270M Rapid Scanning Imaging Spectrograph/Monochromator

User Manual

Including:

Graphical Monochromator Interface Software

and

SPEX.SYS Device Driver

SPEX

Part Number 80121

About the Manuals...

You may have more than one manual, depending on your system configuration. To find the manual that has the information you need, these guidelines may help.

- Each manual generally covers a product and the features and accessories peculiar to and/ or contained within that product.
- Accessories that can be applied to other products are normally covered by separate documentation.
- Software that is exclusively used with one instrument or system is covered in the manual for that product.
- Software that can be used with a number of other products is covered in its own manual.
- If you are reading about a product that interacts with other products, you will be referred to other documentation as necessary.

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1 Overview of the 270M:

The 270M is a new generation spectrometer. It includes several new innovations, along with the best of proven technology and features.

1.1 Total Automation:

All moving parts of the 270M are automated. The slits, scanning drive, and optional turret, shutters, and side port selection mirrors are controlled remotely by any of several computer/ software options or the HandScan via the optional SPEX232 interface. You can alter system performance and function as necessary without direct access to the instrument. With computer program control, it is possible to automatically adjust bandpass, change gratings, switch detectors or inputs without operator intervention.

1.2 Rapid Scanning Wavelength Drive:

A unique high speed sine drive moves the 270M's grating in steps that correspond to linear increments of wavelength change at the exit slit, or the center pixel of an array detector. The constant step size simplifies control, and eliminates the possibility of disparities in scanned data that could arise from using a direct worm drive that may have significant unevenness of wavelength movements. For 1200 g/mm gratings a step equals 0.03125 nm. Step sizes for all other grating groove densities can be calculated by applying an inversely proportional scale factor. For example: a 300 g/mm grating would move 0.125 nm per step. This conversion is done automatically by Spex controllers and software.

1.3 Optical Design Optimized for Imaging:

Optical performance is radically improved over earlier designs by a unique Czerny-Turner configuration utilizing a proprietary aspheric optical correction. The optical correction provides for exceptional imaging capabilities. Astigmatism, inherent in classical Czerny-Turner systems, is negligible. The fast (f/4) system delivers near perfect spectral imaging over an area 25 mm wide by 12 mm high in the spectrograph image plane. The computer aided geometric design prevents rediffracted light from reaching the detector. With other designs this rediffracted light can be detected as a spurious signal.

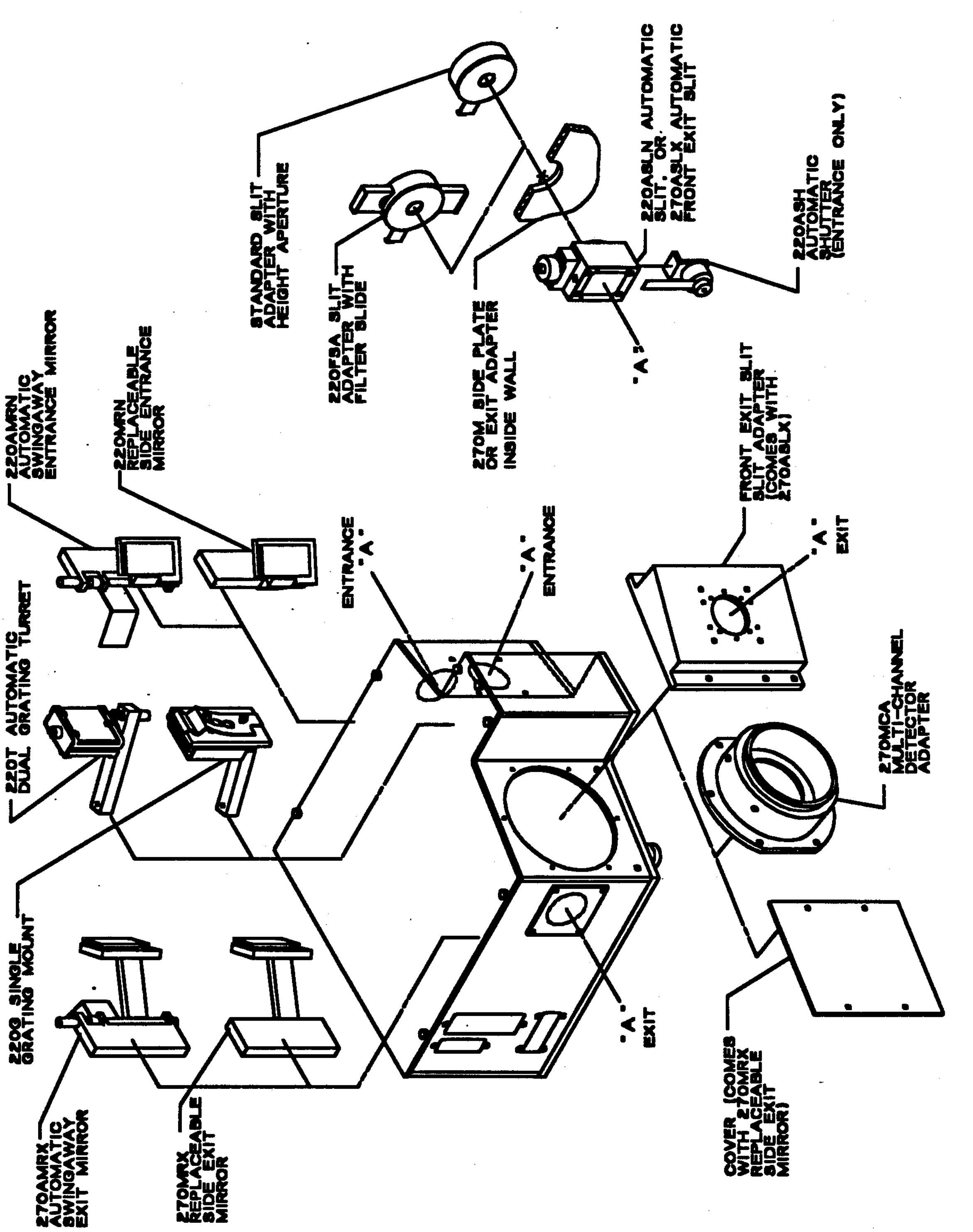

Figure 1: 270M Options

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1.4 Dual Axis Grating Turret:

Instruments equipped with an optional 220TK grating turret pay no penalty in optical performance for the convenience of automated grating interchange. To maintain image quality, throughput, and flatness of field it is essential that the grating is scanned by rotating on the correct axis. That axis is vertical, at the center of the face of the grating. This turret indexes the selected grating using a turret pivoting axis that is separate from the scanning axis. Either selected grating is positioned so that the center of its face is exactly on the scanning axis. By scanning the grating on this axis, throughput and image quality are preserved to the maximum extent possible throughout the scanning range. Because the turret is interchangeable, there is no limitation on the number of different gratings that can be mounted in a system.

2 Unpacking:

Your 270M was shipped in packing designed to protect it from harm under normal shipping conditions.

If shipping damage is noticed upon delivery, the carrier should note such damage on the receipt, and sign all copies. This will facilitate processing a damage claim with the carrier.

Open the top of the shipping carton and remove packing material until the instrument is exposed.

CAUTION: Do not use slit housings or other protrusions for lifting. Reach down around the edges of the instrument, grasp the bottom, and carefully lift it out of the
remaining packing. Place it on a sturdy table. Check through the packing and gather the small parts, cables, and documents that were shipped with it.

2.1 Inspection for Damage:

Inspect the instrument for visible evidence of any damage. Check that all readily visible mechanical and electrical components are in their proper places and intact. **If damage is evident, do not operate the instrument. Notify SPEX Industries Customer Service Department and the carrier at once.**

Many public carriers do not recognize claims for concealed damage reported later than 15 days after delivery. For a shipping damage claim, inspection by the carrier agent is normally required. For this reason, the original packing should be retained as evidence. While SPEX Industries, Inc. is not liable for damage in transit, the company will extend every effort to aid and advise.

2.2 Initial Setup:

Install the three leveling legs by screwing them into the threaded holes provided in the bottom of the instrument, two near the front corners, and one at the rear in the center. Place the pads provided under the legs and level the instrument.

Remove the top cover and familiarize yourself with the various components in your spectrometer. Refer to figure Figure 1 for component names and locations.

2.2.1 Removal of Shipping Restraints:

CAUTION: Take care not to touch any of the optical surfaces in the instrument. Damage can easily occur and degrade performance. Such damage is not covered by the warranty. Fingerprints on a grating surface cause permanent damage. Once a fingerprint is on a grating, it is probably best to leave it alone. (See Cleaning Optics under **Installation and Care of Optics.**) Attempts to remove a fingerprint usually do not significantly restore any lost grating performance, even though the cosmetic appearance may be improved. There is a high risk of cleaning attempts contributing to further damage and degradation of performance.

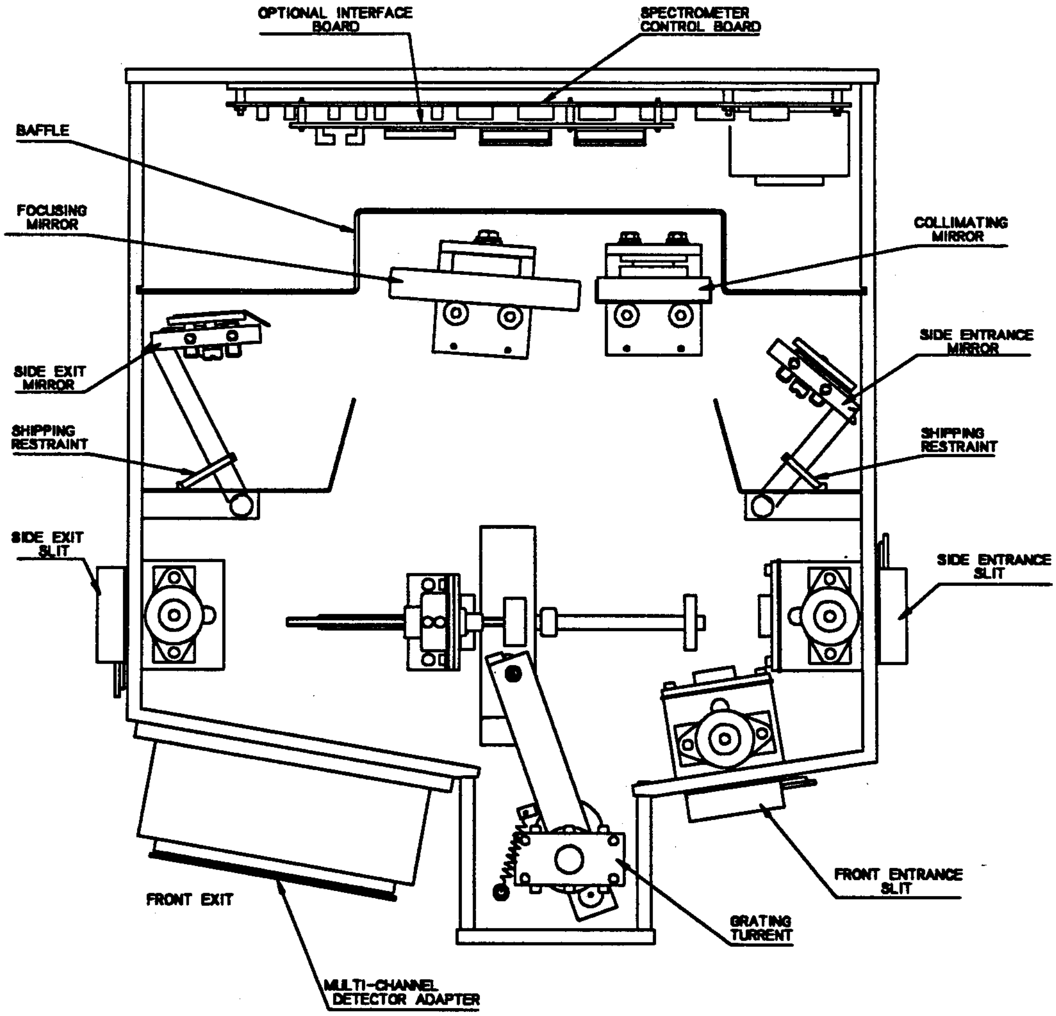

Figure 2: **270M Component Locations**

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If your 270M has motorized swing-away side entrance or exit mirrors (220AMRN or 270AMRX), the restraints must be removed. Taking care to avoid touching the any mirror surfaces, using wire cutters, cut the nylon straps that hold the mirrors against the side walls. See Figure 3 to locate the restraints.

WARNING: Never move the swingaway mirrors by hand when the power is on. The miniature gearhead motors are delicate and expensive. Forcing them manually may result in time consuming, costly repair.

If you have a grating turret, remove the foam block that is packed above it, along with the tape that secures the block. Save the block , for if you ever need to ship your 270M for any reason, the block is needed to repack the instrument.

Last, while holding the plastic grating cover in place, **CAREFULLY** remove the tape that holds the cover on the grating (if you have a turret, only the grating facing the interior of the 270M is covered, be careful to avoid touching the surface of the other grating). When the tape is removed, hold the bottom edge of the cover in place, and tilt the top edge of the cover away from the grating, then move the cover down and away from the grating. This technique minimizes the risk of grating damage. Anything, including dust, smoke, or organic vapors, that comes in contact with the surface of the grating is likely to cause damage or loss of reflectivity.

2.2.2 Environmental Considerations:

Your spectrometer should be kept in an atmosphere free of dust, corrosives and smoke. For specified performance, the 270M should be operated in a room where temperature control is maintained within $\pm 2^{\circ}$ C.

3 Electrical Connections:

The electrical connectors on the 270M are clustered on the same side as the side exit slit location. Connections for controllers or computers vary depending on the options present. The locations of the connectors are shown in the diagram.

3.1 Power Connection:

The 270M requires connection to an AC power source. The connector for the line cord, the power switch, fuse and 220/110 volt selection are provided in an integrated power module. Refer to Appendix A: 270M AC Power selection and Fusing, for further information.

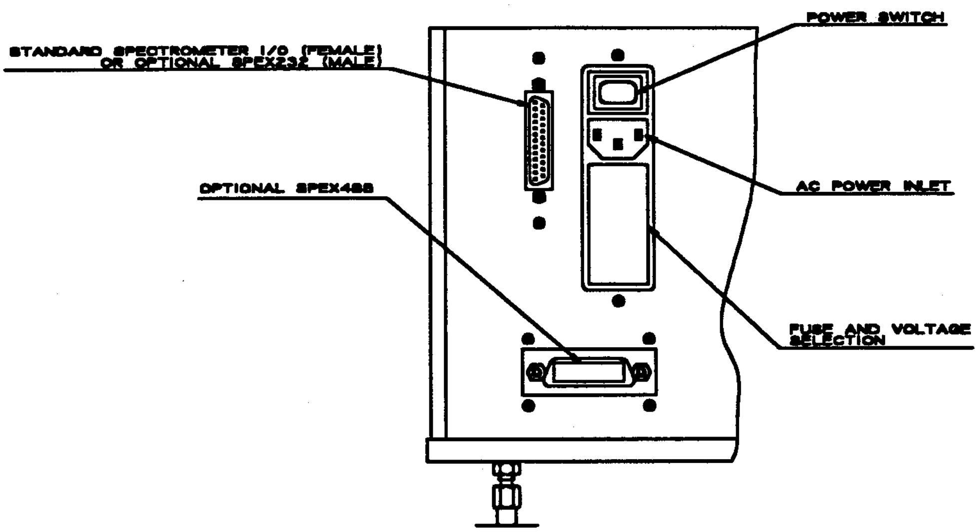

Figure 3: **Electrical Connections**
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3.2 Control Cable Connections:

The cable connections for the 270M vary, depending on the interface used and the controlling device or computer attached. The following table lists the cable connections to the 270M that are required for the various configurations. Some configurations involving a controller and a computer will require other cabling between the controller and the computer. Refer to the manual for your controller for further information.

3.3 Shutter Cable Connections:

If you have a 225MCD or 226MCD shutter, connect the shutter cable to the BNC connector and refer to your detector system manual to determine proper connection to the detector control electronics.

270M Control Interface Cabling

Interface type:	270M connector:	Cable number:	Connects to:	Software/ Controller Options:
Standard Spectrometer I/O (TTL)	25 pin "D" female	35816	PC parallel (LPT) port	Graphical Monochromator Interface (GMI), or User program via SPEX.SYS driver
Standard Spectrometer I/O (TTL)	25 pin "D" female	33990A	DataScan Mono Drive 1 or 2 connector	AutoScan, or user program via DataScan Programmer's Instruction Set
Standard Spectrometer I/O (TTL)	25 pin "D" female	33990A	DM3000 Mono1,2,3,or 4 connector on CTI board	DM3000 software for Research Spectroscopy
Standard Spectrometer I/O (TTL)	25 pin "D" female	33990A	QuikScan Motor Drive connector on Digital card	QuikView, or AutoScan (if special ordered for motor control via QuikScan digital board), or user program via PDALOAD.EXE driver
Optional SPEX232	25 pin "D" male	36406	HandScan connector	HandScan controller
Optional SPEX232	25 pin "D" male	97133	PC COM port, High memory accessible	QuikView if special ordered for use with SPEX232-270M
Optional SPEX232	25 pin "D" male	97133	PC COM port	User program via 270M Programmer's Instruction Set
Optional SPEX488	24 contact "D" female	user provided cable	IEEE-488 GPIB	User program via 270M Programmer's Instruction Set

Connector pin assignments are listed in Appendix B.

4 Software Installation and Control Interfacing:

The 270M must be controlled by an external controller or computer. The full automation of all moving parts of the spectrometer makes it unnecessary to have direct physical access to the instrument.

If your 270M does not contain the optional SPEX232 or SPEX488 interface, the Graphical Monochromator Interface (GMI) software is provided. Along with the GMI, there is a software driver, SPEX.SYS, that contains the low level code that the GMI is built on. SPEX.SYS is described in a following subsection.

Spex also offers several software options to control your 270M, such as AutoScan for use via a DataScan controller, QuikView for use in conjunction with a QuikScan Photodiode Array, and the DM3000 Spectroscopy Computer. Each of these are configured at the factory for your system and you need not be concerned with protocols or handshaking.

A Programmer's Instruction set is also provided with systems that include the optional DataScan controller, or the SPEX232 or SPEX488 interfaces.

Each group of controlling options is outlined in this section, along with direction to further documentation, if necessary.

Refer to the **Electrical Connections** section for appropriate cable connections.

At this point, the installation procedure branches. Please find the subsection pertaining to the software/ controller you will be using.

4.1 Standard Graphical Monochromator Interface Software (GMI):

If your 270M does not contain the optional SPEX232 or SPEX488 interface, the GMI software is provided on a diskette for installation on a PC running MS DOS 3.3 or 5.0. You will need to know the number of an available parallel port (LPT1,2,3,or 4). Connect the 35816 cable to that port, and to the 270M standard spectrometer I/O connector.

To Install the GMI software on your PC:

- Boot your PC
- Insert the diskette into the floppy drive and from the DOS prompt, type"A: [Enter]"

- at the A:\> prompt, type "install [Enter]"
- Follow the instructions on the monitor screen to install the GMI software on your computer.
- To run the GMI software after installation, at the DOS c:\ prompt: type "CD\GMI [Enter]" (to go to the directory where GMI is installed) and then type "GMI [Enter]" to execute the program.

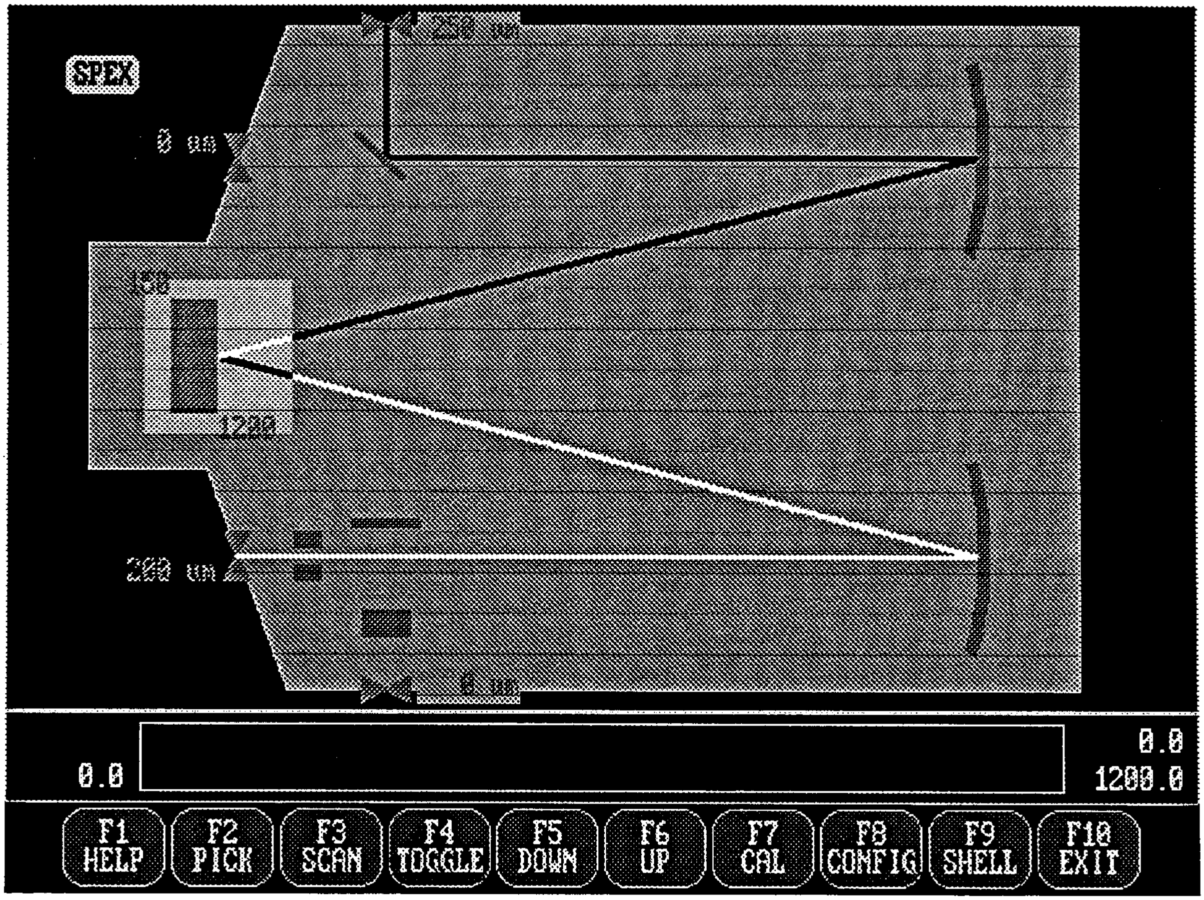

Figure 4: **Display shown by GMI Software**

GMISET.PCX

If communications with the 270M fails, the GMI will prompt to offer running in demo mode. To correct this, check that the 270M is powered on, and the 35816 cable is properly connected to the 270M standard spectrometer I/O connector and the parallel port on your PC that you specified when installing the GMI.

The GMI screen displays a graphical representation of the 270M. The screen shows the available devices in the spectrometer that can be controlled. Present slit widths, wavelength, turret and side mirror positions are displayed. The screen also has brief prompts to assist you, and the [F1] key calls detailed context-sensitive help messages to further explain the various functions called.

4.2 SPEX.SYS Driver:

The SPEX..SYS driver is a low level interface to software that you or your programmer may create. This driver is used by and included with the GMI software. To avoid confusion, it is best to be sure that the interface and 270M are functioning properly first, then proceed to writing, testing and debugging your program. Writing programs utilizing device drivers such as SPEX.SYS requires considerable programming skill, and is therefore not recommended for the occasional or novice programmer.

Please complete the GMI installation and perform the **Initial Checks** in section 7 of this manual with the GMI before proceeding to programming with SPEX.SYS.

Documentation for SPEX.SYS is in Appendix D. This documentation is normally sufficient to get an experienced programmer started writing controlling routines for the 270M.

4.3 Optional HandScan:

If your 270M will be controlled by a HandScan, please refer to the HandScan section of the DataScan / HandScan / SPEX232 / SPEX488 manual.

Note: Your optional SPEX 232 interface that connects to the HandScan can also be used to control your 270M from a computer. If you would like to use the SPEX 232 connected directly to your computer, please perform the initial checks as described in section 27 using the HandScan, then refer to the Programmer's Instruction Set section of the DataScan / SPEX232 / SPEX488 manual. The support diskette provided contains files to get a programmer started writing routines for a DOS PC.

4.4 Optional SPEX232 and SPEX488 Interfaces, and DataScan Controller:

Example programs using the Programmer's Instruction Set is provided on a diskette for use with on a PC running MS DOS 3.3 or 5.0. Please refer to the Programmer's Instruction Set section of the DataScan / HandScan / SPEX232 / SPEX488 manual for setup procedures and information about writing your own programs with the Instruction Set. Please use the sample programs provided on the support diskette to verify communications and perform the 270M **Initial Checks**.

The DataScan and the SPEX 232 interface also connect to the HandScan. If you have a HandScan, please perform the **Initial Checks** with the HandScan, then refer to the Programmer's Instruction Set section of the DataScan / HandScan / SPEX232 / SPEX488 manual.

4.5 Optional DM3000 Spectroscopy Computer:

The DM3000 software controls the 270M via the Standard Spectrometer I/O connector. Please refer to the DM3000 manual to set up the software and familiarize yourself with it. Then return to the 270M manual **Initial Checks** section.

4.6 Optional AutoScan Software:

The AutoScan Software controls the 270M via the DataScan, or via the QuikScan digital board in systems special ordered in that configuration. Please refer to the AutoScan manual to set up the software and familiarize yourself with it. Then return to the 270M manual **Initial Checks** section.

4.7 Optional QuikScan PDA system:

If your 270M is to be controlled by your PC along with your QuikScan diode array system, please refer to the QuikScan PDA manual to install the controller boards and the QuikView Software manual to familiarize yourself with the software. Then return to the 270M manual **Initial Checks** section.

4.8 PDALOAD.EXE Driver:

The PDALOAD.EXE driver is installed with the QuikView software that is provided with the QuikScan photodiode array detector. Please complete the QuikScan installation and check out your 270M with QuikView before proceeding to programming with PDALOAD.EXE. To avoid confusion, it is best to be sure that the interface and 270M are functioning properly first, then proceed to test and debug your program. This method of programming requires considerable programming skill, and is therefore not recommended for the novice or occasional programmer. The documentation provided in the PDALOAD.EXE driver section of the QuikView Manual is sufficient to get an experienced programmer started writing controlling routines for the 270M.

4.9 Controlling the 270M with the Standard Spectrometer Interface:

This subsection details the functionality of the standard Spectrometer I/O, for those who wish to interface directly to the hardware using TTL logic. This discussion does not apply to systems with optional 232 or 488 interfaces, or the DataScan controller.

The easiest way to confirm proper operation of this interface is to install the Graphical Monochromator Interface (GMI) software and SPEX.SYS driver on a DOS PC. Refer to the GMI instructions earlier in this section for further information.

The appendix on page 52 includes a pin function table for the Standard Spectrometer I/O (TTL) connector.

4.9.1 Interface Circuits

The Parallel I/O or Interface Control Circuits consist of 3 input and 2 output buffers (they are all uni-directional). The buffers are TTL compatible and the pinout is arranged as to be consistent with the full line of SPEX Monochromators.

The input signals are terminated in the traditional 220/330 ohm pull-up / pull-down arrangement, the termination then feeds the input of a Schmidt Trigger (74 HCT14).

The output buffers are TTL 74 HC 9114 open collector drivers which should be terminated at the receiving end in the same manor as the input signals are terminated.

4.9.2 Basic Operation

At power up reset, the STATE COUNTER is forced to STATE 4, and all devices are disabled from normal operation.

The Shutter circuits default to the inactive or CLOSED positions.

The DC Motor Control circuits test the Direction Select Jumpers and move the motors in the appropriate rotational direction to set the 4 devices in the preferred positions.

The four Accessory (Slit) Stepper Motor Driver Circuits are disabled, and the Wavelength Motor sequence counter is set to 0 (this is of little consequence at this time).

When the RESET signal becomes inactive, If the SELECT CLOCK is high the STATE COUNTER remains in STATE 4, if SELECT CLOCK is low the COUNTER will advance to STATE 5.

Operation of the controller is now completely a function of the host computer. Raising and lowering the SELECT CLOCK line will advance the STATE COUNTER with each transition, high or low. Before the host can intelligently control the different devices, it must first locate the INDEX (Wavelength Drive) position. This is done by initiating a SELECT CLOCK transition and reading back the INDEX level on pin 7 of the I/O connector P2. This signal is high in all states of the STATE COUNTER other than STATE 0. When this state is reached this level goes low. When the host reads this level it may now keep track of the STATE COUNTER allowing itself to select any desired device and operate it.

For example, let's say we want to open the Front Entrance Shutter. Knowing we are at the Index position initiate the following sequence of events:

1. Lower and raise the SELECT LINE 3 times, after the 3rd low to high transition lower the signal once more. (we are now in STATE 7)

2. Lower the DIR signal (to OPEN the shutter).

3. Initiate a STEP pulse (lower then raise the STEP line).

4. Go back to the Index position.

To close the shutter, repeat the above steps except that in step 2 set DIR = high.

The reset dose little or nothing for system initialization or calibration of the Wavelength Drive or Slits. Once power has been applied it is the software that must position these devices to their optical starting positions.

4.9.3 Programming tip:

For those cases where more than one device is to be moved at the same time, the program should first select and change states for shutters, if appropriate to protect against inadvertant exposure of the detector. Next start the DC motors for the turret or side mirrors moving if needed. Then step the slit or wavelength motors, as they can be controlled while the DC motors are in motion. Finally, open the shutter when ready to expose the sample or detector. Before taking data, allow sufficient time for the slowest device that you moved to reach its new position.

When finished setting accessories to the desired positions the state counter should be returned to the INDEX position (state Ø). This will keep power consumption down.

4.10 Signal Descriptions

- **SELECT**

This signal is used to select the device to be operated. It is a static level which rests high or low as you move from one device to the next.

When power is first applied to the 270M Controller Card, a reset pulse is developed. Among other things this pulse initializes the internal State Counter to the IDLE State (state 4).

If the host computer or controlling device has the SELECT signal asserted LOW (0) the state counter will remain in the IDLE state. Once the SELECT signal is asserted HIGH the state counter moves to the Entrance Mirror state (state 5).

Further transitions of the select signal will cause the state counter to advance to successive states.

Each device is associated with a high or low level. The table below lists state counter, device and SELECT signal relationships.

Counter	State Name	Device Type	SELECT	INDEX
state 0	WAVELENGTH_STATE	Drive Motor	low	low
state 1	FRONT_ENT_SLIT	1/2 step	high	high
state 2	FRONT_EXIT_SLIT	1/2 step	low	high
state 3	DEVICE_3 Not Implemented	high	high	
state 4	IDLE STATE	None	low	high
state 5	ENTRANCE_MIRROR	DC Motor	high	high
state 6	TURRET	DC Motor	low	high
state 7	FRONT_ENT_SHUTTER	Binary	high	high
state 8	DEVICE_8 Not Implemented		low	high
state 9	SIDE_ENT_SLIT	1/2 step	high	high
state 10	SIDE_EXIT_SLIT	1/2 step	low	high
state 11	DEVICE_11 Not Implemented		high	high
state 12	DEVICE 12 Not Implemented		low	high
state 13	EXIT_MIRROR	DC motor	high	high
state 14	SPARE DC Motor	DC Motor	low	high
state 15	ENT_SHUTTER_2	Binary	high	high

- **DIRECTION**

The DIRECTION signal is an input to the 270M Controller Card which is used to control the direction of movement for the selected device. This line may be left high or low during transitions between devices, but should be asserted to the appropriate level at least 500 ns before any STEP pulses are made.

The wavelength drive motor, DC motor and half-step (slit) motor drivers are provided with jumper options to determine the direction of rotation for a high or low DIR input signal. The shutters require a low DIR signal to open a shutter and a high DIR to close it.

- **STEP**

This line should be kept HIGH (1) and activated by asserting it LOW and then HIGH. The negative (low going) edge initiates the step or switching action.

This signal is used to generate step pulses for the wavelength motor and slit stepper motors or to strobe the position data to the shutter or DC motors. The maximum repetition rate to the wavelength motor is 2560 hz. Do not exceed 400 hz for the slit step motors.

The STEP line should be held high during any SELECT or DIRECTION signal transitions.

- **INDEX**

This line is asserted low when the state counter is at state 0 (the wavelength state) It is used to mark the home position.

Once the INDEX position is found, one uses the SELECT line to advance to the desired state. It is the responsibility of the host program to keep track of device selections. It should be noted that only one device may be selected at a time.

- **SENSE**

The SENSE signal is used to report device status to the host. A LOW indicates an active SENSE condition. The meaning of the SENSE depends on the devices selected.

Shutter SENSE:

When a shutter is selected, SENSE will be low to indicate the shutter is closed, and high to indicate open. There is no feedback from the shutter to indicate the shutter's actual position. The SENSE is simply a logic indication of the last attempt to operate the device.

DC Motor Position SENSE:

A low is asserted if the device selected has been positioned in the preferred position. As in the case of the shutter this is a logical indication of the last attempt to set the device direction.

Half Step (Slit) Driver SENSE:

Outputs an alternate PHASE condition of 3 high and 5 low SENSE signals. This is accomplished with feedback from the motor driver circuits.

Wavelength Drive SENSE:

There is an internal signal that indicates the phase of the drive motor. This signal is a nearly square wave with a period of many steps. When the calibration / high limit switch is actuated, this signal is seen on the SENSE line. To Calibrate your controller to the 270M, you should step toward the high limit, until the first SENSE transition from high to low. For accuracy, it is recommended that you then back off 200 steps, and advance slowly again to the SENSE high to low transition. This exact step position corresponds to the wavelength that is shown on the DMD.INI label on the rear of your 270M.

5 Accessory Installation:

A full line of accessories are available for the 270M from light sources, optical fibers and interfaces to detectors and sample compartments. Most of these are shipped with separate documentation. The accessories described here are only those which are user installable and, in effect, become part of the 270M.

5.1 270MCA Spectrograph Exit Port Installation:

If your 270M has a spectrograph exit port for an array detector, remove all of the tape and the cover plate from the adapter flange and find the two 10-32 oval point retaining screws that will hold the detector mounting cup inside the adapter flange. If your 270M was shipped together with an array detector purchased from Spex on the same order, the detector mounting cup may be mounted to your detector. Otherwise, mount the cup to your detector with the three 8-32 flat head screws, washers, and nuts provided.

If you have a 226MCD shutter that was not factory installed, install it on the front surface of the detector mounting cup. See the Accessories section for instructions.

Insert the detector mounting cup, with the detector attached, into the adapter flange. If your array detector was shipped from Spex with the mounting cup attached, there may be pencil marks at the top of the cup and the adapter flange to provide a reference location for detector alignment. Snug the two 10-32 retaining screws to hold the detector. See the alignment section for final adjustment.

5.2 225MCD Shutter:

This external mount shutter replaces the spacer/ height limiter at the entrance slit. It is intended for exposure control on a Spectrum One CCD and QuikScan PDA detector systems. To install it, remove the four 6-32 socket head capscrews along with the spacer and remove the two 10-32 setscrews to the right of the slit. Then open the cover and attach the 225MCD in its place with the two 6-32 and two 10-32 screws provided with the shutter. replace the cover to the shutter.

The BNC connector on the right side of the shutter housing connects to the shutter cable of a Spectrum One or QuikView detection system.

5.3 226MCD Shutter:

This is an internal mount shutter that is intended for exposure control on Spectrum One CCD and QuikScan PDA detector systems. It attaches to the detector mounting cup of the 270MCA multichannel array adapter, fitting into the spectrograph exit port of the 270M. To Install it, see Figure 6: 226MCD Installation. There are four holes in the cup. Use only three of these holes, leaving the top hole unused. Insert 3 of the 2-56 screws provided, screwing on the three 0.5 inch spacers, followed by three set screws. Place the shutter on the set screws and fasten it in place using the three 0.375 inch spacers. Fasten the baffle plate over the shutter with three phillips head 2-56 screws. Remove the plug from the purge port on the back of the 270M, and replace it with the BNC connector provided. the wiring on the BNC connector should pass through the purge port and under the circuit board(s) inside and should be routed neatly with the existing wiring towards the spectrograph exit. When the detector/ cup/ shutter assembly is inserted into the multichannel adapter flange, connect the shutter wiring to the BNC and neatly secure any slack wiring with the existing wire retainers.

The BNC connector on the back of the 270M connects to the shutter cable of a Spectrum One or QuikScan detection system.

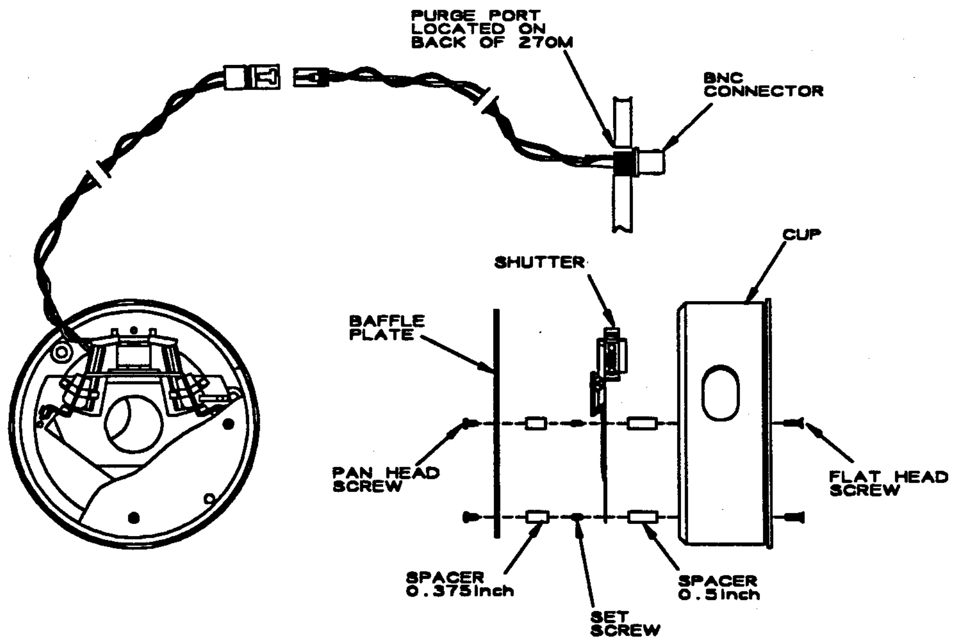

Figure 5: **226MCD Shutter Installation**

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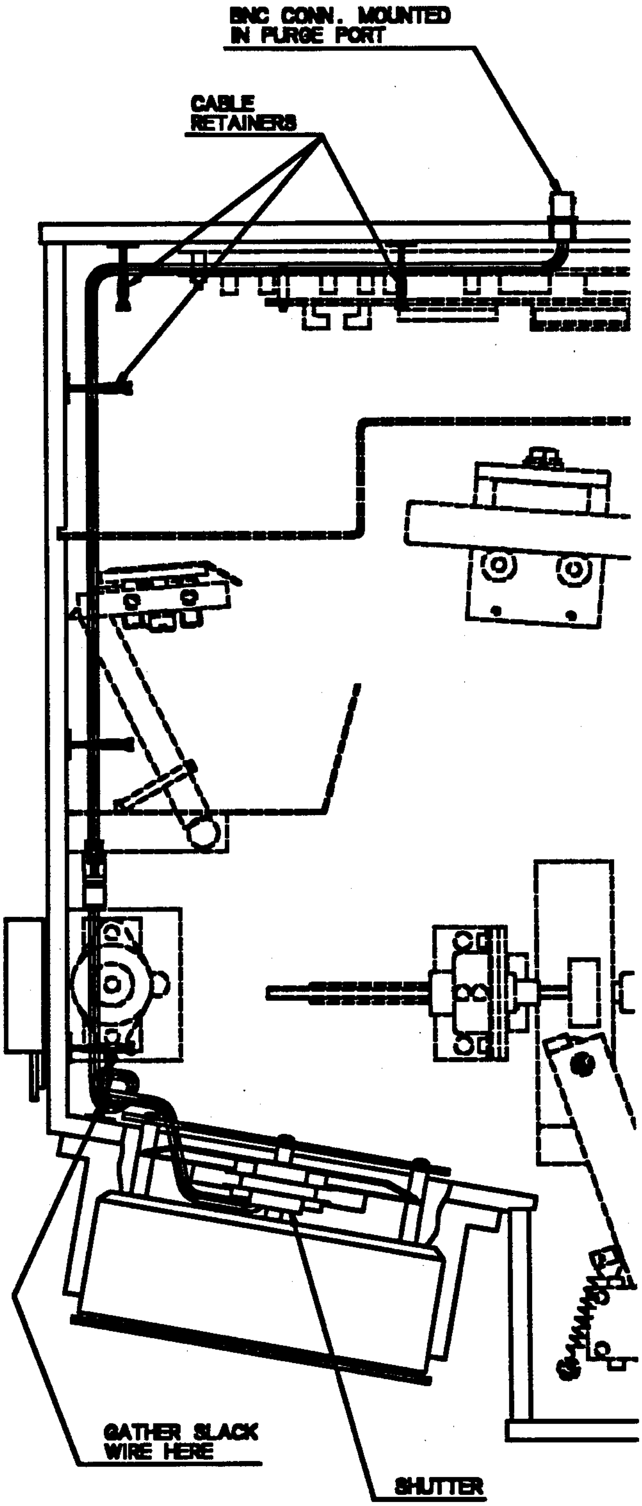

Figure 6: 226MCD Wiring

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6 Installation and Care of Optical Components:

Excepting those times when exchanging optional gratings, most users will not need to open the instrument after the inital unpacking

6.1 Mirrors and Gratings:

The mirrors and gratings in your spectrometer require no routine maintenance. Still, care should be exercised to prevent damage to their surfaces which will degrade throughput. Your spectrometer should be kept in an atmosphere free of dust, corrosives and smoke. Be careful to avoid touching a grating surface.

WARNING: Never turn the swingaway mirrors by hand when the power is on. The gearhead motors are delicate. Forcing them manually may result in time consuming, costly repair.

Dust or other solid debris should be blown off with dry dusting gas or nitrogen. **Be sure to hold cans of dusting gas upright. If they are tilted or inverted, liquid propellant may be discharged, causing greater damage to the optic.** If particles cannot be dislodged, consider leaving well enough alone, rather than risking surface damage. A fingerprint on a mirror or grating surface should be flushed off as soon as practical by squirting the surface of the mirror with research-grade methanol from a clean squeeze bottle. The power to the 270M should be turned off to avoid damage to the electronics, and should remain off until all traces of methanol vapor have dissipated, precluding any risk of ignition. Gratings should be removed from the instrument for flushing. When flushing a mirror, place some paper towels below the mirror to absorb the excess methanol. Blow off the grating or mirror with dry dusting gas or nitrogen to prevent spots or streaks. Be careful to avoid squirting or splashing the electronics or mechanical components. If the flow from the wash bottle does not remove the fingerprint, call Spex Customer Service for further advice.

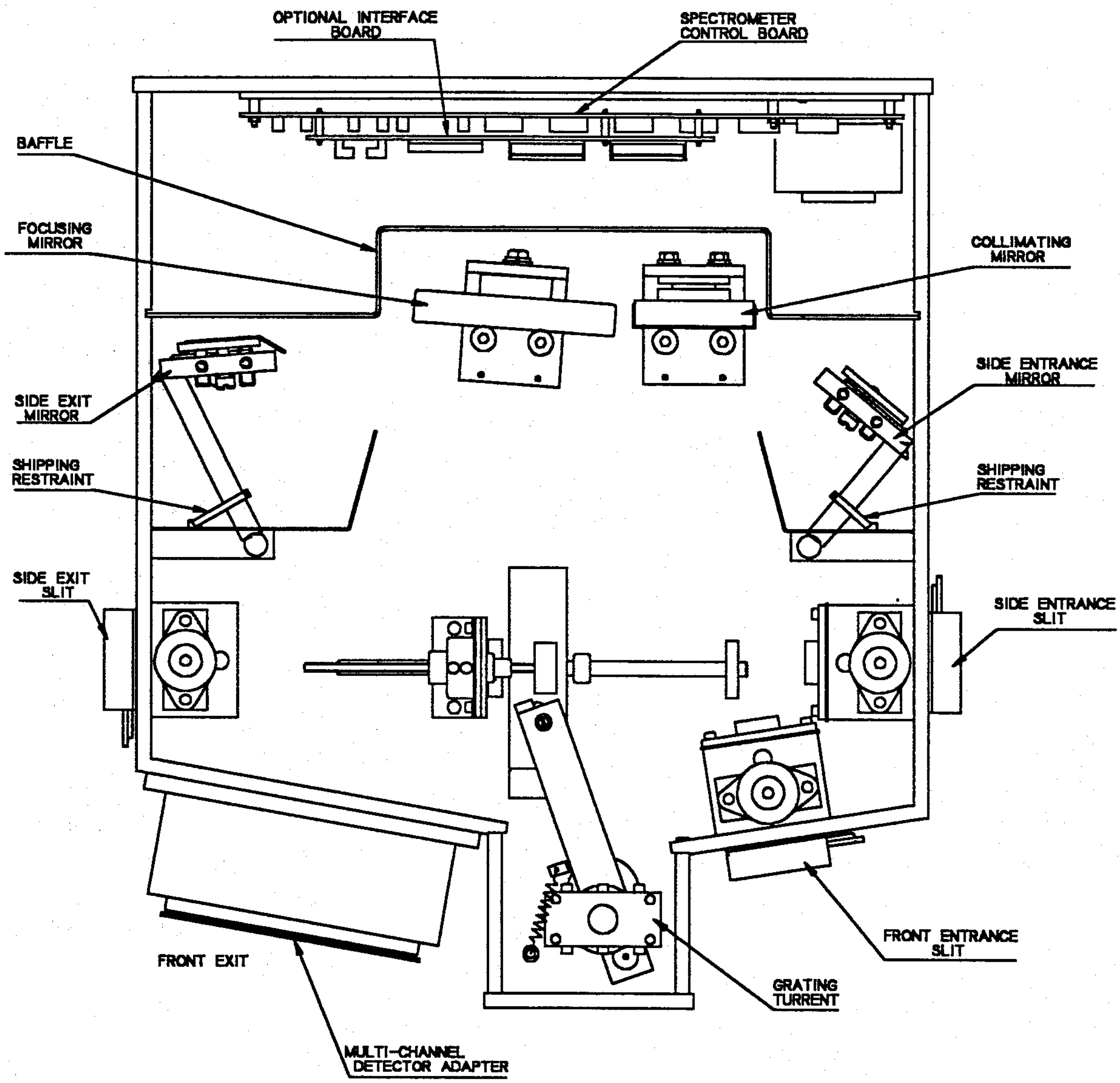

Figure 7: **270M Component Locations**
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6.2 Single Grating Mounts:

If your 270M has the standard single grating mount, each grating shipped with your 270M is mounted in a prealigned capsule. The first grating is shipped in the instrument. Additional gratings are packed separately.

Normally, any grating that has been aligned in the instrument need not be realigned each time it is installed. In the alignment section of this manual, there is a procedure to follow, should it become necessary.

The standard 220G single grating mount is shown in Figure 9. To remove the grating from the instrument, hold the grating mount by the sides, being careful not to touch the grating surface. The slotted leaf spring retainer at the rear of the mounting bracket is pulled upward to disengage the stud on the back of the grating mount. Then the mount and grating can be removed as a unit by withdrawing the stud through the backup plate.

To prepare an additional mounted grating for installation, place it face-up on an uncluttered clean surface. Carefully peel tape off one side of the grating and, using the tape on the other side as a hinge, swing the cover up and away from the grating. Separate the cover from the grating. Grasp the grating mount and place it in the instrument so that the stud passes through the keyhole slot in the retainer spring, and the three contact points engage properly. The top point is rounded and fits into a cup at the top of the backup plate in the instrument. At the bottom of the grating mount there is another rounded

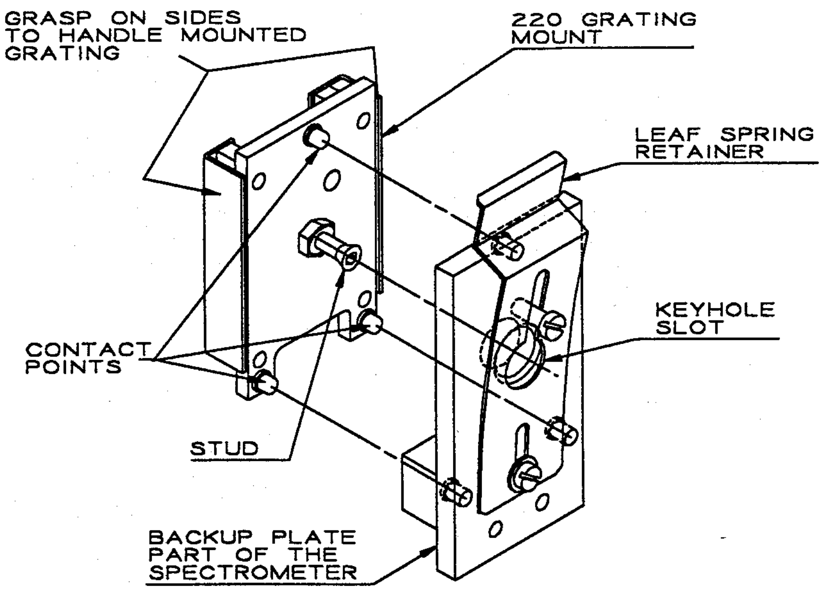

Figure 8: **220G Single Grating Mount Installation**

MAN0027

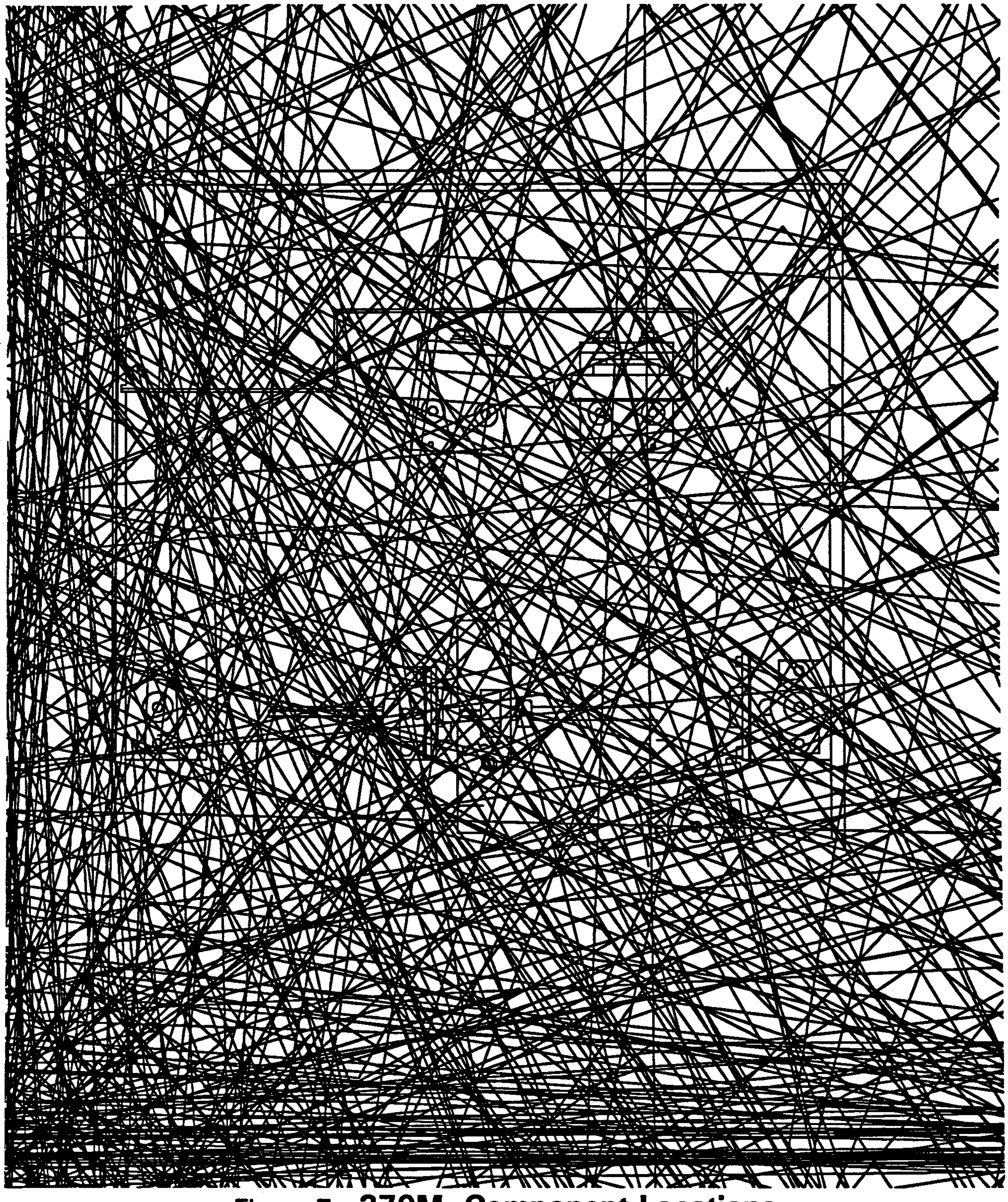

Figure 7: **270M Component Locations**
MAN0025

6.2 Single Grating Mounts:

If your 270M has the standard single grating mount, each grating shipped with your 270M is mounted in a prealigned capsule. The first grating is shipped in the instrument. Additional gratings are packed separately.

Normally, any grating that has been aligned in the instrument need not be realigned each time it is installed. In the alignment section of this manual, there is a procedure to follow, should it become necessary.

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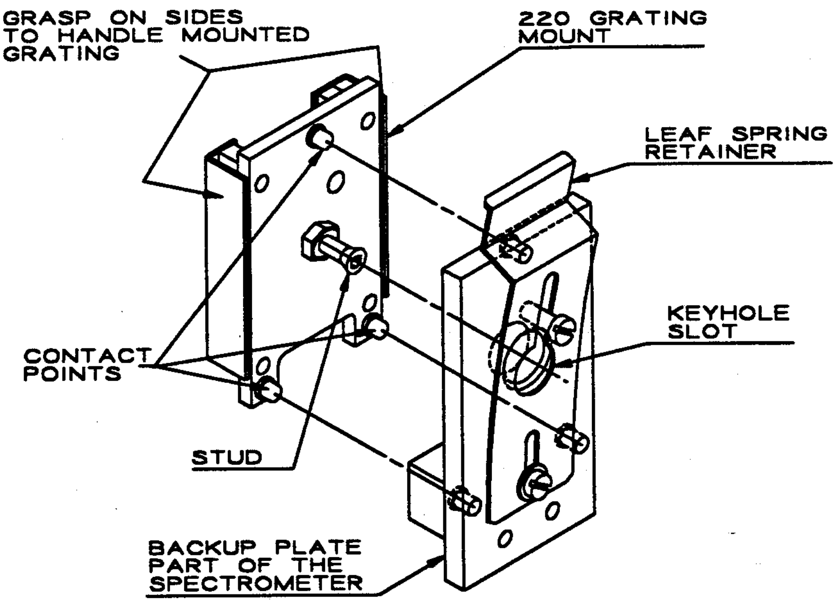

Figure 8: 220G Single Grating Mount Installation

MAN0027

contact point that indexes in a grooved insert on the backup plate. The third point, also at the bottom, is a slightly convex surface on the grating capsule that rests against a flat surface on the backup plate. With all three points in proper positions, push the retaining leaf spring back and down to hold the grating in place, ready for use.

6.3 Turret Grating Mounts:

Systems with grating turrets have mounted and aligned gratings on the each turret assembly. It is best not to remove gratings from the mounts or disturb their adjustments.

If your 270M has a turret option, you may select either grating on the turret automatically, using the controller or software that is connected to your system. Refer to the manual that pertains to your system's controller or software.
If you have the 270TK interchangeable turret, it may be removed and replaced with other prealigned turrets. To remove a turret, refer to Figure 9. First loosen the setscrew in the collar at the top of the turret shaft. Then remove the collar and shim washer. Grasp the turret by the sides, being careful not to touch the face of either

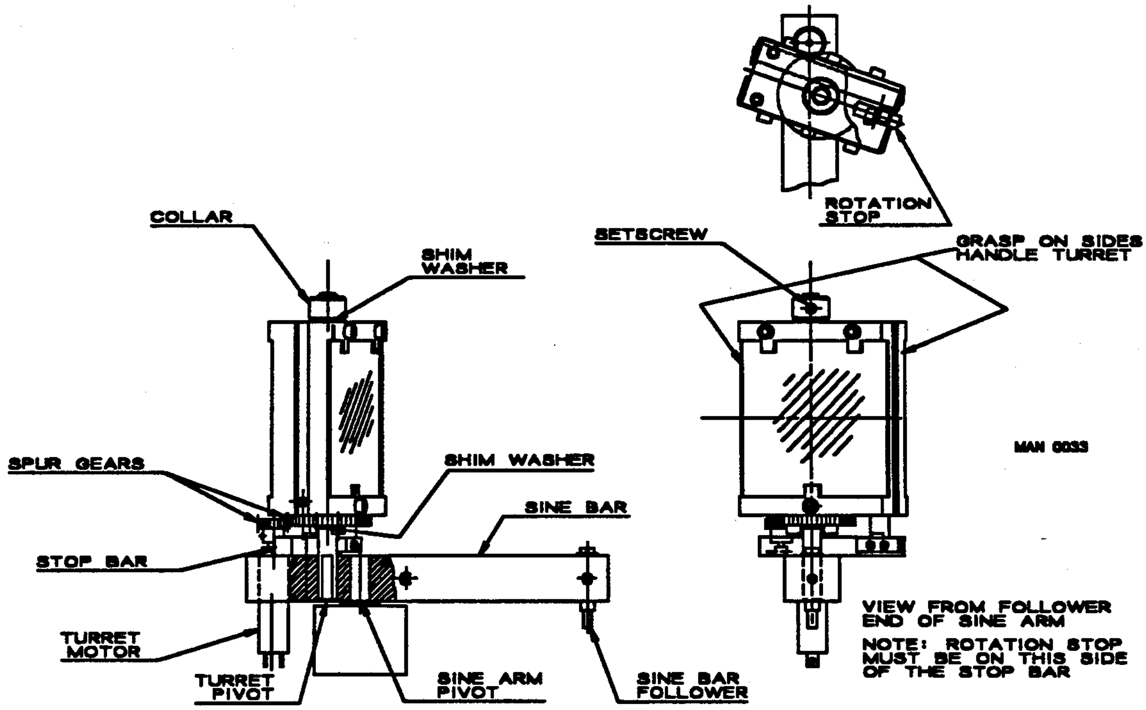

Figure 9: 270TK Interchangeable Grating Turret

MAN0033

grating. Lift the turret up and out of the instrument, leaving one shim washer on the shaft. To replace a turret, reverse the procedure, taking care to place the rotation stop of the turret on the same side of the stop bar as the sine arm pivot. Gently engage the spur gears. you need not turn the turret to a stop position. When the instrument is powered, the turret motor will rotate the turret to the selected position. When replacing the top shim washer and collar, leave a minimal clearance under the collar to insure free rotation of the turret.

6.4 Entrance and Exit Slits:

Your spectrometer has motorized adjustable slits located at the entrance and exit ports. The 220ASLN and 270ASLX slits are controlled remotely by the HandScan or your Computer. The slit width can be varied in steps of 12.5 μm. Since the dispersion of the 270M with 1200 g/mm gratings is 3.1 nm/mm, opening the slits by 0.1 mm allows an additional 0.31 nm of spectral bandwidth to pass through the instrument. In this case, a slit setting of 0.5 mm equates to a 1.55 nm bandpass. Assuming broadband light entering the spectrometer, the bandpass at the exit for moderate to narrow slit widths will approximate a Gaussian distribution. The nominal bandpass is measured at half of the peak intensity.

6.5 Spectrograph Exit Port:

The 270MCA is an adapter to mount and support most multichannel array detectors that conform to the industry standard three bolt circular pattern and focal plane position. The Spex QuikScan and Spectrum One detectors fit, of course, as do most other manufacturer's spectroscopic array detectors. If your detector is not from Spex, please refer to the spectrograph port interface drawing in the **Mechanical Interfacing** section and compare dimensions with the detector or documentation you have with your array system. The spectrograph port provides for translation in and out to locate the array in the focal plane, and rotation to align the array pixels with the vertical slit image.

7 Initial Checks:

7.1 Equipment Required:

- HandScan or IBM PC/AT compatible computer
- If using a computer, you will also need the GMI diskette for parallel interface control, or the Datascan/ SPEX232/ Spex488 support diskette for serial or GPIB interface control.
- Mercury lamp, or fluorescent room light.
- Photodetector and detection electronics.

7.2 Checkout:

For HandScan, AutoScan, and QuikScan controlled systems, the wavelength, slit, turret, mirror, and 220ASH shutter drives will run through a self-test and self-calibration when the controlling program or device runs a hardware initialization routine. For a fully loaded system, this may require a few minutes, as each automated device is initialized in sequence. With the top cover removed, you can verify the movement of the various drives. Do not interfere with or force any of the devices to move, as this may result in damage to your 270M. With the slit blocking/ height limiting slides open, you may observe and verify each of the slits opening and closing, in turn, during initialization. At the end of the initialization, the slits will be "closed" to a nominal width of 10 microns. Following initialization, depending on the controller you use, the wavelength drive will be positioned at the calibration switch at the high end of its travel, or it will be set to the nominal center of its range. Some software options will then reset the various drives to their last-used positions.

Assuming that there was no damage discovered during unpacking and installation, the optics in the 270M should require no further attention.
As an initial check to determine that the calibration and alignment are good, you may verify that the visible mercury lines are passed through the exit. To check this, illuminate the entrance slit with the mercury lamp, and with your controller, tune the wavelength drive to 546 nm. Note that the correct steps/nm factor must be used when configuring your controller. A 1200 g/mm grating in a 270M requires 32 steps/nm factor. Other grating groove densities require proportionally more or less steps/nm. With the slits opened to 250 microns, the green line should be visible through the exit slit. If your system has no exit slit, hold a piece of ground glass as a focus screen in the center of the spectrograph focal plane to find the green image of the entrance slit (frosted tape on a microscope slide makes a good substitute, or use tracing paper). Extra lamp intensity, or a darkened room may help you see it. The same test can be repeated at the 577 and 579 nm orange doublet lines.

If you wish to accurately check calibration, mount a photodetector at the exit, and close the slits to 13 microns and set the height limiter to 1 mm. when you scan past the spectral lines that your detector responds to, they should peak within +/- 0.1 nm of their indicated wavelengths, if you are using a 1200 g/mm grating. For other gratings, the tolerance scales inversely to g/mm. Note that all calibration scans should be made in the direction of increasing wavelength. When moving to shorter wavelengths, overshoot by at least 10 nm with a 1200 g/mm grating, (or 320 steps in any case) to allow for backlash correction. Backlash correction is automatic with HandScan, DM3000 QuikView, and AutoScan software. Refer to the calibration data shipped with the instrument for the calibration plots that were run on your spectrometer prior to shipment from the factory.

8 Optical Interfacing Considerations:

8.1 Grating Selection:

Once the spectrometer itself is chosen, a key variable in determining the working specifications of the system is the grating.

Groove density affects resolution or bandpass or coverage on an array detector. The grating can often be chosen to enhance sensitivity over a range of wavelengths of interest. There are gratings available to allow the 270M to be used from 185 nm to 50 μm and beyond. In many cases resolution or throughput can be enhanced by choosing a higher groove density. Or you may change the spectral coverage on your array by selecting a different groove density than you are now using.

The blaze wavelength of a Ruled grating is its wavelength of peak efficiency. generally the efficiency will stay stronger farther toward longer wavelengths than shorter. Although Ruled gratings can be highly efficient, beware of the inevitable grating ghosts that can reduce signal to noise ratios. This is not apparent from efficiency data. The effect can be quite distracting when using a single grating system in conjunction with a laser. Even worse, if the signal of interest is weak compared to the laser, as in Raman spectroscopy, for example. The ghosts are caused by minute mechanically induced errors in groove spacing. Even using state-of-the-art dual interferometer controlled ruling engines cannot eliminate this problem entirely. Generally, the ghosts are most severe in high groove density gratings, Ghost intensity increases as the square of groove density.

Most systems using Low density gratings for broad coverage on an array, or blazed for the Infrared do not suffer significantly from ghosts. Ruled gratings remain the best choice for these cases.

Standard Holographic gratings are created by optical holographic techniques, and as a result, have no spacing error, hence no ghosts. They generally exhibit broader response, at the expense of high peak efficiency. There are Holographic gratings optimized for wavelengths from the UV to the near IR.

The newer Blazed Holographic gratings provide the high efficiency comparable to that of a ruled grating without the ghosts. For many cases in the UV and Visible, these are now the best gratings available.

The growing list of available gratings is too extensive to describe adequately in this manual. The gratings are also too important to system performance to make quick, uninformed selections.

Contact your Spex sales representative for detailed information and advice in selecting gratings for your specific applications. In order to assure you of optimal selections for your applications, we need to know:

- The total range of wavelengths you wish to work over
- The spectral resolution / bandpass you need
- The type of source you are using
- The spectroscopic phenomenon you will observe, i.e., emission, absorption, transmission, fluorescence, Raman, etc.
- The type and spectral response of your detector
- If an array detector is used, the size if the pixels and the array size
- For arrays also, the coverage required in a single readout.

8.2 Optical Coupling at the Entrance Slits:

To allow the 270M to provide its maximum throughput, one of the most important considerations is the proper coupling of light into the entrance slit. The Ideal is to maximize the signal of interest, while minimizing noise. To accomplish this, some understanding of the optical requirements is helpful.

The 270M, like most spectrometers, is an imaging system. An image at the entrance slit will be dispersed into its various wavelengths, and for each wavelength present in the signal, an image of the entrance image (as masked by the entrance slit) will be formed at the exit.

The best results are obtained when your signal is imaged on the entrance slit, on the optical axis that is defined by the center of the slit and the center of the collimating mirror. If the signal is visible light , a quick check can be made by placing a white card in front of the collimating mirror. You should see homogeneous illumination across the entire active surface. If some image or structure is observed in the card, the image is probably not well focused at the entrance.

To optimize the signal to noise ratio, it is important that the collimating mirror is filled, but not overfilled by the signal beam. Underfilling usually implies that more signal can be obtained, by using faster collection optics. Overfilling the spectrometer optics can only increase the possibility of stray light reaching the detector. Limit the aperture of the beam so that the collimating mirror is just filled.

8.3 Exit Slit Considerations:

Bandpass in optical spectrometers is determined by multiplying the dispersion by the exit slit width, or the width of the image of the entrance slit that is formed at the exit, whichever is the greater of the two widths. The difference is significant in instruments such as the 270M which have a magnification factor due to the exit arm focal length being greater than the entrance arm focal length. The 270M has a nominal 220 mm entrance arm, and 270 mm exit arm. The magnification factor is the ratio of the entrance arm to the exit arm lengths, or 1.23. Hence, the image of the entrance slit at the exit is 23% larger than the entrance slit width.

If you set the entrance and exit slits to the same width, the resolution will be consistent with the entrance slit width, but throughput will be limited by the exit slit width. With the 270m, setting the exit up to 23% wider than the entrance will give more throughput without sacrificing resolution. Beyond that, the resolution degrades, as the increase in exit slit width will allow a larger bandpass to exit.

8.4 Spectrograph Port Focusing:

Please refer to the instructions provided with your array detector, and set it up in a realtime display mode for final adjustment. If reatime display is not available, the alignment will take longer, as you must view the change in detected signal after each trial adjustment.

If you have a linear photodiode array with raw video output, displayed the video on an X-Y monitor or oscilloscope with video intensity on the Y axis versus horizontal pixel position on the X axis. The raw video display updates in true realtime. With no lag time, you will be less likely to overshoot the optimum.

The 270 M spectrograph port provides for translation in and out to locate the array in the focal plane, and rotation to align the array pixels with the vertical slit image. The goal is to get the best focus and vertical alignment. to start, set up a spectral lamp at the entrance (e.g. Mercury, neon, or fluorescent desk lamp). Acceptable results can often be attained without coupling optics, provided that the source or reflected beam is directly on the optical axis entering the slit. (For best results, the lamp should be properly coupled to the entrance slit. See the Optical Interfacing section for further information.)

Set the spectrometer drive to the wavelength of a known spectral line, such as the mercury 546.1 nm emission line. Set the entrance slit to 80% of the width of a pixel on your array, or slightly smaller (this takes into account the magnification factor of the

270M). Adjust the light intensity until you have a low to mid scale signal on the display. Ideally, set the 270M to a wavelength region where several lines are imaged on various parts of the array simultaneously. With multiple lines, you can optimize focus over the entire array. If this is not possible, then move the spectrometer drive to position spectral lines alternately at the center and ends of the array. While observing the realtime spectral display, rotate the detector to minimize the width of the image on the array. Then translate the detector in and out to find the best focus.

As you approach the proper focus, the peak will become narrower, and the intensity will be more concentrated in the central pixels of the peak.. Best focus is reached at maximum detected intensity in the central pixel. Be careful not to be fooled by apparent intensity fluctuations that may occur as a function of small movements of a narrow image being shared between adjacent pixels. For an unintensified array detector, the full width at half maximum (FWHM) should be 3-4 pixels. For intensified detectors, ther is a spreading of the image due to the intensifier, so FWHM will be 4-5 pixels. Be sure that the display of your detection system is set up to display intensity versus pixels. Expand sufficiently on the horizontal pixel axis that you can easily discern individual pixels.

Optimization of the focus adjustment is an iterative process. Repeat the rotation and translation with successively smaller movements until no further improvement is observed.

If you are using a CCD, it is best to check the rotation of the detector via an image display, after obtaining what you think is the best focus and rotation as described above. If the rotation is correct, the image of a spectral line with full slit height should be perpendicular to the x axis.

Through your careful attention during alignment, you can be assured that you will realize the exceptional performance capability that was designed and built into your 270M by Spex.

9 Mechanical Interfacing:

Your Spex 270M is designed to facilitate mounting of accessories and other devices at the entrance and exit ports. There are bolt patterns The leveling feet may be removed from the bottom to provide threaded mounting holes to attach the 270M to a larger system or baseplate. It is best to avoid straining or torquing the spectrometer bottom, as this may affect alignment of the optics.

Before finalizing any mechanical fixturing, it is best to review the Optical Interfacing in Section 8, so that all components can be mounted in optimal locations.

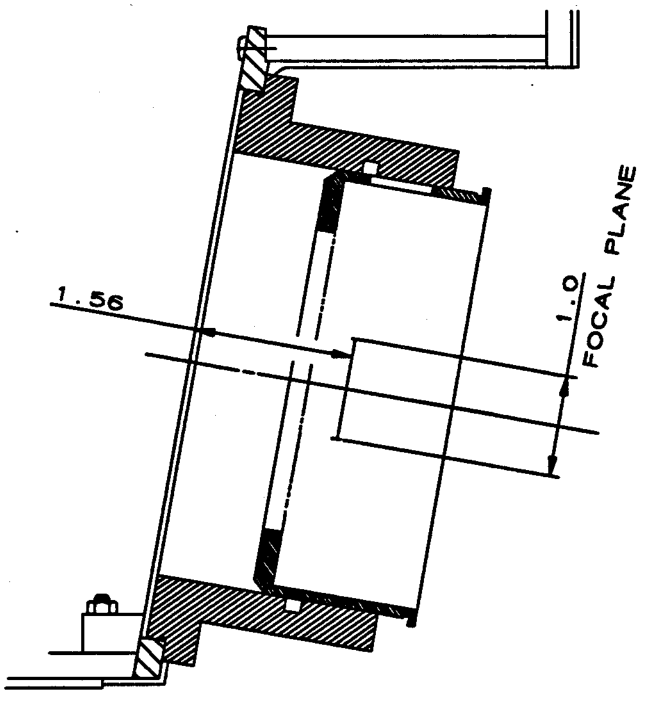

Figure 10: 270MCA Focal Plane Position MAN0019

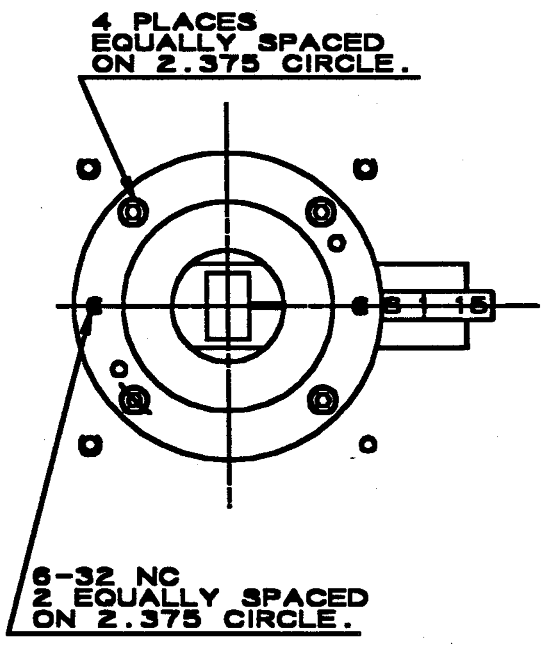

Figure 11: Standard Slit Adapter MAN0020

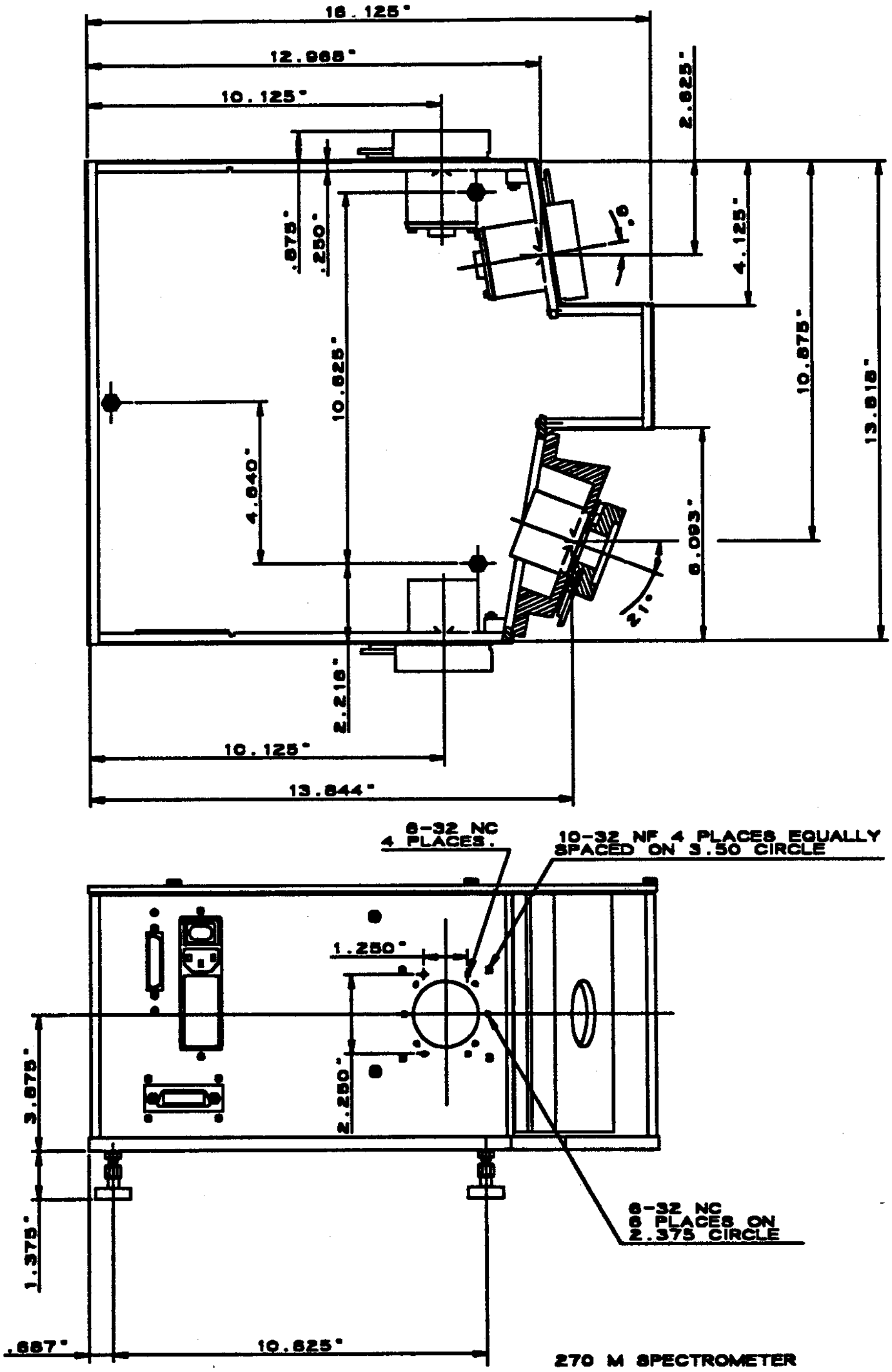

Figure 13: **270M Dimensions**

MAN0011

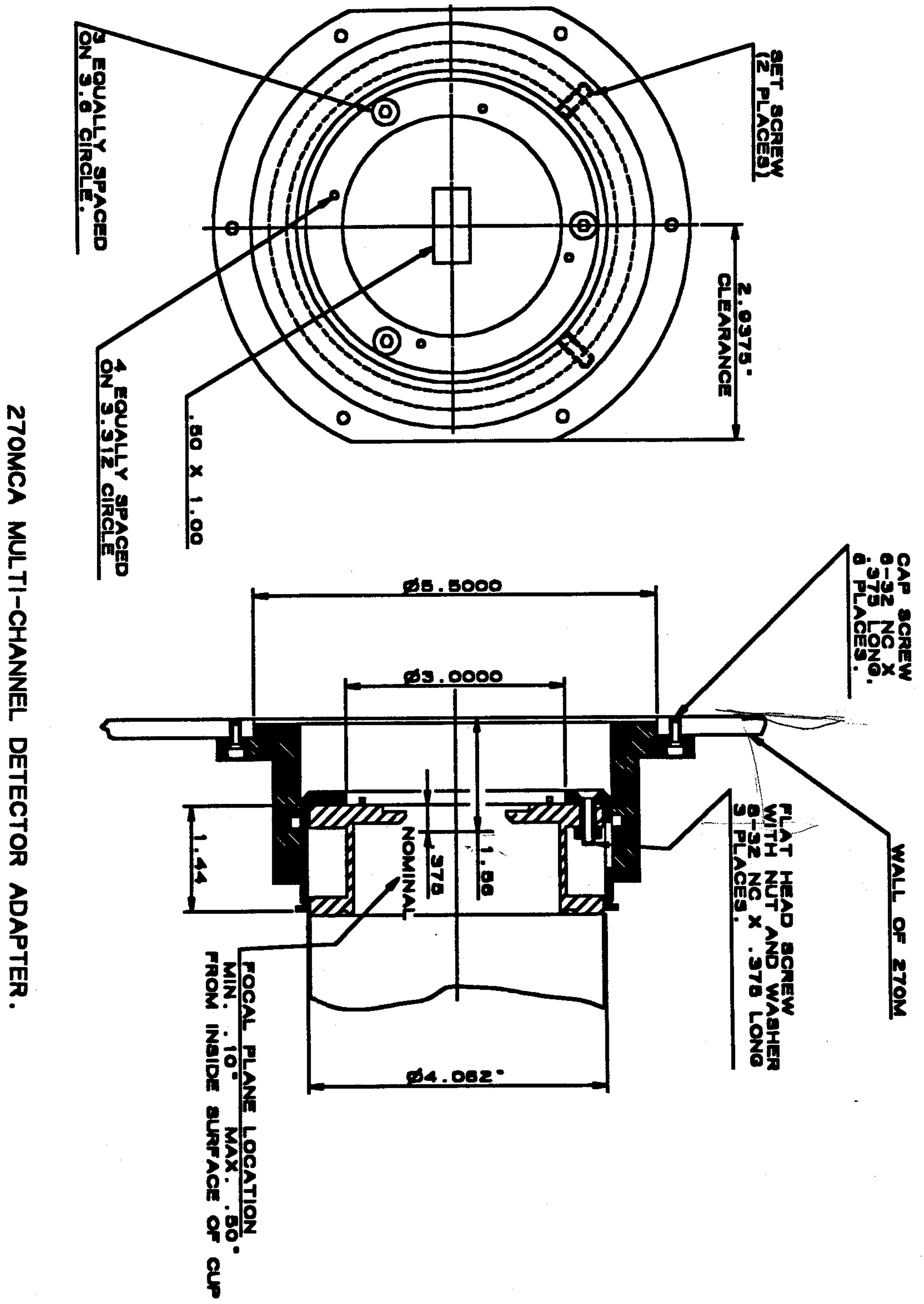

Figure 12: **270MCA Interface Dimensions**

MAN0018

10 Application Examples:

The 270M is quite versatile, and may be operated in various ways, depending on the measurement and the requirements of associated equipment such as detectors. Following are a few representative operating examples for typical uses.

10.1 As a Monochromatic Illuminator:

With a broadband light source directly coupled to an entrance slit, the 270M can provide a specific bandpass at the exit. The spectral bandpass can be varied by changing the slit widths. The scan drive facilitates tuning or selecting the central wavelength of the exiting beam.

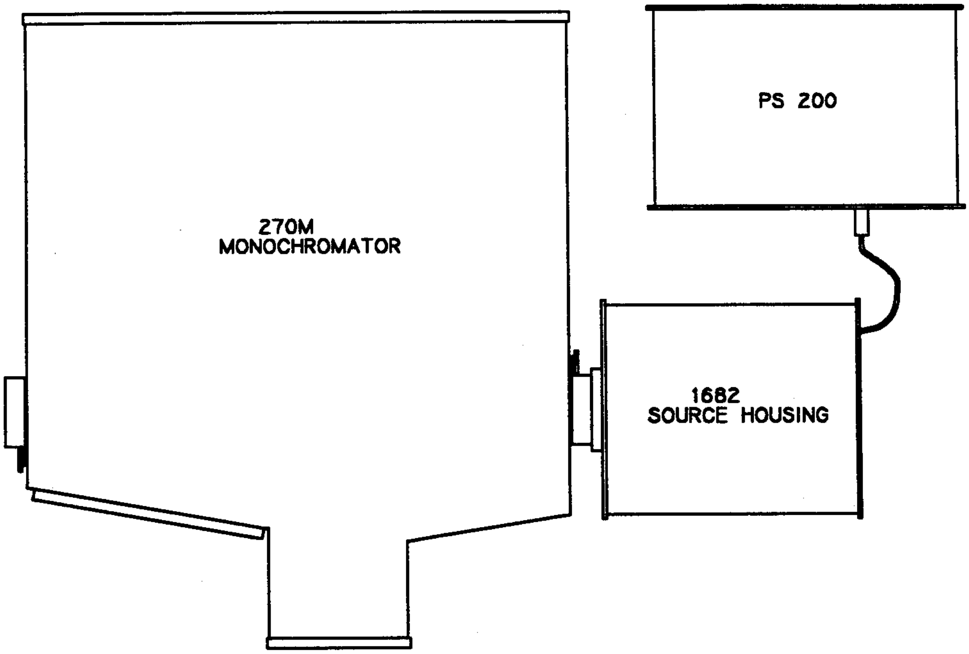

Figure 14: **270M as a Monochromatic Illuminator**

MAN0028

One might wish to alternately illuminate samples with two wavelengths of light to perform two measurements, let's say transmission at 580 nm, and fluorescence excited by 400 nm light.

The 270M's imaging optics maintain a small illumination spot size at the exit. (Traditional designs spread the spot, reducing its intensity. This is due to aberrations that are eliminated by the 270M design.) For the two measurements the bandpasses can be optimized independently. Under computer control the motorized slits change as programmed. The high speed drive minimizes slewing time.

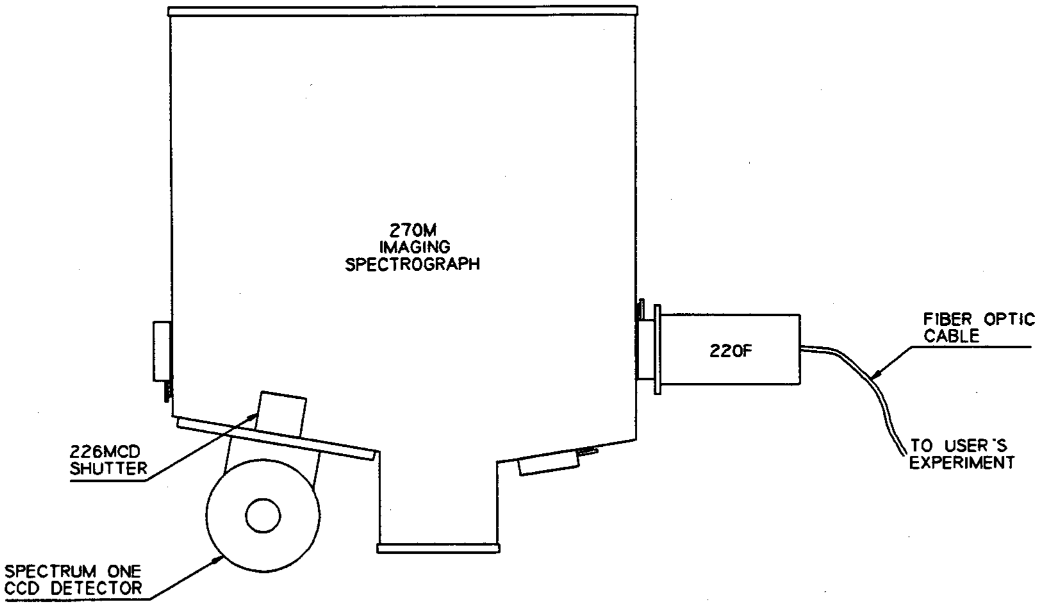

Figure 15: **270M as a Scanning Monochromator**

MAN0030

10.2 As a Scanning Monochromator:

Another typical application of the 270M is the measurement of the spectral output of something emits light. This could be a lamp, or the sun, or a laser diode, a glow discharge,....or whatever. If the source is stable over the range of seconds to minutes, or can be pulsed reproducibly, the 270M can be scanned to sequentially present the wavelengths to the detector for measurement.

In this case, using a controller or computer, the start and end wavelengths, as well as the scan speed and wavelength increment between datapoints are programmed.

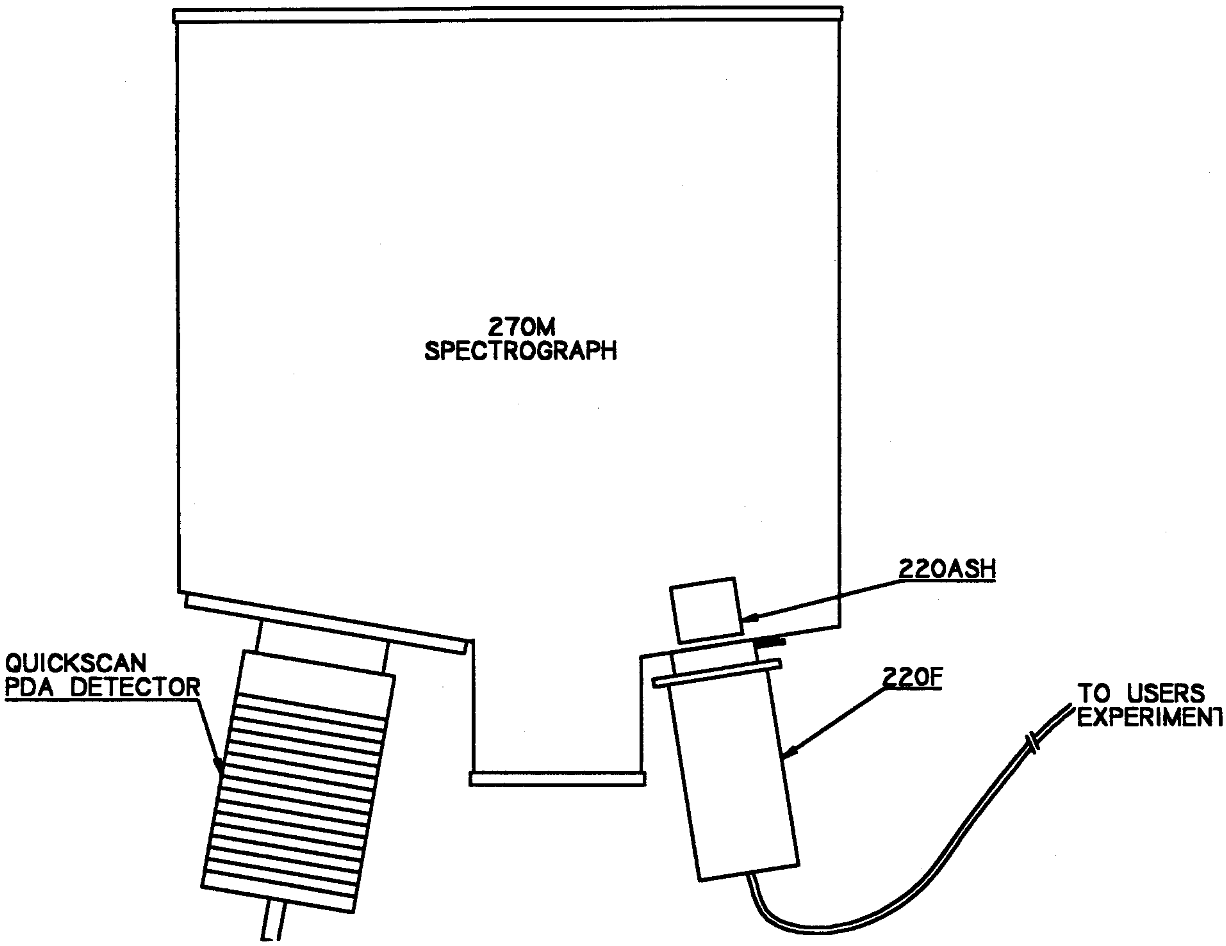

Figure 16: **270M as a Spectrograph**

MAN0031

10.3 As a Simple Spectrograph:

Some measurements must be made practically instantaneously, such as logging or monitoring changes in a spectrum from a process. This requires the simultaneous detection of signals over a range of wavelengths. A linear detector such as a PDA positioned in the focal plane of the 270M can capture transient spectral distributions with a time resolution that depends only on the readout or gating time of the detection system.

To set up for this scenario, the light from the process is coupled via an optical fiber to the entrance slit. to minimize coupling loss, an optional fiber optic interface is used to aperture match the fiber to the spectrometer. The QuikScan PDA detector is mounted at the focal plane in the exit of the 270M.

If acquisition of wavelengths beyond the width of the array are required, a tradeoff may be made by using a lower groove density grating that will not disperse the wavelengths so widely. Of course, with closer spacing, resolution would be lower. An alternative, if experimental conditions permit, would be to keep the higher resolution grating, but acquire more than one region, using the rapid slewing capability of the 270M to quickly reposition the grating. Depending on the software you are using, overlapping regions may be "glued" to form continuous spectra.

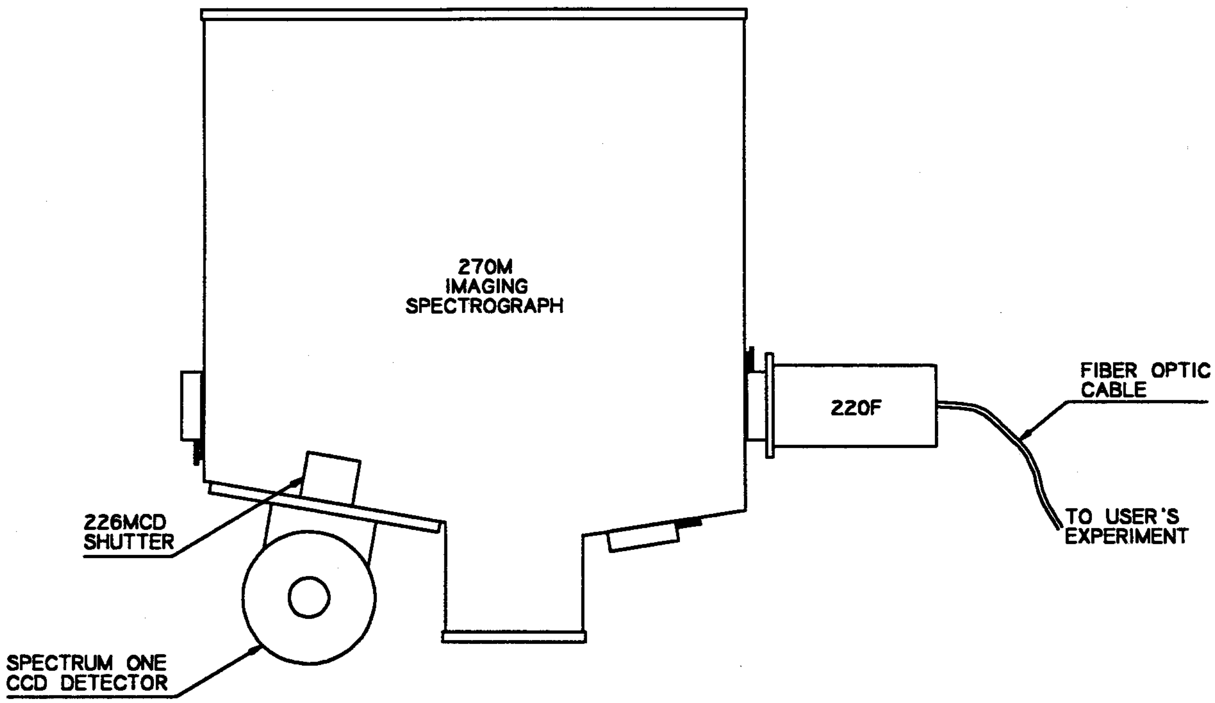

Figure 17: 270M as an Imaging Spectrograph
MAN0031

10.4 As an Imaging Spectrograph:

Multiple spectra from light imaged at various heights in the entrance slit can be simultaneously detected with a two dimensional array such as a CCD. The capabilities of a simple spectrograph are multiplied. This is made possible by the imaging optics, which permit close vertical spacing of signals without crosstalk, unlike conventional designs.

A stack of optical fibers imaged on the entrance slit can each carry separate spectral signals from various locations. All of the signals will be captured by the detector during the same exposure time.

Alternatively, a "slice" of a sample or reaction can be imaged directly into the entrance slit. The 270M provides the two-dimensional image quality required to study the spatial/spectral profile of a flame, or other source that exhibits a varied distribution of spectral signals.

11 Specifications:

Focal Length:	0.27 meter
Entrance Aperture Ratio:	f/4
Image Magnification at the Exit:	1.23
Scanning range with 1200 g/mm grating:	0-1100 nm
Multichannel coverage with 1200 g/mm grating:	77 nm over 25 mm array width
Flat Field Area in Focal Plane:	25mm wide X 12 mm high
Spectral Dispersion with 1200 g/mm grating:	3.1 nm/mm
Spectral Resolution as a scanning monochromator with 1200 g/mm grating:	0.1 nm at 546 nm
Vertical Image Quality:	Resolve 25 fibers, 200 μm each, in 0.5"
Wavelength Positioning Accuracy:	+/- 0.1 nm
Wavelength Repeatability:	+/- 0.05 nm
Maximum Scan / Slew Rate:	70 nm/second
Wavelength Drive Step Size for 1200 g/mm grating:	0.03125 nm/step
Slit Width Drive Step Size:	12.5 μm/step
Overall Length:	16.25 inches (41.3 cm)
Overall Width:	15.5 inches (39.4 cm)
Overall Height:	7.5 inches (19.0 cm)
Weight:	34 Pounds (15.5 kg)

12 Alignment:

The 270M and its associated grating(s) are aligned together at the factory. Performance data in the form of calibration reports and plots are shipped with the instrument. Normally you need not make any adjustments to the instrument to obtain specified performance. If you suspect the instrument has become misaligned, review the Optical Components Installation section first, before proceeding to Alignment. A prerequisite to these procedures is that the instrument must be completely and properly installed.

12.1 Equipment Required:

- HandScan or IBM PC/AT compatible computer
- If using a computer, AutoScan or DM3000, or the GMI software can be used to control the 270M, or the DataScan/ SPEX232/ Spex488 support diskette program "232_SCAN.BAS or 488_SCAN.BAS. Refer to the **Software Installation and Control Interfacing** section for further information on connections and usage.
- Mercury lamp, or fluorescent room light.
- Coupling optics to image the source on the entrance slit, in a stable fashion.
- Photodetector such as a silicon cell or photomultiplier and housing adapted to the exit slit, and detection electronics such as DataScan or DM3000.

12.2 Grating Adjustment:

Caution: Never touch the diffracting surface of a grating. The surface is easily marred and cannot be cleaned as a mirror can. The following three adjustments should be made on a grating the first time it is installed in the instrument. This is done at the factory when the grating is ordered with the instrument and normally will not require further attention. Whenever a grating is reinstalled, the adjustments should be checked but generally none will be required.

The wavelength calibration and vertical adjustment can be done in either order, but the rocking should be done last. For all these procedures the cover of the monochromator must be removed, and a mercury lamp installed at the entrance slit.

12.2.1 Wavelength Centering Adjustment:

Set both slits to 0.25 nm and set the monochromator to 546.1 nm. Unless the wavelength is grossly out of calibration, a green line will be seen through the exit slit. If not, adjust he wavelength until the line is centered; if it does so with 0.1 nm of 546.1, no calibration is required. Otherwise, set the monochromator to 546.1 nm and, referring to Figure 19, adjust the wavelength centering screws on the mount of the grating to bring the line through the instrument. If more than 1/8 turn is required on either screw, also adjust the other in the opposite direction to balance the total adjustment between them. Further accuracy may be had by placing a detector at the exit slit and adjusting for maximum intensity. Bear in mind that, like any mechanical train of parts there is some inevitable backlash in the wavelength drive. When your adjustment nears the optimum, be sure to check it by scanning the drive with your

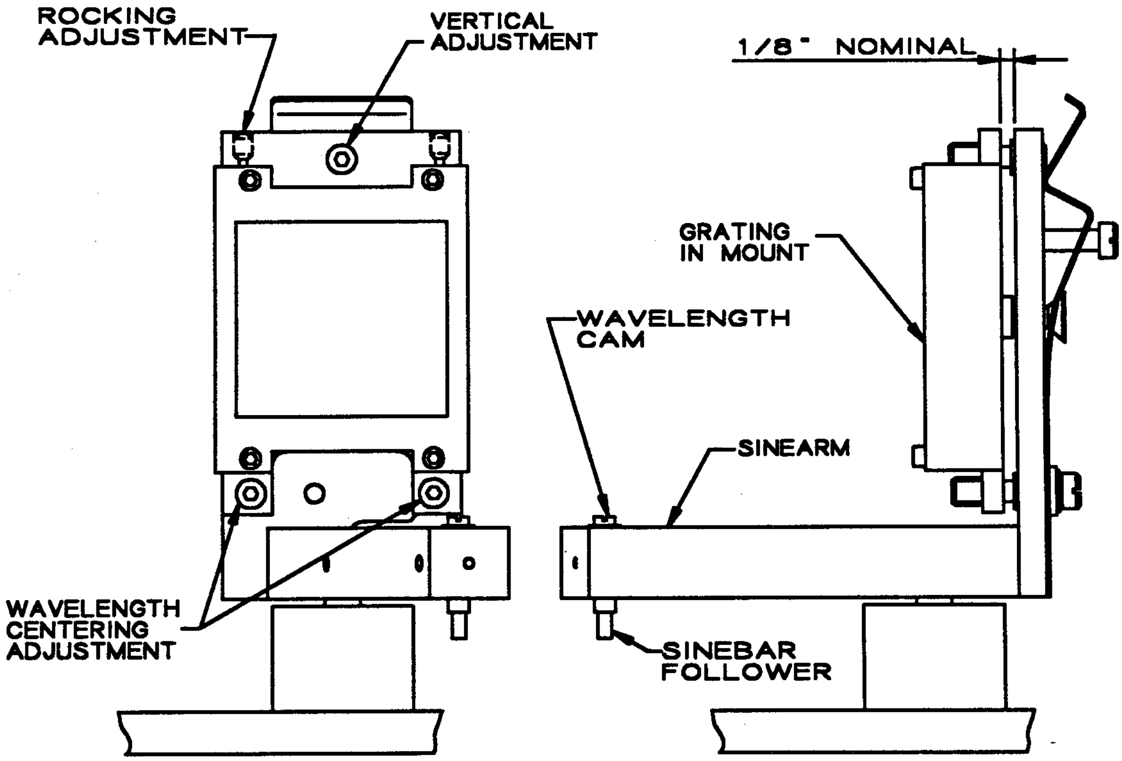

Figure 18: 220G Single Grating Mount Adjustments

MAN0032

controller or software so that the backlash is always taken in the direction of increasing wavelength. Replace the monochromator's cover. If photoelectric detection is available, scan slowly from 540 to 548 nm to ascertain that the peak is detected within 0.1 nm of 546.1.

12.2.2 Grating Vertical Adjustment:

Set the monochromator to 546.1 nm. Set the entrance slit height to 1 mm. Observe the image at the exit slit. If it is not vertically centered, center it with the vertical adjusting screw on the grating mount.

12.2.3 Rocking the Grating:

If the grating grooves are not parallel to the slits, the diffraction plane will be tilted, and lines imaged at the exit will appear at different heights as a function of wavelength. To correct this, the vertical adjustment must have been already done. Set the monochromator to 0.0 and check whether the exit slit image is vertically centered. If it is not, the grating must be rocked. While sitting at 0 nm, repeat the vertical adjustment as above, then return to 546.1 nm. Use the rocking adjustment screws to re-center the image. If more than 1/8 turn of either screw is required, adjust the other in the opposite direction to balance the adjustment between them. Set the monochromator to 0 nm and check the centering; If it is not centered, repeat the vertical adjustment. When the grating is properly aligned, the image will be vertically centered at both 0 and 546.1 nm.

13 In Case of Difficulty...

Your 270M is designed to provide years of reliable service. If you are experiencing a problem, reviewing this section before contacting us will save time and help you eliminate some simple errors that can be easily corrected.

13.1 Troubleshooting:

Some of the more common difficulties that may be encountered are listed below. With each, some suggestions are given that will help correct the problem for most cases.

Spectrometer not responding to any commands:

- Be sure the power cord is connected to live power. Double check that the switch is on, and check the fuse. Refer to Appendix A for proper fuse requirements.
- Check external cable connections. See the **Electrical Connections** section for proper external cable connections.
- Check internal ribbon cable connections, and jumpers on circuit boards. See the circuit board layout drawings appendix.
- Review the section under **Control Interfacing** that pertains to your controller or computer interface software.
- Check system software or firmware configuration to see that it matches the actual hardware. See **Software Installation** for more information.

Spectrometer responds to some commands, but not all.

- Check to be sure that the failing command is valid, that parameters are within limits for that drive or function
- If you purchased software from us with your system, using the documentation provided with your software, check to see that it matches the actual hardware. In particular, check that the device you wish to control is configured properly.
- If you are running your own software, stop your program and load the software diskette provided with the system to see if the device in question can be controlled. See the subsection that applies to your system under **Software Installation** for more information.

Side port mirror does not move:

- If the mirror is at the side wall, GENTLY nudge it by hand, just enough to get it "unstuck." The miniature gearhead motors are delicate and expensive. Forcing them by applying too much pressure, or moving them too far may result in time consuming, costly repair.

■

Slit and wavelength drives and accessories do not move:

- If your 270M is equipped with a turret or side mirror assembly, you may test as follows: With the power disconnected, remove the top cover and gently move the mirror or turret part way through its range of movement. When the system is powered, the device should return to its home position.
- Check control cable connections. See **Electrical Connections** section.
- Review the section under **Control Interfacing** that pertains to your controller or computer interface software.
- If you are using your own program, as opposed to software purchased with the system, pay particular attention to interfacing setup connections and parameters.

Background signal too high, background reduced when room lights are turned off:

- Be sure all covers are in place
- Make sure that the area between the source or sample and the entrance slit is enclosed, and light tight. Block the entrance slit as a test.
- Check detector mounting and/ or housing for light leaks.
- Starting from the detector, close exit and entrance slits and shutters in turn to determine where stray light may be entering the system. Note that to prevent damage to the knife edges, the slits do not close completely, and will therefore not block all of the light, however, with the signal blocked, reducing the slit width will reduce any stray light that is passing through it.
- Be sure all openings and screw holes are plugged.
- Check that the cover, side, and baseplate should fit tightly, light seals should be partly compressed, not flattened.
- If leaks persist, use a small flashlight in a dark room to isolate where the leaks are by shining at any suspicious part or joint in the system. and observing detected signal levels.

Signal too noisy:

- Try to increase signal strength at the detector. See **Optical Interfacing Considerations** for suggestions.
- Check for light leaks as suggested under "Background signal too high" in this section.
- If noise is reduced by turning off the spectrometer, rearrange power connections to be sure the spectrometer, source, and detector are tied to the same ground and, if possible, the same power circuit.

- Adding redundant grounds to various points in the total system often helps. Please understand that ground loops and electromagnetic interference can sometimes be challenging problems. In extreme cases, the best approach is to patiently experiment by trying various combinations of grounding connections. As a general rule, try to keep ground wires short, make tight connections, avoid painted, coated, and anodized surfaces when possible. Consider a "star ground" of wires radiating from a single, central location, preferably connected to a grounded metal table surface under the system.
- In extreme cases, such as working with or around high powered pulsed lasers or other high energy apparatus, it may be helpful to construct RFI / EMI shields or cages to contain the noise at its source, or to isolate the detection system from the noise. In these cases, colleagues who are working with similar apparatuses may be your best resource for noise control suggestions.

14 Service Policy:

If you need assistance in resolving a problem with your Spex instrument, contact us directly, or through our representative or affiliate in your area, if outside the United States.

Often it is possible to correct, reduce, or localize the problem to a replaceable component through discussion with our Customer Service Engineers.

All Spex Instruments are covered by a warranty. The warranty statement is printed on the inside cover of this manual. Service for out-of-warranty instruments is also available, for a fee. Contact us for details and cost estimates.

If an instrument or component must be returned, The method described in this section should be followed to expedite servicing and reduce your down-time.

If your problem relates to software, please verify your computer's operation by running any diagnostic routines that were provided with it. Be ready to provide version numbers for the DOS that you are using, as well as the software version and firmware version of any controller or interface options in your system. Also knowing the memory type and allocation, and other computer hardware configuration data from the PC's CMOS Setup utility may be useful.

14.1 Return Authorization:

All Instruments and Components returned to the factory must be accompanied by a Return Authorization Number issued by our Customer Service Department. If in the United States, you may contact the Customer Service department directly at (908)549-7144. The fax number for Service is (908)549-2571. Or you may write to SPEX Industries, Spectrometer Customer Service, 3880 Park Avenue, Edison, N.J. 08820. From other locations worldwide, contact the representative or affiliate for your area.

To issue a Return Authorization number, we require:

- The model and serial number of the instrument
- A list of items and/or components to be returned
- A description of the problem, including operating settings
- The instrument user's name, mailing address, telephone, and telefax numbers
- The shipping address for shipment of the instrument to you after service
- Your Purchase Order number and billing information for any non-

warranty services
- The Original Spex Sales Order number is helpful to know
- Your Customer Account Number, if known, is also helpful
- Any special instructions

14.2 Removing returnable components from your instrument:

Turn off the power switch and disconnect the power cord and other cables from the instrument.

14.2.1 Removing a Grating:

Refer to the **Optical Components: Changing Gratings** section and follow the instructions until the point where the grating or turret is removed. Then cover the grating using only the grating cover that was shipped with the instrument. To prepare a cover, apply a strip of vinyl electrical tape along each side, leaving a 1/2" (1 cm) flap extending beyond each side. Exercise extreme caution to avoid contacting the grating surface. Tilt the cover so that the bottom edge slips under the grating first, then gently rotate the top of the cover until the grating is fully covered. While holding it in place, secure it by sticking the tape flaps to the sides of the grating mount. Do the same for each grating to be returned.

14.2.2 Removing a Circuit Board:

To remove a Circuit board form the 270M, open the top cover and open the wire harness retainers to provide slack in the wiring. Disconnect the wiring from the boards, noting the connector numbers for future reference. Push the wiring aside as you lift out the baffle from between the circuit boards and the mirror mounts. From the outside of the rear wall remove the screws holding the board spacers and lift the board(s) out of the instrument, disconnecting and noting connector locations for the cables as you go. Pack the board(s) in an antistatic bag for return to the factory.

14.3 Packing the 270M:

To prepare your 270M for shipment, it is important to restrain the side entrance and exit mirrors, if your instrument is so equipped. If the side mirrors are not rotated to the side walls, turn on the power, and they should automatically retract to the walls. With care to avoid contacting the mirror surface, secure the mirror assemblies to the side walls with nylon cable ties or an equivalent. There are attachments provided on the baffles for this purpose.

To protect the grating, use only the cover that was shipped with the instrument. To prepare the cover, apply a strip of vinyl electrical tape along each side, leaving a 1/2" (1 cm) portion extending beyond each side. Exercise extreme caution to avoid contacting the grating surface. Tilt the cover so that the bottom edge slips under the grating first, then gently move the top of the cover to slip over the top of the grating. While holding it in place, secure it by sticking the tape to the sides of the grating mount. If your instrument is equipped with a grating turret, cover only the grating that faces the interior of the 270M. Replace the wrapped foam packing block that was removed on initial unpacking. It fits snugly above the turret. Tape it in place. Make a thorough inspection of the interior and remove or secure any loose objects. Finally, replace the cover and screws.

Appendix A: 270M AC Power Selection and Fusing

Input Voltage	Fuse
100 Vac	1/2 A slow blow
120 Vac	1/2 A slow blow
220 Vac	1/4 A slow blow
240 Vac	1/4 A slow blow

Appendix B: 270M Interface Connector Pin Assignments

Standard Spectrometer I/O (TTL) Interface connector

Pin#	Name	Function
9	Select Clock	Input to step through addressable devices
22	Ground	For Select Clock
10	Direction	Input to assert direction for device to move. High is forward, generally toward longer wavelengths.
23	Ground	For Direction
11	Step	Pulse input to move a stepping device. Negative true (normally high) clocks on rising edge.
24	Ground	For Step
12	Index	Output, low when wavelength drive is selected
25	Ground	For Sense and Index
13	Sense	Output gives phase or position of device selected

Optional SPEX232 Interface connector

Pin#	Name	Function
2	TXD	Transmits data from the SPEX-232
3	RXD	Receives data
6	DTR	Data Terminal Ready (to receive a byte)
7	Ground	Reference/ return for all other lines
22	+5V	To assert other lines high as required for additional handshaking

Optional SPEX488 Interface connector

Contact#	Name	Function
1	DIO 1	Data input / output line
2	DIO 2	Data input / output line
3	DIO 3	Data input / output line
4	DIO 4	Data input / output line
5	EOI (24)	End Or Identify
6	DAV	Data Valid
7	NRFD	Not Ready For Data
8	NDAC	Not Data Accepted
9	IFC	Interface Clear
10	SRQ	Service Request
11	ATN	Attention
12	SHIELD	Protective Shield
13	DIO 5	Data input / output line
14	DIO 6	Data input / output line
15	DIO 7	Data input / output line
16	DIO 8	Data input / output line
17	REN (24)	Remote Enable
18	GND (6)	Signal ground for DAV
19	GND (7)	Signal ground for NRFD
20	GND (8)	Signal ground for NDAC
21	GND (9)	Signal ground for IFC
22	GND (10)	Signal ground for SRQ
23	GND (11)	Signal ground for ATN
24	GND LOGIC	Signal ground for EOI, REN

Appendix C: Spectrometer Control Board Data

Optional Jumpers

J1	Wavelength Drive Direction	Not installed for 270M
J200	DC Motor Direction (set of 4)	Only the SIDE ENT jumper is installed in 270M
J201	Half Step Motor Direction (set of 4)	None installed for 270M

P2 I/O Control Connector
(dual 5 pin straight header, 0.1 inch centers)

Pin	Nomenclature	Description
1	SELECT_CLOCK	Clock to select next device
2	GND	Signal return
3	DIR	Direction or position to set selected device
4	GND	Signal return
5	STEP*	Used to generate step pulse or clock position
6	GND	Signal return
7	INDEX*	Low (0v) if wavelength is selected device
8	GND	Signal return
9	SENSE	Selected device sense output
10	GND	Signal return

Revised November 24, 1992

Appendix D: Circuit Board Drawings

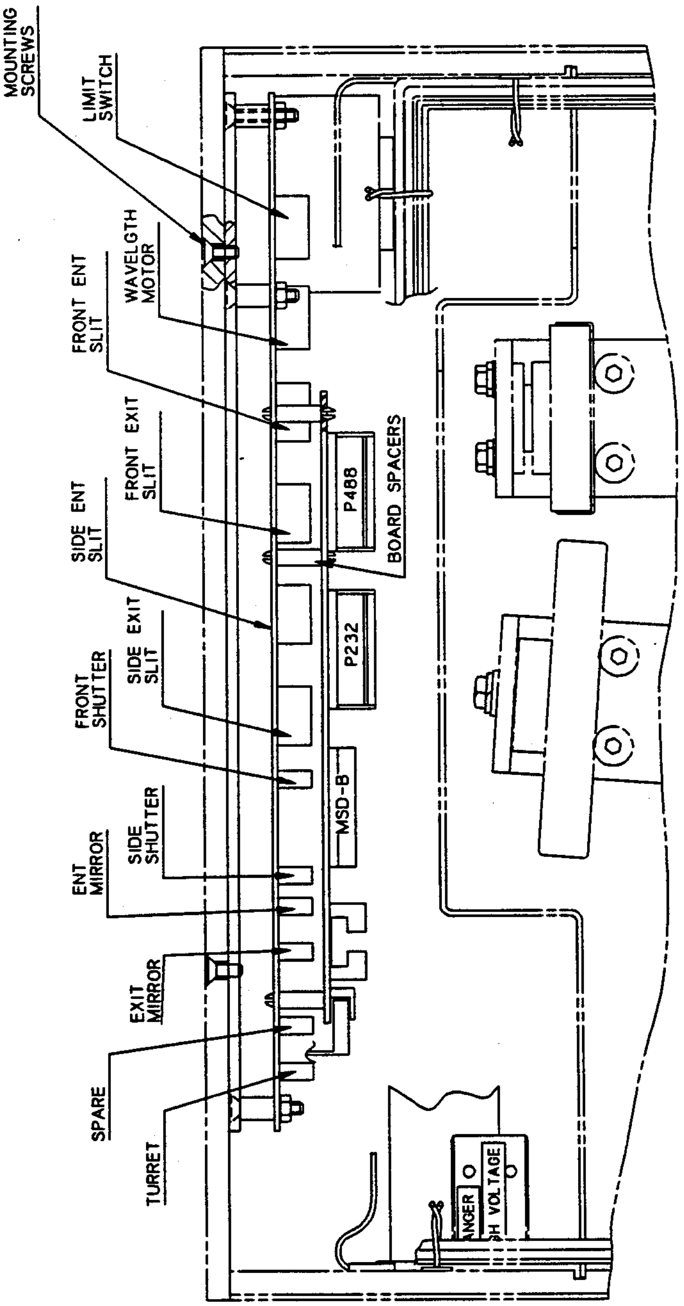

Figure 19: **Circuit Board Location**

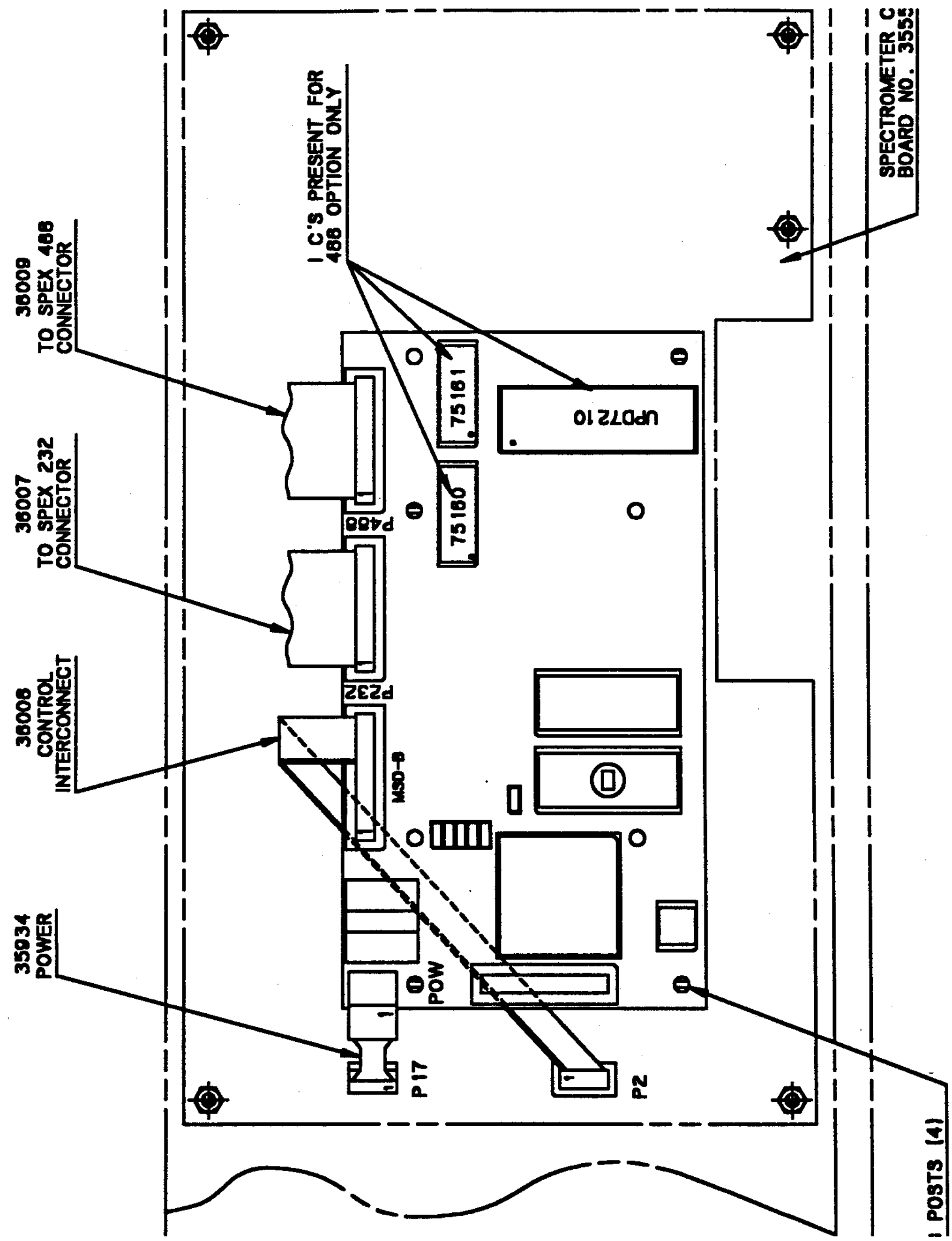

Figure 20: **SPEX232/SPEX488 Location and Connections**

MAN0024

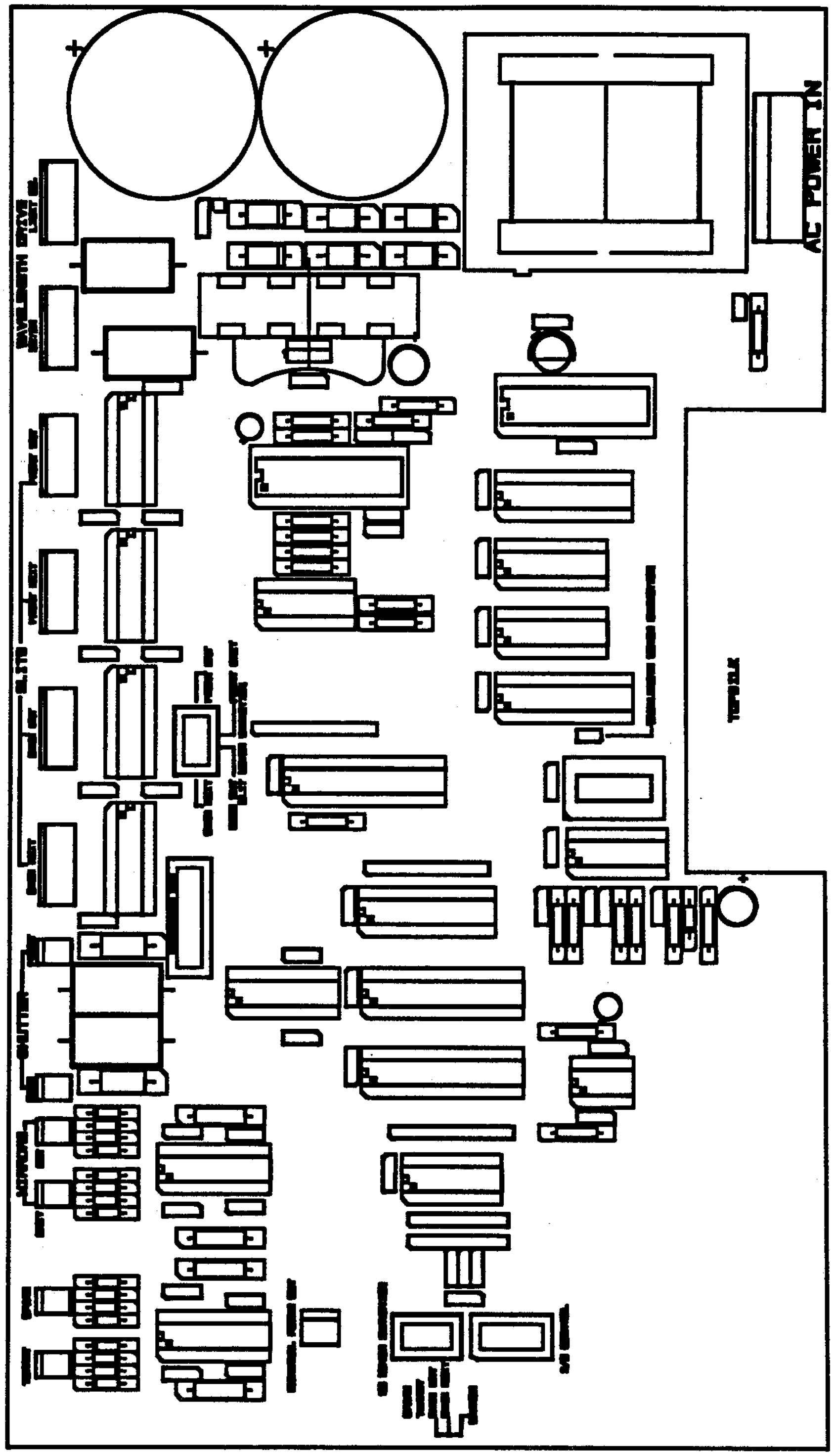

Figure 21: **Spectrometer Control Board Connector & Jumper Locations**

MAN0057

Appendix E: SPEX.SYS Device Driver, Version 1.1

Instructions for use with the 270M Spectrometer:

If your 270M has the parallel interface, as opposed to the optional SPEX232 or SPEX488 interfaces, and you wish to write a programmed routine to run the 270M, this section applies to you.

This section covers the usage and protocol for the SPEX.SYS device driver commands, in the context of its use with a 270M. The commands discussed directly control the spectrometer. You have total flexibility to create elegant, efficient programs.

This method of interfacing requires considerable programming skill, and is therefore generally recommended only for the professional programmer. Teaching the skill of programming is beyond the scope of this document.

To facilitate control of the 270M from your DOS computer via a parallel (LPT) port, a Graphical Monochromator Interface software (GMI) and a cable (Spex #35816) were shipped with your 270M from the factory. The best way to become familiar with control of your 270M is to install and run the GMI. Then test all of the drives and accessories that are in your spectrometer. Satisfy yourself that the interface and mechanisms are working properly before trying to use the device driver with your own program.

The GMI uses the device driver SPEX.SYS which is included on the GMI diskette. The device driver provides functions that allow you to control the actions of the 270M and its accessories by writing ASCII strings to "SPEX0000" (as if it were a file name).

1 Installing the SPEX.SYS device driver:

To use the device driver, it must first be installed on the hard drive of your DOS computer. Refer to the GMI documentation for installation instructions. If you wish to move the SPEX Device Driver to another directory, DOS must be notified where the driver can be found, by inserting or editing a line in the CONFIG.SYS file, which is found in the root directory of the drive you use to load your operating system from.

The entry should look like one of these lines:

device=C:\SPEX.SYS
device=C:\SPEX.SYS /0
device=C:\SPEX.SYS /1
device=C:\SPEX.SYS /2
device=C:\SPEX.SYS /3

"device=" tells the operating system that we want to install a device driver.

"C:\SPEX.SYS" tells the operating system where the device driver can be found. If the device driver is on the D: drive in a directory called \DRIVERS then the DEVICE statement in CONFIG.SYS should be: "device=D:\DRIVERS\SPEX.SYS"

If no port parameter is given, the device driver will use the default (LPT1) printer port to communicate to the monochromator.
"/0" tells the device driver to use the LPT1 printer port.
"/1" tells the device driver to use the LPT2 printer port.
"/2" tells the device driver to use the LPT3 printer port.
"/3" tells the device driver to use the LPT4 printer port.

NOTE: These optional parameters tell the device driver which port to use when communicating with the Spex system. These numbers are actually index numbers into a table of base addresses for printer ports that can be found in the BIOS memory area of the computer. The BIOS memory area begins at segment 0040 (hex). The location of the base address table can be found at offset 0008 (hex) within this segment.

Once the driver is installed and tested using the GMI software provided, you can begin to write code to control your 270M.

2 SPEX0000 Command Protocol:

Each command sent to the driver is an ASCII string of not more than 128 characters. There are several possible first characters in a command string (see below). Initial spaces, line feeds, and carriage returns within commands are ignored. The commands must end with a semicolon (;) to be interpreted by the driver. After the command string has been processed, the internal command buffer is flushed and ready to receive the next command. A slash (\) is used to enter comments into a program. Liberal use of comments is recommended to embed explanations that will be helpful in future program maintenance. Comments are ignored by the driver when the program is running.

COMMANDS

Character	Function
F OR f	Set step frequencies for mono drive, slit drives, shutters, et al.
I or i	Initialize system partial or full initialization.
A or a	Move device to absolute step position.
R or r	Move device to step position relative to current position.
C or c	Calibrate device (set to new step position).
Q or q	Query step position of device.
QS or qs	Query number of states in system.
\	Comment.

2.1 Setting Frequencies:

The device driver maintains frequency values in motor steps per second that it uses to regulate the speed at which devices are controlled. The frequencies are preset to default values, We recommend that you not change these frequencies. If you do not use this command, the default values will be used. There are four different frequency values, one for each of the four device types (mono, slit, shutter, dc). These frequencies are adjusted by the following function call:

SYNTAX:
"F [MONOFREQ] [SLITFREQ] [SHUTTERFREQ] [DCFREQ];"

Four parameters are expected regardless of whether you are setting all frequency values or only one. Using a zero as a place holder tells the driver that you do not want to change the frequency for that particular device. Monochromator wavelength scanning speed is controlled by MONOFREQ. Slit speed is controlled by SLITFREQ. Shutter control pulse width is set by SHUTTERFREQ. Turret and mirror control pulse width is set by DCFREQ.

EXAMPLES:
"F 3000 400 400 400;" - set frequency for monochromator to 3000, frequency for slit, shutter, and dc each to 400 (these are the default frequencies).

"F 0 0 0 600;" - set frequency for dc to 600, others stay as they are.

NOTE:
This is the only function that can be called before initializing the system (see 2, below).

2.2 Initializing the System:

Before spectrometer devices can be accurately positioned, they must be set to known positions. The driver must be told what these known positions are and several variables within the driver must be set. This must be done before making calls to any of the other device driver functions that move device components.
At the very least, the initialization call is responsible for setting the counter that is used for delays when communicating with the hardware. The protocol is allows initialization of selective parts of the system. The parts of the system include:

- monochromator scan drive,
- shutters,
- slits, and
- internal variables (delay counter and device position table).

The parameters that are passed to the call will vary depending on what is being initialized. If the monochromator is being initialized, then the calibration position (in steps) must be passed. If the slits are being initialized, then the maximum width of the slits must be passed in the same fashion. How the driver interprets the parameters is determined by the first parameter, which will be interpreted as the summation of the numbers in the left column of the following table:

Device Initialization Selection

Number	On	Off
1	initialize mono drive	do not initialize mono
2	initialize shutters	do not initialize shutters
4	initialize slits	do not initialize slits
8	do not initialize internal variables	initialize internal variables

Hence, a 7 will be interpreted as : Initialize mono drive, shutters, slits, and internal variables.

SYNTAX:

"I [FLAGS] [MONOSTEPS if number 1 in summation]
[SLITSTEPS if number 4 in summation];"

EXAMPLES:

"I 0;" - initialize table and set delay counter used for communication with hardware.

"I 9 38000;" - initialize monochromator only. Do not initialize table or set delay counter.

"I 10;" - initialize shutters only. Do not initialize table or set delay counter.

"I 12 1120;" - initialize slits only. Do not initialize table or set delay counter.

"I 7 34000 1120;" - FLAGS is given the value of 7 (i.e. 1+2+4). Therefore the monochromator, shutters, slits, and internal variables are all initialized (i.e. total system initialization). Because the monochromator is being initialized, the calibration position is supplied (34000) and because the slits are being initialized, the maximum slit width is supplied (1120).

"I 4 1120;" - FLAGS is given the value of 4 (i.e. initialize slits and initialize internal variables). The maximum slit width is supplied (1120).

Whether the system is initialized partially or not, the FIRST (and possibly the only) initialization command should set the internal variables and the counter that is used for communication delays. To the user of this protocol, this means that the first initialization string can not consist of a FLAG parameter with a value greater than seven (so that the internal variables are set). It also means that if there is more than one initialization command sent to the device driver, the commands other than the first should have a FLAG parameter with a value of at least eight (so that the internal variables are not reset). If the control program that you write will be called several times in a session, then you should only initialize if the computer or the spectrometer have been turned off.

2.3 Moving a device:

There are two ways to move the device, either a relative step move or an absolute step move. The relative step move function requires a number of steps to move the device from its current position. The absolute step move function requires a number that is the target position of the device after the function call.
Both functions include parameters that specify which device is to be moved and whether limits of the device are to be checked (check limits if third parameter is non-zero). If the check limits parameter is non-zero and the device has a limit switch, then the motor will not be moved if the switch is closed and it will stop if the switch becomes closed while moving. The check limit parameter should only be non-zero when moving the monochromator towards the limit switch (i.e. from one wavelength to one that is higher). The step position for absolute moves must be in the range between 0 and the maximum step position for that device (i.e. for 270M systems: 38000 for mono, 1120 for slits). If it is desired to move a below this range then relative moves are required.

SYNTAX:
"R [HWARE NUMBER] [RELATIVE STEPCOUNT] [CHECKLIMIT];"

"A [HWARE NUMBER] [ABSOLUTE STEP POSITION] [CHECKLIMIT];"

EXAMPLES:
"R 0 5000 1;" - move mono 5000 steps and stop if the calibration switch fires.

"A 10 0;" - close side exit slit and do not check the limit.

NOTE:
During the operation of these commands, the device driver constantly checks to see if the user wishes to interrupt by determining if the escape key has been pressed. This command flushes the keyboard buffer before moving the device. Keystrokes other than the escape key are read and ignored by the device driver. If the escape key is pressed, it is left in the keyboard buffer for the calling program to deal with. If a command has been interrupted in this way you can find the current position of the motor you were moving with the Query command.

Device-Hardware Number Table

Hardware Number	Device
0	Monochromator motor
1	Front Entrance Slit
2	Front Exit Slit
5	Entrance Mirror
6	Turret
7	Front Entrance Shutter
9	Side Entrance Slit
10	Side Exit Slit
13	Exit Mirror
15	Side Entrance Shutter

A step is the smallest increment that a device can be moved by the driver.

For a sine drive monochromator,such as the 270M, one mono step is proportional to change in wavelength. However, one can determine the proper step position value for a given wavelength as follows:

Given:
lambda = desired wavelength.
steps_per_unit = number of steps per unit.
groove_density = current groove density of the grating.
sgroove_density = standard groove density of the grating (always 1200 for a 270M).

Find:
step = step position to move monochromator to yield the desired wavelength.

Solution:
step = lambda * steps_per_unit * (groove_density / sgroove_density)

Example:
Let the desired wavelength be 570 nm and let there be 32 steps per nm. Find the required step position if the groove density is 300 and the standard groove density is 1200.

step = 570 nm * (32 steps/nm) * (300/1200) = 4,560

For slits, each step is proportional to a change in slit width. Using information provided, one can determine the proper step for a desired slit width as follows:

Given:
width = desired slit width in microns
microns_per_step = number of microns per step

Find:
step = step position to move slit to yield the desired slit width

Solution:
step = width / microns_per_step

Example:
Let the desired width be 2000 microns and let there be 12.5 microns per step. Find the required step position.
step = 2000 μm / (12.5 μm/step) = 160.0

2.4 Device Calibration:

The device driver maintains an internal table that contains the current position in steps for all devices in the system. When there is a need to make a correction to the position that is in the table, "Calibrate" is the function call to make. The function call expects to be given the device hardware number of the device to calibrate, as well as the value to set the current position to.

SYNTAX:
"C [HWARE NUMBER] [VALUE];"

EXAMPLES:
"C 0 12000;" - tell driver that the monochromator is at the step position 12000.

"C 10 2000;" - tell driver that the side exit slit is at the step position 2000.

2.5 To Query a Device:

This function is very similar to the calibrate device function. But rather than writing a value to the internal device driver table, we read from it. The device driver responds by placing an ASCII numeric string telling the step position of the requested device into an internal buffer. The contents of the internal buffer become known to the caller only when the device is read (see 6).

SYNTAX:

"Q [HWARE NUMBER];"

EXAMPLES:
"Q 0;" - ask for position of monochromator. Read device - get answer from device.

"Q 10;" - ask for position of side exit slit. Read device - get answer from device.

2.6 To Query Number of States:

This function is used to determine the number of states that exist on the system controlled by the device driver. The device driver responds, placing an ASCII numeric string telling the number of states into an internal buffer. The contents of the internal buffer become known to the caller only when the device is read (see 6).

SYNTAX:
"QS;"

EXAMPLE:
"QS;" - ask for number of states. Read device - get answer from device.

2.7 Reading the Device:

This function is used to get information from the device driver. Unlike the other commands in the protocol, this function is not sent to the device driver in the form of a command. Instead, it is "received" by one's program whenever a request to read from the device driver is made. The device driver maintains an internal buffer used exclusively for this function. Whenever the driver is read, it sends whatever information is stored in this internal buffer back to the caller. It is up to the programmer to be sure that this buffer contains the proper information. This is easy to assure by sending a command that modifies the internal buffer immediately before reading the device. As of this writing, only the "Query device" command (see above) modifies the internal buffer.

3 Hardware Table Specification:

Hardware Number	Device	Frequency	Regulated by
0	Monochromator motor*	3000	MONOFREQ
1	Front Entrance Slit	400	SLITFREQ
2	Front Exit Slit	400	SLITFREQ
5	Entrance Mirror	400	DCFREQ
6	Turret	400	DCFREQ
7	Front Entrance Shutter	400	SHUTTERFREQ
9	Side Entrance Slit	400	SLITFREQ
10	Side Exit Slit	400	SLITFREQ
13	Exit Mirror	400	DCFREQ
15	Side Entrance Shutter	400	SHUTTERFREQ

* - Device has a calibration (limit) switch.

4 Power On Settings for the 270M:

At startup (hardware startup, not device driver initialization), the entrance mirror will be set to use the front entrance slit, the exit mirror will be set to use the front exit slit, the shutters will be closed, and the turret will be set to grating 1.

When power is first applied to a 270M, the controller has no way of knowing the slit width or the grating position. Therefore the controller must move the slit motors and the wavelength motors to a known position.

"I 9 38000;" - moves the wavelength motor until the calibration switch fires, which is nearly 38000 steps from zero wavelength. This calibration position varies somewhat from one machine to another. You will find the correct value on the "DMD.INI steps" tag on the back of your instrument. This command will reset the device driver.

"I 12 1120;" - opens all four slits completely and then closes them by 1120 steps. Even if you have only one, two, or three slits, the driver will send signals to initialize all four possible slits.

5 Communicating with the SPEX.SYS Driver:

Each of the following subsections discusses a mode of communication from a programming language, or from DOS or a text file.

5.1 Communicating from "C" language:

To begin communications with the device driver, use "fopen()" with the name of the device driver as the filename

```
hDevice = fopen("SPEX0000","r+");
```

To terminate communications with the device driver, use "fclose()" with the file handle that was returned from the "fopen()" call.

```
fclose(hDevice);
```

To send a command to the device, use "fprintf()" in conjunction with "fflush()". "fflush()" empties C's internal file buffer.

```
fprintf(hDevice,"%s",command);
fflush(hDevice);
```

To read the device (only in the case of using the device driver query function), use "fgets()". Use "fseek()" before and after the use of "fgets()" because C requires that the calls to read and write not be adjacent to one another.

```
static void ReadQuery(char * buffer)
{
  fseek(hDevice, 0L, SEEK_SET);
  fgets(lpBuffer, cbBUFFERLEN, hDevice);
  fseek(hDevice, 0L, SEEK_SET);
}
```

5.2 Communicating from GWBasic:

To begin communications with the device driver, use "OPEN" with the name of the device driver as the filename. This let us send commands to the driver by virtue of the attribute FOR OUTPUT.

```
OPEN "SPEX0000" FOR OUTPUT AS #1
```

To terminate communications with the device driver, use "CLOSE" with the file handle that used in the call to "OPEN".

```
CLOSE #1
```

To send a command to the device, use "PRINT#".

```
PRINT# 1, "F 3000 400 400 400;";
```

To read the device (only in the case of using the device driver query function) the device must be reopened with attributes to be able to read from the device (i.e. open using FOR INPUT). After reading the device (580 INPUT# 1, REPLY), the device is closed and then reopened with attributes to be able to write to the device (i.e. open using FOR OUTPUT).

```
550 '****************** READ QUERY **********************************
560 CLOSE #1                          'CLOSE AS OUTPUT DEVICE
570 OPEN "SPEX0000" FOR INPUT AS #1      'OPEN AS INPUT DEVICE
580 INPUT# 1, REPLY                      'READ REPLY FROM DEVICE
590 CLOSE #1                          'CLOSE AS INPUT DEVICE
600 OPEN "SPEX0000" FOR OUTPUT AS #1     'RESTORE AS OUTPUT DEVICE
610 RETURN
```

5.3 Communicating from Turbo Pascal 5.5:

To begin communications with the device driver, use "assign()" with the name of the device driver as the filename then open the file for output by using "rewrite()".

```
assign(fptr, 'SPEX0000');
rewrite(fptr);
```

NOTE:

```
var fptr : text;
```

To terminate communications with the device driver, use "close()" with the variable that was used in the "assign()" and "rewrite()" calls. close(fptr);

To send a command to the device, use "write()".

```
write(fptr,'I ', mono_calib_steps, ' ', max_slit_steps,';');
```

To read the device (only in the case of using the device driver query function), reset the file for input, read from the file, then reset the file for output.

```
procedure read_query;
var
  position : longint;
begin
  reset(fptr);
  read(fptr, position);
  rewrite(fptr);
end;
```

5.4 Communicating from a Text File:

Create a text file that contains the command(s) (and comments if desired) that you would like to send to the device driver. For instance, a text file created for the purpose of interfacing with the device driver might contain the following line(s):

```
(beginning of text)
F 3000 0 0 0;        \Set monochromator frequency to 3000;
I 7 38000 1120;      \Initialize system;
(end of text)
```

After the text file has been created (assume that our text file is called INITSYS), the commands in the text file can be sent to the device driver by using the DOS COPY command like this:

COPY INITSYS SPEX0000 (press carriage return key)

5.5 Communicating from the DOS Command Line:

Interfacing with the device driver from the command line is very similar to interfacing with the device driver from a text file. The only difference is that the device driver commands are coming from the keyboard/screen rather than from a text file. Type the line: COPY CON: SPEX0000 at the command line. Enter the commands that you want to be sent to the device driver. When you are finished typing in the commands that you want to send, press either the F6 key or the Ctrl-Z key combination. Then press the ENTER key to send the commands to the device driver.

A sample session might look like this:

```
COPY CON: SPEX0000    [return]
F 3000 0 0 0;         [return]
I 7 38000 1120;       [return]
[ctrl-Z] [return]
```

This sends the same commands as the text file sample listed above. [return] and [ctrl-Z] should not be typed in as they appear here. They are only interpretations of what keys are to be pressed on the keyboard.

Reading the device driver in response to a query command (Q or QS) can be done in the following way:

```
COPY SPEX0000 CON:
```

Appendix F: Program Examples for SPEX.SYS:

These program listings are offered free of charge as examples to help you get started. Although they have been tested, please understand that they are not supported or guaranteed to the extent that our for-sale optional software packages are.

1 Sample BASIC Program:

```
10 KEY OFF                                  'TURN FUNCTION KEYS OFF
20 OPEN "SPEX0000" FOR OUTPUT AS #1         'OPEN DEVICE
30 WHILE A$ <> "D" AND A$ <> "d"            'WHILE NOT EXIT KEY
40   CLS                                    'CLEAR SCREEN
50   PRINT "A) INITIALIZE SYSTEM"           'PRINT OPTIONS
60   PRINT "B) SET FREQUENCIES"
70   PRINT "C) MOVE DEVICE"
80   PRINT "D) QUIT"
90   LOCATE 6, 1
100  INPUT "SELECTION : ",A$                'GET OPTION
110  IF A$ = "A" OR A$ = "a" THEN GOSUB 200 'INITIALIZE SYSTEM
120  IF A$ = "B" OR A$ = "b" THEN GOSUB 260 'SET FREQUENCIES
130  IF A$ = "C" OR A$ = "c" THEN GOSUB 340 'MOVE DEVICE
140  INPUT "<ENTER>", K$
150 WEND                                    'GET NEXT OPTION
160 CLOSE 1                                 'CLOSE DEVICE
170 CLS                                     'CLEAR SCREEN
180 KEY ON                                  'TURN ON FUNCTION KEYS
190 END                                     'END OF PROGRAM
200 '****************** INITIALIZE SYSTEM ********************************
210 PRINT "INITIALIZE SYSTEM"
220 B = 38406!                              'INITIALIZE MAX MONO STEPS
230 C = 1120                                'INITIALIZE MAX SLIT STEPS
240 PRINT# 1, "I 7"; B; C; ";";             'SEND INITIALIZATION STRING
250 RETURN
260 '****************** SET FREQUENCIES ***********************************
270 LOCATE 8, 1
280 INPUT "MONO FREQUENCY.........", B      'GET FREQUENCIES
290 INPUT "SLIT FREQUENCY.........", C
300 INPUT "SHUTTER FREQUENCY......", D
310 INPUT "DC FREQUENCY...........", E
320 PRINT# 1, "F "; B; C; D; E; ";";        'SEND FREQUENCY STRING
330 RETURN
340 '****************** MOVE DEVICE ***************************************
```

```
350 LOCATE 8, 1
360 INPUT "DEVICE NUMBER..........", B        'B=DEVICE NUMBER
F370 LOCATE 10, 1
380 PRINT "A) ABSOLUTE MOVE"                  'PRINT OPTIONS
390 PRINT "B) RELATIVE MOVE"
400 LOCATE 13, 1
410 INPUT "SELECTION : ", C$                  'GET OPTION
420 IF C$ = "A" OR C$ = "a" THEN GOSUB 460   'ABSOLUTE MOVE
430 IF C$ = "B" OR C$ = "b" THEN GOSUB 500   'RELATIVE MOVE
440 GOSUB 540                                 'QUERY DEVICE
450 RETURN
460 '****************** MOVE ABSOLUTE *************************************
470 INPUT "ABSOLUTE POSITION......", D        'D = POSITION
480 PRINT# 1, "A "; B; D; ";";                'SEND MOVE ABSOLUTE  STRING
490 RETURN
500 '****************** MOVE RELATIVE *************************************
510 INPUT "RELATIVE POSITION......", D        'D = POSITION
520 PRINT# 1, "R "; B; D; ";";                'SEND MOVE RELATIVE  STRING
530 RETURN
540 '****************** QUERY DEVICE **************************************
550 PRINT# 1, "Q "; B; ";";                   'QUERY DEVICE
560 CLOSE #1                                  'CLOSE AS OUTPUT  DEVICE
570 OPEN "SPEX0000" FOR INPUT AS #1           'OPEN AS INPUT  DEVICE
590 INPUT# 1, F                               'READ REPLY FROM  DEVICE
600 LOCATE 24, 1
610 PRINT "CURRENT POSITION IS "; F           'SHOW REPLY
620 CLOSE #1                                  'CLOSE AS INPUT  DEVICE
630 OPEN "SPEX0000" FOR OUTPUT AS #1          'RESTORE AS OUTPUT  DEVICE
640 RETURN
```

2 Sample Pascal Program:

```
program spexpas;
uses crt;
var
  fptr : text;
  selection : char;
  exitflag : Boolean;

procedure initialize;
var
  calib_mono_steps, max_slit_steps : longint;
begin
  calib_mono_steps := 38406;
  max_slit_steps := 1120;
  write(fptr,'I ', calib_mono_steps, ' ',max_slit_steps,';');
  readln;
end;

procedure frequencies;
var
  mono_freq, slit_freq, shutter_freq, dc_freq : longint;
begin
  write('Mono frequency.........');  readln(mono_freq);
  write('Slit frequency.........');  readln(slit_freq);
  write('Shutter frequency......');  readln(shutter_freq);
  write('DC frequency...........');  readln(dc_freq);
  write(fptr,'F ', mono_freq, ' ',slit_freq,' ', shutter_freq,'  ', dc_freq,';');
  readln;
end;

procedure query;
var
  position : longint;
begin
  reset(fptr);
  read(fptr, position );
  writeln('Position : ',position);
  rewrite(fptr);
end;
```

```
procedure move_device;
var
  device_num : integer;
  selection : char;
  steppos : longint;
begin
  write('Device number...........'); readln(device_num);
  writeln('A) Absolute move');
  writeln('B) Relative move');
  write('Selection : ');
  readln(selection);
  case selection of
    'a','A':
          begin
            write('Absolute position.......');  readln(steppos);
            write(fptr,'A ',device_num,' ',steppos,';');
            write(fptr,'Q ',device_num,';');
            query;
          end;
    'b','B':
          begin
            write('Relative position.......');  readln(steppos);
            write(fptr,'R ',device_num,' ',steppos,';');
            write(fptr,'Q ',device_num,';');
            query;
          end;
  end;
  readln
end;

begin
  exitflag := FALSE;
  assign (fptr, 'SPEX0000');
  rewrite(fptr);
  repeat
    clrscr;
    writeln('A) Initialize System');
    writeln('B) Set Frequencies');
    writeln('C) Move Device');
    writeln('D) Quit');
    gotoxy(1,6);
    write('Selection : ');
```

```
    readln(selection);
    case selection of
      'a','A':  initialize;
      'b','B':  frequencies;
      'c','C':  move_device;
      'd','D':  exitflag := TRUE;
    end;
  until exitflag;
  close(fptr);
end.
```

3 Sample C Program:

```
#include "conio.h"
#include "stdio.h"
#define cbBUFFERLEN 40
#define TRUE   1
#define FALSE  0
FILE *   fptr;
char     achBuffer[cbBUFFERLEN + 1];

void initialize(void)
{
  long   calib_mono_steps, max_slit_steps;

  calib_mono_steps = 38406;
  max_slit_steps = 1120;
  fprintf(fptr,"I 7 %ld %ld;", calib_mono_steps, max_slit_steps);
  fflush(fptr);
}

void frequencies(void)
{
  long  mono_freq, slit_freq, shutter_freq, dc_freq;

  printf("\nMono frequency.........");  scanf("%ld",&mono_freq);
  printf("Slit frequency.........");  scanf("%ld",&slit_freq);
  printf("Shutter frequency......");  scanf("%ld",&shutter_freq);
  printf("DC frequency...........");  scanf("%ld",&dc_freq);
  fprintf(fptr,"F %ld %ld %ld %ld;", mono_freq, slit_freq,
        shutter_freq, dc_freq);
  fflush(fptr);
}

void query(void)
{
  long   position;

  fseek(fptr, 0L, SEEK_SET);
  fgets(achBuffer, cbBUFFERLEN, fptr);
  fseek(fptr, 0L, SEEK_SET);
  printf("\n\nPosition : %s\n", achBuffer);
```

```
}

void move_device(void)
{
 int      device_num;
 int      selection;
 long      steppos;

 printf("\nDevice number..........."); scanf("%d",&device_num);
 printf("A) Absolute move\n");
 printf("B) Relative move\n");
 selection = getch();
 switch ((char) selection)
   {
    case 'a':
    case 'A':
             printf("Absolute position......."); scanf("%ld",&steppos);
             fprintf(fptr,"A %d %ld;",device_num, steppos);
             fflush(fptr);
             fprintf(fptr,"Q %d;",device_num);
             fflush(fptr);
             query();
             break;
    case 'b':
    case 'B':
             printf("Relative position......."); scanf("%ld",&steppos);
             fprintf(fptr,"R %d %ld;", device_num, steppos);
             fflush(fptr);
             fprintf(fptr,"Q %d;",device_num);
             fflush(fptr);
             query();
             break;
   }
}

void main(void)
{
 int selection;
 int      exitflag;

 exitflag = FALSE;
 fptr = fopen("SPEX0000","r+");
```

```
  do
    {
      printf("\n\nA) Initialize System\n");
      printf("B) Set Frequencies\n");
      printf("C) Move Device\n");
      printf("D) Quit\n");
      selection = getch();
      switch ((char) selection)
        {
          case 'a':
          case 'A':
                  initialize();
                  break;
          case 'b':
          case 'B':
                  frequencies();
                  break;
          case 'c':
          case 'C':
                  move_device();
                  break;
          case 'd':
          case 'D':
                  exitflag = TRUE;
                  break;
        }
    }
  while (!exitflag);
  fclose(fptr);
}
```