HEDL Air Filter Examination System Software

E. E. Stapleton

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**Pacific Northwest Laboratory
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SUMMARY

This document describes the system software and operation of the Hanford Engineering Development Laboratory (HEDL) air filter sample counting systems. Included are a description of how each program functions with flow charts, sample printouts, program listings and a listing with comments of test routines that exercise the hardware.

This effort is a result of a work order from HEDL Operational Safety to the Instrument Calibration and Evaluations section of the Pacific Northwest Laboratory (PNL) to upgrade the HEDL counting systems to include standardization, radon subtraction, and detector cooling.

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INTRODUCTION

Two automatic and one manual examining and counting systems were developed for reading Hanford Engineering Development Laboratory (HEDL) air sample filters. Before these new systems were developed, different computers, interfaces, and printouts had been used.

The three systems have now been standardized except for one software file that determines whether the tape is used on an automatic or a manual system. As shown in Figure 1, these systems are composed of a planchette sample changer (auto system shown), an alpha/beta detector and its cooling system, four single channel analyzers, four scalers, a timer, a computer interface, a desktop computer, and a dot-matrix printer. Data collection and control are performed by the Hewlett Packard 9815 desk top computer. This computer has up to 360 program steps with 20 data registers, a 16-character-wide thermal printer, and a high-speed cassette drive system. A detailed list of these hardware components and references to the manufacturer's literature can be found in Appendix A.

Data sent to the thermal printer is used to verify that the system is working properly while the test is in progress, and may be discarded or used for diagnosis in the event of a failure.

The system software consists of four callable functions that each use one or more programs. At the conclusion of any function, the system resumes its ready state; any of the four functions may then be selected.

System startup is initiated by the Auto-Start feature of the controlling HP9815 desk top computer. When power is applied to the system, the computer immediately runs a start program and assumes the ready state.

All programs for this system are resident on cassette. This cassette is also used for the storage of system constants and temporary data, and thus cannot be write protected.

FIGURE 1. Hardware Configuration for Air Filter Examination System

SYSTEM SOFTWARE

OVERVIEW

The software for the air filter examination system consists of four callable functions, a function select program, and an auto-start program. The four callable functions consist of twenty programs that interact by exchanging data via memory registers and the system's cassette drive. Twenty files on block 1 of the cassette hold these programs (see Table 1). Table 1 also lists the interaction of these functions. Although there are a total of 21 files, only 20 files are used on any system tape. This is because file 17 comes in two versions; one for the automatic systems (17A) and one for the manual systems (17M). Thus, there are a total of 21 files listed in Appendix A.

TABLE 1. Program Placement on Cassette Files and Interaction Between Programs

<u>File #</u>	<u>Program</u>	<u>Files Called</u>
Ø	Header (Auto-Start)	1
1	Function Select	2, 4, 7, 13
2	Initialize Parameters (1 of 2) (List)	3, 1
3	Initialize Parameters (2 of 2) (Change)	2
4	Background Test (1 of 3) (Test)	5, 1
5	Background Test (2 of 3) (Print Header)	6
6	Background Test (3 of 3) (Report)	1
7	Chi-Squared Test (1 of 6) (Set up)	8, 1
8	Chi-Squared Test (2 of 6) (Test)	9, 1
9	Chi-Squared Test (3 of 6) (Calculate)	10
10	Chi-Squared Test (4 of 6) (Report)	11, 1
11	Chi-Squared Test (5 of 6) (Report)	12
12	Chi-Squared Test (6 of 6) (Report)	1
13	Filter Examination (1 of 6) (Prepared Registers)	14, 1
14	Filter Examination (2 of 6) (Print Header)	15
15	Filter Examination (3 of 6) (Print Header)	16
16	Filter Examination (4 of 6) (Print Header)	17
17A	Filter Examination (5 of 6) (Automatic Test)	18, 1
17M	Filter Examination (5 of 6) (Manual Test)	18, 1
18	Filter Examination (6 of 6) (Print Result)	19
19	Alert Record (Record Alerted Data)	17, 20, 1
20	Alert List (Listed Recorded Data)	1

HEADER (AUTO-START) PROGRAM

The HP9815A desktop computer uses an auto-start feature where the program in file 0 of the cassette drive will be loaded and executed when the power is switched on. To use this option, the RUN/AUTO-START/PRGM switch must be in the AUTO-START position prior to switching the power on.

File 0 contains the header program, which prints an introduction and instructions for selecting the functions to be listed. The program then instructs the computer to load and execute the function select program in file 1.

The header program neither generates nor requires any data. The computer defaults the register set to 10 and program step size to 360 when power is applied. See Figure 2 for a flow diagram of the header program and Figure 3 for the printout.

FIGURE 2. File 0 - Header (Auto-Start) Program Flow Diagram

FIGURE 3. Printout of Header (Auto-Start) Program

FUNCTION SELECT PROGRAM

The function select program is the return point when any system function is terminated or after the header program runs. This program lists the four system functions available plus "stop" and "instructions" options, assigning each function a lettered key. When the program suspends itself after the listing, any of the six keys listed may be pushed to start a function. (Key 0 turns off the system. The power can be turned off and back on, with the Auto-Start option, to restart the system.) For a given function selection, the appropriate file is loaded and executed, thus overlaying the function select program. Once this is done, the lettered keys will have changed functions or have no meaning.

The function select program resides in file 1 of the cassette. It neither generates nor uses any data. See Figure 4 for a flow diagram of the function select program and Figure 5 for the printout.

FIGURE 4. File 1 - Function Select Program Flow Diagram

```

A - INSTRUCTIONS
B - INITIALIZE
  PARAMETERS
C - BACKGROUND
  TEST
D - CHI SQUARE
  TEST
E - FILTER EXAM
0 - STOP

PRESS *END*
THEN LETTER
  
```

FIGURE 5. Printout of Function Select Program

INITIALIZE PARAMETERS PROGRAM

This function is selected by pressing key "B" in the function select program. The program is stored in two files (2 and 3) on cassette. File 2 is first loaded and prints instructions to either: (1) change any of the eight parameters used by the test routines, (2) list the parameters, or (3) stop (return to function select.) The eight parameters that may be listed or changed are shown in Table 2, with their units and typical values. See Appendix C for further information on the storage of these data and others. File 2 holds the instruction, list and stop options while file 3 is loaded to do the change option. When changes are complete, file 2 is reloaded.

The initialize parameters program does not use data, but does access data for storage and listing on cassette files -0 and -2. Buttons A through H and 0 are used to select parameters for change in the change option and registers R0 through R9 are used as temporary data storage when reading and writing the cassette files. See Figure 6 for a flow diagram of the initialize parameters program and Figure 7 for a sample printout.

TABLE 2. Constants Accessible by the "Initialize Parameters" Program

<u>Key</u>	<u>Parameter</u>	<u>Typical Value</u>	<u>Units</u>
A	Background Test Count Time	10.00	minutes
B	Beta Alert Level	1×10^{-11}	$\mu\text{Ci/cc}$
C	Alpha Alert Level	3×10^{-13}	$\mu\text{Ci/cc}$
D	^{239}Pu Alert Level	3×10^{-13}	$\mu\text{Ci/cc}$
E	Sample Monitor Volume	1440	CFD
F	Sample Exposure Period	1-7	Days
G	Standard Beta Source	23000	d/m
H	Standard Alpha Source	5190	d/m

FIGURE 6. Files 2 and 3 - Initialize Parameters Program Flow Diagrams

```

ENTER:
A - TO CHANGE
B - TO LIST
O - TO STOP

```

Options

```

A-BKGND TM
B-B ALERT
C-F ALERT
D-PU ALERT
E-SMPL VOL
F-PERIOD
G-B SOURCE
H-A SOURCE

O-STOP

```

Change Options

```

LETTER?
A
VALUE? 10.0

LETTER?
B
VALUE? 3.00 -11

LETTER?
C
VALUE? 5.00 -13

LETTER?
D
VALUE? 5.00 -13

LETTER?
E
VALUE? 1440

LETTER?
F
VALUE? 1

LETTER?
G
VALUE? 20100

LETTER?
H
VALUE? 5380

LETTER?

```

Changing

```

CURRENT VALUES:

BKGND CNT TIME
= 10.0 MIN
BETA ALERT LEVEL
= 3.0 -11 UC/CC
ALPHA ALERT LEVEL
= 5.0 -13 UC/CC
PU233 ALERT LEVEL
= 5.0 -13 UC/CC
SMPL VOL
= 1440.00 CFD
PERIOD
= 1.00 DAYS
BETA SOURCE
= 20100 D/MIN
ALPHA SOURCE
= 5380 D/MIN

```

Listing

FIGURE 7. Sample Printouts from Initialize Parameters Program

BACKGROUND TEST PROGRAM

The background test program is stored in three files (4, 5 and 6) on the cassette. The first file loaded (4) performs the test and then calls the second and third files (5 and 6) which print the test results.

This program examines an empty filter holder for a specified period of time (typically ten minutes) and calculates the average beta, alpha, ^{239}Pu , and radon counts per minute. These averages are then stored on cassette (see Appendix C). The chi-squared test and filter examination programs then use these values to adjust their gross counts by these background averages.

The background test program examines the count time stored in memory and displays it to alert the operator to check the timer setting, see Figure 8.

At this point the operator may abort the test and reset the time through the initialize parameters program, set the timer, or continue the test. If the program notes a difference between the expected time and the timer setting when the test is finished, an alert message is printed. However, the data is calculated by the timer setting, thus assuring the quality of the background data. Also, the timer value replaces the time value originally stored. All timer readings are assumed to be in 0.01 minute increments.

Refer to Figure 9 for a flow diagram, and Figure 10 for a completed test result. Note that the chi-square test result prints out on the same page of the external printer, if the chi square is acceptable.

```
*BACKGROUND TEST

BLANK FILTER IN
PLACE?
PUSH 'RUN' TO
CONTINUE
PUSH 'A' TO STOP

EXPECTED RUN =
      10.00 MIN.

PUSH RUN OR A

** END **
```

Normal

```
*BACKGROUND TEST

BLANK FILTER IN
PLACE?
PUSH 'RUN' TO
CONTINUE
PUSH 'A' TO STOP

EXPECTED RUN =
      10.00 MIN.

PUSH RUN OR A

*NOTE:
THE PERIOD OF
TEST DID NOT
EQUAL THE TIME
EXPECTED. TIME
SET IN MEMORY
TO      0.10 MIN.

** END **
```

Timer Error

FIGURE 8. Sample Printouts from Background Test

FIGURE 9. Files 4, 5, and 6 - Background Test Program Flow Diagram

DATE_____ SHIFT_____ AUTO-MANUAL RM INITIALS_____

BACKGROUND TEST RESULT

AVERAGE BACKGROUND (COUNTS/MINUTE)

BETA	=	10.70
ALPHA	=	0.00
^{239}Pu	=	0.00
RADON	=	0.00

FIGURE 10. Printout of Background Test Results

CHI-SQUARED TEST PROGRAM

The chi-squared test program is stored in six files (7 through 12) on the cassette. The first file loaded (7) prompts the operator to ensure proper set-up. The threshold dial and window on the radon channel must be lowered to accept the ^{239}Pu pulses for this test. The second file (8) performs the test, checks for correct time, and prints out the raw data for each scaler after each count cycle.

The third file (9) completes the chi-squared and efficiency calculations and prints the results on the thermal printer. The fourth file (10) evaluates each counters performance for acceptability. The results are printed on the thermal printer and, if the counters are found acceptable or conditionally acceptable, the next two files (11 and 12) are loaded, which formats and prints the results below the background data on the external printer.

This program examines a known source of radioactive material for twenty periods of any value (typically one minute). By calculating the chi-squared values of a standard source, the probability of the data comprising a normal set can be determined. Deviations indicate that hardware recalibration is necessary.

The chi-squared values are determined for beta, alpha, ^{239}Pu and radon by the equation:

$$\text{Chi}^2 = \frac{\sum_{i=1}^n (x_i - \bar{x})^2}{\bar{x}}$$

where: x_i = individual count

$\bar{x}$ = mean count

n = number of counts

Since a limited number of registers are available in the HP9815A calculator (23 through 26 for this program) the following form of the chi-squared equation was actually used.

$$\text{Chi}^2 = \frac{\sum_{i=1}^n x_i^2 - \frac{\left(\sum_{i=1}^n x_i\right)^2}{n}}{\bar{x}}$$

The mean, or average, count and the detector efficiencies for each channel are also calculated. For the mean count:

$$\bar{x} = \frac{\sum_{i=1}^n x_i}{n}$$

The detector efficiency is then calculated by:

$$\%E = \frac{(\bar{x} - x_B)}{S} * 100\%$$

where: x_B = background count rate

S = source strength.

The background count rates and standard sample source strengths are retrieved from the cassette data files when the counting process concludes. The efficiency is expressed as a percentage and reflects the ratio of the number of radiation particles which were detected with respect to the number of radiation particles generated by the source. Since a plane detector mounted above the source is used, the detector efficiency must be less than 50%. The beta, alpha and ^{239}Pu detector efficiencies are saved for later use in

calculating radiation particle concentration in the filter examination program. The radon data is printed out but not saved since only the net counts/min is used by the filter examination program. Registers 10, 11, 12 are used to pass the radon data between files.

The activity of the radioactive sources used for this test are entered into memory via the initialize parameters program prior to running the chi-squared test. The data is entered as the number of disintegrations per minute. At this time, the alpha, ^{239}Pu , and radon source are considered to be the same, thus only the alpha source can be initialized. A typical mixture for the source is ^{90}Sr and ^{239}Pu with activities of 16,100 beta decays and 4900 alpha decays per minute. The calculator's range will not limit the maximum source strengths to be used.

Please refer to Figures 11 through 13 for flow diagrams of the chi-squared test, Figure 14 for a sample printout during the test, and Figure 15 for a printout of the test results.

The acceptance test is stored in file 10 on the cassette and is used to evaluate the chi-squared results for acceptability.

The criteria for accepting or rejecting a counter's performance is based on the probability of exceeding given limits as shown below:

Probability	99%	90%	10%	1%
Chi^2	7.63	11.65	27.20	36.19

Depending on the value of Chi^2 , each counter's performance will be acceptable, conditionally acceptable or unacceptable.

To be acceptable: $10\% \leq \text{Chi}^2 \leq 90\%$

To be conditionally acceptable: $1\% \leq \text{Chi}^2 < 10\%$ or $90\% < \text{Chi}^2 \leq 99\%$

To be unacceptable: $\text{Chi}^2 < 1\%$ or $\text{Chi}^2 > 99\%$.

If a counter is found unacceptable, the data is not sent to the external printer and the system returns to the wait mode.

FIGURE 11. Files 7 and 8 - Chi-Squared Test Program Flow Diagrams

FIGURE 12. Files 9 and 10 - Chi-Squared Test Program Flow Diagrams

FIGURE 13. Files 11 and 12 - Chi-Squared Test Program Flow Diagrams

FIGURE 14. Sample Printout from Chi-Squared Test Program

DATE_____ SHIFT_____ AUTO-MANUAL RM INITIALS_____

BACKGROUND TEST RESULT

AVERAGE BACKGROUND (COUNTS/MINUTE)

BETA	=	10.70
ALPHA	=	0.00
²³⁹ Pu	=	0.00
RADON	=	0.00

CHI SQUARE TEST RESULT

BETA SOURCE	=	16100 D/M
ALPHA SOURCE	=	4900 D/M

CHANNEL	MEAN C/M	CHI SQ.	% EFF
BETA	2477.40	9.35	15.32
ALPHA	1280.65	19.26	26.14
²³⁹ Pu	901.25	20.78	18.39
RADON	922.95	19.71	18.84

FIGURE 15. Printout of Chi-Squared Test Results

FILTER EXAMINATION PROGRAM

The filter examination program is stored on eight cassette files (13 through 20). The first file (13) is loaded and is used to initialize the data registers prior to running tests on the samples. The second, third and fourth files (14, 15 and 16) are used to print the header information on the external printer. The fifth file (17) is called to examine the sample presently in place, forward the changer when finished (auto system), determine if the timer was correct, and then either load the next file (18) or abort the examination if the timer reading was incorrect. Two versions of file 17 exist, one for an automatic system (17A) and one for the manual system (17M).

File 18 prints the net counts/minute on the external printer, then subtracts the radon counts from the gross beta, gross alpha and ^{239}Pu channels prior to calculating the $\mu\text{Ci/cc}$ levels. Extensive testing has shown that if 100 counts are detected in the radon channel, 120 counts is an acceptable number to be subtracted from the gross beta, 100 counts from the gross alpha, and 10 counts from the ^{239}Pu . File 18 then looks for alert conditions, and flags the external printout if over limit conditions exist.

The seventh file (19) checks to see if an alert condition was previously detected. If no alert condition existed, and it was not the last sample, file 17 is again loaded and the next sample examined. If an alert condition was detected, the sample percentage over-limits is calculated and recorded. The last file (20) is loaded after all samples have been read and one or more samples were found to be over-limit. This file prints out a summary of the samples which exceeded the alert levels on the thermal printer.

This program examines a series of samples (up to 100 per run) for two minutes each. It then divides the gross counts of each channel by 2, subtracts the background and prints the net counts-per-minute for each channel on the external printer. By using the efficiency data collected earlier and the present net radon, it determines the concentrations of beta, alpha, and ^{239}Pu radiation for the air filtered by each sample filter. The known air flow rate and period of exposure must be entered into memory via the "initialize parameters" routine prior to running the filter examination program. For each sample examined, the data are compared against alert level limits (also entered

via "initialize parameters") to help the operator recognize high radiation levels. For each sample with an over-limit value, the concentration in the report is followed by "*" to help point to it. In addition, the next program will calculate the percentage of over-limit, and record it onto the cassette data files (-3 to -102). Finally, when all samples have been examined and if there were any over-limit readings, "Alert List" is called to print a summary of the over-limit samples on the thermal printer.

The concentrations are calculated by the equation:

$$C = Q * AC \text{ (}\mu\text{Ci/cc)}$$

where: C = concentration

AC = adjusted counts/minute

= gross counts - background counts - radon counts (alpha and ^{239}Pu)

The factor Q is precalculated to save time and is evaluated as:

$$Q = \frac{1.59 * 10^{-11} * 100}{A * \text{Sample Vol} * \text{No. Days} * \%E}$$

where: sample volume is previously entered (ft^3/day)

No. days is the exposure time (days)

%E = % efficiency for each channel

A = absorption factor

= 0.8 for beta

= 0.7 for alpha and ^{239}Pu

given: there are 2.2×10^6 d/m/ μCi or $\frac{4.505 \times 10^{-7} \mu\text{Ci}}{\text{d/m}}$
there are 3.53×10^{-5} ft^3/cc

The information passed between the filter examination files is stored in the data registers as defined in Table 3. Many of these registers experience multiple use (e.g., the over-limit data to be recorded will temporarily replace data in registers 0 - 3).

The program checks the timer reading after every sample. If the timer does not equal 200 (assumed 0.01 min increments) the program prints an error message and aborts. Please refer to Figures 16 through 19 for flow diagrams of the filter examination program, Figures 20 and 21 for sample printouts from the exam.

In Figure 21, sample no. 4 has been flagged as over-limit beta, and sample no. 7 for both alpha and ^{239}Pu . These also are printed out on the alert list after all counting has been completed.

Using the alert levels and the calculated concentrations for each, the percent over-limit values are calculated:

$$\%OL = \frac{\text{concentration}}{\text{alert level}} - 1 * 100\%$$

The current sample number and the three values for beta, alpha, and ^{239}Pu are then stored in the data registers 0 through 3 to be recorded onto a cassette file.

One hundred files which hold four data items each (files -3 through -102) are used to store over-limit data as it becomes known by the filter examination program. A file counter, kept in register 7, points to the next available file to store data. When data are stored, the pointer is decremented by 1. The filter examination program always sets the pointer to -3 to start a new run. When the filter examination program is done, a message is printed and the alert list program is called to list a summary of the alerted data on the thermal printer.

TABLE 3. Register Use for Data Passage in Filter Examination

<u>Register</u>	<u>Use</u>	<u>Register</u>	<u>Use</u>
A	Current sample counter	0	Unused
B	Internal control loop	1	Raw data sample no.
C	Internal control loop	2	Raw data timer count
D	Internal control loop	3	Raw data Radon count, net radon
E	Temporary data	4	Raw data ²³⁹ Pu count, net ²³⁹ Pu
F	Total no. of samples in run	5	Raw data alpha count, net alpha
G	Internal control loop	6	Raw data beta count, net beta
H	Internal control loop	7	File counter for over- limit samples
I	Temporary data	8	Q for beta
J	Temporary data	9	Q for alpha
		10	Q for ²³⁹ Pu
		11	Sample volume in CFD
		12	Period
		13	Alert level for beta
		14	Alert level for alpha
		15	Alert level for ²³⁹ Pu
		16	Background for beta
		17	Background for alpha
		18	Background for ²³⁹ Pu
		19	Background for radon

FIGURE 16. Files 13 through 16 - Filter Examination Program Flow Diagrams

FIGURE 17. File 17 - Filter Examination Program Flow Diagram

FIGURE 18. File 18 - Filter Examination Program Flow Diagram

FIGURE 19. Files 19 and 20 - Filter Examination Program Flow Diagram

```

* FILTER EXAM *

CONSTANTS READY?
TIMER = 2.0 MIN?

FIRST SAMPLE
IN PLACE?

PUSH 'RUN' TO GO
ON, 'A' TO STOP

NO. SAMPLES?
      10.00

```

Printout from Either
Auto or Manual Systems

```

      SAMPLES
      EXCEEDING
      ALARM LIMITS

SAMPLE      4
BETA 1233.9%OL

SAMPLE      7
ALPHA 1867.5%OL
PU239 1356.2%OL

%OL=%OVER LIMIT

```

Alert List
Auto/Manual

```

ENTER SAMPLE #
OR *A* TO END

      13
PUT NEXT SAMPLE
IN HOLDER

ENTER SAMPLE #
OR *A* TO END

      18

```

Normal Printout from
Manual System

```

TIMER READS
      1.00 MIN.
FILTER EXAM
ABORTED
#####

```

Timer Error
Auto/Manual

FIGURE 20. Sample Printouts from Filter Examination Program

DATE_____ SHIFT_____ AUTO-MANUAL RM INITIALS_____

COMMENTS: _____

SAMPLE ON SAMPLE OFF
 DATE_____ DATE_____
 TIME_____ TIME_____
 SAMPLE PERIOD 1.00 DAY
 SAMPLE VOLUME 1440 CFD
 COUNT TIME 2 MINUTES

NOTE: Refer to the daily/weekly air sample collection list to find the actual locations which correspond to the sample number.

The $\mu\text{Ci/cc}$ of Beta, Alpha and ^{239}Pu INCLUDE radon subtraction.

FILTER EXAM RESULTS

SMPL	BETA	ALPHA	^{239}Pu	RADON
1	20 NET C/M 1.15E-12 $\mu\text{Ci/cc}$	8 NET C/M 1.21E-13 $\mu\text{Ci/cc}$	1 NET C/M 3.43E-14 $\mu\text{Ci/cc}$	6 NET C/M
2	27 NET C/M 1.03E-12 $\mu\text{Ci/cc}$	14 NET C/M 6.04E-14 $\mu\text{Ci/cc}$	1 NET C/M 0.00E+00 $\mu\text{Ci/cc}$	13 NET C/M
3	26 NET C/M 3.96E-13 $\mu\text{Ci/cc}$	20 NET C/M 1.21E-13 $\mu\text{Ci/cc}$	2 NET C/M 1.72E-14 $\mu\text{Ci/cc}$	18 NET C/M
4	4442 NET C/M 4.00E-10 $\mu\text{Ci/cc}^*$	0 NET C/M 0.00E+00 $\mu\text{Ci/cc}$	0 NET C/M 0.00E+00 $\mu\text{Ci/cc}$	0 NET C/M
5	17 NET C/M 1.10E-12 $\mu\text{Ci/cc}$	5 NET C/M 6.04E-14 $\mu\text{Ci/cc}$	1 NET C/M 5.13E-14 $\mu\text{Ci/cc}$	4 NET C/M
6	11 NET C/M 2.34E-13 $\mu\text{Ci/cc}$	10 NET C/M 1.81E-13 $\mu\text{Ci/cc}$	3 NET C/M 1.97E-13 $\mu\text{Ci/cc}$	7 NET C/M
7	32 NET C/M 2.77E-12 $\mu\text{Ci/cc}$	164 NET C/M 9.84E-12 $\mu\text{Ci/cc}^*$	85 NET C/M 7.28E-12 $\mu\text{Ci/cc}^*$	1 NET C/M
8	13 NET C/M 0.00E+00 $\mu\text{Ci/cc}$	16 NET C/M 1.21E-13 $\mu\text{Ci/cc}$	1 NET C/M 0.00E+00 $\mu\text{Ci/cc}$	14 NET C/M
9	14 NET C/M 5.04E-13 $\mu\text{Ci/cc}$	8 NET C/M 6.04E-14 $\mu\text{Ci/cc}$	0 NET C/M 0.00E+00 $\mu\text{Ci/cc}$	7 NET C/M
10	14 NET C/M 0.00E+00 $\mu\text{Ci/cc}$	14 NET C/M 6.04E-14 $\mu\text{Ci/cc}$	0 NET C/M 0.00E+00 $\mu\text{Ci/cc}$	13 NET C/M

FIGURE 21. Printout of Filter Examination Program Results

ALERT LIST PROGRAM

The alert list program resides on cassette file 20 and is loaded to run by the filter examination program. This program reads the data stored in cassette files and prints a summary of the samples which exceeded the alert levels.

When called, the last file minus one is left in data register 7. This is used to set up a loop to read the cassette files (-3 through R7-1) and list the over-limit data. The sample no. and the percent over-limit data is printed. See Figure 20, alert list. Non-over-limit data is not printed. When the program finishes, the function select program is loaded. Note: once the filter examination is restarted, the data stored in the cassette files is over-written.

OPERATING PROCEDURES

Although the functions of this system may be selected in any order, the normal procedure is to (1) run the background test program, (2) the chi-squared test program, and (3) the filter examination test program.

GENERAL

A few conventions should be explained prior to starting any tests. Most of these will concern the calculator itself. This document does not discuss the settings for the single-channel analyzers or the power supply for the detector. However, other hardware settings are discussed briefly. Further information may be found in the manufacturer's literature referenced in Appendix A.

The four scalers and the timer, TC 547P, can be set. Once initially set, only the timer and the radon-channel single-channel analyzer should ever need to be changed. All four scalers are set identically. Use Table 4 to get the proper switch settings.

TABLE 4. Scaler and Timer Switch Settings

<u>Switch</u>	<u>Scaler</u>	<u>Timer</u>
Count/Stop	Count	Count
Mode	Slave	Master
Gate	Coinc.	Coinc.
Scaler/Timer	Scaler	Timer
0.01 min/0.1 sec	(either)	0.01 min
PRESET (upper)	OFF	(to be set later)
PRESET (lower)	(not used)	(to be set later)

The planchette sample changer, PSC-1, is set to the "single-cycle" position on the front rotary switch. While running, the "START" switch will cause the changer to move blank planchettes until a numbered planchette is under the detector. The "RESET" switch is used to move all of the sample holders to the

right stack and reposition holder no. 1 under the detector. A manual advance switch is provided on the interface unit in the electronics rack.

The HP9815A calculator (or desktop computer if you prefer) uses a cassette to store all of this system's programs and some data which is used by several programs. Since this requires that data will be written to the cassette, the RECORD switch on the cassette itself must be enabled (right position). This makes the cassette vulnerable to being over-written if the calculator is carelessly used. Although a backup cassette will probably exist, it is extremely important to either remove the cassette (and store properly) when running the calculator by itself, or to not use any of the cassette function keys (five keys at the upper lefthand side of the keyboard).

The thermal sensitive paper used in the printer can be replaced easily by following the diagram exposed when the cover immediately behind the printer is lifted.

When running the system programs, you will be asked to select lettered keys or enter numbers. The lettered keys are the lower left group of pale lettered keys on the calculator. When selecting an option by these, depress only one key one time. If an undefined key is pushed, an error message is printed. When entering numbers, the RUN KEY MUST BE DEPRESSED TO RESTART THE PROGRAM. The decimal may or may not be entered as needed. Very large or very small values may be entered using the scientific notation. Five examples are shown. For each, the display format must be changed to see the value properly:

- 1.) Enter 23000
 - a) to reformat: (gold key) (+-) (0)
 - b) to enter: (2) (3) (0) (0) (0) (RUN/STOP)
- 2.) Enter -42
 - b) to enter: (4) (2) (+-) (RUN/STOP)
- 3.) Enter 61.092
 - a) to reformat: (gold key) (+-) (3)
 - b) to enter: (6) (1) (.) (0) (9) (2) (RUN/STOP)

4.) Enter 3×10^{13}

a) to reformat: (gold key) (E EX) (2)

b) to enter: (3) (E EX) (1) (3) (RUN/STOP)

5.) Enter 4.5×10^{-11}

b) to enter: (4) (.) (5) (E EX) (+-) (1) (1) (RUN/STOP)

While running the programs, you normally do not need to change the display format before entering the value, but the changes are shown here to help you become familiar with the calculator.

START-UP PROCEDURE

When this system is new to the operator or if the power has been off to the hardware (other than the calculator), consult the "general" section of this chapter.

When the air filter examination system is to be started, the power will normally be applied to the calculator last (i.e., start the other hardware, check switches, and load filters first.) To activate the programs, the RUN/AUTO-START/PRGM switch at the lower right of the calculator key should be set to AUTO START. Then, the power is turned on (the rocker switch at the front-right position to the "1" position.) When this is done, the calculator begins by running the header (auto-start) program and then the function select program. At this point the function select program will have printed a list of options.

FUNCTION SELECT PROGRAM

The function select program is run automatically when start-up is done via the auto-start. It is also the return point from any function whether it completed or found an error. The options that may be selected by this program are:

A - instructions (a brief note referring to this document)

- B - initialize parameters (a routine used to enter data to be used in the calibration routines and filter examinations)
- C - background test (for background radiation calibration)
- D - chi-squared test (for calibration and detector quality analysis)
- E - filter examination (to examine a set of sample filters)

Each of these options may be selected by pushing the corresponding lettered key of the calculator. The "0" function may be used to stop the entire system. To recover from this point, the start-up procedure can be repeated.

INITIALIZE PARAMETERS PROGRAM

When the initialize parameters option, "B", is selected, a list of further options is listed:

- A - To change
- B - To list
- 0 - To stop

Again, pressing one of the identified lettered keys starts the desired sequence. Starting with "0", this option simply terminates this program and returns to the function select program. Option "B" is entered to list the nine parameters as they presently reside in memory (see Figure 7 for examples.) Then, the above three options are repeated. Any of these parameters may be changed or initialized by entering the "A" option. Here, an abbreviated list of the parameters is printed and the lettered keys are reprogrammed to select any of the nine parameters (key "0" again means stop but here it will only return to the above three options.) To enter a value, first press the corresponding lettered key. When asked to enter the value, enter it and press (RUN) to resume the program (see "general" section). The parameters may be entered in any order or re-entered as often as desired.

BACKGROUND TEST PROGRAM

When this test is called as option "C" the operator will be given two chances to see that: first, the proper filter (blank) is in place, and second, the time value matches the timer setting on the TC547P Timer. In both events, the RUN/STOP key may be pushed to proceed, or the A key may be pushed to abort this test and return to the function select program.

Setting the TC547P timer is done as follows: (1) be sure the 0.01 min/0.1 sec toggle switch is in the 0.01-min position, (2) use the PRESET switches to set the time. (For example: 10 minutes = 1×10^3 hundredths thus the upper switch is set to 1 and the lower switch to the 10^3 position.)

If the timer reading at the end of the test does not match the value set in memory, the true timer value is used to calculate the background radiation rates and the time in memory is changed. Thus, the data is still useful.

A summary of the test results is printed, and the data is stored on cassette for later use. The function select program is called when finished.

CHI-SQUARED TEST PROGRAM

When this program is called via option "D", the operator is given three chances to abort. First, the operator is asked to check the sample. Second, he is told to change the setting of the single-channel analyzer for the radon channel. Third, he is asked to verify the run time expected against the TC547P timer (see previous section for setting the timer.) In either case, the operator may continue by pressing the RUN/STOP key or he may abort the run by pressing "A".

The program, if allowed to continue, then reads the sample twenty times, printing the raw count data for each reading on the thermal printer. (This is done to keep the operator informed of the progress. All data/information printed on the thermal printer may be discarded.) Next, a summary is printed and the acceptability test is run. If all channels are found acceptable or conditionally acceptable, the final results are printed on the external printer for permanent filing. Resulting data are stored on the cassette for use by the filter examination program. When completed, or a counter is found

unacceptable, the program returns to function select after the operator is reminded to return the radon channel to its original setting.

FILTER EXAMINATION PROGRAM

When the filter examination program is called by the "E" option of the function select program, the operator is given one opportunity to abort the test. Then he is asked to enter the number of samples to be processed by this run. For each run, all of the following parameters must be the same: alert levels, sample volume, sample period. The program may be run more than once to process a stack of samples if the parameters need to be changed between known subsets of the stack.

For the filter examination program the TC547P timer must always be set for 2.0 minutes. The program checks the timer after every sample and will abort the remainder of the test if an error is detected (returns to the function select program.) See "Background Test" section for an explanation of setting the timer.

As each sample is examined, a report is printed. First, the sample number (the actual number of the planchette holder for the sample when using the automatic system) is printed. Then the adjusted net (true counts-background) and the concentrations (in micro curies per cubic centimeter) are listed for each channel (only net counts for the radon channel.) See Figure 20 for a sample printout. Each concentration is compared to the alert levels entered. Over-limit values are flagged in the printout.

When the series of samples has been tested and if any over-limit samples were detected, the program calls the alert list program which summarizes the samples which exceeded the alert levels in memory. This is the conclusion of the test and the program returns to the function select routine.

APPENDIX A

AIR FILTER EXAMINATION SYSTEM HARDWARE REFERENCES

APPENDIX A

AIR FILTER EXAMINATION SYSTEM HARDWARE REFERENCES

Hewlett-Packard Co., "HP9815A Calculator Operating and Programming Manual"

Hewlett-Packard Co., "HP9815A Calculator 98134A General I/O Interface Operating and Service Manual"

Hewlett-Packard Co., "HP9815A Calculator 98136A Serial I/O Interface Operating and Service Manual"

Nuclear Enterprises Limited, "Westinghouse PSC System Information Manual"

APPENDIX B

PROGRAM LISTINGS OF THE 21 FILES USED BY THE AIR FILTER EXAMINATION SYSTEM

APPENDIX B

PROGRAM LISTINGS OF THE 21 FILES USED BY THE AIR FILTER EXAMINATION SYSTEM

0000 PRNT*	0045	0091 T
0002 LINE	0046	0092 T
0003 LINE	0047	0093 E
0004 LINE	0048	0094 R
0005	0049	0095 E
0006	0050 S	0096 D
0007	0051 Y	0097 LINE
0008	0052 S	0098 K
0009 T	0053 T	0099 E
0010 H	0054 E	0100 Y
0011 E	0055 M	0101 LINE
0012	0056 LINE	0102 LINE
0013 H	0057 LINE	0103 END*
0014 E	0058 LINE	0104 0
0015 D	0059 T	0105 ENTER†
0016 L	0060 0	0106 1
0017 LINE	0061	0107 LD&GO
0018	0062 S	0108 END
0019	0063 E	
0020	0064 L	
0021 A	0065 E	
0022 I	0066 C	
0023 R	0067 T	
0024	0068	
0025 F	0069 A	
0026 I	0070 LINE	
0027 L	0071 P	
0028 T	0072 R	
0029 E	0073 0	
0030 R	0074 G	
0031 LINE	0075 R	
0032	0076 A	
0033	0077 M	
0034	0078 ,	
0035	0079	
0036 C	0080 P	
0037 0	0081 U	
0038 U	0082 S	
0039 N	0083 H	
0040 T	0084 LINE	
0041 I	0085 T	
0042 N	0086 H	
0043 G	0087 E	
0044 LINE	0088	
	0089 L	
	0090 E	

0000	PRNT α	0046	E	0091	
0002	LINE	0047	R	0092	
0003	A	0048	S	0093	
0004		0049	LINE	0094	
0005	-	0050	C	0095	T
0006		0051		0096	E
0007	I	0052	-	0097	S
0008	N	0053		0098	T
0009	S	0054	B	0099	LINE
0010	T	0055	A	0100	E
0011	R	0056	C	0101	
0012	U	0057	K	0102	-
0013	C	0058	G	0103	
0014	T	0059	R	0104	F
0015	I	0060	O	0105	I
0016	O	0061	U	0106	L
0017	N	0062	N	0107	T
0018	S	0063	D	0108	E
0019	B	0064	LINE	0109	R
0020		0065		0110	
0021	-	0066		0111	E
0022		0067		0112	X
0023	I	0068		0113	A
0024	N	0069		0114	M
0025	I	0070	T	0115	LINE
0026	T	0071	E	0116	O
0027	I	0072	S	0117	
0028	A	0073	T	0118	-
0029	L	0074	LINE	0119	
0030	I	0075	D	0120	S
0031	Z	0076		0121	T
0032	E	0077	-	0122	O
0033	LINE	0078		0123	P
0034		0079	C	0124	LINE
0035		0080	H	0125	LINE
0036		0081	I	0126	END α
0037		0082		0127	PRNT α
0038		0083	S	0129	P
0039	P	0084	O	0130	R
0040	A	0085	U	0131	E
0041	R	0086	A	0132	S
0042	A	0087	R	0133	S
0043	M	0088	E	0134	
0044	E	0089	LINE	0135	*
0045	T	0090		0136	E

0137	N		0187	PRNTα
0138	D		0189	C
0139	*		0190	ENDα
0140	LINE		0191	0
0141	T		0192	ENTER↑
0142	H		0193	4
0143	E		0194	LD&GO
0144	N		0195	LBL
0145			----	D
0146	L		0197	PRNTα
0147	E		0199	D
0148	T		0200	ENDα
0149	T		0201	0
0150	E		0202	ENTER↑
0151	R		0203	7
0152	LINE		0204	LD&GO
0153	LINE		0205	LBL
0154	ENDα		----	E
0155	STOP		0207	PRNTα
0156	LBL		0209	E
----	A		0210	ENDα
0158	PRNTα		0211	0
0160	A		0212	ENTER↑
0161	LINE		0213	1
0162	R		0214	3
0163	E		0215	LD&GO
0164	A		0216	LBL
0165	D		----	0
0166			0218	PRNTα
0167	B		0220	*
0168	0		0221	*
0169	0		0222	*
0170	K		0223	*
0171	LINE		0224	
0172	ENDα		0225	E
0173	GOTO	0000	0226	N
0175	LBL		0227	D
----	B		0228	
0177	PRNTα		0229	*
0179	B		0230	*
0180	ENDα		0231	*
0181	0		0232	*
0182	ENTER↑		0233	LINE
0183	2		0234	ENDα
0184	LD&GO		0235	STOP
0185	LBL		0236	END
----	C			

0000 PRNTα	0046 0	0092 RCL	R000
0002 LINE	0047 P	0094 FIX	1
0003	0048 LINE	0096 PRNTα	
0004 E	0049 ENDα	0098 B	
0005 N	0050 STOP	0099 A	
0006 T	0051 LBL	0100 C	
0007 E	---- 0	0101 K	
0008 R	0053 0	0102 G	
0009 :	0054 ENTER↑	0103 N	
0010 LINE	0055 1	0104 D	
0011 A	0056 LD&GO	0105	
0012	0057 STOP	0106 C	
0013 -	0058 LBL	0107 N	
0014	---- A	0108 T	
0015 T	0060 0	0109	
0016 0	0061 ENTER↑	0110 T	
0017	0062 3	0111 I	
0018 C	0063 LD&GO	0112 M	
0019 H	0064 STOP	0113 E	
0020 A	0065 LBL	0114	
0021 N	---- B	0115 =	
0022 G	0067 PRNTα	0116	
0023 E	0069 LINE	0117 PRINT	
0024 LINE	0070 C	0118	
0025 B	0071 U	0119 M	
0026	0072 R	0120 I	
0027 -	0073 R	0121 N	
0028	0074 E	0122 ENDα	
0029 T	0075 N	0123 0	
0030 0	0076 T	0124 ENTER↑	
0031	0077	0125 2	
0032 L	0078 V	0126 +≠-	
0033 I	0079 A	0127 LOAD	
0034 S	0080 L	0128 RCL	R000
0035 T	0081 U	0130 SCI	1
0036 LINE	0082 E	0132 PRNTα	
0037 0	0083 S	0134 B	
0038	0084 :	0135 E	
0039 -	0085 LINE	0136 T	
0040	0086 LINE	0137 A	
0041 T	0087 ENDα	0138	
0042 0	0088 0	0139 A	
0043	0089 ENTER↑	0140 L	
0044 S	0090 +≠-	0141 E	
0045 T	0091 LOAD	0142 R	

0143 T		0190 RCL	R002	0240 F	
0144		0192 PRNTα		0241 D	
0145 L		0194 P		0242 ENDα	
0146 E		0195 U		0243 RCL	R004
0147 V		0196 2		0245 PRNTα	
0148 E		0197 3		0247 P	
0149 L		0198 9		0248 E	
0150		0199		0249 R	
0151 =		0200 A		0250 I	
0152 PRINT		0201 L		0251 0	
0153		0202 E		0252 D	
0154 U		0203 R		0253 LINE	
0155 C		0204 T		0254	
0156 /		0205		0255 =	
0157 C		0206 L		0256 PRINT	
0158 C		0207 E		0257	
0159 ENDα		0208 V		0258 D	
0160 RCL	R001	0209 L		0259 A	
0162 PRNTα		0210		0260 Y	
0164 A		0211 =		0261 S	
0165 L		0212 PRINT		0262 ENDα	
0166 P		0213		0263 RCL	R005
0167 H		0214 U		0265 FIX	0
0168 A		0215 C		0267 PRNTα	
0169		0216 /		0269 B	
0170 A		0217 C		0270 E	
0171 L		0218 C		0271 T	
0172 E		0219 ENDα		0272 A	
0173 R		0220 RCL	R003	0273	
0174 T		0222 FIX	2	0274 S	
0175		0224 PRNTα		0275 0	
0176 L		0226 S		0276 U	
0177 E		0227 M		0277 R	
0178 V		0228 P		0278 C	
0179 L		0229 L		0279 E	
0180		0230		0280 LINE	
0181 =		0231 V		0281	
0182 PRINT		0232 0		0282 =	
0183		0233 L		0283 PRINT	
0184 U		0234 LINE		0284	
0185 C		0235		0285 D	
0186 /		0236 =		0286 /	
0187 C		0237 PRINT		0287 M	
0188 C		0238		0288 I	
0189 ENDα		0239 C		0289 N	

```

0290 ENDα
0291 RCL      R006
0293 PRNTα
0295 A
0296 L
0297 P
0298 H
0299 A
0300
0301 S
0302 0
0303 U
0304 R
0305 C
0306 E
0307 LINE
0308
0309 =
0310 PRINT
0311
0312 D
0313 /
0314 M
0315 I
0316 N
0317 LINE
0318 LINE
0319 ENDα
0320 GOTO      0000
0322 END

```


0000	PRNTα	0046	-	0091	T
0002	LINE	0047	S	0092	O
0003	A	0048	M	0093	P
0004	-	0049	P	0094	LINE
0005	B	0050	L	0095	LINE
0006	K	0051		0096	ENDα
0007	G	0052	V	0097	GOSUB L01
0008	H	0053	O	0099	STOP
0009	D	0054	L	0100	GOTO 0099
0010		0055	LINE	0102	LBL
0011	T	0056	F	----	01
0012	M	0057	-	0104	PRNTα
0013	LINE	0058	P	0106	L
0014	B	0059	E	0107	E
0015	-	0060	R	0108	T
0016	B	0061	I	0109	T
0017		0062	O	0110	E
0018	A	0063	D	0111	R
0019	L	0064	LINE	0112	?
0020	E	0065	G	0113	ENDα
0021	R	0066	-	0114	RETURN
0022	T	0067	B	0115	LBL
0023	LINE	0068		----	02
0024	C	0069	S	0117	PRNTα
0025	-	0070	O	0119	V
0026	A	0071	U	0120	A
0027		0072	R	0121	L
0028	A	0073	C	0122	U
0029	L	0074	E	0123	E
0030	E	0075	LINE	0124	?
0031	R	0076	H	0125	ENDα
0032	T	0077	-	0126	STOP
0033	LINE	0078	A	0127	PRINT
0034	D	0079		0128	STO J
0035	-	0080	S	0129	O
0036	P	0081	O	0130	ENTER↑
0037	U	0082	U	0131	RETURN
0038		0083	R	0132	LBL
0039	A	0084	C	----	03
0040	L	0085	E	0134	1
0041	E	0086	LINE	0135	O
0042	R	0087	LINE	0136	ENTER↑
0043	T	0088	O	0137	O
0044	LINE	0089	-	0138	ENTER↑
0045	E	0090	S	0139	2

0140	+-			0196	RCL	J	0258	GOSUB	L01
0141	RCDATA			0197	STO	R001	0260	RETURN	
0142	RETURN			0199	GOSUB	L03	0261	LBL	
0143	LBL			0201	GOSUB	L01	----	G	
----	A			0203	RETURN		0263	PRNT	
0145	PRNT			0204	LBL		0265	G	
0147	A			----	D		0266	END	
0148	END			0206	PRNT		0267	GOSUB	L02
0149	GOSUB	L02		0208	D		0269	2	
0151	+-			0209	END		0270	+-	
0152	LOAD			0210	GOSUB	L02	0271	LOAD	
0153	RCL	J		0212	2		0272	RCL	J
0154	STO	R000		0213	+-		0273	STO	R005
0156	1			0214	LOAD		0275	GOSUB	L03
0157	0			0215	RCL	J	0277	GOSUB	L01
0158	ENTER			0216	STO	R002	0279	RETURN	
0159	0			0218	GOSUB	L03	0280	LBL	
0160	ENTER			0220	GOSUB	L01	----	H	
0161	+-			0222	RETURN		0282	PRNT	
0162	RCDATA			0223	LBL		0284	H	
0163	GOSUB	L01		----	E		0285	END	
0165	RETURN			0225	PRNT		0286	GOSUB	L02
0166	LBL			0227	E		0288	2	
----	B			0228	END		0289	+-	
0168	PRNT			0229	GOSUB	L02	0290	LOAD	
0170	B			0231	2		0291	RCL	J
0171	END			0232	+-		0292	STO	R006
0172	GOSUB	L02		0233	LOAD		0294	STO	R007
0174	2			0234	RCL	J	0296	GOSUB	L03
0175	+-			0235	STO	R003	0298	GOSUB	L01
0176	LOAD			0237	GOSUB	L03	0300	RETURN	
0177	RCL	J		0239	GOSUB	L01	0301	LBL	
0178	STO	R000		0241	RETURN		----	0	
0180	GOSUB	L03		0242	LBL		0303	0	
0182	GOSUB	L01		----	F		0304	ENTER	
0184	RETURN			0244	PRNT		0305	2	
0185	LBL			0246	F		0306	LD&GO	
----	C			0247	END		0307	END	
0187	PRNT			0248	GOSUB	L02			
0189	C			0250	2				
0190	END			0251	+-				
0191	GOSUB	L02		0252	LOAD				
0193	2			0253	RCL	J			
0194	+-			0254	STO	R004			
0195	LOAD			0256	GOSUB	L03			

0000	NOP	0046	LINE	0091	+*-	
0001	NOP	0047	P	0092	LOAD	
0002	PRNT α	0048	U	0093	RCL	R000
0004	LINE	0049	S	0095	FIX	2
0005	*	0050	H	0097	PRNT α	
0006	B	0051		0099	LINE	
0007	A	0052	'	0100	E	
0008	C	0053	R	0101	X	
0009	K	0054	U	0102	P	
0010	G	0055	N	0103	E	
0011	R	0056	'	0104	C	
0012	O	0057		0105	T	
0013	U	0058	T	0106	E	
0014	N	0059	O	0107	D	
0015	D	0060	LINE	0108		
0016		0061		0109	R	
0017	T	0062	C	0110	U	
0018	E	0063	O	0111	N	
0019	S	0064	N	0112		
0020	T -	0065	T	0113	=	
0021	LINE	0066	I	0114	LINE	
0022	LINE	0067	N	0115		
0023	B	0068	U	0116	PRINT	
0024	L	0069	E	0117		
0025	A	0070	LINE,	0118	M	
0026	N	0071	P	0119	I	
0027	K	0072	U	0120	N	
0028		0073	S	0121	.	
0029	F	0074	H	0122	LINE	
0030	I	0075		0123	LINE	
0031	L	0076	'	0124	P	
0032	T	0077	A	0125	U	
0033	E	0078	'	0126	S	
0034	R	0079		0127	H	
0035		0080	T	0128		
0036	I	0081	O	0129	R	
0037	N	0082		0130	U	
0038		0083	S	0131	N	
0039		0084	T	0132		
0040	P	0085	O	0133	O	
0041	L	0086	P	0134	R	
0042	A	0087	END α	0135		
0043	C	0088	STOP	0136	A	
0044	E	0089	O	0137	END α	
0045	?	0090	ENTER $\uparrow$	0138	STOP	

0139	1		0194	RBYTE	2	0259	RCL	R006
0140	+@-		0196	1		0261	RCL	R000
0141	DATA	2	0197	5		0263	+	
0143	FIX	8	0198	AND	2	0264	STO	R004
0145	4		0200	+		0266	5	
0146	WBYTE	2	0201	1		0267	ENTER↑	
0148	0		0202	0		0268	0	
0149	WBYTE	2	0203	WBYTE	2	0269	ENTER↑	
0151	PAUSE		0205	ROLL↓		0270	+@-	
0152	PAUSE		0206	8		0271	RCDATA	
0153	PAUSE		0207	WBYTE	2	0272	0	
0154	PAUSE		0209	ROLL↓		0273	ENTER↑	
0155	PAUSE		0210	NEXT	C	0274	5	
0156	PAUSE		0211	STO I	B	0275	LD&GO	
0157	LBL		0213	NEXT	B	0276	STOP	
----	01		0214	0		0277	LBL	
0159	RBYTE	2	0215	WBYTE	2	----	A	
0161	1		0217	FIX	4	0279	0	
0162	6		0219	CFG	1	0280	ENTER↑	
0163	AND	2	0220	RCL	R005	0281	1	
0165	IF 0		0222	1		0282	LD&GO	
0166	GOTO	L02	0223	0		0283	END	
0168	GOTO	L01	0224	0				
0170	LBL		0225	+				
----	02		0226	ENTER↑				
0172	9		0227	RCL	R000			
0173	WBYTE	2	0229	IF X=Y				
0175	5		0230	GOTO	L04			
0176	STO	B	0232	SFG	1			
0177	9		0233	LBL				
0178	STO	G	----	04				
0179	8		0235	ROLL↓				
0180	WBYTE	2	0236	STO	R000			
0182	FOR	B+G	0238	RCL	R009			
0183	6		0240	RCL	R000			
0184	STO	C	0242	+				
0185	1		0243	STO	R001			
0186	STO	H	0245	RCL	R008			
0187	+@-		0247	RCL	R000			
0188	STO	D	0249	+				
0189	CLEAR		0250	STO	R002			
0190	FOR	C+HD	0252	RCL	R007			
0191	1		0254	RCL	R000			
0192	0		0256	+				
0193	*		0257	STO	R003			

0000	NOP		0060	WRTα	3	0113	U	
0001	NOP		0062	A		0114	N	
0002	FIX	2	0063	U		0115	D	
0004	1		0064	T		0116		
0005	DATA	3	0065	0		0117	T	
0007	2		0066	-		0118	E	
0008	7		0067	M		0119	S	
0009	WBYTE	3	0068	A		0120	T	
0011	7		0069	N		0121		
0012	4		0070	U		0122	R	
0013	WBYTE	3	0071	A		0123	E	
0015	4		0072	L		0124	S	
0016	4		0073	ENDα		0125	U	
0017	WBYTE	3	0074	4		0126	L	
0019	7		0075	GOSUB	L02	0127	T	
0020	5		0077	WRTα	3	0128	ENDα	
0021	WRTX	3	0079	R		0129	2	
0023	2		0080	M		0130	WBYTE	3
0024	WBYTE	3	0081			0132	4	
0026	1		0082	I		0133	GOSUB	L01
0027	2		0083	N		0135	1	
0028	WBYTE	3	0084	I		0136	3	
0030	8		0085	T		0137	GOSUB	L02
0031	GOSUB	L01	0086	I		0139	WRTα	3
0033	WRTα	3	0087	A		0141	A	
0035	D		0088	L		0142	V	
0036	A		0089	S		0143	E	
0037	T		0090	ENDα		0144	R	
0038	E		0091	9		0145	A	
0039	ENDα		0092	GOSUB	L03	0146	G	
0040	9		0094	8		0147	E	
0041	GOSUB	L03	0095	GOSUB	L01	0148		
0043	4		0097	1		0149	B	
0044	GOSUB	L02	0098	3		0150	A	
0046	WRTα	3	0099	GOSUB	L02	0151	C	
0048	S		0101	1		0152	K	
0049	H		0102	WBYTE	3	0153	G	
0050	I		0104	WRTα	3	0154	R	
0051	F		0106	B		0155	0	
0052	T		0107	A		0156	U	
0053	ENDα		0108	C		0157	N	
0054	9		0109	K		0158	D	
0055	GOSUB	L03	0110	G		0159		
0057	4		0111	R		0160	(	
0058	GOSUB	L02	0112	0		0161	C	

0162	O		0209	NEXT	B
0163	U		0210	RETURN	
0164	N		0211	END	
0165	T				
0166	S				
0167	/				
0168	M				
0169	I				
0170	N				
0171	U				
0172	T				
0173	E				
0174	)				
0175	LINE				
0176	END				
0177	0				
0178	ENTER↑				
0179	6				
0180	LD&GO				
0181	LBL				
----	01				
0183	STO	G			
0184	1				
0185	3				
0186	GOTO	L05			
0188	LBL				
----	02				
0190	STO	G			
0191	3				
0192	2				
0193	GOTO	L05			
0195	LBL				
----	03				
0197	STO	G			
0198	9				
0199	5				
0200	LBL				
----	05				
0202	ENTER↑				
0203	1				
0204	STO	B			
0205	ROLL↓				
0206	FOR	B+G			
0207	WYTE	3			

0000	NOP		0053	GOSUB	L01	0112	D
0001	NOP		0055	1		0113	O
0002	NOP		0056	7		0114	N
0003	1		0057	GOSUB	L02	0115	
0004	6		0059	2		0116	
0005	FIELD	3	0060	5		0117	=
0007	1		0061	WBYTE	3	0118	PRINT
0008	4		0063	3		0119	ENDα
0009	GOSUB	L02	0064	1		0120	1
0011	RCL	R001	0065	WBYTE	3	0121	GOSUB L01
0013	WRTα	3	0067	WRTα	3	0123	NOP
0015			0069	2		0124	NOP
0016			0070	3		0125	IF CFG 1
0017			0071	9		0126	GOTO L06
0018	B		0072	ENDα		0128	RCL R000
0019	E		0073	2		0130	PRNTα
0020	T		0074	0		0132	LINE
0021	A		0075	WBYTE	3	0133	*
0022			0077	2		0134	N
0023			0078	9		0135	O
0024			0079	WBYTE	3	0136	T
0025	=		0081	WRTα	3	0137	E
0026	PRINT		0083	P		0138	:
0027	ENDα		0084	U		0139	LINE
0028	2		0085			0140	
0029	GOSUB	L01	0086	ENDα		0141	T
0031	1		0087	RCL	R003	0142	H
0032	4		0089	WRTα	3	0143	E
0033	GOSUB	L02	0091			0144	
0035	RCL	R002	0092			0145	P
0037	WRTα	3	0093	=		0146	E
0039			0094	PRINT		0147	R
0040			0095	ENDα		0148	I
0041			0096	2		0149	O
0042	A		0097	GOSUB	L01	0150	D
0043	L		0099	1		0151	
0044	P		0100	4		0152	O
0045	H		0101	GOSUB	L02	0153	F
0046	A		0103	RCL	R004	0154	LINE
0047			0105	WRTα	3	0155	
0048			0107			0156	T
0049	=		0108			0157	E
0050	PRINT		0109			0158	S
0051	ENDα		0110	R		0159	T
0052	2		0111	A		0160	

0161	D	0206	I	0252	1
0162	I	0207	N	0253	3
0163	D	0208		0254	GOTO L05
0164		0209	M	0256	LBL
0165	N	0210	E	----	02
0166	O	0211	M	0258	STO G
0167	T	0212	O	0259	3
0168	LINE	0213	R	0260	2
0169		0214	Y	0261	LBL
0170	E	0215	LINE	----	05
0171	O	0216		0263	ENTER↑
0172	U	0217	T	0264	1
0173	A	0218	O	0265	STO B
0174	L	0219		0266	ROLL↓
0175		0220	PRINT	0267	FOR B+G
0176	T	0221		0268	WBYTE 3
0177	H	0222	M	0270	NEXT B
0178	E	0223	I	0271	RETURN
0179		0224	N	0272	END
0180	T	0225	.		
0181	I	0226	LINE		
0182	M	0227	ENDα		
0183	E	0228	LBL		
0184	LINE	----	06		
0185		0230	PRNTα		
0186	E	0232	LINE		
0187	X	0233			
0188	P	0234	*		
0189	E	0235	*		
0190	C	0236			
0191	T	0237	E		
0192	E	0238	N		
0193	D	0239	D		
0194	.	0240			
0195		0241	*		
0196	T	0242	*		
0197	I	0243	ENDα		
0198	M	0244	0		
0199	E	0245	ENTER↑		
0200	LINE	0246	1		
0201		0247	LD&GO		
0202	S	0248	STOP		
0203	E	0249	LBL		
0204	T	----	01		
0205		0251	STO G		

0000	NOP	0046	U	0092	L
0001	NOP	0047	N	0093	O
0002	PRNTα	0048	'	0094	W
0004	*	0049		0095	E
0005	C	0050	T	0096	R
0006	H	0051	O	0097	
0007	I	0052		0098	D
0008		0053	G	0099	I
0009	S	0054	O	0100	A
0010	O	0055	'	0101	L
0011	U	0056	O	0102	=
0012	A	0057	N	0103	
0013	R	0058	,	0104	4
0014	E	0059		0105	.
0015		0060	'	0106	7
0016	T	0061	A	0107	5
0017	E	0062	'	0108	U
0018	S	0063		0109	P
0019	T	0064	T	0110	P
0020	LINE	0065	O	0111	E
0021	LINE	0066		0112	R
0022	S	0067	S	0113	
0023	A	0068	T	0114	D
0024	M	0069	O	0115	I
0025	P	0070	P	0116	A
0026	L	0071	LINE	0117	L
0027	E	0072	ENDα	0118	=
0028		0073	STOP	0119	
0029	I	0074	PRNTα	0120	0
0030	N	0076	S	0121	.
0031		0077	E	0122	5
0032	P	0078	T	0123	0
0033	L	0079		0124	LINE
0034	A	0080	R	0125	ENDα
0035	C	0081	A	0126	PRNTα
0036	E	0082	D	0128	LINE
0037	?	0083	O	0129	LINE
0038	LINE	0084	N	0130	P
0039	P	0085		0131	U
0040	U	0086	C	0132	S
0041	S	0087	H	0133	H
0042	H	0088	N	0134	
0043		0089	N	0135	R
0044	'	0090	L	0136	U
0045	R	0091		0137	N

0138		0185	R
0139	Q	0186	U
0140	R	0187	N
0141		0188	
0142	A	0189	Q
0143	LINE	0190	R
0144	LINE	0191	
0145	ENDα	0192	A
0146	STOP	0193	ENDα
0147	FIX	0194	STOP
0149	PRNTα	0195	Q
0151	LINE	0196	ENTER↑
0152	E	0197	S
0153	X	0198	LD&GO
0154	P	0199	LBL
0155	E	----	A
0156	C	0201	Q
0157	T	0202	ENTER↑
0158	E	0203	1
0159	D	0204	LD&GO
0160		0205	END
0161	R		
0162	U		
0163	N		
0164	S		
0165			
0166	=		
0167			
0168	1		
0169			
0170	M		
0171	I		
0172	N		
0173	.		
0174			
0175	E		
0176	A		
0177	C		
0178	H		
0179	LINE		
0180	P		
0181	U		
0182	S		
0183	H		
0184			

0000	0			0051	PAUSE			0106	ROLL↓	
0001	#REGS			0052	PAUSE			0107	NEXT	C
0002	1			0053	PAUSE			0108	STO I	B
0003	3			0054	LBL			0110	NEXT	B
0004	#REGS			----	02			0111	0	
0005	CLRA+J			0056	RBYTE	2		0112	WBYTE	2
0006	PRNTα			0058	1			0114	RCL	R005
0008	LINE			0059	6			0116	RCL	R004
0009	B			0060	AND	2		0118	IF X=Y	
0010	E			0062	IF 0			0119	GOTO	L04
0011	T			0063	GOTO	L03		0121	GOTO	L06
0012	A			0065	GOTO	L02		0123	LBL	
0013				0067	LBL			----	04	
0014	A			----	03			0125	FIX	0
0015	L			0069	9			0127	RCL	R009
0016	P			0070	WBYTE	2		0129	PRNTα	
0017	H			0072	5			0131	PRINT	
0018	A			0073	STO	B		0132		
0019				0074	9			0133		
0020	F			0075	STO	G		0134		
0021	U			0076	8			0135		
0022				0077	WBYTE	2		0136		
0023	R			0079	FOR	B+G		0137		
0024	N			0080	6			0138		
0025	LINE			0081	STO	C		0139		
0026	ENDα			0082	1			0140		
0027	1			0083	STO	H		0141		
0028	STO	I		0084	+÷-			0142	ENDα	
0029	1			0085	STO	D		0143	STO+	A
0030	0			0086	CLEAR			0144	2	
0031	0			0087	FOR	C+HD		0145	Y↑X	
0032	STO	R004		0088	1			0146	STO+	R000
0034	LBL			0089	0			0148	RCL	R008
----	01			0090	*			0150	PRNTα	
0036	1			0091	RBYTE	2		0152	PRINT	
0037	+÷-			0093	1			0153		
0038	DATA	2		0094	5			0154		
0040	FIX	8		0095	AND	2		0155		
0042	4			0097	+			0156		
0043	WBYTE	2		0098	1			0157		
0045	0			0099	0			0158		
0046	WBYTE	2		0100	WBYTE	2		0159	ENDα	
0048	PAUSE			0102	ROLL↓			0160	STO+	F
0049	PAUSE			0103	8			0161	2	
0050	PAUSE			0104	WBYTE	2				

0162	Y↑X		0226	RCL	F	0281	
0163	STO+	R001	0227	STO	R003	0282	M
0165	RCL	R007	0229	RCL	I	0283	I
0167	PRNTα		0230	÷		0284	N
0169	PRINT		0231	STO	R005	0285	.
0170			0233	RCL	E	0286	LINE
0171			0234	STO	R006	0287	C
0172			0236	RCL	I	0288	H
0173	ENDα		0237	÷		0289	I
0174	STO+	E	0238	STO	R008	0290	
0175	2		0240	RCL	J	0291	S
0176	Y↑X		0241	STO	R010	0292	Q
0177	STO+	R002	0243	RCL	I	0293	
0179	RCL	R006	0244	÷		0294	T
0181	PRNTα		0245	STO	R012	0295	E
0183	PRINT		0247	RCL	I	0296	S
0184	ENDα		0248	STO	R009	0297	T
0185	STO+	J	0250	0		0298	LINE
0186	2		0251	ENTER↑		0299	A
0187	Y↑X		0252	9		0300	B
0188	STO+	R003	0253	LD&GO		0301	O
0190	2		0254	LBL		0302	R
0191	0		----	06		0303	T
0192	ENTER↑		0256	RCL	R005	0304	E
0193	RCL	I	0258	1		0305	D
0194	IF X=Y		0259	0		0306	LINE
0195	GOTO	L05	0260	0		0307	*
0197	1		0261	÷		0308	*
0198	STO+	I	0262	FIX	2	0309	*
0199	GOTO	L01	0264	PRNTα		0310	*
0201	LBL		0266	LINE		0311	*
----	05		0267	LINE		0312	*
0203	RCL	R001	0268	T		0313	*
0205	STO	R004	0269	I		0314	*
0207	RCL	R000	0270	M		0315	*
0209	STO	R001	0271	E		0316	*
0211	RCL	R002	0272	R		0317	*
0213	STO	R007	0273			0318	*
0215	RCL	R003	0274	R		0319	*
0217	STO	R011	0275	E		0320	*
0219	RCL	A	0276	A		0321	*
0220	STO	R000	0277	D		0322	*
0222	RCL	I	0278	S		0323	LINE
0223	÷		0279	LINE		0324	LINE
0224	STO	R002	0280	PRINT		0325	ENDα

0326 1
0327 0
0328 #REGS
0329 0
0330 ENTER†
0331 1
0332 LD&GO
0333 END

0000	1		0070	RCL	R005	0147	0	
0001	7		0072	RCL	G	0148	ENTER↑	
0002	#REGS		0073	RCL	R013	0149	0	
0003	FIX	8	0075	GOSUB	L02	0150	ENTER↑	
0005	RCL	R002	0077	STO	R013	0151	1	
0007	STO	G	0079	RCL	R006	0152	+*-	
0008	RCL	R001	0081	RCL	H	0153	RCDATA	
0010	RCL	R000	0082	RCL	R014	0154	PRNTα	
0012	GOSUB	L01	0084	GOSUB	L02	0156	LINE	
0014	STO	A	0086	STO	R014	0157	B	
0015	RCL	R005	0088	RCL	R007	0158	E	
0017	STO	H	0090	RCL	I	0159	T	
0018	RCL	R004	0091	RCL	R015	0160	A	
0020	RCL	R003	0093	GOSUB	L02	0161	:	
0022	GOSUB	L01	0095	STO	R015	0162	ENDα	
0024	STO	B	0097	RCL	R007	0163	RCL	R000
0025	RCL	R008	0099	RCL	J	0165	GOSUB	L03
0027	STO	I	0100	RCL	R016	0167	RCL	R003
0028	RCL	R007	0102	GOSUB	L02	0169	GOSUB	L04
0030	RCL	R006	0104	STO	R016	0171	RCL	R006
0032	GOSUB	L01	0106	RCL	G	0173	GOSUB	L05
0034	STO	C	0107	STO	R000	0175	PRNTα	
0035	RCL	R012	0109	RCL	H	0177	A	
0037	STO	J	0110	STO	R001	0178	L	
0038	RCL	R011	0112	RCL	I	0179	P	
0040	RCL	R010	0113	STO	R002	0180	H	
0042	GOSUB	L01	0115	RCL	A	0181	A	
0044	STO	D	0116	STO	R003	0182	:	
0045	0		0118	RCL	B	0183	ENDα	
0046	ENTER↑		0119	STO	R004	0184	RCL	R001
0047	+*-		0121	RCL	C	0186	GOSUB	L03
0048	LOAD		0122	STO	R005	0188	RCL	R004
0049	RCL	R001	0124	RCL	R013	0190	GOSUB	L04
0051	STO	R013	0126	STO	R006	0192	RCL	R007
0053	RCL	R002	0128	RCL	R014	0194	GOSUB	L05
0055	STO	R014	0130	STO	R007	0196	PRNTα	
0057	RCL	R003	0132	RCL	R015	0198	P	
0059	STO	R015	0134	STO	R008	0199	U	
0061	RCL	R004	0136	RCL	J	0200	:	
0063	STO	R016	0137	STO	R010	0201	ENDα	
0065	0		0139	RCL	D	0202	RCL	R002
0066	ENTER↑		0140	STO	R011	0204	GOSUB	L03
0067	2		0142	RCL	R016	0206	RCL	R005
0068	+*-		0144	STO	R012	0208	GOSUB	L04
0069	LOAD		0146	1		0210	RCL	R008

0212	GOSUB	L05	0266	PRNTα
0214	PRNTα		0268	M
0216	R		0269	E
0217	N		0270	A
0218	:		0271	N
0219	ENDα		0272	
0220	RCL	R010	0273	=
0222	GOSUB	L03	0274	PRINT
0224	RCL	R011	0275	ENDα
0226	GOSUB	L04	0276	RETURN
0228	RCL	R012	0277	LBL
0230	GOSUB	L05	----	04
0232	0		0279	PRNTα
0233	ENTER↑		0281	C
0234	1		0282	H
0235	3		0283	I
0236	#REGS		0284	↑
0237	1		0285	2
0238	0		0286	=
0239	LD&GO		0287	PRINT
0240	LBL		0288	ENDα
----	01		0289	RETURN
0242	2		0290	LBL
0243	Y↑X		----	05
0244	2		0292	PRNTα
0245	0		0294	%
0246	+		0295	E
0247	+*-		0296	F
0248	+		0297	F
0249	X≠Y		0298	
0250	+		0299	=
0251	RETURN		0300	PRINT
0252	LBL		0301	ENDα
----	02		0302	RETURN
0254	-		0303	END
0255	X≠Y			
0256	+			
0257	1			
0258	0			
0259	0			
0260	*			
0261	RETURN			
0262	LBL			
----	03			
0264	FIX	2		

0000	1		0046	RCL	G	0106	ENTER↑	
0001	3		0047	ENTER↑		0107	RCL	J
0002	#REGS		0048	RCL	R003	0108	IF X<Y	
0003	CFG	1	0050	IF X<Y		0109	GOSUB	L01
0004	7		0051	GOSUB	L01	0111	IF X<Y	
0005	.		0053	IF X<Y		0112	GOTO	L21
0006	6		0054	GOTO	L11	0114	RCL	H
0007	3		0056	ENTER↑		0115	ENTER↑	
0008	STO	G	0057	RCL	J	0116	RCL	R004
0009	1		0058	IF X<Y		0118	IF X<Y	
0010	1		0059	GOSUB	L01	0119	GOSUB	L02
0011	.		0061	IF X<Y		0121	IF X<Y	
0012	6		0062	GOTO	L11	0122	GOTO	L21
0013	5		0064	RCL	H	0124	ENTER↑	
0014	STO	H	0065	ENTER↑		0125	RCL	I
0015	2		0066	RCL	R003	0126	IF X<Y	
0016	7		0068	IF X<Y		0127	GOSUB	L02
0017	.		0069	GOSUB	L02	0129	IF X<Y	
0018	2		0071	IF X<Y		0130	GOTO	L21
0019	STO	I	0072	GOTO	L11	0132	GOSUB	L03
0020	3		0074	ENTER↑		0134	LBL	
0021	6		0075	RCL	I	----	21	
0022	.		0076	IF X<Y		0136	PRNTα	
0023	1		0077	GOSUB	L02	0138	LINE	
0024	9		0079	IF X<Y		0139	P	
0025	STO	J	0080	GOTO	L11	0140	U	
0026	PRNTα		0082	GOSUB	L03	0141	:	
0028	LINE		0084	LBL		0142	ENDα	
0029			----	11		0143	RCL	G
0030			0086	PRNTα		0144	ENTER↑	
0031	R		0088	LINE		0145	RCL	R005
0032	E		0089	A		0147	IF X<Y	
0033	S		0090	L		0148	GOSUB	L01
0034	U		0091	P		0150	IF X<Y	
0035	L		0092	H		0151	GOTO	L31
0036	T		0093	A		0153	ENTER↑	
0037	S		0094	:		0154	RCL	J
0038	LINE		0095	ENDα		0155	IF X<Y	
0039	LINE		0096	RCL	G	0156	GOSUB	L01
0040	B		0097	ENTER↑		0158	IF X<Y	
0041	E		0098	RCL	R004	0159	GOTO	L31
0042	T		0100	IF X<Y		0161	RCL	H
0043	A		0101	GOSUB	L01	0162	ENTER↑	
0044	:		0103	IF X<Y		0163	RCL	R005
0045	ENDα		0104	GOTO	L21	0165	IF X<Y	

0166 GOSUB L02	0228 LBL	0277 N
0168 IF X<Y	---- 41	0278 A
0169 GOTO L31	0230 PRNTα	0279 L
0171 ENTER↑	0232 LINE	0280 ENDα
0172 RCL I	0233 LINE	0281 RETURN
0173 IF X<Y	0234 ENDα	0282 LBL
0174 GOSUB L02	0235 IF SFG 1	---- 03
0176 IF X<Y	0236 GOTO L04	0284 PRNTα
0177 GOTO L31	0238 0	0286 A
0179 GOSUB L03	0239 ENTER↑	0287 C
0181 LBL	0240 1	0288 C
---- 31	0241 1	0289 E
0183 PRNTα	0242 LD&GO	0290 P
0185 LINE	0243 STOP	0291 T
0186 R	0244 LBL	0292 A
0187 N	---- 01	0293 B
0188 :	0246 SFG 1	0294 L
0189 ENDα	0247 PRNTα	0295 E
0190 RCL G	0249 N	0296 ENDα
0191 ENTER↑	0250 0	0297 RETURN
0192 RCL R011	0251 T	0298 STOP
0194 IF X<Y	0252	0299 LBL
0195 GOSUB L01	0253 A	---- 04
0197 IF X<Y	0254 C	0301 1
0198 GOTO L41	0255 C	0302 0
0200 ENTER↑	0256 E	0303 #REGS
0201 RCL J	0257 P	0304 0
0202 IF X<Y	0258 T	0305 ENTER↑
0203 GOSUB L01	0259 A	0306 1
0205 IF X<Y	0260 B	0307 LD&GO
0206 GOTO L41	0261 L	0308 END
0208 RCL H	0262 E	
0209 ENTER↑	0263 ENDα	
0210 RCL R011	0264 RETURN	
0212 IF X<Y	0265 LBL	
0213 GOSUB L02	---- 02	
0215 IF X<Y	0267 PRNTα	
0216 GOTO L41	0269 C	
0218 ENTER↑	0270 0	
0219 RCL I	0271 N	
0220 IF X<Y	0272 D	
0221 GOSUB L02	0273 I	
0223 IF X<Y	0274 T	
0224 GOTO L41	0275 I	
0226 GOSUB L03	0276 0	

0000	1		0054	ENTER↑		0106	R.	
0001	3		0055	2		0107	C	
0002	#REGS		0056	+÷-		0108	E	
0003	FIX	0	0057	LOAD		0109		
0005	1		0058	1		0110	=	
0006	6		0059	7		0111	PRINT	
0007	FIELD	3	0060	GOSUB	L02	0112		
0009	1		0062	RCL	R005	0113	D	
0010	DATA	3	0064	WRTα	3	0114	/	
0012	8		0066	B		0115	M	
0013	GOSUB	L01	0067	E		0116	ENDα	
0015	1		0068	T		0117	6	
0016	4		0069	A		0118	GOSUB	L01
0017	GOSUB	L02	0070			0120	WRTα	3
0019	1		0071	S		0122	C	
0020	WBYTE	3	0072	0		0123	H	
0022	WRTα	3	0073	U		0124	A	
0024	C		0074	R		0125	N	
0025	H		0075	C		0126	N	
0026	I		0076	E		0127	E	
0027			0077			0128	L	
0028	S		0078			0129	ENDα	
0029	0		0079	=		0130	1	
0030	U		0080	PRINT		0131	2	
0031	A		0081			0132	GOSUB	L02
0032	R		0082	D		0134	WRTα	3
0033	E		0083	/		0136	M	
0034			0084	M		0137	E	
0035	T		0085	ENDα		0138	A	
0036	E		0086	2		0139	N	
0037	S		0087	GOSUB	L01	0140		
0038	T		0089	1		0141	C	
0039			0090	7		0142	/	
0040	R		0091	GOSUB	L02	0143	M	
0041	E		0093	RCL	R006	0144	ENDα	
0042	S		0095	WRTα	3	0145	1	
0043	U		0097	A		0146	5	
0044	L		0098	L		0147	GOSUB	L02
0045	T		0099	P		0149	WRTα	3
0046	ENDα		0100	H		0151	C	
0047	2		0101	A		0152	H	
0048	WBYTE	3	0102			0153	I	
0050	3		0103	S		0154		
0051	GOSUB	L01	0104	0		0155	S	
0053	0		0105	U		0156	0	

0157	.			0219	L		
0158	ENDα			0220	P		
0159	1			0221	H		
0160	5			0222	A		
0161	GOSUB	L02		0223	ENDα		
0163	WRTα	3		0224	6		
0165	%			0225	GOSUB	L02	
0166				0227	RCL	R001	
0167	E			0229	WRTX	3	
0168	F			0231	-5		
0169	F			0232	GOSUB	L02	
0170	ENDα			0234	RCL	R004	
0171	2			0236	WRTX	3	
0172	GOSUB	L01		0238	5		
0174	0			0239	GOSUB	L02	
0175	ENTER↑			0241	RCL	R007	
0176	1			0243	WRTX	3	
0177	+÷-			0245	2		
0178	LOAD			0246	GOSUB	L01	
0179	1			0248	0		
0180	GOSUB	L01		0249	ENTER↑		
0182	FIX	2		0250	1		
0184	WRTα	3		0251	2		
0186	B			0252	LD&GO		
0187	E			0253	LBL		
0188	T			----	01		
0189	A			0255	STO	G	
0190				0256	1		
0191	ENDα			0257	3		
0192	6			0258	GOTO	L03	
0193	GOSUB	L02		0260	LBL		
0195	RCL	R000		----	02		
0197	WRTX	3		0262	STO	G	
0199	5			0263	3		
0200	GOSUB	L02		0264	2		
0202	RCL	R003		0265	LBL		
0204	WRTX	3		----	05		
0206	5			0267	ENTER↑		
0207	GOSUB	L02		0268	1		
0209	RCL	R006		0269	STO	B	
0211	WRTX	3		0270	ROLL↓		
0213	2			0271	FOR	B+G	
0214	GOSUB	L01		0272	WYTE	3	
0216	WRTα	3		0274	NEXT	B	
0218	A			0275	RETURN		
				0276	END		

0000	1		0064	END α		0121	5
0001	3		0065	6		0122	.
0002	#REGS		0066	GOSUB	L02	0123	6
0003	FIX	2	0068	RCL	R010	0124	0
0005	2		0070	WRTX	3	0125	U
0006	5		0072	5		0126	P
0007	WBYTE	3	0073	GOSUB	L02	0127	P
0009	3		0075	RCL	R011	0128	E
0010	1		0077	WRTX	3	0129	R
0011	WBYTE	3	0079	5		0130	
0013	WRT α	3	0080	GOSUB	L02	0131	D
0015	2		0082	RCL	R012	0132	I
0016	3		0084	WRTX	3	0133	A
0017	9		0086	2		0134	L
0018	END α		0087	GOSUB	L01	0135	=
0019	2		0089	GOSUB	L08	0136	
0020	0		0091	PRNT α		0137	2
0021	WBYTE	3	0093	S		0138	.
0023	2		0094	E		0139	S
0024	9		0095	T		0140	0
0025	WBYTE	3	0096			0141	END α
0027	WRT α	3	0097	R		0142	GOSUB L08
0029	P		0098	A		0144	PRNT α
0030	U		0099	D		0146	
0031			0100	O		0147	
0032	END α		0101	N		0148	
0033	6		0102			0149	
0034	GOSUB	L02	0103	C		0150	P
0036	RCL	R002	0104	H		0151	R
0038	WRTX	3	0105	N		0152	E
0040	5		0106	N		0153	S
0041	GOSUB	L02	0107	L		0154	S
0043	RCL	R005	0108			0155	
0045	WRTX	3	0109	L		0156	R
0047	5		0110	O		0157	U
0048	GOSUB	L02	0111	W		0158	N
0050	RCL	R008	0112	E		0159	
0052	WRTX	3	0113	R		0160	LINE
0054	2		0114			0161	
0055	GOSUB	L01	0115	D		0162	
0057	WRT α	3	0116	I		0163	
0059	R		0117	A		0164	
0060	A		0118	L		0165	W
0061	D		0119	=		0166	H
0062	0		0120			0167	E
0063	N						

0168	N		0216	*
0169			0217	*
0170	D		0218	*
0171	0		0219	*
0172	N		0220	*
0173	E		0221	*
0174	LINE		0222	*
0175	LINE		0223	*
0176	LINE		0224	*
0177	LINE		0225	*
0178	LINE		0226	*
0179	END α		0227	*
0180	STOP		0228	*
0181	1		0229	*
0182	0		0230	*
0183	#REGS		0231	END α
0184	0		0232	RETURN
0185	ENTER†		0233	END
0186	1			
0187	LD&GO			
0188	LBL			
----	01			
0190	STO	G		
0191	1			
0192	3			
0193	GOTO	L05		
0195	LBL			
----	02			
0197	STO	G		
0198	3			
0199	2			
0200	LBL			
----	05			
0202	ENTER†			
0203	1			
0204	STO	B		
0205	ROLL↓			
0206	FOR	B+G		
0207	WBYTE	3		
0208	NEXT	B		
0210	RETURN			
0211	LBL			
----	08			
0213	PRNT α			
0215	*			

0000	2	0046	=	0091	
0001	0	0047		0092	T
0002	#REGS	0048	2	0093	0
0003	PRNT%	0049	.	0094	
0005	LINE	0050	0	0095	G
0006	*	0051		0096	0
0007		0052	M	0097	0
0008	F	0053	I	0098	N
0009	I	0054	N	0099	,
0010	L	0055	2	0100	
0011	T	0056	LINE	0101	
0012	E	0057	F	0102	'
0013	R	0058	I	0103	A
0014		0059	R	0104	'
0015		0060	S	0105	
0016	E	0061	T	0106	T
0017	X	0062		0107	0
0018	A	0063	S	0108	
0019	M	0064	A	0109	S
0020		0065	M	0110	T
0021	*	0066	P	0111	0
0022	LINE	0067	L	0112	P
0023	LINE	0068	E	0113	LINE
0024	C	0069	LINE	0114	END%
0025	0	0070	I	0115	STOP
0026	N	0071	N	0116	0
0027	S	0072		0117	ENTER↑
0028	T	0073	P	0118	+%-
0029	A	0074	L	0119	LOAD
0030	N	0075	A	0120	RCL R004
0031	T	0076	C	0122	STO R019
0032	S	0077	E	0124	RCL R003
0033		0078	?	0126	STO R018
0034	R	0079	LINE	0128	RCL R002
0035	E	0080	LINE	0130	STO R017
0036	A	0081	P	0132	RCL R001
0037	D	0082	U	0134	STO R016
0038	Y	0083	S	0136	0
0039	?	0084	H	0137	ENTER↑
0040	T	0085		0138	2
0041	I	0086	'	0139	+%-
0042	M	0087	R	0140	LOAD
0043	E	0088	U	0141	RCL R002
0044	R	0089	N	0143	STO R015
0045		0090	'	0145	RCL R001

0147	STO	R014	0208	7	0258	LBL
0149	RCL	R000	0209	5	----	A
0151	STO	R013	0210	EEX	0260	1
0153	RCL	R004	0211	+@-	0261	0
0155	STO	R012	0212	9	0262	#REGS
0157	RCL	R003	0213	ENTER↑	0263	0
0159	STO	R011	0214	STO	0264	ENTER↑
0161	RCL	R008	0215	RCL	0265	1
0163	STO	F	0217	÷	0266	LD&GO
0164	0		0218	RCL	0267	STOP
0165	ENTER↑		0220	÷	0268	END
0166	1		0221	RCL		
0167	+@-		0223	÷		
0168	LOAD		0224	STO		R008
0169	2		0226	3		
0170	.		0227	+@-		
0171	2		0228	STO		R007
0172	7		0230	PRNTα		
0173	1		0232	LINE		
0174	4		0233	N		
0175	EEX		0234	0		
0176	+@-		0235	.		
0177	9		0236			
0178	ENTER↑		0237	S		
0179	STO	E	0238	A		
0180	RCL	R012	0239	M		
0182	÷		0240	P		
0183	RCL	R008	0241	L		
0185	÷		0242	E		
0186	RCL	R011	0243	S		
0188	÷		0244	?		
0189	STO	R010	0245	ENDα		
0191	RCL	E	0246	STOP		
0192	ENTER↑		0247	PRINT		
0193	RCL	R012	0248	STO		F
0195	÷		0249	1		
0196	RCL	R007	0250	STO		A
0198	÷		0251	NOP		
0199	RCL	R011	0252	0		
0201	÷		0253	ENTER↑		
0202	STO	R009	0254	1		
0204	1		0255	4		
0205	.		0256	LD&GO		
0206	9		0257	STOP		
0207	8					

0000	NOP		0059	WBYTE	3	0116	I	
0001	NOP		0061	2		0117	N	
0002	FIX	0	0062	WBYTE	3	0118	I	
0004	1		0064	5		0119	T	
0005	DATA	3	0065	GOSUB	L01	0120	I	
0007	1		0067	WRTα	3	0121	A	
0008	2		0069	D		0122	L	
0009	WBYTE	3	0070	A		0123	S	
0011	2		0071	T		0124	ENDα	
0012	7		0072	E		0125	9	
0013	WBYTE	3	0073	ENDα		0126	GOSUB	L03
0015	7		0074	9		0128	4	
0016	4		0075	GOSUB	L03	0129	GOSUB	L01
0017	WBYTE	3	0077	4		0131	WRTα	3
0019	4		0078	GOSUB	L02	0133	C	
0020	4		0080	WRTα	3	0134	O	
0021	WBYTE	3	0082	S		0135	M	
0023	7		0083	H		0136	M	
0024	0		0084	I		0137	E	
0025	WRTX	3	0085	F		0138	N	
0027	3		0086	T		0139	T	
0028	6		0087	ENDα		0140	S	
0029	WBYTE	3	0088	9		0141	:	
0031	2		0089	GOSUB	L03	0142	ENDα	
0032	7		0091	4		0143	6	
0033	WBYTE	3	0092	GOSUB	L02	0144	1	
0035	7		0094	WRTα	3	0145	GOSUB	L03
0036	6		0096	A		0147	2	
0037	WBYTE	3	0097	U		0148	GOSUB	L01
0039	4		0098	T		0150	7	
0040	4		0099	O		0151	0	
0041	WBYTE	3	0100	-		0152	GOSUB	L03
0043	5		0101	M		0154	2	
0044	2		0102	A		0155	GOSUB	L01
0045	8		0103	N		0157	7	
0046	WRTX	3	0104	U		0158	0	
0048	4		0105	A		0159	GOSUB	L03
0049	4		0106	L		0161	2	
0050	WBYTE	3	0107	ENDα		0162	GOSUB	L01
0052	4		0108	4		0164	WRTα	3
0053	8		0109	GOSUB	L02	0166	S	
0054	6		0111	WRTα	3	0167	A	
0055	WRTX	3	0113	R		0168	M	
0057	3		0114	M		0169	P	
0058	6		0115			0170	L	

0171	E			0226	7		
0172				0227	GOSUB	L02	
0173	O			0229	WRTα	3	
0174	N			0231	T		
0175	ENDα			0232	I		
0176	2			0233	M		
0177	1			0234	E		
0178	GOSUB	L02		0235	ENDα		
0180	WRTα	3		0236	9		
0182	S			0237	GOSUB	L03	
0183	A			0239	1		
0184	M			0240	7		
0185	P			0241	GOSUB	L02	
0186	L			0243	0		
0187	E			0244	ENTER↑		
0188				0245	1		
0189	O			0246	5		
0190	F			0247	LD&GO		
0191	F			0248	STOP		
0192	ENDα			0249	LBL		
0193	2			----	01		
0194	GOSUB	L01		0251	STO	G	
0196	7			0252	1		
0197	GOSUB	L02		0253	3		
0199	WRTα	3		0254	GOTO	L05	
0201	D			0256	LBL		
0202	A			----	02		
0203	T			0258	STO	G	
0204	E			0259	3		
0205	ENDα			0260	2		
0206	9			0261	GOTO	L05	
0207	GOSUB	L03		0263	LBL		
0209	1			----	03		
0210	7			0265	STO	G	
0211	GOSUB	L02		0266	9		
0213	WRTα	3		0267	5		
0215	D			0268	LBL		
0216	A			----	05		
0217	T			0270	ENTER↑		
0218	E			0271	1		
0219	ENDα			0272	STO	B	
0220	9			0273	ROLL↓		
0221	GOSUB	L03		0274	FOR	B→G	
0223	2			0275	WBYTE	3	
0224	GOSUB	L01		0277	NEXT	B	
				0278	RETURN		
				0279	END		

0000	NOP		0057	M		0112	M
0001	NOP		0058	P		0113	I
0002	WRTα	3	0059	L		0114	N
0004	T		0060	E		0115	U
0005	I		0061			0116	T
0006	M		0062	V		0117	E
0007	E		0063	O		0118	S
0008	ENDα		0064	L		0119	ENDα
0009	9		0065	U		0120	3
0010	GOSUB	L03	0066	M		0121	GOSUB L01
0012	2		0067	E		0123	WRTα 3
0013	GOSUB	L01	0068	ENDα		0125	N
0015	WRTα	3	0069	3		0126	O
0017	S		0070	GOSUB	L02	0127	T
0018	A		0072	RCL	R011	0128	E
0019	M		0074	FIX	0	0129	:
0020	P		0076	WRTX	3	0130	
0021	L		0078	WRTα	3	0131	R
0022	E		0080			0132	SHIFT
0023			0081	C		0133	E
0024	P		0082	F		0134	F
0025	E		0083	D		0135	E
0026	R		0084	ENDα		0136	R
0027	I		0085	1		0137	
0028	O		0086	6		0138	T
0029	D		0087	FIELD	3	0139	O
0030	ENDα		0089	2		0140	
0031	3		0090	GOSUB	L01	0141	T
0032	GOSUB	L02	0092	WRTα	3	0142	H
0034	FIX	2	0094	C		0143	E
0036	5		0095	O		0144	
0037	FIELD	3	0096	U		0145	D
0039	RCL	R012	0097	N		0146	A
0041	WRTX	3	0098	T		0147	I
0043	WRTα	3	0099			0148	L
0045			0100	T		0149	Y
0046	D		0101	I		0150	SHIFT
0047	A		0102	M		0151	/
0048	Y		0103	E		0152	SHIFT
0049	ENDα		0104	ENDα		0153	W
0050	2		0105	5		0154	E
0051	GOSUB	L01	0106	GOSUB	L02	0155	E
0053	WRTα	3	0108	WRTα	3	0156	K
0055	S		0110	2		0157	L
0056	A		0111			0158	Y

```

0159
0160 A
0161 I
0162 R
0163
0164 S
0165 A
0166 M
0167 P
0168 L
0169 E
0170
0171 C
0172 O
0173 L
0174 L
0175 E
0176 C
0177 T
0178 I
0179 O
0180 N
0181
0182 L
0183 I
0184 S
0185 T
0186
0187 T
0188 O
0189
0190 F
0191 I
0192 N
0193 D
0194 END*
0195 1
0196 GOSUB L01
0198 6
0199 GOSUB L02
0201 WRT* 3
0203 SHIFT
0204 T
0205 H
0206 E

```

```

0207
0208 A
0209 C
0210 T
0211 U
0212 A
0213 L
0214
0215 L
0216 O
0217 C
0218 A
0219 T
0220 I
0221 O
0222 N
0223 S
0224
0225 W
0226 H
0227 I
0228 C
0229 H
0230
0231 C
0232 O
0233 R
0234 R
0235 E
0236 S
0237 P
0238 O
0239 N
0240 D
0241
0242 END*
0243 O
0244 ENTER†
0245 1
0246 6
0247 LD&GO
0248 LBL
---- 01
0250 STO G

```

```

0251 1
0252 3
0253 GOTO L05
0255 LBL
---- 02
0257 STO G
0258 3
0259 2
0260 GOTO L05
0262 LBL
---- 03
0264 STO G
0265 9
0266 5
0267 LBL
---- 05
0269 ENTER†
0270 1
0271 STO B
0272 ROLL↓
0273 FOR B+G
0274 WBYTE 3
0276 NEXT B
0277 RETURN
0278 END

```

0000	NOP		0051	2		0100	U	
0001	NOP		0052	9		0101	D	
0002	WRTα	3	0053	WBYTE	3	0102	E	
0004	SHIFT		0055	WRTα	3	0103		
0005	T		0057	C		0104	SHIFT	
0006	O		0058	SHIFT		0105	R	
0007			0059	I		0106	A	
0008	T		0060	SHIFT		0107	D	
0009	H		0061	/		0108	O	
0010	E		0062	SHIFT		0109	N	
0011			0063	C		0110		
0012	S		0064	C		0111	S	
0013	A		0065			0112	U	
0014	M		0066	0		0113	B	
0015	P		0067	F		0114	T	
0016	L		0068			0115	R	
0017	E		0069	SHIFT		0116	A	
0018			0070	B		0117	C	
0019	N		0071	SHIFT		0118	T	
0020	U		0072	E		0119	I	
0021	M		0073	T		0120	O	
0022	B		0074	A		0121	N	
0023	E		0075	SHIFT		0122	SHIFT	
0024	R		0076	,		0123	.	
0025	SHIFT		0077	SHIFT		0124	ENDα	
0026	.		0078			0125	3	
0027	ENDα		0079	SHIFT		0126	GOSUB	L01
0028	2		0080	A		0128	1	
0029	GOSUB	L01	0081	SHIFT		0129	3	
0031	6		0082	L		0130	GOSUB	L02
0032	GOSUB	L02	0083	P		0132	1	
0034	WRTα	3	0084	H		0133	WBYTE	3
0036	T		0085	A		0135	WRTα	3
0037	SHIFT		0086			0137	F	
0038	H		0087	A		0138	I	
0039	E		0088	N		0139	L	
0040			0089	D		0140	T	
0041	ENDα		0090			0141	E	
0042	3		0091	ENDα		0142	R	
0043	1		0092	GOSUB	L06	0143		
0044	WBYTE	3	0094	WRTα	3	0144	E	
0046	WRTα	3	0096	I		0145	X	
0048	SHIFT		0097	N		0146	A	
0049	U		0098	C		0147	M	
0050	ENDα		0099	L		0148		

0149	R			0205	R			0257	3
0150	E			0206	A			0258	9
0151	S			0207	D			0259	ENDα
0152	U			0208	0			0260	2
0153	L			0209	N			0261	0
0154	T			0210	ENDα			0262	WBYTE 3
0155	3			0211	3			0264	2
0156	ENDα			0212	GOSUB L01			0265	9
0157	2			0214	0 -			0266	WBYTE 3
0158	WBYTE 3			0215	ENTER1			0268	WRTα 3
0160	3			0216	1			0270	P
0161	GOSUB L01			0217	7			0271	SHIFT
0163	WRTα 3			0218	LD&GO			0272	U
0165	S			0219	LBL			0273	SHIFT
0166	M			----	01			0274	
0167	P			0221	STO G			0275	ENDα
0168	L			0222	1			0276	RETURN
0169	ENDα			0223	3			0277	END
0170	7			0224	GOTO L05				
0171	GOSUB L02			0226	LBL				
0173	WRTα 3			----	02				
0175	B			0228	STO G				
0176	E			0229	3				
0177	T			0230	2				
0178	A			0231	GOTO L05				
0179				0233	LBL				
0180	ENDα			----	05				
0181	1			0235	ENTER↑				
0182	3			0236	1				
0183	GOSUB L02			0237	STO B				
0185	WRTα 3			0238	ROLL↓				
0187	A			0239	FOR B←C				
0188	L			0240	WBYTE 3				
0189	P			0242	NEXT B				
0190	H			0243	RETURN				
0191	A			0244	LBL				
0192	ENDα			----	06				
0193	1			0246	2				
0194	5			0247	5				
0195	GOSUB L02			0248	WBYTE 3				
0197	GOSUB L06			0250	3				
0199	1			0251	1				
0200	1			0252	WBYTE 3				
0201	GOSUB L02			0254	WRTα 3				
0203	WRTα 3			0256	2				

0000	2		0058	GOTO	L02	0113	GOTO	L04
0001	0		0060	GOTO	L01	0115	1	
0002	#REGS		0062	LBL		0116	6	
0003	1		----	02		0117	WBYTE	2
0004	+@-		0064	9		0119	0	
0005	DATA	2	0065	WBYTE	2	0120	WBYTE	2
0007	FIX	9	0067	2		0122	LBL	
0009	3		0068	STO	B	----	03	
0010	2		0069	6		0124	RBYTE	2
0011	WBYTE	2	0070	STO	G	0126	3	
0013	RBYTE	2	0071	8		0127	2	
0015	1		0072	WBYTE	2	0128	AND	2
0016	5		0074	FOR	B+G	0130	IF 0	
0017	AND	2	0075	6		0131	GOTO	L03
0019	1		0076	STO	C	0133	2	
0020	0		0077	1		0134	0	
0021	*		0078	STO	H	0135	0	
0022	ENTER↑		0079	+@-		0136	ENTER↑	
0023	6		0080	STO	D	0137	RCL	R002
0024	4		0081	CLEAR		0139	IF X=Y	
0025	WBYTE	2	0082	FOR	C+HD	0140	GOTO	L05
0027	ROLL↓		0083	1		0142	GOTO	L06
0028	RBYTE	2	0084	0		0144	LBL	
0030	1		0085	*		----	04	
0031	5		0086	RBYTE	2	0146	1	
0032	AND	2	0088	1		0147	6	
0034	+		0089	5		0148	WBYTE	2
0035	STO	R001	0090	AND	2	0150	0	
0037	4		0092	+		0151	WBYTE	2
0038	WBYTE	2	0093	1		0153	LBL	
0040	0		0094	0		----	05	
0041	WBYTE	2	0095	WBYTE	2	0155	0	
0043	PAUSE		0097	ROLL↓		0156	ENTER↑	
0044	PAUSE		0098	8		0157	1	
0045	PAUSE		0099	WBYTE	2	0158	8	
0046	PAUSE		0101	ROLL↓		0159	LD&GO	
0047	PAUSE		0102	NEXT	C	0160	STOP	
0048	PAUSE		0103	STO I	B	0161	LBL	
0049	LBL		0105	NEXT	B	----	06	
----	01		0106	0		0163	RCL	R002
0051	RBYTE	2	0107	WBYTE	2	0165	1	
0053	1		0109	RCL	A	0166	0	
0054	6		0110	ENTER↑		0167	0	
0055	AND	2	0111	RCL	F	0168	+	
0057	IF 0		0112	IF X=Y		0169	FIX	2

0171	PRNTα	0217	#
0173	LINE	0218	#
0174	LINE	0219	#
0175	T	0220	#
0176	I	0221	#
0177	M	0222	#
0178	E	0223	#
0179	R	0224	#
0180		0225	#
0181	R	0226	#
0182	E	0227	#
0183	A	0228	#
0184	D	0229	#
0185	S	0230	LINE
0186	LINE	0231	LINE
0187	PRINT	0232	ENDα
0188		0233	1
0189	M	0234	0
0190	I	0235	#REGS
0191	N	0236	0
0192	.	0237	ENTER↑
0193	LINE	0238	1
0194	F	0239	LD&GO
0195	I	0240	STOP
0196	L	0241	END..
0197	T		
0198	E		
0199	R		
0200			
0201	E		
0202	X		
0203	A		
0204	M		
0205	LINE		
0206	A		
0207	B		
0208	O		
0209	R		
0210	T		
0211	E		
0212	D		
0213	LINE		
0214	#		
0215	#		
0216	#		

0000	2		0050	E		0100	RBYTE	2
0001	0		0051	R		0102	1	
0002	#REGS		0052			0103	6	
0003	1		0053	S		0104	AND	2
0004	+*-		0054	A		0106	IF 0	
0005	DATA	2	0055	M		0107	GOTO	L02
0007	FIX	9	0056	P		0109	GOTO	L01
0009	1		0057	L		0111	LBL	
0010	ENTER↑		0058	E		----	02	
0011	RCL	A	0059	-		0113	9	
0012	IF X=Y		0060	#		0114	WBYTE	2
0013	GOTO	0044	0061	LINE		0116	2	
0015	PRNTα		0062	0		0117	STO	B
0017	P		0063	R		0118	6	
0018	U		0064	.		0119	STO	G
0019	T		0065	*		0120	8	
0020			0066	A		0121	WBYTE	2
0021	N		0067	*		0123	FOR	B+G
0022	E		0068			0124	6	
0023	X		0069	T		0125	STO	C
0024	T		0070	0		0126	1	
0025			0071	.		0127	STO	H
0026	S		0072	E		0128	+*-	
0027	A		0073	N		0129	STO	D
0028	M		0074	D		0130	CLEAR	
0029	P		0075	LINE		0131	FOR	C+HD
0030	L		0076	LINE		0132	1	
0031	E		0077	ENDα		0133	0	
0032	LINE		0078	STOP		0134	*	
0033	I		0079	STO	R001	0135	RBYTE	2
0034	N		0081	FIX	0	0137	1	
0035			0083	PRINT		0138	5	
0036	H		0084	FIX	9	0139	AND	2
0037	0		0086	4		0141	+	
0038	L		0087	WBYTE	2	0142	1	
0039	D		0089	0		0143	0	
0040	E		0090	WBYTE	2	0144	WBYTE	2
0041	R		0092	PAUSE		0146	ROLL↓	
0042	LINE		0093	PAUSE		0147	8	
0043	ENDα		0094	PAUSE		0148	WBYTE	2
0044	PRNTα		0095	PAUSE		0150	ROLL↓	
0046	LINE		0096	PAUSE		0151	NEXT	C
0047	E		0097	PAUSE		0152	STO I	B
0048	N		0098	LBL		0154	NEXT	B
0049	T		----	01				

0155 0	0208 0	0255 LINE
0156 WBYTE 2	0209 0	0256
0158 2	0210 +	0257
0159 0	0211 FIX 2	0258
0160 0	0213 PRNTα	0259 #
0161 ENTER↑	0215 LINE	0260 #
0162 RCL R002	0216 LINE	0261 #
0164 IF X=Y	0217 T	0262 #
0165 GOTO L04	0218 I	0263 #
0167 GOTO L05	0219 M	0264 #
0169 LBL	0220 E	0265 #
---- 04	0221 R	0266 #
0171 0	0222	0267 LINE
0172 ENTER↑	0223 R	0268 LINE
0173 1	0224 E	0269 ENDα
0174 8	0225 A	0270 1
0175 LD&GO	0226 D	0271 0
0176 STOP	0227 S	0272 #REGS
0177 LBL	0228 LINE	0273 0
---- A	0229 PRINT	0274 ENTER↑
0179 1	0230	0275 1
0180 2	0231 M	0276 LD&GO
0181 WBYTE 3	0232 I	0277 STOP
0183 WBYTE 3	0233 N	0278 END
0185 IF SFG 3	0234 .	
0186 GOTO L03	0235 LINE	
0188 1	0236 F	
0189 0	0237 I	
0190 #REGS	0238 L	
0191 0	0239 T	
0192 ENTER↑	0240 E	
0193 1	0241 R	
0194 LD&GO	0242	
0195 LBL	0243 E	
---- 03	0244 X	
0197 0	0245 A	
0198 ENTER↑	0246 M	
0199 2	0247 LINE	
0200 0	0248 A	
0201 LD&GO	0249 B	
0202 STOP	0250 0	
0203 LBL	0251 R	
---- 05	0252 T	
0205 RCL R002	0253 E	
0207 1	0254 D	

0000	2		0076	RCL	R006	0144	RCL	R004
0001	0		0078	RCL	R006	0146	RCL	R015
0002	#REGS		0080	1		0148	GOSUB	L12
0003	FIX	0	0081	.		0150	2	
0005	3		0082	2		0151	GOSUB	L01
0006	FIELD	3	0083	*		0153	0	
0008	RCL	R001	0084	-		0154	ENTER↑	
0010	WRTX	3	0085	1		0155	1	
0012	FIX	0	0086	+≠-		0156	9	
0014	6		0087	ROUND		0157	LD&GO	
0015	FIELD	3	0088	RCL	R008	0158	LBL	
0017	1		0090	*		----	10	
0018	GOSUB	L02	0091	STO	R006	0160	2	
0020	RCL	R016	0093	GOSUB	L11	0161	+	
0022	RCL	R006	0095	RCL	R006	0162	X≠Y	
0024	GOSUB	L10	0097	RCL	R013	0163	-	
0026	STO	R006	0099	GOSUB	L12	0164	0	
0028	4		0101	2		0165	ROUND	
0029	GOSUB	L02	0102	GOSUB	L02	0166	IF -	
0031	RCL	R017	0104	RCL	R005	0167	CLX	
0033	RCL	R005	0106	RCL	R003	0168	WRTX	3
0035	GOSUB	L10	0108	-		0170	WRT*	3
0037	STO	R005	0109	RCL	R009	0172		
0039	4		0111	*		0173	N	
0040	GOSUB	L02	0112	STO	R005	0174	E	
0042	RCL	R018	0114	GOSUB	L11	0175	T	
0044	RCL	R004	0116	RCL	R005	0176		
0046	GOSUB	L10	0118	RCL	R014	0177	C	
0048	STO	R004	0120	GOSUB	L12	0178	/	
0050	2		0122	2		0179	M	
0051	GOSUB	L02	0123	GOSUB	L02	0180		
0053	RCL	R019	0125	RCL	R004	0181	END*	
0055	RCL	R003	0127	RCL	R003	0182	RETURN	
0057	GOSUB	L10	0129	.		0183	LBL	
0059	STO	R003	0130	1		----	11	
0061	1		0131	0		0185	IF -	
0062	GOSUB	L01	0132	*		0186	CLX	
0064	NOP		0133	-		0187	WRTX	3
0065	NOP		0134	1		0189	WRT*	3
0066	FIX	2	0135	+≠-		0191		
0068	SCI	2	0136	ROUND		0192	END*	
0070	9		0137	RCL	R010	0193	3	
0071	FIELD	3	0139	*		0194	1	
0073	6		0140	STO	R004	0195	WBYTE	3
0074	GOSUB	L02	0142	GOSUB	L11	0197	WRT*	3

0199	SHIFT			0249	1	
0200	U			0250	STO	B
0201	END α			0251	ROLL $\downarrow$	
0202	2			0252	FOR	B+G
0203	9			0253	WBYTE	3
0204	WBYTE	3		0255	NEXT	B
0206	WRT α	3		0256	RETURN	
0208	C			0257	END	
0209	SHIFT					
0210	I					
0211	SHIFT					
0212	/					
0213	SHIFT					
0214	C					
0215	C					
0216	SHIFT					
0217						
0218	END α					
0219	RETURN					
0220	LBL					
----	12					
0222	IF X $\geq$ Y					
0223	RETURN					
0224	SFG	2				
0225	SFG	3				
0226	8					
0227	WBYTE	3				
0229	WRT α	3				
0231	*					
0232	END α					
0233	RETURN					
0234	LBL					
----	01					
0236	STO	G				
0237	1					
0238	3					
0239	GOTO	L05				
0241	LBL					
----	02					
0243	STO	G				
0244	3					
0245	2					
0246	LBL					
----	05					
0248	ENTER $\uparrow$					

0000	NOP		0056	STO	R003	0104	LBL
0001	NOP		0058	4		----	02
0002	IF	CFG 2	0059	ENTER↑		0106	0
0003	GOTO	L33	0060	0		0107	ENTER↑
0005	NOP		0061	ENTER↑		0108	2
0006	RCL	R001	0062	RCL	R007	0109	0
0008	STO	R000	0064	RCDATA		0110	LD&GO
0010	RCL	R006	0065	1		0111	STOP
0012	RCL	R013	0066	STO-	R007	0112	END
0014	÷		0068	CFG	2		
0015	ENTER↑		0069	LBL			
0016	1		----	33			
0017	-		0071	RCL	F		
0018	IF -		0072	ENTER↑			
0019	0		0073	RCL	A		
0020	1		0074	IF X<Y			
0021	0		0075	GOTO	L01		
0022	0		0077	1			
0023	*		0078	2			
0024	STO	R001	0079	WBYTE	3		
0026	RCL	R005	0081	WBYTE	3		
0028	RCL	R014	0083	IF SFG	3		
0030	÷		0084	GOTO	L02		
0031	ENTER↑		0086	1			
0032	1		0087	0			
0033	-		0088	#REGS			
0034	IF -		0089	0			
0035	0		0090	ENTER↑			
0036	1		0091	1			
0037	0		0092	LD&GO			
0038	0		0093	STOP			
0039	*		0094	LBL			
0040	STO	R002	----	01			
0042	RCL	R004	0096	1			
0044	RCL	R015	0097	STO+	A		
0046	÷		0098	0			
0047	ENTER↑		0099	ENTER↑			
0048	1		0100	1			
0049	-		0101	7			
0050	IF -		0102	LD&GO			
0051	0		0103	STOP			
0052	1						
0053	0						
0054	0						
0055	*						

0000	1		0047		0102	PRNTα
0001	0		0048	A	0104	LINE
0002	#REGS		0049	L	0105	%
0003	CFG	3	0050	A	0106	0
0004	RCL	R007	0051	R	0107	L
0006	1		0052	M	0108	=
0007	+		0053		0109	%
0008	STO	H	0054	L	0110	0
0009	3		0055	I	0111	V
0010	+÷-		0056	M	0112	E
0011	STO	C	0057	I	0113	R
0012	1		0058	T	0114	
0013	+÷-		0059	S	0115	L
0014	STO	D	0060	LINE	0116	I
0015	PRNTα		0061	LINE	0117	M
0017	LINE		0062	ENDα	0118	I
0018	LINE		0063	FOR	0119	T
0019			0064	0	0120	LINE
0020			0065	ENTER↑	0121	LINE
0021			0066	RCL	0122	ENDα
0022			0067	LOAD	0123	0
0023			0068	RCL	0124	ENTER↑
0024	S		0070	FIX	0125	1
0025	A		0072	PRNTα	0126	LD&GO
0026	M		0074	S	0127	STOP
0027	P		0075	A	0128	NOP
0028	L		0076	M	0129	LBL
0029	E		0077	P	----	10
0030	S		0078	L	0131	FIX
0031	LINE		0079	E	0133	PRNTα
0032			0080	PRINT	0135	
0033			0081	ENDα	0136	B
0034			0082	RCL	0137	E
0035			0084	IF +	0138	T
0036	E		0085	GOSUB	0139	A
0037	X		0087	RCL	0140	PRINT
0038	C		0089	IF +	0141	%
0039	E		0090	GOSUB	0142	0
0040	E		0092	RCL	0143	L
0041	D		0094	IF +	0144	ENDα
0042	I		0095	GOSUB	0145	RETURN
0043	N		0097	PRNTα	0146	LBL
0044	G		0099	LINE	----	20
0045	LINE		0100	ENDα	0148	FIX
0046			0101	NEXT	0150	PRNTα

```

0152
0153 P
0154 L
0155 P
0156
0157
0158 PRINT
0159
0160 0
0161 L
0162 END*
0163 RETURN
0164 LBL
----- 30
0166 FIX      1
0168 PRNT*
0170
0171 P
0172 0
0173 2
0174 3
0175 9
0176 PRINT
0177 %
0178 0
0179 L
0180 END*
0181 RETURN
0182 END

```

APPENDIX C

DATA FILES ON CASSETTE

APPENDIX C

DATA FILES ON CASSETTE

Three files on block 2 of the system's cassette are used to hold data which was either entered by the operator via the Initialize Parameters program or the results of the Background or Chi-Squared Tests. These files are numbers -0, -1, and -2 and each contains space for 10 data. Their current use is:

File - 0

Data 0 = Background Test Count Time (minutes)
1 = Background Ave. Beta (counts/min.)
2 = Background Ave. Alpha (counts/min.)
3 = Background Ave. PU-239 (counts/min.)
4 = Background Ave. Radon (counts/min.)
5 = unused
6 = unused
7 = unused
8 = unused
9 = unused

File -1

Data 0 = Mean Beta (counts/min.)
1 = Mean Alpha (counts/min.)
2 = Mean PU-239 (counts/min.)
3 = Chi-Squared for Beta
4 = Chi-Squared for Alpha
5 = Chi-Squared for PU-239
6 = % Efficiency for Beta
7 = % Efficiency for Alpha
8 = % Efficiency for PU-239
9 = unused

File - 2

- Data 0 = Alert Level for Beta ($\mu\text{Ci/cc}$)
- 1 = Alert Level for Alpha ($\mu\text{Ci/cc}$)
- 2 = Alert Level for PU-239 ($\mu\text{Ci/cc}$)
- 3 = Sample Volume (CFD)
- 4 = Filter Exposure Period (days)
- 5 = Standard Beta Source Strength (decays/min.)
- 6 = Standard Alpha Source Strength (decays/min.)
- 7 = unused
- 8 = unused
- 9 = unused

APPENDIX D

COPYING PROGRAM CASSETTES

APPENDIX D

COPYING PROGRAM CASSETTES

The process to copy the program cassette takes about 15 to 30 minutes. Since the contents of the program cassette are vulnerable to being over-written, it is highly advisable to keep at least one copy as a backup. To make a copy, follow the steps outlined below. Read all steps before beginning.

1. Use HP #9162-0061 Data Cartridge or equivalent (Stores Stock #19-0431-425) to make copies.
2. First, the new cassette must be pre-formatted or "marked" before loading programs.
 - a. Set the RECORD tab on the cassette to the right position.
 - b. Put the cassette into the drive of the calculator until it seats.
 - c. Enter the following key sequence:
(5)(0)(0)(ENTER)(3)(0)(ENTER)(0)(gold key)(LOAD)
 - d. When the cassette stops, enter:
(8)(0)(ENTER)(3)(ENTER)(0)(+)(gold key)(LOAD)
 - e. When the cassette stops, enter:
(3)(2)(ENTER)(1)(0)(0)(ENTER)(3)(+)(gold key)(LOAD)
 - f. When the cassette stops, enter:
(REWIND)
3. Now, set the RECORD tab on the original program cassette to the left position to protect it during this process.
4. Remove the new cassette from the calculator and insert the original.
 - a. With the original cassette in place, enter:
(0)(ENTER)(0)(LOAD)
 - b. When the cassette stops, remove it and insert the new one.
Now enter: (RECORD)
 - c. Remove the new cassette when stopped, insert the original and enter: (0)(ENTER)(X)(LOAD)
where X will be 1 through 20.

- d. Repeat Step c. for the remaining files. There will be 21 files total that are copied (0-20).
 - e. When stopped, remove the original, insert the new cassette, and enter: (REWIND).
5. Now that the programs are copied, they should be verified. To do this, first set the RECORD tabs of both cassettes to the left (protected) position.
6. Do the following steps (a. and b.) for files (X) 0 through 16:
- a. Insert the original cassette and enter:
(0) (ENTER) (X) (LOAD)
 - b. When stopped, remove the original cassette, insert the new copy and enter:
(gold key) (REWIND)
- This will verify each file. If no error occurs, no message is printed. If an error does occur, a message will be printed. If you find an error, confirm it by trying to verify the same file again. If it is still bad, go back to Step 4 and rewrite the new cassette. If it is still bad, try another cassette.
7. When finished, you have another exact duplicate of the original program cassette. However, no data is transferred. It will be necessary to run the Initialize Parameters program when the new cassette is used.
8. Remember to push the RECORD tab back to the right (no protection) before using it.

APPENDIX E

TEST ROUTINES

APPENDIX E

TEST ROUTINES

These routines are located on a separate tape entitled TEST RTN's. These routines exercise the scalers and sample charger without the clutter of the applications programs. Comments have been added to provide the technician with a guide to how each step functions.

FILE	0		This file reads each digit of each scaler. It prints
TYPE	0		the decimal number of all 8 bits on the input port but
USED	45		only the lower four bits represent the scaler digit.
MAX	500		Does not initiate a count cycle.
0000	NOP		
0001	FIX	0	Whole numbers only
0003	1		
0004	+@-		
0005	DATA	2	Low = True
0007	9		Bring lines (0)0 (PMF) and (0)3 (Print) low
0008	WBYTE	2	Output it to scalers & timer
0010	5		
0011	STO	B	Counter to 5, also points to storage registers
0012	9		which are not used in this routine
0013	STO	G	Counter to 9, end point
0014	8		Release line (0)0 (PMF) keep line (0)3 low (Print)
0015	WBYTE	2	Output to Scaler
0017	FOR	B+G	For B = 5 to 9 (5 scalers)
0018	6		
0019	STO	C	Set up counter for # of digits in each scaler (6)
0020	1		
0021	STO	H	
0022	+@-		Start at 6 & decrement counter (-1) each time
0023	STO	D	
0024	FOR	C+HD	
0025	RBYTE	2	Read input port
0027	PRINT		Print it
0028	1		Bring line (0)1 (Print Advance) low while keeping
0029	0		line (0)8 low
0030	WBYTE	2	Send to Scalers (causes scaler to put next digit on line)
0032	8		Release Print Advance
0033	WBYTE	2	Out it
0035	NEXT	C	Read next digit (6 total)
0036	PRNTα		
0038	LINE		Print a space (line) between scalers
0039	ENDα		
0040	NEXT	B	Read next scaler (5 total)
0041	0		
0042	WBYTE	2	Release all lines
0044	END		

Printout of Scaler Digits

(A Pulser can be used to Drive Scalers)

8
9
0
0
4
4 = 890044 on timer

0
1
2
0
8
2 = 12082 on radon scaler

2
0
0
0
0
5
0 = 200050 on Pu scaler

1
1
0
1
0
0 = 110100 on alpha scaler

1
0
1
0
1
1 = 101011 on beta scaler

FILE	1		This file resets the timer and scalers; waits until
TYPE	0		counting done (preset goes high); then reads the
USED	148		timer and scalers and prints the data.
MAX	500		
0000	NOP		
0001	FIX	0	No decimals
0003	1		
0004	+÷-		
0005	DATA	2	Low = True
0007	4		
0008	WBYTE	2	Bring reset-low
0010	0		
0011	WBYTE	2	Release it, this causes the start of the counting cycle
0013	PAUSE		
0014	PAUSE		Wait, some scalers take 1/6 sec. to
0015	PAUSE		bring preset high and start counting.
0016	PAUSE		
0017	PAUSE		
0018	FAUSE		
0019	LBL		
----	01		
0021	RBYTE	2	Read input port
0023	1		
0024	6		
0025	AND	2	Mask for line (I) 4, preset
0027	IF 0		Done counting?
0028	GOTO	L02	Yes
0030	GOTO	L01	No, loop here till done
0032	LBL		
----	02		
0034	9		Bring PMF and Print low
0035	WBYTE	2	
0037	5		Set up counters for # of scalers, also point
0038	STO	B	to storage registers (i.e., time stored in Reg. 5)
0039	9		
0040	STO	G	
0041	8		
0042	WBYTE	2	Release PMF, keep Print low
0044	FOR	B→G	for 5-9 (data stored in Reg's 5-9)
0045	6		
0046	STO	C	Read 6 digits
0047	1		
0048	STO	H	
0049	+÷-		
0050	STO	D	Decrement counter each time through

File 1, Cont'd

0051	CLEAR		Clear temp registers (stack) at start of each scaler
0052	FOR	C+HD	
0053	1		Multiply by 10 going in to move digit over one place
0054	0		before each read. Highest digit read first (saves in
0055	*		register X).
0056	RBYTE	2	Read input port.
0058	1		
0059	5		Logically 'and' with 15 to mask off all except
0060	AND	2	lower 4 bits
0062	+		Add to Y and save in X
0063	1		
0064	0		
0065	WBYTE	2	Keep Print low - bring Print Adv low
0067	ROLL↓		Pop stack - gets rid of last entry (step 65)
0068	8		
0069	WBYTE	2	Release Prnt Adv - points to next digit
0071	ROLL↓		Pop stack
0072	NEXT	C	Get next digit
0073	STO I	B	Store scaler quantity in reg pointed to by B.
0075	NEXT	B	Get next scaler.
0076	0		
0077	WBYTE	2	Release all lines.
0079	NOP		
0080	NOP		
0081	FIX	0	
0083	RCL	R009	Print results,
0085	PRNTα		
0087	B		
0088	E		
0089	T		
0090	A		
0091	=		
0092			
0093	PRINT		
0094	ENDα		
0095	RCL	R008	
0097	PRNTα		
0099	A		
0100	L		
0101	P		
0102	H		
0103	A		
0104	=		
0105			
0106	PRINT		
0107	ENDα		

File 1, Cont'd

```
0108 RCL      R007
0110 PRNTα
0112 P
0113 U
0114 2
0115 3
0116 9
0117 =
0118
0119 PRINT
0120 ENDα
0121 RCL      R006
0123 PRNTα
0125 R
0126 A
0127 D
0128 0
0129 N
0130 =
0131
0132 PRINT
0133 ENDα
0134 RCL      R005
0136 PRNTα
0138 T
0139 I
0140 M
0141 E
0142 =
0143
0144 PRINT
0145 ENDα
0146 STOP
0147 END
```

XX

```
BETA=      293
ALPHA=     619
PU239=      64
RADON=      93
TIME=     100
```

Printout of Results of File 1

FILE 2
 TYPE 0
 USED 142
 MAX 500

```

0000 NOP
0001 FIX 0
0003 1
0004 +÷-
0005 DATA 2
0007 GOSUB L02
0009 RCL R009
0011 STO R004
0013 RCL R008
0015 STO R003
0017 RCL R007
0019 STO R002
0021 RCL R006
0023 STO R001
0025 RCL R005
0027 GOSUB L04
0029 LBL
---- 01
0031 GOSUB L02
0033 CFG 1
0034 RCL R005
0036 RCL R000
0038 GOSUB L03
0040 RCL R006
0042 RCL R001
0044 GOSUB L03
0046 RCL R007
0048 RCL R002
0050 GOSUB L03
0052 RCL R008
0054 RCL R003
0056 GOSUB L03
0058 RCL R009
0060 RCL R004
0062 GOSUB L03
0064 IF SFG 1
0065 GOSUB L04
0067 GOTO L01
  
```

This file reads the timer & scalars, prints the results, then re-reads them until stopped, comparing the first read to subsequent reads, only printing when the new readout is different. Use this to find a skipped or missing digit when problem is intermittent. May be a result of noise on Print Advance line.

Read scalars
 Move data to lowered number registers and save

Print output of scalars 1st time through

Re-read scalars
 Clear Flag 1
 Move new data into X
 Move X into Y and get original data
 Compare

If any scaler output does not read as first
 print the data
 Do again; forever

File 2, Cont'd.

```
0069 LBL
----- 02
0071 9
0072 WBYTE 2
0074 5
0075 STO B
0076 9
0077 STO G
0078 8
0079 WBYTE 2
0081 FOR B+G
0082 6
0083 STO C
0084 1
0085 STO H
0086 +*-
0087 STO D
0088 CLEAR
0089 FOR C+HD
0090 1
0091 0
0092 *
0093 RBYTE 2
0095 1
0096 5
0097 AND 2
0099 +
0100 1
0101 0
0102 WBYTE 2
0104 ROLL↓
0105 8
0106 WBYTE 2
0108 ROLL↓
0109 NEXT C
0110 STO I B
0112 NEXT B
0113 0
0114 WBYTE 2
0116 RETURN
```


File 2, Cont'd.

```
0117 LBL
---- 03
0119 IF X=Y
0120 RETURN
0121 SFG      1
0122 RETURN
0123 LBL
---- 04
0125 RCL      R009
0127 PRINT
0128 RCL      R008
0130 PRINT
0131 RCL      R007
0133 PRINT
0134 RCL      R006
0136 PRINT
0137 RCL      R005
0139 PRINT
0140 RETURN
0141 END
```

FILE	3	This file reads a planchette number and prints it
TYPE	0	
USED	39	
MAX	500	

0000	CLEAR		Clear temp registers (stack)
0001	FIX	0	No decimal
0003	1		
0004	+÷-		
0005	DATA	2	Low = true
0007	3		
0008	2		
0009	WBYTE	2	Set line (0) 5 low - puts high order digit to input
0011	RBYTE	2	Read it
0013	1		
0014	5		
0015	AND	2	Mask off all except lower 4 bits
0017	1		
0018	0		
0019	*		Multiply it by 10
0020	ENTER↑		Save it
0021	6		
0022	4		
0023	WBYTE	2	Set line (0) 6 low and return (0) 5 high. Puts L0 to input.
0025	ROLL↓		Replace 64, above, with H0 digit
0026	RBYTE	2	Read L0 digit
0028	1		
0029	5		
0030	AND	2	Mask off upper 4 bits
0032	+		Add to H.O.
0033	PRINT		Print planchette number
0034	0		
0035	WBYTE	2	Return all lines high
0037	STOP		
0038	END		

XX

9	<u>Printout of planchette numbers</u>
10	
11	
12	
13	
14	

FILE 4
 TYPE 0
 USED 31
 MAX 500

This file causes the changer to advance to the next planchette. Prints 'done' after a 'changer done' pulse received from the changer.

```

0000 1
0001 +@-
0002 DATA 2 Low = True
0004 1
0005 6
0006 WBYTE 2 Bring line (0)4 low = change command
0008 0
0009 WBYTE 2 Return it to high
0011 LBL
---- 01
0013 RBYTE 2 Read input port
0015 3
0016 2
0017 AND 2 Mask all except line (I)5
0019 IF 0 = done?
0020 GOTO L01 No. Loop until reset & enable pulse received
0022 PRNTα from changer
0024 D Print done
0025 0
0026 N
0027 E
0028 ENDα
0029 STOP
0030 END

```

FILE	5
TYPE	0
USED	53
MAX	500

This file advances the changer one position, reads the planchette, and prints it. It is a combination of File 3 and File 4.

```

0000 +*-
0001 DATA      2
0003 1
0004 6
0005 WBYTE      2
0007 0
0008 WBYTE      2
0010 LBL
---- 01
0012 RBYTE      2
0014 3
0015 2
0016 AND        2
0018 IF 0
0019 GOTO      L01
0021 3
0022 2
0023 WBYTE      2
0025 RBYTE      2
0027 1
0028 5
0029 AND        2
0031 1
0032 0
0033 *
0034 ENTER↑
0035 6
0036 4
0037 WBYTE      2
0039 ROLL↓
0040 RBYTE      2
0042 1
0043 5
0044 AND        2
0046 +
0047 PRINT
0048 0
0049 WBYTE      2
0051 STOP
0052 END

```

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