



15 Discovery Way, Acton, MA 01720

Phone: (978)263-3584, Fax: (978)263-5086

Web Site: www.princetoninstruments.com

Operating Instructions

Acton Series

SP-2150i



0.150 Meter Focal Length Dual Grating Imaging Monochromator / Spectrograph

Acton SP-2150i Operating Instructions

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I: Brief Introduction and SP-2150i Description

Brief Introduction:

This instruction manual is intended to assist you in set-up and operation of your new SP-2150i monochromator/spectrograph. Even if you are an experienced user of spectroscopic equipment, we suggest that you follow the manual (at least initially) to insure proper setup and operation. If you have any questions about the information contained in this manual, please feel free to contact the Princeton Instruments customer service department at techsupport@princetoninstruments.com or (800) 874-9789 / (609) 587-9797.

SP-2150i Description:

The SP-2150i is a 150 mm focal length monochromator/spectrograph. It features an astigmatism-corrected optical system, dual indexable gratings and interchangeable grating turrets. The SP-2150i includes a direct digital grating scan mechanism with full wavelength scanning capabilities, plus built-in RS-232 and USB computer interfaces. Two standard models are available:

Model SP-2155: Monochromator version of the SP-2150i.

Model SP-2156: Spectrograph version of the SP-2150i.

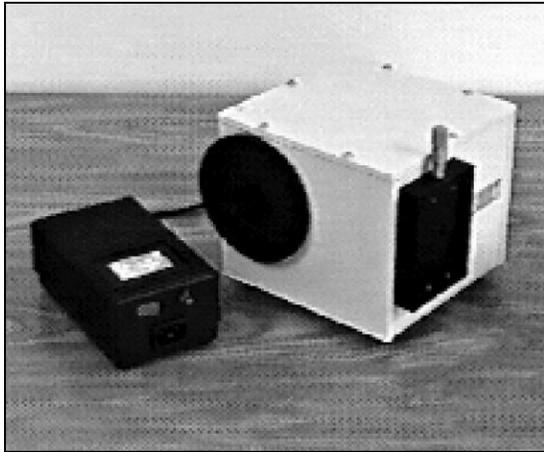


Figure 1. SP-2150i and Power Supply

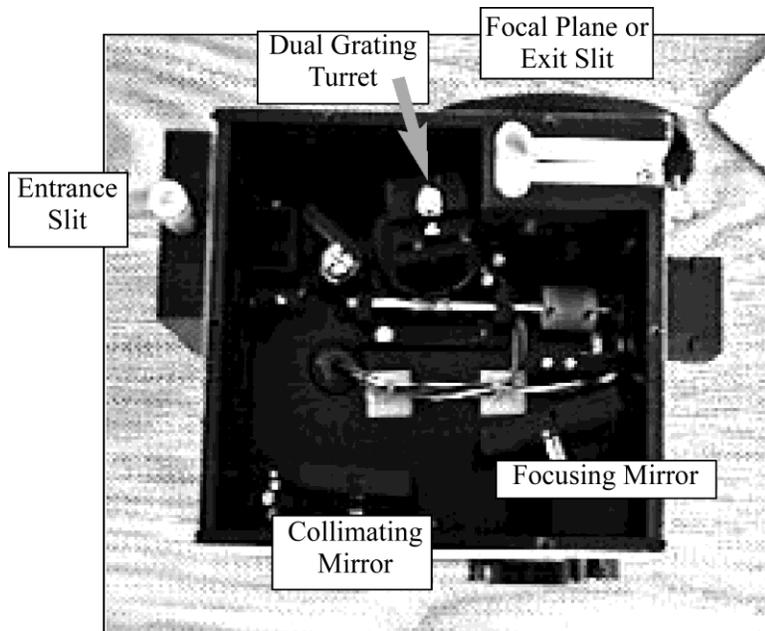


Figure 2. Basic Optical Layout

Inside the SP-2150i:

Cylindrical field correction, or added vertical power introduced by a toroidal mirror, results in an astigmatism-corrected optical system capable of multichannel spectroscopy. A stepping motor based direct digital scanning system is standard, with control electronics built-in. RS-232 and USB interfaces for computer control are included.

II: SP-2150i Specifications

Note: Each SP-2150i is operated for at least 15 minutes prior to calibration to insure optimum stability. End users should follow this practice if their application calls for optimum stability & reproducibility.

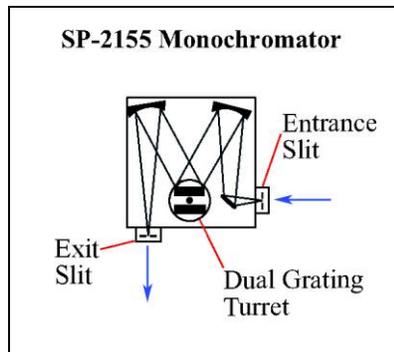


Figure 3. SP-2155 Monochromator

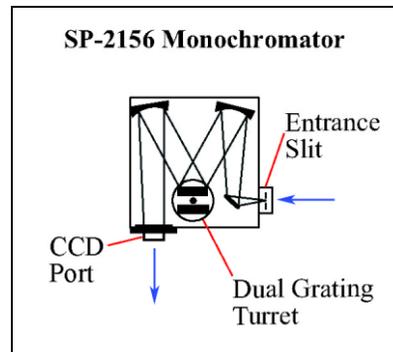


Figure 4. SP-2156 Monochromator

Optical System: Astigmatism-Corrected Czerny-Turner

High Throughput: Grating remains fully illuminated throughout the entire scanning range.

Focal Length: 150 mm

Aperture Ratio: f/4

Stray Light: $<5 \times 10^{-4}$

Resolution: 0.4 nm or better with 10 μm wide by 4 mm high slits and a standard 1200 g/mm grating (200 μm wide slits provide a 1.0 nm bandpass with a 1200 g/mm grating)

Reciprocal Linear Dispersion: 5 nm/mm (nominal) with a 1200 g/mm grating

Focal Plane Area: 10 mm high X 25 mm wide

Wavelength Scanning System: Direct digital scanning system with CMOS-based microprocessor. Provides maximum grating rotation and linear (constant nm/min.) wavelength scanning controlled by computer.

Scanning Range: 0-1400 nm with a 1200 g/mm grating. 0-2800 nm with a 600 g/mm grating.

Wavelength Accuracy: ± 0.25 nm with a 1200 g/mm grating

Wavelength Repeatability: ± 0.05 nm with a 1200g/mm grating

Computer Interface: The SP-2150i includes RS-232 and USB computer compatibility.

Slits: Bilaterally adjustable slits are available from 10 μm to 3 mm widths. Available slit heights are 4 mm and 14 mm. 4 mm is normally provided with monochromators, while 14 mm height is intended for spectrographs. Optional slits for imaging purposes provide a 10 μm – 3 mm width adjustment plus 12 X 12 mm aperture (716-MS) or 10 μm - 12 mm width adjustment, 14 mm high (SPS-718-12).

Dual Indexable Gratings: Two gratings can be mounted in the SP-2150i at the same time, and selected by computer. It takes 20 seconds to index a new grating into operating position.

Wavelength Readout: Wavelengths can be read by computer.

Conversion from Spectrograph to Monochromator: The SP-2150i is designed for easy conversion from monochromator to spectrograph. Conversion time is less than 60 seconds and can be completed in the field.

Electrical Requirements: The SP-2150i runs on 100 -240 VAC, 50 -60 Hz, automatically selected by the power supply.

Tested and conforms to **European CE Standards**

III: SP-2150i Setup

Section III-A: Unpacking and Inspection

Carefully unpack and examine the SP-2150i and any accessories purchased.

Note: Report any damage immediately to the carrier and to Princeton Instruments, and save all packing material.

Section III-B: Connecting the SP-2150i Monochromator/Spectrograph to a Computer

The SP-2150i is designed for operation by computer using RS-232 or USB and this method enables wavelength scanning at a pre-set linear scan rate, change of scanning speeds, indexing of gratings, rapid GOTO wavelength positioning, and change of grating turrets if available. Figure 5 shows the cable connections necessary for operation of the SP-2150i by computer using RS-232 or USB connections. Subsequent sections in this manual describe actual operating instructions for the SP-2150i.

Controlling the SP-2150i with Monochromator Control Software:

The Monochromator Control software is a stand-alone Acton Series software program for basic scanning and calibration. Utilities for grating updates and communications are also included. Normally, the software is installed in the directory C:\Program Files\Princeton Instruments\MonoControl. This directory contains the subdirectories Bin and Data. The Bin directory contains the executable code for the program.

Upon installation, a Monochromator Control icon is usually placed on the desktop for starting the software. If this icon is not on the desktop, check for the program in the Windows Start menu\Programs or go directly to the MonoControl\Bin directory and start the software there. When the Monochromator Control software loads, there is a main screen with selections for monochromator operation and for various setup functions. (If the buttons are grayed out, exit the program, connect an Acton Series spectrometer, wait for the spectrometer to initialize, and then restart the program.) Click on the Operation button and a screen will come up which allows for basic control of the monochromator wavelength. All functions of this software are described in the Monochromator Control software manual supplied on the Monochromator Control software install CD.

Controlling the SP-2150i Monochromator at the Command Level:

Although it requires more programming on the user's part, the monochromator can also be controlled with direct commands through its USB 1.1 port or RS-232 port. This operation is described in Section IV.

SP-2150i Cable Connections: RS-232 or USB

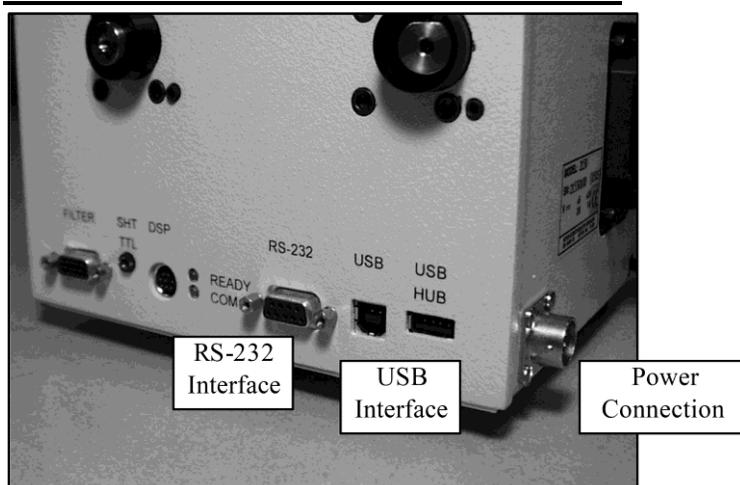


Figure 5. Details of the RS-232, USB, and Power Connections on the SP-2150i

Section III-C: Cables and Connections for SP-2150i

Princeton Instruments supplies the following two computer interface cables with the SP-2150i:

- CC-499-2 IBM AT or compatible 9 pin female (DB9S) connector to 9 pin male connector (DB9P).
- 3650-USB-06 USB Cable Type A to Type B.

If none of these cables are compatible with your system, consult Princeton Instruments for a custom cable. If you have facilities for constructing a custom cable, use the RS-232 pin arrangement shown in Table 1. See also Appendix B.

Table 1: RS-232 Computer Interface Pin Arrangement:

Pin#	Description
1	Open
2	RD data from SP-2150i to computer
3	TD data from computer to SP-2150i
4	open
5	Ground
6	Open
7	RTS
8	CTS
9	open

A terminal or RS-232 computer port must be set up as follows: 9600 baud, 8 data bits, no parity, 1 start bit, 1 stop bit.

Section III-D: Mounting Accessories to the SP-2150i Slit Assemblies

All Acton accessories come with their own set of instructions for proper mounting and operation. The instructions below are only general information. Please refer to the individual instructions for detailed information.

Accessories: The full range of Acton series accessories mount directly to the SP-2150i slit assemblies. To assist you in mounting accessories, a drawing of the standard slit assemblies has been provided in Appendix V-C. The general procedure for mounting an accessory to the slit is as follows:

1. Place the accessory directly against the face of the slit body. Light sources normally mount on the entrance slit, detectors on the exit slit. Other accessories such as fiber bundles normally mount on the entrance slit, but are also compatible with the exit slit.
2. Using four (4) 8-32 screws normally provided with the accessory, secure the accessory to the slit body.

Light sources fitted with light collection/focusing optics are normally factory aligned to the standard slit.

Note: In some instances with light sources, there is limited access to the bottom two screw holes. In this case, Princeton Instruments provides special slotted holes in the light source housing to facilitate mounting of the source to the slit.

Section III-E: Mounting Focal Plane Detectors to the SP-2150i Spectrograph

Refer to the SP-2150i schematic found in the Appendices Section. This shows details of the standard spectrograph, along with details about the mounting flange for array detectors.

The standard mounting flange for CCDs and diode arrays accommodates detectors with two different bolt circles. There are three (3) equally spaced 10-32 tapped holes on a 3.60" bolt circle, and three (3) equally spaced holes on a 3.88" bolt circle designed to accept 10-32 button head screws.

A set of special cross-shaped baffles are mounted in the array detector mounting flange to define the focal plane area and reduce potential stray light. This unique baffle shape permits mounting of many different array detectors.

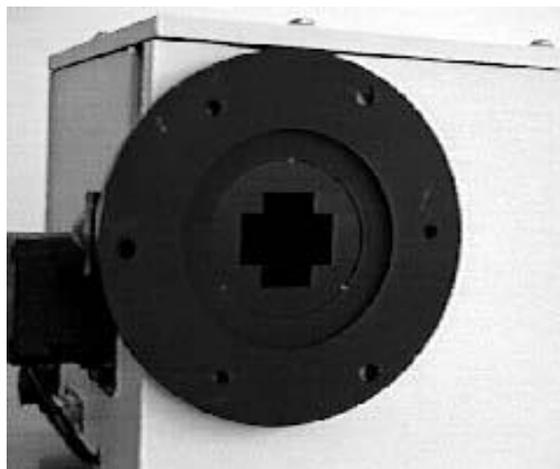


Figure 6. Standard Array Detector Mounting Flange

To mount an array detector to the SP-2150i, use the following procedure:

1. The array detector mounting flange is attached to a sliding tube, which slides into the instrument.

Note: At this point it is very important to check the focal plane distance of the array detector. This is the distance from the front mounting surface of the array detector to the actual CCD or diode array element. Because array detector focal distances vary, the correct distance is crucial in order to determine if a spacer is required for proper focus. Generally, a spacer is required if the detector focal plane distance is between 0.340" to 0.670". This spacer is normally provided with spectrographs. If the detector focal plane distance falls between 0.670" and 1.00", then no spacer is required.

2. Using a 1/8" Allen wrench, loosen the two (2) set screws located at the top and side of the front plate.
3. Gently slide the array detector mounting flange all the way out of the SP-2150i housing. Make sure that the sliding tube and O-ring are kept clean.
4. Position the array detector mounting flange against the array detector and match the hole patterns. When correctly positioned, the baffles should be square to the array detector. If it does not align properly, contact Princeton Instruments.

Note: Refer to the Detector System Manual for specific instructions on how to mount the array detector to the mounting flange. These instructions vary with the detector nose design.

5. Fasten the array detector mounting flange to the detector and then carefully slide this assembly back into the SP 2150i housing.
6. Re-tighten the set screws and clamp to secure the detector assembly.

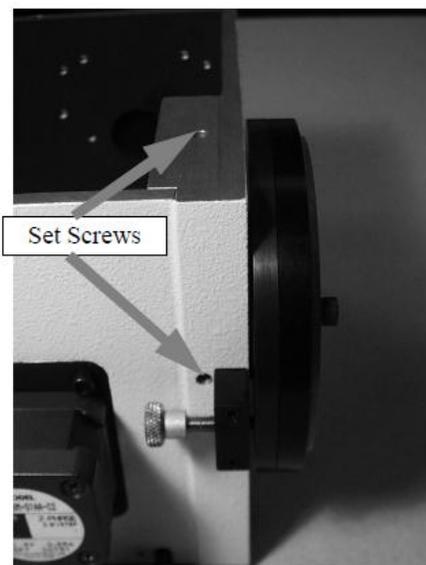


Figure 7. View of Sliding Tube Set Screws.

Refer to Section IV-C for focusing procedures for array detectors.

Section III-F: Slit Width Adjustments in the Model 716 Bilateral Slits

The slit width of each bilateral slit assembly (716 type) is adjustable from 0.010 millimeters to 3 millimeters (10 to 3,000 μm) by a micrometer knob located on the top of the slit housing. The micrometer knob is graduated in 0.010 millimeter (10 μm) increments.

Each clockwise revolution of the micrometer knob increases the slit width 0.25 millimeters (250 μm). For maximum reproducibility, the slit width should be set in a clockwise direction (increasing slit widths) each time it is changed. Refer to the drawing below.

The micrometer knob should not be rotated below a reading of 0.00 or above 3.00. A micrometer setting of less than 0.010 millimeters (10 μm) should not be used, because a stop is provided to prevent the slit jaws from contacting each other.

Note: Damage May Be Done If Slit Jaws Are Opened Wider Than 3.0 mm.

Slit Width Micrometer Settings Slit Width Adjustable from 10 Micrometers to 3000 Micrometers (3 mm)

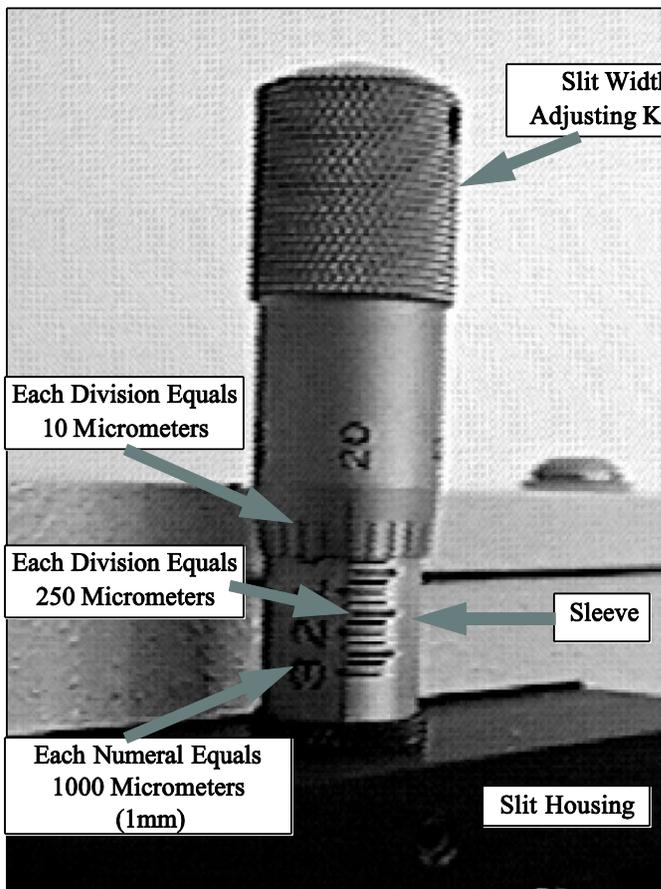


Figure 8. Slit Width Setting:
200 Micrometers (0.200 mm)

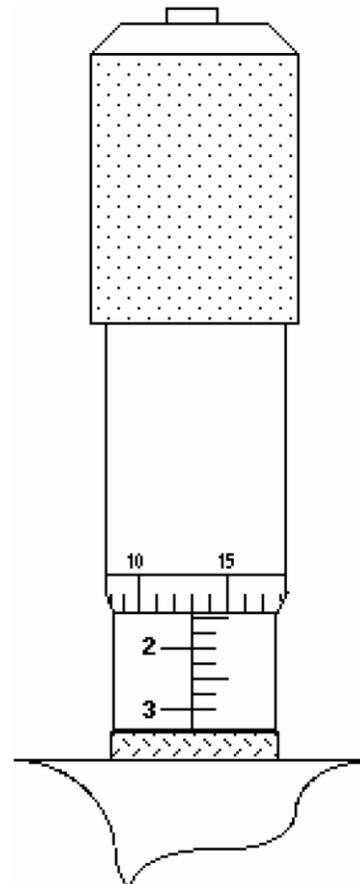


Figure 9. Slit Width Setting:
1380 Micrometers (1.38 mm)

IV: SP-2150i Operation

Section IV-A: Initialization

When power is turned ON to the SP-2150i, it initializes to a wavelength of 0.0nm for grating number 1. If the power is switched OFF and then ON again to the SP-2150i, it will initialize. Initialization gives the system a reference, or starting position to keep track of wavelength position, grating location, and other parameters. Alternative start-up parameters can be programmed if the factory defaults are not suitable (See Appendix A).

Section IV-B. Operating the SP-2150i Using a Computer

Standard operation of the SP-2150i is with Monochromator Control Software supplied with the Instrument. Please refer to the manual on the Monochromator Control Software CD for Installation and Operating Instructions.

The SP-2150i monochromator or spectrograph can also be controlled from an RS-232 terminal or from a computer using RS-232 or USB. The same command set, listed below, is used for RS-232 or USB control.

Commands can be sent as single commands or grouped into strings of commands. All commands are single words (contain no spaces) and all commands in a string are separated by at least one space. Parameters, if needed, precede the command and are separated from the command by at least one space (e.g., 546.7 GOTO).

For RS-232 operation, the port setup is 9600 baud, 8 data bits, 1 stop bit and no parity. All commands or strings of commands must be terminated with a carriage return (0D hex). The SP-2150i responds to a command when the command has been completed by returning the characters "OK" followed by carriage return and line feed (hex ASCII sequence 20 6F 6B 0D 0A). The default condition is to echo each character that is sent to the SP-2150i. If no echo is desired, the command **NO-ECHO** will suppress the echo. The command **ECHO** will return the SP-2150i to the default echo state.

SP-2150i Commands:

Command	Function	Example
NM/MIN	Sets scan speed	100.0 NM/MIN (this sets the scan rate to 100 nm per/min)
NM	Scans to destination wavelength to nearest 0.1 nm at selected scan rate.	250.0NM (this causes the SP-2150i to scan to 250 nm)
GOTO	Goes to destination wavelength to nearest 0.1 nm at selected scan rate.	250.0 NM (causes the SP-2150i to go to 250 nm)

GRATING	Selects either the first or second grating on the selected turret. Requires approximately 20 seconds.	2 GRATING (indexes grating number 2 into position. Moves to the same wavelength as the previous grating or 200 nm default if wavelength is not accessible by the selected grating.)
TURRET	Selects parameters for the gratings on turret 1, 2, or 3.	2 TURRET (selects parameters for turret number 2)
?NM	Sends the current wavelength to the computer or terminal with the format 250.0.	
?NM/MIN	Sends the present scan speed to computer or terminal with the format 100.0	
?GRATING	Sends the present grating position (1 or 2) on the selected turret to the computer or terminal	
?GRATINGS	Sends the groove spacing and blaze wavelength of each grating position 1 through 6 (2 grating positions for each of 3 turrets) to the computer or terminal.	
?TURRET	Sends the selected turret number (1, 2, 3, or 4) to the computer or terminal.	
?TURRETS	Sends the groove spacing of each grating for each turret to the computer or terminal.	

Section IV-C: Focusing and Alignment of Array Detectors

With the CCD or diode array properly mounted to the SP-2150i using the procedure detailed in Section III-E, use the following procedure to align and focus the array detector to the SP-2150i optical system. We assume that the array detection system is running for the following procedure.

1. Mount a light source such as a mercury pen-ray type to the entrance slit of the SP-2150i. Princeton Instruments offers a standard mercury lamp, Model MS-416, designed for this purpose. Any light source with line output can be used. If there are no "line" sources available, it is possible to use a broadband source such as tungsten for the alignment. If this is the case, use only a wavelength setting of 0.0nm for alignment purposes.
2. With the SP-2150i properly connected to a computer, turn the power ON and move the spectrograph to a wavelength of 435.8 nm if using a mercury lamp, or 0.0 for a broadband source, or another wavelength corresponding to a spectrum produced by a different "line" source.

If the SP-2150i is not connected to a computer, please return to Section III-B or III-C. If you are unfamiliar with operation of the SP-2150i, refer to Section IV-B.

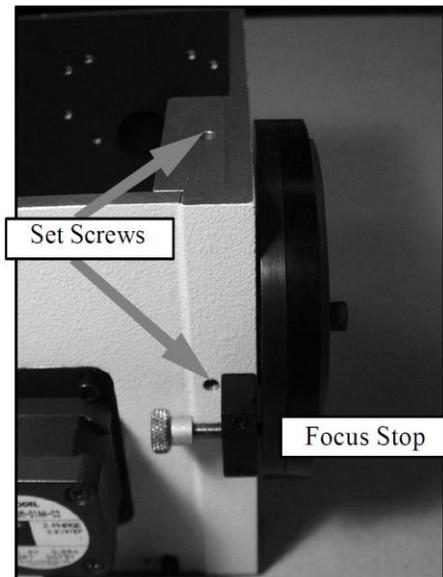


Figure 10. Locations of Set Screws and Focus-Stop Screw

3. With the array detector operating, check the image of the light source if running in an imaging mode with a CCD. Otherwise, check the line intensity and shape.
4. Using a 1/8" Allen wrench, loosen the two (2) #10-32 set screws (approximately 2 turns) located on the top and side of the front plate.
5. Slowly move the array detector IN or OUT until sharpest image is achieved, or sharpest line is achieved.
6. Move the focus-stop screw until it just contacts the array detector mounting flange. This enables you to rotate the detector without changing the focus position.
7. When best focus is achieved, tighten the set screws to secure the detector.
8. At this time the array detector is aligned to the SP-2150i for best spectral resolution. The light source can be removed if desired, and replaced by fiber optics or other light sources.
9. If fibers or other imaging input optics are used to bring light into the SP-2150i, they will require adjustment along the optical axis to achieve best vertical image quality.

Section IV-D: Converting the SP-2150i from Monochromator to Spectrograph, or Spectrograph to Monochromator

Monochromator to Spectrograph: This procedure requires that you have the monochromator version, Model SP-2155, plus the array detector mounting flange.

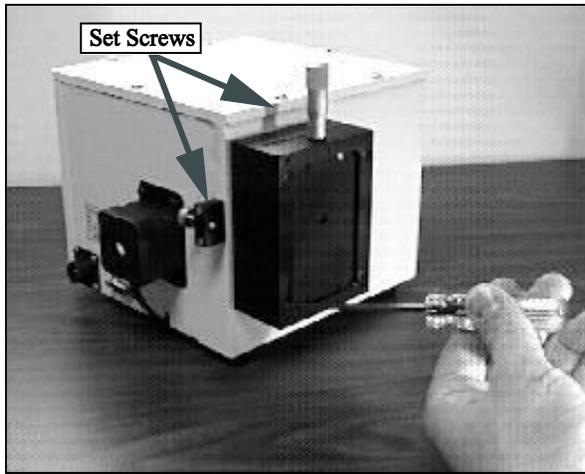


Figure 11. Removal of the 8-32 Screws Securing the Exit Slit to the SP-2150i Housing

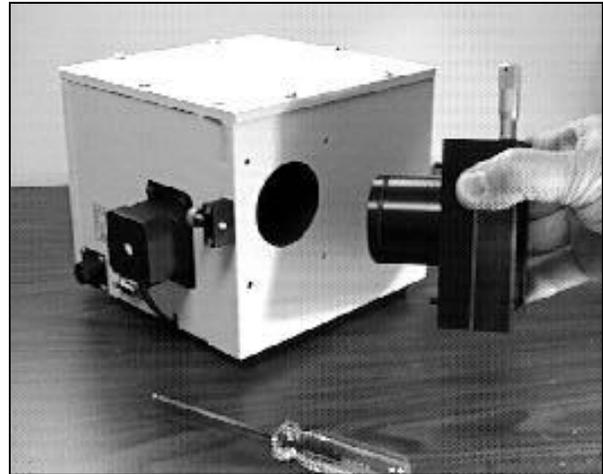


Figure 12. Removing the Exit Slit, With Sliding Tube, From the SP-2150i Housing

1. Using an 1/8" Allen wrench, loosen the two (2) #10-32 set screws located at the top and side of the front plate.
2. Remove the four (4) 8-32 socket head cap screws (SHCS) that secure the exit slit to the SP-2150i housing.

Note: The four tapped holes from which the screws were removed, need to be filled with set screws to prevent light leaks. Details of the slit assemblies can be found in the drawing located in the Appendices Section.

3. Gently slide the slit assembly out of the SP-2150i housing and store in a clean, dry area. The exit slit assemblies are attached to a sliding tube which is removed along with the slit body.
4. Slide the array detector mounting flange into the SP-2150i housing so that it rests against the housing. It may be necessary to turn the focus-stop screw counter clockwise so that it does not interfere with the array detector mounting flange.
5. The SP-2150i has now been converted from monochromator to spectrograph.
6. Refer to Sections III-E "Mounting Array Detectors...", and IV -C "Focus and Alignment..." for actual mounting, alignment, and focus of array detectors.

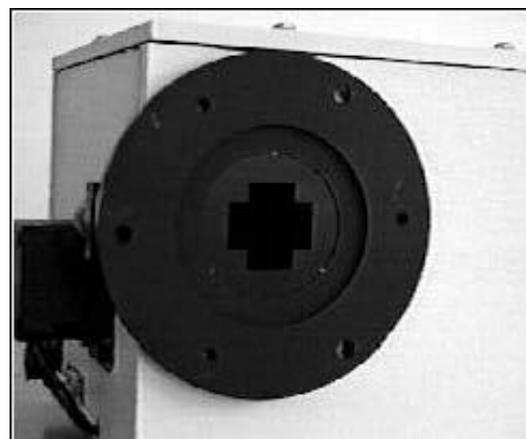


Figure 13. Array Detector Mounting Flange Mounted in Place of the Exit Slit

Spectrograph to Monochromator: This procedure requires that you have the spectrograph version, Model SP-2156, plus the Model SPS-716-2 exit slit assembly. A spacer may be required.

1. Loosen the set screws on the top and side and gently slide the array detector mounting flange out of the SP-2150i housing.
2. Remove the array detector if attached and then store the array detector mounting flange in a clean, dry place.
3. Locate the Model SPS-716-2 exit slit assembly and then gently slide it into the SP-2150i housing until it rests against the housing. Exit slit assemblies are attached to a sliding tube to fit the SP-2150i housing.
4. Using four (4) 8-32 socket head cap screws (SHCS), secure the slit assembly against the SP-2150i housing. There are four (4) tapped holes in the SP-2150i housing to facilitate mounting the exit slit. Tightening the two set screws is not crucial, but good practice.

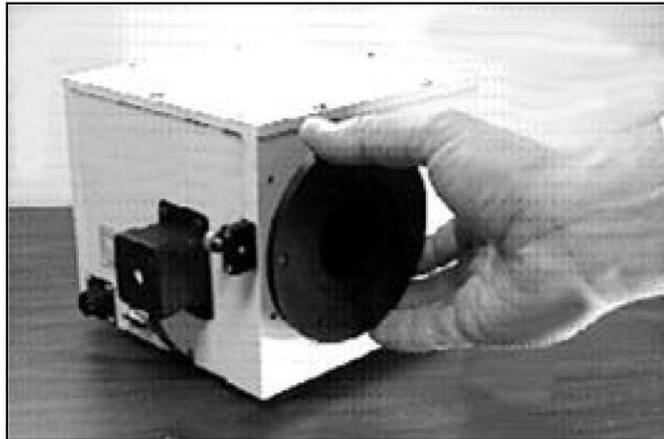


Figure 14. Removing the Array Detector Mounting Flange

Note: The slit aperture is slightly offset in the slit assembly. Orient it so that the aperture is on the upper side when properly mounted. On the bilateral slits, the micrometer points upward. Refer to the drawing in the appendices section of this manual for correct orientation if necessary.

5. The SP-2150i has now been converted from spectrograph to monochromator.

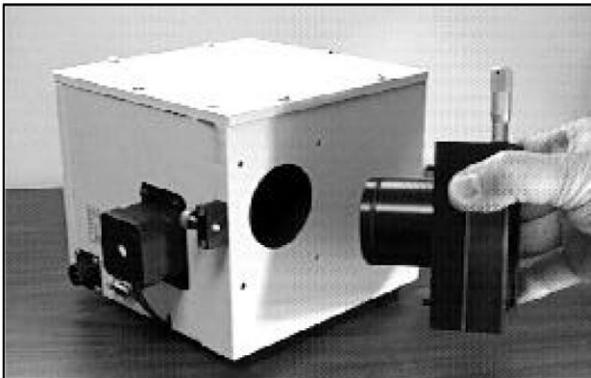


Figure 15. Installing Exit Slit Assembly, with Sliding Tube, Into the SP-2150i Housing

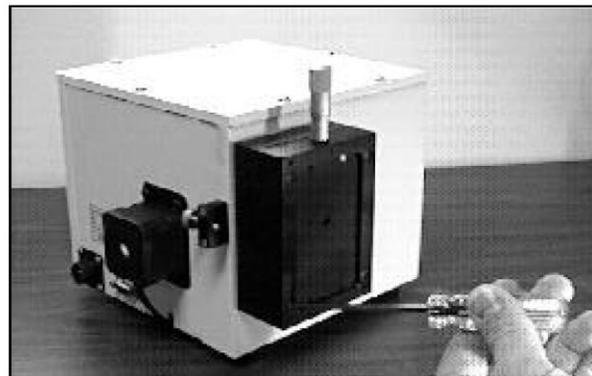


Figure 16. Securing the Exit Slit Assembly to the Housing Using Four (4) 8-32 Screws

Section IV-E: Interchanging Grating Turrets

Caution: Optical surfaces of gratings and mirrors are extremely delicate and can be permanently damaged by contact with anything. Do not touch, talk, or breathe on or over the gratings, or optical surfaces inside the SP-2150i.

General: Every SP-2150i is supplied with kinematically mounted grating turrets to permit easy removal and interchanging of grating turrets without re-alignment of the instrument. To interchange turrets, use the following procedure:

1. Locate the container holding the new turret.
2. Move the SP-2150i to a wavelength of 0.0nm for grating number one, or the lowest grating number on the turret installed.
3. Remove the SP-2150i cover. Refer to the caution above.
4. Turrets are held in position by a single screw with a knurled knob located at the top of the turret (see picture). Turn the knurled screw in a counter clockwise direction until it disengages from the kinematic mount. The screw is spring loaded and captive in the turret.
5. Lift the grating turret straight out of the housing, taking great care not to allow anything to make contact with the gratings. Grasp the screw and/or top portion of the grating turret when handling the grating turrets.
6. Place the removed grating turret on a clean, dry surface.
7. Remove the cover from the grating turret storage container. Remove the grating turret from the storage by loosening the knurled screw. This is similar to Step 4 above.
8. With extreme care, place the new grating turret on the kinematic mount inside the SP2150i housing. The kinematic mount will only accept the turret in one orientation. Normally this will be when the lowest grating number is facing the concave mirrors inside the housing. (Remember that you previously scanned to 0.0nm for the lowest grating number.)
9. Using your index finger and thumb, simultaneously push straight down and turn the knurled screw clockwise to engage the kinematic mount. When the screw engages the tapped hole, continue to turn it clockwise until the turret is secured. Don't overtighten!
10. Replace and secure the SP-2150i cover. Place the previously removed grating turret in the turret storage container, and secure it using the knurled screw.
11. At this point you must tell the SP-2150i what turret is currently installed, so that the correct calibration information can be used for those specific gratings. Refer to Section IV-B or IV-C to complete the turret installation procedure.

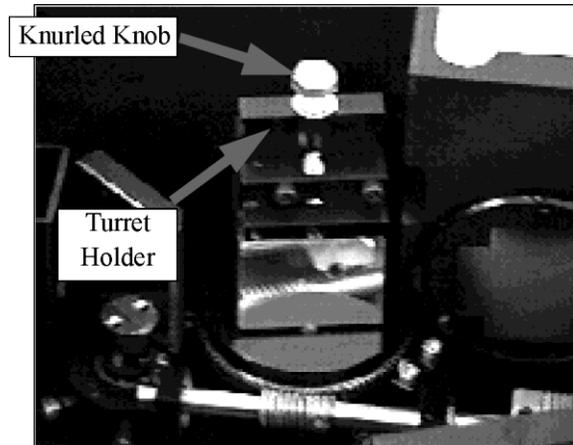


Figure 17. Dual Grating Turret Mounted Inside the SP-2150

V: Appendices and Schematic Drawings

Appendix V-A: Selecting Alternate Start-Up Parameters

The following are the Start-Up parameters and their default values:

GRATING	#1
WAVELENGTH	0.0 nm
SCAN SPEED	100.0 nm/min

Each of the above may be changed through the RS-232 port or USB port using the following commands. These values are stored in non-volatile memory and will be in effect after the next power-up.

- INIT-GRATING** Selects which of the two gratings on the installed turret the SP-2150i will go to after finding 0.0 nm on the first grating.
(e.g., 2 **INIT-GRATING** selects the second grating as the default)
- INIT-WAVELENGTH** Sets an initial wavelength for the SP-2150i after initialization. (e.g., 435.84 **INIT-WAVELENGTH** Notice that two digits after the decimal point are required)
- INIT-SRATE** Sets an initial scan rate for the SP-2150i.
(e.g., 500.00 **INIT-SRATE** Notice that two digits after the decimal point are required)

The following command is used to return all grating parameters and start-up parameters to the original factory settings.

- RESTORE-FACTORY-SETTINGS** Note that any gratings installed at a later date (after initially receiving the SP-2150i) will be erased from memory using this “restore command”.

Appendix V-B: Cable Connection Diagrams - Monochromators & Spectrographs to Computer

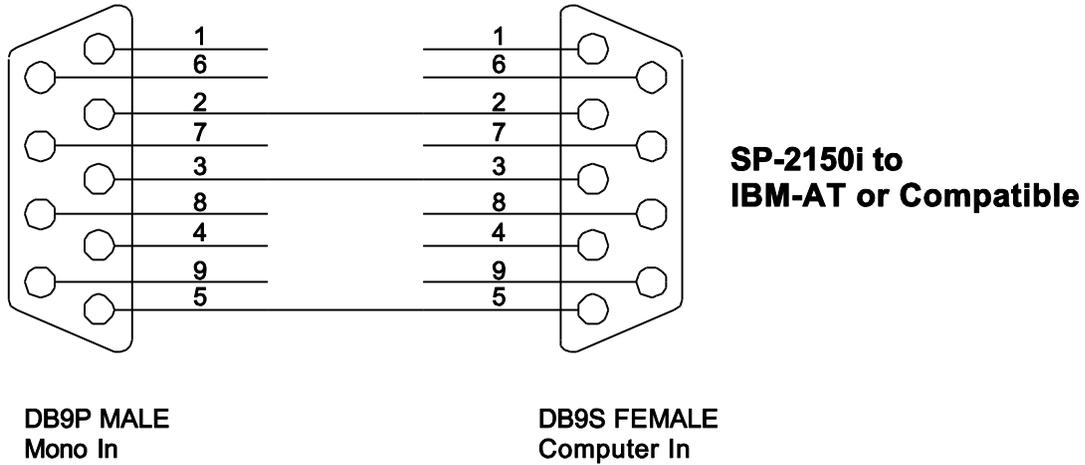


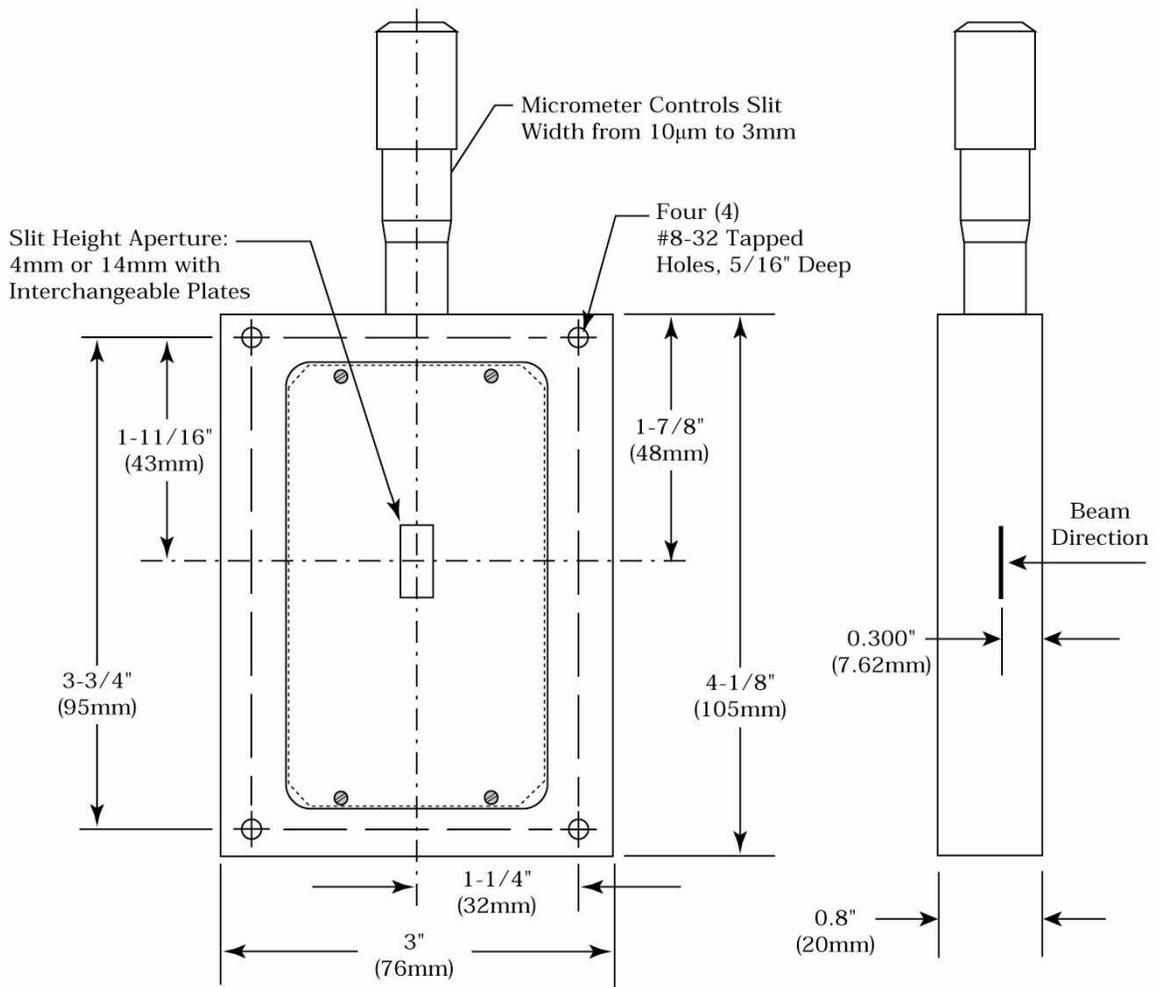
Figure 18. RS-232 Cable Wiring



Figure 19. Cable Connections (Back Panel)

POWER	Power connection +5 and +24 Volts
USB HUB	USB Hub 1.1 compatible.
USB	USB connection to computer.
RS-232	RS-232 connection to computer.
READY	Ready light is on when the instrument is ready to operate. (Green light comes on after the instrument initializes. Yellow = busy)
COM	Com light flashes when communicating with the computer. (Busy)
DSP	DSP connection to connect two monochromators as doubles.
SHT TTL	SHT TTL connection for TTL control of shutter.
FILTER	Filter driver connection for Acton FA-2448 Filter Wheel.

Appendix V-C: Standard Slit Assembly Drawing



Appendix V-D: Accessories Listing

SP-2150i Monochromators & Spectrographs

- SP-2155** **SP-2150i, 150 mm Monochromator:** Internal image correction with original polished aspheric optics, interchangeable dual grating turret, exclusive SpectraDrive™ stepping motor scanning system with 32-bit microprocessor control, RS-232 and USB computer interfaces, micrometer controlled entrance and exit slits, 90° optical path and scan control software for Windows. Gratings are required for operation.
- SP-2156** **SP-2150i, 150 mm Spectrograph:** Same as above with a standard multichannel detector adapter flange on exit port. Provides a 90° optical path.

Other Acton Series Monochromators & Spectrographs

The Acton Series of instruments are also available in 300, 500, and 750 mm focal lengths, each with multiple configurations. Contact your sales engineer or visit our website www.princetoninstruments.com for details.

Slit Assemblies: Bilaterally Adjustable

- SP-716-1** **Bilaterally adjustable ENTRANCE slit assembly** for SP-2150i monochromator or spectrograph. Micrometer adjustable widths from 10 µm to 3 mm. Supplied with interchangeable 4.0 mm and 14.0 mm high baffles.
- SP-716-2** **Bilaterally adjustable EXIT slit assembly** with adapter for SP-2150i monochromator. Micrometer adjustable widths from 10 µm to 3 mm. Supplied with interchangeable 4.0 mm and 14.0 mm high baffles.

Grating Turret

- 150-483** Additional interchangeable dual grating turret. Requires gratings.

Light Sources

Sources with 220 V, 50 Hz are also available in all models.

- DS-421** **30 Watt Deuterium Light Source** with housing, power supply, mounting flange, and light collection mirror. Provides output from 190 to 350 nm.
- MS-416** **Low Pressure Mercury Light Source** with power supply and mounting flange for Acton monochromators and spectrographs. Provides output at typical mercury wavelengths (line output).
- TS-425** **30 Watt Tungsten-Halogen Light Source** with housing, power supply, mounting flange, and light collection mirror. Provides output from 350 nm to >2.0 µm
- TS-428** **250 Watt Tungsten-Halogen Light Source** with housing, AC power supply, mounting flange, variable brightness control and light collection mirror. Provides output from 350 nm to >2.0 µm.
- TS-428-DC** **Same as TS-428 with Regulated DC Power Supply.**
- TDS-429** **Dual Light Source** with 30 watt deuterium & 30 watt tungsten-halogen lamps. Includes housing with light collection mirror, mounting flange, and power supply. Provides combined output from 190 to >2.0 µm.
- XS-433** **75 Watt Xenon Light Source** includes power supply, housing, mounting flange and light collection mirror. Provides continuous spectral output from 190 nm to 750 nm and declining continuum out to 2.6 µm.

Detectors and Accessories: All detectors include mounting flanges for Acton Series and SpectraPro slit assemblies.

- PD-438** **Universal Photomultiplier Tube Housing** for standard 1 1/8" side window photomultiplier tubes. Requires side window PMT, and photometer/power supply for operation. Accepts Acton tubes P1, P2 or P3 below, or customer specified 1 1/8" side window PMTs.
- PD-439** Same as PD-438 above, also includes integrated **light tight shutter**.
- PD-471** **Photomultiplier Tube Housing** for 1 /8-inch tubes with built in HV supply. Only for SpectraHub.
- P1** **Side Window Photomultiplier Tube** (or equivalent) for wavelength region 185-650 nm. Fits PD-438, PD-439, or PD-471 housing.
- P2** **Side Window Photomultiplier Tube** (or equivalent) for wavelength region from 185-900 nm. Fits PD-438, PD-439, or PD-471 housing.
- P3** **Side Window Photomultiplier Tube** (or equivalent) for wavelength region from 300-1100 nm. Fits PD-438, PD-439, or PD-471 housing.
- SI-440** **General-purpose Single Channel Detector** with a 10 mm diameter active area for use from 400 to 1100 nm. Enclosed in housing with the BNC connector.
- SI-440-UV** **Single Channel Detector** with a UV-enhanced, 10 mm diameter active area for use from 200 to 1100 nm operation.
- SCA-440-UV** **Source Compensation Accessory** with UV silicon photocell (positive current) and housing with beam splitter that redirects a portion of the beam to the UV silicon photocell. Compensates for source fluctuations at a target wavelength. Mounts on the exit slit of a monochromator that is used for illumination.
- ID-441** **InGaAs Detector**, includes pre-amplifier, uncooled version. Range 800 nm – 1700 nm.
- ID-441-C** **InGaAs Detector**, includes pre-amplifier, cooled version, requires Model 442-1-A, thermoelectric cooling for operation.
- 442-1-A** **Thermoelectric cooling** for ID-441-C detectors.
- SpectraHub** **SpectraHub data acquisition system**, 20-bit A-D converter, single channel detector interface. Requires SpectraSense software.

Filter Wheels and Order Sorting Filter Assemblies

- FA-2448** **Six Position Filter Wheel Assembly.** Manual sample indexing, holds up to six samples, each 1.0" diameter; automated via SP Control Cable. Can be used with the SP-2150i. Requires FA-2448-F Filter Set or customer-supplied filters of 25 mm (1 inch) diameter and 5 mm or less in thickness.
- FA-2448-1** **Order Sorting Filter Assembly.** Includes FA-2448-F Filter Set with 320, 590, 665, and 715 nm filters mounted in FA-2448 filter wheel. Manual indexing of filters for elimination of unwanted second order radiation; automated via SP Control Cable. Can be used with the SP-2150i.
- FA-2448-2** **Motorized Six Position Filter Wheel Assembly**, with stepping motor and FA-2448-4 controller. Enables indexing by computer with RS-232 or USB. Requires computer with RS-232 or USB for computerized operation. Set or customer-supplied filters of 25 mm (1 inch) diameter and 5 mm or less in thickness. For the older SP-150 models.

- FA-2448-3** **Motorized Order Sorting Filter Assembly.** Includes FA-2448-F Filter Set with 320, 590, 665, and 715 nm filters mounted in FA-2448 filter wheel. Enables computer controlled indexing of order sorting filters for elimination of unwanted second order radiation. Requires computer with RS-232 or USB for operation. Requires FA-2448-F Filter Set. For the older SP-150 models.
- FA-2448-4** **Controller Only** for FA-2448 or 2448-1 filter wheel assemblies. Retrofit kit which enables changing the FA-2448 or 2448-1 from manual to computer controlled indexing. Requires FA-2448 type filter wheel and computer with RS-232 or USB for operation. May require FA-2448-F Filter Set.
- FA-2448-F** **Order Sorting Filter Set.** Includes four filters: 320, 590, 665, and 715 nm.

Fiber Optic Light Guides: All Fiber optic light guides contain 19 fibers, 200 μ m diameter, arranged in a line pattern at the slit end, and round at the source end.

- LG-455-020-1** **UV-VIS Fiber Optic Bundle** 1.0 meter long, for 190 nm to 1100 nm. Requires mount.
- LG-455-020-3** **UV-VIS Fiber Optic Bundle** 3.0 meter long, for 190 nm to 1100 nm. Requires mount.
- LG-456-020-1** **VIS-NIR Fiber Optic Bundle** 1.0 meter long, for 400 nm to 2200 nm. Requires mount.
- LG-456-020-1** **VIS-NIR Fiber Optic Bundle** 3.0 meter long, for 400 nm to 2200 nm. Requires mount.
- FC-446-010** **Fixed-Position Fiber Adapter** is a low-cost solution for positioning fiberoptic bundles directly at the entrance (or exit) ports of SpectraPro spectrometers. Accepts 10 mm diameter ferrule.
- FC-446-020** **Fiber Coupler** with horizontal translation capability for 10 mm diameter fiber optic bundle. Accepts 10 mm diameter ferrule.
- FC-446-021** **Fiber Coupler** with X-Y Micrometer alignment adjustments. Accepts 10 mm diameter ferrule.
- FC-446-030** **Imaging Fiber Adapter** is designed specifically for our imaging spectrometers. The all-reflective design eliminates chromatic aberrations and the aspheric mirror cancels astigmatism, allowing precise imaging of fibers at the spectrograph entrance slit. Includes up/down, left/right screw alignment adjustments. Accepts 10 mm diameter ferrule. Also includes a 0.75" thick spacer to insert an optional FA-2448 series Filter Wheel for order sorting function.

Connecting Cables

- CC-499-2** Cable for IBM-PC AT or compatible computer. 9 pin **female** connector to 9 pin **male** connector.
- 3650-USB-06** USB Cable Type A to Type B

If the above cables are not compatible with your system, contact Princeton Instruments for a custom cable.

Appendix V-E: Gratings for SP-2150i

Grooves/mm	Blaze Wavelength	Standard Part Number	Mechanical Limit
50	600 nm	150-05-600	
75	8 μ m	150-07.5-8	
150	300 nm	150-015-300	
150	500 nm	150-015-500	11.2 μ m
150	800 nm	150-015-800	
150	4 μ m	150-015-4	
300	300 nm	150-030-300	5.6 μ m
300	500 nm	150-030-500	
300	750 nm	150-030-750	
300	1 μ m	150-030-1	
300	2 μ m	150-030-2	
600	300 nm	150-060-300	2.8 μ m
600	500 nm	150-060-500	
600	750 nm	150-060-750	
600	1 μ m	150-060-1	
600	1.6 μ m	150-060-1.6	
1200	Blazed Holographic UV [†]	150-120-HUV	1400 nm
1200	300 nm	150-120-300	
1200	500 nm	150-120-500	
1200	750 nm	150-120-750	
1800	Blazed Holographic UV [†]	150-180-HUV	933 nm
1800	500 nm	150-180-500	
2400	240 nm	150-240-240	700 nm
2400	Blazed Holographic UV [†]	150-240-HUV	
2400	Holographic VIS ^{††}	150-240-HVIS	
3600	240 nm	150-360-240	466 nm
3600	Holographic UV ^{†††}	150-360-HUV	

Notes:

[†] Blazed Holographic, 190-450 nm, optimum range

^{††} Holographic, 450- mechanical limit, optimum range

^{†††} Holographic, 190-466 nm, optimum range

Gold, Silver and Acton Exclusive VUV Reflective Coated Optics are available on Request.

Ordering Information

Electronic Orders

Electronic orders accepted with proper Company Letterhead and complete contact information.

Fax Orders

Orders may be placed by fax with written confirmation. Please include complete name and address with these orders.

FAX: (978) 263-5086

MasterCard / VISA

MasterCard & VISA accepted for purchases.

Written Orders

Submit all written orders to our mailing address:

Princeton Instruments-Acton

15 Discovery Way
Acton, MA 01720 U.S.A.

Orders accepted subject to current pricing.
All orders FOB Princeton Instruments-Acton or shipping charges & insurance added separately.
All orders subject to new customer approval.

• SpectraPro® is a registered trademark of Acton Research Corporation •

Appendix V-F: Certification and Warranty

Certification

Princeton Instruments certifies that this instrument was thoroughly tested and inspected and found to meet the specifications furnished by Princeton Instruments when it was shipped from the factory.

Warranty

Princeton Instruments instruments and accessories are warranted for a period of one full year from date of delivery to be free from defects in material and to conform to the specifications furnished by Princeton Instruments. The company's obligation under this warranty is limited to servicing or adjusting an instrument returned to the factory, prepaid, and to repairing or replacing at the factory any part or parts thereof. All purchased items carry the original manufacturer's warranty.

Princeton Instruments shall not be liable for consequential damages resulting from accident, alteration, misuse, improper installation, operation on low or excessive voltages or any use in violation of the operating instructions furnished by Princeton Instruments.

If any defect appears within the warranty period, the purchaser shall promptly notify Princeton Instruments. No material will be accepted for repair or replacement without prior authorization from Princeton Instruments. Upon such authorization and in accordance with instructions of Princeton Instruments, parts, materials or equipment for which repair or replacement is requested shall be returned to Princeton Instruments for examination, with shipping charges prepaid by the purchaser. Final determination as to whether a product or part is actually defective rests with Princeton Instruments.

In such cases where necessary repairs are not covered by this warranty, an estimate of repair charges will be submitted to the purchaser before servicing the equipment.

Princeton Instruments reserves the right to make changes or improvements upon its products without imposing any obligations upon itself to install the same upon its products previously manufactured.

This warranty is expressly in lieu of all other obligations or liabilities on the part of Princeton Instruments, and Princeton Instruments neither assumes, nor authorizes any other person to assume for them, other obligations or liability in connection with the sale of equipment manufactured by Princeton Instruments.

Appendix V-G: Drawings

