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A 15 CHANNEL 2 - AND 3 - FOLD COINCIDENCE COUNTING SYSTEM FOR RADIOACTIVITY STANDARDIZATION.

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C O N T E N T S

LIST OF FIGURES

PAGE

LIST OF TABLES

SYNOPSIS

The 4π β-γ liquid scintillation coincidence counting system which is used at the National Accelerator Centre for standardizing radioisotopes, has been extended to allow for up to fifteen data points to be measured simultaneously by introducing a 15-fold coincidence unit and a 32-channel scaler into the system. A new control / data acquisition computer program has been written and its operation explained in detail. The advantages of the new system are discussed, and the activity of a ^{139}Ce source as measured by the new system and the old 3-fold system is compared.

SINOPSIS

Die 4π β-γ vloeistofsintillasie koinsidensieteller wat deur die Nasionale Versnellersentrum vir die standaardisering van radioisotope gebruik word, is uitgebrei om tot vyftien data punte gelyktydig te meet deur 'n 15-voudige koinsidensieeenheid en 'n 32-kanaal teller by die sisteem te voeg. 'n Nuwe beheer / datainsameling rekenaarprogram is geskryf en die werking daarvan word in detail verduidelik. Die voordele van die nuwe sisteem word bespreek en die aktiwiteit van 'n ^{139}Ce bron, soos gemeet deur die nuwe en die ou 3-voudige sisteme, word vergelyk.

INTRODUCTION

The 4π β-γ coincidence counting system which is used at the NAC for standardizing radioisotopes, has been upgraded. Whereas before only three data points could be measured simultaneously, and the procedure repeated five times to give a sufficient number of points for polynomial fitting purposes, the new counting system enables all 15 points to be measured concurrently, the ideal situation as pointed out by Steyn et al[1]). There are a number of advantages which this system has over the previous one:

i) Data collection is much quicker;

ii) individual point scatter is reduced (because the same average gamma count is used for all the point determinations) thus facilitating a more reliable selection of the trend of the data points;

iii) any minor systematic fault or timing problem in a particular TSCA/COINC UNIT channel will affect only a single point and not five as with the 3-fold coincidence system;

iv) reproducibility is enhanced (with respect to repeat measurements and corresponding background measurements) because the discrimination levels on the TSCAs can remain fixed once set; and

v) it will facilitate greater statistical accuracy for short-lived isotopes with half lives of the order of hours (eg. ^{123}I) because a number of sources can be counted in a relatively short period. This will ensure that the prepared samples will still have sufficiently high count rates without the need for more radioactive solution having to be dissolved in the scintillator liquid where problems with dissolving and/or adsorption might occur. There will also be less dependence on decay corrections.

15-FOLD COINCIDENCE UNIT

The electronic configuration has been expanded by allowing provision for an additional 12 TSCAs on the variable β channel side, and by replacing the previous coincidence unit with a new one. This 15-fold coincidence unit was designed and built by the NAC. A block diagram of the 4π β-γ counting system is shown in figure 1.

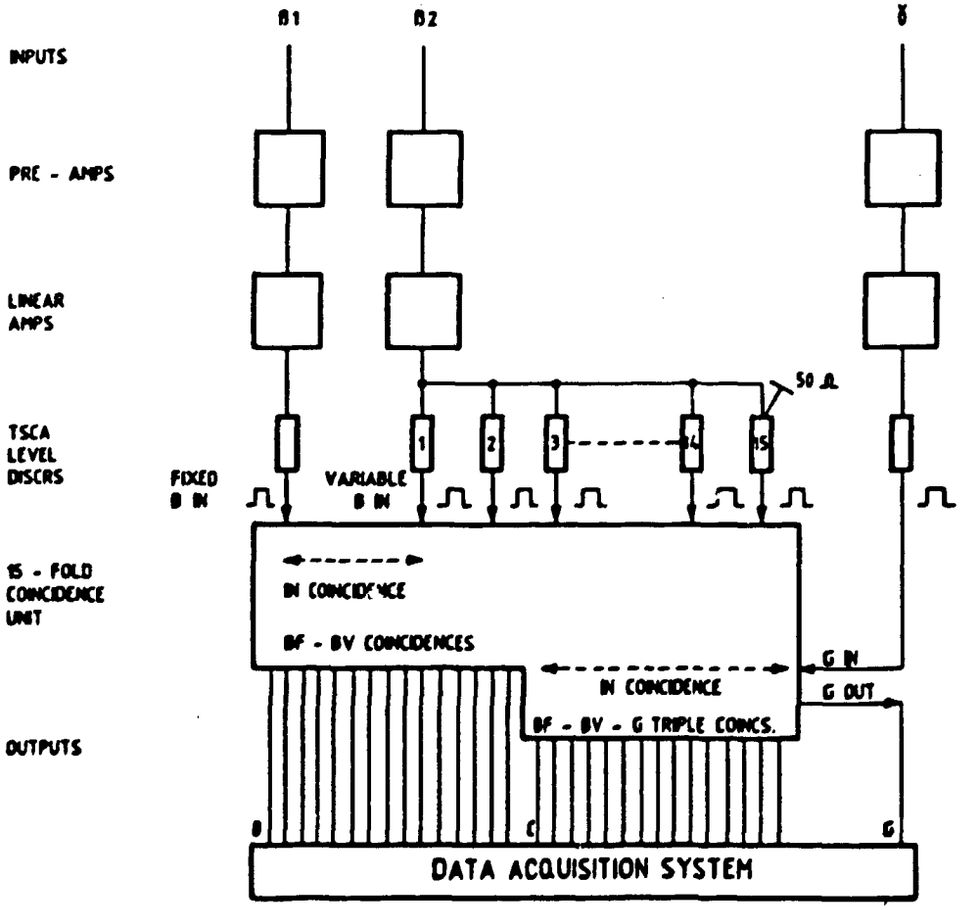


Fig. 1. Block diagram of the electronic configuration.

THE DATA ACQUISITION SYSTEM

Hardware

The previous data acquisition hardware[2]) is still in use, but the 8 x 24 bit scaler unit has been replaced with a 32-channel, 24-bit scaler.

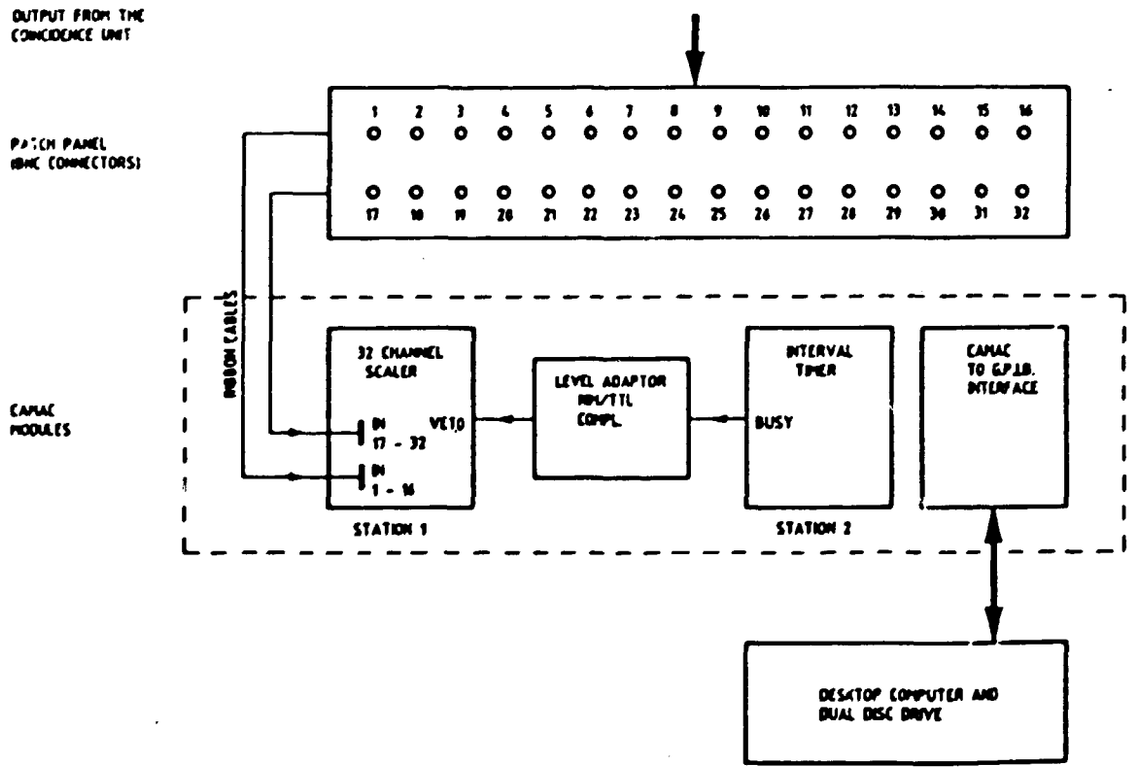


Fig. 2. Data acquisition hardware.

Figure 2 shows a block diagram of the data acquisition hardware. As can be seen, the coincidence unit output signals are interfaced to the scaler module via a specially built patch panel. The scaler will always count input signals (single ended TTL) unless it is disabled by feeding the appropriate signal level into the VETO input. This has been achieved by selecting the TTL option for the VETO input (setting a side switch on the scaler), and converting the BUSY signal from the timer (NIM standard) into a complementary TTL level. Hence the scaler will only count when the timer has been activated.

All communication between the desktop-computer and the CAMAC modules is done via a CAMAC to GPIB interface module.

Computer Programs

1. Data Acquisition Program

The data acquisition control program has been completely rewritten. Some of the computer code from the previous suite of programs[2]), such as that for controlling the programmable interval timer, has been retained. The structure of the various data files has been left unchanged as far as possible so as to minimise changes to another program which prepares the data for transfer to a mainframe computer. Details of the program and data file structures are given in the appendix.

There are two versions of the data acquisition program. The one version, program COINC, does not make use of the scaler overflow facility. Instead, if during the SOURCE counting mode any channel reaches the maximum number of counts, namely 16 777 216, that particular channel will reset itself to zero and carry on counting. All of the scaler side option switches should be OFF.

The other version, program COINC2, does make use of the overflow facility. Here the scaler side option switches must be set as follows:

LCO (Load and clear at overflow) set ON;
LOF (LAM at overflow) set ON; and
OVF (overflow) set to bit 24 ON.

A LAM (look-at-me service request) is generated as soon as at least one of the scalers arrives at half full scale, namely 8388608. All of the scalers are loaded into an internal buffer ready for readout independent of the data acquisition. Each time an overflow occurs the program reads each scaler value and adds it to its previous total. In all other respects program COINC2 is identical to COINC.

2. Program INIT initializes and formats a data disc for use with the data acquisition program.

3. Programs SCALER and SCALE2 make use of the internal TEST facility provided for checking the scaler. An increment test on all the 32 channels is performed. For this test the 24 bits of each scaler are considered as three words of 8 bits. The three words are all incremented by one. Program SCALER displays each word of each channel after every increment.

   Program SCALE2 increments each word of each channel a specified number of times before the values are read out.

Loading a Program

The disc drive must be switched on and after a short while the program disc inserted into drive 0. The required program will be loaded into memory and executed by entering the following:

```
LOAD "NAME" END LINE
RUN
```

Here "NAME" refers to the required program name. Those programs that require a data disc will prompt for a disc to be inserted into drive 1. Other inputs such as the date and time are prompted for.

USING THE DATA ACQUISITION PROGRAM

Special Function Keys

The special function keys are labelled as follows:

K1	SOURCE
K2	BACKGRD
K3	GENERAL
K4	RESOLV
K5	CORREC
K6	PRINT
K8	STOP

The function keys K1 to K4 all activate the counting system. Except for the "GENERAL" function, the input signals to the scaler must be as follows:

channels 1 to 15	B signals (ie. B1 to B15)
channels 17 to 31	C signals (ie. C1 to C15)
channel 32	G signal.

Once the counting system has been activated, the program will only respond to the function keys. Key K7 should be used to abort a run.

After loading and running program COINC2 (or COINC) and entering the date and time, the following will be displayed on the screen:

```
SELECT ANY KEY


CORREC  PRINT                STOP
SOURCE  BACKGRD  GENERAL  RESOLV
```

The choice of key is selected according to one's requirements.

SOURCE Key

This key is pressed when a source is to be counted. After entering the nuclide file name, a search is made on the data disc to ensure that the name is not being duplicated. Then the number of repeat measurements is entered, followed by the time interval. At the end of a run the program will ask whether a background measurement is required. If the reply is negative and a previous background measurement is in the computer memory, this will be used. Otherwise one has a choice of using the last background measurement stored on disc. If this is not used, then no background file is stored for that particular source measurement. In this case a message is displayed indicating that a background measurement should be made at a later stage. If a background measurement is required, then the procedure is the same as for the BACKGRD key except that no nuclide name is necessary.

BACKGRD Key

This key is pressed when a background measurement is to be made. After requesting and locating a previous nuclide file name for which a background has not yet been measured (or which needs to be re-measured), the program prompts for the number of repeats and the time interval. If this is the first background measurement for the specified file and the last source file on disc is also without a background file, then background files for all these source files inclusive will be created.

GENERAL Key

This calls a general purpose counting routine. The number of scalers to be used is specified as well as the starting channel number. After counting for the specified period, the counts corresponding to the selected channels are displayed on screen. This routine is used primarily for the determination of the correction constants.

RESOLV Key

This routine aids in the measurement of the coincidence resolving time for each of the 15 channels. Only the time interval t is prompted for. After reading the scalers, the resolving times are calculated according to the following formula:

$$\tau_R = \frac{Ct}{2BG} \times 10^6 \text{ microseconds.}$$

Here B, G and C are the 4π , γ and coincidence counts respectively.

Key K7

To ABORT any of the above runs once the counting system has been activated, the unlabelled function key K7 must be pressed. This returns the program to the selection mode.

CORREC Key

Pressing this key will cause the following to be displayed:

```
CORRECTION FILE UPDATE

OPTIONS ARE
DISPLAY OR CHANGE

B DEAD TIMES ----------------->1
SAT PULSE CORR FACTORS------->2
COINC RESOLVING TIMES-------->3
Γ DEAD TIME------------------->4
EXIT------------------------->5
?
```

When the correction constants are available, they can be entered into a correction file by selecting the appropriate option. Further computer prompts make the entry procedure self-explanatory. If a correction file is being created (rather than updated) for a specified nuclide filename and the last source file on disc is also without a correction file, then correction files for all these source files inclusive will be created. The normal procedure will be to first complete all of the source counting before creating all of the correction files in one go.

PRINT Key

Pressing this key will cause the following to be displayed:

```
                PRINT ROUTINE

PRINT DATA ------------------->1
PRINT BACKGROUND ------------->2
PRINT CONSTANTS -------------->3
PRINT NUCLIDES ON DISC ------->4
PRINT STATUS OF FILES-------->5
EXIT ------------------------->6
?
```

When options 1, 2 or 3 are selected, the program prompts for the nuclide filename. If background and/or correction files do not yet exist for the associated source file, a message indicating this will be printed. When option 5 is selected, information regarding the record no. of the last entry for each file type is printed. A prompt is then generated asking whether the status of the files of any particular nuclide filename is required.

STOP Key

Pressing this key will stop the program.

THE COUNTING SYSTEM IN OPERATION

Testing

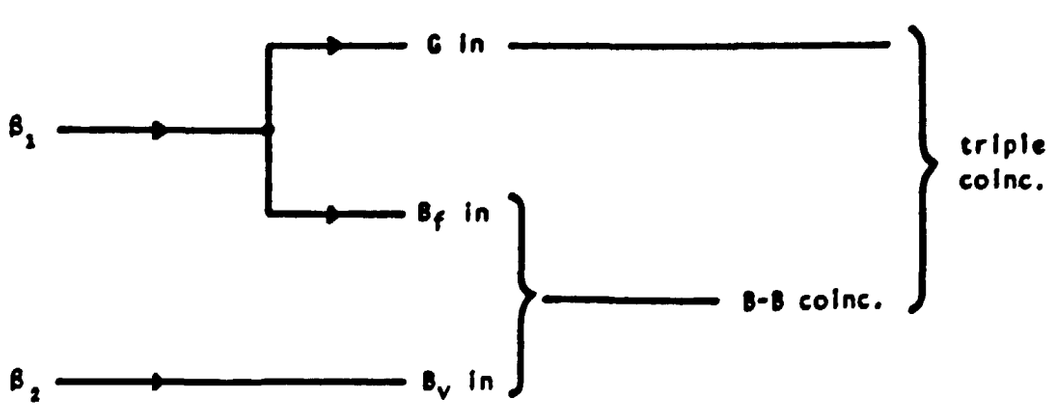
i) Pulse Generator

When these tests were carried out, only 11 TSCA modules with constant fraction discrimination were available for the variable β channel. A tail pulse generator linked to a linear amplifier provided all of the signal inputs to the TSCA modules. The count rates from the B and C outputs of the 15-fold coincidence unit were thus all expected to be exactly the same. This was indeed the case for rates up to 75000 s^{-1}. The testing of higher count rates was not considered necessary because rates well below this value are used when standardizing radioisotopes.

The overflow facility on the scaler was also thoroughly checked to ensure that no significant number of counts are lost during buffer transfer and scaler readout. The situation where the specified time period is completed during the reading of the scaler overflow values was also carefully monitored. In both cases the measured count rates were as expected.

ii) Random Pulses

Here a Ce-139 source preparation provided random pulses. The fixed B and variable B signals were fed into the coincidence unit as follows:



Here the triple coinc. and B-B coinc. count rates should be identical.

With a 0.75 V discr. level on B_f and a 1.0 V level on each of ten B_v signals, the results indicated in table I show that the system is operating successfully. The small differences between the double and triple coincidence counts are possibly due to random losses or gains as a result of relative timing effects within the coincidence unit.

time	B_f	B_v channel	B-B coinc.	triple coinc.	diff.	diff. as % of B-B coinc.
50s	1836485	1	1286380	1286423	-43	-0.0033
		2	1287681	1287692	-11	-0.0009
		3	1287814	1287833	-19	-0.0015
		4	1288746	1288771	-25	-0.0019
		5	1288759	1288697	62	0.0048
		6	1288202	1288128	74	0.0057
		7	1287141	1287200	-59	-0.0046
		8	1288325	1288264	61	0.0047
		9	1285636	1285582	54	0.0042
		10	1286231	1286260	-29	-0.0023

Table I. B-B and triple coincidence comparison.

Coincidence Resolving Times

The coincidence resolving times for the fifteen channels were determined by mixing two independent γ-pulse trains, the one feeding the 4π inputs of the coincidence circuit and the other feeding only the γ input. The RESOLV routine of the computer program was used, and the values shown in table II were obtained.

channel	resolving time (μsec)
1	0.5776 ± 0.0050
2	0.5557 ± 0.0042
3	0.5767 ± 0.0047
4	0.5754 ± 0.0046
5	0.5732 ± 0.0045
6	0.5715 ± 0.0044
7	0.5720 ± 0.0045
8	0.5758 ± 0.0046
9	0.5694 ± 0.0046
10	0.5685 ± 0.0046
11	0.5717 ± 0.0044
12	0.5685 ± 0.0043
13	0.5701 ± 0.0043
14	0.5734 ± 0.0042
15	0.5760 ± 0.0046

Table II. Coincidence resolving times as measured with the 15-fold coincidence unit.

Standardization Measurement

A Ce-139 solution was standardized with the new system by counting six sources. Three of these were also counted using the previous system for comparison purposes. The activity as measured with the new system was 1.502 ± 0.0017 MBq g^{-1} compared with 1.506 ± 0.0039 MBq g^{-1} measured with the old system. The agreement within experimental error indicates that the upgraded counting system is working reliably.

Figure 3 shows values of BG/C as a function of G/C for measurements made on the same source using each system. The counting period was the same for both measurements but the measurement using the old system was undertaken two days later. Figure 4 shows a comparison of the residuals of a second order polynomial fit to the data. A factor two reduction in scatter shows that the new system has the potential for greater precision.

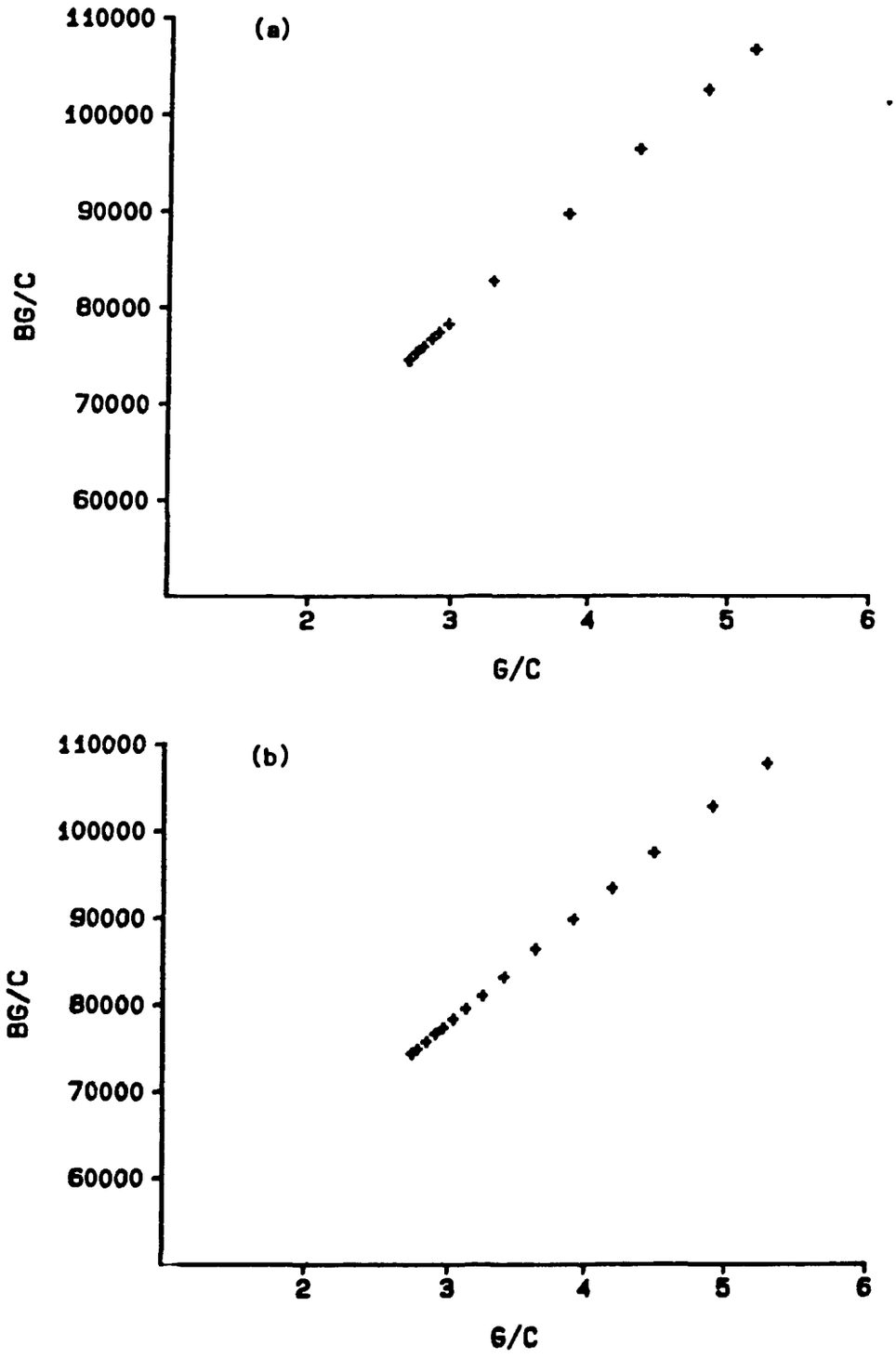


Fig.3. Values of BG/C as a function of G/C as measured by

(a) new 15-fold coincidence unit, and

(b) old 3-fold coincidence unit.

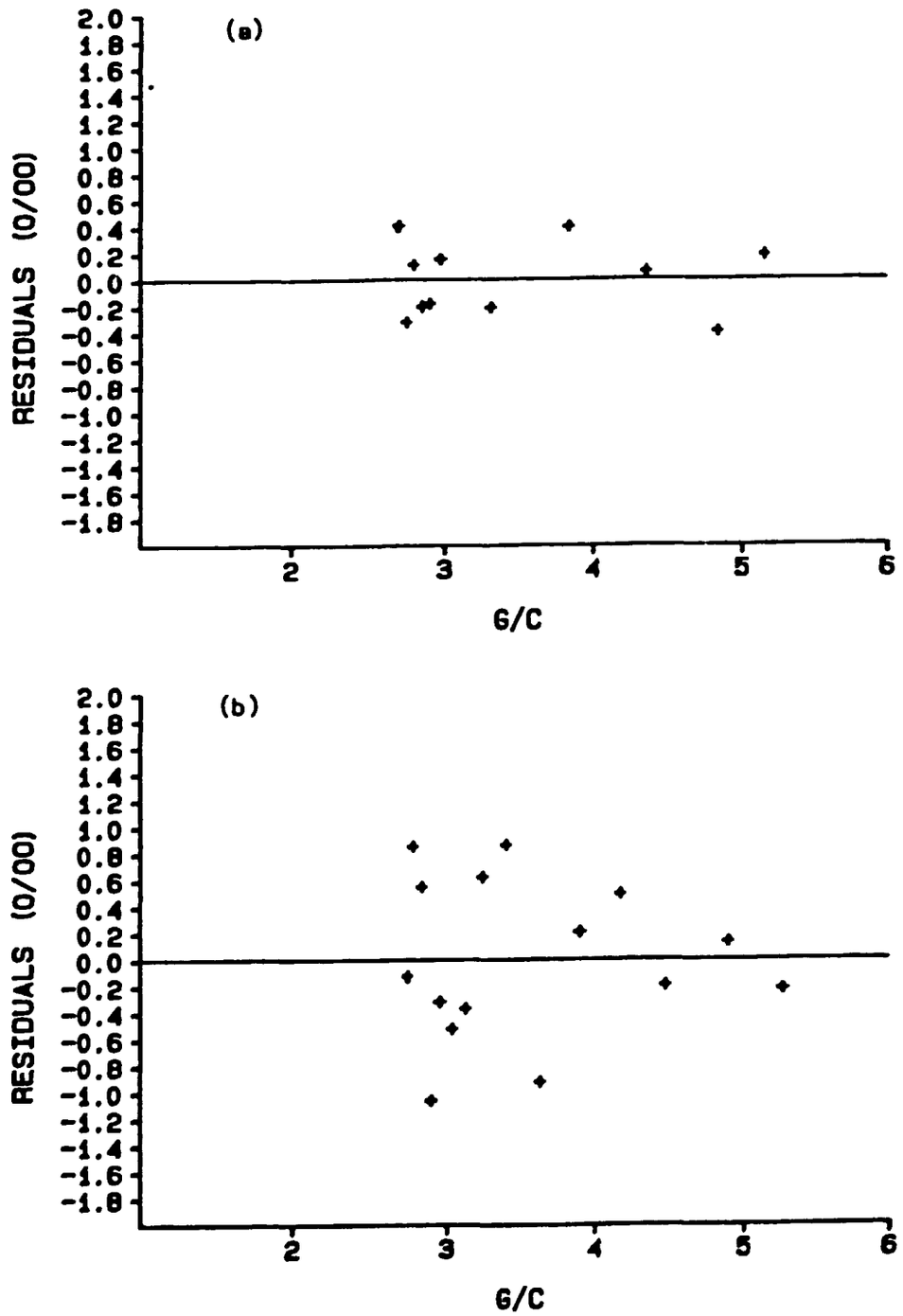


Fig. 4. Residuals of a second order polynomial fit to the data shown in figure 3 for

(a) new 15-fold coincidence unit, and
(b) old 3-fold coincidence unit.

REFERENCES

1. J Steyn, S M Botha and J C van Staden, Die Internasionale Vergelyking van Radioaktiwiteitsmetings op 'n Oplossing van ^{139}Ce (Maart 1976). NPRL Special Report FIS 90, Pretoria (1976).

2. H Gargan and H Thomas, HP-85 Desktop Computer Program for running a CAMAC Crate. NEERI Report 54792757 (1983).

ACKNOWLEDGEMENT

Thanks are due to Messrs V C Wikner and J V Pilcher for their expert advice during the design and construction of the coincidence unit and the development of the control portion of the data acquisition program respectively.

APPENDIX A

Disc File Structure

Each nuclide filename has three files associated with it, namely a SOURCE file, a BACKGROUND file and a CORRECTION file.

The nuclide filenames along with relevant information such as file positioning are stored in an index file RD-IND. This file consists of 82 records consisting of one string variable 6 characters long and 9 full precision digits.

The first record is the leader record and contains the following:

V1$	Name of the last nuclide (source file) written to disc;
N1	record number of the last nuclide on the disc;
S2(1)	last background file record number written to disc;
S2(2)	date S2(1) was stored;
S2(3)	last correction file ecord number written to disc;
S2(4)	date S2(3) was stored;
S2(5)	not used;
S2(6)	not used;
S2(7)	not used;
S2(8)	Today's date.

The next 81 records each contain the following:

N2$	Nuclide name associated with the following pointers;
P1(1)	record number of the source file;
P1(2)	record number of the background file;
P1(3)	record number of the correction file;
P1(4)	not used;
P1(5)	the number of data points (P1(5)=5 ie. 5x3 points);
P1(6)	the number of source repeats;
P1(7)	the number of background repeats;
P1(8)	the date on which the nuclide was recorded;
P1(9)	the time when the nuclide was recorded.

The layout of the other files is as follows:

Source data file "S-FILE"

There are 81 records. Each record consists of a 9 column by 15 row matrix containing the values as indicated in figure 5.

		1	2	3	4	5	6	7	8	9
repeat 0	1	B1	B2	B3	C1	C2	C3	G	T	D
	2	B4	B5	B6	C4	C5	C6	G	T	D
	3	B7	B8	B9	C7	C8	C9	G	T	D
	4	B10	B11	B12	C10	C11	C12	G	T	D
	5	B13	B14	B15	C13	C14	C15	G	T	D
repeat 1	6									
	7									
	8									
	9									
	10									
repeat 2	11									
	12									
	13									
	14									
	15									

Fig. 5. Source data matrix where

B1 to B15 are the β counts,
C1 to C15 are the coincidence counts,
G is the γ count,
T is the counting period in seconds and
D is the decay correction factor (set to 1).

Background file "B-FILE"

There are 81 records. Each record consists of an 8 column by 15 row matrix as indicated in figure 6.

		1	2	3	4	5	6	7	8
repeat 0	1	b1	b2	b3	c1	c2	c3	g	T
	2	b4	b5	b6	c4	c5	c6	g	T
	3	b7	b8	b9	c7	c8	c9	g	T
	4	b10	b11	b12	c10	c11	c12	g	T
	5	b13	b14	b15	c13	c14	c15	g	T
repeat 1	6								
	7								
	8								
	9								
	10								
repeat 2	11								
	12								
	13								
	14								
	15								

Fig. 6. Background data matrix where

b1 to b15 are the β background rates,
c1 to c15 are the coincidence background rates,
g is the γ background rate and
T is the counting period in seconds.

Correction file "C-FILE"

There are 81 records. Each record consists of three 5 x 3 matrices followed by one single number as indicated in figure 7.

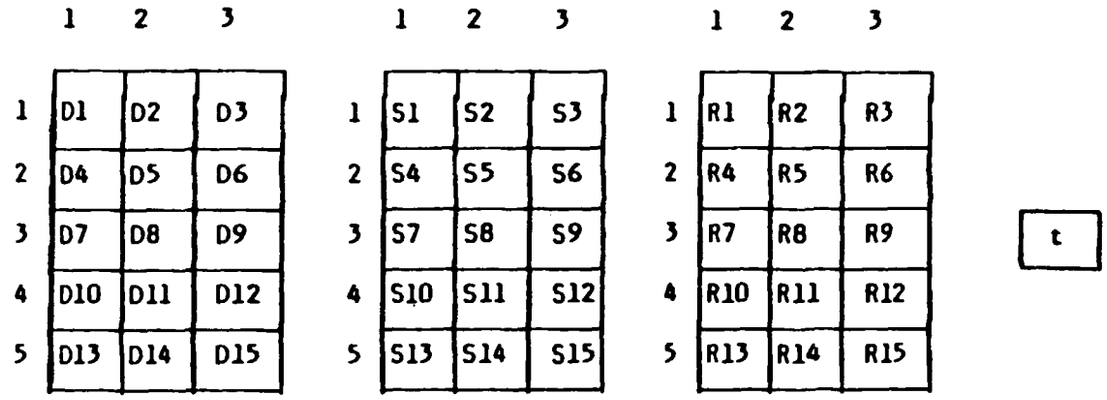


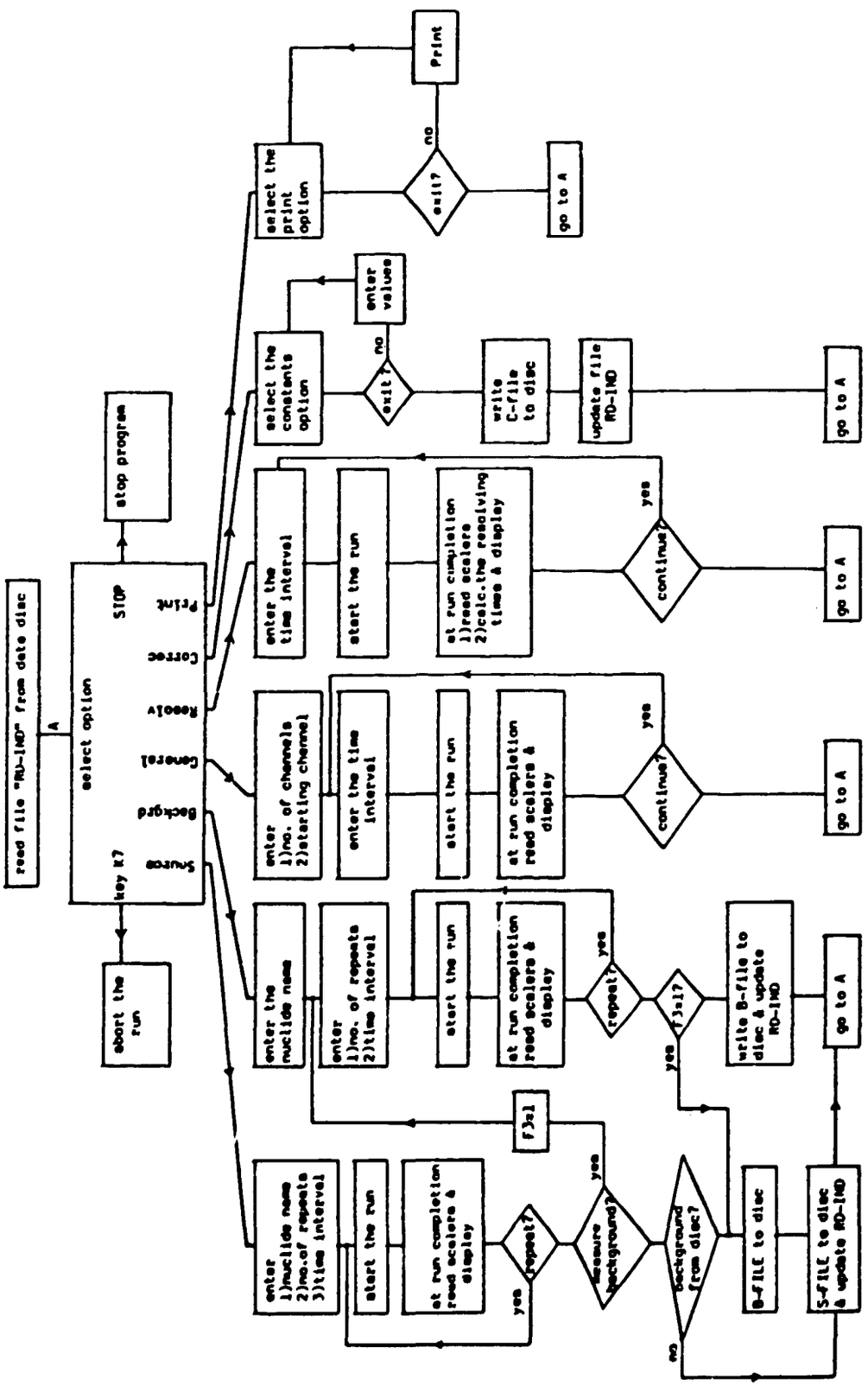
Fig. 7. Correction data matrices where

D1 to D15 are the beta dead times in micro-seconds,
S1 to S15 are the satellite pulse correction factors,
R1 to R15 are the coincidence resolving times in micro-seconds and the single number t is the gamma dead time in micro-seconds.

Program Flags

F1	=	1	Source routine
	=	2	Backgrd routine
	=	3	General routine
	=	4	Correc routine
	=	5	Print routine
	=	6	Resolv routine
F2	=	1	A new background measurement is in memory.
F3	=	1	A background measurement has been started from within the source routine.

Simplified Flowchart of the Data Acquisition Program



Computer Program Listings

1. Program COINC2

```
 10 REM ---> "COINC2.NUPROG"
 20 OPTION BASE 1
 30 DIM V1$[6],N2$[6],S2(8),P1(9
    ),T$[20],N1$[6],A1(15,9),A2(
    32)
 31 DIM A3(9),B7(5,3),S7(5,3)
 32 DIM T7(5,3),B1(15,8),B2(32)
 33 DIM B3(8),B4(15,8),Q2(9),V2$
    [6],S3(8),A5(32)
 36 F2,F3=0
 37 ENABLE KBD 33
 38 OUTPUT 701 USING "#,B" ; 10,
    0,1
 39 SEND 7 ; UNL TALK 1
 40 ON KEY# 8," STOP" GOTO 200
 45 ON KEY# 7,"" GOTO 137
 50 ON KEY# 1,"SOURCE" GOTO 1000
 60 ON KEY# 2,"BACKGRD" GOTO 400
    0
 70 ON KEY# 3," GENERAL" GOTO 50
    00
 75 ON KEY# 4," RESOLV" GOTO 600
    0
 80 ON KEY# 5,"CORREC" GOTO 7000
 90 ON KEY# 6,"PRINT" GOTO 8000
 95 CLEAR
 96 DISP "PRESS CLEAR ON THE 890
    1 GPIB    INTERFACE.THEN PRE
    SS CONT"
 97 PAUSE
110 CLEAR
111 DISP "INSERT DATA DISC INTO
    DRIVE UNIT 1 AND PRESS CONT"
114 DISP @ DISP @ DISP @ DISP "A
     REMINDER :" @ DISP "IS COIN
    C UNIT SWITCHED ON ?"
120 PAUSE
121 MAT P1=ZER
122 ASSIGN# 1 TO "RD-IND.DRIVE1"
123 READ# 1,1 ; V1$,N1,S2()
125 ASSIGN# 1 TO *
126 IF N1=81 THEN DISP "DATA DIS
    C FULL" @ BEEP @ GOTO 111
127 DISP "ENTER TODAYS DATE"
128 DISP "DD,MM,YYYY"
129 BEEP @ INPUT D5,M5,Y5
130 LET D8,S2(8)=Y5+(M5+D5*100)*
    10000
131 DISP "ENTER THE TIME IN HOUR
    S AND MINUTES"
132 DISP "HH,MM"
133 BEEP @ INPUT H5,S5
134 I5=H5*3600+S5*60
135 SETTIME I5,0
136 N9=N1
137 CLEAR
138 DISP "SELECT ANY KEY"
140 KEY LABEL
141 ABORTIO 7
142 IF N9=82 THEN DISP "DATA DIS
    C FULL.DONT USE SOURCE  OPTI
    ON."
143 IF N9=82 THEN DISP "WHEN DIS
    C IS REPLACED,STOP THE  PROG
    RAM AND PRESS RUN"
150 GOTO 150
200 DISP "PROGRAM STOPPED" @ STO
    P
220 DEF FNA(T$) = POS("YN",UPC$(
    T$))+1
300 CLEAR @ DISP "ENTER TIME PER
    IOD REQUIRED IN   SECONDS"
310 BEEP @ INPUT T1
315 IF T1<.000003814 THEN DISP "
    TIME PERIOD TOO SMALL" @ GOT
    O 300
320 IF T1<=.249954304 THEN 400
330 IF T1<1.998848 THEN 410
340 IF T1<15.99995904 THEN 420
350 IF T1<128 THEN 430
360 IF T1<1024 THEN 440
370 IF T1<8192 THEN 450
380 IF T1<65536 THEN 460
390 CLEAR @ DISP "TIME PERIOD TO
    O LARGE" @ GOTO 300
400 I1=INT(T1/.000003814) @ T1=I
    1*.000003814 @ C1=1 @ GOTO 4
    60
410 I1=INT(T1/.0000305) @ T1=I1*
    .0000305 @ C1=2 @ GOTO 460
420 I1=INT(T1/.00024414) @ T1=I1
    *.00024414 @ C1=4 @ GOTO 460
430 I1=INT(T1/.001953125) @ T1=I
    1*.001953125 @ C1=8 @ GOTO 4
    60
440 I1=INT(T1/.015625) @ T1=I1*.
    015625 @ C1=16 @ GOTO 460
450 I1=INT(T1/.125) @ T1=I1*.125
     @ C1=32 @ GOTO 460
455 I1=INT(T1) @ T1=I1 @ C1=64
460 RETURN
510 SET TIMEOUT 7;1
520 ON TIMEOUT 7 GOSUB 710
530 RESET 7
540 X1=SPOLL(701)
550 OUTPUT 701 USING "#,B" ; 35
560 OUTPUT 701 USING "#,B" ; 10,
    0,2
570 SEND 7 ; UNL TALK 1
580 OUTPUT 701 USING "#,B" ; 16,
    1,2,C1
590 SEND 7 ; UNL TALK 1
600 IF I1>=32767 THEN I1=I1-6553
    6
610 X1=BINAND(I1,-256) @ X2=BINA
    ND(I1,255)
620 X1=X1/256 @ X1=BINAND(X1,255
    )
630 OUTPUT 701 USING "#,B" ; 16,
    0,2,X2,X1
640 SEND 7 ; UNL TALK 1
650 OUTPUT 701 USING "#,B" ; 26,
    0,2
```

```
660 SEND 7 ; UNL TALK 1
670 OUTPUT 701 USING "#,B" ; 65
680 SEND 7 ; UNL TALK 1
690 ENABLE INTR 7;8
700 RETURN
710 CLEAR @ DISP "CHECK THAT THE
     CAMAC CRATE POWER IS ON , T
    HEN PRESS CONT"
720 BEEP @ PAUSE
730 RESET 7
740 ON TIMEOUT 7 GOTO 780
750 X1=SPOLL(701)
760 ON TIMEOUT 7 GOSUB 710
770 RETURN
780 PRINT "ERROR ON GPIB PROGRAM
     STOPPED"
790 BEEP @ CLEAR @ DISP "PROGRAM
     HALTED PLEASE CHECK BUS ERR
    OR" @ NORMAL @ STOP
800 STATUS 7,1 ; X1
810 IF BIT(X1,3)=0 THEN 930
815 OFF INTR 7
830 X1=SPOLL(701)
832 IF BIT(X1,6)=0 THEN 890
835 OUTPUT 701 USING "#,B" ; 64
836 SEND 7 ; UNL TALK 1
844 OUTPUT 701 USING "#,B" ; 97
846 OUTPUT 701 USING "#,B" ; 0,0
    ,24
848 SEND 7 ; UNL TALK 1
850 ENTER 701 USING "#,B" ; X1,X
    2
852 X3=SPOLL(701)
857 IF BIT(X2,1)=1 THEN 864
858 IF BIT(X2,0)=1 THEN 1800
859 PRINT X1,X2
860 GOTO 910
864 IF F1=1 THEN 1200
866 IF F1=2 THEN 4210
868 IF F1=3 THEN 5070
869 IF F1=6 THEN 5070
890 PRINT "ERROR ON GPIB"
900 BEEP @ CLEAR @ DISP "PROGRAM
     HALTED PLEASE CHECK BUS ERR
    OR" @ STOP
910 PRINT "ERROR ON CAMAC CRATE"
920 BEEP @ CLEAR @ DISP "PROGRAM
     HALTED PLEASE CHECK BUS ERR
    OR" @ STOP
930 PRINT "ERROR ON HP 85"
940 BEEP @ CLEAR @ DISP "PROGRAM
     HALTED PLEASE CHECK BUS ERR
    OR" @ STOP
1000 IF N9=82 THEN GOTO 137
1001 F1=1
1002 MAT A1=ZER
1003 CLEAR @ DISP "SOURCE ENTRY
     ROUTINE"
1005 DISP " "
1006 T$=""
1010 DISP "ENTER THE NUCLIDE NAM
     E (<=6CHR)" @ BEEP @ INPUT
     T$
1020 IF T$<>"" AND LEN(T$)<7 THE
     N 1030
1025 CLEAR @ DISP "BAD ENTRY" @
     GOTO 1010
1030 N1$=T$
1040 ASSIGN# 1 TO "RD-IND.DRIVE1
     "
1042 READ# 1,1 ; V1$,N1,S2()
1044 FOR I=2 TO N1+1
1046 READ# 1,I ; N2$,P1()
1048 IF N1$=N2$ THEN DISP @ DISP
      "NAME ALREADY EXISTS ON DI
     SC.TRY AGAIN" @ GOTO 1005
1050 NEXT I
1052 N1=N1+1
1054 P1(3)=0
1056 CLEAR
1058 DISP "NO. OF REPEATS(0,1 OR
      2)"
1060 BEEP @ INPUT R1
1065 IF R1=0 OR R1=1 OR R1=2 THE
     N 1070
1067 CLEAR @ DISP "BAD ENTRY" @
     GOTO 1050
1070 P1(6)=R1+1
1080 CLEAR
1085 N=1
1090 GOSUB 300
1100 CLEAR @ MAT A2=ZER
1105 DISP "SOURCE REPEAT";N-1
1106 DISP
1110 DISP "TIME INTERVAL=";T1;"(
     Y OR N)"
1120 BEEP @ INPUT T$
1130 IF T$="Y" THEN 1155
1140 IF T$="N" THEN GOTO 1090
1150 CLEAR @ DISP "BAD ENTRY" @
     GOTO 1110
1155 GOSUB 510
1157 ON INTR 7 GOTO 800
1160 CLEAR
1162 PEN 1 @ GCLEAR
1164 SCALE 0,10,0,10
1166 MOVE 1,9
1168 LABEL "TIME INTERVAL = "&VA
     L$(T1)
1170 MOVE 0,7
1172 LABEL "**********************
     ************"
1174 MOVE 1,6
1176 LABEL "   COUNTING IN PROGR
     ESS"
1178 MOVE 0,5
1180 LABEL "**********************
     ************"
1191 MOVE 1,1
1192 W1=TIME
```

```
1193 WAIT 10000
1194 W2=INT(TIME-W1)
1195 LABEL VAL$(W2) @ LABEL "
      SECONDS ELAPSED"
1196 WAIT 9150
1197 PEN -1 @ LABEL VAL$(W2)
1198 WAIT 1 @ PEN 1
1199 GOTO 1194
1200 ALPHA
1201 OUTPUT 701 USING "#,B" ; 10
     ,0,2
1210 SEND 7 ; UNL TALK 1
1220 CLEAR
1230 SEND 7 ; LISTEN 1
1240 OUTPUT 701 USING "#,B" ; 16
     ,0,1,32,31,0
1250 SEND 7 ; UNL TALK 1
1260 SEND 7 ; LISTEN 1
1270 OUTPUT 701 USING "#,B" ; 10
     0
1290 DISP "SOURCE"
1300 FOR J1=1 TO 32
1310 OUTPUT 701 USING "#,B" ; 2,
     0,1
1320 ENTER 701 USING "#,B" ; A,B
     ,C,D
1330 LET A5(J1)=A+256*B+65536*C
1335 A2(J1)=A2(J1)+A5(J1)
1340 DISP "SCALER";J1;"=";A2(J1)
1350 NEXT J1
1355 A=T1
1356 DISP " "
1357 DISP "TIME PERIOD=";A;"SECO
     NDS"
1358 PRINT @ PRINT "NUCLIDE->";N
     1$
1359 PRINT "SOURCE  REPEAT ";N-1
1360 FOR J1=1 TO 32
1370 PRINT USING "K,X,DD,X,K,X,8
     D" ; "SCALER",J1,"=",A2(J1)
1380 NEXT J1
1385 PRINT " "
1386 PRINT "TIME PERIOD=";A;"SEC
     ONDS"
1390 M,M'=1
1400 FOR J1=1 TO 3
1410 A3(J1)=A2(M)
1420 A3(J1+3)=A2(M+16)
1430 M=M+1
1440 NEXT J1
1450 A3(7)=A2(32)
1455 A3(8)=A
1457 A3(9)=1
1460 X1=N*5-5+M1
1470 FOR J1=1 TO 9
1480 A1(X1,J1)=A3(J1)
1490 NEXT J1
1500 M1=M1+1
1510 IF M1<=5 THEN GOTO 1400
1520 N=N+1
1530 IF N<=P1(6) THEN GOTO 1100
1540 DISP "MEASURE BACKGROUND(Y
     OR N)"
1550 BEEP @ INPUT T$
1560 IF T$="Y" THEN 1566
1562 IF T$="N" THEN 1574
1564 CLEAR @ DISP "BAD ENTRY" @
     GOTO 1540
1566 F3=1
1568 GOTO 4000
1570 F3=0
1572 GOTO 1596
1574 IF F2=1 THEN P1(7)=Q1 @ GOT
     O 1596
1576 IF S2(1)=0 THEN GOTO 1606
1578 DISP "LAST BACKGROUND RECOR
     DED ON : "
1579 DISP USING "DDCDDC4D" ; S2(
     2)
1580 DISP "DO YOU WANT TO USE IT
     (Y OR N)"
1582 BEEP @ INPUT T$
1584 IF T$="Y" THEN 1590
1586 IF T$="N" THEN 1606
1588 CLEAR @ DISP "BAD ENTRY" @
     GOTO 1578
1590 DISP @ DISP "PLEASE WAIT" @
      ASSIGN# 1 TO "BFILE.DRIVE1
     "
1591 READ# 1,S2(1) ; B1(,)
1592 ASSIGN# 1 TO *
1593 ASSIGN# 1 TO "RD-IND.DRIVE1
     "
1594 READ# 1,S2(1)+1 ; V2$,Q2()
1595 ASSIGN# 1 TO * @ P1(7)=Q2(7
     )
1596 S2(1)=N1 @ S2(2)=D8 @ S2(8)
     =D8 @ P1(2)=N1
1598 ASSIGN# 1 TO "BFILE.DRIVE1"
1600 PRINT# 1,N1 ; B1(,)
1602 ASSIGN# 1 TO *
1604 CLEAR @ GOTO 1610
1606 CLEAR @ DISP "NO BACKGROUND
      STORED" @ P1(2)=0 @ P1(7)=
     1
1608 DISP @ DISP "REMEMBER TO ME
     ASURE THE BACKGROUND LATER"
1610 V1$=N1$ @ N2$=N1$
1630 P1(1)=N1 @ P1(5)=5 @ P1(8)=
     D8
1635 DISP @ DISP "DATA STORE IN
     PROGRESS"
1640 GOSUB 3800
1650 ASSIGN# 1 TO "SFILE.DRIVE1"
1660 PRINT# 1,P1(1) ; A1(,)
1670 ASSIGN# 1 TO *
1680 ASSIGN# 1 TO "RD-IND.DRIVE1
     "
1690 PRINT# 1,1 ; V1$,N1,S2()
1700 PRINT# 1,N1+1 ; N2$,P1()
```

```
1710 ASSIGN# 1 TO *
1716 N9=N1
1720 GOTO 137
1800 SEND 7 ; LISTEN 1
1805 OUTPUT 701 USING "#,B" ; 10
     ,0,1
1806 SEND 7 ; UNL TALK 1
1810 OUTPUT 701 USING "#,B" ; 16
     ,0,1,128,31,0
1830 SEND 7 ; LISTEN 1
1840 OUTPUT 701 USING "#,B" ; 10
     0
1850 PRINT "SOURCE COUNTS AT OVE
     RFLOW"
1860 FOR J1=1 TO 32
1870 OUTPUT 701 USING "#,B" ; 2,
     0,1
1880 ENTER 701 USING "#,B" ; A,B
     ,C,D
1890 LET A5(J1)=A+256*B+65536*C
1900 A2(J1)=A2(J1)+A5(J1)
1910 PRINT "SCALER";J1;"=";A2(J1
     )
1920 NEXT J1
1921 SEND 7 ; UNL TALK 1
1922 OUTPUT 701 USING "#,B" ; 65
1923 SEND 7 ; UNL TALK 1
1925 ENABLE INTR 7;8
1930 ON INTR 7 GOTO 800
1940 GOTO 1197
3800 LET H5=INT(TIME/3600)
3810 LET S5=INT((TIME-H5*3600)/6
     0)
3820 P1(9)=H5+S5/100
3830 RETURN
4000 F1=2
4005 F2=1
4006 MAT B1=ZER
4007 CLEAR @ DISP "BACKGROUND EN
     TRY ROUTINE"
4010 IF F3=1 THEN GOTO 4030
4011 DISP
4012 T$=""
4013 DISP "ENTER THE NUCLIDE NAM
     E" @ BEEP @ INPUT T$
4014 IF T$<>"" AND LEN(T$)<7 THE
     N 4016
4015 CLEAR @ DISP "BAD ENTRY" @
     GOTO 4013
4016 N1$=T$
4017 ASSIGN# 1 TO "RD-IND.DRIVE1
     "
4018 READ# 1,1 ; V1$,N1,S2()
4019 FOR I=2 TO N1+1
4020 READ# 1,I ; N2$,P1()
4021 IF N1$=N2$ THEN 4029
4022 NEXT I
4023 CLEAR
4024 ASSIGN# 1 TO *
4025 DISP "NUCLIDE->";N1$;" NOT
     FOUND"
4026 DISP "DO YOU WISH TO TRY AG
     AIN(Y OR N)" @ BEEP @ INPUT
      T$
4027 ON FNA(T$) GOTO 4028,4010,1
     37
4028 CLEAR @ DISP "BAD ENTRY" @
     GOTO 4025
4029 ASSIGN# 1 TO *
4030 DISP "NO. OF BACKGROUND REP
     EATS(0,1 OR 2)"
4035 BEEP @ INPUT R1
4040 IF R1=0 OR R1=1 OR R1=2 THE
     N 4060
4050 CLEAR @ DISP "BAD ENTRY" @
     GOTO 4020
4060 P1(7)=R1+1
4062 Q1=R1+1
4080 CLEAR
4090 N=1
4100 GOSUB 300
4110 CLEAR
4120 DISP "BACKGROUND REPEAT";N-
     1
4130 DISP
4140 DISP "TIME INTERVAL=";T1;"(
     Y OR N)"
4150 BEEP @ INPUT T$
4152 IF T$="Y" THEN 4160
4154 IF T$="N" THEN GOTO 4100
4156 CLEAR @ DISP "BAD ENTRY" @
     GOTO 4140
4160 CLEAR @ DISP "TIME INTERVAL
     =";T1
4170 DISP
4180 DISP "**********************
     ***********"
4182 DISP
4184 DISP "COUNTING IN PROGRESS.
     PLEASE WAIT"
4186 DISP
4188 DISP "**********************
     ***********"
4190 GOSUB 510
4195 ON INTR 7 GOTO 800
4200 GOTO 4200
4210 OUTPUT 701 USING "#,B" ; 10
     ,0,2
4220 SEND 7 ; UNL TALK 1
4230 CLEAR
4240 SEND 7 ; LISTEN 1
4250 OUTPUT 701 USING "#,B" ; 16
     ,0,1,32,31,0
4260 SEND 7 ; UNL TALK 1
4270 SEND 7 ; LISTEN 1
4280 OUTPUT 701 USING "#,B" ; 10
     0
4290 DISP "BACKGROUND"
4300 FOR J1=1 TO 32
4310 OUTPUT 701 USING "#,B" ; 2,
     0,1
```

```
4320 ENTER 701 USING "#,B" ; A,B
     ,C,D
4330 LET B2(J1)=A+256*B+65536*C
4340 DISP "SCALER";J1;"=";B2(J1)
4350 NEXT J1
4360 A=T1
4370 DISP
4380 DISP "TIME PERIOD=";A;"SECO
     NDS"
4390 PRINT @ PRINT "NUCLIDE->";N
     1$
4395 PRINT "BACKGROUND REPEAT ";
     N-1
4400 FOR J1=1 TO 32
4410 PRINT USING "K,X,DD,X,K,X,8
     D" ; "SCALER",J1,"=",B2(J1)
4420 NEXT J1
4430 PRINT
4440 PRINT "TIME PERIOD=";A;"SEC
     ONDS"
4450 M,M1=1
4455 FOR J1=1 TO 3
4460 B3(J1)=B2(M)/A
4465 B3(J1+3)=B2(M+16)/A
4470 M=M+1
4475 NEXT J1
4480 B3(7)=B2(32)/A
4485 B3(8)=A
4490 X1=N*5-5+M1
4500 FOR J1=1 TO 8
4510 B1(X1,J1)=B3(J1)
4520 NEXT J1
4530 M1=M1+1
4540 IF M1<=5 THEN GOTO 4455
4550 N=N+1
4560 IF N<=P1(7) THEN GOTO 4110
4565 IF F3=1 THEN GOTO 1570
4570 CLEAR @ DISP "DATA STORE IN
      PROGRESS"
4580 ASSIGN# 1 TO "BFILE.DRIVE1"
4600 IF P1(2)<>0 THEN GOTO 4650
4610 FOR I=P1(1) TO N1
4620 PRINT# 1,I ; B1(,)
4630 NEXT I
4640 GOTO 4660
4650 PRINT# 1,P1(2) ; B1(,)
4660 ASSIGN# 1 TO *
4670 N7=P1(1)
4680 ASSIGN# 1 TO "RD-IND.DRIVE1
     "
4690 IF P1(2)<>0 THEN GOTO 4760
4700 FOR I=N7+1 TO N1+1
4710 READ# 1,I ; N2$,P1()
4720 P1(2)=I-1
4725 P1(7)=R1+1
4730 PRINT# 1,I ; N2$,P1()
4740 NEXT I
4750 GOTO 4770
4760 PRINT# 1,P1(1)+1 ; N2$,P1()
4770 IF S2(1)<N1 THEN GOTO 4790
4780 GOTO 4810
4790 S2(1)=N1
4800 S2(2)=D8 @ S2(8)=D8
4810 PRINT# 1,1 ; V1$,N1,S2()
4820 ASSIGN# 1 TO *
4830 GOTO 137
5000 F1=3
5001 CLEAR @ DISP "GENERAL PURPO
     SE ROUTINE"
5002 DISP " "
5005 DISP "NO. OF CHANNELS BEING
      USED"
5006 INPUT Z6
5007 Z7=Z6-1
5008 DISP "STARTING CHANNEL"
5009 INPUT Z8
5010 Z9=32+Z8-1
5011 Y9=Z8
5012 Z8=Y9
5020 ON INTR 7 GOTO 800
5030 GOSUB 300
5047 DISP " "
5048 DISP "**********************
     ***********"
5049 DISP " "
5050 DISP "COUNTING IN PROGRESS.
     PLEASE WAIT"
5051 DISP " "
5052 DISP "**********************
     ***********"
5055 GOSUB 510
5060 GOTO 5060
5070 OUTPUT 701 USING "#,B" ; 10
     ,0,2
5080 SEND 7 ; UNL TALK 1
5090 CLEAR
5100 A=T1
5110 DISP "TIME PERIOD =";A;"SEC
     ONDS"
5112 DISP " "
5115 SEND 7 ; LISTEN 1
5116 OUTPUT 701 USING "#,B" ; 16
     ,0,1,Z9,Z7,0
5117 SEND 7 ; UNL TALK 1
5120 SEND 7 ; LISTEN 1
5125 OUTPUT 701 USING "#,B" ; 10
     0
5130 FOR J1=1 TO Z6
5132 OUTPUT 701 USING "#,B" ; 2,
     0,1
5134 ENTER 701 USING "#,B" ; A,B
     ,C,D
5160 LET A=A+256*B+65536*C
5170 IF F1=3 THEN DISP "SCALER";
     Z8;"=";A
5172 IF F1=6 THEN B2(Z8)=A
5175 Z8=Z8+1
5177 IF Z8>32 THEN Z8=1
5180 NEXT J1
5182 IF F1=6 THEN GOTO 6040
```

```
5185 DISP " "
5190 DISP "CONTINUE (Y OR N)"
5200 INPUT T$
5210 ON FNA(T$) GOTO 5220,5012,1
     37
5220 DISP "BAD ENTRY" @ GOTO 519
     0
6000 F1=6
6020 Z6=32
6022 Z7=31
6024 Z9=32
6026 Z8=1
6030 GOTO 5020
6040 FOR Z8=1 TO 15
6045 IF B2(Z8)=0 THEN B2(Z8)=1
6050 B2(Z8)=B2(Z8+16)*T1*1000000
     /(2*B2(Z8)*B2(32))
6060 NEXT Z8
6065 DISP "COINC RESOLVING TIMES
     " @ DISP
6070 FOR Z8=1 TO 14 STEP 2
6080 DISP USING 6090 ; "CH",Z8,B
     2(Z8),"µS","CH",Z8+1,B2(Z8+
     1),"µS"
6090 IMAGE AA,2D,2X,D.4D,X,AA,X,
     AA,2D,2X,D.4D,X,AA
6100 NEXT Z8
6110 DISP USING 6120 ; "CH15",B2
     (15),"µS"
6120 IMAGE 4A,2X,D.4D,X,AA
6130 DISP @ DISP "CONTINUE(Y OR
     N)"
6140 INPUT T$
6150 ON FNA(T$) GOTO 6160,6020,1
     37
6160 DISP "BAD ENTRY" @ GOTO 613
     0
7000 F1=4
7005 CLEAR
7010 DISP "CONSTANTS EDIT ROUTIN
     E"
7050 GOTO 8140
7060 IF P1(3)<>0 THEN GOTO 7070
7061 MAT B7=ZER
7062 MAT S7=ZER
7063 MAT T7=ZER
7064 G7=0
7065 GOTO 7105
7070 CLEAR @ DISP "DATA LOAD IN
     PROGRESS"
7080 ASSIGN# 1 TO "CFILE.DRIVE1"
7090 READ# 1,P1(3) ; B7(,),S7(,)
     ,T7(,),G7
7100 ASSIGN# 1 TO *
7105 CLEAR
7106 IF P1(3)<>0 THEN DISP "CORR
     ECTION FILE UPDATE" @ DISP
7107 IF P1(3)=0 THEN DISP "NEW C
     ORRECTION FILE " @ DISP
7110 DISP "OPTIONS ARE"
7120 DISP "DISPLAY OR CHANGE"
7130 DISP
7140 DISP "6 DEAD TIMES --------
     -------->1"
7150 DISP "SAT PULSE CORR FACTOR
     S------->2"
7160 DISP "COINC RESOLVING TIMES
     -------->3"
7170 DISP "Γ DEAD TIME----------
     -------->4"
7180 DISP "EXIT----------------
     -------->5"
7190 BEEP @ INPUT R1
7200 IF R1=INT(R1) AND R1>0 AND
     R1<6 THEN 7220
7210 CLEAR @ DISP "BAD ENTRY" @
     GOTO 7110
7220 ON R1 GOTO 7230,7420,7580,7
     740,7850
7230 CLEAR
7240 DISP "6 DEADTIMES IN µSECS"
7250 DISP
7260 DISP USING 7270 ; "X","Y=1"
     ,"Y=2","Y=3"
7270 IMAGE A,8X,3A,7X,3A,7X,3A
7280 FOR I=1 TO P1(5)
7290 DISP USING 7300 ; I,B7(I,1)
     *1000000,",",B7(I,2)*100000
     0,",",B7(I,3)*1000000
7300 IMAGE D,2X,D.7D,A,D.7D,A,D.
     7D
7310 NEXT I
7320 DISP
7330 DISP "ANY CHANGES(Y OR N)"
7340 BEEP @ INPUT T$
7350 ON FNA(T$) GOTO 7360,7370,7
     105
7360 CLEAR @ DISP "BAD ENTRY" @
     GOTO 7240
7370 DISP
7380 DISP "ENTER X,Y,NEW VALUE I
     N µSECS"
7390 BEEP @ INPUT R1,R2,R3
7395 IF R1>5 OR R2>3 THEN DISP "
     SUBSCRIPT(S) INCORRECT" @ G
     OTO 7370
7400 B7(R1,R2)=R3*.000001
7410 GOTO 7230
7420 CLEAR
7430 DISP "SAT PULSE CORR FACTOR
     S"
7440 DISP
7450 DISP USING 7270 ; "X","Y=1"
     ,"Y=2","Y=3"
7460 FOR I=1 TO P1(5)
7470 DISP USING 7300 ; I,S7(I,1)
     ,",",S7(I,2),",",S7(I,3)
7480 NEXT I
7490 DISP
7500 DISP "ANY CHANGES(Y OR N)"
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```
7510 BEEP @ INPUT T$
7520 ON FNA(T$) GOTO 7530,7540,7
     105
7530 CLEAR @ DISP "BAD ENTRY" @
     GOTO 7430
7535 DISP
7540 DISP "ENTER X,Y,NEW VALUE"
7550 BEEP @ INPUT R1,R2,R3
7555 IF R1>5 OR R2>3 THEN DISP "
     SUBSCRIPT(S) INCORRECT" @ G
     OTO 7535
7560 S7(R1,R2)=R3
7570 GOTO 7420
7580 CLEAR
7590 DISP "COINC RES.TIMES IN μS
     ECS"
7600 DISP
7610 DISP USING 7270 ; "X","Y=1"
     ,"Y=2","Y=3"
7620 FOR I=1 TO P1(5)
7630 DISP USING 7300 ; I,T7(I,1)
     *1000000,",",T7(I,2)*100000
     0,",",T7(I,3)*1000000
7640 NEXT I
7650 DISP
7660 DISP "ANY CHANGES(Y OR N)"
7670 BEEP @ INPUT T$
7680 ON FNA(T$) GOTO 7690,7700,7
     105
7690 CLEAR @ DISP "BAD ENTRY" @
     GOTO 7590
7695 DISP
7700 DISP "ENTER X,Y,NEW VALUE I
     N μSECS"
7710 BEEP @ INPUT R1,R2,R3
7715 IF R1>5 OR R2>3 THEN DISP "
     SUBSCRIPT(S) INCORRECT" @ G
     OTO 7695
7720 T7(R1,R2)=R3*.000001
7730 GOTO 7580
7740 CLEAR
7750 DISP "Γ DEAD TIME"
7760 DISP G7*1000000;"μS"
7770 DISP "ANY CHANGES(Y OR N)"
7780 BEEP @ INPUT T$
7790 ON FNA(T$) GOTO 7800,7810,7
     105
7800 CLEAR @ DISP "BAD ENTRY" @
     GOTO 7750
7810 DISP "ENTER THE NEW VALUE I
     N μSECS"
7820 BEEP @ INPUT R1
7830 G7=R1*.000001
7840 GOTO 7740
7850 CLEAR @ DISP "DATA STORE IN
      PROGRESS"
7855 H9=0
7860 ASSIGN# 1 TO "CFILE.DRIVE1"
7865 IF P1(3)<>0 THEN GOTO 7902
7866 DISP @ DISP "CREATING CORRE
     CTION FILES "
7867 DISP USING 7868 ; P1(1),"TO
     ",N1
7868 IMAGE DD,X,AA,X,DD
7869 H9=1
7870 FOR I=P1(1) TO N1
7880 PRINT# 1,I ; B7(,),S7(,),T7
     (,),G7
7890 NEXT I
7900 GOTO 7904
7902 PRINT# 1,P1(3) ; B7(,),S7(,
     ),T7(,),G7
7904 ASSIGN# 1 TO *
7906 N7=P1(1)
7910 ASSIGN# 1 TO "RD-IND.DRIVE1
     "
7920 IF P1(3)<>0 THEN GOTO 7960
7930 FOR I=N7+1 TO N1+1
7935 READ# 1,I ; N2$,P1()
7940 P1(3)=I-1
7945 PRINT# 1,I ; N2$,P1()
7950 NEXT I
7955 GOTO 7970
7960 PRINT# 1,P1(1)+1 ; N2$,P1()
7970 IF S2(3)<N1 THEN GOTO 7973
7972 GOTO 7978
7973 IF H9=0 THEN GOTO 7978
7974 S2(3)=N1
7976 S2(4)=D8 @ S2(8)=D8
7978 PRINT# 1,1 ; V1$,N1,S2()
7980 ASSIGN# 1 TO *
7990 GOTO 137
8000 F1=5
8001 CLEAR
8002 IF F1=4 THEN GOTO 137
8005 DISP TAB(9);"PRINT ROUTINE"
8010 DISP " "
8020 DISP "PRINT DATA ----------
     ---------->1"
8030 DISP "PRINT BACKGROUND ----
     ---------->2"
8040 DISP "PRINT CONSTANTS -----
     ---------->3"
8050 DISP "PRINT NUCLIDES ON DIS
     C ------->4"
8055 DISP "PRINT STATUS OF FILES
     ---------->5"
8060 DISP "EXIT ----------------
     ---------->6"
8070 BEEP @ INPUT R8
8075 IF R8=6 THEN PRINT @ PRINT
8076 IF R8=6 THEN PRINT @ PRINT
     @ PRINT @ PRINT
8080 IF R8=6 THEN GOTO 137
8090 IF R8=1 OR R8=2 OR R8=3 THE
     N 8130
8095 IF R8=4 THEN 8680
8100 IF R8=5 THEN 8760
8125 CLEAR @ DISP "BAD ENTRY" @
     GOTO 8005
8130 CLEAR
```

```
8140 DISP "ENTER THE REQUIRED NU
     CLIDE NAME"
8150 T$=""
8160 BEEP @ INPUT T$
8170 IF T$<>"" AND LEN(T$)<7 THE
     N 8190
8180 CLEAR @ DISP " BAD ENTRY" @
      GOTO 8140
8190 ASSIGN# 1 TO "RD-IND.DRIVE1
     "
8200 READ# 1,1 ; V1$,N1,S2()
8210 FOR I=2 TO N1+1
8220 READ# 1,I ; N2$,P1()
8230 IF T$=N2$ THEN 8310
8240 NEXT I
8245 V1$=T$
8250 CLEAR
8260 ASSIGN# 1 TO *
8270 DISP "NUCLIDE->";V1$;" NOT
     FOUND"
8280 DISP "DO YOU WISH TO TRY AG
     AIN(Y OR N)" @ BEEP @ INPUT
      T$
8290 ON FNA(T$) GOTO 8300,8130,8
     001
8300 CLEAR @ DISP "BAD ENTRY" @
     GOTO 8270
8310 ASSIGN# 1 TO *
8315 IF F1=4 THEN GOTO 7060
8320 GOSUB 8900
8325 IF R8=2 THEN 8510
8327 IF R8=3 THEN 8580
8330 CLEAR @ DISP "DATA LOAD IN
     PROGRESS"
8340 ASSIGN# 1 TO "SFILE.DRIVE1"
8350 READ# 1,P1(1) ; A1(,)
8360 ASSIGN# 1 TO *
8370 FOR J1=1 TO P1(6)
8380 PRINT
8390 PRINT "SOURCE REPEAT";J1-1
8400 PRINT
8410 PRINT "NUM";TAB(7);"@";TAB(
     16);"C"
8411 I=1
8412 K8=J1*5-4
8413 PRINT USING 8414 ; I*3-2,A1
     (K8,1),A1(K8,4),"Γ",A1(K8,7
     )
8414 IMAGE DD,X,8D,X,8D,X,2A,9D
8415 PRINT USING 8416 ; I*3-1,A1
     (K8,2),A1(K8,5),"T=",A1(K8,
     8)
8416 IMAGE DD,X,8D,X,8D,X,2A,9D
8417 PRINT USING "DD,X,8D,X,8D"
     ; I*3,A1(K8,3),A1(K8,6)
8420 FOR I=2 TO P1(5)
8430 K8=J1*5-5+I
8440 PRINT USING "DD,X,8D,X,8D"
     ; I*3-2,A1(K8,1),A1(K8,4)
8460 PRINT USING "DD,X,8D,X,8D"
     ; I*3-1,A1(K8,2),A1(K8,5)
8480 PRINT USING "DD,X,8D,X,8D"
     ; I*3,A1(K8,3),A1(K8,6)
8490 NEXT I
8500 NEXT J1
8510 IF P1(2)=0 THEN PRINT @ PRI
     NT "NO BACKGROUND AVAILABLE
     " @ GOTO 8000
8520 CLEAR @ DISP "DATA LOAD IN
     PROGRESS."
8525 ASSIGN# 1 TO "BFILE.DRIVE1"
8530 READ# 1,P1(2) ; B4(,)
8535 ASSIGN# 1 TO *
8540 FOR J1=1 TO P1(7)
8542 PRINT
8544 PRINT "BACKGROUND RATE --RE
     PEAT ";J1-1
8546 PRINT
8548 PRINT "NUM";TAB(7);"@";TAB(
     16);"C"
8550 I=1
8552 K8=J1*5-4
8554 PRINT USING 8555 ; I*3-2,B4
     (K8,1),B4(K8,4),"Γ",B4(K8,7
     )
8555 IMAGE DD,X,4D.3D,X,4D.3D,X,
     2A,4D.3D
8556 PRINT USING 8555 ; I*3-1,B4
     (K8,2),B4(K8,5),"T=",B4(K8,
     8)
8558 PRINT USING 8559 ; I*3,B4(K
     8,3),B4(K8,6)
8559 IMAGE DD,X,4D.3D,X,4D.3D
8560 FOR I=2 TO P1(5)
8562 K8=J1*5-5+I
8564 PRINT USING 8559 ; I*3-2,B4
     (K8,1),B4(K8,4)
8566 PRINT USING 8559 ; I*3-1,B4
     (K8,2),B4(K8,5)
8568 PRINT USING 8559 ; I*3,B4(K
     8,3),B4(K8,6)
8570 NEXT I
8572 NEXT J1
8573 PRINT @ PRINT "------------
     --------------------"
8574 GOTO 8000
8580 IF P1(3)=0 THEN PRINT @ PRI
     NT "NO CORRECTIONS AVAILABL
     E"
8582 IF P1(3)=0 THEN PRINT @ PRI
     NT "----------------------
     ---------"
8584 IF P1(3)=0 THEN GOTO 8000
8590 CLEAR @ DISP "DATA LOAD IN
     PROGRESS.PLEASE    WAIT"
8595 ASSIGN# 1 TO "CFILE.DRIVE1"
8600 READ# 1,P1(3) ; B7(,),S7(,)
     ,T7(,),G7
8605 ASSIGN# 1 TO *
8610 PRINT @ PRINT "@ DEAD TIME"
     ;TAB(16),"SAT PULSE"
```

```
8615 FOR I=1 TO P1(5)
8620 FOR J1=1 TO 3
8625 PRINT USING "D.8D,X,2A,3X,D
     .10D" ; B7(I,J1)*1000000,"μ
     S",S7(I,J1)
8630 NEXT J1
8635 NEXT I
8640 PRINT @ PRINT "COINC RESOLV
     ING TIMES IN μS"
8645 PRINT
8650 FOR I=1 TO P1(5)
8655 PRINT USING 8660 ; T7(I,1)*
     1000000,",",T7(I,2)*1000000
     ,",",T7(I,3)*1000000
8660 IMAGE D.7D,A,D.7D,A,D.7D
8665 NEXT I
8670 PRINT @ PRINT "Γ DEAD TIME
     = ";G7*1000000,"μS"
8672 PRINT @ PRINT "------------
     --------------------"
8675 GOTO 8000
8680 PRINT @ PRINT "NUCLIDE";TAB
     (12);"DATE";TAB(24);"TIME"
8685 PRINT
8690 ASSIGN# 1 TO "RD-IND.DRIVE1
     "
8700 READ# 1,1 ; V1$,N1,S2()
8705 IF N1<>0 THEN 8725
8710 PRINT "DISC IN DRIVE1 CONTA
     INS NO DATA AS YET"
8715 ASSIGN# 1 TO *
8720 GOTO 8000
8725 FOR I=2 TO N1+1
8730 READ# 1,I ; N2$,P1()
8735 PRINT USING "6A,4X,DDCDDC4D
     ,3X,DD.DD" ; N2$,P1(8),P1(9
     )
8740 NEXT I
8745 ASSIGN# 1 TO *
8747 PRINT @ PRINT "------------
     --------------------"
8750 GOTO 8000
8760 PRINT @ PRINT "STATUS OF FI
     LES"
8765 ASSIGN# 1 TO "RD-IND.DRIVE1
     "
8770 READ# 1,1 ; V2$,Q3,S3()
8775 IF Q3<>0 THEN 8795
8780 PRINT "DISC IN DRIVE1 CONTA
     INS NO DATA AS YET"
8785 ASSIGN# 1 TO *
8787 PRINT @ PRINT "------------
     --------------------"
8790 GOTO 8000
8795 PRINT
8797 PRINT "LAST NUCLIDE ON DISC
      : ";V2$
8799 PRINT "CORRESPONDING RECORD
      NO. = ";Q3
8801 PRINT "LAST B-FILE RECORD N
     O. = ";S3(1)
8803 PRINT USING 8804 ; "DATE OF
      LAST B-FILE : ",S3(2)
8804 IMAGE 22A,DDCDDC4D
8805 PRINT "LAST C-FILE RECORD N
     O. = ";S3(3)
8807 PRINT USING 8804 ; "DATE OF
      LAST C-FILE : ",S3(4)
8809 CLEAR
8810 DISP "STATUS OF A PARTICULA
     R FILE      (Y OR N)"
8812 BEEP @ INPUT T$
8814 IF T$="Y" THEN 8820
8816 IF T$="N" THEN 8785
8818 CLEAR @ DISP "BAD ENTRY" @
     GOTO 8810
8820 DISP @ DISP "ENTER THE REQU
     IRED NUCLIDE NAME"
8822 T$=""
8824 BEEP @ INPUT T$
8826 IF T$<>"" AND LEN(T$)<7 THE
     N 8830
8828 CLEAR @ DISP "BAD ENTRY" @
     GOTO 8820
8830 FOR I=2 TO Q3+1
8832 READ# 1,I ; V2$,Q2()
8834 IF T$=V2$ THEN 8866
8836 NEXT I
8838 CLEAR
8840 DISP "NUCLIDE->";T$;" NOT F
     OUND"
8860 DISP "DO YOU WISH TO TRY AG
     AIN(Y OR N)" @ BEEP @ INPUT
      T$
8862 ON FNA(T$) GOTO 8864,8820,8
     785
8864 CLEAR @ DISP "BAD ENTRY" @
     GOTO 8840
8866 PRINT @ PRINT "NUCLIDE->";V
     2$
8868 PRINT USING 8869 ; "DATE-",
     Q2(8),"  TIME ",Q2(9)
8869 IMAGE K,DDCDDC4D,K,DD.DD
8870 PRINT "RECORD NO. OF THE S-
     FILE = ";Q2(1)
8872 PRINT "RECORD NO. OF THE B-
     FILE = ";Q2(2)
8874 PRINT "RECORD NO. OF THE C-
     FILE = ";Q2(3)
8876 PRINT "NO. OF DATA POINTS =
      ";Q2(5)*3
8878 PRINT "NO. OF SOURCE REPEAT
     S = ";Q2(6)-1
8880 PRINT "NO. OF BACKGROUND RE
     PEATS = ";Q2(7)-1
8882 GOTO 8809
8900 PRINT
8910 PRINT "NUCLIDE->";N2$
8920 PRINT USING 8940 ; "DATE-",
     P1(8),"  TIME ",P1(9)
8930 PRINT

8940 IMAGE K,DDCDDC4D,K,DD.DD
9950 RETURN
9999 END
```

2. Program INIT

```
 10 REM **INITIALIZES AND FORMAT
    S A DATA DISC FOR USE WITH T
    HE 32 SCALER COINC COUNTING
    SYSTEM**
 15 OPTION BASE 1
 20 DIM S2(8),P(9),N$[6]
 25 CLEAR @ DISP "INSERT DATA DI
    SC INTO DRIVE UNIT 1 AND PRE
    SS   CONT"
 26 PAUSE
 30 CLEAR @ DISP "PLEASE WAIT.DA
    TA DISC BEING INITIALIZED"
 40 INITIALIZE "DRIVE1",":D701",
    14,6
 50 Q1=2
 60 CLEAR @ DISP "PLEASE WAIT.DI
    SC BEING FORMATED"
 70 CREATE "RD-IND.DRIVE1",82,81
 80 CREATE "SFILE.DRIVE1",81,108
    0
 90 CREATE "BFILE.DRIVE1",81,960
100 CREATE "CFILE.DRIVE1",81,368
110 LET N$=""
120 N1=0
130 MAT S2=ZER
140 MAT P=ZER
150 DISP "ENTER TODAYS DATE"
160 DISP "DD,MM,YYYY"
170 BEEP @ INPUT D,M,Y
210 LET S2(8)=Y+(M+D*100)*10000
220 ASSIGN# 1 TO "RD-IND.DRIVE1"
230 PRINT# 1,1 ; N$,N1,S2()
240 PRINT# 1,Q1 ; N$,P()
250 ASSIGN# 1 TO *
260 DISP "COMPLETED"
270 STOP
280 END
```

3. Program SCALER

```
  1 CLEAR
  5 DISP "4434 SCALER TEST PROGR
    AM"
  6 DISP " "
  7 DEF FNA(T$) = POS("YN",UPC$(
    T$))+1
 10 SEND 7 ; LISTEN 1
 20 OUTPUT 701 USING "#,B" ; 35
 30 SEND 7 ; UNL TALK 1
 40 DISP "NO. OF CHANNELS TO TES
    T"
 50 INPUT C1
 51 C2=C1-1
 52 DISP "STARTING CHANNEL"
 53 INPUT C3
 54 C4=32+C3-1
 55 H1=C3
 57 C3=H1
 60 SEND 7 ; LISTEN 1
 70 OUTPUT 701 USING "#,B" ; 16,
    0,1,0,128,0
 80 SEND 7 ; UNL TALK 1
 90 SEND 7 ; LISTEN 1
100 OUTPUT 701 USING "#,B" ; 16,
    0,1,C4,C2,0
110 SEND 7 ; UNL TALK 1
120 SEND 7 ; LISTEN 1
130 OUTPUT 701 USING "#,B" ; 100
140 FOR J1=1 TO C1
160 OUTPUT 701 USING "#,B" ; 2,0
    ,1
180 ENTER 701 USING "#,B" ; A,B,
    C
190 DISP "  ";C3;"  ";A;"  ";B;"
    ";C
195 A=0 @ B=0 @ C=0
196 C3=C3+1
197 IF C3>32 THEN C3=1
200 NEXT J1
210 DISP "CONTINUE (Y OR N)"
220 INPUT T$
230 ON FNA(T$) GOTO 240,57,250
240 DISP "BAD ENTRY" @ GOTO 210
250 SEND 7 ; LISTEN 1
260 OUTPUT 701 USING "#,B" ; 35
270 SEND 7 ; UNL TALK 1
280 DISP "PROGRAM STOPPED"
290 STOP
300 END
```

4. Program SCALE2

```
  1 CLEAR
  5 DISP "4434 SCALER TEST PROGR
    AM"
  6 DISP " "
  7 DEF FNA(T$) = POS("YN",UPC$(
    T$))+1
 10 SEND 7 ; LISTEN 1
 20 OUTPUT 701 USING "#,B" ; 35
 30 SEND 7 ; UNL TALK 1
 31 WAIT 1
 40 DISP "NO. INCREMENT CYCLES"
 50 INPUT C1
 51 C2=31
 54 C4=32
 55 H1=1
 57 C3=H1
 59 FOR Z1=1 TO C1
 60 SEND 7 ; LISTEN 1
 70 OUTPUT 701 USING "#,B" ; 16,
    0,1,0,128,0
 80 SEND 7 ; UNL TALK 1
 81 NEXT Z1
 90 SEND 7 ; LISTEN 1
100 OUTPUT 701 USING "#,B" ; 16,
    0,1,C4,C2,0
110 SEND 7 ; UNL TALK 1
120 SEND 7 ; LISTEN 1
130 OUTPUT 701 USING "#,B" ; 100
140 FOR J1=1 TO 32
160 OUTPUT 701 USING "#,B" ; 2,0
    ,1
180 ENTER 701 USING "#,B" ; A,B,
    C,D
190 DISP "  ";C3;"  ";A;"  ";B;"
      ";C;"  ";D
195 A=0 @ B=0 @ C=0
196 C3=C3+1
197 IF C3>32 THEN C3=1
200 NEXT J1
210 DISP "CONTINUE (Y OR N)"
220 INPUT T$
230 ON FNA(T$) GOTO 240,10,250
240 DISP "BAD ENTRY" @ GOTO 210
250 SEND 7 ; LISTEN 1
260 OUTPUT 701 USING "#,B" ; 35
270 SEND 7 ; UNL TALK 1
280 DISP "PROGRAM STOPPED"
290 STOP
300 END
```

APPENDIX B

15-Fold Coincidence Unit

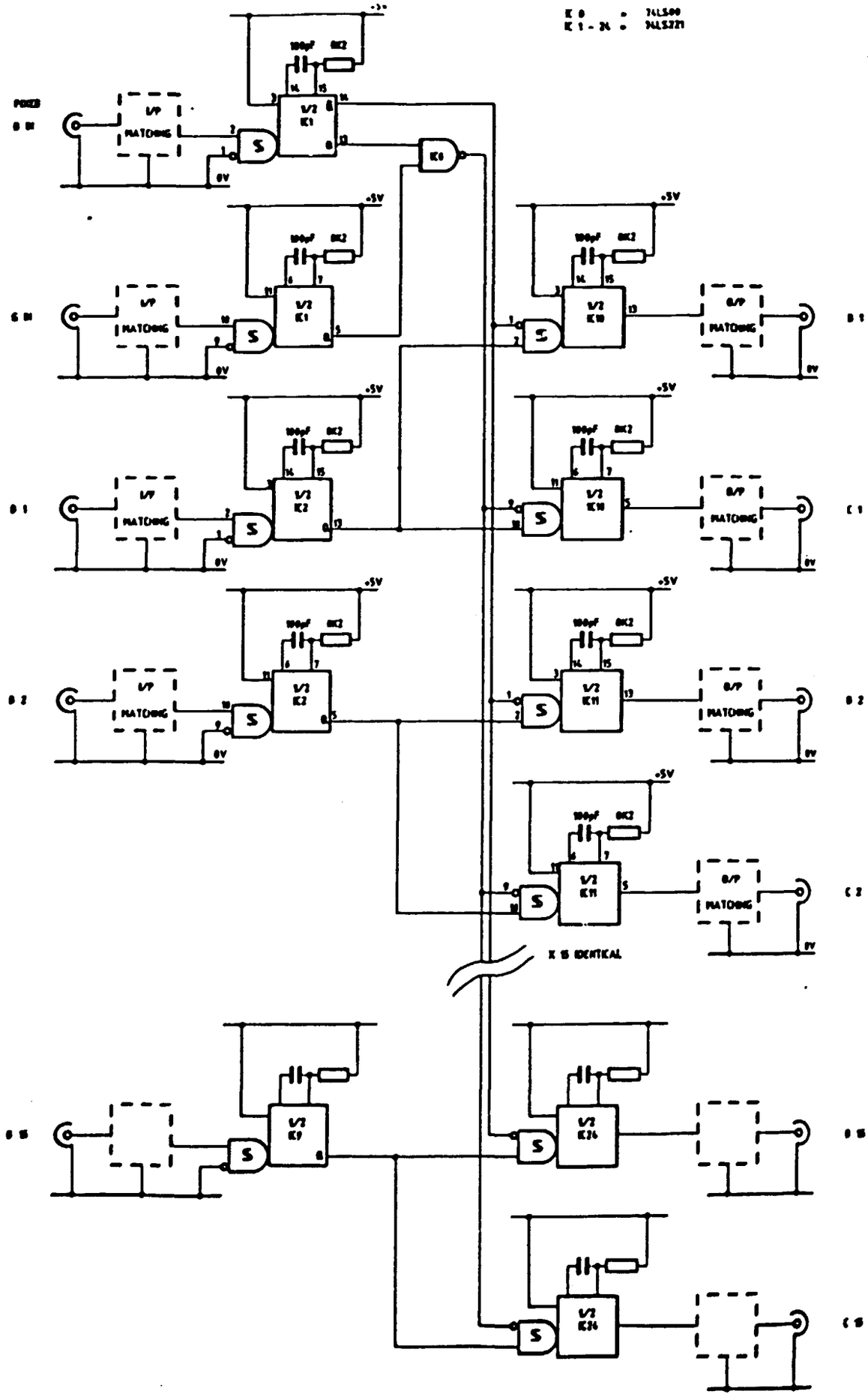
The 15-fold coincidence unit, as shown in the schematic drawing, is of a straightforward design. The 74LS221 dual monostable multivibrator was used throughout. This integrated circuit has both a positive and a negative triggered input enabling it to be used as an AND gate to derive the coincidence pulses. An added advantage is a Schmitt-triggered input which gives it better noise immunity. The monostable pulse duration is fixed at 0.57 μS by external 8k2 Ω and 100 pf components. The pulse duration is determined by the expression

$$t_w(\text{out}) = 0.7\ C_{ext}\ R_{ext}$$

and can be changed by using different R_{ext} values.

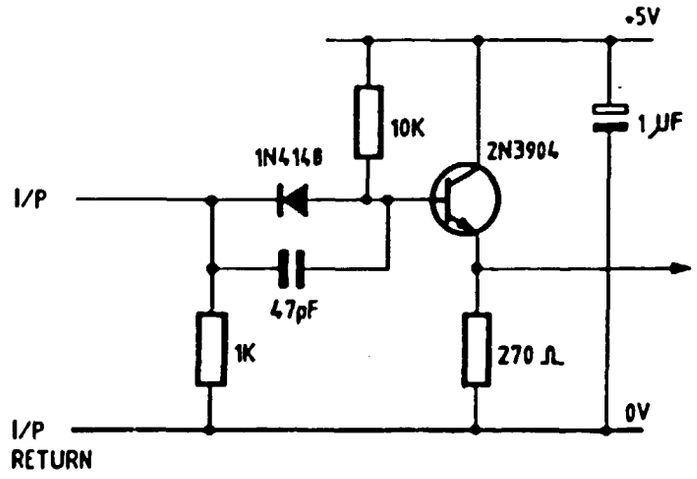
Input and output matching was used. This was accomplished by mounting small printed circuit boards onto the isolated BNC connectors directly behind the front panel of the unit. This helps to reduce noise pickup. The input matching circuit has an input impedance of 1 kΩ and it changes the positive NIM logic signals from the TSCAs to TTL levels. The output can drive a 50 Ω load.

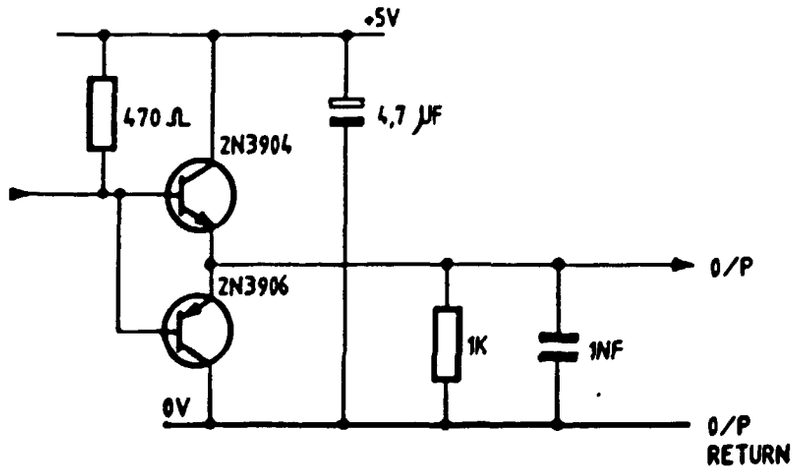
Great care was taken to eliminate noise and spikes on the output. To achieve this, lines to and from the matching circuits were kept as short as possible and were shielded against inductive coupling. Care was also taken with the layout of the main printed circuit board, and all the ICs were decoupled. All earth loops were also eliminated.



15-fold coincidence unit circuit diagram

input matching circuit





output matching circuit