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ON-LINE DATA TAKING PROGRAM FOR PDP-8 COMPUTER AND DECTAPE

by

Seigi Iwata and Akira Imanishi

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Tanashi-Shi, Midoricho
Tokyo, Japan

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Abstract

A program which takes counter data on line with the PDP-8 computer equipped with DEC tapes is described. The data are transfered with a 3-cycle data break facility from a logic interface to a computer memory. As a preliminary analysis during the data taking, they are processed to obtain eight kinds of pulse height distributions for particular events satisfying selected coincidence logics. Every 208 events are transfered to a DEC tape for a parmanent storage. This program provides an example that controls the data acquisition and transfer. The complete listing of the program is presented.

§1 Introduction

The program KRUN3 is written with an intension to take the counter data on line with the PDP-8 computer equipped with DEC tapes as a parmanently recording device. The 8-word information of each event is transfered from a logic interface to a computer memory by three-cycle data break operation. During the data acquisition, pulse-height distributions for particular kinds of events are summarized for the purpose of monitoring the experiment. A group of the raw data is recorded into the DEC tape upon receipt of a logic signal indicating the overflow of the computer memory.

This program was used in the K^+-meson photoproduction experiment[1], where Λ° hyperons were also detected in coincidence with the K^+ mesons. The information of each event was constructed, so as to identify both particles. The contents of the 8-computer words have been listed in the previous report[1]. They consisted of a run-identification number, a magnet current, coincidence logics, and four kinds of pulse heights.

The program starts the logic interface to enable the data taking. At each occurence of a master coincidence signal of the K^+ spectrometer, the data supplied to a data buffer are read into successive locations of the computer memory, independently on the program sequence. These data are processed during the data acquisition to obtain preliminary results on absolute numbers of the K^+ mesons and the decay protons from Λ° hyperons. Time-of-flight spectra for those events that satisfy the required coincidence logics and have the required pulse heights are useful for this purpose. At the same time, a contribution of accidental coincidences is subtracted from them. Every 208 events are

transferred to a DEC tape. At the moment when the interface informs the end of run or when the DEC tape is found to have no room for the data storage, the computer disenables the data taking and prints out the run parameters. The pulse-height distributions are printed out together with total counts of various coincidence logics according to a request from an operator.

The raw data supplied from the data buffer are temporarily stored into locations from 4400 to 7577_8, where 208_{10} events can be stored. Memory locations from 2400 to 4377 are used to store the summary of the run, while the program occupies from 0001 to 2377_8.

§2 Program Description

Commands

The control of the program returns to a loop waiting for a command at the end of each work. Four legal commands typed on a keyboard instruct the next operation. They must be terminated by a carriage return (↵). A bell rings when any kind of illegal command is typed in, and the correct command is waited for. The legal commands are;

S↵ Initialization for new run.

Discrimination levels for the 1-st (TOF) and the 2-nd(dE/dx) pulse heights are recorded by a switch register. After clearing the contents of data and summary locations, the control returns to the command-waiting routine.

D↵ Enable data taking.

Word count and current address registers are set to given values. The program starts the operation of the logic interface.

T↵ Print out the summary.

O↵ Print out the raw data.

The raw data stored into the DEC tape are printed out for a monitoring purpose. This command cannot be used during the data acquisition.

It should be noted that, during the data taking, the interrupt caused by the keyboard is regarded as an erroneous operation of the system. The highest priority of the program interrupt is given to the DEC tape control unit according to its timing requirement.

Program Sequence

The program sequence is illustrated by the flow diagram shown in Fig. 1.

1) Clear I/O flags.

2) Set the block number of a DEC tape to an initial value (usually 1).

3) Set discrimination levels for the pulse heights of TOF and dE/dx by a switch register. They are recorded by a repeated operation of "CONTINUE" in the following sequence; upper dE/dx, lower dE/dx, upper TOF, and lower TOF. With one in the 1-st bit of the switch register, the above procedure is bypassed and the previously recorded values are used.

4) Clear contents of count registers and data locations, and wait for a command.

5) Start the data taking.

The program interrupt is enabled after setting the parameters for the data transfer. The program waits for the first event, checking the content of a register prepared for the data-break operation.

6) Store the run number and the magnet current associated with the first event.

7) Classify the event.

The content of each bit of the logic code is successively examined by the shifting operation for this purpose.

7-a) K^+ channel.

A good event is selected at this stage by checking the presence of an accidental mark and the indication of momentum channels.

7-b) Λ° channel.

For a good K^{+} event, the presence of a coincident Λ° signal is examined. The event is classified according to the momentum channel of the K^{+} spectrometer, a mark for up or down Λ° telescopes, and a true or an accidental coincidence mark.

In course of this, contents of count registers for corresponding logics are incremented.

8) Analyze the pulse heights.

Eight kinds of the pulse height distributions are stored at this stage. The pulse height of a K^{+} counter is recorded for the good K^{+} event, whose TOF is in a given range. The pulse height of the TOF is stored for the good K^{+} event, the coincident proton events in the up and the down Λ° telescopes, and corresponding accidental ones. In this case, only the event having the required dE/dx is processed. Bad events with logically impossible logic codes bypass this step.

9) Pick up the next event.

The same procedure is repeated bypassing the step 6).

10) Upon receipt of an interrupt signal indicating an overflow of the data locations, the program writes a successive number into the second word of each data, after the data taking is disenabled. The raw data are then transferred to a DEC tape.

11) Check a resultant space of the tape.

If a sufficient space is confirmed, the data taking is enabled at once. Otherwise, the run parameters and total counts are printed out indicating the end of tape. In the latter case, another control unit already equipped with a new tape is manually activated in place of the old one. The program must restart at step 1).

12) When an interrupt signal indicating the end-of-run is identified, the operation same as 10) is done, and the program waits for a command.

13) Print out the summary.

In order to save a time, the pulse-height spectra are printed out with a scale reduced by a factor of two. In addition, the contribution of accidentals is subtracted from them.

When an oscilloscope is equipped, the results of the step 8) are available for the scope display.

The program uses TC01 TAPE ROUTINES supplied from DEC[3]. It controls the operation to transfer the data in units of 128_{10} words using the TC01 tape system.

Acknowledgements

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References

1) S. Iwata, INS-J-115('70).

2) S. Iwata, INS-J-119('70).

3) DECTAPE Programming Manual.

Appendix

Program Listing

for

On-Line Data Taking Program

KRUN3

```
*1
/ON-LINE DATA TAKING PROGRAM,KRUN3
        JMP I 2
        INIR
DIS,    BACK
DTERR,  ERROR
NCOM,   0
WC,     0
CA,     0
IR1,    0
IR2,    0
IR3,    0
RUN,    0
MAG,    0
SIGN,   0
SCALER,LOGIC1
PHA,    2377
TYPE,   0
        TLS
        TSF
        JMP .-1
        TCF
        CLL CLA
        JMP I TYPE
CRLF,   0
        TAD C215
        JMS TYPE
        TAD C212
        JMS TYPE
        JMP I CRLF
SPC1,   0
        TAD C240
        JMS TYPE
        JMP I SPC1
SPC2,   0
        JMS SPC1
        JMS SPC1
        JMP I SPC2
C212,   212
C215,   215
C240,   240
C260,   260
BELL,   207
NCR,    -215
NSPC,   -240
MRBOUT,-377
BACK,   CLL CLA
        TAD LIK1
        RAR
        TAD AC1
        ION
        JMP I 0
RETDTK,TAD NFULW
        DCA WC
        TAD BANK+1
        DCA CA
        6514
RETURN,TAD LIK2
        CLL RAR
        TAD AC2
        ION
        JMP I PROG
```

```
AC1,    0
AC2,    0
LIK1,   0
LIK2,   0
P.OG,   0
I.W12S,W12S
In12S,A12S
W3DG,   DGTL3
W4DG,   DGTL4
W5DG,   DGTL5
W4OC,   OCTL4
BLOCK,  BLOKME
SEPRAT,CR4LF
EVENT,  EVNTME
RUNNO,  RUNME
READ,   READR
PRINT,  MESAGE
FLAGCR,FLGCLR
WATCOM,ERRCOM
CIRCLE,PIWAIT
WAIT,   DWAIT
FBLK,   0
BLKS,   0
ADRS,   0
CHAR,   0
REG,    0
WRD1,   0
WRD2,   0
WRD3,   0
TEMP,   0
HOLD,   0
CONT1,  0
CONT2,  0
CONT3,  0
CONT4,  0
POINTR,0
SUBSVC,0
SVCNT,  0
MASK1,  7
MASK2,  17
FULB,   15
NFULB,  -15
FULE,   320
NFULE,-320
FULW,  3200
NFULW,-3200
BANK,   DATA
        DATA-1
PLS20,  20
PLS10,  10
PLS4,   4
MIN20,  -20
MIN5,   -5
MIN4,   -4
MIN3,   -3
MIN2,   -2
EUPPER,0
ELOWER,0
TOFU,   0
TOFL,   0
```

```
PHDEDX,EUPPER-1
LCOIN, 0
SIDE,  0
C4K,   4000
LMEM,  TOF1
```

```
/START-WAITING ROUTINE, RUN 3
*200
INIT,  IOF
       JMS I FLAGCR   /CLEAR FLAGS
       IAC
       DCA BLKS
       IAC
       DCA FBLK
       JMP CLEAR1
MAIN,  STA
       DCA SIGN
       TAD MIN4      /SET DISCRI. LEVELS
       DCA CONT1
       TAD PHDEDX
       DCA IR1
DISCRI,FLT
       LAS
       SPA
       JMP .+6        /UNCHANGED SETTING
       CMA
       DCA I IR1
       LAS
       ISZ CONT1
       JMP DISCRI
       CLL CLA
CLEAR1,TAD SCALER     /CLEAR COUNTER MEMORY
       DCA IR1
       TAD NOCH
       JMS RESET
       TAD PHA
       DCA IR1
       TAD M5200
       JMS RESET      /CLEAR DATA MEMORY
       JMP I WATCOM
NOCH,  -54
M5200, -5200
```

```
START, ION
       TAD BANK+1
       CIA
       TAD CA
       SNA CLA          /FIRST DATA IN?
       JMP START        /NO, CHECK AGAIN
       TAD I BANK       /YES
       DCA RUN          /STORE RUN NO
       TAD BANK+1
       TAD PLS3
       DCA REG
       TAD I REG
       DCA MAG          /STORE MAGNET CURRENT
       TAD PLS10
       JMP GO
PIWAIT,CLA
       TAD COMPAR       /WAIT UNTIL NEXT DATA IN
       CIA
       TAD CA
       SZA CLA
       JMP .+6
       TAD SIGN
       SZA CLA          /ISTHIS RUN OVER?
       JMP PIWAIT       /NO
       IOF              /YES
       JMP I WATCOM
       TAD COMPAR
       TAD PLS3
       DCA REG
       TAD COMPAR
       TAD MEND
       SNA CLA          /LAST ONE?
       JMP .+4
       TAD COMPAR       /NO
       TAD PLS10
       JMP GO+1
       TAD BANK+1
       DCA IR1
       IAC
       TAD NFULW
       JMS RESET
GO,    TAD BANK+1
       DCA COMPAR
       JMP I CLASS
CLASS, SELECT
MEND,  -7577
PLS3,  3
COMPAR,
RESET, 0
       DCA CONT1
       DCA I IR1
       ISZ CONT1
       JMP .-2
       JMP I RESET
```

```
/PRINT OUT SERIES OF CHARACTERS
MESAGE,0
        CLA CMA
        TAD MESAGE
        DCA IRI
        TAD I IRI
        DCA TEMP
        TAD TEMP
        RTR
        RTR
        RTR
        JMS TYPECH
        TAD TEMP
        JMS TYPECH
        JMP MESAGE+4
TYPECH,0
        AND MASK3
        SNA
        JMP I IRI       /END OF MASSAGE
        TAD MIN40
        SMA
        JMP .+3
        TAD C340
        JMP DONE
        TAD MIN3
        SZA
        JMP .+3
        TAD C212
        JMP DONE
        TAD MIN2
        SZA
        JMP .+3
        TAD C215
        JMP DONE
        TAD C245
DONE,   JMS TYPE
        JMP I TYPECH
MASK3,  77
MIN40,  -40
C245,   245
C340,   340
```

```
*400
/EVENT CLASSIFICATION
/SCALER NO.1
SELECT,DCA SIDE
       ISZ REG
       TAD I REG
       RTL CLL
       SNL
       JMP MOMCH
       CLA
       TAD C4K       /ACCIDENTAL MARK
       DCA SIDE
       TAD I REG
       RTL CLL
 MOMCH,RAL           /CHECK MOMENTUM CHANNEL
       SNL
       JMP KLOW
       RAL
       SNL
       JMP KHIGH
       JMS KMARK
       ISZ DHL2
       SKP
       ISZ DHL1
       JMP GOBACK
       ISZ HL2
       SKP
       ISZ HL1
       JMP GOBACK
 KHIGH,JMS KMARK     /HIGH MOMENTUM CHANNEL
       ISZ DH2
       SKP
       ISZ DH1
       JMP BADM-3
       ISZ H2
       SKP
       ISZ H1
       JMP BADM-3
  KLOW,RAL
       SNL
       JMP BADM
       JMS KMARK
       ISZ DL2
       SKP
       ISZ DL1
       JMP .+4
       ISZ L2
       SKP
       ISZ L1
       TAD C16
       TAD SIDE
       DCA SIDE
       JMP I LMDA
  BADM,JMS KMARK     /BAD EVENT
       ISZ DNHL2
       SKP
       ISZ DNHL1
       JMP GOBACK
       ISZ NHL2
       SKP
```

```
       ISZ NHLI
       JMP GOBACK
  C16,16
 LMDA,LAMDA
KMARK,0             /JUMP 4 LOCATIONS IF TRUE COINCIDENCE
       CLA
       TAD SIDE
       SPA CLA
       JMP I KMARK
       TAD PLS4
       TAD KMARK
       DCA KMARK
       JMP I KMARK
GOBACK,TAD PLS4
       TAD REG
       DCA REG
       JMP I READY
READY,PIWAIT

DGTL5,0             /DOUBLE PRECISION DECIMAL PRINT,5 DIGITS
       STA
       TAD I DGTL5
       DCA IR2
       TAD I IR2
       DCA WRD1
       TAD I IR2
       DCA WRD2
       TAD MIN5
       DCA CONT3
       TAD I ADR2
       DCA IR2
       ISZ DGTL5
STEP3,DCA CONT4
       TAD I IR2
       DCA HSUB
       TAD I IR2
       DCA LSUB
STEP4,CLL
       TAD LSUB
       TAD WRD2
       DCA TEMP
       RAL
       TAD HSUB
       TAD WRD1
       SNL
       JMP I S5
       ISZ CONT4
       TAD TEMP
       DCA WRD2
       JMP STEP4
   S5,STEP5
 HSUB,0
 LSUB,0
 ADR2,TEMPWR
```

```
*557
LOGIC1,.          /COUNT REGISTERS FOR K-COIN.
   DH1,0
   DH2,0
   DL1,0
   DL2,0
  DHL1,0
  DHL2,0
 DNHL1,0
 DNHL2,0
    H1,0
    H2,0
    L1,0
    L2,0
   HL1,0
   HL2,0
  NHL1,0
  NHL2,0
```

```
*600
/COUNT REGISTERS FOR LAMDA COIN.
  HLA1,0
  HLA2,0
 HSLA1,0
 HSLA2,0
  HLB1,0
  HLB2,0
 HSLB1,0
 HSLB2,0
 HLAB1,0
 HLAB2,0
HSLAB1,0
HSLAB2,0
 HNOL1,0
 HNOL2,0
  LLA1,0
  LLA2,0
 LSLA1,0
 LSLA2,0
  LLB1,0
  LLB2,0
 LSLB1,0
LSLB2,0
 LLAB1,0
LLAB2,0
LSLAB1,0
LSLAB2,0
 LNOL1,0
 LNOL2,0
```

```
/SCALER NO.2
LAMDA,TAD I REG
      RTR CLL
      RAR
      SNL
      JMP NOTLB
      RAR
      SNL
      JMP LMARK+4
      JMS SCALE
      HLAB2
LMARK,TAD PL2       /MARK FOR IDENTIFICATION
      TAD PL2
      DCA LCOIN
      JMP I PH
      JMS SCALE
      HLB2
      JMP LMARK+1
NOTLB,RAR
      SNL
      JMP .+4
      JMS SCALE
      HLA2
      JMP LMARK+2
      RAR
      SNL
      JMP NOTB
      RAR
      SNL
      JMP .+4
      JMS SCALE
      HSLAB2
      JMP LMARK
      JMS SCALE
      HSLB2
      IAC
      JMP LMARK+1
 NOTB,RAR
      SNL
      JMP .+5
      JMS SCALE
      HSLA2
      IAC
      JMP LMARK+2
      JMS SCALE
      HNOL2
      TAD C4K
      JMP LMARK+2
   PH,SPECT
```

```
SCALE,0             /CHECK L-MARK AND COUNT IN DOUBLE PRECISION
       CLA
       TAD SIDE
       AND MASK
       TAD I SCALE
       DCA WRD2
       CMA
       TAD WRD2
       DCA WRD1
       ISZ I WRD2
       SKP
       ISZ I WRD1
       ISZ SCALE
       JMP I SCALE
 MASK,77
  PL2,2
 TOF1,.              /POINTER FOR DATA BANK
       2400
       2600
       3000
       3200
       3400
       3600
       4000
       4200


*745
 STEP5,CLA
       TAD CONT4
       TAD C260
       JMS TYPE
       ISZ CONT3
       JMP I S3
       TAD I W5DG
       DCA ADRS
       JMP I ADRS
    S3,STEP3
TENPWR,.            /POWERS OF TEN
       7775
       4360
       7777
       6430
       7777
       7634
       7777
       7766
       7777
       7777
```

```
*1000
/INTERRUPT CONTROL
INTR,   DTSF
        JMP .+5
        DCA AC1         /DECTAPE FLAG
        RAL
        DCA LIK1
        JMP I MCOM
        DCA AC2
        RAL
        DCA LIK2
        TAD Z 0
        DCA PROG
        6501            /DATA REGION FULL?
        SKP
        JMP FULL
        6511
        JMP I OTHER
STOP,   TAD .-4         /END OF RUN
        DCA REPT
        TAD WC
        TAD FULW
        CMA
        STL RAR
        STL RAR
        STL RAR
        DCA CONT1
        DCA TEMP
        TAD CONT1
        TAD PLS20
        ISZ TEMP
        SPA
        JMP .-3
        CLA
        TAD TEMP
        CIA
        JMP .+6
FULL,   TAD WEVNTS+1
        DCA REPT
        TAD NFULE
        DCA CONT1
        TAD NFULB
        DCA MWB
        JMS FLGCLR
        TAD FBLK
        DCA MWB+1
        TAD BANK
        IAC
        DCA POINTR
WEVNTS, ISZ EVCNT
        SPA CLA         /=SKP
        ISZ SUBEVC
        TAD EVCNT
        DCA I POINTR    /WRITE EVENT NO.
        TAD PLS10
        TAD POINTR
        DCA POINTR
        ISZ CONT1
        JMP WEVNTS
```

```
DWRITE,JMS I IW128    /TRANSFER DATA
       DATA
DATAA, 7000
MWB,   0
       0
       JMS I WAIT
       TAD MWB
       CIA
       TAD FBLK
       DCA FBLK
       TAD FBLK
       TAD DTEND      /CHECK THE END OF DEC TAPE
REPT,  SPA CLA
       JMP RETDTK     /CONTINUE DATA TAKING
       IOF
       JMS RUNME
       TAD I BANK
       JMS I W40C
       JMS CRLF
       JMS BLOKME
       TAD BLKS
       JMS I W40C
       JMS SPC2
       STA
       TAD FBLK
       JMS I W40C
       JMS CRLF
       TAD FBLK
       DCA BLKS
       JMS EVNTME
       JMS I W5DC
       SUBEVC
       JMS CR4LF
       DCA SIGN
       JMP RETURN
OTHER, TIYF
DTEND, 1 -8702
FLGCLR,0
       DTXA
       6512
       6504
       KCC
       TCF
       JMP I FLGCLR
BLOKME, 0
       JMS I PRINT
       0214
       1703
       1340
       7500
       JMP I BLOKME
RUNME, 0
       JMS I PRINT
       2225
       1540
       1617
       7500
       JMP I RUNME
```

```
EVNTME,0
        JMS I PRHNT
        0526
        0516
        2423
        7500
        JMP I EVNTME
CR4LF, 0
        JMS I PRINT
        4543
        4343
        4330
        JMP I CR4LF
```

```
/TYPE OUT ORIGINAL DATA
*1200
ODOUT, JMS I BLOCK
        JMS OCTL
        JMP ONEBLK
        DCA MRB+1
        JMS OCTL
        JMP ONEBLK
        CLL CMA
        TAD MRB+1
        JMP .+4
ONEBLK,TAD TEMP
        DCA MRB+1
        STA
        DCA OCTL
        JMS CRLF
CNTNUE,TAD .+4
        DCA RTPNT
        TAD OCTL
        TAD FULB
        SZL
        JMP .+6
        DCA OCTL
        TAD MN7000
        DCA RTPNT
        TAD NFULB
        JMP .+3
        CLL CLA
        TAD OCTL
        DCA MRB
DREAD, JMS I IR12R
        DATA
MN7000,7000
MRB,    0
```

```
        0
        JMS I WAIT
        IOF
        TAD BANK+1
        DCA IR1
        TAD MRB
        DCA CONT1
        TAD MIN20
        DCA CONT2
TTYPE,  TAD I IR1
        DCA HOLD
        TAD HOLD
        CMA IAC
        TAD I BANK
        SNA CLA
        JMP .+5
        HLT
        LAS
        SMA CLA
        JMP RTPNT+2
        TAD HOLD
        JMS I W40C
        JMS LOAD
        JMS I W40C
        JMS SPC1
        JMS LOAD
        JMS DGTL3
        JMS LOAD
        JMS I W40C
        TAD MIN4
        DCA DGTL3
        JMS LOAD
        JMS I W4DG
        ISZ DGTL3
        JMP .-3
        JMS CRLF
        ISZ CONT2
        JMP TTYPE
        JMS I SEPRAT
        ISZ CONT1
        JMP TTYPE-2
        TAD FULB
        TAD MRB+1
        DCA MRB+1
RTPNT,  NOP
        JMP CNTNUE
        JMS I SEPRAT
        JMP I WATCOM
```

```
OCTL,   0
        DCA TEMP
        JMS I READ
        TAD HOLD
        TAD MSPC
        SZA CLA
        JMP .+4
        ISZ OCTL
        TAD TEMP
        JMP I OCTL
        TAD HOLD
        TAD MCR
        SNA CLA
        JMP I OCTL
        TAD HOLD
        AND MASK1
        DCA HOLD
        TAD TEMP
        CLL RAL
        RTL
        TAD HOLD
        DCA TEMP
        JMP OCTL+2
LOAD,   0
        JMS SPC2
        TAD I IR1
        JMP I LOAD
DGTL3,  0                       /BCD-TO-DECIMAL PRINT,3 DIGITS
        DCA TEMP
        TAD MIN3
        DCA CONT3
STEP1,  TAD TEMP
        CLL RTL
        RTL
        DCA TEMP
        TAD TEMP
        RAL
        AND MASK2
        TAD C260
        JMS TYPE
        ISZ CONT3
        JMP STEP1
        JMP I DGTL3
```

```
/COMMAND WAIT ROUTINE
*1400
TTYF,   TCF
        KSF
        JMP ERROR
COMMD,  JMS I FLAGCR    /READ IN COMMAND CHARACTERS
        JMS READR
        TAD HOLD
        DCA TEMP
        JMS READR
        TAD HOLD
        TAD MCR
        SZA CLA
        JMP ERRCOM
        TAD C212
        JMS TYPE
        TAD ADRSC1
        DCA IR1
        TAD MIN4
        DCA CONT1
        TAD ADRSC2
        DCA CONT2
CMCH,   TAD TEMP
        TAD I IR1
        SZA CLA
        JMP .+4
        TAD I CONT2
        DCA CONT2
        JMP I CONT2
        ISZ CONT2
        ISZ CONT1
        JMP CMCH
ERRCOM, TAD BELL
        JMS TYPE        /ILLEGAL COMMAND
        JMS CRLF
        JMP COMMD
ERROR,  DCA TEMP
        IOF
        JMS I PRINT
        3522
        2245
        4300
        TAD TEMP
        HLT
        JMS I FLAGCR
        LAS
        SMA CLA
        JMP ERRCOM
        JMP I TRY       /TRY AGAIN
TRY,    STOP
BEGIN,  START
```

```
ADRSC1,.
        -324
        -323
        -317
        -324
ADRSC2,.+1
        DATK
        MAIN
        ODOUT
        TABLE
DATK,   TAD NFULW       /ENABLE DATA TAKING
        DCA WC
        TAD BANK+1
        DCA CA
        DCA SUBEVC
        DCA EVCNT
STA
        DCA SIGN
        6514
        JMP I BEGN
DGTL4,  0               /PRINT 4 DIGITS
        DCA TEMP
        TAD MIN4
        DCA CONT3
        TAD ADDCN1
        DCA POINTR
        DCA CONT4
STEP2,  CLL
        TAD TEMP
        TAD I POINTR
        SNL
        JMP .+4
        DCA TEMP
        ISZ CONT4
        JMP STEP2
        CLA
        TAD CONT4
        TAD C260
        JMS TYPE
        ISZ POINTR
        ISZ CONT3
        JMP STEP2-1
        JMP I DGTL4
ADDCN1,.+1
        -1750
        -144
        -12
        -1
```

```
READR, 0                /READ ASR-33
       CLL CLA
       KSF
       JMP .-1
       KRB
       TLS
       TSF
       JMP .-1
       TCF
       DCA HOLD
       TAD HOLD
       TAD MRBOUT
       SZA CLA
       JMP I READR
       JMP ERRCOM
OCTL4, 0                /PRINT OCTAL
       DCA TEMP
       TAD MIN4
       DCA CONT3
STEP6, TAD TEMP
       CLL RAL
       RTL
       DCA TEMP
       TAD TEMP
       RAL
       AND MASK1
       TAD C260
       JMS TYPE
       ISZ CONT3
       JMP STEP6
       JMP I OCTL4
```

```
/DEC TAPE SUBROUTINE
*1600
/TC01 IOT DEFINITIONS

DTXA=6764 /XOR AC TO STATUS A
DTRB=6772 /READ STATUS B
DTCA=6762 /CLEAR STATUS A
DTRA=6761 /READ STATUS A
DTLA=6766 /LOAD STATUS A (CLEAR AND XOR)
 DTLB=6774 /LOAD STATUS B
DTSF=6771 /SKIP ON TC01 FLAGS

R12B,    0                          /READ 128 WORDS
         JMS DWAIT  /WAIT IF MOTION IS ON
         TAD R12B
         DCA W12B
         CLA IAC                    /SET TO WRITE
         JMP DGR-2
W12B,    0
         JMS DWAIT  /WAIT IF MOTION IS ON
         TAD DR128C
         DCA DRET   /READ WRITE RETURN AFTER SEARCH
DGR,     CLA CMA                    /FIRST
         JMS DGET   /CORE LOC
         DCA R12B
         JMS DGET
         DCA DUF                    /UNIT AND FIELD
         JMS DGET
         DCA DNCB
         TAD DCRET
         DCA DSERH
         DCA DSTOP  /DON'T STOP TRANSPORT AFTER SEARCH
         JMS DGET   /GET BLOCK NUMBER
         JMP DTS1-1 /INITIATE SEARCH
DRET,    0
DUF,     0
         JMP I W12B
DTEMP,
DTEMX,
DGET,    0                          /PICK UP ARGUEMENTS
         TAD I W12B
         ISZ W12B
         JMP I DGET
DCRET,   DRET
DR12B,   TAD D20                    /WRITE
         TAD D30                    /READ
         DTXA                       /SET FUNCTION
         TAD R12B
         DCA I DCAA /ADRESS OF DATA
         ISZ MCOM   /POINT INT TO DATA
 DR127,   DTXA                       /SEND A READ OR WRITE
         TAD D7600  /SET WORD COUNT FOR 128(10)WORDS
         DCA I DWC
         JMP I DIS  /EXIT
         JMP DTS3A
DINT,    DTRB                       /READ STATUS B
```

```
            SPA CLA
            JMP DER                 /ERROR FLAG
            ISZ DNCB    /COUNT BLOCKS
            JMP DR127   /CONTINUE OPERATION
DTURNX,      TAD D200    /COMPLEMENT MOTION AND DIRECTION
            TAD D400
            JMP DR127
DR12RC,     DR12R
DCAA,       7755                    /POINTER TO CURRENT ADDRESS
DWC,        7754                    /POINTER TO WORD COUNT
DNCB,       0
D30,        30
DCINT,      DINT-1
D20,        20
DTEM,       0
DBLK,       DTBLK
D400,       400
D614,       614
DTBLK,      0
D200,       200
DSERR,      0
            DCA R12R    /STORE BLOCK NUMBER
            JMS DWAIT
            TAD DTURNX
            DCA DSTOP
            TAD R12R
            DCA DTEM
DTS1,       TAD DBLK
            DCA I DCAA
            TAD DCINT
            DCA MCOM    /INTERRUPT RETURN
DTS2,        CLA IAC
            TAD DSERR
            DCA DTEMP
            TAD I DTEMP
            AND D7700   /PICK UP UNIT NUMBER
            TAD D614    /SET TO SEARCH,NORMAL,REVERSE
            DTLA                    /LOAD STATUS A
            DTLB                    /FIELD 0
            ISZ DTEMP
            ION                     /ENABLE INTERRUPT
            JMP I DTEMP             /RETURN TO USER
DTS34,      DTRB                    /LOOK FOR END ZONE
            RTL
            SPA CLA
            JMP DTURNX /IN END ZONE; TURN AROUND
            DTRB
            SPA CLA
            JMP DER                 /ERROR FLAG
            DTRA
```

```
D7[illegible],   RTL
                 RTL
D7600,           7600                    /OPERATE 2 CLA
                 TAD DTBLK
                 CMA IAC
                 TAD DTEM
                 SNA
                 JMP DTFIND /FOUND BLOCK CHECK DIR
                 CMA IAC
                 SNL
                 IAC
                 SNL CLA
DTURN,           TAD D400   /TURN IF HERE
                 JMP DR127  /XOR TO A STATUS AND DISMIS
DER,             DTRA
                 AND D200   /STOP TAPE IF RUNNING
                 TAD D2                  /DON'T CLEAR ERRORS
                 DTXA
                 DTRB                    /ERROR STATUS B
                 JMP I DTERR
DTFIND,          SNL CLA                 /TEST MOTION
                 JMP DR127  /DON'T TURN YET
                 TAD I DSERH             /GET COMPLETION RETURN
                 DCA DSERH
DSTOP,           0                       /EITHER A 0 OR TAD D200 (STOP)
                 DTXA                    /CLEAR FLAG
                 TAD DUF
                 DTLB                    /SET MEM FIELD
                 JMP I DSERH             /EXIT TO COMPLETION RETURN
D2,              2
DWAIT,           0                       /WAIT FOR NO MOTION
                 DTRA
                 AND D200
                 SZA CLA
                 JMP .-3
                 JMP I DWAIT
```

```
*2000
/PULSE-HEIGHT ANALYSIS
 SPECT,ISZ REG
       TAD REG
       IAC
       DCA WRD3
       TAD PHDEDX
       DCA IR3
       TAD I WRD3
       JMS SPH      /DE/DX CONDITION
       JMP DEDX
       SKP
  DOOR,JMP I CIRCLE
       TAD DOOR-2
       DCA LOC
       TAD LCOIN
       SPA CLA
       JMP NOLMD
       TAD LCOIN    /TOF WITH LAMDA COIN.
       TAD MIN4
       SNA CLA
       JMP DCOIN
       TAD LCOIN
       TAD LMEM
       DCA IR2
       JMS STORE
 NOLMD,TAD PLS4     /SPECTROMETER CHANNEL
       TAD LMEM
       DCA IR2
       TAD SIDE
       SPA CLA
       JMP LOC+1
       JMS STORE
   LOC,JMP DEDX
       ISZ IR2      /ACCIDENTAL K-COIN.
       JMP LOC-1
  DEDX,TAD PHDEDX
       TAD P2
       DCA IR3
       TAD I REG
       JMS SPH
       JMP I CIRCLE
       ISZ REG       /TOF CONDITION
       TAD DOOR
       DCA LOC
       TAD P2
       JMP NOLMD
```

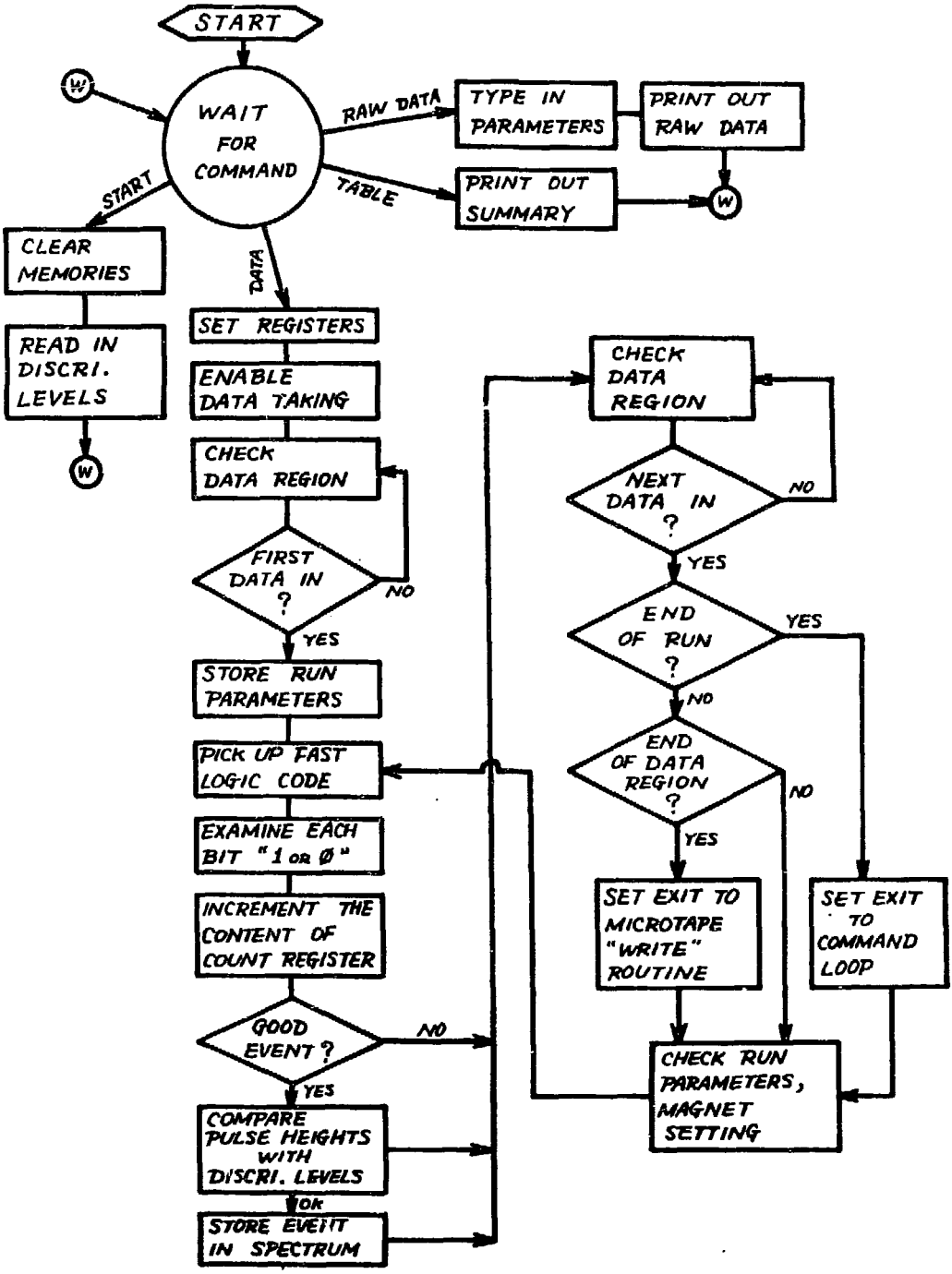
```
  SPH,0             /SKIP IF PULSE-HEIGHT CONDITION IS SATISFIED
       AND MASK4
       DCA CHAR
       TAD CHAR
       TAD I IR3
       SMA CLA
       JMP I SPH
       TAD I IR3
       TAD CHAR
       SMA CLA
       ISZ SPH
       JMP I SPH
STORE,0             /STORE  THE PULSE HEIGHT
       TAD I REG
       AND MASK4
       TAD I IR2
       DCA ADRS
       ISZ I ADRS
       NOP
       JMP I STORE
DCOIN,TAD LMEM      /ACCIDENTAL LAMDA COIN.
       IAC
       DCA IR2
       JMS STORE
       ISZ IR2
       JMS STORE
       JMP NOLMD
MASK4,177
   F2,2




*2244
/SUMMARY
TABLE,JMS I SEPRAT
       JMS I RUNNO
       TAD RUN
       SPA CLA      /TARGET FULL?
       IAC
       TAD CODE     /EMPTY
       JMS TYPE
       TAD RUN
       RTL
       SNL CLA
       JMP DOWN     /LAMDA-A DOWN
       JMS I PRINT /LAMDA-A UP
       5501
       2555
       0000
       JMP .+5
```

```
DOWN,JMS I PRINT
     5501
     0455
     0000
     TAD RUN
     AND MASK5
     JMS I W40C   /RUN NO.
     JMS I PRINT
     4543
     4040
     4015
     0107
     7500
     TAD MAG
     JMS I W3DG   /MAGNET EXCITATION
     JMS CRLF
     JMS CRLF
     TAD SCALER   /LOGIC COUNTS
     DCA IR1
     TAD MIN2
     DCA CONT1
LINE1,TAD MIN4    /SPECTROMETER COIN.
     JMS DTYPE
     JMP LINE1
     JMS CRLF
     TAD MIN2
     DCA CONT1
LINE2,TAD MIN2    /LAMDA COIN.
     TAD MIN5
     JMS DTYPE
     JMP LINE2
     JMS CRLF
     JMS CRLF
     TAD M50
     DCA CONT1
     DCA HOLD
CHANL,JMS CRLF
     TAD HOLD
     JMS I W4DG
     JMS SPC1
     TAD LMEM
     DCA IR1
     TAD MIN4
     DCA CONT2
NOTYET,JMS SPC1
     TAD HOLD
     CLL RAL
     TAD I IR1
     DCA ADRS1
     TAD HOLD
     CLL RAL
     TAD I IR1
     DCA ADRS2
     TAD I ADRS2
     CIA
     TAD I ADRS1
```

```
        DCA PROG
        ISZ ADRS1
        ISZ ADRS2
        TAD I ADRS2
        CIA
        TAD I ADRS1
        TAD PROG     /TRUE COIN.-ACCIDENTAL COIN.  IN TWO CHANNELS
        SMA
        JMP PLUS
        CIA
        DCA PROG
        TAD CODE+1   /MINUS SIGN
        JMS TYPE
CONTNT, TAD PROG
        JMS I W4DG
        ISZ CONT2
        JMP NOTYET
        ISZ HOLD
        ISZ CONT1
        JMP CHANL
        JMP I WATCOM
 PLUS, DCA PROG
        JMS SPC1
        JMP CONTNT
 CODE, 305
        255
MASK5, 1777
  M50, -62
ADRS1, 0
 ADRS2, 0
DTYPE, 0
        DCA CONT2
        JMS CRLF
        JMS SPC1
        JMS SPC1
        ISZ IR1
        TAD IR1
        DCA .+2
        JMS I W5DG
        0
        ISZ IR1
        ISZ CONT2
        JMP DTYPE+4
        ISZ CONT1
        JMP I DTYPE
        ISZ DTYPE
        JMP I DTYPE



*4400
 DATA, 0



$
```

ON-LINE DATA TAKING PROGRAM

(a) MAIN ROUTINE



(b) INTERRUPT SERVICE ROUTINE