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1680 Double Spectrometer

The SPEX 1680 Double Spectrometer is a high performance, double monochromator. While allowing only the selected wavelength of light to pass through it, 1680 also minimizes spectral contamination from stray light, without sacrificing throughput. As shown in the optical diagram (Fig 1), incoming light focused into the entrance slit is directed by a 45° mirror (M1) to a collimating mirror (M2). From here, the light is dispersed by grating G1, onto mirror M3. Since the grating sorts the light according to its wavelength, only a narrow wavelength band of light can pass through the slot to the second half of the monochromator. Here the light is dispersed again and further purified before the selected wavelength is focused out through the exit slit.

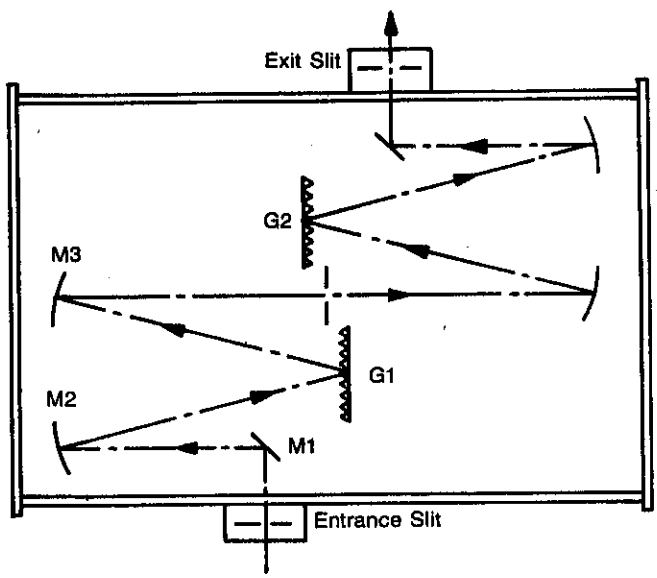


Fig 1
Optical Layout

To vary the wavelength of light passed by the 1680, both gratings are rotated simultaneously in the same direction. This additive-dispersion coupling is responsible for the 1680's high resolution. And the gratings are kinematically mounted to simplify replacement when your experiments demand a change in blaze, dispersion, or spectral coverage.

Two slit arrangements are offered with the 1680. The 1679F straight slits slide into slots at the entrance and exit ports of the 1680. The 1679A slits, on the other hand, are bilaterally, continuously adjustable from 50 to 5000 microns.

The Model 1680A has its wavelength adjusted by a knob on the face plate next to the position counter.

The Model 1680B comes with its own internally mounted drive circuitry, it couples directly to a SPEX MINIDRIVE 2 or CD2A COMPUDRIVE scan controller, or SPEX DM1B Spectroscopy Laboratory Coordinator. Of course, for the more adventurous, the 1680's drive can also be controlled directly by a computer system.

1 SPECIFICATIONS (1200 gr/mm grating)

Focal Length	220 mm
Dispersion	1.8 nm/mm
Resolution	0.2 nm at 500 nm
Repeatability	±0.2 nm
Aperture	f/4
Spectral Range	185-900 nm
Accuracy	±0.4 nm

2 INSTALLATION OF MECHANICAL COMPONENTS

Inspect carton for damage before unpacking the 1680. If any damage is discovered, notify the carrier and SPEX Industries immediately. After unpacking, move the 1680 to a sturdy bench. Attach steel leveling legs, two in front, one in center rear, and two plastic legs in rear. Place disc pads beneath steel legs and adjust until level. Plastic legs should not support any weight. They are outriggers, for stability only.

2.1 Wavelength Counter

In the 1680's front panel you'll find a four-digit wavelength counter that displays the central wavelength of light that will pass through the monochromator. This counter is calibrated in nanometers, though graduations permit reading to a precision of 1 A. The displayed wavelength is correct *only* when 1200 gr/mm gratings are installed. You should also be aware that grating monochromators pass more than one order of diffracted light. That is, for any counter reading λ, the monochromator also transmits wavelength λ/n, where n is an integer. In the majority of cases, other aspects such as grating blaze and source output negate any spurious contributions from overlapping orders. Yet the existence of the phenomenon should always enter into the interpretation of results.

2.2 Drive Systems

2.2.1 Model 1680A

Your 1680's central wavelength is determined by rotating the knob on the front plate while observing the counter reading. Always approach the final wavelength from at least 10 nm below.

2.2.2 Model 1680B

Your 1680 scans its spectral range with a drive system that is linear in wavelength. To supply the proper signals to its motor, an internal Large Stepper Driver (LSD) provides an electronic link to the outside world. Gratings can be rotated in steps as small as 0.02 nm (1200 gr/mm grating).

The SPEX MINIDRIVE 2, CD2A COMPUDRIVE and DM1B Coordinator all connect directly to the 1680 for full control. On the other hand, you might opt for your own device or computer. To help you interface the sytems, a drive schematic is included in the appendix.

OPTICAL COMPONENTS

Your 1680 has been aligned at the factory and, except for unpacking, the instrument should be ready to operate. Should you find, however, that the wavelength of the mechanical counter (Section 2) does not agree with the actual wavelength passing out the exit slit, proceed to Section 4. (Counter reads true for 1200 gr/mm gratings only).

The top cover of your 1680 can be lifted off after the six screws have been removed.

3.1 Gratings

NEVER TOUCH THE SURFACE OF A GRATING, FOR FINGERPRINTS CAN RARELY BE REMOVED TO ANYONE'S SATISFACTION.

The gratings supplied with your 1680 maybe installed by placing them in the three point mounting bracket (Fig 2A) and securing with the thumbscrews. Be sure each grating is properly seated.

An alternative mount is shown in Fig 2B. In this case, a slotted leaf spring is pulled up to remove a grating, pulled back and pushed down to install. The keyhole slot in the leaf spring catches the head of a stud in the rear of the grating holder.

Normally, a grating that has been aligned in the instrument need not be realigned each time it is installed. However, should realignment be necessary, consult Section 4.

3.2 Mirrors

The mirrors in your 1680 require no routine maintenance. Still, care should be exercised to prevent damage to their surfaces which will seriously degrade throughput. In general, your 1680 should be kept in an atmosphere free of dust, corrosives, and smoke.

Fingerprints, if they are located soon enough, can usually be washed off by squirting the surface of the mirror with research-grade methanol from a squeeze bottle.

3.3 Slits

Since the 1680 is an additive dispersion instrument, both entrance and exit slits influence the bandpass. Because of this, the most consistent results call for

3.3.1 1679F Slit Blades

Slits of fixed widths (0.25, 0.5, 1.25, 2.5 and 5.0 mm) slip into slots at the 1680's entrance and exit ports. With a standard grating, SPECTRAMATE provides a dispersion of 1.8 nm/mm, resulting in bandpasses of 0.45, 0.9, 2.25, 4.5 and 9 nm.

3.3.2 1679A Bilaterally Adjustable Slits

Your 1680 has bilateral, continuously adjustable slits located at the entrance and exit ports. Note that each is calibrated in units of 100μ. Since the dispersion with standard gratings is 1.8 nm/mm, rotating the slit barrel by one division allows an additional 0.18 nm of light to pass through the instrument. For example, a slit setting of 0.5 mm translates into a 0.9 nm bandpass.

4 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 each grating the first time it is installed in the instrument. Whenever a grating is reinstalled the adjustments should be checked, but no adjustment will generally be required.

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

4.1 Wavelength Calibration

Set both slits to 0.5 nm (about 250μ), and set the monochromator to 546.1 nm. Hold a white card in the optical path after intermediate slot. Unless the wavelength is grossly out of calibration, a green line will fall on the card. Using a ruler, check to see that the line falls in the center of the slot. If not, adjust the wavelength by scanning the grating until the line is centered; if it does so within 0.5 nm of 546.1, no calibration is required. Otherwise, set the monochromator at 546.1 nm and (referring to Fig 2A), adjust screw S1 on the mount of the first grating. If more than ⅛ turn is required, also adjust S2 in the opposite direction to balance the total adjustment between them.

Now check whether the image falls on the exit slit. If not, adjust the wavelength by scanning the grating until it does; if the setting is within 0.5 nm of 546.1, no calibration is required. Otherwise, set the wavelength to 546.1 nm and adjust S1 on the second grating; if more than ⅛ turn is required, also adjust S2 as described above. Further accuracy may be had by viewing the image through the slit and adjusting for maximum intensity.

Replace the monochromator's cover. If photoelectric detection is available, scan slowly from 554 to 548 nm to ascertain that the peak occurs within 0.5 nm of 546.1.

4.2 Vertical Adjustment

Set the monochromator at 546.1 nm. Observe the image on the mirrors on either side of the intermediate slot. If they are not vertically centered, adjust screw S3 (Fig 2 on the first grating until they are. Then observe the image on the exit slit. If it is not centered, adjust S3 on the second grating.

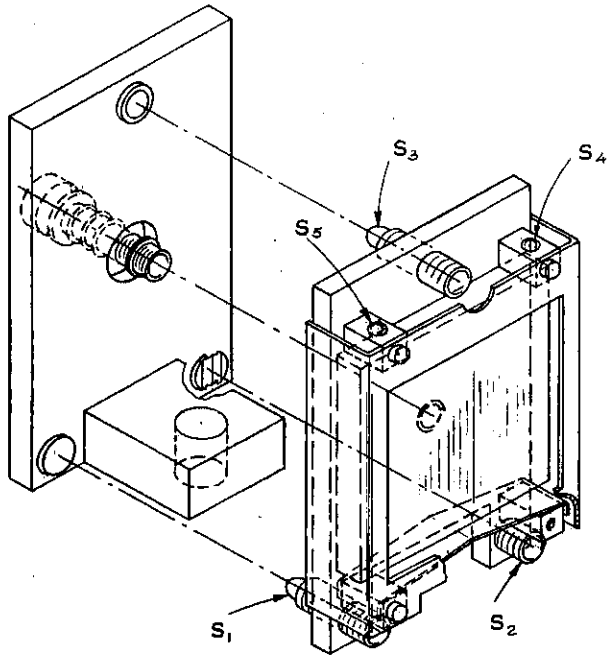


Fig 2A

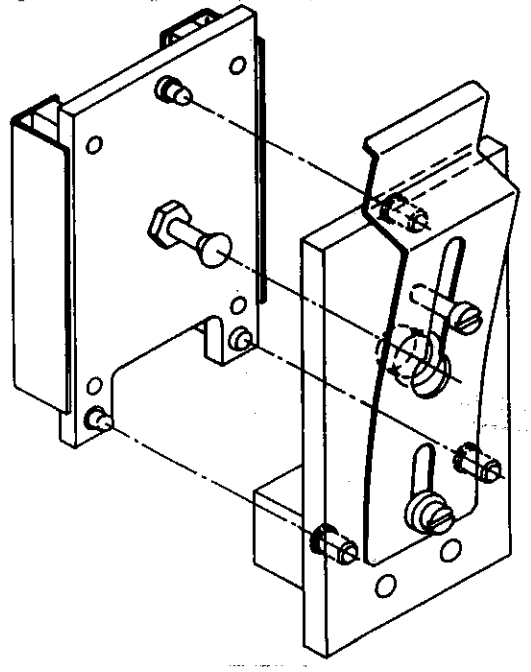


Fig 2B

4.3 Rocking Gratings

The vertical adjustment must have already been done. Set the monochromator at 0.0 and check whether the exit slit image is still vertically centered. If it is not, the grating must be rocked. While sitting at 0 nm repeat the vertical adjustment above, then return to 546.1 nm. Adjust screw S4 (Fig 2) to recenter the image; if more than ⅛ turn is required, adjust S5 in the opposite direction to balance the adjustment between them. Set the monochromator to 0 nm and check the centering; if it is off, repeat vertical adjustment. When the grating is properly aligned, the image will be vertically centered at both 0 and 546.1 nm.

5 TECHNICAL NOTES AND APPLICABLE EQUATIONS

5.1 Fundamental grating equation applied to Czerny-Turner mount

$$m\lambda = d(\sin\alpha + \sin\beta) \text{ where}$$

m = order
λ = wavelength
d = grating spacing
α = angle of incidence
β = angle of diffraction

5.2 Theoretical Resolving Power

$$R_T = \frac{\lambda}{\Delta\lambda} = \frac{\nu}{\Delta\nu} = (\sin\alpha + \sin\beta)\frac{W}{\lambda} = mN$$

λ = wavelength
ν = wavenumber
N = total number of grating grooves
W = width of grating ruling
m = order of diffraction

These expressions all yield numbers which are wavelength dependent though if resolution is expressed as $\Delta\nu$, it is independent of the wavelength or frequency observed.

5.3 Factors Influencing Resolution

Source — Since resolution is a linear function of grating width (i.e., optical path difference), resolution deteriorates if the source illuminates less than the full width of the grating. As a consequence, the source or condensing lens should fully illuminte the collimating mirror. This can usually be checked visually by opening the spectrometer or, in the case of energy outside the visible spectrum, by making certain that throughput is reduced when the edges of the collimating mirror are obstructed.

Slit Width — Slits seem to be the most misunderstood parts of the spectrometer. A good habit to cultivate is thinking in terms of spectral bandpass rather than mechanical slit width. Bandpass is a function of the

reciprocal linear dispersion which, in turn, depends on the wavelength, the grating constant, the focal length of the instrument and the spectral order (see Section 3.3).

5.4 Factors Influencing Throughput

Source — Maximum throughput is attained whenever the source subtends at least as large a solid angle at the slit as does the collimating mirror in the spectrometer. When the source is too small, or cannot be brought close enough to the entrance slit, the relay optics must meet this criterion.

Slits and Grating — When using photoelectric detection, the careful choice of combinations of slit widths and grating orders can often pay large dividends in throughput. For instance, by going from the first to the second order of the grating the dispersion is doubled (usually at a price of about 10-15% loss in efficiency); this doubled dispersion permits the slits to be set twice as wide (for the same resolution) and the throughput increases quadratically. Changing to a grating with a smaller ruling constant (more grooves/mm) provides the same gains without the loss in grating efficiency which results from the use of higher orders.

Grating — Two cautions are worth remembering.

One is that the grating is most efficient at its blaze wavelength and that the efficiency falls faster toward shorter wavelengths than toward longer wavelengths. A good rule of thumb for a grating with a blaze at λ, is that the efficiency will fall about 50% of maximum at $2\lambda/3$ and 2λ.

The second caution concerns overlaping spectral orders which become increasingly troublesome at longer wavelengths. At any position of the grating rotation the wavelengths at the exit slit are uniquely determined by the geometry of the optical system. The difficulty arises since the same geometry also brings integral higher frequency harmonics (shorter wavelengths) to the exit slit at the same time. Thus, unless the detector is blind to the unwanted orders, or is made blind by filtering, it will respond to wavelengths other than those of interest. For instance, a photomultiplier with an S-1 photocathode viewing a grating rotated to bring wavelengths at 1 micron to the exit slit will also receive and respond to energy at 500 nm. Other photocathodes are sensitive to ultraviolet when used in the visible. In such cases a glass lens or the glass bulb of the photomultiplier itself may do the filtering since soda-lime glass cuts off at approximately 300 nm.

6.0 Large-step Driver (LSD) Pinouts

Pin #	MONO OUTPUT (Internal) (9-pin female)
1	Φ1
2	Φ3
3	Φ2,4 COMMON
4	SW HIGH LIMIT
5	SW LOW LIMIT
6	Φ1,3 COMMON
7	Φ2
8	Φ4
9	SW LIMIT/RET

Pin #	CONTROL INPUT (25-pin female)
9	N/C
10	DIRECTION
11	STEP
12	LIMIT LO
13	LIMIT HI
21	5V/RET
22	5V/RET
23	DIR/RET
24	STEP/RET
25	LSW/RET

Maximum Recommended Speed is 500 steps/s.

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