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Dounreay Shuftier Diagnostic Software Operations Manual

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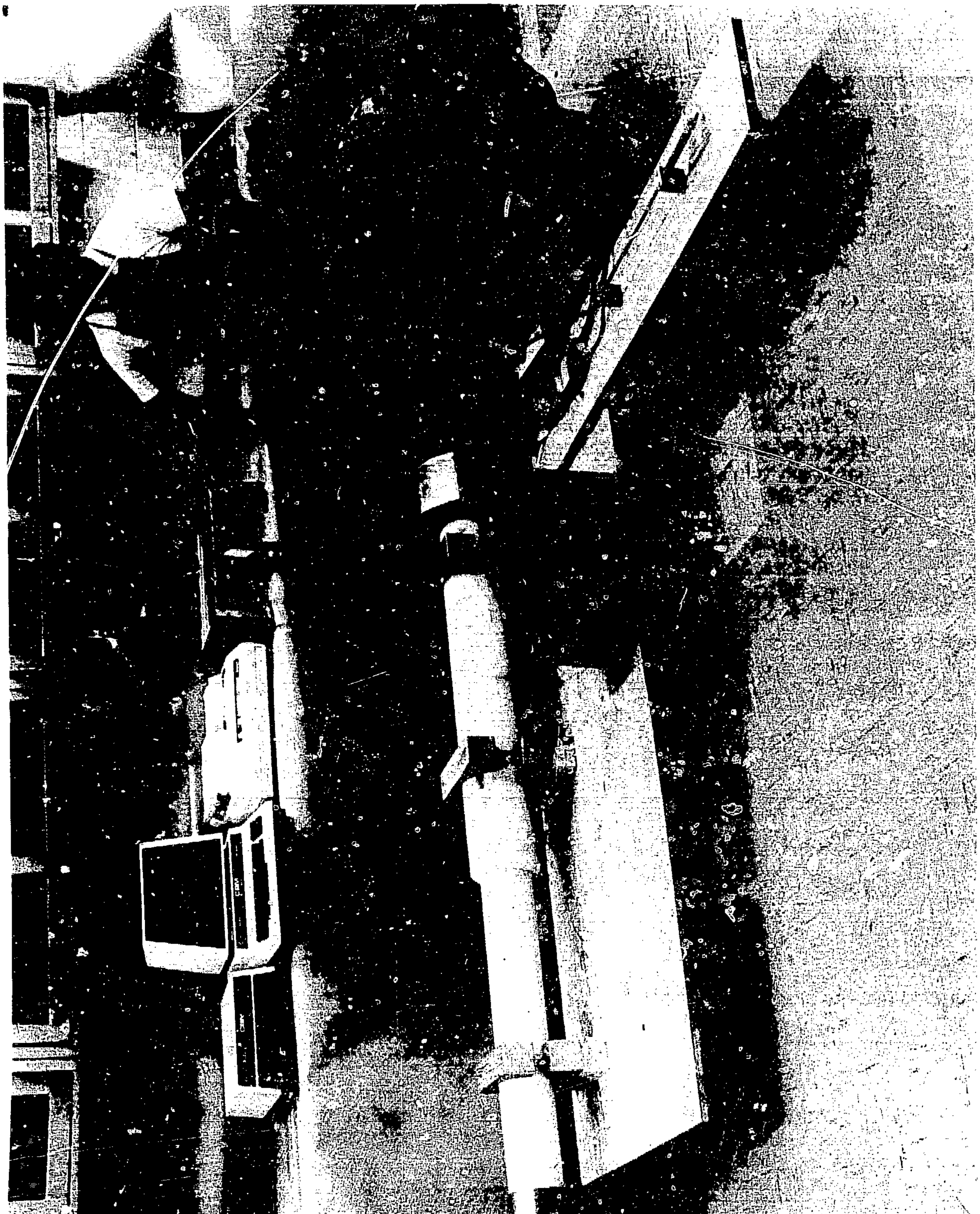
DOUNREAY SHUFFLER DIAGNOSTIC SOFTWARE OPERATIONS MANUAL

by

G. W. Eccleston, B. Stuewe,
S. Klosterbuer, and T. Van Lyssel

ABSTRACT

This operations manual describes the test software for the Dounreay Shuffler. The Shuffler is an assay system, controlled by a Commodore PET computer, that measures the plutonium content in leached hulls at the fuel reprocessing plant in Dounreay, Scotland. The Shuffler contains a ^{252}Cf neutron source that is moved between storage and irradiation locations to obtain measurement data. A stepping motor control (SMC) module operates the Shuffler and accepts commands from the PET to move the source. This manual briefly describes the Shuffler and provides details on running and using the diagnostic software test program. The communications protocol for message transmittal between the PET and SMC is defined and a detailed example of message sending is presented in an appendix.



The Dounreay Shuffler is designed to nondestructively measure the plutonium content in leached hulls at the Dounreay, Scotland, Prototype Fast Reactor (PFR) fuel reprocessing facility. The hulls are measured in a 200-mm-diam by 1-m-tall stainless steel basket. The hot cell crane automatically handles and positions the basket for measurements. The baskets are measured by scanning them in 100-mm segments.

The figure on the facing page is a photograph of the Dounreay Shuffler assay system. A stepping motor control (SMC) module mounted in a Harwell 6000 series crate controls the Shuffler.

The assay of plutonium content consists of collecting a neutron background and then running a cyclical sequence to measure delayed neutrons. This sequence starts with the ^{252}Cf neutron source moving to an irradiation position near the sample. In this source position, fissions will be induced in the plutonium in the sample. Following the irradiation period, the source is moved to the storage position, and delayed neutrons resulting from plutonium fissions are counted. This irradiation-and-counting sequence is continued for the number of cycles specified by the operator. The sample is then moved to the next segment, and the measurement procedure is repeated. After the measurements are completed, the delayed-neutron counts are summed and, with a calibration fit, the plutonium mass in the sample is determined.

This manual describes the software that tests each component of the Dounreay Shuffler assay system. The manual is primarily a reference document for the Shuffler diagnostic program. A complete listing of the NDA5TST diagnostic program is in Appendix E. Detailed information on the complete system and the assay program is in the Harwell System NDA5 operations manual for the neutron interrogation system.

SYSTEM CONFIGURATION

Major components composing the Shuffler instrument are shown in Fig. 1. Table I lists the components and gives a brief description.

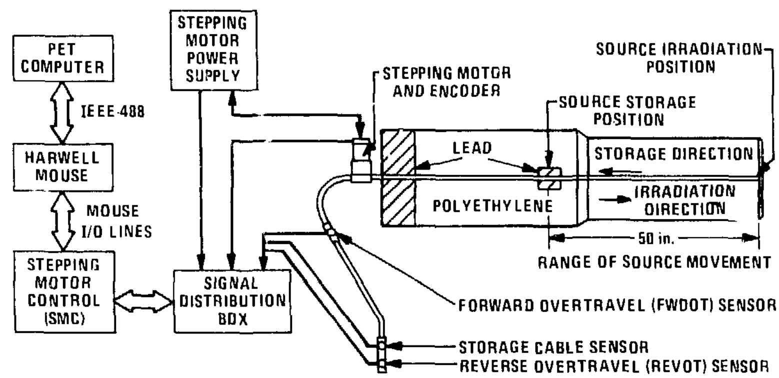


Fig. 1. Shuffler component diagram.

PROGRAMS

The following programs supplied with the Shuffler are contained on a floppy diskette:

Diagnostic program document	- NDA5TST.DOC
Diagnostic program	- NDA5TST
Example assay program document	- NDA5LA.DOC
Example assay program	- NDA5LA.

The document files (NDA5TST.DOC) and (NDA5LA.DOC) briefly describe the NDA5TST and NDA5LA programs. The diagnostic program (NDA5TST) operates and tests the Shuffler to help isolate problems. NDA5LA is a program containing examples that illustrate features required in the Shuffler assay program.

TABLE I

SHUFFLER COMPONENT DESCRIPTION

Item	Description
1. PET computer	Runs test and assay programs
2. Harwell MOUSE	Contains timer, scalers and provides communication between PET and SMC
3. Stepping motor control module (SMC)	Motorola 6809 computer card that communicates with the PET and controls the stepping motor
4. Signal distribution box	Provides signal interface between stepping motor and SMC
5. Stepping motor	Moves source between store and irradiate positions as controlled by the SMC module
6. Power supply	Powers the stepping motor
7. Storage sensor	Senses when the source has reached the storage position (see Fig. 1)
8. Reverse overtravel sensor	Senses when the source has reached the reverse overtravel position (see Fig. 1)
9. Forward overtravel sensor	Senses when the source has reached the forward overtravel position (see Fig. 1)
10. Californium source	Neutron source to provide sample irradiation
11. Teleflex cable	Connected to source and runs through gear attached to stepping motor to allow source movement
12. Storage position	Shielded position in center of tube
13. Irradiation position	Position at end of tube near sample

PET COMPUTER

The PET computer runs the test and assay programs. The PET sends commands to the SMC module through the Harwell MOUSE module to transfer the source to either the irradiation or the storage position for measurements.

HARWELL MOUSE

The MOUSE module was developed by Harwell and contains a timer, scalers, and input/output (I/O) lines. The high byte of the I/O lines is used to communicate between the PET and SMC. The low byte is not used in these communications.

SMC MODULE

The SMC module contains a Motorola 6809 microprocessor and digital logic to control the Shuffler. The module interfaces with the Shuffler through a signal distribution box. Software contained in read-only memory (ROM) in the SMC module communicates with the PET computer through the MOUSE I/O lines. The software controls movement of the ^{252}Cf source contained in the Shuffler.

Connector Slots

A front-panel view of the SMC module is shown in Fig. 2 (see also Fig. B-1 in Appendix B). The front panel contains two connector slots (P1 and P2). Connector P1 accepts a ribbon cable that routes the Shuffler control lines to the signal distribution box. Connector P2 accepts a nonstandard RS232 connector and allows a terminal to directly control and test the module.

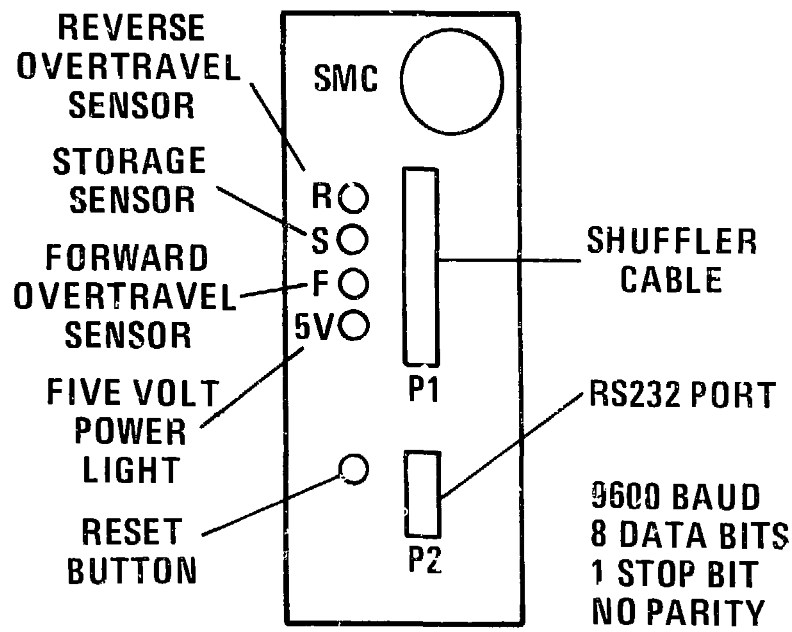


Fig. 2. Front panel of the SMC module.

Reset Button

The RESET push-button switch on the front panel allows the Motorola computer software in the SMC module to be manually reset and initialized. Push this button when the system is initially started or not performing properly.

Sensor Lights

The red F and R light-emitting-diodes (LEDs) on the front panel indicate that the source cable has moved too far in either the forward (F) or reverse (R) direction. When the forward over-travel sensor is unblocked, the F LED turns on. When the reverse over-travel sensor is blocked, the R LED turns on. The motor is stopped when one of these sensors is triggered. The green (S) LED comes on when the storage position sensor is blocked by the end of the source cable and indicates that the

Sensor Lights (cont)

source is in the storage position. The LED labeled 5 V shows that the module has 5-V power.

NOTE: When the source is in the storage position, the proximity sensors should read:

Reverse over-travel sensor -- Unblocked → LED off
Storage sensor -------------- Blocked → LED on
Forward over-travel sensor -- Blocked → LED off

MECHANICAL SYSTEM

The mechanical portion of the Shuffler is constructed primarily from polyethylene and lead, and it fits into the hot cell port in the existing PFR fuel reprocessing facility in Dounreay. The Shuffler contains a tube that guides a ^{252}Cf neutron source between the storage and irradiation positions. The source is connected to a Teleflex cable and is moved by a gear attached to a stepping motor. Three proximity sensors mounted on the cable takeup tube detect the end of the cable and provide control information for positioning the source in the instrument (see description of sensor lights above).

^{252}Cf SOURCE

The Shuffler contains a ^{252}Cf neutron source. Initially, this source contained approximately 3 mg of ^{252}Cf emitting 7.0×10^9 n/s. Therefore, the source emits a large quantity of radiation and requires shielding for personnel protection. To ensure that the source is always completely shielded and kept inside the instrument, its

^{252}Cf SOURCE (cont)

movement is limited by using over-travel position sensors and mechanical stops. These stops prevent the source from moving past the reverse over-travel sensor. Appendix A contains a detailed description of the source and instructions for replacing the source in the Shuffler.

INSTRUMENT POWER

The SMC module sits in and draws 5 V of power from a Harwell Series 6000 crate. The stepping motor power supply is wired for 120-Vac, 50-Hz power. The power supply can be wired to operate from 240 Vac. Appendix B contains the descriptions and specifications of the design electronics, including the wiring schematic for the power supply.

PROGRAM FUNCTION

NDA5TST is a diagnostic program that allows each feature of the Dounreay Shuffler to be individually operated and tested.

START THE SYSTEM

Start the Shuffler instrument by turning on the ac power to the following modules:

- PET computer,
- Harwell 6000 series crate, and
- SMC module power supply.

LOAD A PROGRAM

Place a floppy disk containing program NDA5TST into disk drive unit 0. To load program NDA5TST, type

DLOAD"NDA5TST",DO (RETURN)

NOTE: The (RETURN) symbol means that you must press the return key on the PET keyboard.

RUN THE PROGRAM

To run the basic program, type

RUN(RETURN)

TO GET OUT (EXIT A PROGRAM)

Anytime you need to stop and exit a program, type

X(RETURN)

COMMANDS AND MENUS

Program NDA5TST prints a SELECT COMMAND message requesting a command:

SELECT COMMAND (H FOR HELP) -> ?

The H for HELP option lists a menu of available commands (see p. 9). Type H(RETURN) to get this list. Each time the program completes a command, it prints the SELECT COMMAND message and waits for you to type a new command.

SELECTING COMMANDS

To give the computer a command, type the correct letter (shown on the menu) and then press (RETURN). For example, to enter the command "BLOCK ALL SENSORS" in the NDA5TST program, type

B(RETURN)

PROGRAM START-UP

Running the NDA5TST program initiates a start-up sequence that resets the MOUSE module, resets the SMC module, checks that the stepping motor power supply is on, reads and displays the Shuffler status, waits 5 s, and then prints the command menu. Your interaction is required only if the stepping motor power supply is off.

COMMAND MENU

Type H(RETURN) at the SELECT COMMAND prompt to list the following command menu on the PET screen:

```
                DIAGNOSTIC MENU

A   - ASSAY CYCLE SIMULATION
T   - TEST CABLE SENSORS
L   - LIST SYSTEM STATUS
R   - RESTART STEPPING MOTOR CONTROL MODULE
O   - TURN STEPPING MOTOR ON
F   - TURN STEPPING MOTOR OFF
P   - POSITION SOURCE AT STORAGE LOCATION
I   - MOVE SOURCE TO IRRADIATION POSITION
S   - MOVE SOURCE TO STORAGE POSITION
M   - MOVE SOURCE N INCHES
B   - BLOCK ALL CABLE SENSORS
U   - UNBLOCK ALL CABLE SENSORS
D   - IRRADIATION POSITION REPEATABILITY TEST
C   - SEND A COMMAND TO THE SHUFFLER
Z   - CHANGE TIMER FREQUENCY (DEFAULT IS 50 Hz)
X   - EXIT FROM NDA5TST

SELECT COMMAND (H FOR HELP) -> ?
```

COMMAND EXPLANATIONS

A - Assay Cycle Simulation

The A option tests the Shuffler assay cycle and MOUSE scalers. This assay test lists background count rates, source transfer times, and the times and count rates associated with irradiation and delayed-neutron cycles.

T - Test Cable Sensors

The T option uses the stepping motor, stepping slowly, to unblock and then block the three proximity sensors. The test determines if the sensors are able to correctly detect when they are blocked and unblocked by the cable. Sensor errors are printed on the PET screen. Refer to p.4 for a description of the sensors.

L - List System Status

The L option lists the Shuffler instrument status. This list contains the following information:

- Location of the ^{252}Cf source,
- Stepping motor power (on or off),
- Proximity sensor status (blocked or unblocked),
- Last command sent to the SMC,
- Current command at the SMC,
- Last reply received from the SMC,
- Shuffler error status, and
- MOUSE error status.

R - Restart Stepping Motor Control Module

The R option resets the MOUSE module and sends a nonmaskable interrupt to the Motorola computer in the SMC module. This interrupt resets the Motorola software, moves the source to storage, and waits for a command from the PET computer. Errors received during the reset are listed on the PET screen.

O - Turn Stepping Motor On

The O option turns the stepping motor power on.

F - Turn Stepping Motor Off

The F option turns the stepping motor power off. The motor power should be turned off when the stepping motor is not being used to reduce heating of the motor and noise.

P - Position Source at Storage Location

The P option turns the stepping motor power on, moves the source to storage, positions it at the storage sensor, and then turns the motor power off.

I - Move Source to Irradiation Position

The I option turns the stepping motor power on, positions the source at the storage sensor, moves the source rapidly from the storage to the irradiation position, and then turns the motor power off.

Irradiation source position adjustment--the SMC contains a fixed number of steps (1244) in the ROM software to move the ^{252}Cf source from the storage to the irradiation position. You can adjust the number of steps up to 127 in both directions with an eight-position rocker switch mounted

I - Move Source to Irradiation Position (cont)	on the SMC module. Please refer to the heading Position Adjustment in Appendix B for an example of the adjustment procedure.
S - Move Source to Storage Position	The S option turns the stepping motor power on, moves the source rapidly from the irradiation to the storage position, positions the source at the storage sensor, and then turns the motor power off. If the storage sensor is blocked when you select this option, the source is repositioned at the storage sensor.
M - Move Source N Inches	The M option steps the source a selected distance of N inches. You select both the direction and distance to move the source. Movement in the irradiation direction is into the Shuffler, and movement in the storage direction is out of the Shuffler. NOTE: If an over-travel sensor is activated, then source movement in that direction stops.
B - Block All Cable Sensors	The B option turns the stepping motor power on, moves the source slowly out of the Shuffler (storage direction) until all the proximity sensors are blocked, and then turns the motor off. Selecting the L option after the B option lists the Shuffler status, showing the status of the sensors.

U - Unblock All Cable Sensors

The U option turns the stepping motor power on, moves the source slowly into the Shuffler (irradiation direction) until all the proximity sensors are unblocked, and then turns the motor power off. Selecting the L option after the U option lists the Shuffler status, showing the status of the sensors.

D - Irradiation Position Repeatability Test

The D option tests the repeatability of positioning the source at the irradiation location. You specify the number of times (N) to reposition the source. This option moves the source rapidly from the storage to the irradiation position and then single-steps the motor, counting the number of steps, in the irradiation direction until the forward over-travel sensor is unblocked. This number is printed on the screen and should be repeatable within a few steps. The mean and the standard deviations of the number of steps to unblock the sensor are calculated and displayed on the PET screen.

> **NOTE:** Accurate repositioning of the irradiation source keeps a more constant neutron flux on the sample and provides better precision in assay measurements.

C - Send a Command to the Shuffler

The C option allows you to select and transmit communication commands from the PET computer to the SMC module and then check for correct transmission with the L option. Selecting the C option prints the following list on the PET screen:

C - Send a Command to the Shuffler (cont)

SHUFFLER COMMANDS

1 - STEPPING MOTOR OFF
2 - STEPPING MOTOR ON
3 - POSITION SOURCE AT STORAGE
4 - TRANSFER FROM STORE TO IRRADIATE
5 - TRANSFER FROM IRRADIATE TO STORE
6 - BLOCK ALL SENSORS
7 - UNBLOCK ALL SENSORS
8 - SET MOTOR DIRECTION TOWARD IRRADIATE
9 - SET MOTOR DIRECTION TOWARD STORAGE
10 - MOVE SOURCE ONE STEP

SELECT COMMAND(X TO EXIT H FOR HELP) -> ?

Command Example A--Using the C option, you can determine whether the stepping motor is taking steps. For example, select movement in the irradiation direction and then make the motor take two steps. The commands you need to select are as follows:

Command 2 - STEPPING MOTOR ON
Command 8 - SET MOTOR DIRECTION TOWARD IRRADIATE
Command 10 - MOVE SOURCE ONE STEP
Command 10 - MOVE SOURCE ONE STEP
Command 1 - STEPPING MOTOR OFF

C - Send a Command to the Shuffler (cont)

The dialog on the PET screen for the above five commands is as follows:

```
SELECT COMMAND (H FOR HELP) -> ?C

SELECT COMMAND(X TO EXIT H FOR HELP) -> ? 2
SELECT COMMAND(X TO EXIT H FOR HELP) -> ? 8
SELECT COMMAND(X TO EXIT H FOR HELP) -> ? 10
SELECT COMMAND(X TO EXIT H FOR HELP) -> ? 10
SELECT COMMAND(X TO EXIT H FOR HELP) -> ? 1
SELECT COMMAND(X TO EXIT H FOR HELP) -> ? X

SELECT COMMAND (H FOR HELP) -> ?
```

Command Example B--The command mode tests error conditions. For example, send an invalid command to the Shuffler. The valid commands range from zero through ten, so in the command mode input the number 12. The following sequence should appear on the PET screen:

```
SELECT COMMAND(X TO EXIT H FOR HELP) -> ?
12 RETURN)

#11 INVALID COMMAND SENT BY PET COMPUTER

SELECT COMMAND(X TO EXIT  H FOR HELP) -> ?
```

The second line of the above sequence is an error message. Error message No. 11 indicates that an invalid command was sent. The C option test for error conditions is used to produce error messages either 11, 12, or 14 (see Appendix C for error

C - Send a Command to the Shuffler (cont)

messages). Another error situation would be attempting to move the source using command 4 without first turning on the motor power supply using command 2. This situation will produce error number 12, a general error.

Command Example C--Usually, you use the I option on the main menu to transfer the source rapidly to the irradiation position. To do the same task using the C command, you must do the following:

Command 2 - STEPPING MOTOR ON
Command 4 - TRANSFER FROM STORE TO IRRADIATE
Command 1 - STEPPING MOTOR OFF

The dialog on the PET screen for the above three commands is as follows:

```
SELECT COMMAND(X TO EXIT H FOR HELP) -> ? 2
SELECT COMMAND(X TO EXIT H FOR HELP) -> ? 4
SELECT COMMAND(X TO EXIT H FOR HELP) -> ? 1
```

Z - Change Timer Frequency (Default is 50 Hz)

The Z option allows you to specify the PET computer clock frequency. This option does not set the frequency directly. The PET internal clock times Shuffler events, and the program must have the correct frequency value to calculate count rates and source transfer times accurately. The clock frequency is governed by the power supply, which will be either 50 or 60 Hz. The default setting in the program is 50 Hz.

X - Exit From NDA5TST

Typing X will allow exit from the program.

SUMMARY

The NDA5TST code permits the Shuffler to be tested easily and thoroughly. The menu-driven program performs control and test functions using options the operator selects from the menu. The options are input at the PET keyboard.

Structure

The software was developed in modules, using structured coding concepts where possible. Each module is an isolated control function and is accessed with subroutine (GOSUB) calls. The subroutines provide examples of how to implement control functions in a program.

Documentation

The NDA5TST program is highly documented with remark (REM) statements on most lines of the code. This manual provides a general description of the subroutines in NDA5TST. A detailed discussion of the code for PET-to-SMC communications is in Appendix D.

CODE DESCRIPTION

A complete listing of the NDA5TST code is in Appendix E. The remark statements should provide sufficient information to understand the operation of the program. A list and description of variables in the program is given in Table D-4 of Appendix D. The following discussion describes features of each subroutine in the program.

Program Header
Lines 100-175

The program header contains the program name, software creation and revision dates, program purpose, and the variables used in the code. The meanings of the variables are also given and, if restricted, their allowable ranges of values.

Start-up Subroutine
Lines 180-400

The start-up subroutine resets the SMC module, reads the MOUSE inputs to determine the Shuffler status, resets the MOUSE module, and checks that the stepping motor power supply is on.

Menu Subroutine
Lines 500-594

The menu subroutine prints the option menu on the PET screen and a message requesting your input. The program waits until an input is received.

Option Subroutine
Lines 600-700

The option subroutine accepts an option command from the PET keyboard and, if allowable, performs a call to the selected subroutine.

Assay Subroutine
Lines 1000-1220

The assay subroutine requests the following initial information:

NUMBER OF ASSAY CYCLES TO RUN -> ?
DO YOU WANT SCALER OPERATION (Y OR N) -> ?

When you select scaler operation with the Y option, the program requests a background count time.

INPUT BACKGROUND COUNT TIME (0.1 TO 250 SEC) -> ?

The irradiation and delayed count times are always input. These values represent the amount of time

Assay Subroutine (cont)

the source is held at the storage and irradiation positions.

```
INPUT IRRADIATION TIME    (0.1 TO 250 SEC) -> ?
INPUT DELAYED COUNT TIME (0.1 TO 250 SEC) -> ?
```

When you select scaler operation, the assay option collects a background count for a specified time (defined as TB in the code). This subroutine then completes a total of A1 cycles. Each cycle consists of moving the source from storage to irradiation and back to storage. Source transfer times (defined as T1 and T3 in the code), irradiation times (T2), delayed-neutron count times (T4), and count rates are collected at each cycle, and the information is printed on the PET screen.

Sensor Test Subroutine Lines 2000-2700

The sensor test subroutine serves only as a diagnostic tool. The test blocks and unblocks the source cable position sensors to determine if the sensors are operating properly.

Single-Step Subroutine Lines 2790-2990

The single-step subroutine single-steps the source a distance of N inches in the direction D selected. In the code, D = 8 for the irradiation direction and D = 9 for the storage direction. This subroutine tests for position repeatability, checks that the motor can take single steps, and checks that the motor can move the source, after an assay, further into the Shuffler to decrease the radiation level.

Status Subroutine Lines 3000-3300	The status subroutine first reads the MOUSE inputs and outputs, then prints the status of the Shuffler system on the PET screen.
Clock Frequency Subroutine Lines 3400-3495	The clock frequency subroutine allows you to specify the power line frequency (variable FR in the code) for correct timing using the PET jiffy clock. This program does not physically set the clock frequency; it obtains the FR value from your input.
Motor On Subroutine Lines 3500-3510	The motor on subroutine sets the variable to a value of 2 (for the variable C in the code) for the Shuffler communications subroutine, which turns the stepping motor power supply on.
Motor Off Subroutine Lines 3550-3560	The motor off subroutine sends a C value of 1 to the Shuffler communications subroutine, which turns the stepping motor power supply off.
Irradiation Transfer Subroutine Lines 4000-4080	The irradiation transfer subroutine turns the stepping motor power on (C = 2), requests a rapid transfer of the source from storage to irradiate (C = 4), and then turns the motor off (C = 1). The transfer time (TR in the code) measured with the jiffy clock is converted to seconds by dividing by FR and is printed on the PET screen.
Storage Transfer Subroutine Lines 5000-5070	The storage transfer subroutine turns the stepping motor power on (C = 2), requests a rapid transfer of the source from irradiate to storage (C = 5), and then turns the motor off (C = 1). The value of TR measured with the jiffy clock is

Storage Transfer Subroutine (cont)

converted to seconds by dividing by FR; this new number is printed on the PET screen.

Position Source at Storage Subroutine
Lines 6000-6039

The subroutine to position the source at storage sends a command (C = 3) to the SMC to position the source at the storage sensor. The positioning time TR measured with the jiffy clock is converted to seconds and is printed on the PET screen.

Single-Command Subroutine
Lines 6500-6585

The single-command subroutine allows you to select one of the ten possible control commands (see p. 14) and send it to the communications subroutine for transmittal to the Shuffler.

Position Repeatability Subroutine
Lines 7000-7486

The position repeatability subroutine runs source-positioning cycles to measure the repeatability precision at the irradiation position. Delays at code lines 7010, 7047, 7065, and 7131 are used to slow the motor down and ensure that each step is complete before the next step is commanded by the computer. These delays ensure that an accurate count of steps is obtained between the irradiation transfer position and the forward over-travel sensor.

Communications Subroutine
Lines 7900-8525

The communications subroutine performs synchronization and message transmittal between the PET and the SMC. The PET jiffy clock is used to determine a maximum response time between messages during the communications sequence, ensuring that the PET is not left waiting for a response if the SMC develops a problem. A detailed description of the

Communications Subroutine (cont)

communications code is provided in Appendix D. This subroutine handles all communications with the SMC, provides error messages if the SMC detects a problem, and resets the SMC software if the maximum time for a message response is exceeded.

Read MOUSE Inputs Subroutine
Lines 9000-9090

The subroutine to read MOUSE inputs reads the high and low (I2 and I1 in the code) bytes of the MOUSE input lines. The high byte is converted to variables representing the source position (R,S, and F) sensors, the stepping motor power (P), the last command received from the Shuffler (I), and the Shuffler error (E) condition.

Read MOUSE Outputs Subroutine
Lines 9100-9140

The subroutine to read MOUSE outputs reads the high and low (O2 and O1 in the code) bytes on the MOUSE output lines. The high byte is converted and masked to obtain the last command (O) that the PET sent to the SMC module.

Set MOUSE Outputs Subroutine
Lines 9200-9220

The subroutine to set MOUSE outputs sets the high and low (O2 = S2 and O1 = S1 in the code) bytes of the MOUSE output lines. Before calling this subroutine, use the subroutine to read the MOUSE output lines to obtain the low byte. This byte is not used in the communications. Instead, the low byte should be sent to the output lines to keep these lines from being altered. The high byte is established by adding the value 16 to the variable (C). This procedure ensures that the

Set MOUSE Outputs Subroutine (cont)

nonmaskable interrupt (NMI in the code) line of the SMC module is maintained high. If the line were set low, the SMC software would be reset.

Shuffler Restart Subroutine Lines 9400-9494

The subroutine to restart the Shuffler sets the NMI line of the SMC high, then low, and then high again to cause an interrupt at the Motorola computer that resets the SMC and initializes the software. The MOUSE module is also reset. A reset may be necessary when communications synchronization is lost or when some other problem occurs with the SMC or the MOUSE.

> **NOTE:** The SMC can also be reset by manually depressing the red button on the front panel.

MOUSE Control Subroutine Lines 9600-10000

The MOUSE control section of the code contains subroutines to operate and control the MOUSE module to perform scaler operation, timing, and other tasks. Descriptions of the operational commands and their meanings are provided in the Harwell MOUSE Users Guide(AERE-R 9463).

DESCRIPTION

CALIFORNIUM-252

Californium-252 is a spontaneous fission neutron emitter. It has a 2.646-yr half-life, emits 2.34 x 10^{12} n/s/g, is a reliable source of neutrons, and can be packaged in a small container.

SHUFFLER SOURCE

The Shuffler is designed to use a ^{252}Cf source encapsulated in a special package designed by Savannah River Laboratories, the SR-CF-100 package. The first source supplied for the Shuffler was loaned by Savannah River Laboratories. It contained 2.892 mg of ^{252}Cf, emitting 6.69 X 10^{9} n/s. This source emits a large quantity of radiation and must be shielded and handled with care.

CABLE ATTACHMENT

The Shuffler operates by moving the ^{252}Cf source between the storage and irradiation positions. The source is attached to a Teleflex cable, and the cable is moved using a gear wheel controlled by a stepping motor. Figure A-1 shows the configuration of the cable bushing attachment. The source is securely held to the coupler bushing by set screws and Loctite.

SHIPMENT

SHIPPING CASK

The source is shipped in Atkinson Steel Company Cask #127. This cask is certified to transport

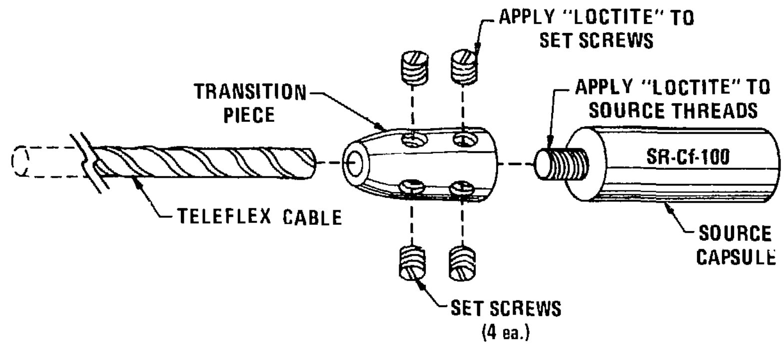


Fig. A-1. Cable bushing attachment.

SHIPPING CASK (cont)

up to 2 Ci (3.75 mg) of ^{252}Cf. The cask requires a special insert (see Fig. A-2) for the source to be shipped with the Teleflex cable attached to it.

SOURCE TRANSFERS

PRACTICE WITH DUMMY SOURCE

A dummy source and Teleflex cable sent should be used to practice transfers until the procedure is well established.

PROCEDURE

The transfer procedure requires the following general steps:

1. Run the NDA5TST program and move the source to the irradiation position using the menu command U. Manually switch the stepping motor power supply off.

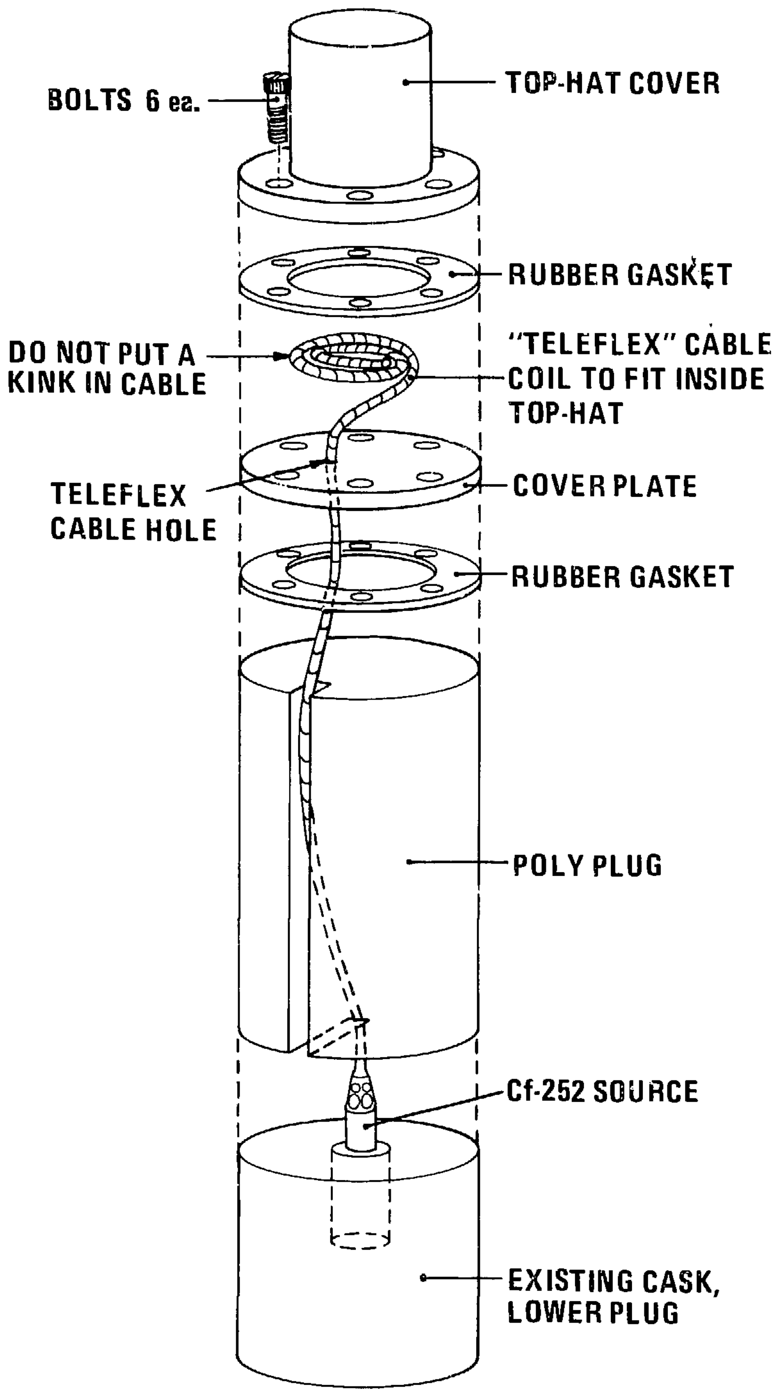


Fig. A-2. Shipping cask insert.

PROCEDURE (cont)

2. Unbolt the stepping motor, remove the Swagelok connections on the Teleflex cable takeup tube, and dismount the motor and tube.

   CAUTION: Be careful that the cable does not come out of the tube if a live source is attached to it.

3. Keeping the cable all the way in the instrument, slowly remove the source keeper tube from the Shuffler.

4. Slowly remove the Teleflex cable and <u>quickly</u> place the old source in a large shield. (Remember, it is a strong radiation source.)

5. Remove the new source from its shield and <u>quickly</u> insert it fully into the Shuffler. Put light machine oil on the Teleflex cable.

6. Replace the source keeper tube in the instrument.

7. Run the end of the Teleflex cable through the stepping motor gear box and into the Teleflex tube. Bolt the motor and tube onto the Shuffler assembly.

PROCEDURE
(cont)

8. After you securely bolt the assembly, rotate the stepping motor gear wheel by hand to ensure that the cable and source move easily in the Shuffler.

9. Switch on the stepping motor power supply and test slow movement of the source using the U and B options in program NDA5TST. If the system appears to operate properly, use the I and S options to test fast movement of the source. If this test is successful, use the A option to test the overall assay capability of the Shuffler.

10. Load the Shuffler assay program, recalibrate the instrument, and continue with assay measurements using the new source.

CONTROL ELECTRONICS

IRRADIATION SOURCE POSITION ADJUSTMENT

The side panel view of the SMC module is shown in Fig. B-1. An eight-position rocker switch on the side panel adjusts the irradiation source position. Switch positions 1 through 7 represent the number of binary steps to adjust the source position. Switch position 8 represents adding or subtracting an adjustment number to the fixed position (1244 steps) value in ROM. Twenty-five motor steps will move the source a distance of one inch.

SWITCH SETTINGS

The OFF setting on the switch is an open position producing a set (1) value and the ON setting grounds the switch, producing a clear (0) value.

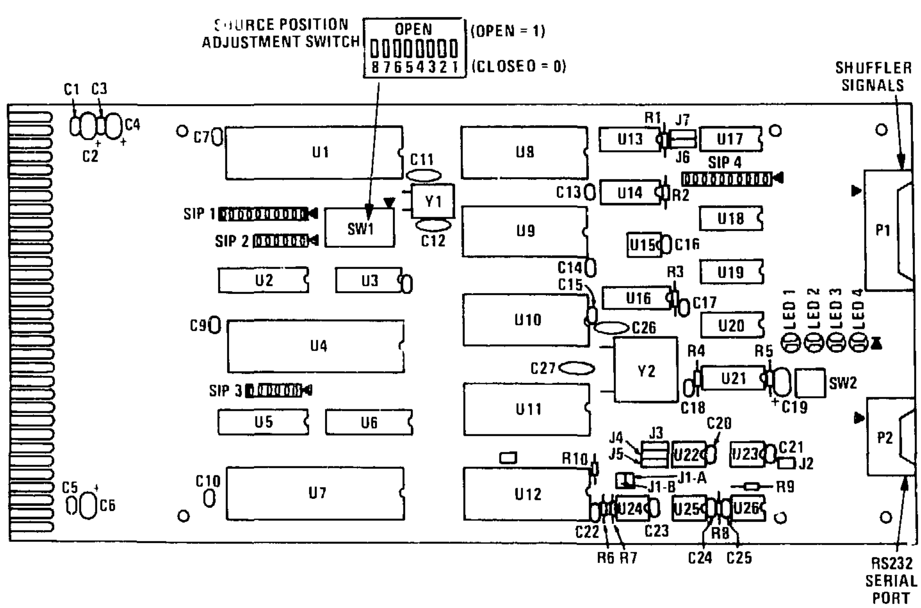


Fig. B-1. Side view of the SMC module.

Add 12 Steps

To add 12 decimal (14 octal) steps to the irradiation position, put switch 8 in the OFF position. Assign an octal value of 14 to switch positions 1 through 7 by putting switches 3 and 4 in the OFF position and switches 1, 2, 5, 6, and 7 in the ON position. This setting will now move the source 1256 steps from storage to irradiation.

Subtract 12 Steps

To subtract 12 decimal (14 octal) steps from the irradiation position, put switch 8 in the ON position. Assign an octal value of 14 to switch positions 1 through 7 by putting switches 3 and 4 in the OFF position and switches 1, 2, 5, 6, and 7 in the ON position. This setting will now move the source 1232 steps from storage to irradiation.

SIGNAL LINES

Signal and message lines between the SMC and MOUSE modules and the Shuffler are shown in Fig. B-2.

MOUSE INPUT/OUTPUT LINES

The MOUSE has 16 input and 16 output lines numbered from 0 to 15. The high bytes (8 through 15) of the lines are used for PET-to-SMC communications. The bit designations are given below.

Output Lines

The output lines (OUT0 through OUT15) convey messages sent from the PET to the SMC module. The bit definitions are as follows:

PET command	(OUT8, OUT9, OUT10, OUT11)
Restart the SMC module	(OUT12)

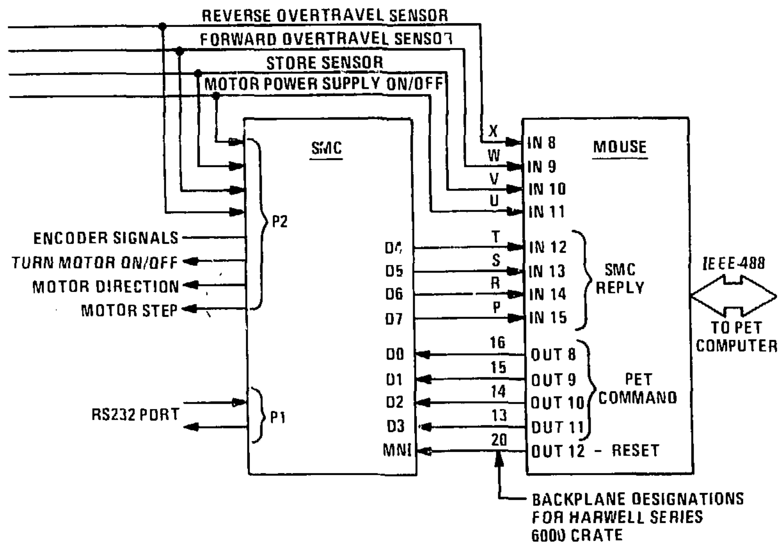


Fig. B-2. Signal lines for the SMC module.

Input Lines

The input lines (IN0 through IN15) convey messages sent from the SMC module to the PET. The bit definitions are as follows:

Reverse over-travel sensor	(IN8)
Forward over-travel sensor	(IN9)
Store sensor	(IN10)
Power on/off	(IN11)
SMC message	(IN12, IN13, IN14, IN15)

DISTRIBUTION-BOX WIRING

Signals between the SMC module and the Shuffler are routed through a distribution box. Wiring and signal definitions for the box are listed in Tables B-1 through B-IV.

TABLE B-1

SMC RIBBON CABLE TO ENCODER CABLE

J1 PIN	J4 PIN	WIRE COLOR	CONNECTOR	WIRE COLOR	ENCODER SIGNAL FUNCTION
1	1	BLACK	A	BLACK	B
2	2	RED	B	RED	+5 VOLTS
3	3	WHITE	C	WHITE	A
4	4	GREEN	D	GRN/PUR	GROUND
11	5	BLUE	E	BLUE	A
13	6	ORANGE	F	ORANGE	B

TABLE B-II

SMC RIBBON CABLE TO STEPPING MOTOR DRIVER CABLE

J1 PIN	J3 PIN	WIRE COLOR	SIGMA DRIVER	SIGMA DRIVER FUNCTION
5	1	WHITE	10	BSTEP
6	2	SHIELD	8	GROUND
7	3	GREEN	7	BDIR
8	4	BLACK	4	MOTOR
16	5	RED	6	+5 VOLTS

TABLE B-III

SMC RIBBON CABLE TO SENSOR CABLE

J1 PIN	J2 PIN	WIRE COLOR	CONNECTOR	WIRE COLOR	SENSOR FUNCTION
9	1	WHITE	1	WHITE	REV OVER-TRAVEL
10	2	GREEN	2	WHITE	FWD OVER-TRAVEL
12	3	RED	3	RED	+12 VOLTS
14	4	SHIELD	4	BLACK	GROUND
15	5	BLACK	5	WHITE	STORE

TABLE B-IV

STEPPING MOTOR DRIVER WIRING CONNECTIONS

STEPPING MOTOR DRIVER	WIRE COLOR	CONNECTOR	WIRE COLOR	STEPPING MOTOR FUNCTION
11	RED	A	RED	FWD MOTOR VOLTAGE
12	WHITE	B	YELLOW	FWD MOTOR VOLTAGE
13	GREEN	C	ORANGE	REV MOTOR VOLTAGE
14	BLACK	D	BLACK	REV MOTOR VOLTAGE

POWER SUPPLY WIRING

The power supply of the stepping motor can be wired to operate from 120 or 240 Vac. The unit is initially configured to operate from 120 Vac.

Changing Wiring to 240 Vac

To change the wiring from 120 Vac to 240 Vac, follow the steps below and refer to the wiring diagram shown in Fig. B-3.

1. Move the ac line from strip position No. 2 to No. 4.
2. Remove the jumper between strip position No. 1 and No. 3.
3. Remove the jumper between strip position No. 2 and No. 4.
4. Insert a jumper between strip position No. 2 and No. 3.

Changing Wiring to 120 Vac

To change the wiring back to 120 Vac, leave the ac line on No. 4 and replace the jumpers that were removed in the above steps. See Fig. B-4.

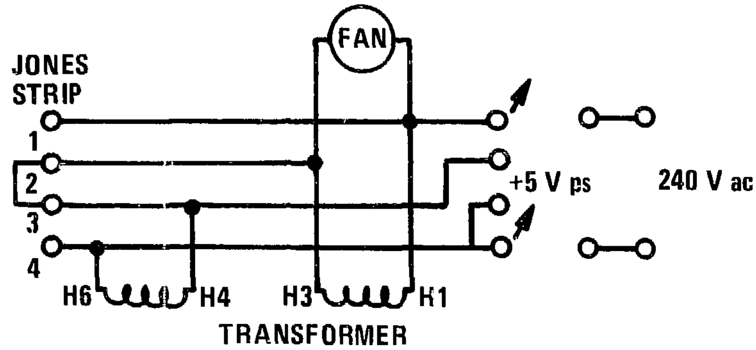


Fig. B-3. 240 Vac wiring drawing

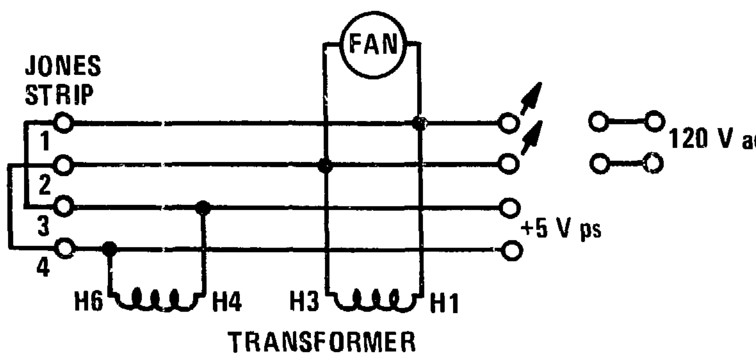


Fig. B-4. 120 Vac wiring drawing

SCHEMATICS AND COMMERCIAL COMPONENTS

ELECTRICAL SCHEMATIC

A foldout electrical schematic (Los Alamos Drawing No. 68Y-155671) for the Dounreay Shuffler SMC module is included as Fig. B-5.

MECHANICAL SCHEMATICS

The mechanical design and fabrication drawings of the Dounreay Shuffler unit are contained in Los Alamos National Laboratory drawings 68Y-155466 D1 through D15. These drawings are not included

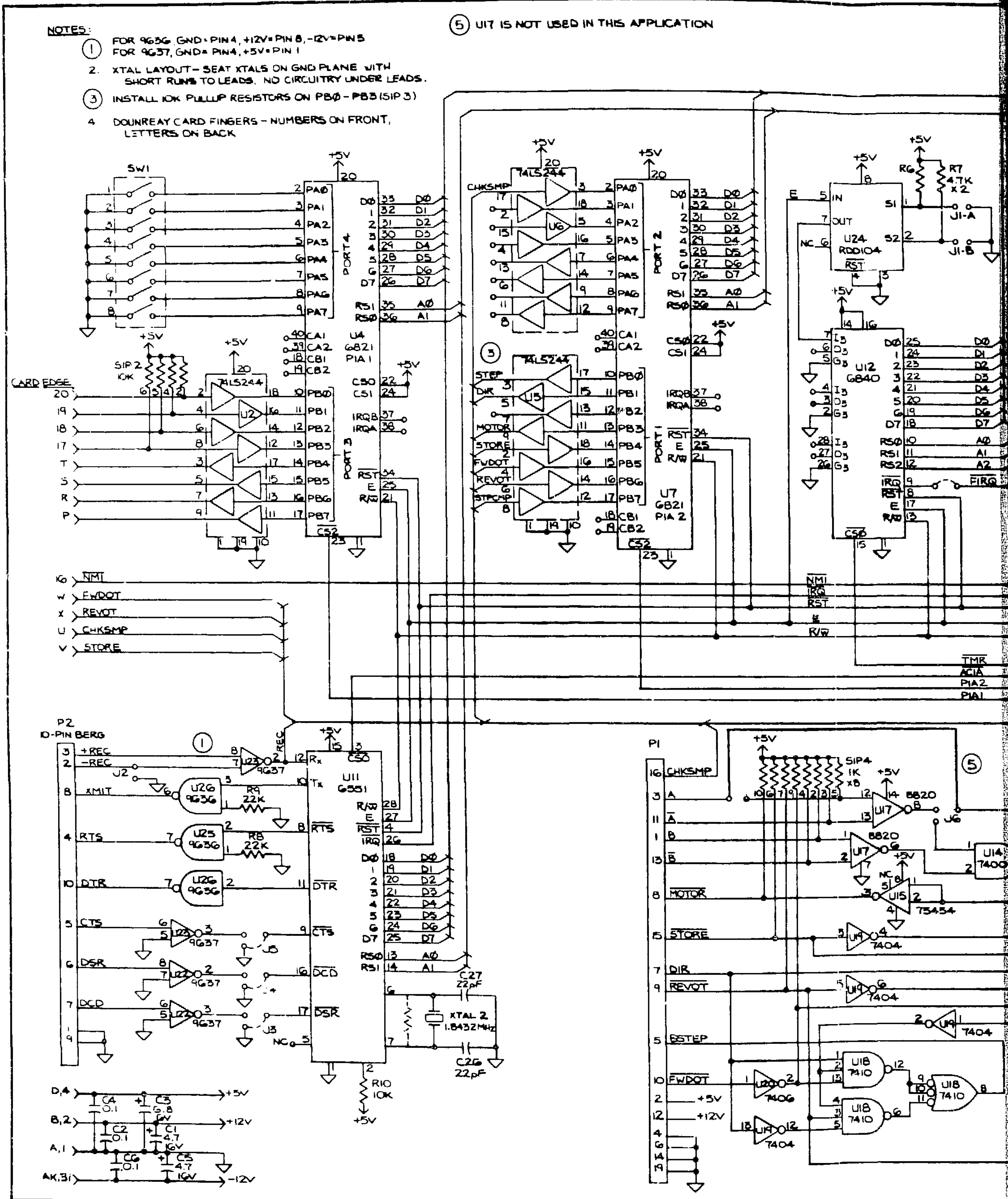
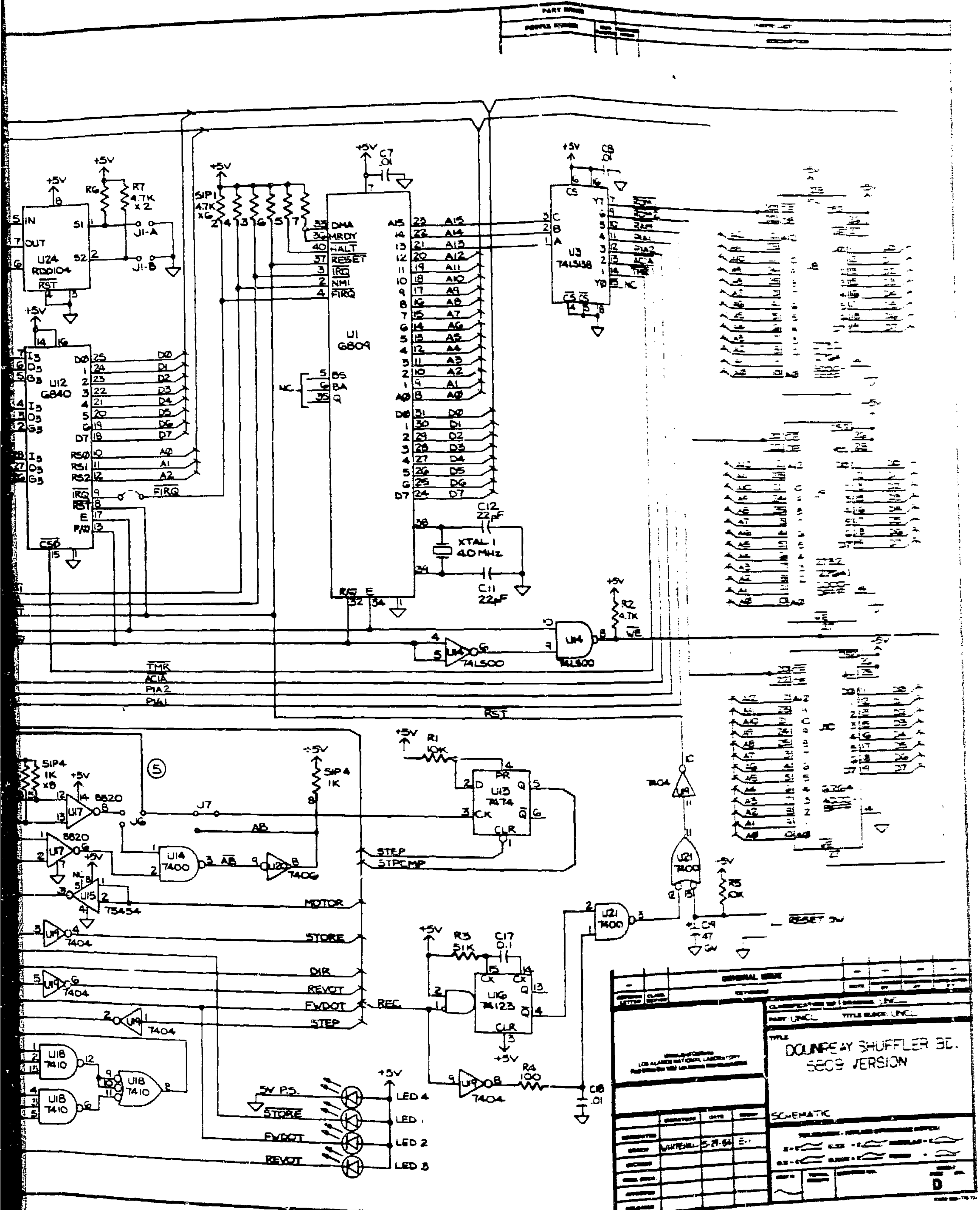


Fig. B-5. SMC electronic schemati



lectronic schematic.

MECHANICAL SCHEMATICS (cont)

with this manual. They are on file at both Los Alamos and the Dounreay facility.

COMMERCIAL EQUIPMENT

Several items composing the Shuffler were obtained from commercial sources. Table B-V shows the commercial items.

TABLE B-V

COMMERCIAL COMPONENTS USED IN SHUFFLER

Item	Model Number	Manufacturer
Proximity Sensors	FYAA3A1-2	Micro Switch
Stepping Motor	21-3450D-23821	Sigma Instruments, Inc.
Encoder	A236-12	Datametrics, Inc.
Motor Power Supply	29B-16-105	Sigma Instruments, Inc.

ERROR MESSAGE EXPLANATION

The five possible error messages from the Shuffler SMC module are listed below with explanations of possible causes and corrections.

Error No. 11: Invalid Command Sent by PET Computer

Error number 11 is on code line 8241. This error is produced when the PET computer sends a command outside the allowed range (0 through 10) to the SMC module.

Error No. 12: Check Sensors, Power Supply, and Motor Status

Error number 12 is on code line 8242. This message represents a general error condition. The stepping motor power supply may be off. The source could have been moved too far in either direction producing an over-travel sensor error.

Error No. 13: Over-Travel Sensor Failed to Stop Steps

Error number 13 is on code line 8243. This error results if the hardware in the SMC module fails or if the over-travel sensor is not properly working. A sensor improperly seated cannot reliably sense a blocked condition. A malfunctioning sensor is indicated if a source movement results in the maximum allowable number of steps occurring without an over-travel signal being generated. Use the T option in program NDA5TST to check operation of the cable position sensors.

Error No. 14: Encoder Failed to Provide Step-Completion Signal

Error number 14 is on code line 8244. The SMC module monitors the stepping motor encoder for a step-complete pulse each time the motor takes a step. This error results if the stepping motor encoder fails or if an over-travel sensor has been activated, and stops the motor from taking steps.

Error No. 14: Encoder Failed to Provide Step-Completion Signal (cont)	Occasional errors not involving over-travel sensors indicate that the encoder should be realigned.
Error No. 15: Encoder Provided Excess Step-Completion Signal	Error number 15 is on code line 8245. This error results when a step-complete signal is produced and the SMC module did not issue a step pulse. This error generally occurs if noise is being generated on the signal cables.

PET-TO-SHUFFLER COMMUNICATIONS

PET-TO-SHUFFLER MESSAGE FORMAT

The PET computer and the SMC module communicate through a simple handshake sequence.

PET MESSAGES

The PET initiates all communications with the SMC and sends commands on bits 8, 9, 10, and 11 of the high byte of the MOUSE output lines. PET messages are denoted in the code by the variable O (letter "O"), and the value ranges from 0 (zero) to 15. Table D-I shows the message numbers and their meanings. Bit 12 of the MOUSE output line is wired to the microprocessor of the NMI port of the SMC. This bit must be held high to prevent interrupts occurring that would reset the SMC.

SMC MESSAGES

The SMC waits for commands from the PET computer and sends reply messages to the PET on bits 12, 13, 14, and 15 of the high byte of the MOUSE input lines. SMC messages are denoted in the code by the variable I and the values range from 0 (zero) to 15. Table D-I shows the message numbers and their meanings.

MESSAGE SYNCHRONIZATION

Messages between the PET and the SMC follow the set of synchronized steps shown in Table D-II.

TABLE D-I

PET AND SMC MESSAGES

MESSAGE NUMBER	PET COMMAND (O)	SMC REPLY (I)
0	Request completion signal	Busy
1	Turn motor on	Motor turned on
2	Turn motor off	Motor turned off
3	Position source at storage	Source positioned at storage
4	Move source to irradiate	Source at irradiate
5	Move source to storage	Source at storage
6	Block sensors	Sensors blocked
7	Unblock sensors	Sensors unblocked
8	Set direction to irradiate	Direction set to irradiate
9	Set direction to storage	Direction set to storage
10	Take one step	One step taken
11	none	Error message 11
12	none	Error message 12
13	none	Error message 13
14	none	Error message 14
15	none	Error message 15

TABLE D-II

SYNCHRONIZED STEPS FOR COMMANDS BETWEEN PET AND SMC

MESSAGE STEP	PET COMMAND	SMC REPLY
1.	Wait for SMC ready.	Busy (send a zero) or waiting for a command (send a nonzero number).
2.	Send variable C. Wait until SMC receives command and sends a zero indicating acceptance.	Send a zero when valid command accepted and then process command.
3.	Request command completion signal by sending zero.	Ater processing, wait for PET request for completion signal.
4.	Wait for SMC completion signal.	Send completion signal by repeating variable C number, or send error message (number 11 - 15).

COMMAND PROCESSING

While the SMC is processing a command, its message number is set to zero. After the SMC completes a command and receives a completion signal request (0) from the PET, it will

1) Echo the command number if completed successfully, or
2) Send an error message number if a problem occurred.

COMMUNICATIONS EXAMPLE

A sample communications code is shown in Table D-III. The PET BASIC code that implements communications with the SMC is explained below, using the sample. Variables used in this example and throughout the BASIC code (NDA5TST) are described in Table D-IV. Please refer to the NDA5TST program listing in Appendix E for a complete example of the communication code.

Communication Subroutines

Three subroutines are called from the communications code. Refer to the examples of MOUSE communications at the end of this appendix for complete details of these subroutines. The subroutines perform the following functions:

Subroutine 9000: Reads the MOUSE input lines and converts the high byte (I2) to the variable I to obtain the SMC message.

Subroutine 9100: Reads the MOUSE output lines to obtain the value of the low (O1) output byte.

TABLE D-III

SAMPLE COMMUNICATIONS CODE

LINE	CODE	REMARK
8000	TI$="000000"	:REM ZERO PET CLOCK
8010	GOSUB 9000	:REM GET SMC STATUS
8020	IF TI>FR*5 GO TO 8400	:REM 5 SEC RESPONSE LIMIT
8030	IF I=0 GO TO 8010	:REM WAIT FOR SMC READY
8040	GOSUB 9100 : S1=01 : S2=C	:REM SET UP OUTPUT LINES
8045	GOSUB 9200	:REM SEND COMMAND TO SMC
8050	GOSUB 9000	:REM GET SMC STATUS
8060	IF TI>FR*5 GO TO 8415	:REM 5 SEC TIME LIMIT
8070	IF I ≠ 0 GO TO 8050	:REM WAIT FOR SMC BUSY
8080	S2=0 : GOSUB 9200	:REM REQUEST COMPLETION SIGNAL
8090	GOSUB 9000	:REM GET SMC STATUS
8100	IF TI>FR*15 GO TO 8435	:REM 15 SEC TIME LIMIT
8110	IF I=0 GO TO 8090	:REM WAIT FOR COMPLETION SIGNAL
8120	IF I=C THEN RETURN	:REM COMPLETION OK
8130	:REM --- PROCESS ERROR CONDITIONS ---	

TABLE D-IV

PROGRAM VARIABLE DEFINITIONS

CODE VARIABLE	DEFINITION	VALUES	
R	Reverse overtravel sensor	0=unblocked	1=blocked
F	Forward overtravel sensor	0=unblocked	1=blocked
S	Store sensor	0=unblocked	1=blocked
P	Motor power	0=off	1=on
D	Source movement direction	8=irradiate	9=store
E	Fatal error	0=no	-1=yes
EM	MOUSE error	0=no	-1=yes
EL	Error listing	0=yes	1=no
ER	Error on repeatability test	0=no	-1=yes
ES	Error status	0=no	-1=yes
EC	MOUSE error code	See MOUSE Manual	

TABLE D-IV (cont)

PROGRAM VARIABLE DEFINITIONS

CODE VARIABLE	DEFINITION	VALUES
I	Input to PET from SMC	0-15
O	Output from PET to SMC	0-15
C	Command to SMC	0-10
O1	MOUSE output low byte	-
O2	MOUSE output high byte	-
I1	MOUSE input low byte	-
I2	MOUSE input high byte	-
S1	MOUSE output low byte	-
S2	MOUSE output high byte	-
TR	Transfer time (s)	
TI	Transfer time (Hz/10)	
TB	Background count time (s)	
TO	Delay Time (ticks)	
T1	Transfer time from store to irradiate (s)	
T2	Irradiation time (s)	
T3	Transfer time from irradiate to store (s)	
T4	Delayed neutron count time (s)	
T5	MOUSE timer preset time (s/10)	
A0	Assay cycle counter	
A1	Total number of assay cycles	
A2	Assay cycle output line counter	
A3	Assay cycle output line counter	
BC	Background count rate (counts/s)	
FM	Flux monitor count rate (counts/s)	
DN	Delayed neutron count rate (counts/s)	
FR	Frequency of PET clock (Hz)	
MU	Mean number of steps to FWDOT sensor in repeatability test	
S	Standard deviation of steps in repeatability test	
M	Trial number in repeatability test	
X(M)	Number of steps to FWDOT sensor in repeatability test trial number M	
L	Single step counter	
N	Total number of trials in repeatability test	
NP	Number of blank lines to be printed	

Communication Subroutines (cont)

Subroutine 9200: Sets the output lines of the MOUSE module. This subroutine adds 16 to the high byte (S2) to ensure that the SMC interrupt line is held high.

Sample Code Description

The rest of the code is described below.

Line 8000: Zeros the PET jiffy clock to monitor response timing.

Line 8010: Reads the MOUSE input lines to obtain the SMC message status (I).

Line 8020: Transfers out of the communications subroutine if the SMC has not reached a ready state within 5 s. The time is measured in hertz, and you need to know the line frequency (FR) to obtain the time in seconds. Line 8400 prints a timeout message on the PET screen. An interrupt to the SMC is then generated to reset the module; if the interrupt is successful, the PET program transfers to the main menu.

Line 8030: If the SMC is not ready, its message status equals zero (I = 0), and this line transfers the code back to the read SMC status line.

Sample Code Description (cont)

Line 8040: The SMC is ready for a command, so subroutine 9100 is called to obtain the low byte (01) on the MOUSE output lines. The low byte is set equal to S1. The high byte (S2) is set equal to the variable C.

Line 8045: Subroutine 9200 adds 16 to S2 and places S1 and S2 on the MOUSE output lines. S2 contains the control message for the SMC. Adding the number 16 keeps the SMC module interrupt line high to prevent a module reset.

Line 8050: Reads the MOUSE input lines to obtain I.

LINE 8060: Transfers out of the communications subroutine if the SMC has not sent a busy signal within 5 s. Line 8415 prints a timeout message on the PET screen. An interrupt to the SMC is then generated to reset the unit, and, if the interrupt is successful, the PET program transfers to the main menu.

LINE 8070: If the SMC has not accepted the command, the variable I on the input line will be nonzero. Therefore, this line transfers the program to line 8050, the read MOUSE input line.

Sample code Description (cont)

Line 8080: The PET command has been accepted by the SMC. The PET requests a command completion signal from the SMC by setting the high byte to zero (S2 = 0) and calling subroutine 9200 to transmit it to the SMC. The low byte, S1, will not have changed from its initial value.

Line 8090: The PET reads the MOUSE input lines to obtain I.

Line 8100: Transfers out of the communications subroutine if the SMC has not provided a command completion signal within 15 s. Line 8435 prints a timeout message on the PET screen. An interrupt to the SMC is then generated to reset the unit and, if the interrupt is successful, the PET program transfers to the main menu.

Line 8110: Checks for command completion by the SMC. If I = 0 the SMC is busy processing the command, and the code loops back to the read status subroutine.

Line 8120: If the SMC status equals the command (I = C), then the task was successfully completed, and the code returns to the calling program. Otherwise, I equals an error message number that appears on the PET screen.

COMMUNICATION ERRORS

If a communication error occurs and message synchronization is lost, the PET program will time out and reset the SMC module. The SMC then positions the source at storage and waits for a command from the PET. If the reset attempt is unsuccessful, the PET displays an error message to inform you of the problem. You should then do a manual reset by pushing the RESET button on the front panel of the SMC module.

MOUSE COMMUNICATIONS

INTRODUCTION

The PET communicates with the SMC through the MOUSE using codes that must be converted between the MOUSE and the PET computer. This section describes the codes and subroutines for communications through the MOUSE.

The MOUSE input lines carry the signals from the SMC to the PET. The low byte in the code is designated by I1 and the high byte is designated by I2. The MOUSE output lines carry signals from the PET computer to the SMC.

CONVERT FROM ASCII TO DECIMAL

The MOUSE module is designed to transmit and receive string data. The data received must be converted from the ASCII value to a decimal value before use by the PET code. An example of the code for conversion of the low byte (I1$) and high byte (I2$) ASCII strings to the decimal values I1 and I2 follows:

CONVERT FROM ASCII TO DECIMAL (cont)

```
I1=0 : IF I1$ <> "" THEN I1=ASC(I1$)
I2=0 : IF I2$ <> "" THEN I2=ASC(I2$)
```

SMC Messages

Signals from the SMC to the PET are transmitted on bits 12 through 15 of the high byte (I2) of the MOUSE input lines. Bit 12, an NMI line used to reinitialize the SMC controller, should be held high to prevent reset interrupts from occurring. The following BASIC code shifts these SMC messages to values between 0 and 15 for interpretation by the PET:

```
I = (I2 and 240)/16    :REM SMC message = I
```

READ MOUSE INPUTS SUBROUTINE 9000

The subroutine reads the 16 input lines on the Harwell MOUSE unit into the PET computer using the following PET BASIC code:

```
OPEN 1,13,8          :REM Open IEEE port to read
PRINT#1,CHR$(0)      :REM Set read to input line
GET#1,I1$,I2$        :REM Read high byte I2$ and
                      low byte I1$
CLOSE 1              :Release port.
```

READ MOUSE OUTPUTS SUBROUTINE 9100

Signals from the PET computer to the SMC are transmitted on bits 8 through 11 of the high byte of the output lines. This subroutine reads MOUSE output lines to obtain the value of the low output byte. Data placed on the MOUSE output lines can be read and verified using the following code:

READ MOUSE OUTPUTS SUBROUTINE (cont)

```
OPEN 1,13,8          :REM Open IEEE port to read
PRINT#1,CHR$(255)    :REM Read output line
GET#1,02$,01$        :REM Read bytes
CLOSE 1              :REM Release port
```

SEND COMMAND C SUBROUTINE 9200

This subroutine sets the output lines of the MOUSE module. The code adds 16 to the high byte (S2) of the output line. This procedure ensures that the NMI line, bit 12, is kept high to prevent a reset or interrupt. The code required to send a command from the PET computer to the SMC module is as follows:

```
OPEN 1,13,7                        :REM Write to MOUSE
PRINT#1,CHR$(02+16),CHR$(01) :REM Send command C
CLOSE 1
```

SMC RESET

The command to send an NMI to the SMC module uses bit 12 of the MOUSE output. The communications sequence is modified from the above discussion because the SMC initializes variables and restarts the program. If the restart is successful, the SMC module places a value of 8 on the communications line. The PET computer should wait for this value to ensure the reset is successful.

ADDITIONAL INFORMATION

Detailed information on the communication and control operations between the PET computer and MOUSE module is contained in the Harwell MOUSE Users Manual (AERE-R-9463).

```
READY.

 100 REM ---------------
 101 REM DISK NAME - NDA5TST.V55
 102 REM DIAGNOSTIC PROGRAM TO CONTROL AND
 103 REM TEST THE DOUNREAY SHUFFLER
 104 REM G ECCLESTON    CREATED 2-APR-84
 105 REM S STUEWE       REVISED 23-JUL-84
 106 REM ---------------
 107 REM
 108 REM VARIABLES
 109 REM    R = REVOT SENSOR    0=UNBLOCKED  1=BLOCKED
 110 REM    F = FWDOT    "            "            "
 111 REM    S = STORE    "            "            "
 112 REM    P = MOTOR POWER     0=OFF  1=ON
 113 REM
 114 REM    E = FATAL ERROR              0=NO    -1=YES
 116 REM   EM = MOUSE ERROR              0=NO    -1=YES
 117 REM   EL = ERROR LISTING            0=YES    1=NO
 118 REM   ER = ERROR ON REPEAT TEST     0=NO    -1=YES
 119 REM   EC = MOUSE ERROR CODE (SEE MOUSE MANUAL FOR MEANINGS)
 120 REM   ES = ERROR STATUS (EQUAL TO FATAL ERROR)
 121 REM
 122 REM    I = INPUT TO PET FROM STEPPING MOTOR CONTROLLER BOARD  (RANGE 0-15)
 123 REM    O = OUTPUT FROM PET TO STEPPING MOTOR CONTROLLER BOARD (RANGE 0-15)
 124 REM    C = COMMAND NUMBER (RANGE 1-10)
 125 REM
 126 REM   T0 = PET CLOCK TIMING LOOP VALUE (SEC * PET TIMING FREQUENCY)
 127 REM   T1 = TRANSFER TIME FROM STORAGE TO IRRADIATION (SEC)
 128 REM   T2 = TIME AT IRRADIATION (SEC)
 129 REM   T3 = TRANSFER TIME FROM IRRADIATION TO STORAGE (SEC)
 130 REM   T4 = TIME AT STORAGE (SEC)
 131 REM   T5 = MOUSE TIMER VALUE (0.1 SEC)
 132 REM
 133 REM     MU = MEAN NUMBER OF STEPS IN REPEATABILITY TEST
 134 REM      S = STANDARD DEVIATION OF STEPS IN REPEATABILITY TEST
 135 REM   X(M) = NUMBER OF STEPS TO FWDOT SENSOR IN REPEATABILITY
 136 REM          TEST TRIAL NUMBER M
 137 REM      D = DIRECTION FOR SOURCE MOVEMENT (8=TO IRRADIATE,9=TO STORE)
 139 REM
 140 REM     BC = BACKGROUND COUNT RATE (CPS)
 141 REM     FM = FLUX MONITOR COUNT RATE (CPS)
 142 REM     DN = DELAYED NEUTRON COUNT RATE (CPS)
 143 REM     FR = FREQUENCY OF PET CLOCK (NOMINALLY 50 HZ)
 146 REM
 170 REM ---------------
 172 REM   DISK FILE "NDA5TST.DOC" CONTAINS A DESCRIPTION OF THE
 173 REM   CAPABILITIES AND REQUIREMENTS OF THE NDA5TST DIAGNOSTIC
 174 REM   PROGRAM.
 176 REM ---------------
 178 REM
 179 REM --- STARTUP AND VARIABLE INITIALIZATION ---
 180 EL=0                                        :REM ALLOW ERROR LISTING
 181 DIM X(50) : PRINT"BYTES FREE =";FRE(0)    :REM REPEAT TEST VARIABLE
 183 E=0 : GOSUB 9000                           :REM READ MOUSE INPUTS
 185 IF P=1 GOTO 195                            :REM CHECK MOTOR POWER
 186 PRINT"TURN STEPPING MOTOR POWER ON"
 188 PRINT"HIT  R  AND  RETURN   KEY WHEN READY"
 189 INPUT C1$ : IF C1$<>"R" GOTO 188          :REM WAIT FOR CHARACTER
 190 GOTO 183                                   :REM RECHECK MOTOR POWER
 195 FR=50                                      :REM CLOCK FREQ DEFAULT=50 HZ
 198 REM
 199 REM --- TOGGLE NMI LINE TO RESET SHUFFLER AND STORE SOURCE ---
```

```
200 GOSUB 9400                                  :REM NMI SUBROUTINE
449 REM
500 PRINT SPC(20)"■■****** LOS ALAMOS SHUFFLER ******■"
505 PRINT SPC(15)"************* DIAGNOSTIC MENU **************■"
510 PRINT SPC(15)" A - ASSAY CYCLE SIMULATION"
515 PRINT SPC(15)" T - TEST CABLE SENSORS"
520 PRINT SPC(15)" L - LIST SYSTEM STATUS"
525 PRINT SPC(15)" R - RESTART STEPPING MOTOR CONTROL MODULE"
530 PRINT SPC(15)" O - STEPPING MOTOR ON"
535 PRINT SPC(15)" F - STEPPING MOTOR OFF"
540 PRINT SPC(15)" P - POSITION SOURCE AT STORAGE LOCATION"
545 PRINT SPC(15)" I - MOVE SOURCE TO IRRADIATION POSITION"
550 PRINT SPC(15)" S - MOVE SOURCE TO STORAGE POSITION"
555 PRINT SPC(15)" M - MOVE SOURCE N INCHES"
560 PRINT SPC(15)" B - BLOCK ALL CABLE SENSORS"
565 PRINT SPC(15)" U - UNBLOCK ALL CABLE SENSORS"
570 PRINT SPC(15)" D - IRRADIATION POSITION REPEATABILITY TEST"
575 PRINT SPC(15)" C - SEND A COMMAND TO THE SHUFFLER "
580 PRINT SPC(15)" Z - CHANGE TIMER FREQUENCY (DEFAULT IS 50 HZ)"
585 PRINT SPC(15)" X - EXIT FROM PROGRAM"
592 PRINT SPC(15)"■*******************************************■"
600 INPUT"■SELECT COMMAND (H FOR HELP) ->";C1$
602 PRINT"■"
605 IF C1$="H" THEN GOTO 500
610 IF C1$="A" THEN GOSUB 1000              :REM ASSAY SUBROUTINE
620 IF C1$="T" THEN GOSUB 2000              :REM TEST SENSORS
625 IF C1$="U" THEN GOSUB 2400              :REM UNBLOCK SENSORS     C=7
630 IF C1$="B" THEN GOSUB 2500              :REM BLOCK SENSORS       C=6
635 IF C1$="M" THEN GOSUB 2800              :REM MOVE SOURCE N INCHES C=8,9,10
640 IF C1$="L" THEN GOSUB 3000              :REM LIST STATUS
645 IF C1$="Z" THEN GOSUB 3400              :REM CHANGE FREQUENCY
650 IF C1$="I" THEN GOSUB 4000              :REM MOVE TO IRRADIATE   C=4
655 IF C1$="S" THEN GOSUB 5000              :REM MOVE TO STORE       C=5
660 IF C1$="P" THEN GOSUB 6000              :REM POSITION AT STORAGE C=3
665 IF C1$="C" THEN GOSUB 6500              :REM SEND COMMAND
670 IF C1$="D" THEN GOSUB 7000              :REM REPEATABILITY TEST
675 IF C1$="O" THEN C=2 : GOSUB 8000        :REM STEPPING MOTOR ON   C=2
680 IF C1$="F" THEN C=1 : GOSUB 8000        :REM STEPPING MOTOR OFF  C=1
685 IF C1$="X" THEN C=1 : GOSUB 8000: END   :REM EXIT PROGRAM
690 IF C1$="R" THEN GOSUB 9400              :REM NMI SUBROUTINE
695 GOTO 600
998 REM
999 REM --- ASSAY CYCLE SIMULATION ---
1000 INPUT"NUMBER OF ASSAY CYCLES TO RUN-> ";A1  : IF A1<1 GOTO 1000
1001 A1=INT(A1) : EM=0 : TB=0 : BC=0 : PRINT    :REM INITIALIZE VARIABLES
1002 PRINT : INPUT"DO YOU WANT SCALER OPERATION (Y OR N) ->";S$
1003 IF S$<>"N" AND S$<>"Y"  GOTO 1002          :REM CHECK ENTRY
1005 IF S$="N" GOTO 1010                        :REM SKIP IF NO SCALER USE
1006 INPUT"INPUT BACKGROUND COUNT TIME (0.1 TO 250 SEC) ->";TB
1007 IF TB<=0 THEN 1006                         :REM INPUT MUST BE >0
1010 INPUT"INPUT IRRADIATION TIME      (0.1 TO 250 SEC) ->";T2
1011 IF T2<=0 THEN 1010                         :REM INPUT MUST BE >0
1020 INPUT"INPUT DELAYED COUNT TIME    (0.1 TO 250 SEC) ->";T4
1021 IF T4<=0 THEN 1020                         :REM INPUT MUST BE >0
1050 TB=TB*10                                   :REM CONVERT TO MOUSE TIME
1060 T2=T2*10                                   :REM CONVERT TO MOUSE TIME
1070 T4=T4*10                                   :REM CONVERT TO MOUSE TIME
1100 A0=0 : J0=A0+1                             :REM ASSAY CYCLE COUNTER
1105 FOR J=1 TO 10                              :REM CLEAR OUTPUT VARIABLES
1106 FM(J)=0 : DN(J)=0 : NEXT J
1110 C=3 : GOSUB 6000 :  IF E THEN RETURN       :REM POSITION SOURCE AT ZERO
1111 C=2 : GOSUB 8000                           :REM STEPPING MOTOR ON
1112 A2=A1  : A3=0                              :REM SET LINE COUNTERS
1113 PRINT : PRINT : A0=0 : J0=A0+1
1114 PRINT"-------------------- COUNT TIMES AND TRANSFER TIMES (SEC)";
1115 PRINT" -------------------"
```

```
1116 PRINT"CYCLE"SPC(2)"BACKGROUND"SPC(6)"T(S->I)"SPC(7)"IRRADIATION";
1117 PRINT SPC(5)"T(I->S)"SPC(4)"DELAYED NEUTRON"
1118 REM
1119 REM
1120 REM --- BACKGROUND MEASUREMENT (USES MOUSE SCALER 2) ---
1121 IF S$="N" GOTO 1130                           :REM SKIP IF NO SCALER USE
1122 IF A3<>0 THEN 1130                            :REM SKIP AFTER 1 BCKGRND MEA
1123 GOSUB 9916 : IF EM THEN RETURN                :REM IF MOUSE ERROR EM=1
1124 T5=TB : GOSUB 9600                            :REM START TIMER AND SCALER
1125 GOSUB 9800 : TG=Z2/10                         :REM READ TIME TO GO (TG) SEC
1126 IF TG<>0 THEN 1125                            :REM WAIT FOR TB SECONDS
1127 N=2 : GOSUB 9700 : BC=INT(Z2/(TB/10))         :REM READ SCALER NUMBER 2
1128 REM --- IRRADIATION MEASUREMENT (USES MOUSE SCALER 1) ---
1130 C=4 : GOSUB 8000                              :REM XFR TO IRRADIATE
1140 T1=(TI/FR)*10                                 :REM CONVERT XFR TIME TO SEC
1141 IF S$="Y" GOTO 1151                           :REM SKIP IF SCALER USE
1145 T0=T2*FR/10 : GOSUB 7500                      :REM WAIT T2 SEC USING PET CL
1150 GOTO 1160                                     :REM SKIP SCALER OPERATION
1151 T5=T2 : GOSUB 9600                            :REM START TIMER AND SCALERS
1152 GOSUB 9800 : TG=Z2/10                         :REM READ TIME TO GO (TG)
1153 IF TG<>0 THEN 1152                            :REM FM COUNT FOR T2 SECONDS
1154 N=1 : GOSUB 9700 : FM(J0)=(Z2/(T2/10))        :REM READ SCALER NUMBER 1
1155 GOSUB 9916 : IF EM THEN RETURN                :REM IF MOUSE ERROR EF=1
1156 REM --- DELAYED NEUTRON MEASUREMENT (USES MOUSE SCALER 2) ---
1160 C=5 : GOSUB 8000 :  IF E THEN RETURN          :REM XFR TO STORAGE
1161 T3=(TI/FR)*10                                 :REM CONVERT XFR TIME TO SEC
1171 IF S$="N" GOTO 1180                           :REM SKIP IF NO SCALER USE
1172 T5=T4 : GOSUB 9600                            :REM START TIMER AND SCALERS
1173 GOSUB 9800 : TG=Z2/10                         :REM READ TIME TO GO (TG)
1174 IF TG<>0 THEN 1173                            :REM DN COUNT FOR T4 SECONDS
1175 N=2 : GOSUB 9700 : DN(J0)=(Z2/(T4/10))        :REM READ SCALER NUMBER 2
1176 GOSUB 9916 : IF EM THEN RETURN                :REM IF MOUSE ERROR EF=1
1177 GOTO 1190                                     :REM SKIP IF SCALER USE
1180 T0=T4*FR/10 : GOSUB 7500                      :REM WAIT T4 SEC USING PET CL
1185 REM --- OUTPUT RESULTS ---
1190 A0=A0+1 : J0=A0+1                             :REM INCREMENT COUNTERS
1191 T1=T1/10+0.00000001 : T3=T3/10+0.00000001     :REM FIX OUTPUT LENGTH
1192 PRINT" ";A0+A3,TB/10,T1,T2/10,T3,T4/10        :REM OUTPUT TIMES
1194 IF A0=A2 THEN N=A2 : GOTO 1200                :REM SET # OF LINES TO PRINT
1196 IF A0=10 THEN N=10 : GOTO 1200                :REM SET # OF LINES TO PRINT
1198 GOTO 1130                                     :REM WAIT FOR 10 CYCLES OR END
1200 PRINT SPC(15)"■ CYCLE","BC(CPS)","FM(CPS)","DN(CPS)"
1204 FOR J=1 TO N                                  :REM PRINT IN GROUPS OF 10
1205 FM(J)=INT(FM(J)):DN(J)=INT(DN(J))
1206 PRINT SPC(17);J+A3,BC,FM(J),DN(J)
1208 NEXT J
1210 IF N=10 THEN A2=A2-10 : A0=0 : A3=A3+10       :REM UPDATE LINE COUNTERS
1212 IF A0<>A2 THEN GOTO 1113                      :REM BRANCH IF NOT LAST CYCLE
1215 C=1 : GOSUB 8000                              :REM STEPPING MOTOR OFF
1220 RETURN
1998 REM
1999 REM --- TEST CABLE SENSOR OPERATION ---
2000 GOSUB 2400                                         :REM UNBLOCK ALL SENSORS
2010 IF R<>0 THEN PRINT SPC(15)"ERROR - REVOT SENSOR NOT UNBLOCKED"
2020 IF F<>0 THEN PRINT SPC(15)"ERROR - FWDOT SENSOR NOT UNBLOCKED"
2030 IF S<>0 THEN PRINT SPC(15)"ERROR - STORE SENSOR NOT UNBLOCKED"
2040 IF E GOTO 2600                                     :REM ABORT ON FATAL ERROR
2045 PRINT SPC(20)"■SENSOR UNBLOCK COMPLETED■■"
2060 REM
2100 GOSUB 2500                                         :REM BLOCK ALL SENSORS
2120 IF R<>1 THEN PRINT SPC(15)"ERROR - REVOT SENSOR NOT BLOCKED"
2130 IF F<>1 THEN PRINT SPC(15)"ERROR - FWDOT SENSOR NOT BLOCKED"
2140 IF S<>1 THEN PRINT SPC(15)"ERROR - STORE SENSOR NOT BLOCKED"
2150 IF E GOTO 2700                                     :REM ABORT ON FATAL ERROR
2155 PRINT SPC(20)"■SENSOR BLOCK COMPLETED■■"
2165 PRINT SPC(20)"■SENSOR TEST COMPLETED"
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2170 C=3 : GOSUB 8000                                  :REM PLACE SOURCE AT ZERO
2180 NP=2 : GOSUB 10000                                :REM PRINT 2 BLANK LINES
2190 RETURN
2192 REM
2400 PRINT SPC(20)"UNBLOCKING ALL SENSORS" : C=7 : GOSUB 8000 : RETURN
2500 PRINT SPC(20)"BLOCKING ALL SENSORS"   : C=6 : GOSUB 8000 : RETURN
2600 PRINT SPC(20)"ERROR WHILE UNBLOCKING ALL SENSORS": RETURN
2700 PRINT SPC(20)"ERROR WHILE BLOCKING ALL SENSORS": RETURN
2780 REM
2790 REM --- MOVE SOURCE N INCHES ---
2800 C=2  : GOSUB 8000                                 :REM MOTOR ON
2815 NP=3 : GOSUB 10000                                :REM PRINT 3 BLANK LINES
2820 PRINT SPC(15)"SELECT DIRECTION FOR SOURCE MOVEMENT"
2825 PRINT,"**********************************************"
2830 PRINT SPC(15)"    I = MOVE SOURCE TOWARD IRRADIATE"  :REM INTO SHUFFLER
2840 PRINT SPC(15)"    S = MOVE SOURCE TOWARD STORE"      :REM OUT OF SHUFFLER
2850 PRINT: INPUT" DIRECTION = ->";D$ : IF D$<>"I" AND D$<>"S" GOTO 2850
2855 IF D$="I" THEN D=8 : GOTO 2870                    :REM D=8 TO IRRADIATE
2860 IF D$="S" THEN D=9 : GOTO 2870                    :REM D=9 TO STORE
2870 C=D  : GOSUB 8000                                 :REM SEND COMMAND=D
2875 PRINT:PRINT
2880 INPUT"INPUT NUMBER OF INCHES MOVEMENT  N= ->";N:N=INT(N*25)
2890 FOR J=1 TO N                                      :REM 25 STEPS/INCH
2892 C=10 : GOSUB 8000                                 :REM MOVE 1 STEP
2895 GOSUB 9000                                        :REM READ INPUTS
2900 IF R=1  GOTO 2935                                 :REM CHECK REVOT SENSOR
2905 IF F=0  GOTO 2955                                 :REM CHECK FWDOT SENSOR
2915 NEXT J                                            :REM NEXT STEP
2925 PRINT SPC(15)"COMPLETED ";J-1;" STEPS IN THE ";D$;" DIRECTION"
2930 GOTO 2965
2935 PRINT SPC(15)"BLOCKED REVERSE OVERTRAVEL SENSOR AFTER ";J;" STEPS"
2945 GOTO 2965
2955 PRINT SPC(15)"UNBLOCKED FORWARD OVERTRAVEL SENSOR AFTER ";J;" STEPS"
2965 C=1  : GOSUB 8000 : IF E THEN RETURN              :REM TURN MOTOR OFF
2970 RETURN
2998 REM
2999 REM ---  LIST SYSTEM STATUS ---
3000 PRINT SPC(20)"SHUFFLER INSTRUMENT STATUS"
3001 ES=E                                              :REM SAVE ERROR STATUS
3002 GOSUB 9000                                        :REM READ INPUTS
3003 E=ES                                              :REM RESET ERROR STATUS
3004 GOSUB 9100                                        :REM READ OUTPUTS
3007 PRINT TAB(8)"  *********************************************  "
3008 IF S=1 THEN PRINT TAB(18)"  SOURCE IS IN THE STORAGE SHIELD"
3009 IF S=0 THEN PRINT TAB(18)"  SOURCE IS IN THE IRRADIATION POSITION"
3014 ES=E                                              :REM SAVE ERROR STATUS
3016 GOSUB 9000                                        :REM READ INPUTS
3018 E=ES                                              :REM RESET ERROR STATUS
3020 GOSUB 9100                                        :REM READ OUTPUTS
3022 IF P=0 THEN PRINT TAB(15)"     STEPPING MOTOR POWER IS OFF"
3024 IF P=1 THEN PRINT TAB(15)"     STEPPING MOTOR POWER IS ON"
3030 IF R=0 THEN PRINT TAB(15)"     REVOT SENSOR IS UNBLOCKED"
3040 IF R=1 THEN PRINT TAB(15)"     REVOT SENSOR IS   BLOCKED"
3050 IF S=0 THEN PRINT TAB(15)"     STORE SENSOR IS UNBLOCKED"
3060 IF S=1 THEN PRINT TAB(15)"     STORE SENSOR IS   BLOCKED"
3070 IF F=0 THEN PRINT TAB(15)"     FWDOT SENSOR IS UNBLOCKED"
3080 IF F=1 THEN PRINT TAB(15)"     FWDOT SENSOR IS   BLOCKED"
3100 PRINT TAB(18)"LAST COMMAND SENT TO THE SMC       =";C
3102 PRINT TAB(18)"CURRENT COMMAND AT THE SMC         =";O
3110 PRINT TAB(18)"LAST COMMAND RECEIVED FROM THE SMC =";I
3120 PRINT TAB(18)"ERROR STATUS E                     =";E
3130 PRINT TAB(18)"MOUSE ERROR STATUS EM              =";EM
3150 PRINT : PRINT SPC(13);
3160 PRINT"MOUSE OUTPUTS  (PET TO SMC) LOW BYTE=";O1;"  HIGH BYTE=";O2
3165 PRINT SPC(10);
3170 PRINT"MOUSE INPUTS   (SMC TO PET) LOW BYTE=";I1;"  HIGH BYTE=";I2
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3189 PRINT
3200 GOSUB 8200
3300 RETURN
3380 REM --- SPECIFY TIMER FREQUENCY ---
3381 REM
3382 REM  NOTE: THE NDA5TST PROGRAM MAKES USE OF THE PET COMPUTER'S INTERNAL
3383 REM  CLOCK FOR TIMING SOURCE TRANSFERS AND CREATING PROGRAM DELAYS. THE
3384 REM  PET JIFFY CLOCK OPERATES AT A RATE EQUAL TO THE PET'S POWER SUPPLY
3385 REM  FREQUENCY. BECAUSE OF THIS, IT IS NECESSARY TO USE A VARIABLE (FR)
3386 REM  FOR THE TIMER FREQUENCY TO PREVENT SOFTWARE MODIFICATIONS WHEN
3387 REM  CHANGING THE COMPUTER'S POWER SUPPLY FREQUENCY. THE PROGRAM DEFAULTS
3388 REM  TO A POWER SUPPLY FREQUENCY OF 50 HZ.
3390 REM
3400 PRINT SPC(15)"■CURRENT TIMER FREQUENCY (HZ) = ";FR
3405 NP=2 : GOSUB 10000                    :REM PRINT 2 BLANK LINES
3480 INPUT"INPUT NEW TIMER FREQUENCY (HZ) ->";FR : PRINT
3485 IF FR<=0 GOTO 3400                    :REM KEEP FR>0
3490 NP=2 : GOSUB 10000                    :REM PRINT 2 BLANK LINES
3495 RETURN
3497 REM
3499 REM --- TURN STEPPING MOTOR ON ---
3500 C=2:  GOSUB 8000                      :REM STEPPING MOTOR ON
3510 RETURN
3520 REM
3540 REM --- TURN STEPPING MOTOR OFF ---
3550 C=1:  GOSUB 8000                      :REM STEPPING MOTOR OFF
3560 RETURN
3998 REM
3999 REM --- TRANSFER SOURCE FROM STORE TO IRRADIATE ---
4000 C=2 : GOSUB 8000                      :REM MOTOR ON
4010 IF NOT E THEN 4040                    :REM SKIP IF NO ERROR CONDITION
4020 GOSUB 3000                            :REM ELSE LIST STATUS
4030 T0=FR*5 : GOSUB 7500                  :REM 5 SEC WAIT
4040 C=4 : GOSUB 8000 : TR=TI              :REM TRANSFER TO IRRADIATE
4050 PRINT,"■■TRANSFER TIME FROM STORE TO IRRADIATE (SEC) =";TR/FR
4060 C=1 : GOSUB 8000                      :REM MOTOR OFF
4070 NP=3 : GOSUB 10000                    :REM PRINT 3 BLANK LINES
4080 RETURN
4998 REM
4999 REM --- TRANSFER SOURCE FROM IRRADIATE TO STORE ---
5000 C=2 : GOSUB 8000                      :REM MOTOR ON
5015 IF NOT E THEN 5040                    :REM SKIP IF NO ERROR CONDITION
5020 GOSUB 3000                            :REM ELSE LIST STATUS
5030 T0=FR*5 : GOSUB 7500                  :REM 5 SEC WAIT
5040 C=5 : GOSUB 8000 : TR=TI              :REM TRANSFER TO STORE
5050 PRINT,"■■TRANSFER TIME FROM IRRADIATE TO STORE (SEC) =";TR/FR
5060 C=1 : GOSUB 8000                      :REM MOTOR OFF
5070 NP=3 : GOSUB 10000 : RETURN           :REM PRINT 3 LINES AND RETURN
5998 REM
5999 REM --- POSITION SOURCE AT STORAGE LOCATION  ---
6000 C=3 : GOSUB 8000 : TR=TI              :REM POSITION SOURCE AT STORE
6010 PRINT,"■■SOURCE POSITIONING TIME (SEC) =";TR/FR : PRINT
6020 NP=3 : GOSUB 10000                    :REM PRINT 2 BLANK LINES
6030 RETURN
6498 REM
6499 REM --- SEND COMMAND C TO STEPPING MOTOR CONTROL BOARD (SMC) ---
6500 REM
6501 REM  EXAMPLE: A NORMAL TRANSFER FROM STORE TO IRRADIATE REQUIRES THE
6502 REM  FOLLOWING SEQUENCE OF COMMANDS:
6504 REM  1) - SEND C=2 TO TURN THE MOTOR ON
6505 REM  2) - SEND C=4 TO TRANSFER FROM STORE TO IRRADIATE
6506 REM  3) - SEND C=1 TO TURN THE MOTOR OFF
6507 REM
6508 REM  MOVEMENT COMMANDS C=3, 6 AND 7 DO NOT REQUIRE THE PET TO TURN
6509 REM  THE MOTOR ON BEFORE EXECUTION.  COMMANDS C=4, 5 AND 10 DO.
6510 REM
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6511 PRINT,,"      SHUFFLER COMMANDS":PRINT,,"     ********************* "
6513 PRINT,,"    1=STEPPING MOTOR OFF"
6514 PRINT,,"    2=STEPPING MOTOR ON"
6515 PRINT,,"    3=POSITION SOURCE AT STORAGE"
6520 PRINT,,"    4=TRANSFER FROM STORE TO IRRADIATE"
6525 PRINT,,"    5=TRANSFER FROM IRRADIATE TO STORE"
6530 PRINT,,"    6=BLOCK ALL SENSORS"
6535 PRINT,,"    7=UNBLOCK ALL SENSORS"
6540 PRINT,,"    8=SET MOTOR DIRECTION TOWARD IRRADIATE"
6545 PRINT,,"    9=SET MOTOR DIRECTION TOWARD STORE"
6550 PRINT,,"   10=MOVE SOURCE ONE STEP":PRINT:PRINT
6555 INPUT"SELECT COMMAND (X TO EXIT   H FOR HELP) ->";C$ : PRINT
6560 IF C$="X" THEN RETURN                          :REM EXIT TO MAIN MENU
6565 IF C$="H" THEN 6511                            :REM BRANCH TO COMMAND LIST
6570 C=VAL(C$) : IF C=0 OR C>15 THEN 6555           :REM CONVERT STRING TO DECIMAL
6580 GOSUB 8000                                     :R'M SEND COMMAND
6585 GOTO 6555
6590 REM
6999 REM --- IRRADIATION POSITION REPEATABILITY TEST ---
7000 C=3 : GOSUB 8000                               :REM POSITION SOURCE AT STORE
7001 INPUT"NUMBER OF TRIALS (MAX=50) N ->":N : IF N<1 OR N>50 GOTO 7001
7002 N=INT(N)
7003 NP=4 : GOSUB 10000                             :REM PRINT 4 BLANK LINES
7006 PRINT SPC(15)"****************************************"
7007 PRINT SPC(15)" LOS ALAMOS SHUFFLER REPEATABILITY TEST"
7008 PRINT SPC(15)"****************************************"
7009 EL=1 : ER=0                                    :REM ERROR MESSAGES OFF
7010 T0=INT(FR/4) : GOSUB 7500                      :REM 1/4 SEC TEST DELAY
7015 N0=0
7030 PRINT SPC(19)"STEPS TO FWDOT SENSOR UNBLOCK"
7035 PRINT,," FROM IRRADIATE POSITION"
7040 C=3 : GOSUB 8000 : GOSUB 7400                  :REM REPOSITION SOURCE
7046 C=2 : GOSUB 8000                               :REM TURN STEPPING MOTOR ON
7047 T0=INT(FR/4) : GOSUB 7500                      :REM 1/4 SEC TEST DELAY
7050 C=4 : GOSUB 8000                               :REM MOVE TO IRRADIATE
7055 T0=INT(FR/2) : GOSUB 7500                      :REM 1/2 SEC TEST DELAY
7060 C=8 : GOSUB 8000                               :REM DIRECTION TO IRRADIATE
7065 T0=INT(FR/4) : GOSUB 7500                      :REM 1/4 SEC TEST DELAY
7070 L=0                                            :REM ZERO STEP COUNTER
7080 C=10 : GOSUB 8000                              :REM TAKE A SINGLE STEP
7090 L=L+1                                          :REM INCREMENT STEP COUNTER
7100 GOSUB 9000                                     :REM CHECK FOR FWDOT SENSOR
7110 IF F=0 THEN 7130                               :REM SKIP IF FWDOT SENS UNBL
7115 IF L>100 THEN 7125                             :REM SKIP IF EXCEED 100 STEP
7116 T0=INT(FR/4) : GOSUB 7500                      :REM 1/4 SEC STEP DELAY
7120 GOTO 7080                                      :REM BRANCH FOR NEXT STEP
7125 PRINT"ABORT ON NUMBER OF STEPS >100": ER=-1:REM SET TEST ERROR FLAG
7126 T0=INT(FR/4) : GOSUB 7500                      :REM 1/4 SEC WAIT
7130 C=3 : GOSUB 8000 : GOSUB 7400                  :REM POS SOURCE AT STORE
7131 T0=FR*5 : GOSUB 7500                           :REM 5 SEC WAIT
7260 PRINT SPC(30);L                                :REM PRINT NUMBER OF STEPS
7265 M=N0+1 : X(M)=L                                :REM STORE NUMBER OF STEPS
7270 N0=N0+1 : IF N0<>N THEN 7040                   :REM SKIP IF NOT LAST STEP
7290 C=3 : GOSUB 8000                               :REM POS SOURCE AT STORE
7292 GOSUB 7450                                     :REM CALCULATE STATISTICS
7295 EL=0                                           :REM ERROR MESSAGES ON
7300 RETURN
7399 REM --- CHECK FOR REVERSE OVERSHOOT ---
7400 GOSUB 9000                                     :REM READ INPUTS
7410 IF R=1 THEN 7420                               :REM IS REVOT SENSOR UNBLKD
7415 GOTO 7430                                      :REM SKIP IF UNBLOCKED
7420 PRINT"CABLE PAST REVERSE OVERTRAVEL SENSOR":REM ERROR-REVOT SENS UNBLK
7425 ER=-1                                          :REM SET TEST ERROR FLAG
7430 RETURN
7440 REM --- CALCULATE MEAN & STANDARD DEVIATION ---
7450 MU=0 : IF ER=-1 THEN 7484                      :REM SKIP STATISTICS IF ER
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7451 IF N=1 THEN MU=X(1) : S=0 : GOTO 7470        :REM SKIP IF ONLY 1 TRIAL
7452 FOR J=1 TO N                                 :REM LOOP FOR NUMBER OF TRIALS
7454 MU=MU+X(J) : NEXT J                          :REM SUM STEPS
7456 MU=MU/N                                      :REM CALCULATE MEAN
7458 S=0
7460 FOR J=1 TO N                                 :REM LOOP FOR NUMBER OF TRIALS
7462 S=S+(X(J)-MU)↑2                              :REM SUM DIFF SQUARED
7464 S=S/(N-1)                                    :REM CALCULATE VARIANCE
7466 S=SQR(S)                                     :REM CALCULATE SIGMA
7470 NP=10 : GOSUB 10000                          :REM PRINT 10 BLANK LINES
7472 PRINT,"**********************************************************■"
7474 PRINT,,"      MEAN # OF STEPS = ";MU
7475 PRINT,,"      STANDARD DEVIATION =";S : PRINT
7476 PRINT,"**********************************************************"
7480 NP=10 : GOSUB 10000                          :REM PRINT 10 BLANK LINES
7482 GOTO 7486                                    :REM SKIP IF NO ERROR
7484 PRINT"■ERROR IN TEST, NO STATISTICS GENERATED■■"
7486 RETURN
7487 REM
7488 REM --- PET CLOCK TIMING LOOP ---
7489 REM
7490 REM  NOTE:  PET TIME IS IN FRACTIONS OF A SECOND GIVEN BY THE INVERSE OF
7491 REM  THE PET POWER SUPPLY FREQUENCY (HZ).  THE VARIABLE FR IS USED TO
7492 REM  DENOTE THE TIMER FREQUENCY. THE PET CLOCK DIFFERS FROM THE MOUSE
7493 REM  TIMER IN THAT INPUTS TO THE MOUSE TIMER MUST BE IN TENTHS OF A SECO
7494 REM
7495 REM  EXAMPLE:   A 2 SEC DELAY REQUIRES THE FOLLOWING STATEMENTS
7496 REM                  T0=2*FR : GOSUB 7500
7499 REM
7500 TI$="000000"                                 :REM ZERO PET CLOCK
7510 IF TI<T0 GOTO 7510                           :REM LOOP FOR T0/FR SEC
7520 RETURN
7530 REM
7900 REM --- PET/SMC COMMUNICATION SUBROUTINE MODULE ---
7910 REM
7920 REM   VARIABLES:
7930 REM       I = INPUT TO PET FROM THE SMC
7940 REM       C = COMMAND TO THE SMC FROM PET
7950 REM      S1 = MOUSE OUTPUT LINE LOW BYTE
7997 REM      S2 = MOUSE OUTPUT LINE HIGH BYTE
7999 REM
8000 TI$="000000"                                 :REM ZERO PET CLOCK
8010 GOSUB 9000                                   :REM GET SMC STATUS
8020 IF TI>FR*5  GOTO 8400                        :REM 5 SEC WAIT LIMIT
8030 IF I=0 GOTO 8010                             :REM WAIT TILL SMC READY
8040 GOSUB 9100 : S1=01 : S2=C : GOSUB 9200       :REM SEND COMMAND=C
8050 GOSUB 9000                                   :REM GET SMC STATUS
8060 IF TI>FR*5 GOTO 8415                         :REM 5 SEC WAIT LIMIT
8070 IF I<>0 GOTO 8050                            :REM WAIT FOR ACKNOWLEDGE=
8080 S2=0 : GOSUB 9200                            :REM READY FOR COMPLTE SIG
8090 GOSUB 9000                                   :REM GET SMC STATUS
8100 IF TI>FR*15  GOTO 8435                       :REM 15 SEC WAIT LIMIT
8110 IF I=0 GOTO 8090                             :REM WAIT FOR COMPLETE SIG
8120 IF I=C THEN RETURN                           :REM COMPLETION SIGNAL=C
8200 REM --- ERROR CONDITION I<>C OUTPUT ---
8205 IF I<11 OR I>15 THEN RETURN                  :REM IF NO ERROR RETURN
8210 IF EL=1 THEN RETURN                          :REM IF MESSAGES OFF RETUR
8215 PRINT,"■";
8220 ON I-10 GOTO 8241,8242,8243,8244,8245        :REM BRANCH TO ERROR MSGE
8225 PRINT"ERROR I OUT OF RANGE AT STATEMENT 8220  I=";I : RETURN
8230 REM
8240 REM --- SHUFFLER ERROR MESSAGES ---
8241 PRINT"#11 INVALID COMMAND SENT BY PET COMPUTER"                 : GOTO 82
8242 PRINT"#12 ERROR: CHECK SENSORS, POWER SUPPLY AND MOTOR STATUS": GOTO 82
8243 PRINT"#13 AN OVERTRAVEL SENSOR FAILED TO STOP STEPS"            : GOTO 82
8244 PRINT"#14 ENCODER FAILED TO PROVIDE STEP COMPLETION SIGNAL"     : GOTO 82
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8245 PRINT"#15 ENCODER PROVIDED EXCESS STEP COMPLETION SIGNAL"
8250 T0=FR*2 : GOSUB 7500                           :REM 2 SEC WAIT
8260 RETURN
8397 REM
8399 REM --- PRINT COMMUNICATION ERROR MESSAGE ---
8400 PRINT,"▒▒▒COMMUNICATION ERROR - STEPPING MOTOR CONTROLLER NOT READY"
8410 GOTO 8465                                      :REM ATTEMPT A RESTART
8415 PRINT,"▒▒▒COMMUNICATION ERROR - SMC DID NOT ACKNOWLEDGE";
8425 PRINT" PET COMMAND"
8430 GOTO 8465                                      :REM  ATTEMPT A RESTART
8435 PRINT,"▒▒▒COMMUNICATION ERROR - SMC COMMAND DID NOT COMPLETE"
8445 GOTO 8465                                      :REM ATTEMPT A RESTART
8460 REM --- SYSTEM IS LOST - ATTEMPT AN INTERRUPT RESTART ---
8465 GOSUB 3000                                     :REM LIST ERROR STATUS
8470 T0=FR*3 : GOSUB 7500                           :REM 3 SEC WAIT
8475 PRINT,"▒PULSING NMI TO RESTART STEPPING MOTOR CONTROL MODULE  ▒▒▒"
8480 T0=FR*2 : GOSUB 7500                           :REM 2 SEC WAIT
8490 GOSUB 9400                                     :REM TOGGLE NMI LINE
8500 IF NOT E THEN 600                              :REM IF NO ERROR - GO TO ME
8505 E=-1                                           :REM SET ERROR FLAG
8510 NP=3 : GOSUB 10000                             :REM PRINT 3 BLANK LINES
8515 PRINT"    ERROR--STEPPING MOTOR CONTROL DOES NOT RESPOND TO NMI INTERRUP
8520 NP=3 : GOSUB 10000                             :REM PRINT 3 BLANK LINES
8525 GOTO 600                                       :REM RETURN TO MENU
8998 REM
8999 REM --- READ MOUSE INPUTS AND CONVERT ---
9000 OPEN 1,13,8 : PRINT#1,CHR$(0) : GET#1,I2$,I1$ : CLOSE 1
9010 I1=0 : IF I1$<>"" THEN I1=ASC(I1$)                 :REM NUMERIC CONVERSION
9020 I2=0 : IF I2$<>"" THEN I2=ASC(I2$)                 :REM NUMERIC CONVERSION
9030 R=(I2 AND 1)                                       :REM REVOT SENSOR
9040 F=(I2 AND 2)/2                                     :REM FWDOT SENSOR
9050 S=(I2 AND 4)/4                                     :REM STORE SENSOR
9060 P=(I2 AND 8)/8                                     :REM POWER ON/OFF
9070 I=(I2 AND 240)/16                                  :REM SHUFFLER TO PET INP
9080 E=0 : IF I>=11 THEN E=-1                           :REM SET ERROR FLAG
9090 RETURN
9099 REM --- READ MOUSE OUTPUTS AND CONVERT ---
9100 OPEN 1,13,8 : PRINT#1,CHR$(255) : GET#1,O2$,O1$ : CLOSE 1
9110 O1=0 : IF O1$<>"" THEN O1=ASC(O1$)                 :REM NUMERIC CONVERSION
9120 O2=0 : IF O2$<>"" THEN O2=ASC(O2$)                 :REM NUMERIC CONVERSION
9130 O=O2 AND 15                                        :REM LAST PET COMMAND
9140 RETURN
9198 REM
9199 REM --- SET MOUSE OUTPUTS ---
9200 S2=S2+16                                           :REM KEEP NMI LINE HIGH
9210 OPEN 1,13,7 : PRINT#1,CHR$(S2);CHR$(S1) : CLOSE 1
9220 RETURN
9398 REM
9399 REM --- TOGGLE NMI LINE TO RESTART SHUFFLER AND STORE SOURCE ---
9400 GOSUB 9100                                  :REM READ MOUSE TO GET O1
9405 GOSUB 9900                                             :REM RESET MOUSE
9410 OPEN 1,13,7 : PRINT#1,CHR$(16);CHR$(O1)  : CLOSE 1    :REM SET NMI HIGH
9420 OPEN 1,13,7 : PRINT#1,CHR$(0);CHR$(O1)   : CLOSE 1    :REM SET NMI LOW
9430 T0=FR : GOSUB 7500                                     :REM 1 SEC WAIT
9450 OPEN 1,13,7 : PRINT#1,CHR$(16);CHR$(O1)  : CLOSE 1    :REM SET LINE HIGH
9460 GOSUB 9000                                             :REM GET SMC STATUS
9465 IF I<>8 THEN 9485                                      :REM SKIP IF FLAG<>8
9468 GOSUB 3000                                             :REM LIST STATUS
9470 T0=FR*4 : GOSUB 7500                                   :REM 4 SEC WAIT
9480 RETURN
9485 T0=FR*5 : GOSUB 7500                                   :REM 5 SEC TIMEOUT
9487 GOSUB 9000                                             :REM REREAD STATUS
9488 IF I<>8 THEN E=-1                                      :REM ERROR IF I<>8
9490 GOSUB 3000 : T0=FR*4 : GOSUB 7500                      :REM LIST STATUS
9491 IF E=0 THEN RETURN                                     :REM SKIP IF NO ERRO
9492 REM --- NMI ERROR LISTING ---
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9493 NP=7 : GOSUB 10000
9494 PRINT,"■■       FAILED TO RESTART STEPPING MOTOR CONTROLLER"
9495 PRINT,"      SYSTEM INOPERABLE - CHECK STEPPING MOTOR CONTROLLER"
9496 NP=8 : GOSUB 10000
9497 T0=FR*4 : GOSUB 7500
9498 RETURN
9590 REM -------- START MOUSE TIMER AND RUN FOR T5/10 SECONDS ------------
9600 A(1)=0:A(4)=0:A(1)=INT(T5/65536):B1=A(1)*65536
9610 A(2)=INT((T5-B1)/256):A(3)=T5-B1-(A(2)*256)
9620 OPEN 1,13,6
9630 PRINT#1,CHR$(A(1));CHR$(A(2));CHR$(A(3));CHR$(A(4)): CLOSE 1
9640 RETURN
9680 REM
9690 REM --- READ MOUSE SCALER NUMBER N ---
9700 OPEN 1,13,3: PRINT#1,CHR$(N): GET#1,A$(1),A$(2),A$(3),A$(4): CLOSE 1
9710 Z2=0
9720 FOR Z1=1 TO 4
9730 IF A$(Z1)="" THEN A1(Z1)=0: GOTO 9750
9740 A1(Z1)=ASC(A$(Z1))
9750 Z2=Z2*256+A1(Z1): NEXT Z1
9760 RETURN
9790 REM --- READ TIME TO GO ---
9800 OPEN 1,13,9: PRINT#1,CHR$(0): GET#1,A$(1),A$(2),A$(3): CLOSE 1
9810 Z2=0
9820 FOR Z1=1 TO 3
9830 IF A$(Z1)="" THEN A1(Z1)=0: GOTO 9850
9840 A1(Z1)=ASC(A$(Z1))
9850 Z2=Z2*256+A1(Z1): NEXT Z1
9851 RETURN
9880 REM
9890 REM --- RESET MOUSE MODULE ---
9900 OPEN 1,13,13 : PRINT#1,CHR$(2) : CLOSE 1
9902 REM
9905 REM --- SET SCALERS 1 AND 2 UNDER TIMER CONTROL ---
9910 OPEN 1,13,4 : PRINT#1,CHR$(3) : CLOSE 1
9912 REM
9915 REM --- CHECK MOUSE ERROR STATUS ---
9916 OPEN 1,13,9 : PRINT#1,CHR$(3) : GET#1,B$ : CLOSE 1
9917 IF B$="" THEN B=0 : GOTO 9920
9918 B=ASC(B$)
9920 EM=(B AND 1)*(-1)                              :REM MOUSE ERROR STATUS
9922 IF EM=0 THEN RETURN                            :REM RETURN IF NO ERROR
9925 OPEN 1,13,5 : GET#1,C$(1),C$(2) : CLOSE 1     :REM READ ERROR CODE
9929 EC=0
9930 FOR J=1 TO 2
9935 IF C$(J)="" THEN C(J)=0 : GOTO 9945
9940 C(J)=ASC(C$(J))
9945 EC=EC*256+C(J) : NEXT J
9950 IF EC=0 THEN RETURN                            :REM RETURN IF NO ERROR
9952 NP=4 : GOSUB 10000                             :REM PRINT 4 BLANK LINES
9955 PRINT,"■■      MOUSE MODULE ERROR - CODE # =";EC
9960 PRINT"■      IF ERROR CODE #23333 THEN COUNT TIME TOO SMALL";
9962 PRINT" FOR SCALER OPERATION"
9965 NP=5 : GOSUB 10000                             :REM PRINT 5 BLANK LINES
9970 T0=FR*5 : GOSUB 7500                           :REM 5 SEC WAIT
9975 RETURN
9985 REM
9999 REM --- OUTPUT LINE SPACING ---
10000 FOR II=1 TO NP : PRINT : NEXT II              :REM PRINT NP BLANK LINES
10010 RETURN
READY.
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