0.000	460.000	1	F	T	0.
48.	19-JAN	10:57	JIM	MB17163984.000		0.000	460.000	1	F	T	0.
49.	19-JAN	10:48	JIM	MB17427828.000		0.000	450.000	1	F	T	0.
50.	19-JAN	10:44	SPRINKLE	MB17741562.000		0.000	450.000	1	F	T	0.

OUTPUT FILES (cont)

Other than the log files for the measurement results, the program can write raw spectral data and the results from the confirmatory measurements. The different logical devices can be assigned to appropriate physical devices (See ASS command in the RT-11 OPERATING SYSTEM section).

OUT:BCKGRD.HEU - Raw data from last background measurement.
- Written by get90.src.

DAT:namexx.Ynn - Raw data from assays.
- Single assays nn = 00.
- For autocycle runs, nn is a counter from 01 to 99.
- Written and read by get90.src and put90.src.

OUT:nameyy.yyy - Results from V option (confirmatory results).
- Written and read by wrtdat.src and reddat.src.

TEST PROGRAMS

A few test programs are available for this system.

- DEC test routines (not supplied by LANL)
- UTL73 (Canberra-supplied test routine for the MCA)
- TESTCO (To test the conveyor interface)

TEST PROGRAMS (cont)

- VERIFY (Reads the asylog file or the confirmatory results file as shipper or receiver and then compares 1 to 4 detectors.)

PROGRAM MODIFICATION

Overview

It is LANL's expectation that this set of codes will be adequate for the needs of Y12. However, the user may decide to alter the software. If this becomes a necessity, the following information is provided.

The Y12 and CHNY12 programs are unnecessarily complex because of the memory limits of RT-11. We strongly recommend caution in attempting modifications and the frequent backing up of original and altered code. It may be prudent to consult with the Safeguards Assay Group at Los Alamos for additional advice.

The FORTRAN source code is the *.SRC files, and the common blocks are *.CMN files. The utility INC will include the common blocks in the source code to make *.FOR files as input to the compiler. Each subroutine can have a command file, name.COM, which will include and compile the subroutine:

```
INC name.FOR=name.SRC
FORT/WARN/NOLINE name/LIST
DEL name.FOR.
```

The /noline option must be used on most of the source compilation to keep the link file small enough to run. By deleting the *.FOR files, space

Overview (cont)

is preserved on the disk and the user will not accidentally compile an old version. Several command files exist to help recompile and link.

INCY12.COM - Includes common blocks in all routines

CMPY12.COM - Compiles all routines (FORTRAN and MACRO)

LNKY12.COM - Links the overlaid main program Y12

LNKCHN.COM - Links the parameter change program CHNY12

BLDY12.COM - Will do the above and more

All command files are ASCII and easy to edit. The command files are invoked by typing

$@name <CR>.

A program can be aborted two ways. A clean exit is provided by the exit option. A second alternative is to type <CTRL C> twice. The latter approach can leave the system such that file I/O or the MCA communications still need to be reset; consequently, use the first alternative if possible. Another clean way to terminate the user program on the remote terminal consists of typing

ABO name<CR>

Overview (cont)

at the console terminal, where name is the program name. If available computer memory is an issue,

```
UNL name<CR>
```

will remove the halted job "name" from memory.

Subroutine Summary

The HEU drum monitor is provided with the source code. Seventy-six subroutines are used in its programs. This section starts with a brief description of each subroutine's function and ends with an invocation summary. The invocation summary is an invaluable aid in determining "how did it get there/change that/do what it did."

ACQR90 - Routine to preset count time, start MCA, wait until acquisition is finished
ADATE - Updates assay date/time in common
AEVAX - Notifies VAX assay has ended (not used)
ANALYZ - Does analysis of net peak area data (and uncertainty)
AREA - Determines net peak area
ASOPT - Directs A and V options
ASSAY - Called by each option to get data, reduce it, etc.
AUTCYC - Directs AU and AUD options
BACKGR - Directs B option
BEEP - Sends CRTL-G to user terminal 1
CALIB - Not used
CHANGE - Directs parameter change program

Subroutine Summary (cont)

CHK90 - Upon return from MCA commands, checks if command succeeded

CHNGRL - General routine to input a real number to a prompt, also includes CHNGIN (integer input) and CHNGAL (alphanumeric input)

CHNPRT - Lists parameter values at terminal or line printer

CHNY12 - Dummy calling routine for virtual overlays (not used)

CMPLTN - Types out estimated MCA completion time

COMM - Main routine for VAX communications (not implemented)

COMPAR - Compares shipper and receiver values

CURDTA - Directs AC option

DATA90 - Gets raw spectral data from MCA or disk file

DATTIM - Sets or reads system date/time

DDIAG - Compares data diagnostics (full width at half maximum and centroid)

DIALOG - Dialogue with operator for each assay option

ERRMSG - Prints error messages from errmsg .heu file

EXEC - Controls Y12 program

FRDSK - Directs AD option

GETOP - Gets operator ID

GETSMP - Gets sample ID from operator

GET90 - Writes spectral data from MCA to disk

HEADER - Writes output header for assay options

HELP - Prints available options in Y12 code

Subroutine Summary (cont)

INDEX - Correlates peak indices with energiesto allow generic coding of analysis sections

INIT90 - Initializes MCA

INTFLG - Initializes some logical flags before an option is exercised.

ISONAM - Correlates peak indices with isotopic names to allow generic coding of analysis sections

JULDAT - Julian day/time routine

LGMENU - Menu print and selection for both log files

LHEAD - Writes header for assay log listing

LMCLOG - Lists selected portion of MC log file

LSLOG - Lists selected portion of assay log file

MCBIAS - Directs MB option

MCCHK - Checks MC log file to ensure MC is current

MCHEAD - Writes header for MC log file listing

MCPREC - Directs MP option

NEWNAM - Increments file name for writing raw data to disk (AU option)

NOCALI - Dummy stub for C option

NOSTAT - Dummy stub for conveyor communications (not used)

PASS - Checks for valid password (deactivated at delivery; see pass.com and CMPY12.COM)

PEAKS - Calls AREA and RESGN as appropriate

PRIFIN - Closes line printer to empty buffer

PRINTS - Writes summary information for AU and MP options

Subroutine Summary (cont)

PRINT1 - Writes short, medium, or long output for assay options

PUT90 - Reads spectral data from disk to MCA

READB - Reads background results file

READC - Reads parameter file

READNM - Reads list of available parameter files

REDDAT - Reads confirmatory results file

RESET - At start-up, initializes some variables. Directs D option

RESGN - Computes resolution and centroids of peaks

ROI90 - Intensifies regions of interest on MCA

SLEEP - Program will wait specified time without monopolizing the CPU

START - Initializes some devices at start up of Y12 program

STATUS - Communicates with conveyor

TESTCO - Executive program for testing conveyor communications

TEST90 - Executive program for testing MCA routines

VAXINI - Initializes VAX communications (not used)

VERIFY - Executive program for testing comparison analysis

WRITB - Writes background results file

WRITC - Writes parameter file

WRITLG - Writes assay log file

WRTDAT - Writes confirmatory results file

WTMB - Reads MC log file, writes MB results to another file (not used)

Subroutine Summary (cont)

WTMCLG - Writes MC log file

YESNO - Prompts user with ASCII string, function to set logical*1 to true or false

Y12 - Dummy calling program for Y12 to use virtual overlays

Invocation Summary

The invocation summary from RXVP80 follows. The complete RXVP80 static analysis was provided on a micro-VAX streaming tape.

INVOCATION SUMMARY

ENTRY	LISTS OF CALLS				
ABS	WHICH IS UNDEFINED				
	IS CALLED BY -	INDEX	MCBIAS	MCPREC	SCALE
ACQR90	IS CALLED BY -	ASSAY			
	AND CALLS -	ADCOFF	CDAT	CHK90	CMPLTN
		COLL	CTIM	DATTIM	ERRMSG
		FROMCA	INQADC	IPEEK	IPOKE
		ITTINR	PSET	SLEEP	STATUS
		YESNO			
ADATE	IS CALLED BY -	AUTCYC	MCBIAS		
	AND CALLS -	DATTIM			
ADCOFF	WHICH IS UNDEFINED				
	IS CALLED BY -	ACQR90	INIT90		
AEVAX	IS CALLED BY -	-NONE-			
	AND CALLS -	COMM			
AINT	WHICH IS UNDEFINED				
	IS CALLED BY -	JULDAT			
AMOD	WHICH IS UNDEFINED				
	IS CALLED BY -	CMPLTN			
ANALYZ	IS CALLED BY -	ASSAY			
	AND CALLS -	SQRT	WRTDAT		
AREA	IS CALLED BY -	PEAKS			
	AND CALLS -	DATA90	SQRT		

Invocation Summary

(cont)

```
INVOCATION SUMMARY

ENTRY          LISTS OF CALLS
-------------------------------------------------------------------------------
ASOPT          IS CALLED BY -  Y12

               AND CALLS    -  ASSAY      BEEP      COMPAR    DIALOG
                               GET9O      MCCHK     PRIFIN    PRINT1
                               WRITLG

ASSAY          IS CALLED BY -  ASOPT      AUTCYC    BACKGR    CURDTA
                               FRDSK      MCBIAS    MCPREC

               AND CALLS    -  ACQR9O     ANALYZ    DATA9O    DATTIM
                               DDIAG      ERRMSG    HEADER    PEAKS

AUTCYC         IS CALLED BY -  Y12

               AND CALLS    -  ADATE      ASSAY     DIALOG    GET9O
                               HEADER     MCCHK     NEWNAM    PRIFIN
                               PRINT1     PRINTS    SQRT      WRITLG

BACKGR         IS CALLED BY -  Y12

               AND CALLS    -  ASSAY      DIALOG    ERRMSG    GET9O
                               PASS       PRIFIN    PRINT1    READB
                               SQRT       WRITB     WTMCLG    YESNO

BEEP           IS CALLED BY -  ASOPT      START

               AND CALLS    -  KPOKE

CALIB          WHICH IS UNDEFINED

               IS CALLED BY -  Y12

CDAT           WHICH IS UNDEFINED

               IS CALLED BY -  ACQR9O

CHANGE         IS CALLED BY -  CHNY12

               AND CALLS    -  CHAR       CHNGAL    CHNGIN    CHNGRL
                               CHNPRT     DATTIM    ERRMSG    EXIT
                               GETOP      INDEX     READB     READC
                               READNM     WRITB     WRITC     YESNO

CHAR           WHICH IS UNDEFINED
```

Invocation Summary

(cont)

```
INVOCATION SUMMARY

ENTRY          LISTS OF CALLS
-------------------------------------------------------------------------------
               IS CALLED BY -  CHANGE        NEWNAM

CHK9O          IS CALLED BY -  ACQR9O        DATA9O        GET9O         INIT9O
                               PUT9O         ROI9O

               AND CALLS    -  -NONE-

CHNGAL         IS CALLED BY -  CHANGE

               AND CALLS    -  LENGTH

CHNGIN         IS CALLED BY -  CHANGE        CHNPRT

               AND CALLS    -  LENGTH

CHNGRL         IS CALLED BY -  CHANGE        VERIFY

               AND CALLS    -  LENGTH

CHNPRT         IS CALLED BY -  CHANGE

               AND CALLS    -  CHNGIN        ISONAM        PRIFIN

CHNY12         IS CALLED BY -  -NONE-

               AND CALLS    -  CHANGE

CLOS8O         WHICH IS UNDEFINED

               IS CALLED BY -  PUT9O

CMPLTN         IS CALLED BY -  ACQR9O

               AND CALLS    -  AMOD          DATTIM        SECNDS

COLL           WHICH IS UNDEFINED

               IS CALLED BY -  ACQR9O

COMM           WHICH IS UNDEFINED

               IS CALLED BY -  AEVAX

COMPAR         WHICH IS UNDEFINED
```

Invocation Summary

(cont)

INVOCATION SUMMARY

ENTRY	LISTS OF CALLS				
	IS CALLED BY -	ASOPT	VERIFY		
CROI	WHICH IS UNDEFINED				
	IS CALLED BY -	ROI90			
CTIM	WHICH IS UNDEFINED				
	IS CALLED BY -	ACQR90			
CURDTA	IS CALLED BY -	Y12			
	AND CALLS -	ASSAY	DIALOG	PRINT1	
DATA90	IS CALLED BY -	AREA	ASSAY		
	AND CALLS -	CHK90	ERRMSG	FROMCA	MOD
DATE	WHICH IS UNDEFINED				
	IS CALLED BY -	DATTIM			
DATTIM	IS CALLED BY -	ACQR90 CMPLTN	ADATE LHEAD	ASSAY MCHEAD	CHANGE Y12
	AND CALLS -	DATE SETTIM	JULDAT TIME	SETDAT	SETDT
DDIAG	IS CALLED BY -	ASSAY			
	AND CALLS -	ERRMSG			
DIALOG	IS CALLED BY -	ASOPT FRDSK	AUTCYC MCBIAS	BACKGR MCPREC	CURDTA
	AND CALLS -	GETOP YESNO	GETSMP	NEWNAM	PASS
EROI	WHICH IS UNDEFINED				
	IS CALLED BY -	ROI90			

Invocation Summary

(cont)

```
INVOCATION SUMMARY

ENTRY          LISTS OF CALLS
-------------------------------------------------------------------------------
ERRMSG         IS CALLED BY -  ACQR90      ASSAY       BACKGR      CHANGE
                               DATA90      DDIAG       GET90       GETSMP
                               INIT90      LMCLOG      LSLOG       MCBIAS
                               MCCHK       MCPREC      PASS        PRIFIN
                               PRINT1      PUT90       READB       READC
                               READNM      REDDAT      SCALE       START
                               STATUS      VERIFY      WRITB       WRITC
                               WRITLG      WRTDAT      WTMCLG

               AND CALLS    -  -NONE-

EXIT           WHICH IS UNDEFINED

               IS CALLED BY -  CHANGE      INIT90      TESTSC      VERIFY
                               Y12

FLOAT          WHICH IS UNDEFINED

               IS CALLED BY -  RESGN

FRDSK          IS CALLED BY -  Y12

               AND CALLS    -  ASSAY       DIALOG      PRINT1      WRITB
                               YESNO

FROMCA         WHICH IS UNDEFINED

               IS CALLED BY -  ACQR90      DATA90      GET90

GET90          IS CALLED BY -  ASOPT       AUTCYC      BACKGR      Y12

               AND CALLS    -  CHK90       ERRMSG      FROMCA

GETOP          IS CALLED BY -  CHANGE      DIALOG

               AND CALLS    -  -NONE-

GETSMP         IS CALLED BY -  DIALOG

               AND CALLS    -  ERRMSG      REDDAT      SCALE

HEADER         IS CALLED BY -  ASSAY       AUTCYC      MCPREC
```

Invocation Summary

(cont)

```
INVOCATION SUMMARY

ENTRY          LISTS OF CALLS
-------------------------------------------------------------------------------
               AND CALLS     -  -NONE-

HELP           IS CALLED BY  -  Y12

               AND CALLS     -  -NONE-

IDETCH         WHICH IS UNDEFINED

               IS CALLED BY  -  INIT90

IFIX           WHICH IS UNDEFINED

               IS CALLED BY  -  RESGN

IFREEC         WHICH IS UNDEFINED

               IS CALLED BY  -  PUT90        READNM

IGETC          WHICH IS UNDEFINED

               IS CALLED BY  -  PUT90        READNM

INDEX          IS CALLED BY  -  CHANGE       Y12

               AND CALLS     -  ABS

INIDL          WHICH IS UNDEFINED

               IS CALLED BY  -  START        TESTSC

INIMSG         WHICH IS UNDEFINED

               IS CALLED BY  -  VAXINI

INIT           WHICH IS UNDEFINED

               IS CALLED BY  -  INIT90
```

Invocation Summary

(cont)

INVOCATION SUMMARY

ENTRY	LISTS OF CALLS				
INIT90	IS CALLED BY -	START			
	AND CALLS -	ADCOFF IDETCH	CHK90 INIT	ERRMSG INQADC	EXIT
INQADC	WHICH IS UNDEFINED				
	IS CALLED BY -	ACQR90	INIT90		
INTFLG	IS CALLED BY -	RESET	START	Y12	
	AND CALLS -	-NONE-			
IPEEK	WHICH IS UNDEFINED				
	IS CALLED BY -	ACQR90	PASS		
IPOKE	WHICH IS UNDEFINED				
	IS CALLED BY -	ACQR90	PASS		
IRDL	WHICH IS UNDEFINED				
	IS CALLED BY -	SCALE			
ISLEEP	WHICH IS UNDEFINED				
	IS CALLED BY -	SLEEP			
ISONAM	IS CALLED BY -	CHNPRT			
	AND CALLS -	-NONE-			
ITTINR	WHICH IS UNDEFINED				
	IS CALLED BY -	ACQR90	PASS		
JULDAT	IS CALLED BY -	DATTIM	LMCLOG	LSLOG	MCCHK

Invocation Summary

(cont)

```
INVOCATION SUMMARY

ENTRY          LISTS OF CALLS
-------------------------------------------------------------------------------
               AND CALLS     -  A1NT

KBON           WHICH IS UNDEFINED

               IS CALLED BY  -  Y12

KPEEK          WHICH IS UNDEFINED

               IS CALLED BY  -  STATUS

KPOKE          WHICH IS UNDEFINED

               IS CALLED BY  -  BEEP          STATUS

LENGTH         IS CALLED BY  -  CHNGAL        CHNGIN        CHNGRL

               AND CALLS     -  RCTRLO

LGMENU         IS CALLED BY  -  LMCLOG        LSLOG

               AND CALLS     -  RCTRLO

LHEAD          IS CALLED BY  -  LSLOG

               AND CALLS     -  DATTIM

LMCLOG         IS CALLED BY  -  Y12

               AND CALLS     -  ERRMSG        JULDAT        LGMENU        MCHEAD

LSLOG          IS CALLED BY  -  VERIFY        Y12

               AND CALLS     -  ERRMSG        JULDAT        LGMENU        LHEAD

MCBIAS         IS CALLED BY  -  Y12

               AND CALLS     -  ABS           ADATE         ASSAY         DIALOG
                                ERRMSG        MCCHK         PRIFIN        PRINT1
                                SQRT          WTMCLG        YESNO

MCCHK          IS CALLED BY  -  ASOPT         AUTCYC        MCBIAS
```

Invocation Summary

(cont)

INVOCATION SUMMARY

ENTRY	LISTS OF CALLS				
	AND CALLS -	ERRMSG	JULDAT	YESNO	
MCHEAD	IS CALLED BY -	LMCLOG			
	AND CALLS -	DATTIM			
MCPREC	IS CALLED BY -	Y12			
	AND CALLS -	ABS HEADER YESNO	ASSAY PRINT1	DIALOG SQRT	ERRMSG WTMCLG
MOD	WHICH IS UNDEFINED				
	IS CALLED BY -	DATA9O			
NEWNAM	IS CALLED BY -	AUTCYC	DIALOG		
	AND CALLS -	CHAR			
OPEN8O	WHICH IS UNDEFINED				
	IS CALLED BY -	PUT9O			
PASS	IS CALLED BY -	BACKGR Y12	DIALOG	REDDAT	STATUS
	AND CALLS -	ERRMSG	IPEEK	IPOKE	ITTINR
PEAKS	IS CALLED BY -	ASSAY			
	AND CALLS -	AREA	RESGN		
PRIFIN	IS CALLED BY -	ASOPT MCBIAS	AUTCYC Y12	BACKGR	CHNPRT
	AND CALLS -	ERRMSG			
PRINT1	IS CALLED BY -	ASOPT FRDSK	AUTCYC MCBIAS	BACKGR MCPREC	CURDTA
	AND CALLS -	ERRMSG			

Invocation Summary

(cont)

```
INVOCATION SUMMARY

ENTRY          LISTS OF CALLS
-------------------------------------------------------------------------------
PRINTS         IS CALLED BY -  AUTCYC

               AND CALLS    -  -NONE-

PSET           WHICH IS UNDEFINED

               IS CALLED BY -  ACQR9O

PUT9O          IS CALLED BY -  Y12

               AND CALLS    -  CHK9O      CLOS8O      ERRMSG      IFREEC
                               IGETC      OPEN8O      WRIT8O

RCTRLO         WHICH IS UNDEFINED

               IS CALLED BY -  LENGTH     LGMENU      Y12         YESNO

READB          IS CALLED BY -  BACKGR     CHANGE      RESET

               AND CALLS    -  ERRMSG

READC          IS CALLED BY -  CHANGE     RESET

               AND CALLS    -  ERRMSG

READNM         IS CALLED BY -  CHANGE     RESET

               AND CALLS    -  ERRMSG     IFREEC      IGETC       YESNO

REDDAT         IS CALLED BY -  GETSMP     VERIFY      Y12

               AND CALLS    -  ERRMSG     PASS        YESNO

RESET          IS CALLED BY -  Y12

               AND CALLS    -  INTFLG     READB       READC       READNM
                               ROI9O      STATUS      YESNO

RESGN          IS CALLED BY -  PEAKS

               AND CALLS    -  FLOAT      IFIX

ROI9O          IS CALLED BY -  RESET
```

Invocation Summary

(cont)

INVOCATION SUMMARY

ENTRY	LISTS OF CALLS				
	AND CALLS -	CHK90 YESNO	CROI	EROI	SLEEP
SCALE	IS CALLED BY -	GETSMP	TESTSC		
	AND CALLS -	ABS	ERRMSG	IRDL	YESNO
SECNDS	WHICH IS UNDEFINED				
	IS CALLED BY -	CMPLTN			
SETDAT	WHICH IS UNDEFINED				
	IS CALLED BY -	DATTIM			
SETDT	WHICH IS UNDEFINED				
	IS CALLED BY -	DATTIM			
SETERR	WHICH IS UNDEFINED				
	IS CALLED BY -	START			
SETTIM	WHICH IS UNDEFINED				
	IS CALLED BY -	DATTIM			
SLEEP	IS CALLED BY -	ACQR90	ROI90	START	
	AND CALLS -	ISLEEP			
SPRPAR	WHICH IS UNDEFINED				
	IS CALLED BY -	VAXINI			
SQRT	WHICH IS UNDEFINED				
	IS CALLED BY -	ANALYZ MCBIAS	AREA MCPREC	AUTCYC	BACKGR

Invocation Summary

(cont)

INVOCATION SUMMARY

ENTRY	LISTS OF CALLS				
START	IS CALLED BY -	Y12			
	AND CALLS -	BEEP INTFLG	ERRMSG SETERR	INIDL SLEEP	INIT9O STATUS
STATUS	IS CALLED BY -	ACQR9O Y12	RESET	START	TESTCO
	AND CALLS -	ERRMSG YESNO	KPEEK	KPOKE	PASS
TESTCO	IS CALLED BY -	-NONE-			
	AND CALLS -	STATUS	YESNO		
TESTSC	IS CALLED BY -	-NONE-			
	AND CALLS -	EXIT	INIDL	SCALE	YESNO
TIME	WHICH IS UNDEFINED				
	IS CALLED BY -	DATTIM			
VAXINI	IS CALLED BY -	-NONE-			
	AND CALLS -	INIMSG	SPRPAR		
VERIFY	IS CALLED BY -	-NONE-			
	AND CALLS -	CHNGRL LSLOG	COMPAR REDDAT	ERRMSG YESNO	EXIT
WRIT8O	WHICH IS UNDEFINED				
	IS CALLED BY -	PUT9O			
WRITB	IS CALLED BY -	BACKGR	CHANGE	FRDSK	
	AND CALLS -	ERRMSG			
WRITC	IS CALLED BY -	CHANGE			
	AND CALLS -	ERRMSG			

Invocation Summary

(cont)

```
INVOCATION SUMMARY

ENTRY          LISTS OF CALLS
-------------------------------------------------------------------------------
WRITLG         IS CALLED BY -  ASOPT        AUTCYC

               AND CALLS    -  ERRMSG

WRTDAT         IS CALLED BY -  ANALYZ

               AND CALLS    -  ERRMSG       YESNO

WTMCLG         IS CALLED BY -  BACKGR       MCBIAS       MCPREC

               AND CALLS    -  ERRMSG

Y12            IS CALLED BY -  -NONE-

               AND CALLS    -  ASOPT        AUTCYC       BACKGR       CALIB
                               CURDTA       DATTIM       EXIT         FRDSK
                               GET9O        HELP         INDEX        INTFLG
                               KBON         LMCLOG       LSLOG        MCBIAS
                               MCPREC       PASS         PRIFIN       PUT9O
                               RCTRLO       REDDAT       RESET        START
                               STATUS

YESNO          IS CALLED BY -  ACQR9O       BACKGR       CHANGE       DIALOG
                               FRDSK        MCBIAS       MCCHK        MCPREC
                               READNM       REDDAT       RESET        RO19O
                               SCALE        STATUS       TESTCO       TESTSC
                               VERIFY       WRTDAT

               AND CALLS    -  RCTRLO

** THE FOLLOWING ENTRIES ARE NOT CALLED **

                               AEVAX        CHNY12       TESTCO       TESTSC
                               VAXINI       VERIFY       Y12
```

COMPUTER CONFIGURATION The computer interface information is shown below.

Device	Address	Vector	Interface Board		Baud	Comments
System console	177560	60	Multifunction board		300	VT220
Line printer	176500	300	Multifunction board port A1			
Series 35+ MCA	176100	120	Canberra 8673V		19 k	
User term #1	176540	340	DLV	Chan 0	9600	VT220 (RS-232)
User term #2	176550	350	DLV	Chan 1	9600	Not used (RS-232)
User term #3	176560	360	DLV	Chan 3	9600	Not used (RS-232)
Toledo scale	176570	370	DLV11-J	Chan 3	9600	RS-422 11 data bits
Conveyor	167770	70	DRV11			

The Canberra interface conflicts with Ethernet. We suggest using the vector 130 for Canberra if Ethernet is added to this machine.

DLV11-J BOARD

The DLV11-J device, vector addressing, serial word formats, baud rates, and interface type are selected by installing and/or removing jumpers. The DLV11-J is configured to non-DEC factory standard. The device base address is 776540 and the vector base address is 340. Channel 3, which is normally the console port, is now disabled as the console port. The board is configured as follows (refer to Fig. 6):

- Baud rate is set to 9600.
- For base address of 776540, change "A5" from XO to X1.

DLV11-J BOARD

(cont)

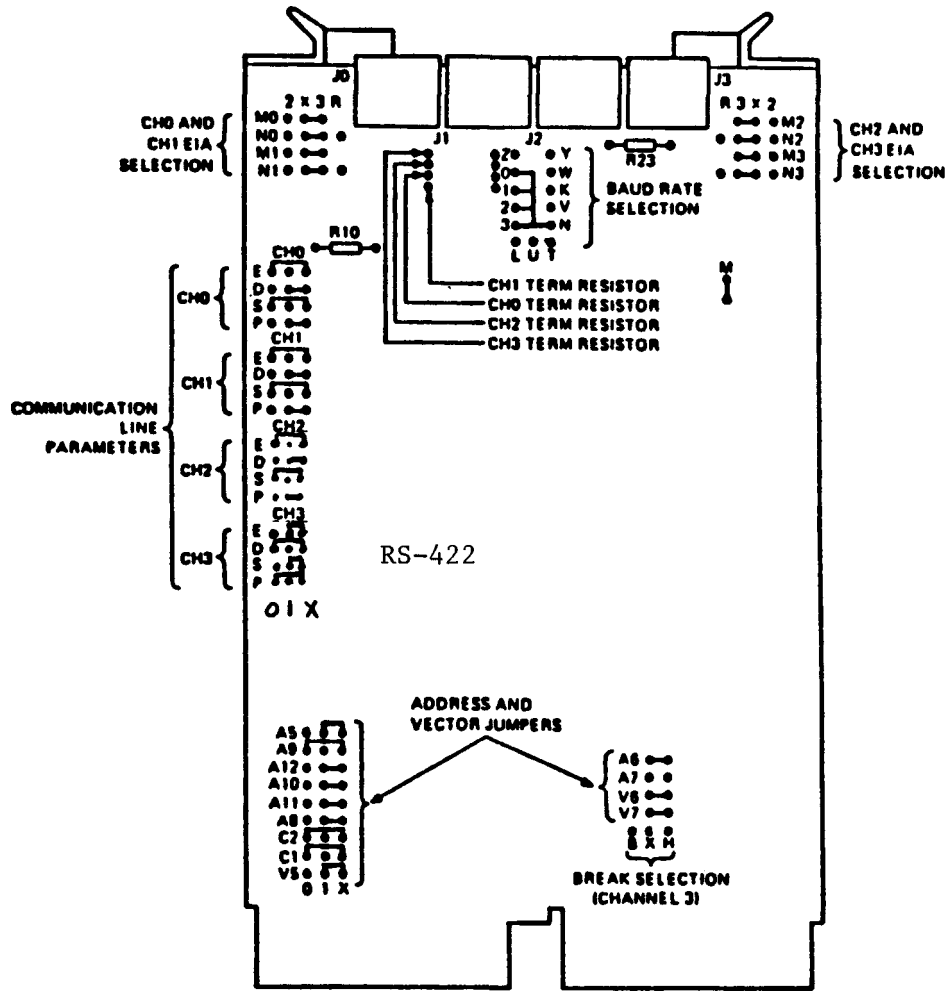

Fig. 6. DLV11-J jumper locations.

- For base vector address of 340, change "V5" from XO to X1.
- To disable Channel 3 as console so it can now be in sequence with the other three channels, change "C1" from X1 to X0 and "C2" from X1 to XO. See Fig. 6 for jumper location.

DLV11-J BOARD (cont)

- RS-422 requires different jumpers and a 100-Ω resistor.
- Disable the BREAK option by removing X to H.

See Digital Memories and Peripherals Handbook 1978-79, pp. 2-148, for detailed configuration description.*

SAMPLE/DETECTOR GEOMETRY

The best compromise between higher response and less sensitivity to sample positioning errors is based on a detector-to-sample center distance of 27 in. This compromise assumes that each detector is recessed 3 in. into its lead collimator and that the collimator is 24 in. from the barrel center. We aligned the bottom detector with the lowest possible SNM height. Then we used a nominal 20-in. spacing between the detector center lines.

RADIOACTIVE SOURCES

Each of the low-resolution detectors has a small ^{241}Am seed embedded in the detector crystal. This seed creates pulses that can be used for analog stabilization. The gamma-equivalent energy of the seed pulses is specified to be 1.7 ± 0.2 MeV. Four 1 μC ^{133}Ba sources were supplied with the HEU drum monitor. They are doubly encapsulated in 1- by 1- by 1/2-in. plastic cases. They are to be used for measurement control assays.

*Digital Equipment Corporation, Maynard, Massachusetts.

PREVENTATIVE MAINTENANCE

Keep the rack fan filters clean.

Periodically verify that the various cooling fans are still functional.

REFERENCES

1. C. Alton Coulter, "Safeguards Uses of Confirmatory Measurements" Nucl. Mater. Manage. XIV (3), (1985), p. 613.

2. J. K. Sprinkle, Jr., "A Confirmatory Measurement Technique for Highly Enriched Uranium," Los Alamos National Laboratory report LA-11021-MS (July 1987).

3. R. Marshall and F. Hsue, Los Alamos National Laboratory Group OS-2, private communication, July (1985).

4. S. -T. Hsue, K. Campbell, and G. Barlich, "Measurement Control Program for New Special Recovery," Los Alamos National Laboratory report LA-10974-MS (April 1987).

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