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A Computer-Controlled Neutron Time-of-Flight Spectrometer Part II

S. H. Merriman

MASTER

OPERATED BY
UNION CARBIDE CORPORATION
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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Computer Sciences Division

MASTER

A COMPUTER-CONTROLLED NEUTRON
TIME-OF-FLIGHT SPECTROMETER PART II

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ABSTRACT

A time-of-flight spectrometer for neutron inelastic scattering research has been interfaced to a PDP-15/30 computer. The computer is used for experimental data acquisition and analysis and for apparatus control. This report was prepared to summarize the functions of the computer and to act as a users' guide to the software system.

INTRODUCTION

The purpose of this report is to summarize the functions of the PDP-15/30 computer which is interfaced to a time-of-flight spectrometer located at the High Flux Isotope Reactor. The report is intended further to serve as a users' guide to the software system and as a supplement to an earlier report¹ which described the spectrometer-computer complex in some detail. Prospective users of the computer are urged to read *A Computer-Controlled Neutron Time-Of-Flight Spectrometer* before reading this document for a more complete introduction to the spectrometer-computer interface and the associated computer software. Apart from minor exceptions, material presented in the earlier report is still valid and will provide more extensive descriptions of certain computer characteristics and functions which will be described only briefly here. All computer functions, for the sake of completeness and easy reference, will be included in this document in a concise form.

The first section of this report contains a brief description of each of the most frequently used user programs, along with a list of the program's Keyboard Commands. The Keyboard Commands, which are made up of two alphanumeric characters, are used by the operator to determine program flow. In the Monitor Mode of operation (that is, when the user directs the software system through the DECwriter), the Keyboard Commands are always preceded by a Control S and followed by a carriage return. In the Batch Mode (the operator communicates with the system via the high speed paper tape reader), the Control S is omitted, and the two-character command is followed by a carriage return. (Monitor and Batch Mode processing will be discussed in Section 2.) Each user program has its own Keyboard Command Decoder which processes the commands and initiates program response.

Section 2 of this report deals with the more infrequently used user programs. It also contains miscellaneous information helpful in implementing the system.

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¹Merriman, S. H., *A Computer-Controlled Neutron Time of Flight Spectrometer*, July 1973 (ORNL/TM-4091).

SECTION 1. USER PROGRAMS

1.1 Program COLL

The time-of-flight data collection program, COLL, is responsible for real-time control and monitoring of the experiments conducted at HB-4 of the HFIR. Program COLL, through manipulation of the Programmed Pulse Generator, Time-Of-Flight Scaler, Interrupt Register, and other interface devices,² modulates the incident neutron beam in a pattern dictated by a pseudorandom function (called pseudorandom because the time distribution approximates that of a random process), and records the scattering pattern of diffracted neutrons as they strike thirty-two banks of high pressure neutron detectors. In addition to accumulating these data, COLL performs the background tasks of sorting the data according to detector and time channel, displaying selected spectra on the oscilloscope, and storing the sorted data in a DECtape or DECdisk file for later cross-correlation with the modulating sequence and possible further analyses.

Program COLL, like all other user programs, resides on DECdisk 1 (or DK1) and is loaded in the following manner:^{3,4}

```

KM15 V5A

$ LOAD (cr)

LOADER V9A

> +COLL (altmode)

↑S ↑S

```

---

²For descriptions of hardware interface modules, see *A Computer-Controlled Neutron Time-Of-Flight Spectrometer* (ORNL/TM-4091).

³Throughout this document, user response is underlined.

⁴"↑" represents a control character.

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The loader searches DK1 for program COLL and then searches the user library (also on DK1), .LIBR5 BIN, for all subprograms called by COLL. After all linking and loading is complete, the loader outputs a "Control S". Execution will begin when the user responds with a second "Control S". Program COLL performs initialization chores, then signals the user that it is ready to accept Keyboard Commands.

In Monitor Mode, the Keyboard Command (preceded by a Control S and followed by a carriage return) is recognized, decoded, and serviced. After the function associated with that command has been completed, program control is returned to a wait loop pending further commands from the user. Readiness to accept the next command is indicated when the DECwriter outputs a ">". The program idles until the operator starts it again with a new command. In Batch Mode, however, the Keyboard Commands (followed by a carriage return) are recognized, decoded, and serviced immediately, one after the other, as they appear on the paper tape. This mode of processing makes it unnecessary for the operator to be present constantly.

The functions carried out by each command are the same whether the processing mode is Monitor or Batch. The normal mode of operation is the Monitor Mode, and therefore, the loading procedure outlined above for program COLL and later for other user programs is in the Monitor Mode. Batch Mode loading is discussed in Section 2.11.

In addition to DK1, where the user programs and library are stored, program COLL references several other input/output devices. These physical I/O devices are referenced by COLL (and other user programs) by means of logical I/O devices. These logical units are related to the physical units by means of a Device Assignment Table (.DAT) which has "slot" numbers that correspond directly to logical I/O device numbers. Each .DAT slot contains the physical device unit number plus a pointer to the appropriate device handler. The user program then references the .DAT slot in I/O statements and the input or output operation is directed to the associated physical unit. The .DAT slots

are permanently assigned at system generation time but may be dynamically modified before executing a program by use of the ASSIGN command. The command "A DTAL 3" would cause DECTape physical unit number 1 to be given logical unit number 3 and DECTape Handler A would carry out the I/O operations. As mentioned above, COLL and user library programs are read from DK1 (.DAT slots -4 and -5). System programs are read from DKO (.DAT slot -1).⁵ Program COLL refers to logical units 2, 3, 4, 6, 7, and 10. .DAT slot 2 is permanently assigned to DECTape drive 1 and is used as the output device for the time-of-flight data at the conclusion of an experiment (unless .DAT 2 is reassigned before COLL is executed). Slots 3 and 4 are assigned to the DECwriter and are used for input and output, respectively. Slot 6 is assigned to the high speed paper tape punch, which will be used by subprogram HELP as the output device for the time-of-flight data in the case of unrecoverable DECTape failure. (See the description of subprogram HELP in Section 2.8.) .DAT slot 10 is assigned to DECdisk 1 and is used as the input device for the pseudorandom sequence file. .DAT slot 7 is assigned to the high speed paper tape reader and is used only in Batch Mode where it serves as the user input device instead of the DECwriter.

Program COLL has ten Keyboard Commands, all of which are available in both Batch and Monitor Modes. Descriptions of these commands follow here. They are also summarized in Section 2.

Program COLL Keyboard Commands

IP - Input parameters for the coming data collection period. All variables necessary to initiate the system prior to starting an experiment are requested as input from the DECwriter (or paper tape reader, in Batch Mode). These variables, in the order of input, and their input formats follow.

---

⁵Permanent .DAT assignments appear in Section 2.4.

1. Number of detectors. Format I7.⁶ Integer having maximum value of 32.
2. Detector identification numbers. Format I7. Integers having value of 1-32.
3. Number of delta-t's in the pseudorandom sequence. Format I7. Integer with maximum value of 936.
4. Value of the last delta-t in the sequence. Format I7.
5. Number of time channels per delta-t. Format I7. Integer with value of 1, 2, or 4.
6. Sequence file identifier. Format A1. One alphanumeric character. The various pseudorandom sequences are stored on DK1 in files having file names of the form "SEQFx BIN" where x is the alphanumeric character 1-9 or A-Z.
7. Indicator of whether the experimental run period will be a function of time or of the intensity of the neutron beam as determined by the Monitor Prescaler. Format I10. Integer with value of 0 for experimental period determined by clock or 1 for period determined by neutron count.
8. Time in minutes of experimental run if indicator above is 0; number of Prescaler overflows if indicator is 1. Format I10.

IT - Input time period that experiment will run. Command IT is an abbreviated version of IP and requires as input only the last two variables that are inputted to IP. The other variables (items 1-6 in above description of IP) are retrieved from DECC disk 1, file ANGLES BIN, where they are stored each time IP is executed. Command IT is useful when multiple experiments having identical parameters are run. IT has a second use in that it can be called while an experiment is in progress to alter the original experimental run period.

---

⁶Number may be typed anywhere in the 7-character field.

1. Indicator of experimental run period as a function of time or of the neutron intensity. Format I7. Value of 0 for clock or 1 for neutron count.
2. Time in minutes if above indicator is 0; number of Pre-scaler overflows if indicator is 1. Format I7.

CD - Collect and display data after IP (or IT) has been called.

Time-of-flight data are collected, sorted, and displayed for the period determined by input parameters to IP (or IT). When the period is over, output subprogram OP is automatically called and the spectra from the detectors named in IP are outputted in a file on the output device assigned to .DAT slot 2 (normally DECTape drive 1). The DECTape drive should be Write Enabled and in Remote Mode. If it is not, any attempted I/O operation causes an "IOPS4" error message which indicates a device-not-ready condition. In Monitor Mode, a recovery can be made if the operator types a Control R after correcting the condition. In Batch Mode, there is no recovery mechanism because an IOPS4 causes an immediate return to the system monitor and therefore, a loss of the user program and data base. The filename is determined by program COLL and will be of the form "HD11-x BIN", where x is A-Z. Subprogram OP prints the filename for user information, reinitializes the system for subsequent experiments, and notifies the user that new commands may be entered. (Note: User should not enter a new command or exit from Program COLL until told to do so. Otherwise, the output of data may not be complete and the data file will be lost.) If the user decides at any time to terminate the experiment before the predetermined period is over, command OP may be used to suspend the time-of-flight data collection and output these data immediately.

While data are being accumulated and sorted by command CD, a continuing, real-time display of the spectrum associated with a detector of the user's choosing appears on the oscilloscope.

By default, data from detector number 1 will be displayed. The operator, however, may select another detector at any time by using command DP. CD requires no user input.

OF - Output time-of-flight for the just concluded experiment. As mentioned above, OP is called automatically by command CD when an experiment is allowed to run for its full period (as defined by command IP or IT) and will never be used by the operator unless the run is terminated prematurely. In this event, command OP is used to write the time-of-flight data collected to the current time in the file HDT1-x BIN. After writing the data into the file, OP reinitializes the system for further experiments and prepares for the next user command. OP requires no input from the user.

DP - Display the time-of-flight data from the chosen detector. Format I7. As noted earlier, DP need never be called unless the user wishes to observe a detector other than number 1, which is always shown by default during a collection period. If the user needs to select another detector while an experiment is in progress, command ID should be used to suspend the experiment temporarily; then DP is used to select the new detector, and finally RD is used to resume the experiment.

ID - Interrupt data collection period temporarily in order to make apparatus or computer parameter changes. ID causes a suspension of the experiment without disturbing any of the experimental conditions and would most likely be used prior to selecting a new display detector with command DP or changing the proposed run time for the experiment with command IT. ID requires no user input.

RD - Resume data collection period after desired changes have been made. The experiment is restarted at the point of interruption by command ID. No user input is required.

IP - List parameters stored in file ANGLES BIN on DKL. The parameters stored are those necessary to initiate the system prior to the start of an experiment; and they are saved so that, in the event of successive similar experiments, the user will not need to type in the same parameters repeatedly. Command IP lists the variables saved from the previous run so that the user can decide whether or not to call IP, which will input new parameters, or whether to call IT, which uses the stored parameters. No user input is required.

SS⁶ - Suspend the current operation of program COLL, reinitialize all program parameters for a fresh start of COLL, and await further commands. No user input is required.

XC - Exit COLL and return to the system Monitor. The command XC causes the same response as a Control C, which is an unconditional and immediate suspension of the user program and a return to the system Monitor. XC has little or no use in Monitor Mode since the user can more easily type a Control C. It was incorporated in Program COLL, however, for use in Batch Mode where the Control C is not applicable to force an exit from COLL. (Control characters are not recognized by the paper tape handler which Batch Mode uses as its input device.) XC does not call for user input.

1.2 Program MAINM

Program MAINM has two functions: to collect sample scattering data in the scan mode and to position the spectrometer equipment prior to collecting data. The scan mode consists of alternately counting neutrons versus scattering angles and then repositioning selected spectrometer components for the purpose of selecting optimum settings for spectrometer hardware prior to an experiment. From

---

⁶The command is actually two space characters.

one to ten detectors and any one of the six stepping motors are used during the scanning operation.

Program MAINM resides on DECdisk 1 and has a similar loading and starting procedure to that of program COLL:

```

KM15 V5A

$ LOAD (cr)

LOADER V9A

< +MAINM (altmode)

↑S ↑S

```

Keyboard Commands operate in the same fashion as described above for program COLL. In addition to the .DAT slots used by the Loader (.DAT -1, -4, and -5), MAINM uses slots 3, 4, 7, and 10. As for program COLL and all other user programs, .DAT slots 3 and 4 represent DECwriter I/O. .DAT slot 7 is assigned to the paper tape reader and is used in Batch Mode as the user input device. .DAT slot 10 is assigned to DECdisk 1 and serves as the I/O device for file ANGLES BIN which is used for storage of certain parameters that may remain constant for multiple experiments. ANGLES stores, in addition to the input parameters for command IP of program COLL (see Section 1.1), the current angle settings of all six motors.

Program MAINM has eleven Keyboard Commands. Five commands -- those for initiating scanning operations -- are not applicable in Batch Mode. Descriptions of the commands follow and are also summarized in Section 2. Five of the commands (those used for scanning operations -- DN, NS, SW, ST, and RN) are not available in Batch Mode because it was assumed that scan mode runs would normally be done with the operator present. (The purpose of using Batch Mode, as will be explained in Section 2, is to run programs without any operator supervision and control.) All commands are available in Monitor Mode.

Program MAINM Keyboard Commands

IC - Input current motor positions in degrees. Command IC need not be called unless the motor positions recorded in file ANGLES BIN no longer agree with actual motor settings (as would be the case if any motors have been manually reset without using the computer to drive them). As part of its initialization process, MAINM reads file ANGLES into core and assumes these to be the correct current angles. Therefore, IC must be called when, for any reason, those values stored in ANGLES become invalid. As the new current angles are inputted to IC, they are stored in file ANGLES. (Note: Actual motor positions and the corresponding values in ANGLES should be compared occasionally since a hardware malfunction could cause discrepancies. It is imperative that the current angles be correct in the computer at all times. Otherwise, motors may become "lost" during driving and run into the limiting apparatus.) As the current angles are inputted, they are checked against the following boundary conditions to see if they are within limits. Phi motors are further checked to see that they are at least 1° apart. (Phi motors span about 10° on their track, and in order to be separated by the requisite 1° , the difference in their settings must be at least 11° .) The presently assigned limits are:

Two Theta-M	-	11 to 90°
Omega	-	0 to 360°
Psi	-	0 to 360°
Phi 1	-	30 to 45°
Phi 2	-	75 to 90°
Phi 3	-	120 to 138°

The Phi limits may be changed with the CL command.

Input variables requested by IC are:

1. Current Two Theta-M angle. Format F10.0.
2. Current Omega angle. Format F10.0.
3. Current Psi angle. Format F10.0.
4. Current Phi 1 angle. Format F10.0.
5. Current Phi 2 angle. Format F10.0.
6. Current Phi 3 angle. Format F10.0.

CL - Change limits for Phi motors. Present upper and lower limits for the three Phi motors are first listed on the DECwriter. Phi boundaries are subject to change depending on the placement of detectors on the motor track. CL requests as input the new boundaries (in degrees).

1. Lower Phi 1 limit. Format F10.0.
2. Upper Phi 1 limit. Format F10.0.
3. Lower Phi 2 limit. Format F10.0.
4. Upper Phi 2 limit. Format F10.0.
5. Lower Phi 3 limit. Format F10.0.
6. Upper Phi 3 limit. Format F10.0.

IF - Input final motor positions in degrees. Command IF requests the desired positions of motors to be moved and drives the selected motors until the desired angles are reached. Any combination of the six motors can be driven simultaneously. If Two Theta-M is to move, the air solenoid will be activated 8 seconds prior to the first pulse and deactivated when the final position is reached. Acceleration and deceleration rates of each motor have been determined experimentally to ease physical wear on the gear assemblies and all positioning of the axes is terminated in a positive direction so that there will be no error due to backlash in the drive gears.

As soon as the last of the motor positions is inputted, the driving process begins. When it is completed, the program indicates readiness to accept a new command by outputting the ">". During the period when the motors are driving, the system should not be interrupted with a Control S and new command unless necessary. There are two reasons for this. One is that if the interrupt should occur at a certain point (that is, between an actual motor pulse and the computer's recognition of the pulse), then the actual motor position and the position stored by the computer would disagree by one pulse. Another is that angles are not stored in file ANGLES until IF is finished driving. Therefore, if IF is aborted, the user should visually check the motor's scales and compare them with the computer values to determine if a one-pulse discrepancy exists and then call IC (if there is a discrepancy) or PA (if no disagreement is found) to write the angles in file ANGLES.

Input variables called for by IF are:

1. Number of motors to be driven. Format I1. Integer having value of 1 to 6.
2. Name of motor to be driven. Format A3. Motor names are TTH, OMG, PSI, PH1, PH2, and PH3.
3. Final position of the motor. Format F10.0.

Items 2 and 3 are repeated for each motor to be pulsed.

PA - Print angles. The current motor positions are written both on the DECwriter and in file ANGLES. No user input is needed.

DN - Detector numbers to be used during a scan. Up to ten detectors may be selected for scanning. Input parameters to DN are:

1. Number of scan detectors. Format I6. Integer having maximum value of 10.

2. Detector identification number. Format I5. Integer from 1 to 32.

Item 2 will be inputted for each detector.

NS - Number of scan steps. The input parameter to NS is:

1. Number of steps. Format I5. Integer.

SW - Number of seconds or number of prescaler counts to determine each scan step period. The length of a scan step usually is time-dependent. It can, however, be determined by the intensity of the diffracted neutrons as measured by the prescaler.

Command SW requests input as follows:

1. Scan step period in seconds. Format I5. If the step period is count-dependent rather than time-dependent, the user inputs a "0" or carriage return here and the next variable is requested.
2. Number of prescaler overflows. Format I5. Incident neutrons are scaled in steps from 64 to 8192, as selected on the front panel of the Prescaler interface module. An overflow occurs when the selected number of neutrons are counted.

ST - Scan step size in degrees and name of motor to be driven. Command ST determines how far the selected motor will be driven prior to each scan period. Input parameters are:

1. Motor to be used in scan. Format A3. The motor names are TTH, OMG, PSI, PH1, PH2, and PH3.
2. Motor step size in degrees. Format F10.0. Floating point number having a minimum value of .005 which is 1/200 of a degree and represents one motor step.

RN - Run a scan. Command RN collects data in the scan mode after all necessary parameters have been initialized by commands DN, NS, SW, and ST. RN alternatively drives the motors the specified step size and counts neutrons for the period established by SW. A profile of counting rate versus angle is outputted to the DECwriter as the scan progresses. A message indicates the end of the scan. Multiple scans may be executed by multiple calls to RN without recalling the initialization commands of NS, SW, DN, and ST. These commands need only be called once unless a new scan requires different input parameters. No input is required for RN.

SS - Suspend the current operation of MAINM, reinitialize all program parameters for a fresh start of MAINM, and await further commands. No input is required.

XM - Exit MAINM and return to the system monitor. Command XM causes the same response as a Control C, which is an unconditional and immediate suspension of the user program and a return to the systems Monitor. XM has little use in Monitor Mode since the user can more easily type a Control C. It was incorporated in MAINM, however, for use in Batch Mode where the Control C is not applicable to force an exit from MAINM. (Control characters are not recognized by the paper tape handler which Batch Mode uses as its input device.) XM does not call for user input.

1.3 Program CORR

The purpose of program CORR is to cross-correlate the time-of-flight data accumulated by program COLL with the pseudorandom sequence used to modulate the incident neutron beam during the data collection. The recovered spectra are then stored in files on the DECdisk and optionally displayed on the oscilloscope.

The calling procedure for CORR is:

```

KML5 V5A

$ LOAD (cr)

LOADER V9A

> +CORR (altmode)

↑S ↑S

```

Program CORR uses .DAT slots 3, 4, 2, and 10. Slots 3 and 4 are assigned to the DECwriter and slot 10 is assigned to DK1, which is the input device for the pseudorandom sequence files. Time-of-flight data input files from program COLL and cross-correlated data output files use the device assigned to .DAT slot 2 (which is normally DECTape drive 1).

Program CORR makes the following ten commands available.

RE - Read data files. The first data file called for contains time-of-flight data which were stored in a file named "HDT1-x BIN" (x = A-Z) by Command OP of program COLL. Command RE then calls for the sequence which is stored in a file named "SEQFx BIN" (x = i-9 or A-Z). Next, a scale factor is requested for the time-of-flight data since cross-correlation of a file having large entries could cause an integer overflow. (The largest integer possible in the PDP-15 is 131071.) Command RE is a prerequisite call for all others in CORR. Input variables to RE are:

1. Raw data filename. Format A6. The filename is always six alphanumeric characters and is usually HDT1-x. (The filename extension BIN need not be appended.)
2. Sequence file identifier. Format A1. One alphanumeric character. The various sequences are stored in files with names of "SEQFx BIN" where x is the alphanumeric character.

3. Time-of-flight data scale factor. Format I7. Integer of value 1-131071.

CO - As pointed out earlier, the desired spectrum can be recovered by cross-correlating the measured time-of-flight spectrum, $Z(t)$, with the sequence, $S(t)$. The function $F(t)$ for time channel I is computed from the following equation:

$$F(I) = \sum_{J=1}^N S(J) * Z(J + I)$$

where N = the number of sequence bits. As determined by command IP during data collection, the number of time channels per sequence bit may be 1, 2, or 4. When the number is 1, the cross-correlation can proceed directly since there is a one-to-one correlation of time channels and sequence bits. When the number of channels per Δt is 2 or 4, however, the sequence bit array, S , must be extended so that it contains the same number of elements as the total time channels. The user specifies whether the sequence will be completed with 0's or 1's. The correlated function is then stored in a file on DECTape drive 1 (or whatever device is assigned to .DAT slot 2). Input parameters to CO are:

1. If number of channels/ Δt equals 1, this input variable is not called for. If the number is 2 or 4, input a "0" or a "1" to extend the sequence. Format I7.
2. Output filename. Format A6. The filename of the cross-correlated data file must be six alphanumeric characters. (Output file structure and contents are defined in Section 2.3.)

The CO command must be immediately preceded by the RE command.

WR - Write selected data on the DECwriter. WR allows the user to get a hard copy of selected parts of the spectrum before and after cross-correlation and selected parts of the sequence. Input variables to WR are:

1. Answer "Y" or "N" to query "OUTPUT F?". Format A1. "N" tells the program to proceed to input item 3. "Y" indicates that the user wishes to examine parts of array F which contains the cross-correlated data. The program then proceeds to item 2 for determining which parts of the spectrum to list.
2. Detector number and lower and upper time channels to be listed. Format I7. Command WR then outputs these elements on the DECwriter.
3. Command WR next asks if additional information is needed. Format A1. If not ("N"), command WR is exited. If a reply of "Y" is given, WR prints the number of detectors used, the total number of channels,⁷ and the number of channels per delta-t from the time-of-flight data file.
4. Answer "Y" or "N" to the question "RAW DATA?". Format A1. "N" causes the program to proceed to input item 6, while a "Y" indicates that the user wants to list parts of the time-of-flight data file as determined by item 5.
5. Detector number and lower and upper channels. Format I7. Command WR then outputs these elements.
6. Answer "Y" or "N" to the query "SEQUENCE?". Format A1. "N" causes WR to be exited. "Y" causes part or all of the sequence to be listed according to input from item 7.
7. Detector number and lower and upper channels. Format I7. (The sequence is the same for all detectors, of course; but to minimize the program size, the same calling sequence was used for items 2, 5, and 7. Use "1" for the detector number.)

---

⁷The total number of channels is equal to the number of detectors times the number of channels per sequence bit times the number of sequence bits.

DP - Initiate display variables. DP establishes default parameters used later by command SC to display cross-correlated data on the oscilloscope. DP must be called before SC and after RE and CO. Command DP initiates the following default display parameters the first time it is called:

Lower time channel = 50

Upper time channel = 150

Horizontal scale factor = 10

Vertical scale factor = 2

Vertical adjustment factor = smallest count in channels 50-150

On the first and subsequent uses of command DP, the detector number to be displayed is requested as input.

1. Detector identification number. Format I7. Integer having value of 1-32.

SC - Display data on scope. The portion of a spectrum defined by the parameters established by command DP (unless the default parameters were overridden by CH, VF, FO, or PI) is shown continuously on the oscilloscope until the user interrupts with another command. SC requires no user input.

FO - Input display scale factors. FO is used when the operator wants to apply scale factors other than those provided by command DP. The scope accommodates a 1024 by 1024 matrix of display points. The default vertical scale factor is 2 and the horizontal scale factor is 10. If the user inputs a positive scale factor, the display will be enlarged by that number. A negative scale factor decreases the display. Input variables are:

1. Horizontal scale factor. Format I7. Positive or negative integer.
2. Vertical scale factor. Format I7. Positive or negative numbers.

VF - Input display vertical adjustment factor. The points to be displayed must be adjusted to appear on the screen if they fall outside the 0-1023 range. For this reason, a vertical adjustment constant (usually the default value -- the smallest count in the chosen channels) is subtracted from each channel before displaying. If an adjustment constant other than the smallest count in the range of channels chosen for display is desired, the command VF is called. Input is:

1. Vertical adjustment factor. Format I7. Positive integer.

CH - Input lower and upper channels to be displayed. If the default limits of channels 50 and 150 are not desired, command CH is used. Here again, the vertical adjustment factor is assumed to be the smallest count in the channels selected by command CH. Input data are:

1. Lowest display channel. Format I7. Positive integer.
2. Highest display channel. Format I7. Positive integer.

PI - Choose display points increment. PI allows the number of points on the scope to be limited for clarity. For example, the user may choose to limit the display to every third point by inputting a "3" to command PI.

1. Points increment. Format I7. Positive integer.

SS⁸ - Suspend the current operation of program CORR, reinitialize all program parameters for a fresh start of CORR, and await further commands. No user input required.

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⁸The command is actually two space characters.

1.4 Program CALC

Program CALC performs file manipulations and simple calculations using data files produced by Programs CORR and COLL. CALC also has the oscilloscope display capabilities described for Program COPR.

The loading sequence for CALC is:

```

KM15 V5A

$ LOAD (cr)

LOADER V9A

> +CALC, RWFILE (altmode)

↑S ↑S

```

Program CALC uses .DAT slots 3, 4, and 2. Slots 3 and 4 are assigned to the DECwriter and slot 2 is assigned to DT1, which is the input and output device for all data files referenced by CALC.

The seventeen keyboard commands available with Program CALC are described below.

AD - Add the contents of two or more data files. Command AD asks for the number of files to be added and for each individual file name. Core space limits the number of working arrays to two; therefore, when more than two data files are to be added, some intermediate adding must occur. The first file will be stored in array F and the second and subsequent files will be read into array F1. The summation of two files will replace the contents of array F. That is,

$$F(I) = F(I) + F1(I), I = 1, N.$$

This is pointed out so that the user will know which file can be expected from commands WR and SC. (WR lists selected elements of arrays F and F1 and command SC displays array F.)

Command AD does the intermediate addition (when more than two files are to be added) and sets up the arrays for the final addition. Command GO (see description below) is then called to compute the final sum. Between commands AD and GO, the user may call WR or SC to examine the F and F1 arrays before the addition is performed. After GO is executed, array F contains the final sum and F1 contains the contents of the last data file requested by AD. Input variables to AD are:

1. Number of files to be added. Format I7.
2. Data file filename. Format A6.

Input item 2 is repeated for each file.

AC - The AC command adds corresponding channels from two or more detectors within a file. The data file is read into working array F. Command GO is then called to perform the addition. WR and SC may be used between commands AC and GO to examine the data file before the addition occurs. After GO is executed, the F array contains the summed detectors. Array F1 is not used. Input variables are:

1. Data file filename. Format A6.
2. Number of detectors to be summed. Format I7.
3. Detector identification number (1-32). Format I7.

Item 3 is repeated for each detector.

AV - AV averages selected time channels for each detector in a data file. The data are read into working array F1 by command AV and command GO is then called to perform the computations. As

described above for commands AD and AC, the data file may be examined by WR and SC before GO is executed. After GO is called, array F contains the averaged channels. Array F1 is unchanged. The averaging algorithm is:

$$F(J) = \sum_{I=J}^{NP+J-1} F1(I)/NP,$$

where NP is the number of channels to be averaged.

Input parameters to AV are:

1. Data file filename. Format A6.
2. Number of time channels over which averaging occurs.
Format I7.

DV - Command DV divides each element of the F and/or F1 array(s). DV is called after command AD, AC, or AV and before command GO to scale the data prior to the adding or averaging operations. The input variable for DV is:

1. Integer to be used as scale factor. Format I7.

SU - Command SU subtracts a constant from each element of the F and/or F1 array(s). SU is called after AD, AV, or AC and before command GO to reduce the data prior to the adding or averaging operations. The input parameter is:

1. Integer to be subtracted. Format I7.

GO - Command GO actually carries out the operations initiated by AD, AC, and AV. After GO is executed, the result always resides in array F. The contents of array F1 vary with different commands and may be ascertained from the description of the command. After concluding the computations, GO outputs the results in a data file of the user's choosing. The input parameter is:

1. Output data file filename. Format AC.

WR - Write selected portions of arrays F and F1 on the DECwriter.

Command WR requires the following input:

1. Answer "Y" or "N" to query "OUTPUT F?". If "N", proceed to item 3; if "Y", go to item 2.
2. Detector number and upper and lower channels to be listed. Format I7.
3. Answer "Y" or "N" to query "F1?". If "N", exit from command WR. If "Y", execute item 4.
4. Detector number and upper and lower channels. Format I7.

SC, DP, CH, FO, VF, PI - Oscilloscope display commands which were described for Program CORR (Section 1.3) are also available in Program CALC. Array F is displayed.

SS⁹ - Suspend the current operation of Program CALC, reinitialize program parameters, and await further keyboard commands. No user input required.

IN - List the following information on the DECwriter: number of detectors, total number of channels, and number of channels per delta-t for the data file(s) read in by a previous command. No user input parameters.

SB - Subtract one data file from another and store the result in a data file of the user's choice. The data files are read into arrays F and F1 and the difference replaces the contents of F. Input parameters are:

---

⁹The command is actually two space characters.

1. Input data file filename. Format A6.
2. Input data file filename. Format A6.
3. Output data file filename. Format A6.

CC - Combine adjacent channels in a data file where the number of channels per delta-t is 2. Output the resulting data (with number channels/delta-t now equal to 1) in a file of the user's choice. Array F contains both the input data and, after computations, the adjusted data. Array F1 is unused. Input parameters are:

1. Input data file filename. Format A6.
2. Output data file filename. Format A6.

1.5 Program COR1

Program COR1 has only one unique function -- smoothing the data within one of the data files created by Programs COLL, CORR, or CALC. It also provides the display and hard-copy capabilities listed for Programs CORR and CALC.

Program COR1 provides eleven keyboard commands.

RF - Read a daca file into array F. User input is:

1. Data file filename. Format A6.

CF - Smooth the data in array F. The user may select the channels over which the smoothing function will be applied. The smoothed data will also reside in array F. Array F1 is not used. User input variables are:

1. Lower limit of channels to be smoothed. Format I7.
2. Upper limit. Format I7.

All detectors in the data file will be processed.

WF - Write an output file for storing the smoothed array F. User input is:

1. Output file filename. Format A6.

SC, DP, CH, FO, VF, PI - Oscilloscope display commands which were described for Program CORR (Section 1.3) are also available for CORL. Array F is displayed.

SS¹⁰ - Suspend Program CORL, reinitialize program parameters, and await commands.

WR - Write selected portions of array F on DECwriter. User input parameters are:

1. Answer "Y" or "N" to "OUTPUT F?". If "Y", go to item 2; if "N", item 3.
2. Detector number and lower and upper time channels to be listed. Format I7.
3. Command WR next asks if additional information is needed. Format A1. If not, WR is exited. If so, the number of detectors, the total number of channels, and the number of channels per delta-t for the data set are printed.

All subsequent questions by WR are not applicable in Program CORL and must be answered with "N". More simply, the user may type a Control S(↑S) and exit WR when item 3 is completed.

1.6 Program CONV

Program CONV converts the cross-correlated neutron count for each time channel stored in a data file to an energy scale and computes the related energy change for the channel. The user may request a hard-copy of the converted data from the DECwriter and/or graphs

---

¹⁰Two spaces.

from the COMLOT pen and ink plotter. CONV will also smooth selected portions of the converted data and plot the smoothed curve. Another option is included for producing plots of the converted data at constant steps of energy. The oscilloscope display commands for Program CORR, CALC, and COR1 are available.

Fourteen keyboard commands are available in Program CONV.

RF - Read a data file into working array F. User input is:

1. Input data file filename. Format A6.

EN - Convert cross-correlated data to an energy scale. Command EN optionally performs three operations on the correlated neutron data for each detector used in an experiment. 1) EN converts the correlated neutron count per channel to an energy scale and computes the corresponding energy change. The converted neutron count versus the changes in energy are then optionally plotted or listed on the DECwriter (or both). 2) Selected channels of the converted data may be smoothed. The smoothed portion of the spectrum may be plotted versus the matching energy changes or listed on the DECwriter. 3) Constant steps of energy may be calculated and plotted (and/or listed) versus the corresponding interpolated converted data.

The user may optionally skip any of the three sections for each detector. Input parameters are:

1. Channel width. Format F10.2.
2. Elastic channel. Format F10.2.
3. Incident wavelength and wavevector constants. Format 2F10.2.
4. Low channel and high channels defining portion of spectrum to be converted. Format 2I10.
5. Background channels. Format 2I10. Enter zeroes if the background channels are not to be subtracted.

Note: Items 1-5 are common to all detectors within a data file and will be requested only once. Items 6-12 are unique for each detector and will be required for each one.

6. The background count and then the maximum and minimum counts in the portion of the spectrum defined by item 4 are printed. EN then requests "MINIMUM AND MAXIMUM HISTOGRAM LIMITS=" for plotting purposes. If the user does not want the plot limits to be determined by the minimum and maximum counts in the selected portion of the spectrum, a new range can be inputted here. Format 2I10.

If the user has no interest in the detector being processed, zeroes may be inputted for item 6. This causes all calculations and plots for the current detector to be omitted and EN will proceed to the next detector.

7. If item 6 is not equal to "0", EN then proceeds to the first of the three operations -- converting the selected channels to an energy scale. EN then prompts the user to select the output medium by typing "0", "1", "2", or "3". "0" produces a plot, "1" produces a DECwriter list, "2" produces both, and "3" indicates no hard copy. Format I10.
8. EN proceeds to the second operation, which is smoothing the converted data, by requesting a resolution Gaussian width (W_0). Format F10.2.
9. If W_0 does not equal "0", EN smooths the spectrum and requests the user's output medium (see item 7). Format I10.
10. As in the first operation, the maximum and minimum counts in the smoothed spectrum are listed. If the user wishes to alter the plot limits, he/she may do so here in response to "MINIMUM AND MAXIMUM LIMITS=". Format 2I10.

11. EN proceeds to the third operation -- finding constant energy steps and the corresponding interpolated converted data. EN calls for energy step size and the first energy step (DELTA E and EO). Format 2F10.0.

If the user sets $EO = 0$, EN will default to the first energy step of the portion of the spectrum being processed. Sometimes for publications or slides of the plots, the user may want to choose a rounded-off number for EO. When EO is not equal to "0", EN then asks for a graph increment. This represents the energy increment per inch on the graph. Therefore, by carefully choosing DELTA E, EO and the width of the graph (see command WD below), the user may produce a custom plot rather than letting the program determine the scales and dimensions.

12. EN next asks the user's output medium (see item 7).

Items 6-12 are repeated for each detector in the data file. After the last detector is processed, EN asks the user if he/she wishes to write the converted data (array F) on a disk file. If so, EN executes command WF (see below).

WF - Write a data file. User input is:

1. Output data file filename. Format A6.

SC, DP, FO, CH, PI, VF - Oscilloscope display commands which were described in Section 1.3 are also available for CONV. Array F is displayed.

WR - Write selected portions of array F on the DECwriter. User input is:

1. Answer "Y" or "N" to "OUTPUT F?". If "Y", go to item 2.

2. Detector number and upper and lower channels to be listed.
Format I7.

SS¹¹ - Suspend CONV, await commands. No user input.

WD - Select plot width in inches. (Default width = 10.) User input is:

1. Plot width. Format I7.

HC - The user may interrupt EN if it is desired to use another command and resume the plotting at a later time on the current detector without having to start over with detector 1. For instance, after EN processes detector 1, the user may want to change the plot width or view the spectrum with the display commands. After using WD or SC, HC may be called to resume processing with detector 2. Command EN is resumed at item 4 (see EN description). Items 4-12 are then executed as described above.

EC - Command EC allows the user to select a different smoothing factor, W_0 . If, during the execution of the second operation (smoothing segment) of command EN, the user decides from the output that the W_0 factor should be altered, EC may be called. EC restarts EN at item 8 (see description of EN above) and the smoothing calculations will be repeated. Items 8-12 are then executed as described above.

1.7 Program XY15

Program XY15, like Program CONV, converts the cross-correlated time-of-flight data stored in a data file to an energy scale and computes the related energy change for each time channel.

---

¹¹Two spaces.

Program XY15 will then plot the converted data on the COMLOT plotter or draw histograms of the data on the DECwriter.

Twelve commands are available with XY15.

RF - Read a data file into working array F. Format A6. User input is:

1. Input data file filename. Format A6.

HS - Produce a histogram of the converted data and/or a pen and ink plot of the converted counts versus energy change. User input variables are:

1. Channel width. Format F10.2.
2. Elastic channel. Format F10.2.
3. Lattice vectors. Format 2F10.2.
4. Incident wavelength and wavevector constants. Format 2F10.2.
5. Low and high channels defining portion of spectrum to be converted and the channel grouping for plotting purposes (usually "1"). Format 3I10.
6. Background channels. Format 2I10. If the user enters "0" for item 6, no background channels will be subtracted. Furthermore, the correlated data will not be converted to an energy scale but will be used in the histogram in its original form (as produced by Program CORR and as read from the data file by command WF).
7. Specify "0" for COMLOT plots, "1" for DECwriter histograms, or "2" for both.

Note: Items 1-7 are common to all detectors within a data file and will be requested only once. Items 8-9 are unique for each detector and will be required for each one.

8. The background count (if any) and then the minimum and maximum counts in the portion of the spectrum defined by item 5 are listed. If the user wants the plotting limits to be something other than the two values just listed, new ones may be inputted here when HS prints "MINIMUM AND MAXIMUM HISTOGRAM LIMITS =". Format 2I10. Setting these limits to "0" will suppress both a plot and histogram but will cause the count versus energy change for each channel to be listed on the DECwriter in table form.
9. Input "CRYSTAL AND SCATTERING ANGLES=". Format 2F10.0. Setting these angles equal to "0" lessens the amount of DECwriter output for a detector.

HC - The user may interrupt HS if it is desired to use another command and resume the plotting at a later time on the current detector without having to start over with detector 1. For instance, the user could interrupt HS after detector 1 is processed, use command SC or WR to examine the data file, and then resume processing with detector 2. Command HC "remembers" the point at which HS was interrupted and when called restarts HS at that point. Items 5-9 are then executed as described above.

WF - Write a data file. User input is:

1. Output data file filename. Format A6.

SC, DP, FO, VF, PI, CH - Oscilloscope display commands which were described in Section 1.3. Array F is displayed.

WR - Write a selected portion of array F on the DECwriter. User input is:

1. Answer "Y" or "N" to "OUTPUT F?". If "Y", go to item 2.

2. Detector number and upper and lower channels to be listed.

Format I7.

SS - Suspend XY15, await further commands. No user input.

SECTION 2. MISCELLANEOUS INFORMATION

2.1 Formatting DECTapes

The tape formatting program, which is stored on a paper tape labeled "DECTape Format Generator TC02", is read into location 17700 by setting the console address switches, depressing the STOP and RESET switches, and finally the READIN switch. The program, which is self-starting, asks for the logical unit of the DECTape drive loaded with the virgin tape and for formatting criteria. The user indicates that a standard format is desired, sets the "WRTM-NORMAL-RDMK" switch (located below the tape drives) to "WRTM" as instructed by the program. The tape is then mounted, two wraps are taken up, and the "WRITE ENABLE" and "REMOTE" switches are set. Striking any key on the DECwriter then starts the formatting.

After the tape is formatted in one direction, the user resets the "WRTM-NORMAL-RDMK" switch to "NORMAL" and again strikes a key to initiate the formatting process in the other direction. The tape should not run off the reel after the first half of formatting; however, due to an occasional short tape or mark track inconsistency, the tape may run off the reel and must be manually rewound about two wraps before continuing the formatting in the opposite direction.

Before using the tape, a directory file must be created on the tape by use of the "N DTx" (x is the logical unit number of the DECTape drive) command of the utility program, PIP.

2.2 Restoring DECdisk from DECTape

In case of an unrecoverable disk error, the contents of the disk may be restored from backup DECTape in the following way:

One side of the disk provides about the same storage capacity as a DECTape. The current contents of the disk were stored on two DECTapes by the PIP command "C DTx (H) +DKy". The DECTapes are labeled "DK0" and "DK1". Care should be taken to use the newest

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version of DECTape "DK1" as there may be several older systems kept on hand.

The V5A DECTape Monitor is loaded into core from DECTape physical unit number 8 with the V5A DECTape bootstrap (location 57637). .DAT slots 1 and 2 are then assigned to the disk handler DK1. The first of the backup tapes is mounted on DECTape drive 1 or 2 and copied to the disk with the PIP command "C DKy (H) <DTx".

IMPORTANT: Because of an error in program PIP, massive files such as .LIBR5 BIN are sometimes copied incorrectly by the "C dest. dev. (H) <source dev." command so that checksum errors result. An attempt by the Linking Loader to later load files from .LIBR5 BIN then results in a ".LOAD 2" error condition. To avoid this, copy .LIBR5 BIN explicitly by use of the "T" command ("T dest. dev. .LIBR5 BIN <source dev. .LIBR5 BIN") after using the "C" command.

After replacing both sides of the disk, the user should use the disk bootstrap to load the V5A DECdisk Monitor into memory.

2.3 User File Structure

All user files are written in Dump Mode, which is one of several modes supported by the Advanced Monitor Software System. Dump Mode data are always binary. The Dump Mode was selected because it makes the most efficient use of DECTape and DECdisk since data are stored back to back in the 255-word blocks without headers. (Other modes require a two-word descriptive header in each block.) Also, in Dump Mode, I/O operations are faster because data are moved directly to or from any core memory area, bypassing the use of line buffers.

Each DECTape, when formatted as described in Section 2.1, can hold up to 56 user files and has 578 blocks (256 words per block) of storage. DECdisk also has a maximum of 56 user files and has 512

blocks of user storage per side. Each file has an ASCII filename (maximum of six characters) and filename extension (three characters). Files are constructed so that they may reside either on DECdisk or DECTape, depending on the user's choice as reflected in the assignment of .DAT slots. That is, user files created by the programs described in Section 1 are device independent and therefore any mass storage device may be used. The files may also be freely moved between DECdisk and DECTape by use of utility program PIP.

User files generated and used by the programs described in Section 1 are in one of three formats. The first is the pseudorandom sequence file which always has a filename and filename extension of the form SEQFx BIN where x is any single alphanumeric character. A sequence file has a maximum length of 52 words (or 936 sequence bits) and is created by program PREP (see Section 2.9).

The sequence file is read from logical unit number 10, so that the device assigned to .DAT slot 10 is expected to contain the file. An 'IOPS 13" (file not found) error occurs if the file is not on logical unit 10. Slot 10 is permanently assigned to DECdisk 1 (DK1). The user can, of course, reassign the slot prior to executing the program.

The second type of user file may hold the time-of-flight data from program COLL, the cross-correlated data from program CORR, or the data which have gone through various kinds of analyses and alterations by programs CALC, COR1, XY15, and CONV. In other words, the spectra (in any form) reside on files with the following format:

Word 1 - number of detectors (maximum 32)

Word 2 - total number of channels (number of detectors
times number of sequence bits times number of
channels per delta-t) (maximum 14800)

Word 3 - number of channels per delta-t (maximum 936)

Word 4 - neutron count for first time channel of first
detector

Word n - neutron count for last time channel of last detector

"n" equals the content of Word #2 plus 3 and cannot exceed 14803. Words #4-n contain sequential histograms from each detector. Due to memory storage limitations, the total buffer and, hence, total number of time channels in any one experiment is 14800 or fewer. Files of this kind are read from logical unit number 2 which is permanently assigned to DECTape 1. The assignment can be changed prior to program execution.

File ANGLES BIN is the third kind of user file and it resides on logical unit number 10 (normally DK1). File ANGLES, as pointed out in Sections 1.1 and 1.2, stores the six motor positions and certain experimental parameters so that the user need not input these variables unless they have changed since the previous run. File ANGLES has 43 data words:

Words 1 through 6	- motor positions
Words 7	- number of detectors
Words 8 through 39	- detector identification numbers
Word 40	- number of sequence bits
Word 41	- last delta-t in the sequence
Word 42	- number of channels/delta-t
Word 43	- sequence file identifier

2.4 Permanent .DAT Assignments

At system generation time, the device assignment table is established for relating logical units to physical units. Each .DAT is given a physical device unit number along with a pointer to a selected device handler. All program I/O then references .DAT slot numbers (or logical unit numbers). The user can override these permanent assignments by using the ASSIGN Monitor Command immediately before loading a program. After the program has completed and the

Monitor has regained control (or when the Monitor has been reinstated by other means, such as a Control C), the permanent slots are reloaded. Negative .DAT slots are used by system programs (except PIP, which also uses all positive slots) and positive slots are reserved for user programs. The permanent device assignment table is:

<u>.DAT Slot</u>	<u>Device and Handler</u>	<u>Use</u>
-15	DKA1	Output (EDIT, UPDATE, SGEN)
-14	DKA1	Input (EDIT, UPDATE, SGEN)
-13	DKA1	Output (MACRO, F4)
-12	TTAO	Listing (MACRO, F4, UPDATE)
-11	DKA1	Input (MACRO, F4)
-10	DKA1	Secondary Input (EDIT, UPDATE, SGEN, MACRO)
-7	DKCO	System Loader
-6	DKB1	System Loader
-5	DKD1	User Library .LIBR5 BIN (LOAD)
-4	DKD1	Input (LOAD)
-3	TTAO	System Output
-2	TTAO	System Input
-1	DKDO	System Library (LOAD)
1	DKA1	Unused
2	DTD1	User I/O (COLL, CORR, CALC, COR1, XY15, CONV)
3	TTAO	User DECwriter Input (all programs)
4	TTAO	User DECwriter Output (all programs)
5	CPAO	User Plotter Output (XY15, CONV)
6	PPAO	User Paper Tape Output (COLL)
7	PRAO	User Paper Tape Input in BATCH MODE (MAINM, COLL)
10	DKD1	User I/O (MAINM, COLL)

2.5 Older Version of MAINM

Prior to April 1976, a motor drive and scan program (Program MAINM) written by L. W. Gilley was in use at HB-4. It was replaced by a new program (also called MAINM) which is currently being used. The older MAINM, however, was kept in the event some future need for it should occur. The older version, along with its library, resides on DECdisk 0 (DKO) and can be loaded with the following sequence:

```

KM15 V5A
$ A DKA0 -4, -5 (cr)
$ LOAD (cr)
> +MAINM (altmode)
↑S ↑S

```

The older MAINM is documented in *Setup and Control Routines for a Pulsed Neutron Time-of-Flight Spectrometer*, ORNL/TM-3683, February 1972.

2.6 System Crash

In the event of a system failure where the monitor does not respond to a Control C from the DECwriter, four steps may be taken in attempting to restore the system.

The first is to assume that the resident Monitor is still correctly in memory. If so, it can be restarted by depressing the STOP and RESET switches, loading 77646 into the console address switches and pressing START. If the system restarts, "KM15 V5A" is outputted on the DECwriter.

A failure of step one to restart the system indicates that the Monitor has been destroyed in memory and must be reloaded from DKO. The system can be bootstrapped into memory with the ".RFSBT B11 Multi-Core Equal Units" loader on paper tape. Depress STOP and RESET, load address 77637, and depress the READ IN switch.

If step two fails, one must assume that the contents of the disk are destroyed and the disk must be restored as outlined in Section 2.2.

If the disks cannot be restored, the operator may, as a last resort, use the V5A DECTape operating system with DECTape as the system device (see Section 2.7).

2.7 DECTape as System Device when Disk is Down

The V5A DECTape Monitor is loaded into memory from DECTape unit number 8 with the "V5A Multi-Core Equal Units" bootstrap (location 77637). All user programs and the user library .LIBR5 BIN (which are used in the V5A DECdisk-based system) are located on the backup DECTape for DK1 labeled "DK1". This tape should be loaded on DECTape drive 2.

User programs were written so that they are executable in either a disk-based operating system or a DECTape-based operating system as long as .DAT slot assignments are correct. All user data files reference .DAT slots 2 and 10 (as described in Section 2.3). In the disk-based system, slot 10 references the disk for the sequence files and file ANGLES. In the DECTape-based system, slot 10 is permanently assigned to DECTape drive 2, on which is already mounted the tape labeled "DK1" which contains the user programs and the sequence and ANGLES files. In both disk and DECTape systems, slot 2 is assigned to DECTape drive 1 for all other user data files. The loading sequence for any user program (after the DECTape drives are mounted as described above) is:

```

KM15 V5A
$ LOAD (cr)
> +program name (altmode)
↑S ↑S

```

2.8 Retrieval of Data Set After System Crash

If a hardware failure occurs which shuts the system down during a time-of-flight data collection period, the data set may, depending on the nature of the breakdown, still be recoverable. First, an attempt to dump the data on DECTape should be made by use of subprogram OP. If OP can be restarted successfully, the data will be written on DECTape in exactly the same manner as does the command OP. To restart OP, consult the program COLL load map for the starting address of OP, set the console address switches to the address of OP + 1. Press STOP and RESET, then START.

If OP fails to restart, subprogram HELP of program COLL may be used in an effort to dump the data set on paper tape. The address of HELP + 1 is loaded in the switches and the STOP, RESET, and START switches are pressed.

If HELP is successful in dumping the data on paper tape, user program TTAPE may be used later for moving the data from paper tape to a disk file in the format acceptable to all user programs. Program TTAPE uses slot 5 as the input device; therefore, assign the paper tape reader (PRAO) to slot 5. The output device is slot 2, which is already assigned to DECTape 1 (DTD 1). The loading sequence is:

```
KM15 V5A
$ A PRAO 5 (cr)
$ LOAD (cr)
< TTAPE, BLOCK, RWFILE (altmode)
↑S ↑S
```

2.9 Creating a New Sequence File

Program PREP (on DK1) is used to generate new sequence files on DK1. PREP must be edited to create a new filename by changing the statement "NAM .SIXBT 'SEQFx@BIN'" so that x is a new alphanumeric character. PREP is then assembled and loaded. When the user starts the program with a control S, the processor halts and the user toggles the new sequence into memory beginning at location 77550. After input to the console data switches is completed, the CONTINUE switch is pressed and PREP writes the new file on DECdisk 1.

2.10 Location of Software Listings

Current hard-copy listings of all user programs, load maps, and the user library (.LIBRS BIN) are located in the file cabinet in the HB-4 computer room. DECTapes having files containing all user programs for the 24K system (both source and object listings) are found in the bin above the DECTape transports. DECTapes having all current user programs for the 32K system are located in the file cabinet along with DECTapes backing up both sides of the disk. Also found here is the original software provided by Digital Equipment Corporation (both on hard-copy and DECTapes).

2.11 Batch Mode Processing

It is sometimes desirable to perform lengthy experiments which require alternating equipment positioning and data collecting without the necessity of frequent user supervision and control. Since all software (user programs MAINM and COLL and attendant system programs) necessary to perform both positioning and collecting functions cannot be memory-resident, a method was devised for swapping the appropriate programs from disk to memory as they are needed. A Batch Processor, which uses the paper tape reader as its input device, coordinates the swapping process.

In the Batch Mode of operation, both data required to instruct the Batch Processor and data required by the user programs will reside on paper tape. Each user program to be loaded and executed by the Batch Processor must be preceded by a "\$JOB" statement in the input stream. A "\$EXIT" signals an exit from the Batch Mode back to the normal Monitor Mode. Input data required by the user programs MAINM and COLL are exactly the same in quantity and format as when these programs are executed in the Monitor Mode.

Program MAINM commands available in Batch Mode are:

- PA - Output angles on DECwriter and store in file "ANGLES"
- IC - Input current angles and store in file "ANGLES"
- IF - Input desired angles, drive to desired positions, and store in file "ANGLES"
- CL - List and change PHI1, PHI2, PHI3 limits
- SS - Reinitialize program parameters and await commands
- XM - Exit from Program MAINM.¹²

Program COLL commands available in Batch Mode are:

- IP - Input experiment parameters and store in file "ANGLES"
- IT - Input experiment running time
- CD - Collect and display data
- ID - Interrupt data collection
- RD - Resume data collection
- OP - Output data at end of experiment
- Space Space - Reinitialize program parameters and await commands
- XC - Exit from Program COLL.¹²

Example: A paper tape for controlling the following experiment in Batch Mode is listed below. Position Two Theta-M at 75°, collect data for 5 minutes, drive Two Theta-M to 80°, and

---

¹²New commands for transferring control from user program back to Batch Processor. All other commands are identical in both Batch and Monitor Modes.

collect data for 10 minutes. (Notice that in the second collection period, it is assumed that all experiment parameters are the same as during the first period and therefore that only "IT", not "IP", need be called.)

After positioning the tape in the reader, input the following command to the DECwriter: "BATCH PR or "B PR".

```
$JOB (cr, lf)
GLOAD (cr, lf)
+MAINM (altmode)
PA (cr, lf)
IP (cr, lf)
1 (cr, lf)
TTH (cr, lf)
75.(cr,lf)
XM (cr,lf)
$JOB (cr, lf)
GLOAD (cr, lf)
+COLL (altmode)
IP (cr, lf)
4 (cr, lf)
1 (cr, lf)
2 (cr, lf)
3 (cr, lf)
4 (cr, lf)
121 (cr, lf)
0 (cr, lf)
2 (cr, lf)
1 (cr, lf)
0 (cr, lf)
5 (cr, lf)
CD (cr, lf)
XC (cr, lf)
$JOB (cr, lf)
```

```

GLOAD (cr, lf)
+MAINM (altmode)
IF (cr, lf)
1 (cr, lf)
TTH (cr, lf)
80.(cr, lf)
XM (cr, lf)
$JOB (cr, lf)

GLOAD (cr, lf)
+COLL (altmode)
IT (cr, lf)
0 (cr, lf)
10 (cr, lf)
CD (cr, lf)
XC (cr, lf)
$EXIT (cr, lf)

```

NOTE: The paper tape leaders can be made up of rubouts.

When the system is under control of the Batch Processor, input from the DECwriter is ignored except for Control C and Control S. The Control C, as always, places the system in Monitor Mode and suspends Batch Mode. The Control S also performs the same function in Batch Mode as in Monitor Mode -- that is, it causes a software interrupt of the user program and puts the system in a wait state pending a new command from the keyboard. Simultaneously, in Batch Mode, it primes the system to read the next command (and data called for by that command) from the DECwriter instead of the paper tape reader. This function was retained in Batch Mode processing to give the user a chance to insert commands at will from the keyboard that are not included in the input data stream on paper tape. After the Control S and subsequent keyboard command have been recognized and serviced, the Batch Processor returns to the paper tape input stream and searches for the next two-character command.

- NOTES: 1. In Batch Mode, an IOPS4 (device-not-ready error message) is a nonrecoverable error and will cause an immediate return to Monitor Mode. The Control R cannot be used to recover as in the Monitor Mode. For this reason, the user output device (normally DT1) must be left WRITE ENABLED and in REMOTE mode. Otherwise, the data set will be lost.
2. When reading the input data from paper tape, if the Batch Processor encounters an unrecognizable character or command, it goes to the next "\$JOB" statement.

2.12 Summary of Keyboard Commands

Program COLL

IP - Input parameters
 IT - Input time
 CD - Collect data
 OP - Output data
 DP - Display data on scope
 ID - Interrupt data collection
 RD - Resume data collection
 LP - List parameters
 SS - Suspend program execution
 XC - Exit from program COLL

Program MAINM

IC - Input current motor positions
 CL - Change motor limits
 IF - Input final motor positions
 PA - Print angles
 DN - Detector numbers during scan
 NS - Number of scan steps
 SW - Scan step period
 ST - Scan step size
 RN - Run a scan

SS - Suspend program execution

XM - Exit from program MAINM

Program CORR

RE - Read data file

CO - Cross-correlate data

WR - Write selected data on DECwriter

DP - Initiate display variables

SC - Display data on scope

FO - Input display scale parameters

VF - Input display vertical adjustment factor

CH - Input display channels

PI - Input display points increment

SS - Suspend program CORR

Program CALC

AD - Add data files

AC - Add channels

AV - Average channels

DV - Divide data by constant

SU - Subtract a constant from data

GO - Conclude operations initiated by commands AD, AC, AV, DV, and SU

WR - Write selected data on DECwriter

SC, DP, FO, VF, PI, CH - Same as for program CORR

SS - Suspend program CALC

IN - List data file information

SB - Subtract data files

CC - Combine channels

Program COR1

RF - Read data file
CF - Smooth data
WF - Write file on DECTape
SC, DO, CH, FO, VF, PI - Same as for program CORR
SS - Suspend program COR1
WR - Write selected data on DECwriter

Program CONV

RF - Read data file
EN - Convert data to energy scale
WF - Write file on DECTape
SC, DP, FO, CH, PI, VF - Same as program CORR
WR - Write selected data on DECwriter
SS - Suspend program CONV
WD - Select plot width
HC - Resume plotting after interruption
EC - Select spectrum to be smoothed

Program XY15

RF - Read data file
HS - Produce histogram
HC - Resume plotting after interruption
WF - Write file on DECTape
SC, DP, FO, VF, PI, CH - Same as program CORR
WR - Write selected data on DECwriter
SS - Suspend program XY15