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**Automated Data Handling of
Uranium Analyses for the NURE Program**

University of California

LOS ALAMOS SCIENTIFIC LABORATORY

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AUTOMATED DATA HANDLING OF URANIUM ANALYSES FOR THE NURE PROGRAM

by

Stanley T. Kosiewicz

ABSTRACT

Data acquisition and processing for uranium analyses by the pellet fluorometric method are automated. Upon command from a dedicated minicomputer voltage signals are processed. Then, concentration data are printed on paper and also placed directly on a magnetic tape cassette. Comparisons of more than 500 calculations done with a desk-top calculator and those done by the automated system show excellent agreement. Benefits of the automated system include decreased errors and savings in time and labor.

INTRODUCTION

Since 1975, the Los Alamos Scientific Laboratory (LASL) has been participating in the National Uranium Resources Evaluation (NURE) Program to assess potential uranium resources of the nation. LASL's area of responsibility has been the Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) of the states of New Mexico, Colorado, Wyoming, Montana, and Alaska. LASL uses the pellet fluorometric method for the determination of uranium.¹ About 38 000 samples per year are being processed by this method. Considerable time and labor are expended in the manual processing of the analytical data for these samples. Also, additional effort is required to check the accuracy of the data.

The data acquisition and processing of these uranium analyses have been automated by interfacing a dedicated minicomputer with a Galvanek-Morrison fluorometer via a controllable digital voltmeter (DVM). The voltage signal generated by a Jarrell Ash fluorometer is sampled by a Fluke DVM

upon command from a Tektronix 4051 minicomputer; operator instructions are provided by the computer on a viewing screen. After blanks, controls, standards, and sample pellets are read, the computer performs a least squares calculation to make a concentration curve. The uranium concentrations of all pellets read are then tested against all rejection, precision, and diagnostic criteria in the current water analysis laboratory guidelines.² Subsequently, the concentrations and diagnostics (if any) are printed using a Texas Instruments 733 terminal. If a set of samples has not been rejected, the sample identifications and concentrations are transferred directly to a magnetic tape cassette, and they are available for any additional processing desired.

EQUIPMENT

The following items, shown in Fig. 1, were used to automate the data acquisition and processing.

*Fig. 1
Equipment used for automated data acquisition and processing*

- (1) Fluorometer. A Jarrell Ash 26-000 fluorometer was used with the meter replaced by a DVM. Positive output was taken from pin 2 of the DVM, while negative output was taken from pin 10. The fluorometer DVM reads in millivolts.
- (2) Digital Voltmeter. The signal from the fluorometer is transmitted to a Fluke 8500A DVM equipped with an optional IEEE 488 interface. Two DVMs are connected to the minicomputer. The DVMs are remotely controlled through an address of 1 or 2. The instruments are operated in a dc volts mode with a maximum range of 312.5 mV. This range will never be exceeded under any conditions to be encountered in trace uranium analyses of natural waters.
- (3) Calculating Minicomputer. The signal from the Fluke DVM is processed by a Tektronix 4051 graphics terminal equipped with an RS 232 optional interface. Total memory of the computer is 16k bytes. The computer uses graphic display for asking questions of the technician, and also displays technician responses entered from the keyboard (Fig. 2). The computer program is written in BASIC language and is stored on a magnetic tape cassette (MDC 900A). This terminal commands the Fluke DVM to sample and subsequently send the fluorometer signal to the terminal for processing into concentration data. The data are then sent to a Texas Instruments 733 terminal, which is used merely as a controllable typewriter and tape recorder.
- (4) Hard Copy Terminal. A Texas Instruments 733 ASR terminal is used to print the concentrations and also to record them on a magnetic tape cassette. It is remotely controlled through an address of 40. The concentrations are first printed (Fig. 3), and then, only acceptable data that are within established analytical guide lines are recorded upon command from the 4051 terminal. Communication between the TI 733 and the Tektronix 4051 is via the RS 232 interface. In addition, data from the 733 terminal can be sent to the

```

ENTER SAMPLE NUMBER
1-1-1-1-1
1-1-1-1-1 THIS SAMPLE IS CONCENTRATED 1 FOR YES, 0 FOR NO.
0
LOAD FIRST PELLETT FOR 339299 HIT RETURN WHEN READY TO READ
*****FLUKEOMETER SCALE WAS USED 1.01 OR 1.111111
1.01
33.729
LOAD SECOND PELLETT FOR 339299 RETURN WHEN READY TO READ
33.729
DO YOU WANT TO REPEAT THIS SAMPLE?
SAMPLE = 339.99
TO REPEAT TYPE 1, TYPE 0 TO CONTINUE.

```

Fig. 2

Computer commands to operator

```

TODAY'S DATE IS 1-1-79
BLANK AX = 0.080 PPB
1 PPB CONTROL = 0.51 PPB
50 PPB STD = 0.0 PPB

SAMPLE = 0.1 1 PPB = 0.11
PELLET 1 = 0.0 PELLET 2 = 0.126
CONCENTRATE NEEDED***

SAMPLE = 0.1 1 PPB = 0.12
PELLET 1 = 0.0 PELLET 2 = 0.000

SAMPLE = 0.1 1 PPB = 0.005
PELLET 1 = 0.0 PELLET 2 = 0.217
CONCENTRATE NEEDED***

SAMPLE = 0.1 1 PPB = 1.155
PELLET 1 = 0.0 PELLET 2 = 0.026
SAMPLE REJECTED***

SAMPLE = 0.0 1 PPB = 1.130
PELLET 1 = 1.0 PELLET 2 = 1.248

SAMPLE = 134000 1 PPB = 15.04
PELLET 1 = 1.0 PELLET 2 = 7.75
TO BE REPEATED BY P = 2****

```

Fig. 3

Computer concentrations printed at TI terminal.

LASL Central Computing Facility (CCF) via a telephone acoustic coupler for additional processing.

5. Cost. Total cost of the system, exclusive of the fluorometer, is roughly \$17,500.

COMPUTER PROGRAM

Introduction

The program was written in BASIC language as required by the Tektronix 4951 terminal. It was not written to achieve maximum computer efficiency, but rather to be simple and interpretable by qualified laboratory personnel. Consequently, the philosophy followed was a 'top-down' structure. Virtually all statements necessary to execute a particular step or function are lumped close together in the text of the program. Control statements issued by the 4951 to either the Fluke DVM or the TI terminal are not standard BASIC commands, but can be interpreted or changed after reading the Fluke and TI instruction manuals.^{8,9}

Table I lists all variables that appear in the program with their usage. Those variables that start as millivolt readings undergo transformation during program execution and exit as concentrations in ppb uranium. The program is listed in the Appendix.

Explanation of Program Statements

Line numbers 100 and 120 are dimension statements that allow a maximum of two blanks, two 1-ppb controls, two 10-ppb standards, and 6 samples (in duplicate) to be processed.

TABLE I
VARIABLES AND THEIR MEANINGS

Variables	Usage
A1	Flags for rejection criteria
A2	Flag for rejection of data set
A\$	Operator name
B1	Blank pellet readings
B5	Average blank reading
B9	Intercept from least squares calculation
B\$	Dummy variable
D	ppb U used for least squares calculation
D5	Allows readings to be repeated if desired
D\$, E\$	Assigned A or B if sample is ≤ 0.2 ppb, or ≤ 0.02 for a concentrate
H5	Allows additional pellet set to be read
F\$, G\$, H\$	Used to read and write alphabetic character on sample ID
I1	Sample identification
I, J, K, N	Looping index
M	DVM address; equals 1 or 2
M9	Slope of least squares calculation
P	Number of samples to be read
R1	First pellet of each sample
R2	Second pellet of each sample
R3	Range of readings for each sample
R8	Average of readings for each sample
S	1 ppb control readings
S6	Average of 1-ppb controls
S9, T9, U9, V9	Used for least squares calculation
T	10-ppb standard readings
T6	Average of 10-ppb standards
U1	Flags for concentrates
X1	Fluorometer scale setting

The statements in lines 130 to 250 are used for the initial run on a given day for a specific operator. Lines 150 to 170 cause the message of line 160 to flash on the terminal screen to get operator attention.

Lines 260 to 310 are used to initialize the given variables.

Line 320 is the first line used for reading the blanks. At line 360, B\$ is a dummy variable; entering any character from the keyboard allows program execution to continue. Lines 370 and 380 call the Fluke DVM at an address of 1 or 2 as specified by the operator. The command string "VROF2J," means

volts dc (V), 312.5 mV range (R0), slow filter (F2), suppress line feed as required by the 4051 (J), and execute the command string (.). The string "?"; means execute the command string and trigger (?) and suppress the carriage return (;). Line 390 assigns the fluorometer voltage signal at the DVM to the variable B1(N), which is then converted from volts to millivolts. Lines 410 and 420 set D(1) and D(2) = 0, while C(1) and C(2) are the fluorometer signals for the blanks. These are later used for the least squares calculation at lines 1330 to 1510. In line 440 the TI 733 is addressed by the @40: to print the blank reading. The next line adds the two blank readings

into B5, which is later used to get the average blank reading if the blanks are not repeated. For the conditional statement in line 500, 1 is tested because there is lower probability for it to be entered wrong than for a 0 or an O to be interchanged. Line 520 pages (erases) the screen.

The 1-ppb controls are similarly read through statements 530 to 700.

The 10-ppb standards are read by statements 710 to 890. Since the 10-ppb standards are used in the least squares calculations, C(3) and C(4) are filled with the signals received for the two 10-ppb standards.

From lines 900 to 1320, the sample voltages are read after the sample identification [I1(J)] is entered from the keyboard. Lines 930, 940, and lines 1000 and 2700 allow a sample ID with an alphabetic character to be input and output, e.g., 123456E. The flag for concentrates [U1(J)] is then entered as is the fluorometer scale (X1) used. For the 0.1 scale the readings are multiplied by 10, and for the 1 scale by 100, since the blanks and standards are always read on the 0.01 fluorometer scale.

A standard least squares calculation is performed using the blanks and the 10-ppb standards for data points. This calculation is done in lines 1330 to 1510. As written, it accepts a maximum of four points. Line 1530 marks the first occasion where millivolts are converted to ppb uranium.

Lines 1544 and 1548 are used to prevent a field overflow from occurring when the blank is being printed (line 1550). This "protection" feature is necessary because an occasional operator error (e.g., forgetting to load a pellet) will produce an abnormally large number, which will cause an overflow when the computer attempts to print it. When this happens, the program "crashes" and terminates execution. When the blank either exceeds 5 ppb or is less than -5 ppb, the average is not printed. However, diagnostics are still printed. Lines 1674 and 1678 perform the same function with the same limits for the 1-ppb controls. Lines 1784 and 1788 "protect" the 10-ppb standard with a lower limit of 5 ppb and an upper limit of 15 ppb. For the samples, lines 2344 and 2348 use an upper limit of 500 ppb and a lower limit of -5 ppb.

From lines 1570 to 1860 the blanks, controls, and 10-ppb standards are checked against current rejection criteria.² When any of the criteria are exceeded,

a message is printed at the TI terminal, and the variable A2 is set equal to 1 to prevent any data from being recorded on the magnetic tape (see line 2530).

Lines 1870 to 2260 calculate ppb uranium for individual sample pellets [R1(J) and R2(J)], their range [R3(J)], and the sample average [R8(J)]. The concentrations are then checked against current criteria, and flags [A1(J)] are set to indicate whether any criteria are exceeded. After statement 2270, the flags have the following meanings:

- (1) A1(J) = 0 good sample, no criteria exceeded
- (2) A1(J) = 1 sample needs to be concentrated
- (3) A1(J) = 2 sample is rejected and must be repeated
- (4) A1(J) = 3 sample is to be repeated by Group P-2

Lines 2270 to 2520 check whether concentrate calculations are required [when U1(K) = 1]; perform them if necessary; print the average sample ppb uranium; print the ppb uranium for the individual pellets, and any diagnostics indicated by the A1(K) flags.

Statement 2530 checks whether A2 = 1, which indicates that the sample set has been rejected. When a set is rejected, no data are transferred to the magnetic tape of the TI terminal. Statements 2540 to 2740 cause acceptable data to be recorded. Statement 2690 turns the recorder on when A1(K) = 0. Statement 2730 turns the recorder off.

Lines 2580 to 2598 check whether a sample is a concentrate, and subsequently, whether a pellet is less than 0.02 ppb (the limit of detection for concentrates); if so, an A is attached to the pellet concentration and the concentration is set equal to 0.02 ppb. When a concentrate's pellet is greater than 0.02 ppb a B is attached to the concentration. The As and Bs are used by LASL Group S-1 as flags.

Lines 2610 to 2685 perform a similar function for samples that are not concentrates. For these samples, the limit of detection is 0.2 ppb. When a pellet is ≤ 0.2 ppb, its concentration is set equal to 0.2 ppb and an A is output on the magnetic tape. Otherwise, a B is output with the concentration.

Lines 2750 to 2780 allow the operator to read another pellet set without reentering the date and operator name.

Lines 2790 to 2810 merely tell the operator "Good-bye."

CONCLUSIONS

A continuing comparison of field water samples is being made using the computer generated data against those obtained using a Hewlett-Packard 9815A desk-top calculator. Comparisons made on more than 500 samples so far demonstrate excellent agreement between the two methods. Figure 4 shows a comparison of uranium concentrations (60 samples) done with the desk calculator vs those obtained by the computer. The barely visible dashed lines in the figure are 95% confidence limits.

The automated data acquisition and processing system decreases labor, saves time, and eliminates manual errors in computation. Manual keypunch operations previously required to transmit data to LASL Group S-1 via the CCF are eliminated resulting in large additional time and labor savings.

Finally, sample throughput may also increase since a technician knows immediately whether a sample or set of samples must be repeated. Satisfaction of operators appears to have increased because of the smoothness and simplicity with which they interact with the system and the immediate feedback they receive from it.

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$$Y = A + B \cdot X$$

$$A = -0.00205473987124$$

$$B = 1.00474490206$$

$$R\text{-SQUARE} = 0.99826345692$$

$$\text{RES ERROR} = 0.00752178122445$$

$$\text{MAX}(\text{ABS}(\text{RESIDUAL})) = 0.242160397184$$

Fig. 4.
Comparison of Hewlett-Packard vs computer
calculation.

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4. "Silent 700 Electronic Data Terminals. Model 733 ASR/LSR Operating Instructions," Texas Instruments Inc., Houston, TX 77001 (September 1977).
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APPENDIX
NURE1 COMPUTER PROGRAM
(LASL Identification LP-1024)

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100 DIM B1(2),S(2),T(2),I1(6),R1(6),C(4),D(4),R3(6),R8(6),A1(6),R2(6)
110 PAGE
120 DIM U1(6)
130 PRINT "GGGGGPellet FLUOROMETER PROGRAMGGGGG"
140 PRINT "VERSION 1"
150 FOR N=1 TO 20
160 PRINT "PLEASE REPORT ANY PROBLEMS TO BILLK"
170 NEXT N
180 PRINT "J"
190 PAGE
200 PRINT @32,26:0
210 PRINT "WHAT IS YOUR NAME PLEASE?"
220 INPUT A$
230 PRINT "THANK YOU. ";A$
240 PRINT "WHAT DAY IS TODAY? PLEASE USE THIS FORM 9/30/78."
250 INPUT C$
260 LET H5=0
270 LET B5=0
280 PRINT "WHICH DVM DO YOU WANT TO USE, 1 OR 2?"
300 INPUT M
310 LET A2=0
320 REM READ BLANK PELLETS
330 FOR N=1 TO 2
340 D5=0
350 PRINT "LOAD BLANK PELLET. HIT RETURN WHEN READY TO READ."
360 INPUT B$
370 PRINT @M:"UR0F2J,"
380 PRINT @M:"?";
390 INPUT @M:B1(N)
400 B1(N)=1000*B1(N)
410 C(N)=B1(N)
420 D(N)=0
430 PRINT B1(N)
440 PRINT @40:B1(N),"J"
450 B5=B5+B1(N)
460 NEXT N
470 PRINT "DO YOU WANT TO REPEAT THE BLANKS?"
480 PRINT "TO REPEAT TYPE 1.TYPE 0 TO CONTINUE."
490 INPUT D5
500 IF D5=1 THEN 330
510 B5=B5/2
520 PAGE
530 REM READ 1PPB CONTROLS
540 S6=0
545 FOR N=1 TO 2
550 D5=0
560 PRINT "LOAD 1PPB CONTROL. HIT RETURN WHEN READY TO READ."
570 INPUT B$
580 PRINT @M:"UR0F2J,"
590 PRINT @M:"?";
600 INPUT @M:S(N)
610 S(N)=1000*S(N)
620 PRINT S(N)
630 PRINT @40:S(N),"J"
640 S6=S6+S(N)
650 NEXT N
660 PRINT "DO YOU WANT TO REPEAT THE 1PPB CONTROLS?"
670 PRINT "TO REPEAT TYPE 1.TYPE 0 TO CONTINUE."
680 INPUT D5

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690 IF D5=1 THEN 540
700 PAGE
710 REM READ 10PPB STANDARDS
720 T6=0
725 FOR N=1 TO 2
730 D5=0
740 PRINT "LOAD 10PPB STD.HIT RETURN WHEN READY TO READ."
750 INPUT B$
760 PRINT @M:"UR0F2J,"
770 PRINT @M:"?";
780 INPUT @M:T(N)
790 T(N)=1000*T(N)
800 PRINT T(N)
810 PRINT @40:T(N),"J"
820 C(N+2)=T(N)
830 T6=T6+T(N)
840 NEXT N
850 PRINT "DO YOU WANT TO REPEAT THE 10PPB STDS?"
860 PRINT "TO REPEAT TYPE 1.TYPE 0 TO CONTINUE."
870 INPUT D5
880 IF D5=1 THEN 720
890 PAGE
900 PRINT "HOW MANY SAMPLES?"
910 INPUT P
920 REM READ SAMPLES
930 F$=" "
940 G$=" "
950 FOR J=1 TO P
960 D5=0
970 PRINT "ENTER SAMPLE NUMBER"
980 PRINT "          BBBBBBB"
990 INPUT I1(J),H$
1000 G$=REP(H$,J,1)
1005 PRINT "PLEASE MAKE SURE THERE IS A SPACE OR LETTER AFTER SAMPLE ID"
1010 PRINT "IS THIS SAMPLE A CONCENTRATE? 1 FOR YES, 0 FOR NO."
1020 INPUT U1(J)
1030 PRI "LOAD FIRST PELLET FOR ";I1(J);" HIT RETURN WHEN READY TO READ"
1040 INPUT B$
1050 PRINT @M:"UR0F2J,"
1060 PRINT @M:"?";
1070 INPUT @M:R1(J)
1080 X1=0.01
1090 PRINT "*****WHAT FLUOROMETER SCALE WAS USED? .01 OR .1 OR 1?****"
1100 INPUT X1
1102 IF X1<>1 THEN 1110
1104 R1(J)=100*R1(J)
1106 GO TO 1130
1110 IF X1<>0.1 THEN 1130
1120 R1(J)=10*R1(J)
1130 R1(J)=1000*R1(J)
1140 PRINT R1(J)
1150 PRINT @40:I1(J),R1(J),"J"
1160 PRINT "LOAD SECOND PELLET FOR ";I1(J);" RETURN WHEN READY TO READ"
1170 INPUT B$
1180 PRINT @M:"UR0F2J,"
1190 PRINT @M:"?";
1200 INPUT @M:R2(J)
1202 IF X1<>1 THEN 1210
1204 R2(J)=100*R2(J)
1206 GO TO 1230
1210 IF X1<>0.1 THEN 1230
1220 R2(J)=10*R2(J)
1230 R2(J)=1000*R2(J)
1240 PRINT R2(J)
1250 PRINT @40:I1(J),R2(J),"J"

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1260 PRINT "DO YOU WANT TO REPEAT THIS SAMPLE?"
1270 PRINT "SAMPLE= ";I1(J)
1280 PRINT "TO REPEAT TYPE 1,TYPE 0 TO CONTINUE."
1290 INPUT D5
1300 IF D5=1 THEN 960
1310 PAGE
1320 NEXT J
1330 REM LST SQRS CALCULATION
1340 REM C IS EQUIV TO MU,D TO PPB
1350 FOR N=3 TO 4
1360 D(N)=10
1370 NEXT N
1380 LET S9=0
1390 LET T9=0
1400 LET U9=0
1410 LET V9=0
1420 FOR I=1 TO 4
1430 U9=C(I)*2+U9
1440 V9=C(I)*D(I)+U9
1450 S9=C(I)+S9
1460 T9=D(I)+T9
1470 NEXT I
1480 REM M9 IS THE SLOPE,B9 IS THE INTERCEPT.
1490 B9=(T9*U9-S9*U9)/(4*U9-S9*S9)
1500 M9=(4*U9-S9*T9)/(4*U9-S9*S9)
1510 PRINT M9,B9
1520 REM TEST BLNKS & STDS FOR REJECTION
1530 B5=B5*M9+B9
1540 PRINT @40: "          TODAY'S DATE IS ";C$;"J"
1544 IF B5>5 THEN 1570
1548 IF B5<-5 THEN 1570
1550 PRINT @40: USING 1560: "          BLANK AV.= ";B5;" PPBJ"
1560 IMAGE FA,10.4D,FA
1570 FOR H=1 TO 2
1580 B1(H)=B1(H)*M9+B9
1590 IF B1(H)>-.6 THEN 1620
1600 LET A2=1
1610 PRINT @40: "          GGGREJECT SET. BLANK READING <-.6PPBJ"
1620 IF B1(H)<0.6 THEN 1650
1630 LET A2=1
1640 PRINT @40: "          GGGREJECT SET. BLANK READING > .6PPBJ"
1650 NEXT H
1660 REM TEST 1PPB CONTROLS
1670 S6=S6/2*M9+B9
1674 IF S6>5 THEN 1700
1678 IF S6<-5 THEN 1700
1680 PRINT @40: USING 1690: "          1PPB CONTROL= ";S6;" PPBJ"
1690 IMAGE FA,10.2D,FA
1692 S(1)=S(1)*M9+B9
1694 S(2)=S(2)*M9+B9
1696 PRI @40: US1 1698: "          PELLET 1= ";S(1);" PELLET 2= ";S(2);"J"
1698 IMAGE FA,10.2D,FA,10.2D,FA
1700 REM ASSUMES LONG TERM CONTROL=1.1PPB.
1710 IF S6<1.7 THEN 1740
1720 LET A2=1
1730 PRINT @40: "          GGGREJECT SET. 1PPB CONTROL IS >1.7PPBGGGJ"
1740 IF S6>0.5 THEN 1770
1750 LET A2=1
1760 PRINT @40: "          GGGREJECT SET. 1PPB CONTROL IS <0.5PPBGGGJ"
1770 REM TEST 10PPB STDS
1780 T6=T6/2*M9+B9
1784 IF T6>15 THEN 1810
1788 IF T6<5 THEN 1810
1790 PRINT @40: USING 1800: "          10PPB STD= ";T6;" PPBJ"

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1800 IMAGE FA,2D,2D,FA
1810 IF T6<11.2 THEN 1840
1820 LET A2=1
1830 PRINT @40:"      GGGREJECT SET. 10PPB STD IS >11.2PPBGGGJ"
1840 IF T6>8.8 THEN 1870
1850 LET A2=1
1860 PRINT @40:"      GGGREJECT SET. 10PPB STD IS <8.8PPBGGGJ"
1870 REM CALC SAMPLE PPB AND CHECK AGAINST CRITERIA
1880 PAGE
1890 PRINT @40:"JJ"
1900 FOR J=1 TO P
1910 LET A1(J)=0
1920 R1(J)=R1(J)*M9+B9
1930 R2(J)=R2(J)*M9+B9
1940 R3(J)=ABS(R1(J)-R2(J))
1950 R8(J)=(R1(J)+R2(J))/2
1960 IF R1(J)>0.2 THEN 2000
1970 IF R2(J)>0.2 THEN 2000
1980 A1(J)=1
1990 GO TO 2260
2000 IF R8(J)>3.1 THEN 2040
2010 IF R3(J)<1.2 THEN 2260
2020 A1(J)=2
2030 GO TO 2260
2040 IF R8(J)>7.1 THEN 2080
2050 IF R3(J)<1.6 THEN 2260
2060 A1(J)=2
2070 GO TO 2260
2080 IF R8(J)>10.1 THEN 2120
2090 IF R3(J)<2.4 THEN 2260
2100 A1(J)=2
2110 GO TO 2260
2120 IF R8(J)>20.1 THEN 2160
2130 IF R3(J)<3.5 THEN 2260
2140 A1(J)=3
2150 GO TO 2260
2160 IF R8(J)>30.1 THEN 2200
2170 IF R3(J)<4.5 THEN 2260
2180 A1(J)=3
2190 GO TO 2260
2200 IF R3(J)<6 THEN 2230
2210 A1(J)=3
2220 GO TO 2260
2230 IF R8(J)>40 THEN 2250
2240 GO TO 2260
2250 A1(J)=3
2260 NEXT J
2270 REM PRINT SAMPLE PPB AT 733 TERMINAL
2280 FOR K=1 TO P
2290 IF U1(K)<>1 THEN 2340
2300 A1(K)=0
2310 R8(K)=R8(K)/10
2320 R1(K)=R1(K)/10
2330 R2(K)=R2(K)/10
2340 PRINT I1(K),R8(K),R1(K),R2(K)
2344 IF R8(K)>500 THEN 2390
2348 IF R8(K)<-5 THEN 2390
2350 PRINT @40: USING 2360:"      SAMPLE= ";I1(K);"      U PPB= ";R8(K);"J"
2360 IMAGE FA,6D,FA,3D,2D,FA
2370 PRI @40: USI 2390:"      PELLET 1= ";R1(K);" PELLET 2= ";R2(K);"J"
2380 IMAGE FA,3D,2D,FA,3D,2D,FA
2390 IF U1(K)=0 THEN 2410
2400 PRINT @40:"      ***THIS SAMPLE WAS CONCENTRATED***JJ"
2410 IF A1(K)>0 THEN 2430
2420 GO TO 2510

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2430 IF A1(K)>1 THEN 2460
2440 PRINT @40:"          CONCENTRATE NEEDED***JJ"
2450 GO TO 2520
2460 IF A1(K)>2 THEN 2490
2470 PRINT @40:"          SAMPLE REJECTED***JJ"
2480 GO TO 2520
2490 PRINT @40:"          TO BE REPEATED BY P-2***JJ"
2500 GO TO 2520
2510 PRINT @40:"          JJ"
2520 NEXT K
2530 IF A2=1 THEN 2750
2540 FOR K=1 TO P
2550 REM ONLY WHEN A1(K)=0 DOES DATA TRANSFER TO 733'S MAG TAPE
2560 IF A1(K)>0 THEN 2740
2570 IF U1(K)=0 THEN 2610
2580 D$="B"
2590 E$="B"
2592 IF R1(K)>0.02 THEN 2596
2593 R1(K)=0.02
2594 D$="A"
2596 IF R2(K)>0.02 THEN 2600
2597 R2(K)=0.02
2598 E$="A"
2600 GO TO 2690
2610 IF R1(K)<=0.2 THEN 2640
2620 D$="B"
2630 GO TO 2650
2640 D$="A"
2645 R1(K)=0.2
2650 IF R2(K)<=0.2 THEN 2680
2660 E$="B"
2670 GO TO 2690
2680 E$="A"
2685 R2(K)=0.2
2690 PRINT @40:"B"
2700 F$=SEG(G$,K,1)
2710 PRINT @40: USING 2720:I1(K),F$,R1(K),D$,R2(K),E$,C$
2720 IMAGE 1X,6D,1A,2X,7D,2D,1A,7D,2D,1A,2X,FA,"          JJ"
2730 PRINT @40:"I"
2740 NEXT K
2750 PRINT "DO YOU WANT TO READ ANOTHER TRAY, ";A$
2760 PRINT "TYPE 1 FOR YES, 0 FOR NO."
2770 INPUT H5
2780 IF H5=1 THEN 260
2790 PRINT @40:"GGGGG"
2800 PRINT "GOOD BYE, ";A$
2810 PRINT @40:"GGGGG"
2820 END

```