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Instructions

**1269**

Spectrometer

# 1269 Spectrometer Instructions

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## 1. UNPACKING AND POSITIONING

1.1 Examine shipping box for damages. Any evidence of such should be noted on the delivery receipt which should be signed by representatives of the addressee and carrier.

1.2 Remove top of shipping box and all inside braces.

**CAUTION: DO NOT LIFT SPECTROMETER BY SLIT HOUSING OR OTHER PROTRUSIONS!**

1.3 Carefully lift the instrument by the two canvas straps only. Four people are needed.

1.4 The spectrometer, including the plywood shipping board, must be temporarily supported so that all shipping bolts are accessible. Placing it crosswise over a sturdy narrow table is best. Remove shipping bolts; lift instrument and remove the plywood board.

1.5 Install leveling legs (part #22420) making sure that the two outer rear legs are shorter than the other three.

1.6 Move the spectrometer to its permanent position. This should be a sturdy table in a room where temperature gradients are not excessive. Preferably temperature should be constant to  $\pm 2^{\circ}\text{C}$ .

1.7 Inspect for previously hidden damages and notify carrier immediately if any are found.

1.8 Place pads (part #22219) under legs.

1.9 Remove sheet metal cover. Level the spectrometer with reference to the bubble on the inside baseplate. Adjust the two front and rear center legs only; the two outer rear legs are safety outriggers and should be lowered until they touch the table without supporting any weight.

1.10 To remove the shipping straps: Open hatch just in front of grating shaft. Two shipping straps (O-rings) are attached to hatch cover on one side and screws on the under side. Carefully remove O-rings and pull up on pins on the drive to which the O-rings were attached. This seats the pads which slide on guide bar and insures proper performance of the sine mechanism. Now place the hatch cover over the opening so that it is completely closed.

1.11 Once more check the instrument for evidence of damage. If visible mechanical and electronic components do not appear intact DO NOT OPERATE THE SPECTROMETER. NOTIFY THE CARRIER AND SPEX INDUSTRIES, INC. AT ONCE. Many public carriers do not recognize claims for concealed damage if reported later than 15 days after delivery. In case of a shipping damage claim, the carrier agent's inspection is required. For this reason, the original packing should be retained as evidence of mishandling or abuse. While Spex Industries, Inc. is not liable for damage in transit, the company will extend every effort to aid and advise.

## 2. DESCRIPTION

### 2.1 Function

The Model 1269 is a state-of-the-art research instrument. Whether the experiment calls for a high-resolution monochromator, a high-speed spectrograph, a derivative-spectrum display unit, or a vidicon-presentation device, the 1269 is readily switched to the proper mode.

Photographically, unvignetted spectra can be recorded with a Graflex-type 4" x 5" film/plate holder or a Polaroid film holder fits on a camera adapter which, in turn, is kinematically interchangeable with the standard slit.

For the highest photoelectric speed, gratings up to 140 mm wide may be selected. For the highest resolution, echelles up to 160 mm wide may be operated at high orders. With a 316 groove/mm echelle set to the 13th order a resolution of 400 000 at 435.8 nm is attainable.

To drive the spectrometer through the selected spectral regions, SPEX offers the CD2A COMPUDRIVE, the DM1B Spectroscopy Laboratory Coordinator and the 1673C MINIDRIVE. Alternatively, the user may have opted for some other external control such as a mini computer. Whatever the case, consult the appropriate manual for connections and operation.

### 2.2 Specifications

The following performance characteristics are in terms of a 1200 groove/mm grating set to first order, and assume that the ambient temperature is maintained to  $\pm 0.5^{\circ}\text{C}$ . All specifications are subject to change without notice.

Focal Length, m	1.26
Aperture Ratio	f/9
Gratings:	
standard size, mm	110 x 110 - 110 x 160
Grooves/mm	30 - 3600
Type	Ruled or Holographic
Spectral Coverage, nm	175 - 1500(a)
Dispersion, nm/mm	0.65
Resolution, nm (at 579.1 nm)	0.006
Photographic/Multichannel Coverage, mm	75
Readout, A (CD2A or DM1B)	7-Digit Display
Accuracy, nm (over 1000 nm)	$\pm 0.05$
Repeatability, nm	$\pm 0.01$
Drive Step Size, nm	0.0002
Dimensions (HWL), cm	45 x 47 x 141
Weight, kg	114 net; 182 boxed

(a) Requires nitrogen purging below 200 nm; range can be extended to far ir with appropriate coarse gratings.

## 2.3 Controls and Connections

The 1269 is a 1.26m focal length spectrometer whose drive is linear in wavelength.

### 2.3.1 Spectrometer Controls

#### 2.3.1.1 Slits and Mirrors

The widths of the entrance and exit slits are controlled by micrometers above them. The slit height is controlled by a fishtail diaphragm on the entrance slit.

The optional swingaway mirrors are controlled by lockable knobs on the top of the instrument.

#### 2.3.1.2 Wavelength Counter

There is a 5-digit mechanical counter on the lower side of the spectrometer which displays wavelength in tenths of nm. A needle-point at right and white marks on the right-hand counter wheel permit reading to 0.01 nm.

#### 2.3.1.3 Limit Stops

Although limit stop switches at both ends of the scanning drive are present to signal SPEX scan units, the operator should avoid scanning to the ends of the drive. One switch is mounted at each end of the wavelength drive within the spectrometer. The high stop is interlocked with SPEX drive units to block forward travel; the low stop blocks reverse. The normal range of operation is from 0 to 1500 nm.

### 2.3.2 Backlash

To insure reproducibility between scans, backlash must be removed from the scanning mechanism by always approaching the start of a scan from at least 20 units below. This is done automatically by all SPEX scan units.

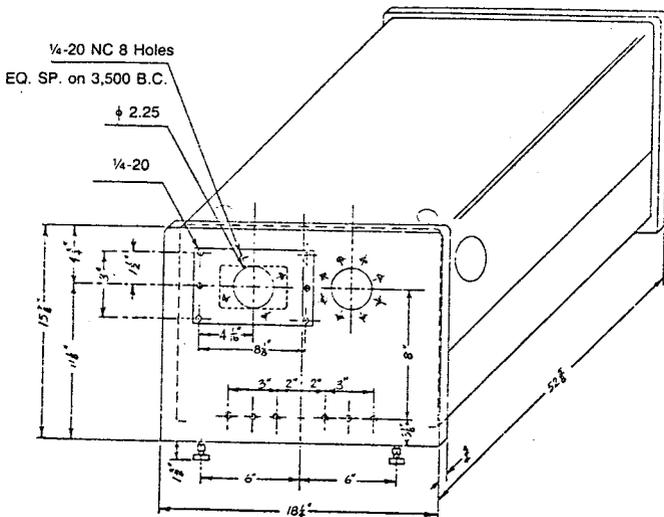
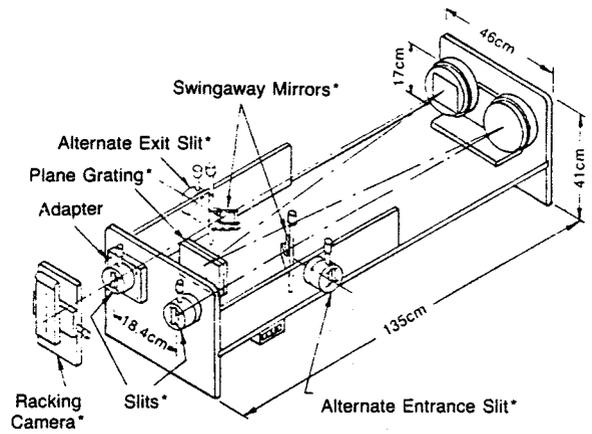


Figure 1  
Sketch of Spectrometer



\*Not Included With Basic Instrument

Figure 2  
1269 Optical Layout

## 3. OPTICAL ALIGNMENT (Call SPEX Representative for Installation Alignment)

### 3.1 Mirrors and Slits

Through the top hatch of the spectrometer carefully remove the two diagonal (upper right and lower left) socket head screws holding the covers on the mirrors. The other two screws merely position the covers and need not be removed. Remove the mirror covers, being careful not to touch the mirror surfaces.

Remove the protective cover from each of the slits.

### 3.2 Grating Installation

**CAUTIONS:** When installing the gratings do not twist the backing plate, or the delicate scanning mechanism will be damaged. Adjust with the toggle only, as described below. Also, to install grating, set the grating angle so that the wavelength counter reads about 1400 nm; the greatest damage can occur when the counter is in midrange.

Anything — including smoke and dust — that comes in contact with the ruled surface of the grating is likely to cause damage or loss of reflectivity.

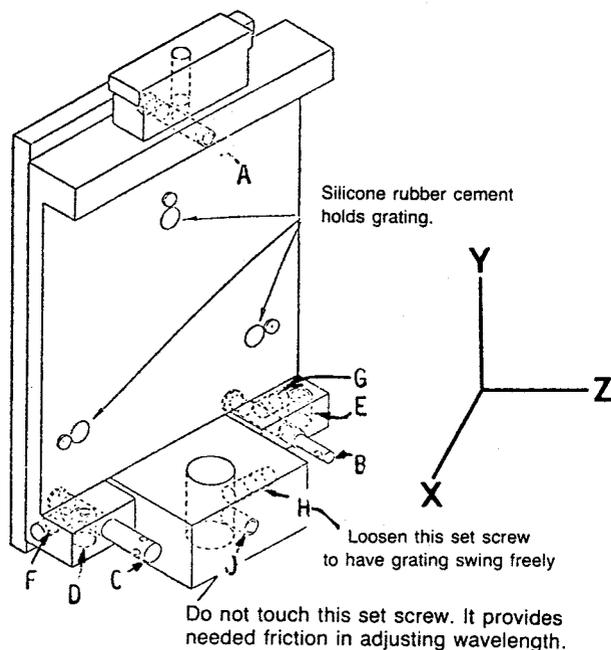
When changing gratings or working in different spectral orders, refocusing of the spectrometer may be necessary to maintain optimum performance.

Remove the hatch cover at the top of the front of the instrument. Make sure that the toggle of the grating mount backing plate is in a vertical position.

**NOTE:** The 1269 is designed to accommodate several grating sizes. To install a 16-mm-thick grating mounted on a 110 mm x 110 mm blank the following modification to the backing plate is required, however.

- 1) Remove the hook which holds the large grating capsule by unscrewing the socket head screw on the long spring rod on the rear of the backing plate. Install the longer hook provided with the grating.
- 2) Position an adapter plate on the backing plate and attach with two 8-32 thumb screws. Proceed with grating installation.

Place the mounted grating 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 grating mount by the T-shaped handle and place it firmly onto the backing plate hook at the right side of the instrument. Check that the backs of screws A, B, and C. (Figure 3) are properly mated with the slot, cone, and flat of the backing plate. Swing toggle to horizontal position. Check again that all locating surfaces are engaged; if not, lift the toggle, correct grating position, and lock the toggle again.



- A tilts grating forward or backward on X axis
- B rotates grating on Y axis. This is wavelength adjustment.
- C rotates grating on Z axis. This is rocking adjustment.
- D & E hold grating in place.
- F & G provide "friction" or "drag"

Figure 3  
Grating Mount and Back Plate Assembly

### 3.3 Preliminary Optical Check

The instrument has been aligned at the factory and arrangements should be made by the customer for proper laboratory installation. A rapid optical check can be made by the customer to see if the spectrometer arrived in correct alignment. Refer to previous sections of this manual for the setup of the instrument.

#### 3.3.1 Necessary Equipment

- 1) Low pressure Hg lamp (e.g. SPEX 1634). (Some fluorescent or germicidal lamps are suitable.)
- 2) Eyepiece which can be focused on the blades of the exit slit (e.g. SPEX 1529).

- 3) Photomultiplier tube sensitive in the appropriate wavelength region (e.g., RCA 1P28), socket and housing (1424S).
- 4) Appropriate PM power supply, amplifier, and recorder.

#### 3.3.2 Wavelength Calibration (see Figures 3 & 4)

If the optional swingaway mirror (1212) or camera (1232) is present, remove it before proceeding with alignment. Entrance and exit slits must be in their usual positions.

Position the Hg lamp as close to the entrance slit as possible. Set entrance slit (S1) at  $25\mu$ , 10 mm high, and the exit slit (S2) at 2 mm. Set up the eyepiece to view S2; focus on the slit blades. Refer to the performance test record included with this manual and note the wavelength of the line with zero wavelength error nearest the blaze angle of the grating. Scan slowly over the region of the line while looking through the eyepiece. Always scan from low to high wavelength and start at least 20 nm below the line peak to remove backlash. When the line is observed through the eyepiece, close S2 to  $25\mu$ , rescan the region stopping where the line appears most intense. Observe the reading on the wavelength counter. If the value is more than 0.5 nm different from the value noted above, a major alignment of the instrument may be necessary. If the error is less than 0.5 nm set the wavelength counter to the specified value, approaching it from at least 20 nm below the value, and adjust screw B on grating until a maximum intensity is observed.

#### 3.3.3 Resolution Check

Replace the Hg lamp at the entrance slit and locate a peak at the wavelength noted on the sample trace (supplied by service). Orient the Hg lamp until maximum intensity is obtained. Scan the region of interest, first removing backlash. The conditions under which the sample trace was run are noted on the trace and these conditions should be matched as closely as possible. If the resolution is significantly poorer, a major realignment may be necessary. CONTACT A SPEX SERVICE REPRESENTATIVE.

#### 3.4 Complete Procedure for Factory Alignment

All moderate misalignments can be corrected with adjustments of the grating mount (screws A and B, Figure 3). Changing the focal distance or position of the mirrors (M1, M2, Figure 4) is especially likely to affect other aspects of the instrument's alignment, and these components should not be touched unless you are prepared to perform a complete alignment. Alignment tools will be needed.

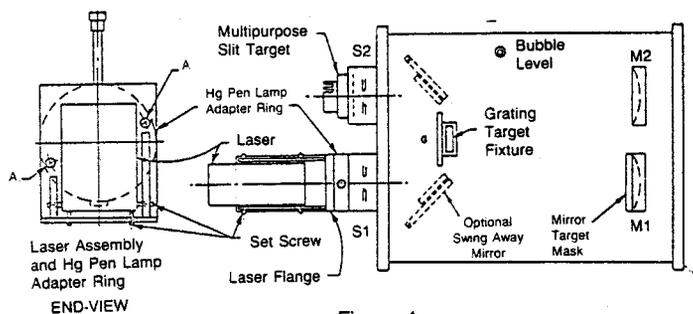


Figure 4

Arrangement of components for alignment.

These should consist of:

- 1) He-Ne gas laser with mounting bracket.
- 2) Adapter ring for mounting the Hg pen lamp between the slit housing and the laser.
- 3) Mirror target mask.
- 4) Grating target fixture.
- 5) Entrance/exit slit target.
- 6) Hg Pen-Ray lamp and transformer (1634 and 1635)
- 7) Phototube and housing (1P28 and 1424S)
- 8) Eyepiece and mounting thumbscrews (1529)

Figure 4 indicates the arrangement of these items. The alignment procedure described is carried out at the factory by experienced technicians. Alignment tools and familiarity with the principles and handling of optical systems are absolutely necessary to accomplish this task. It is recommended that Spex representatives be contacted for such services.

It is necessary to do this procedure, whatever the circumstances, it is imperative that all of Section 3.4.1 through 3.4.10 be read through and thoroughly understood before starting.

Since photomultiplier tubes can be damaged by exposure to high levels of light, power to all photomultipliers should be turned off and tubes removed from the instrument before beginning.

### 3.4.1 Setup

Level the instrument by adjusting the length of the legs. Only the center one of the three legs should touch the table. Set both slits to 2 mm and set the height adjustment on the entrance slit to 2 mm. Mount the adapter ring (Figure 4) on the entrance slit using two 1/4-20 x 1 in. screws, locating the Hg Pen-Ray lamp socket at the top. Mount the laser assembly (Figure 4) on the adapter ring, using the two 1/4-20 x 3/4 in. screws provided. Ignite the laser according to the manufacturer's instructions, and observe the cautions concerned with the operation of this laser as noted in the instruction manual.

**WARNING! DO NOT LOOK DIRECTLY INTO THE LASER BEAM.**

### 3.4.2 Alignment of the Laser Source

Position a mirror target mask on the mirror M1 over the four screws. Loosen the four screws on the laser assembly, allowing the horizontal and vertical axis of the laser to be moved with respect to the slit. Adjust the position of the laser, side to side and up and down, until a spot of maximum intensity is observed on the center of the mirror target mask.

Insert slit target.

Slowly narrow the entrance slit and reposition the laser so that the bright beam goes through the narrowed slit and slit target and is centered on the mirror target mask. With enough effort it is possible to have the entrance slit set to 25 $\mu$  and 2 mm high, and the diffraction pattern will just fill the mirror mask. Opening the entrance slit to 2 mm wide will leave the bright spot centered on the mirror mask.

### 3.4.3 Alignment of the Optics

Remove the grating hatch cover, then the entire center panel of the spectrometer housing. Remove grating. Tape its plastic cover on, and put it in a safe place. Mount the grating target fixture in position on the grating shaft making sure the alignment pin is properly seated and that the base of the target is firmly seated on the base block of the backing plate assembly (see Figure 3). Scan to the low wavelength end (approximately 0 nm) and position the grating target fixture parallel to the end plate of the spectrometer. Aim the laser beam at the target hole in the grating target fixture by adjusting the up and down motion of M<sub>1</sub> with hex nut A and the sideways motion with hex nut B (Figure 5). Remove the grating target fixture and reinstall the grating in position L (Figure 4). Scan to 632.8 nm.

With the mirror target mask in position on M<sub>2</sub>, adjust the position of the grating G so that the reflected laser beam is aimed at the central hole in the mirror target mask. The grating may be moved from side to side with screw B (Figure 3) and up and down with screw A (Figure 3). The multipurpose slit target may be inserted directly into the slit assembly from the outside, placing the end with the white plastic disc near the slit. Aim mirror M<sub>2</sub> (Figure 2) at the central hole in the slit target in the same manner as M<sub>1</sub> was aimed. **DO NOT LOOK DIRECTLY INTO THE LASER BEAM THROUGH THE ALIGNMENT DISC.**

### 3.4.4 Rocking Grating

Reinsert target in the S<sub>2</sub> exit slit.

Open S<sub>1</sub> and S<sub>2</sub> to 1 mm and set shutter to 2 mm high. Scan the counter to approximately 1265.6 nm. This is the second order 632.8 nm line of He-Ne laser. Using the ADJUST control, scan slowly until this line is visible through the slit target and observe the vertical position of the beam on the target.

Adjust cam C (Figure 3) until the image is vertically centered in the target. Tighten the no-mar screw (Screw F, Figure 3) to prevent cam C from rotating.

Scan the counter to 0 nm. Check the vertical centering on the exit slit target. If it is not centered, recenter with screw A on the grating and repeat the above until you are satisfied that the spectrum is centered at high and low wavenumbers. Perfection of this adjustment is most critical on an instrument equipped with curved slits.

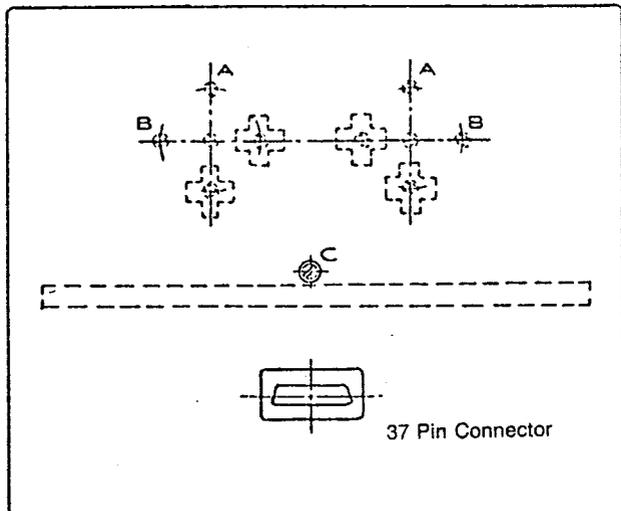


Figure 5  
Rear View of Spectrometer

### 3.4.5 Rough Visual Focus

Turn off the laser source and insert the Hg-Pen-Ray lamp into the hole provided in the Adapter Ring.

Close exit slit down to about  $500\mu$ , entrance slit to about  $10\mu$  wide by 5 mm high. Remove the multipurpose slit target disc and place the focusing eyepiece over the slit. Find 546 nm line (use the visible green line, not the wavelength counter reading which has not yet been calibrated). Locate the slotted focusing screw (through hole C, Figure 5) at the back of the instrument. Loosen the two Allen head screws in front of mirrors M1 and M2. With the eyepiece focused on the slit jaws, have an associate turn the focusing screw C until the line is visually focused. It is a good practice to focus a number of times, always approaching the best focus while turning the screw in the clockwise direction.

### 3.4.6 Paralleling Slits

Adjust both slits  $S_1$  and  $S_2$  (Figure 4) to  $15\mu$  and open shutter of  $S_1$  to 10 mm. Very slowly scan past 546 nm line in both directions, observing the manner in which the illuminated area will move up or down as you scan across the line. If slit is properly paralleled, then, scanning in the direction of increasing wavelength, the central portion of the slit will be illuminated first, with light spreading to both ends uniformly. The line will

disappear first at the center, then evenly toward both ends. Loosen Allen head screws around slit  $S_2$ ; turn until slit is properly paralleled, and retighten.

### 3.4.7 Photoelectric Focus

Readjust the entrance and exit slits to  $6\mu$  width. Set the entrance slit to 2 mm height. Remove the eyepiece from the exit slit. Set up the instrument for photoelectric readout with a stripchart recorder. Refer to the Performance Test Record and scan to the region of the spectrum indicated. Slowly scan this region. Observe the intensity of the lines, the depth of the valley between lines, and the half-width of the line. Adjust the focus slightly, turning the focusing screw through hole C (Figure 5) behind mirrors in increments of  $\frac{1}{8}$  of a turn. Re-scan. Continue to focus and scan until the valley is deepest, relative to the line intensities, and the halfwidth is at a minimum.

**NOTE:** It is advisable to pass through the best focus at least once, back off the focusing screw to eliminate backlash and approach the final value. It is also important to reverse the scan about 20 nm between trials, again to remove backlash, this time from the scanning system.

### 3.4.8 Fine Optical Adjustment with the Laser

Remove the Pen-Ray lamp, turn off the power to the photomultiplier and remove it from the slit, and ignite the laser. Scan to 632.8 nm reading on the wavelength counter and open  $S_1$  and  $S_2$  (Figure 4) to  $25\mu$ . If necessary, repeat steps, 3.4.2 and 3.4.3 to realign the laser and the mirrors.

### 3.4.9 Wavelength Setting (Y-Axis)

Turn off the laser and reinstall the Hg lamp. Place the eyepiece on  $S_2$  and set  $S_1$  and  $S_2$  to  $20\mu$  ( $S_1$  at 2 mm high). Scan 546 nm line, approaching the reading as always, from at least 20 nm lower. When the green line appears most intense in  $S_2$  observe the reading on the wavelength counter. If it is within 5 of 546 nm, turn screw B of the grating mount (Figure 2) and repeak the line; if it is  $>5$  call Spex for instructions. Continue with these adjustments until the green line appears in  $S_2$  at the proper wavelength reading.

### 3.4.10 Alignment of Swingaway Mirror

Place the exit slit on the side of the spectrometer. Set the entrance and exit slits to  $10\mu$ . With the slit target fixture in the exit slit adjust the alignment screws behind the mirror to position the laser beam so that it passes through the exit slit and the slit target fixture.

Check the focus as described previously. If the swingaway mirror is out of focus adjust the three adjustment screws behind the mirror. Make equal adjustments on all screws. Check the alignment of the laser beam after each sequence of focus adjustments. Check the focus again and determine if the resolution is the same as indicated in the test report.

## 4 MAINTENANCE

### 4.1 Mechanical

Periodically the leadscrew and slide mechanism can be cleaned with methanol or acetone to remove all traces of dirt and grease. Then lubricate the leadscrew, slide bar, and H-bar with a heavy weight gear oil or transmission oil. Contact the factory for further details.

All of the following suggestions are extreme measures included for information purposes. **PERFORM THEM ONLY AT YOUR OWN RISK.**

### 4.2 Optical

Before becoming too concerned about a small blemish visible on a grating, remember that it can only affect performance in proportion to its size. Even when new, a grating with the highest performance rarely looks cosmetically perfect.

Dust may be removed from gratings and mirrors with an air-bulb. Observing normal care and cleanliness for optical instruments should preclude any other maintenance. Should cleaning be required, however, the mirrors may be removed and washed in a dilute, mild detergent dissolved in triple-distilled water, followed by rinsing with pure, triple-distilled water. Test your solution for staining on a sacrifice front surface mirror as Spex cannot be responsible for any damage.

Fingerprints *may* be removed from gratings or mirrors provided action is taken within a few minutes of the accident. In a very short time acids on the skin will have attacked the aluminizing and caused irreparable damage. Touch the fingerprint *lightly* with a piece of pressure-sensitive tape and immediately draw it away in a direction toward the edge of the optic. The procedure may be repeated several times with fresh pieces of tape.

### 4.3 Counter Illuminator

To replace the bulbs, remove the side panel. The pilot lamps are mounted in a tube with two end-thrust springs. Push the tube against one of the springs and remove it to replace the pilot lamps. Do not put the tube in place without light bulbs, as shorting may occur. Power for the illuminator is through the spectrometer connector on the rear of the instrument, Section 6.

## 5 TECHNICAL NOTES AND APPLICABLE EQUATIONS

### 5.1 Fundamental Grating Equation Applied to Czerny-Turner Mount (see Figure 6)

Ref: Jenkins & White, Fundamentals of Optics, McGraw Hill

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

$m$  = order  
 $\lambda$  = wavelength  
 $d$  = grating spacing  
 $\alpha$  = angle of incidence  
 $\beta$  = angle of diffraction

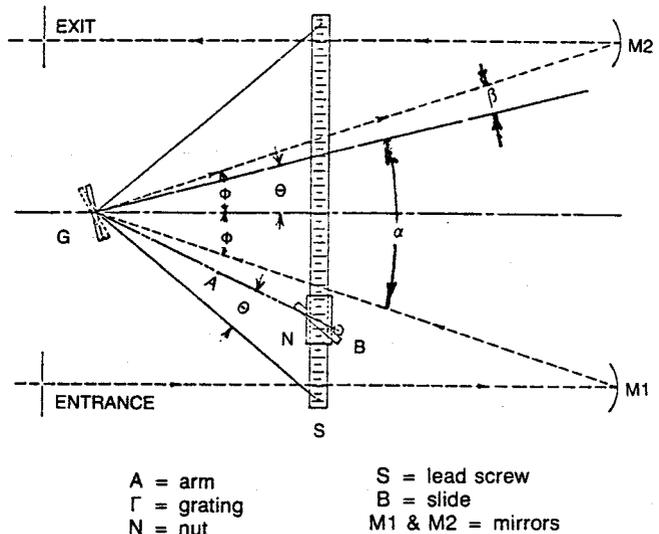


Figure 6  
Definition Sketch for Grating Equation

For convenience in the 1269 instrument, this may be expressed as

$$m\lambda = d (2 \sin \Theta \cos \phi)$$

$\phi = 4^{\circ}54'$  and  $\cos \phi = 0.9964$   
 $\Theta$  = grating rotation measured from zero, its position at the direct image  
 $\alpha = \Theta + \phi$   
 $\beta = \Theta - \phi$

In the Spex Sine Drive the nut N moves along the lead screw S while the arm A moves the slide B attached to nut. The grating is rotated through the same angle as the arm A.

### 5.2 Theoretical Resolving Power

$$R_T = \frac{\lambda}{\Delta\lambda} = \frac{\nu}{\Delta\nu} = 2 \sin \Theta \cos \phi \frac{W}{-\lambda} = mN$$

$\lambda$  = wavelength  
 $\nu$  = wavenumber  
 $N$  = total number of grating grooves  
 $W$  = width of grating ruling  
 $m$  = order of diffraction

These equivalent expressions all yield numbers which are wavelength dependent. It can be seen that the resolution expressed as  $\Delta\nu$  gives a figure 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) it is clear that if the source irradiates less than the full width of the grating, resolution will suffer. This dictates that the source or condensing lens must fully illuminate 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 by slightly obstructing the edges of the collimating mirror.

**Slit Width** — The function of the slit seems to be one of the most misunderstood aspects of the spectrometer. A good habit to cultivate is that of thinking in terms of spectral bandpass rather than mechanical slit width. The bandpass is a function of the reciprocal linear dispersion which depends on the wavelength, the grating constant, the focal length of the instrument and the spectral order.

The following table gives typical values of dispersions. This is calculated for a 1200 gr/mm grating with the right side as the entrance and the left side as the exit

Counter Setting (nm)	Wavelength (nm)	Order	Dispersion (nm/mm)
300	300	1	0.661
400	200	2	0.327
400	400	1	0.655
500	500	1	0.647
600	300	2	0.318
600	600	1	0.636
700	700	1	0.623
800	400	2	0.303
800	800	1	0.607
1000	1000	1	0.562
1000	500	2	0.281
1200	1200	1	0.498
1200	600	2	0.249
1200	400	3	0.166
1200	300	4	0.124
1400	1400	1	0.403
1500	1500	1	0.429

**Slit Height** — Increasing the height of straight slits reduces the instrumental resolution. This results from the well-known slight curvature of the spectra in the exit plane. As the height of the slits is increased the ends of the exit slit begin to pass portions of adjoining wavelengths. The effect on resolution is analogous to increasing the slit width. For this reason the height of straight slits should be limited when maximum resolution is required. On the other hand, curved slits permit full instrumental resolution even at 50 mm of slit height. Their use, however, is warranted only if all the following conditions are met:

- 1) Photoelectric detection is employed;
- 2) Insufficient flux is reaching the detector for good signal-to-noise ratio;

- 3) The source is so large that the spectrometer continues to see more and more flux as the slit height is increased.

## 5.4 Factors Influencing Throughput

**Source** — Maximum throughput will be 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 the same criterion.

**Detector** — The radical difference between photographic and photoelectric detection must be borne in mind. Once the source has been properly placed, the irradiance in the photographic image is solely a function of the f-number of the spectrometer and no optical adjustments can increase the flux per unit area. Photoelectric detectors, however, integrate energy over the entire irradiated area and as a consequence the total flux can be increased simply by increasing the slit height or width. In most cases this will increase flux at the detector as a quadratic function.

**Slits and Grating** — In a system that incorporates an exit slit and photoelectric detection, the combination of slit width, grating groove density and order of grating diffraction can often be optimized for maximum throughput of the system. For example, consider a basic spectrometer equipped with a 600 gr/mm density grating and operated in the visible portion of the spectrum. A method of increasing throughput of this system would be to replace the grating with one having a groove density of 1200 gr/mm. This doubles the dispersion at the exit slit, permitting the entrance and exit slits to be opened to twice the value required for a given resolution with the 600 gr/mm grating, thus increasing the amount of light received by the detector by 4X, assuming that the entrance slit is fully illuminated. Similarly, by using a 600 gr/mm grating blazed for second order maximum efficiency in the visible, and working in second order, the same effect can be achieved.

**Grating** — Two cautions are worth keeping in mind once you have a grating of good efficiency. 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 rule of thumb for a grating with blaze at  $\lambda$ , is that the efficiency will fall about 50% of maximum at  $2\lambda/3$  and  $2\lambda$ .

The second caution concerns overlapping orders of diffraction which become increasingly troublesome as one works 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. Unfortunately, the rules of diffraction allow not only the wavelength,  $\lambda$ , to appear at the slit, but also wavelengths,  $\lambda/n$ , where  $n$  is an integer. These wavelengths are referred to as highest orders of diffraction. 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 used with a grating rotated to bring wavelengths at 1  $\mu\text{m}$  to the exit slit will also receive and respond to energy at 500 nm. Other photocathodes are

sensitive to ultraviolet when being used in the visible; in such cases a glass lens or the glass bulb of the photomultiplier itself, may serve as a filter since soda-lime glass cuts off at approximately 300 nm.

## 6.0 PIN ASSIGNMENTS

### 6.1 Spectrometer Control Connector

Pin #	Assignment	Pin #	Assignment	Pin #	Assignment
1	motor lead 1	14		27	
2	motor lead 2	15	direction signal	28	
3	motor lead 3	16	TTL driving pulse	29	a-c ground (shield)
4	motor lead 4	17	+5 V	30	
5		18	reverse limit switch (low)	31	+24 Vdc
6		19		32	
7		20	motor lead 1' Return	33	
8		21	motor lead 2' Return	34	
9		22	motor lead 3' Return	35	
10		23	motor lead 4' Return	36	ground (0 Vdc)
11		24		37	forward limit switch (high)
12		25			
13		26			

### 6.2 Mini-step Driver (MSD) with typical options (1877C)

Pin #	Control Input (25-pin female)	Mono Output (37-pin female)
1		Motor Phase 1
2		Motor Phase 2
3		Motor Phase 3
4		Motor Phase 4
5		
6		
7		
8		
9	SHUTTER OPEN (neg. true)	+24V/RET
10	FORWARD	
11	STEP	
12	LIMIT SWITCH LOW (pos. true when open)	
13	LIMIT SWITCH HIGH (pos. true when open)	
14		
15		
16		
17		+5 Vdc (to counter lights etc.)
18		LOW LIM
19		
20		
21	RET	1/RET
22	SHUTTER OPEN RET	2/RET
23	FORWARD/RET	3/RET
24	STEP/RET	4/RET
25	LIMIT SWITCH LOW/RET	
26		
27		
28		
29		
30		AC GND
31		
32		+24V SHUTTER SUPPLY
33		XH1 CLUTCH XACTIVE (+24V)
34		
35		
36		
37		GROUND (VAC/RET) HIGH LIM

### 6.3 MSD Options

Each MSD driver has a set of 6 pairs of pins that define the way the driver interprets signals it receives from the controller unit (CD2A, DM1B, etc.) or from the spectrometer itself. Each pair of pins is labelled appropriately on the circuit board and to enable a function listed below, a jumper must be placed across the specified pair only.

#### 6.3.1 STEP, STEP

When a jumper is connected across *one* of these pairs, MSD expects a STEP signal from the controller unit (pin 11 on rear panel of CD2A, DM1B, etc.) to takes the following form:

STEP — A positive pulse for STEP

STEP — A negative pulse for STEP

### 6.3.2 DIRECT. OPTION

When a jumper is connected across *one* of these pairs of pins, the MSD expects the FORWARD signal from the control unit (pin 10 on rear panel of CD2A, DM1B, etc.) to take the following form:

A — FORWARD is High True (+5V)

B — FORWARD is Low True (0V)

#### 6.3.3 SHUTTER OPTION

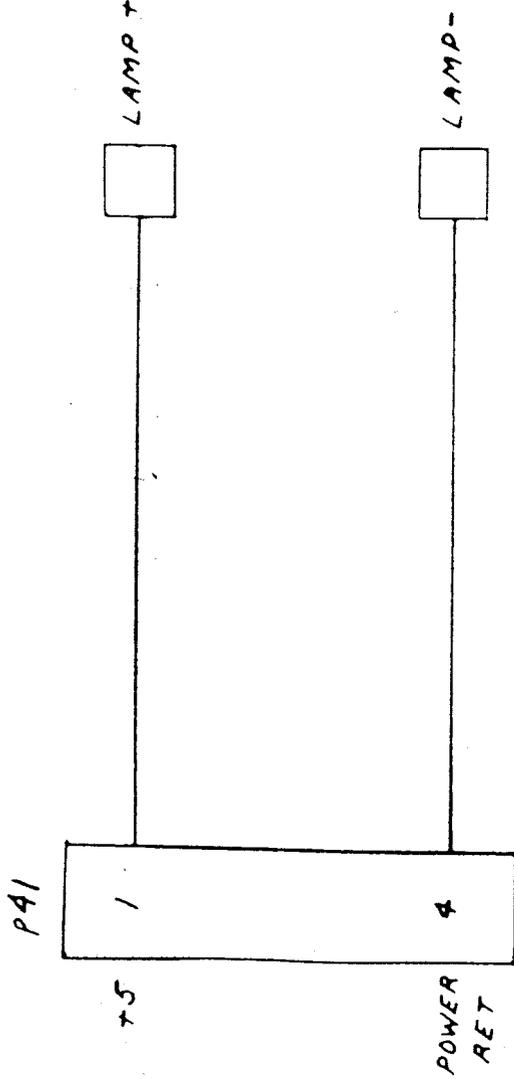
When a jumper is connected across *one* of these pairs, the MSD supplies current to the shutter when the control unit (pin 9 on rear panel of CD2A, DM1B, etc.) gives the following signal:

A — current supplied to shutter when input is Low True (0V)

B — current supplied to shutter when input is High True (+5V)

31575

DATE	BY	REVISION RECORDED	AUTH DR.	CK.



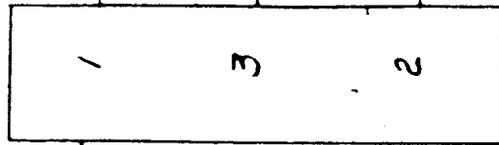
ASSEMBLY B 31574		TOLERANCES (EXCEPT AS NOTED)	SPEX INDUSTRIES INC.	
DECIMAL	±	DECIMAL	SCALE	DRAWN BY DP
FRACTIONAL	±	FRACTIONAL	~	APPROVED BY BAK
ANGULAR	±	ANGULAR	±	TITLE COUNTER HARNESS, WAVELENGTH SCHEMATIC
				DATE 6-2-82
				DRAWING NUMBER 31575

MADE IN U.S.A.

3/573

DATE	BY	REVISION RECORD	AUTH	DR	CK

J3/



SW HIGH LIMIT

SW. LOW LIMIT

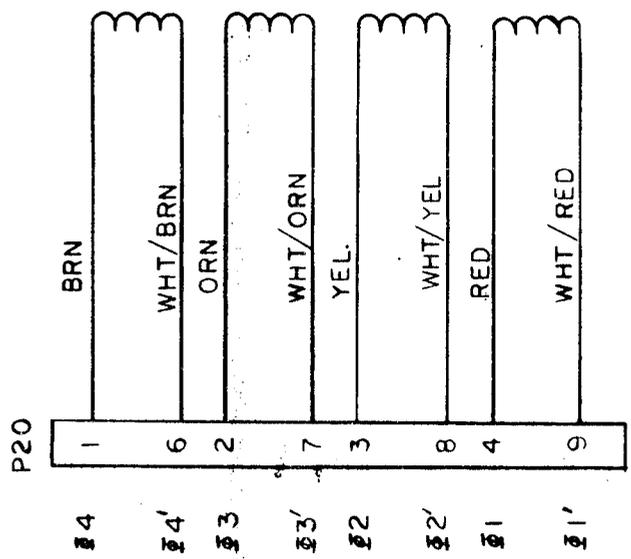
SW LIMIT RET

TOLERANCES (EXCEPT AS NOTED)		SPEX INDUSTRIES INC.	
DECIMAL	±	SCALE	~
FRACTIONAL	±	DRAWN BY	DP
ANGULAR	±	TITLE	LIMIT SWITCH HARNESS SCHEMATIC
DATE		DRAWING NUMBER	
6-7-82		3/573	

ASSEMBLY  
C31572

31011

DATE	REV.	REVISION RECORD	AUTH.	CHK.

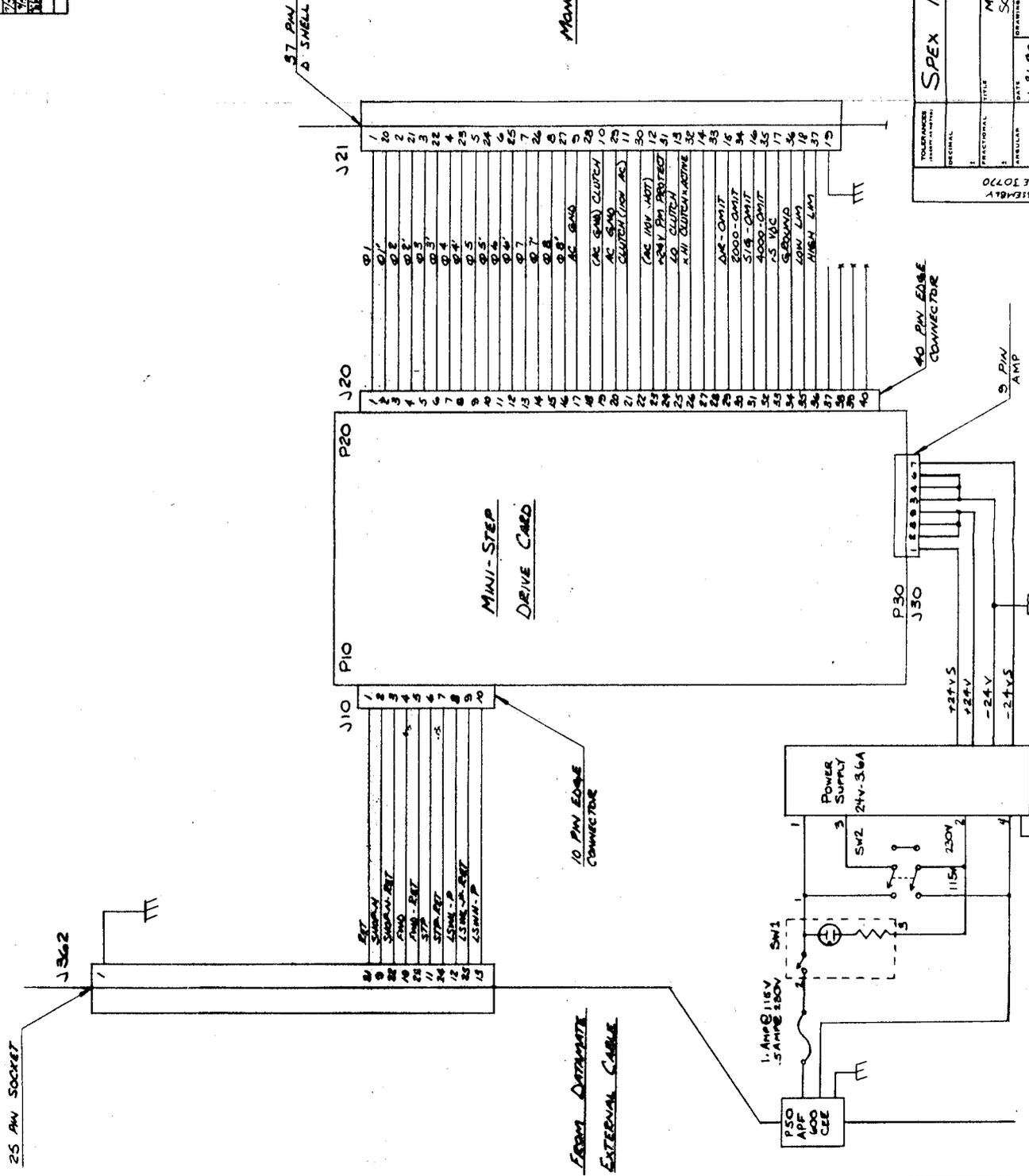


P20

ASSEMBLY NO. C31816		TOLERANCES (EXCEPT AS NOTED)	
DECIMAL	±	SCALE	~
FRACTIONAL	±	DRAWN BY	D.P.
ANGULAR	±	APPROVED BY	DAK
TITLE 4 PHASE MOTOR SCHEMATIC		DATE 1-12-83	
DRAWING NUMBER 31817		SPEX INDUSTRIES, INC.	

30335-C

REV	DESCRIPTION	DATE	BY
1	INITIAL DESIGN	1/31/80	JPM
2	REVISED		
3			
4			
5			
6			
7			
8			
9			
10			

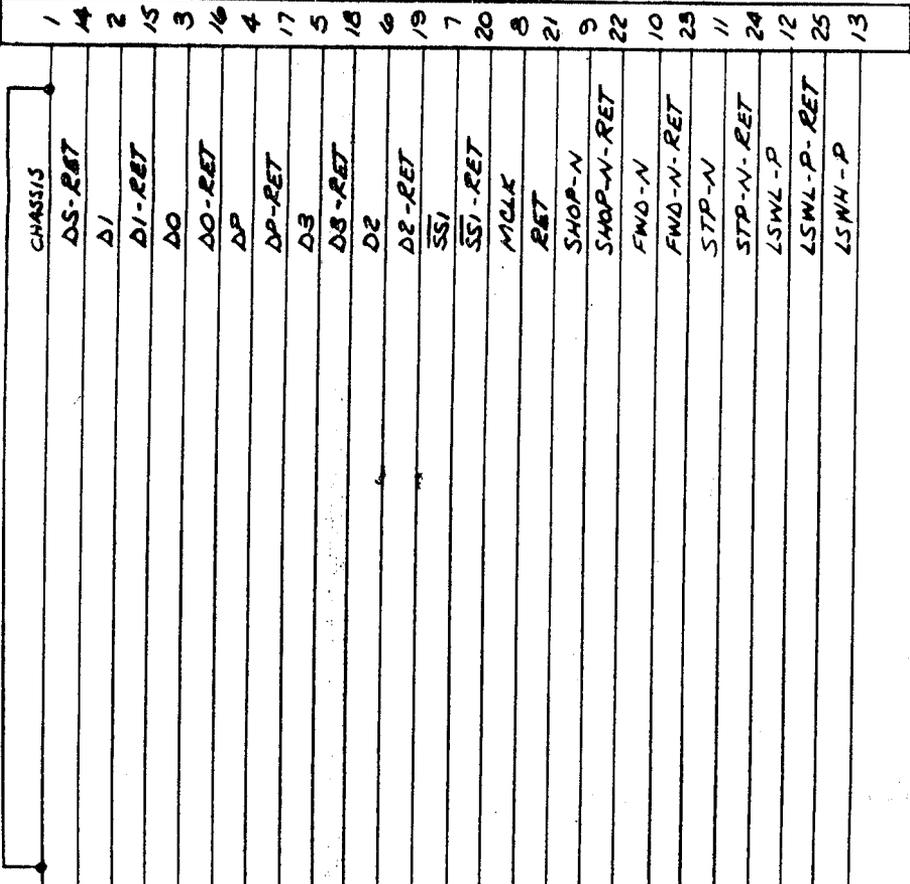


TOLERANCES UNLESS OTHERWISE SPECIFIED	
DECIMAL	FRACTIONAL
1	1
ASSEMBLY E 10770	
SPEX INDUSTRIES INC.	
DRAWN BY M. T. BERNIA	
APPROVED BY JPM	
TITLE M 5 DRIVER SYSTEM SCHEMATIC	
DATE 1-31-80	DRAWING NUMBER 30335-C

25 PIN 'D'  
P361

- 1
- 14
- 2
- 15
- 3
- 16
- 4
- 17
- 5
- 18
- 6
- 19
- 7
- 20
- 8
- 21
- 9
- 22
- 10
- 23
- 11
- 24
- 12
- 25
- 13

DRAIN



25 PIN 'D'  
P362

- 1
- 14
- 2
- 15
- 3
- 16
- 4
- 17
- 5
- 18
- 6
- 19
- 7
- 20
- 8
- 21
- 9
- 22
- 10
- 23
- 11
- 24
- 12
- 25
- 13

DATE	BY	REVISION RECORD	AUTH.	DR.	CK.
11/1	1	CHANGE FROM P361 TO P362	DK		

TOLERANCES (UNLESS AS NOTED)		SPEX INDUSTRIES INC.	
DECIMAL		SCALE	NONE
FRACTIONAL		DRAWN BY	N. TORCHIA
ANGULAR		APPROVED BY	J.P. McNEIL
		TITLE	
		DATAMATE - MS DRIVER	
		EXTERNAL CABLE	
DATE	1-30-80	DRAWING NUMBER	30340-A

ASSEMBLY  
030340



30341-A

DATE	BY	REVISION RECORD	AUTHN. DR. CK.
7/1	A	322 5/20/80 TO 35 4/15/80 A 1/20/80 DRAWN BY 10/15/80	BK

37 PIN 'D'  
P21

1	Ø1
20	Ø1'
2	Ø2
21	Ø2'
3	Ø3
22	Ø3'
4	Ø4
23	Ø4'
5	Ø5
24	Ø5'
6	Ø6
25	Ø6'
7	Ø7
26	Ø7'
8	Ø8
27	Ø8'
9	AC GND
28	(AC GND) CLUTCH
10	AC GND
29	CLUTCH (110V AC)
11	
30	(AC 110V HOT)
12	+24V PM PROTECT
31	LO CLUTCH
13	XHI CLUTCH ACTIVE
32	
14	
33	
15	AIR - OMIT
34	2000 - OMIT
16	5/8 - OMIT
35	4000 - OMIT
17	+5VDC
36	GROUND
18	LOW LIM.
37	HIGH LIM.
19	CHASSIS

37 PIN 'D'  
P21

MINI-STEP  
DRIVE

TOLERANCES (EXCEPT AS NOTED)	DECIMAL	SCALE	DRAWN BY
±		NONE	M. TOECHNIA
FRACTIONAL	TITLE	APPROVED BY	
±	EXTERNAL CABLE (MS DRIVER → MANOC)	F. P. McLAUGHLIN	
ANGULAR	DATE	DRAWING NUMBER	
±	1-31-80		

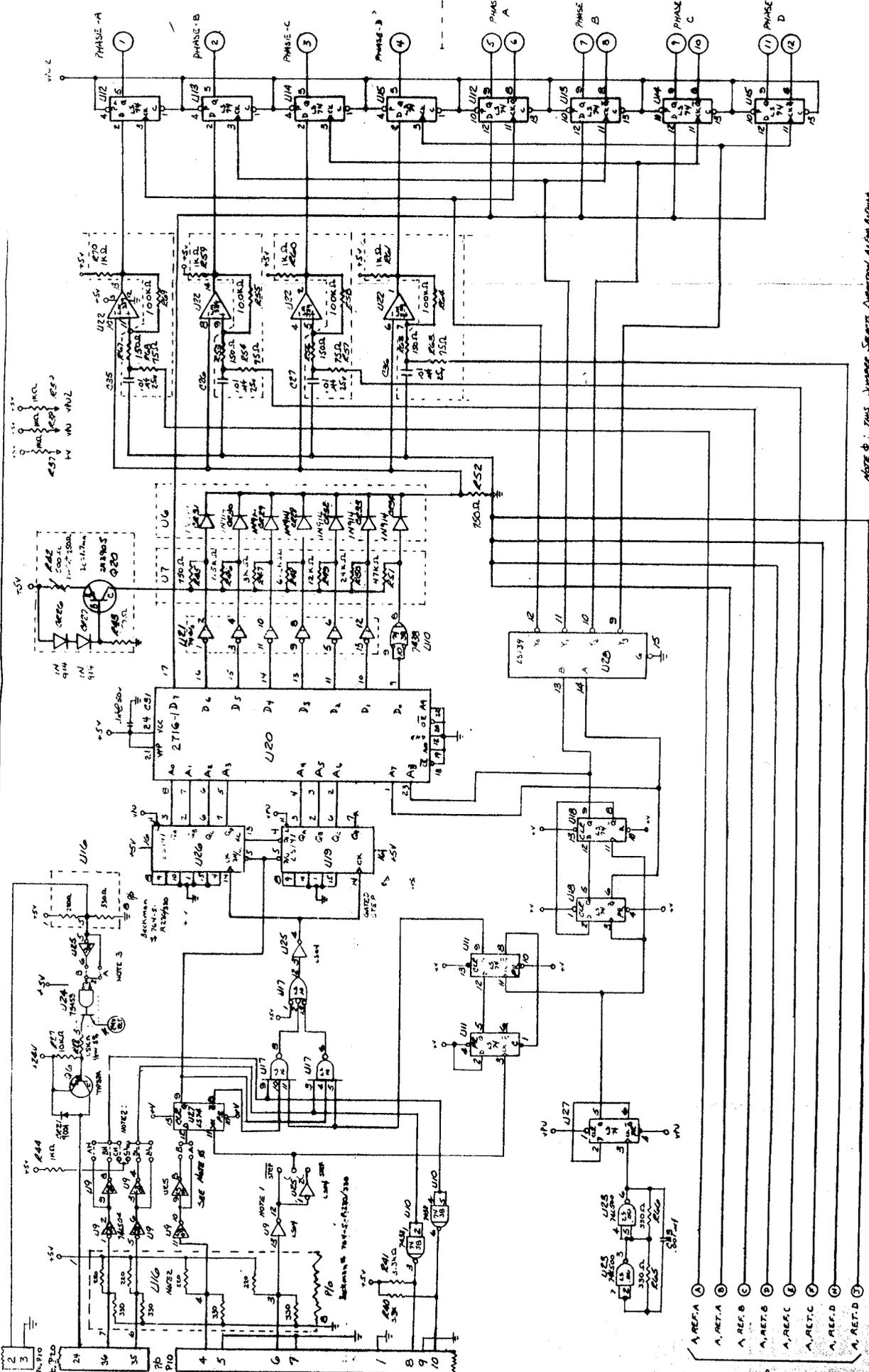
ASSEMBLY  
D30341

30341-A

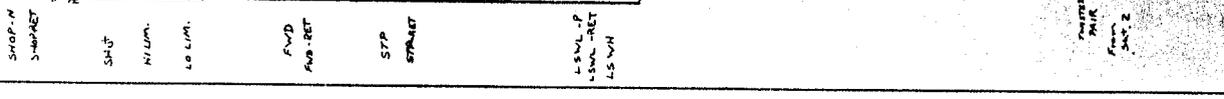
CHOP CONTROL

MOTOR CURRENT DIRECTION CONTROL

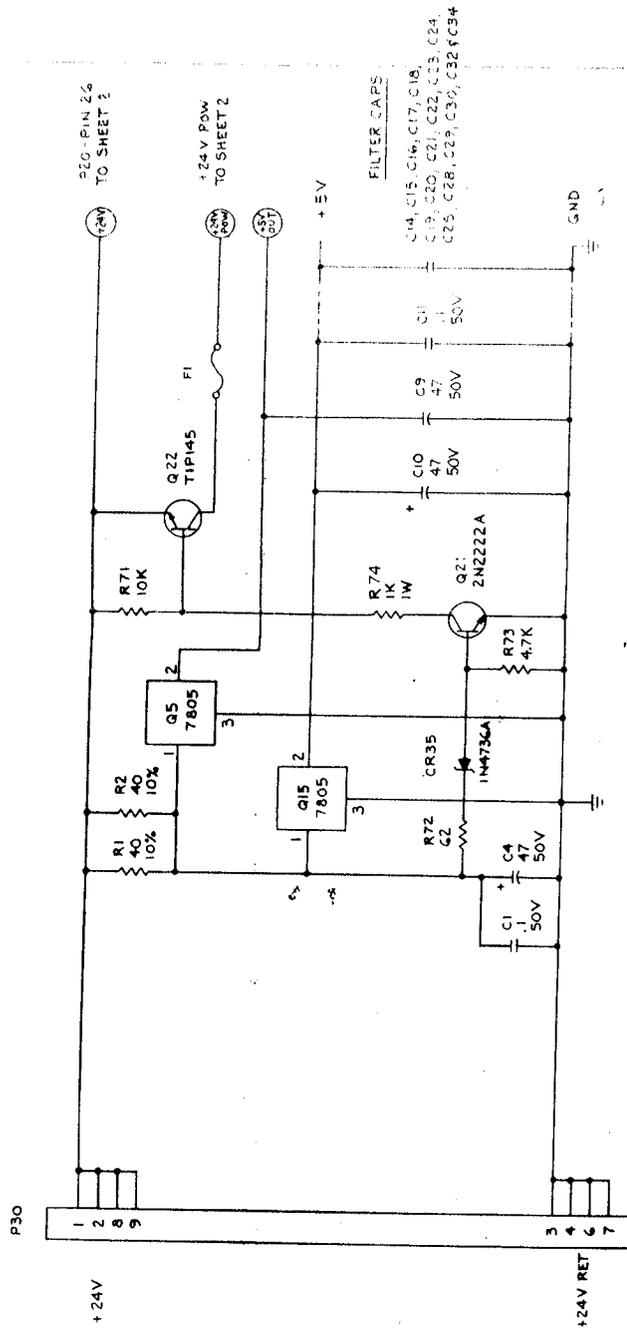
From SHT 2



- NOTE 0 : THIS JUMPER SELECTS DIRECTIONALITY OF MOTOR CURRENT DIRECTION CONTROL. THE PROPER SIGNAL POLARITY MUST BE SELECTED FOR THE MOTOR TO OPERATE PROPERLY.
- NOTE 1 : THIS JUMPER IS USED TO SELECT THE PROPER SIGNAL POLARITY.
- NOTE 2 : THREE SWITCHES ARE TRANSFERRED TO THIS WAY. SWITCH A, B, C (CONTROL) ARE TRANSFERRED TO THIS WAY. SWITCH D, E, F (CONTROL) ARE TRANSFERRED TO THIS WAY.
- NOTE 3 : DISCONNECT WITH ONE 1/4W 10K POT. 1/4W 10K POT.
- NOTE 4 : DISCONNECT WITH ONE 1/4W 10K POT. 1/4W 10K POT.
- NOTE 5 : ALL RESISTORS UNLESS OTHERWISE SPECIFIED ARE 1/4W 5%.







FILTER CAPS

- C14, C15, C16, C17, C18,
- C19, C20, C21, C22, C23, C24,
- C25, C28, C29, C30, C32, C34

WHEN USED WITH A 4 PHASE MOTOR,  
DELETE LISTED ITEMS FROM PC BOARD.

ITEM	DISC'D	SPR. NO.
R56, R42	190A	70204
R11, R45, R15, R14, R40, R41	1K A	70319
R24, R25, R57, R43	75 A	70176
R13, R44, R17, R48	244 A	70180
R49, R44	100K A	70353
R27, R28, R18, R34	330 A	70824
R36, R36	2 A	70893
C2, C13, C27, C26	.01U F	71070
C4, C5, C28, C21, C29	0.1U F	71108
C5, C6	47U F	71296
C19, C10, C17, C8	NP3C	72149
C10, C11, C18, C19	7P1H	72150
C41, C42, C43, C44		
C45, C46, C47, C48		
C49, C50, C51, C52		
C53, C54, C55, C56		
C57, C58, C59, C60		
C61, C62, C63, C64		
C65, C66, C67, C68		
C69, C70, C71, C72		
C73, C74, C75, C76		
C77, C78, C79, C80		
C81, C82, C83, C84		
C85, C86, C87, C88		
C89, C90, C91, C92		
C93, C94, C95, C96		
C97, C98, C99, C100		

REPLACE R42 1000 WITH 100K, 250V, .12 50T 50V  
TO ~700A.  
REPLACE R1 & R2 40A 10W WITH 50A, 2 A