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Operator Manual for X-Ray Residual Stress Mapping Residual Stress User Center High Temperature Materials Laboratory

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1 Purpose

This document is intended to serve as a operator manual for remote control of the TEC x-ray diffraction system. It is assumed that the reader is familiar with the operation of the SaraTEC™ 1630 Acquisition Manager software for the TEC 1630 X-Ray Diffraction System. This manual describes the operation of the new TEC Remote Serial Control Module (RCSM) that runs on the TEC computer and Run-the-System that runs on the motion control computer.

2 Goal

The basic goal is to add enough control of the TEC system to enable stress mapping. In stress mapping, the specimen is positioned using our X-Y-Z-Phi translation system and data is collected using the TEC system. The process is then repeated for the next position using a table of preset positions. X-Y-Z-Phi axis management is handled by "Run-the-System", the LabVIEW program originally developed for the Neutron Residual Stress Mapping Facility, running on a separate computer from the one that controls the TEC. Run-the-System also manages all remote start, stop, and configuration commands that are sent to the TEC system. The two computers communicate over an RS-232 serial line.

3 Theory of Operation

The new RSCM is designed to function as a secondary application that co-exists with and simultaneously executes with the Acquisition Manager. The RSCM handles a set of commands via the serial port and triggers corresponding actions within the concurrently operating Acquisition Manager. Triggering of events within the Acquisition Manager is accomplished by generating a series of "windows message" events. These events allow the RSCM to "trick" the Acquisition Manager into believing that a series of keystrokes and/or mouse clicks are being received. These are basically indistinguishable from a user sitting at the keyboard performing the same operations by hand. By sending the proper simulated keystrokes and mouse clicks to the Acquisition Manager, the measurement procedure can be largely automated.

As reliable control is always a concern with any data collection system, the RSCM also provides a set of response, safety and completion messages back over the serial port. These

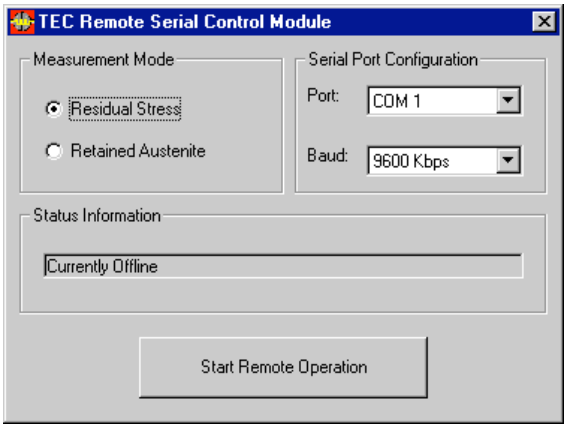
messages are based upon the state of the Acquisition Manager's windowing system and provide a fairly large degree of feedback information. This is possible because almost every window within the Acquisition Manager has a unique title (e.g. "SAFETY WARNING", "power on", "X-Ray On", etc). These window titles are detected by the RSCM and are used as the basis upon which feedback information is generated.

4 Remote Serial Control Module (RSCM) Software Operation

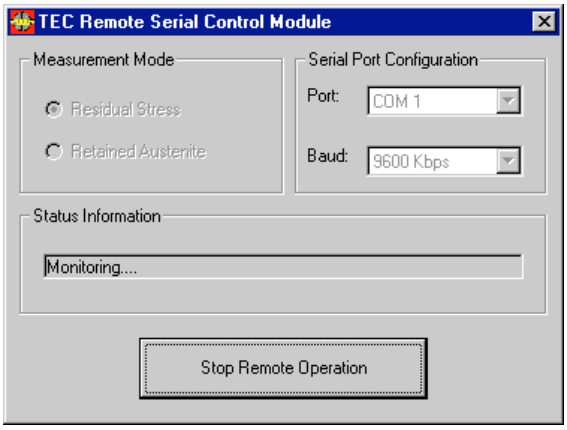
4.1 User Interface

The RSCM user interface is very simple. Since most program interaction is handled remotely over the serial port, only configuration items need to be addressed via the local user interface. The user interface can appear in one of the following two states. The specific variables and messages are discussed in the following sections.

- **Offline Mode** - Command processing inactive



- **Monitoring Mode** - Command processing active



4.2 Measurement Type

Due to differences in the Acquisition Manager user interface between the two measurement types (Residual Stress or Retained Austenite), the RSCM must know which measurement type is desired. This allows the RSCM to enter correct data into the appropriate Acquisition Manager setup forms and also lets it know which response dialogs to expect. This option cannot be changed when the RSCM is in monitoring mode.

- **Residual Stress -** This option should be selected whenever a Residual Stress measurement is to be made with the Acquisition Manager.
- **Retained Austenite -** This option should be selected whenever a Retained Austenite measurement is to be made with the Acquisition Manager.

4.3 Serial Port Configuration

- **Port -** This pull-down selection box allows the user to configure which RS232 serial port ("COM Port") the RSCM will use for communication with the external management computer. The list of available ports comes from the list of serial ports currently active within Windows. This selection cannot be changed when the RSCM is in monitoring mode.
- **Baud -** This pull-down selection box allows the user to configure the baud rate that the RSCM will use for communication with an external management computer. The list of available baud rates is: 1200 kbps, 2400 kbps, 4800 kbps, 9600 kbps, 19200 kbps, 38400 kbps, 57600 kbps, and 115200 kbps. This selection cannot be changed when the RSCM is in monitoring mode.

- **Current Setup –** The above parameters should be set to COM1 and to 9600 kbps to match the wiring and setting currently used by Run-the-System.

4.4 Start/Stop Remote Operation

This button allows the user to change the state of the RSCM between offline mode and monitoring mode.

- **Offline Mode -** No commands received via the serial port will be processed and no control of the Acquisition Manager will be attempted. The button will display "Start Remote Operation".
- **Monitoring Mode -** The RSCM is actively receiving and processing commands via the serial port and will attempt to control the concurrently running Acquisition Manager. The button will display "Stop Remote Operation".

4.5 Status Information

The Status Information display is a single line text field that gives brief status messages regarding the current operating state of the RSCM application. This field displays one of the following strings as appropriate:

- **"Currently Offline…"-** This is the message that is displayed when the RSCM is in offline mode.
- **"Monitoring…." -** This is the default message that is displayed when the RSCM is in monitoring mode.
- **"Command Received: <command>" -** This message is displayed for a period of 5 seconds whenever an external command is received via the serial port. The "<command>" field is a description of the command actually received (see the Section 5. If another serial command is received during the 5-second display period, the currently displayed string will be overwritten.
- **"Measurement in progress." -** This message is displayed whenever a measurement has been started on the Acquisition Manager via commands from the RSCM's serial port. This message is displayed until the measurement either completes, aborts, or an error is detected.
- **"Measurement completed." -** This message is displayed for a period of 10 seconds at the completion of a successful measurement. If a serial command is received during the 10-second display period, the currently displayed string will be overwritten.

- **"Measurement aborted."** - This message is displayed for a period of 10 seconds following a manual abort of the measurement by either an operator at the computer or via the serial port. If another serial command is received during the 10-second display period, the currently displayed string will be overwritten.
- **"Error detected." -** This message is displayed whenever an unexpected dialog box is detected while the system is in monitoring mode. This message will display indefinitely or until another serial command is received.
- **"Safety Warning!" -** This message is displayed whenever a safety warning dialog box is detected while the system is in monitoring mode. At this point the system will switch from monitoring mode back to offline mode and the "Safety Warning!" message will be left displayed. This message will only be cleared following user interaction with the application (e.g. manually re-entering monitoring mode).
- **"Unable to locate Acquisition Manager" -** This message is displayed if, when switching from offline mode to monitoring mode, the RSCM is unable to locate the Acquisition Manager. At this point, the system will remain in offline mode and the "Unable to locate Acquisition Manager" message will be left displayed. This message will only be cleared following user interaction with the application (e.g. manually re-entering monitoring mode).
- **"Updating Setup Dialog Information" -** This message is displayed whenever the automatic measurement procedure is updating the Setup dialog on in the Acquisition Manager. This message will be displayed until the process of updating the dialog either completes, aborts, or an error is detected.
- **"Starting Measurement" -** This message is displayed whenever the automatic measurement procedure is in the final stages of actually initiating a measurement. This message will be displayed until the measurement either starts, aborts, or an error is detected.
- **"Measurement Data Saved" -** This message is displayed once the automatic measurement procedure has completed and the measurement data file has been successfully saved to disk. This message is displayed only briefly prior to the display of the "Measurement Complete" message.

5 Acquisition Manager Configuration

Prior to running the system with the RSCM, various TEC system components must be configured to specific states of operation and several Acquisition Manager parameters must be entered to describe the type and number of measurements to be performed.

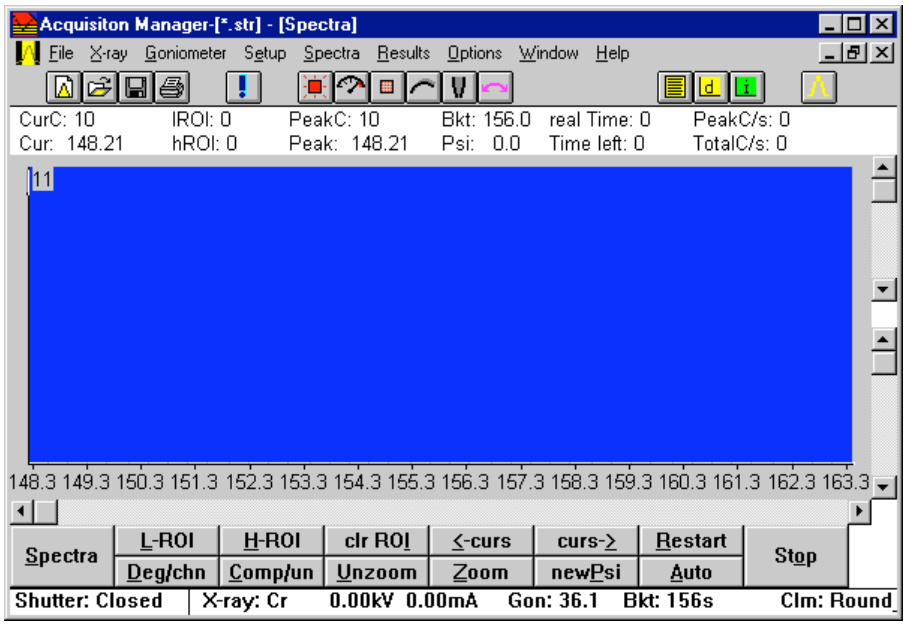
- **Measurement Type** - The Acquisition Manager must be configured to match the desired measurement type that the RSCM is configured for (i.e. Residual Stress or Retained Austenite). This may be accomplished via the Options, Measurement Type item from the Acquisition Manager main menu.
- **X-Ray Status** - The X-Ray High Voltage supply must be configured and ramped up to operating voltage levels.
- **Measurement Setup** - Some fields in the Acquisition Manager "Setup" dialog must be filled in. These fields are: Material, X-ray Type, Channels, Collimator, Bracket, Peak Range, Depth, Depth Units, and Percent Carbide. The Description, Phi Angle, Count Time, Psi Oscillation, and Psi Angle fields will be filled in by the RSCM. Measurement setup is discussed in detail in Section 6.
- **Auto-Filename Generation -** The auto-filename generation option will be ignored. The correct filename will be inserted by the RSCM as discussed in Section 6.4.

5.1 Acquisition Manager Initial State

When the RSCM is placed in monitoring mode, the Acquisition Manager should be in one of the two following menu states with no menu items selected.

- The Acquisition Manager primary screen:

- The Acquisition Manager Spectra window:



5.2 Restrictions on Acquisition Manager Usage

Due to the nature of the RSCM application, it is very dependent upon the state of the Acquisition Manager and is extremely sensitive to extraneous keyboard or mouse input by a

user. If any keyboard or mouse input is made to the Acquisition Manager while the RSCM is in monitoring mode, the RSCM is likely to become "out of sync" with the current state of the Acquisition Manager. This will result in erroneous keyboard/mouse commands being input by the RSCM with completely unpredictable results. For this reason, when the RSCM is in monitoring mode, manual operation of the unit should not be attempted. Additionally, measurement types that require manual adjustment of the detector positions to different Bragg angles should not be used.

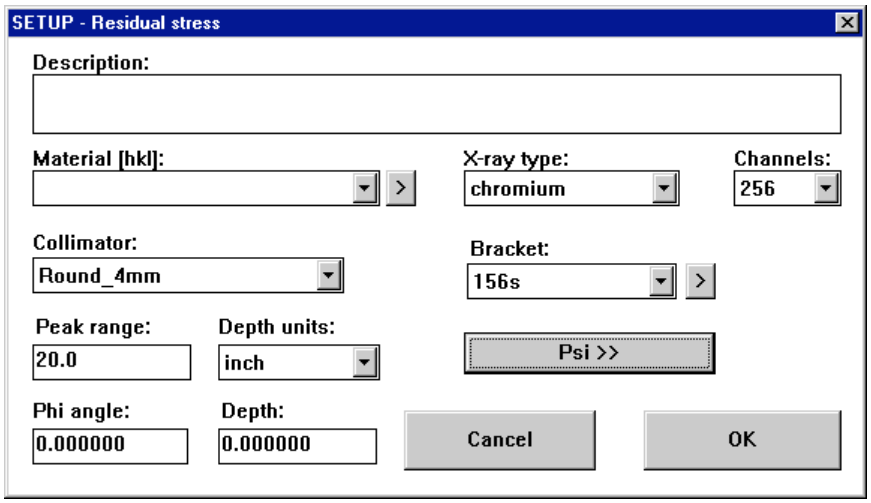
Note: One exception to this is the "F12" Emergency Stop key. This key will remain active at all times and will be recognized and handled appropriately by the RSCM. Another exception is that, for "Retained Austenite" measurements, the 'Warning' prompt asking the user to manually change detector positions will be ignored by the software and the "OK" button may safely be pressed without interfering with the operation of the RSCM.

6 Measurement parameters and commands

Prior to any data collection, whether or not the RSCM is being used for mapping, the Acquisition Manager needs to be told the appropriate values for several parameters of the measurement to be performed. This is done by filling in fields on the "Setup", "Psi Angles", and "File Save As" dialog boxes in the Acquisition Manager. As mentioned in Section 5, most of these fields must be filled in using the keyboard on the TEC computer.

The remaining fields will be filled in by the RSCM using values received from Run-the-System. The values for these fields are stored internally by the RSCM and are not sent to the Acquisition Manager until a data acquisition is started. This means that you cannot bring up the Setup dialog box to check that all fields contain the desired values until after a measurement has been completed. However, if you watch closely you can see the RSCM quickly bring up the dialog boxes and fill in the fields as it begins a measurement.

6.1 SETUP – Residual Stress



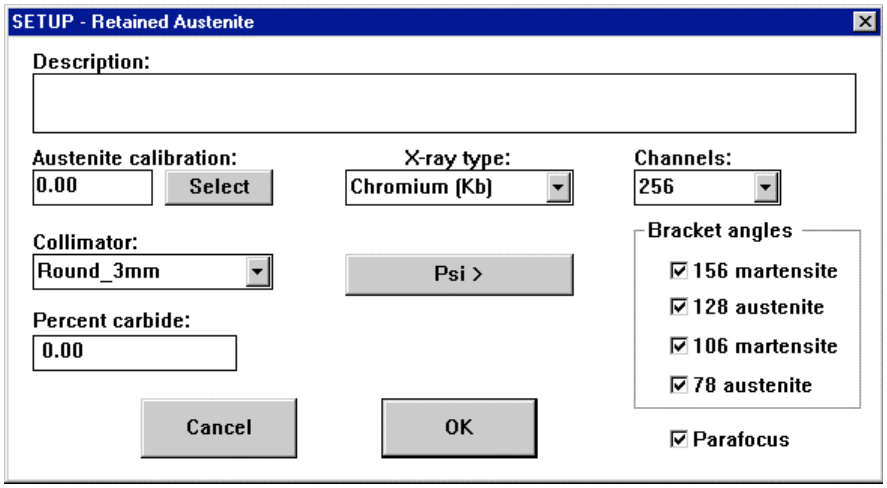
All fields except Description and Phi Angle should be filled in ahead of time by bringing up this dialog box inside the Acquisition Manager on the TEC computer before putting the RSCM in monitoring mode. The "Psi >>" button brings up another dialog box, discussed in Section 6.3. The fields filled in by the RSCM are:

- **Description** - During data collection, Run-the-System positions the X-Y-Z-Phi axes according to a preset table of positions stored in an external file called the "tab" file (described in Section 8.3). In order to make it possible during data analysis to be sure which TEC data file corresponds to which position of the axes, Run-the-System provides two options for updating the description field with a unique value for each point in the map. The first option is to add the name of the tab file, and the current line number in that file, to the front of the description entered (on the Run-the-System computer) by the user. The tab file name will be truncated to a length of 32 characters if necessary. The user-entered description will then be truncated, if necessary, to keep the total length of the modified description to a maximum of 128 characters. The second option is to add the positions of all of the axes to the end of the user-entered description. The labels will be in the form "name=value;". As with the first option, the final description is truncated to 128 characters, so that if the user-entered description is fairly long then some of the positions may disappear from the end of the description field. In addition to the above, the description for each measurement position may be labeled by a user-specified "note". This is done by including a column in the tab file labeled "note", and inserting the character "|" (vertical bar) into the description where the note is desired. During data

collection, the vertical bar will be replaced by the appropriate value from the note column in the tab file. Since the tab file is a table of axis positions, the values entered into the note column must be floating point numbers and may not contain alphabetic characters. The description field may not contain control characters.

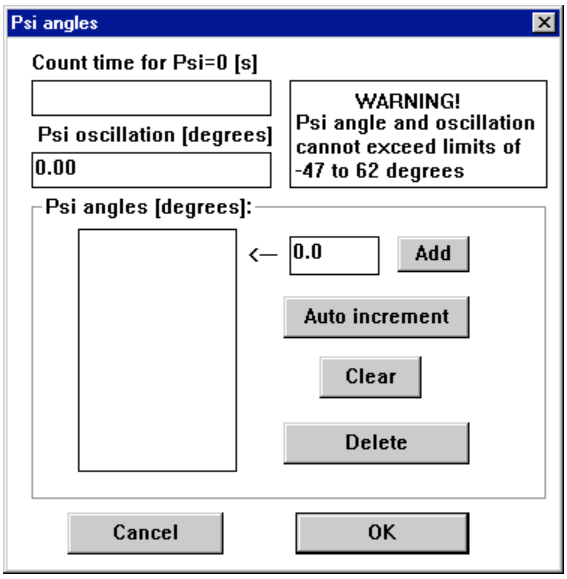
- **Phi Angle** - Since it is possible to change the Phi angle for each point in a map, this field will be automatically updated by the RSCM before each measurement.

6.2 SETUP - Retained Austenite



This description field is handled in the same manner as discussed in the previous section. All other fields should be filled in ahead of time at the TEC computer keyboard.

6.3 Psi angles

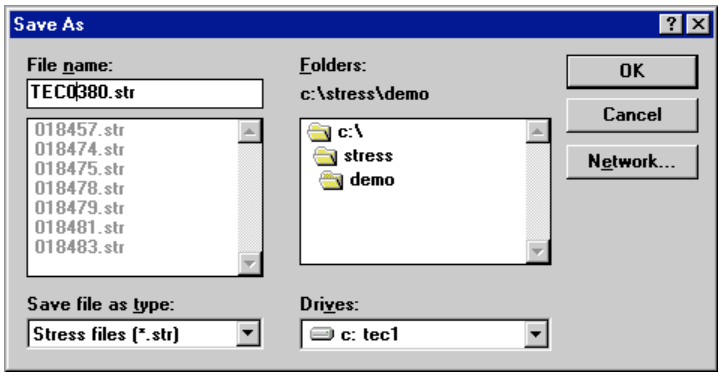


The Psi angles dialog box is the same for Residual Stress or Retained Austenite measurements. All fields are filled in by the RSCM.

- **Count time** - Since it is possible to change the count time for each point in a residual stress map, this field will be automatically updated by the RSCM before each measurement.
- **Psi oscillation** - If the Psi oscillation combined with any Psi angle exceeds the allowed range, the Psi angle entry that causes the problem will be set to 90 degrees and ignored (see next paragraph).
- **Psi angles -** The desired Psi angles are entered in one of three ways: 1) via this dialog box on the TEC computer, 2) via columns in the tab file (Section 8.3), and 3) via a list on the Operate TEC screen (Section 8.3). If no Psi angles have been entered by Run-the-System, then the Psi angles from the last measurement will remain in the dialog box list and will be used for the next measurement. To enter Psi angles via the tab file, create as many columns in the tab file as there are Psi angles desired. Label each of the columns "psi". Since all lines in the tab file must have entries in each column, if fewer Psi angles are desired for some lines than others, fill in the extra entries with a value of 90 degrees. Since this is not a valid angle, it will be ignored by Run-the-System and will not be transmitted to the TEC computer. Likewise, during data collection, any invalid Psi angles, or invalid Psi angles plus Psi oscillation combinations, will be ignored. To enter Psi angles via the list on the

Operate TEC screen, simply enter them using the “Psi Angles” array control. This list and the list in the TEC dialog box are automatically kept synchronized. (In fact, what happens is that whenever any change is made to the list in the Run-the-System, the TEC list is cleared and each entry is resent and added.) Press the “Clear” button to remove all entries from the list. If an invalid entry is made, the entry will be replaced by 90 and then ignored. If any psi columns are included in the tab file, then the “Psi Angles” control will be disabled and the psi angles from the tab file will be the ones used.

6.4 File Save As



During data collection, Run-the-System automatically generates and updates the file name. The name is formed from a 1 to 3-character prefix followed by a 5-digit run number (with leading zeros if necessary). A file extension of “.aus” or “.str” is automatically appended by the RSCM depending on the measurement type. The generated filename will automatically be entered into this TEC dialog box at the end of a measurement and the OK button will be pressed. If a file already exists with the same name, that file will be overwritten.

6.5 Start/Stop Acquisition

When data acquisition is started, the RSCM will bring up the SETUP dialog box, enter the appropriate data into the fields of that dialog box, bring up the Psi Angles dialog box, enter the appropriate data into the fields of that dialog box, close the dialog boxes, bring up the Acquisition Manager “Spectra” window (see Section 5.1) and then press the “Auto” button to start taking a measurement.

From this point, the RSCM software will begin watching for the occurrence of either an unexpected dialog box (safety warning, low count rate, etc) or the “Save As” dialog box. If an unexpected dialog box is detected, an appropriate response message will be generated via the RS232 serial port and the measurement will be aborted.

In order to facilitate typical measurements, the RSCM takes into account certain dialogs that normally occur and handles them automatically. Specifically, the “Standard Austenite calibration not selected” and “Save Existing Spectra to a File?” dialogs will automatically be answered “Yes” and “No”, respectively.

If the “Save As” dialog box is detected, then the appropriate filename will be entered, the “OK” button will be pressed, a Measurement Complete outgoing message will be generated, and the “Measurement completed” status message will be displayed. At this point the measurement is complete.

A measurement already in progress may be halted by pressing the stop button in Run-the-System. When the stop command is received by the RSCM, the “Stop” button on the Spectra acquisition dialog will be pressed, the RSCM will return to the monitoring state, a Measurement Aborted outgoing message will be generated, and the “Measurement aborted” status message will be displayed.

7 Error Checking

Messages are sent between Run-the-System and RSCM to verify successful transmission of commands and successful collection of the data. A dialog box will pop up in case of error, stating the cause of the problem.

The only error message likely to be encountered by the user is the Measurement Aborted message. This message will be sent whenever an RSCM controlled measurement is aborted either via program control, by someone manually pressing the “Stop” button in the Acquisition Manager Spectra window (which is not recommended operation), or because of a dialog box appearing during the measurement procedure.

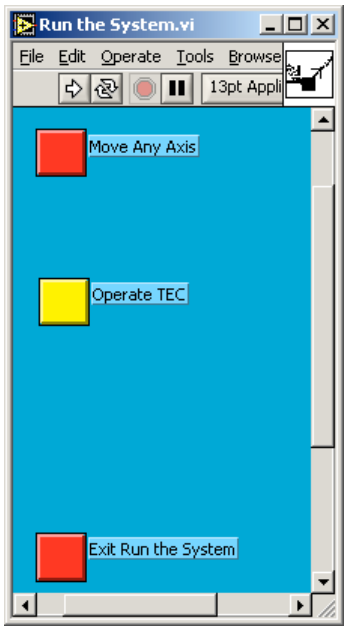
The <cause> field will contain the reason why the measurement was aborted. Valid <cause> messages are:

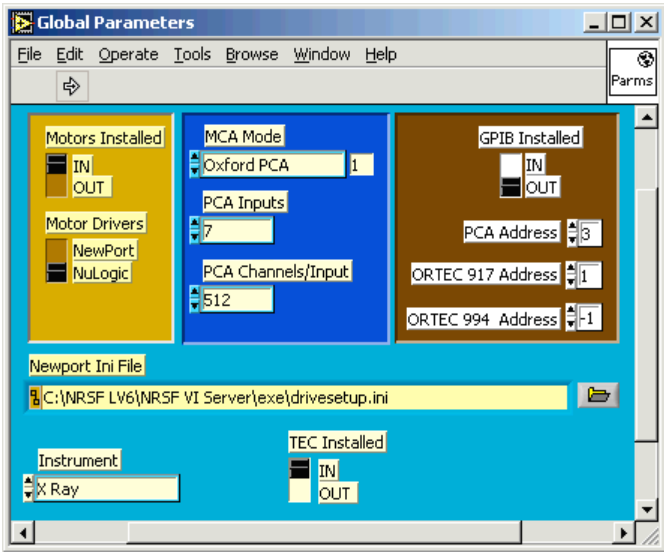
- **“Stop”** - The stop button in the Spectra window was depressed either manually or via RSCM control.
- **“Warning”** - A warning message of some kind has been detected (e.g. “X-ray tube does not match ‘SETUP’ tube” or similar).
- **“Safety Warning” -** A safety warning message has been detected (e.g. “low count rate” or similar**.** *Following a safety warning, the RSCM will automatically transfer into offline mode.*
- **“Emergency Stop” -** The emergency stop button (F12) has been pressed. *Following an Emergency Stop, the RSCM will automatically transfer into offline mode.*
- **“Unexpected Dialog” -** Another dialog box of some kind has appeared and halted the measurement.
- **“Setup Failed” -** The RSCM was unable to bring up the Acquisition Manager’s SETUP dialog screen to configure the measurement.
- **“Psi Setup Failed” -** The RSCM was unable to bring up the Acquisition Manager’s Psi Angles dialog screen to configure the measurement.
- **“Spectra Failed” -** The RSCM was unable to bring up the Acquisition Manager’s Spectra screen in order to begin the measurement.

8 Run-the-System

"Run-the-System" is a LabVIEW program originally written to run the neutron residual stress instrument. It has been extended to operate several instruments. For the TEC X-ray mapping instrument, the actual motion hardware is connected to a second motor controller computer that sits inside the safety enclosure. This second computer plays the role of an intelligent motion controller, conceptually similar to the Newport MM4005 which is used for the neutron stress mapping facility. For normal operation, no user interaction is require at the motor controller computer other than being sure it is booted up and running LabVIEW.

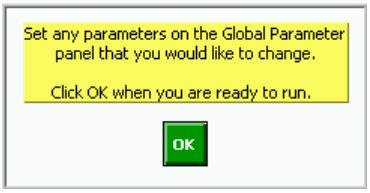
8.1 Startup





Run-the-System opens with the screen shown above. Other buttons appear in the gaps when the program is configured for operation with a different instrument. As with all LabVIEW programs, press the run arrow to begin execution.

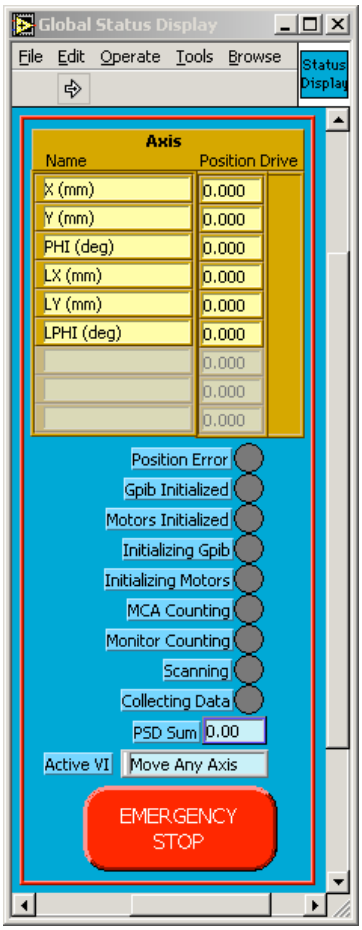
When execution begins, two other windows will open and a dialog box will appear. The Global Parameters window is used to configure Run-the-System for the instrument that is being controlled and the hardware that is present on the instrument. Verify that the controls are set to the following values.



- **Motors Installed** – In
- **Motor Drivers** – nuLogic
- **Instrument** – X-ray
- **TEC Installed** – In
- **All others** – Ignored for this instrument

If Motors Installed or TEC Installed is set to "Out" the corresponding hardware is simulated. This is useful for debugging purposes but is not used for normal operation.

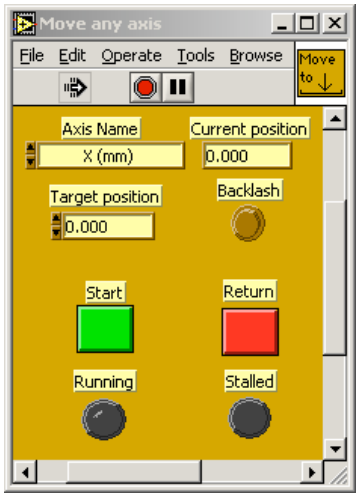
Once these control settings have been verified, press the green "OK" button on the pop-up dialog box to continue. This dialog box only appears the first time the program is run after being loaded. If you later want to change any controls on the Global Parameters page, exit Run-the System, make the changes while Run-the-System is stopped, then hit the run arrow to resume execution. Changing the parameter on the fly may lead to improper initialization.



You will then be asked if you want to initialize the positioners. This is required only when the motor control computer has been rebooted. It is also a good idea to reinitialize if the Run-the-System computer has been rebooted or if the LabVIEW programs have been reloaded on either computer. It is not necessary if Run-the-System has simply been stopped and restarted. The initialization procedure causes the motion stages to move to their home positions, which might not be acceptable if a sample has already been mounted. A more flexible initialization routine will be available in the future.

The "Global Status Display" shows the state of the instrument. The upper region shows the names and positions of the motors. A yellow light turns on when a motor is moving. The central region shows the status of the motion and data collection hardware. Not all of these indicators are relevant to the TEC X-ray instrument. The big red button is an emergency stop to stop all motion. This button is just a request to the LabVIEW program to stop motion, so it is possible that the motion might continue if the program or computer is hung. The best way to be sure that motion stops is to hit the yellow switches on the

front of the nuLogic motor drive boxes in the rack inside the enclosure or the big red external emergency stop button on the outside wall of the enclosure.



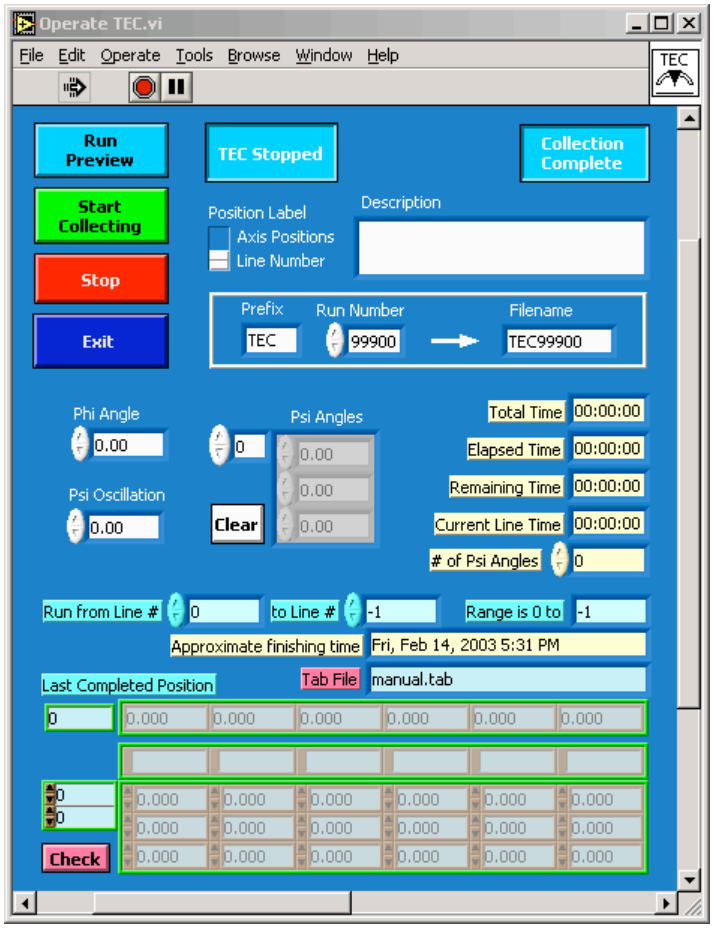
8.2 Move Any Axis

Manual motion of the sample positioning stages is done with "Move Any Axis". Select the desired axis and enter the target position. As a safety precaution, the default target position is the current one. Hit the green "Start" button to begin. When the motion is complete, the current position will be updated in the Global Status Display as well as in Move Any Axis. The target position will be updated also, so you must wait for the move to finish before entering a new target position. Error messages will pop up if the target position is out of range or if there is a problem with the motion. Hit the red "Return" button when finished.

8.3 Operate TEC

The upper region of the front panel contains controls and indicators for the data collection, the middle region contains parameters for the TEC, and the lower region controls the selection of measurement positions. This screen is intended to look and function in a similar manner to Collect Data for the neutron instrument.

For the TEC parameters, just enter the desired values in the boxes. As soon as any value is changed it is automatically sent to the RSCM program. The values are remembered as long as the program remains in memory but will be reset to default values when Run-the-System is reloaded from disk.



Selection of measurement locations is controlled via the "tab" file. The easiest way to create a tab file is to use Excel and save the file as tab-delimited text, hence the name "tab". The first row of the file must contain the name for the measurement time followed by the names of the axes to move. The subsequent rows contain the time to be spent at each position followed by the values of the axes at that position. The measurement time can be specified in hours, minutes, or seconds. If the name for the measurement time contains an "s" anywhere (ex, time (s), sec, s, …) the time will be interpreted as seconds. Similarly, if an "h" appears anywhere in the name the time will be in hours. Note that if the name is simply "time" then the time will be in minutes. This is for compatibility with tab files used for the neutron instrument where the time is in minutes. For the TEC system, it will be most convenient to

specify the time in seconds. A measurement time of zero can be used to move to a position without taking data. This is used to control the order of movement in cases where that might matter. The "Phi Angle" will automatically be updated, if needed, as data collection proceeds line by line from the tab file.

You are prompted for the name of the tab file when this VI starts. The contents of the tab file are then visible in the array control at the bottom of the front panel. The tab file display is grayed out so that it is not possible to modify entries before data collection begins. This is done for the TEC system since the measurement positions are not stored with the data. Axis names are verified for accuracy when the tab file is loaded. For a simple measurement or system test, it is possible to enter the tab file contents manually. When prompted for a tab file name, hit cancel. Your entries can be checked for validity by hitting the "Check" button in the lower left corner of the panel.

As the data collection proceeds, the "Last Position Completed" indicator is updated after each successful measurement. If data collection is halted for some reason, you can restart measurements at the next position. The "Run from Line #" and "to Line #" controls are used to select which lines in the tab file will be used. The controls are initialized to the appropriate values to run the entire tab file. The six indicators that are colored light brown are just for information to let you know the running times for the scan and for the current position and the approximate time that scan will be finished. The "# of Psi Angles" box can be filled in manually in Psi angles were entered at the TEC computer and not through Run-the-System.

The "Start Collection" button does just that. If you want to verify that the motions are all OK without spending the time to make measurements, then you can use the "Run Preview" button. The indicator in the upper right corner shows when the overall data collection process is underway. The one next to it shows when the TEC system itself is busy with a measurement.

9 Motion Control Hardware and Software

The motion control electronics consist of 19" rack mount boxes, each containing the power supply and driver modules for 3 axes, connected by ribbon cables to cards housed in the motor controller computer expansion chassis. The boxes are labeled "nuDrive" and the equipment is made by "nuLogic". The "nu" prefix originates with the fact that the cards are nuBus cards

designed to plug into early Macintosh computers. Since few Macintosh computers had a sufficient number of slots, the cards were housed in an expansion chassis. Since Macintosh computers now use a PCI interface, the expansion chassis is required for us to continue to use the nuBus cards. The expansion chassis must be powered on before the computer or else the computer will not boot. In principle, the expansion chassis could be connected to the computer that runs Run-the-System, but for several reasons we use a separate computer to control the motion hardware. LabVIEW handles the communication between the two computers. The computers communicate over the Ethernet LAN.

9.1 Initialization

The top-level program on the motor control computer is a LabVIEW VI called "Preload VIs". Note that this program is not actually running (ie, the run arrow looks like  rather than ). The program automatically runs once when it is loaded, then stops. The program is loaded automatically when the computer is rebooted so it should always be there. If not, load it by clicking on its alias on the desktop. It's purpose it to load the other VIs that are needed by Run-the-System, and to load the global variables with data from the configuration files discussed below. LabVIEW automatically runs the sub-VIs as needed, based on communication with the Run-the-System computer.

9.2 Configuration files

All information about the particular motion control hardware installed and operational at any particular time is contained in a collection of setup files that are read when Preload VIs is executed. The top-level file is named "preload vis.ini". An example is shown above. The first section tells the current number of active nuDrive boxes. This is followed by a section for each box that lists the filenames for the two configuration files for that box. The final section give the path to the software on the motor control computer. This is needed by LabVIEW for communication between the two computers.

```
[system]
numdrives=2

[Drive1]
dcfile=new drive:NRSF Motor VI's:Drive Setup Vis:x,y,phi setup.dcf
ssfile=new drive:NRSF Motor VI's:Run the System VI's:Axis Controls:x,y,phi setup.SSF

[Drive2]
dcfile=new drive:NRSF Motor VI's:Drive Setup Vis:lx,ly,lphi setup.dcf
ssfile=new drive:NRSF Motor VI's:Run the System VI's:Axis Controls:lx,ly,lphi setup.SSF

[paths]
vifolder=new drive:NRSF Motor VI's:Run the System VI's
```

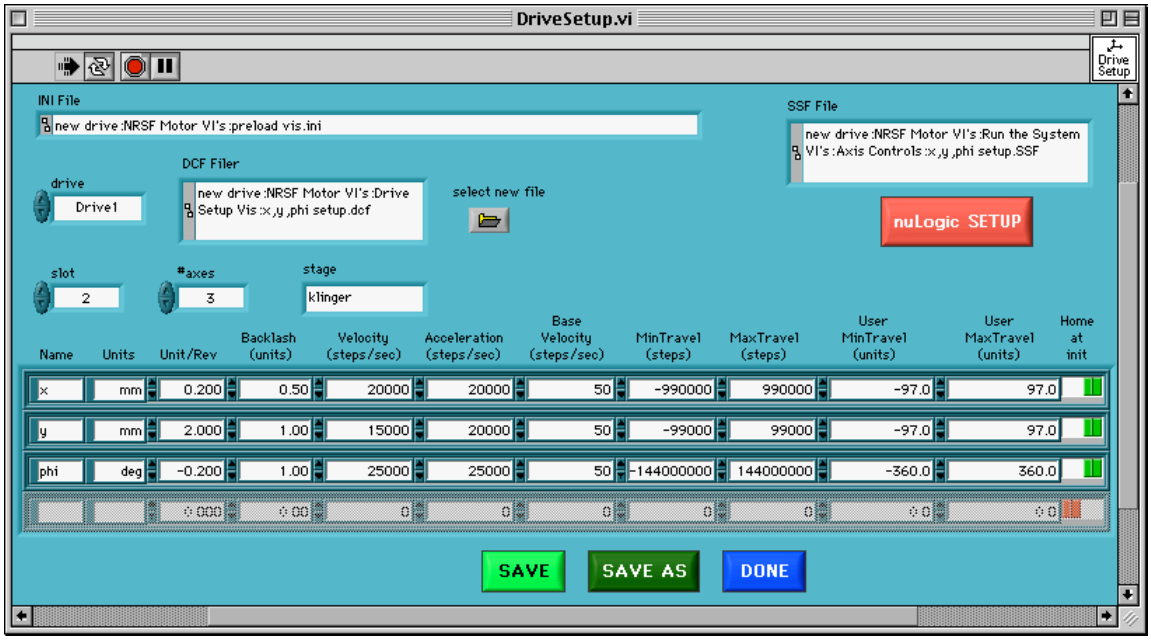
The "ssf" file is a LabVIEW binary file that is read and written using VIs originally supplied by nuLogic. We have been using these files since the beginning but there has been no easy link to the VIs that modified these files (discussed below). Unfortunately, not everything the software needs to know is stored in the ssf files so we created a "dcf" file to hold the additional information. An example of a dcf file is shown at left. The first section describes the drive box, the later sections describe the characteristics of each axis inside the box. Most of the entries are self explanatory. "unitrevs" is units per revolution. "homeinit" tells whether or not to physically move the stage to search for the home position when the axis is

```
[drive]
stage=klinger
slot=3
numaxes=3

[axis1]
name=x
units=mm
backlash=1.000000
unitrevs=2.000000
vel=15000
accel=20000
basevel=50
mintravelstep=-99000
maxtravelstep=99000
mintravelunits=-97.000000
maxtravelunits=97.000000
homeinit=TRUE

[axis2]
name=y
units=mm
backlash=1.000000
unitrevs=2.000000
vel=15000
accel=20000
basevel=50
mintravelstep=-99000
maxtravelstep=99000
mintravelunits=-97.000000
maxtravelunits=97.000000
homeinit=TRUE

[axis3]
name=omega
units=deg
backlash=1.000000
unitrevs=-0.200000
vel=25000
accel=25000
basevel=50
mintravelstep=-144000000
maxtravelstep=144000000
mintravelunits=-360.000000
maxtravelunits=360.000000
homeinit=TRUE
```

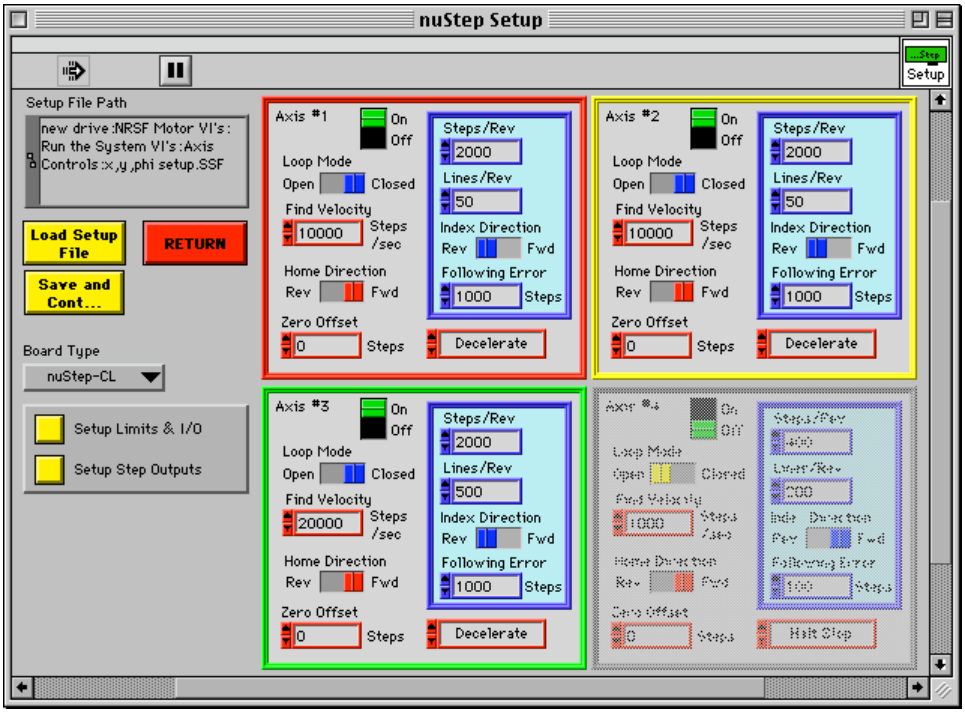
initialized. Otherwise the axis is left in its current position and that position is defined to be zero. Velocities and accelerations are in steps. "basevel" is the base velocity and should be left at 50.

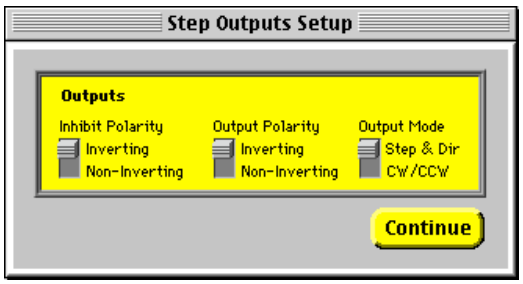
While it is possible to edit the ini and dcf files directly, it is usually preferable to modify them using the "Drive Setup" VI. The ssf files are binary and must be edited via Drive Setup which is described in the Section 9.3.

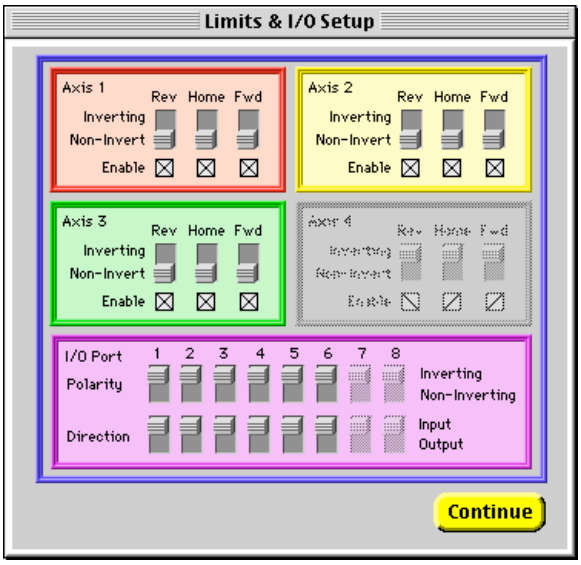
9.3 Drive Setup



The Drive Setup VI is used to edit the configuration files described in Section 9.2. The controls in the upper area of the front panel are used to modify the contents of "preload vis.ini" to point to the appropriate configuration files for the drives. The controls in the lower area of the





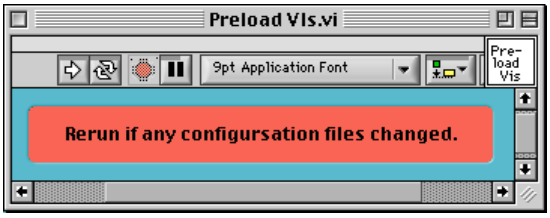


front panel correspond to the contents of the dcf files. Push the big red button labeled "nuLogic Setup" to run the nuLogic routine of the same name to modify the contents of the ssf files. "Loop Mode" open or closed says whether or not to use an encoder. The rest of the parameters describe fixed properties of the equipment and should only rarely be altered.

The small buttons in the lower left lead to two small sub VIs. The "Step Outputs Setup" VI configures the internal indexer signals to match the driver requirements. The settings shown are for nuLogic ministep drives. NuLogic's full step drives use different setting than their ministep drives, but we're unlikely to use the full step drives in the foreseeable future. The "Limits & I/O Setup" VI does what it says it does. This could be useful to override limit switches in case of mechanical problems.

When the changes are complete, push the red "Return" button to go back to the Drive Setup VI. If any settings were changed, you will be prompted to save them to the ssf file. If any changes were made to the parameters for the dcf file, push the green "Save" or "Save As" button to write them to disk. You will not be warned if you hit the "Done" button before saving your changes.

Important: After saving the changes to disk you must run Preload VIs to read these changes into memory. The changes will not take effect until this is done. Similarly, you must exit and restart Run-the-System for the changes to be transmitted between the two computers.



9.4 Z-axis motion

Control of the Z-axis is implemented somewhat differently from the other axes due to the need to drive a larger, hi-current motor. The driver module inside the nuDrive box is replaced with a Parker PDS-15 mounted near the motor. From the computer's perspective there is no difference. From the operator's perspective the main difference is the capability for manual control via a handheld pendent connected directly to the PDS-15 driver. Manual control is completely independent of the computer and can be performed even if the motor driver computer is turned off. Conversely, the computer is completely unaware of any manual moves even if it is turned on. Therefore, the operator must pay careful attention when performing a mixture of manual and automated moves.

The pendent has a locking toggle switch that selects manual or computer operation. In computer mode, the only switch that is active is the Emergency Stop. In Manual mode, there are push buttons for Fast and Slow motion. Multiturn pots above each button set the speed of the corresponding motion. An Up/Down toggle specifies the direction of motion.

The Z-axis is equipped with an electric brake which much be energized to release. The white box mounted near the motor controls the brake. The green light means the brake is released, red means the brake is locked. No light means the power is off and the brake is locked. A toggle switch controls power to the brake. The box has a computer input to control the brake but we decided it was not necessary to finish implementing computer control. Just leave the manual toggle switch in the unlocked position. As long as the power is on the motor will prevent movement and the brake will lock if power is removed. There's almost certainly enough mechanical inertia in the motor and gearbox to prevent motion anyway. If you try to move the motor while the brake is locked, the system will make a very nasty noise, but probably no harm results.

10 TEC Computer Control System

The following are a few observations made about the TEC Computer Control System when the computer was upgraded to a Pentium. The SaraTEC software is written using Borland C, version 3 or there about. The software will not run under any version of Windows NT and so the system operates with Windows 98. The security features of NT require that true device drivers be used when talking to hardware and the SaraTEC software does not use device drivers.

The data acquisition and control hardware consists of three 32-bit parallel I/O cards from National Instruments. These cards cost about $500 each but could be replaced with a single 96-bit I/O card costing about $200. TEC will probably switch to the new card for future systems. This would require only a small change to the cabling but a bigger change to the software. The old cards initially failed to operate in the new system. They were configured to get their timing signals from the system bus clock and the bus clock was too fast in the new computer. The boards have an internal clock and the boards were reconfigured to use the internal clock.

Two of the three boards are configured to use interrupts. It appears one of them uses IRQ 3 and the other IRQ 5. IRQ 3 is normally used by COM2. Initially there was a conflict between these boards and the configuration of the COM ports on the computer. The new TEC computer has 4 COM ports on the motherboard. The RSCM software has a selector to choose the COM port to use but it appears that it does not work if a port other than COM1 is chosen. There may be some juggling required if an additional COM port is needed in the future.

The new motherboard is a TL-MB 800. It is an industrial motherboard with lots of slots and hardware on the board, including a watchdog timer, digital I/O port and micro-PCI slot.