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COUDE SPECTROSCOPY AT LICK OBSERVATORY

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INTRODUCTION

The following text is intended primarily as a summary of operating procedures in the Coudé room of the 120-inch telescope. It should not serve as a substitute for personal instruction in the use of particular instruments; contact Mr. Harlan if you have not used a device before (or for some time) to be sure you are familiar with it and its current modifications.

The material herein is mostly from the Coudé Manual of 1969 and the personal notes of Dr. G. Herbig and Mr. E. Harlan. Although they have reviewed the text, I will take the blame for any errors (for all the good it will do you). Comments, suggestions and revisions should be directed to Mr. Harlan.

The Coudé Summary Sheets at the end are intended to provide tested recipes for observing with various common combinations of gratings and cameras. Users are free to add their own on the blank sheets provided or change those included as appropriate. Check the recipes before observing to assure accuracy.

Copies of this publication are available from Ms. L. Toepfer in Santa Cruz.

David Soderblom
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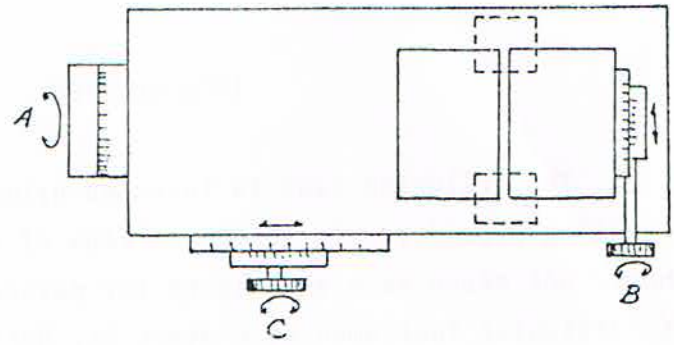
1. OPTICS

a. Slit Assembly



Above is a drawing of the slit assembly looking down. Knob A (on the east side) controls the slit width, and reads in units of 10 microns. One full turn of the drum is 0.50 mm; double turns are counted by the scale beside the drum. This drum is periodically reset (when required) so as to read zero when the jaws just separate in the opening direction. DO NOT GO BELOW ZERO. The selection of a slit size depends on the camera, collimator, emulsion, seeing, and purpose of the program. Projected sizes of 20 to 40 microns are typical. The maximum slit width possible is 2.50 mm. Table 1 (appendix) gives slit settings for a 20 micron projected slit with various camera/collimator combinations and for various grating tilts. The formula for calculating the reduction factor between slit and plate along the camera axis is

$$R.F. = \frac{\text{f.l. camera}}{\text{f.l. collimator}} \times \frac{\cos(A)}{\cos(B-A)}$$

where A is the grating tilt and B is as given below:

	camera:	20,40,80,Varo	160,8
Angle B:			
	6.5-inch coll.	31°.55	19°.55
	9.5-inch coll.	30°.00	18°.00

The slit settings for the Varo camera were calculated assuming an additional reduction of 0.94 due to the image tube.

ALL SETTINGS SHOULD BE MADE IN THE DIRECTION OF INCREASING READINGS.

Knob B (on the west side) controls the separation of the comparison prisms; the scale reads in millimeters. This determines the maximum width of the stellar spectrum on the plate; however, the inner tips of the comparison lines will be slightly farther apart than this setting because the inner edges of the prisms are masked by narrow strips of opaque paint. When setting B, always approach the desired value from smaller numbers.

The maximum extent of the prism separation is 51 mm. The slit can

be used for its entire 50 mm length by swinging the prisms aside. The sizes of the secondary and coude flat mirrors are such as to produce a fully illuminated field five inches in diameter south of declination 38°; north of this some vignetting is present.

Knob C (below the slit) controls a wedge shaped decker behind the slit which limits the outer extent of the comparison lines. The scale reads in millimeters and can be set from 0 to 50. At large decker settings one may not get comparison lines as long as the setting would indicate because the extent of the lines is also limited by the finite size of the prisms.

b. Collimators

6.5-inch collimator: 234 in. focal length; the focus setting is permanently left at 168.000. This collimator is for use with all gratings. Only this collimator should be used with the 160-inch camera for the best image quality.

9.5-inch collimator: 342 in. focal length, focus setting 228.150. At the present time, this is suitable for use only withgrating VII unless one is willing to spill light.

To use the 9.5-inch collimator, raise the 6.5-inch with the push-button controls above it on the I-beam. Keep the mirror covers closed when not in use.

c. Corrector Plates

Schmidt corrector plates should be used with the 20-, 40-, and 80-inch cameras. Once in position, the alignment of the plates can be checked using the dot at the center of each (but please be sure the grating cover is closed first). The dot for the 80-inch plate is near the top. Cleaning and alignment should be referred to Mr. Harlan.

These plates are all made of UBK-7 glass, which in this thickness becomes opaque below 3100 Å.

d. Gratings

Four gratings are mounted in a turret just behind the slit. Gratings

II and III are Babcock originals while the other two are Bausch & Lomb replicas.

grating	size (in.)	grooves/mm	blaze, first order
II	6.5 x 8.5	600	7500 Å
III	6.4 x 8.7	600	11400
V	6 x 7*	400	3900
VII	8 x 12**	900	13000

*aperture reduced for better performance
**double diamond ruling; definition degraded with long focal length cameras

Table 2 (appendix) gives dispersions for the various grating/camera combinations. Tables 3 to 6 give grating settings for different central wavelengths.

Changing Gratings

1. Grating cover must be closed: switch is in slit room on top of the electrical cabinet. The little light on the switch box should be GREE

2. Inside the spectrograph room, push the RAISE button on the wall beneath the slit. A red light above the buttons will light and stay on as long as the turret is off its defining points.

3. After the motor shuts off, the turret should turn easily. In no case should the turret be turned before the motor stops because the defining points may become damaged. If the turret won't turn, or if there is a bumping noise, do not force it; rather push the STOP button, then RAISE again. Repeat until the motor starts again and unsnags the turret.

4. Turn the turret to the desired grating by gently pushing or pulling on the housings beneath the gratings. DO NOT GRAB THE GRATING CELLS. There are triangular pieces of black tape on the rim of the turret to line up with the pointer. You'll also hear the soft clicks of the micr switches.

5. Now push the LOWER button. After a short time the motor will go off. If the red light has also gone out, everything is all right. If it's still lit, the turret has hung up. Turn the turret slightly to position it better and push LOWER again.

Setting the Grating

The counters beneath each grating read angle of incidence to a hun-

dredth of a degree, and are set to read zero when the grating normal points toward the center of the 6.5-inch collimator. Unlock the grating first by pulling the lever toward you. Do not force the grating to an unnatural angle, nor should you change the setting too rapidly, or the grating and counter will get out of phase and the zero point will be changed.

Please note that if grating VII is tilted to a large angle at the same time that grating II, its neighbor, is also highly tilted, there is the possibility that the cover for grating VII will hit the back of grating II. To avoid this, be sure that grating II is set at less than 35°00 and do not use grating VII past 60°00. Also grating V can interfere with grating VII.

A Reminder

The grating surfaces are never to be touched by ANYTHING. Leave the grating cover closed (with the switch in the slit room) when not in use to keep them clean and protected from harm.

e. Cameras

See Table 2 (appendix) for dispersions of the cameras with various gratings.

Each camera has three adjustments: focus, tilt, and height. These focus the plate, rotate the entire plate about a central axis, and provide motion perpendicular to the dispersion, respectively. Table 7 (appendix) indicates appropriate settings for the various cameras. These values are generally variable; the log book should be consulted for current values.

20-inch Conventional

If it is necessary to lower this camera into position, be sure first that the 40-inch camera is fully raised.

Plates of 0.030-inch thickness are necessary. The focal plane of this camera is highly curved, hence plate breakage can easily occur. This can be prevented by following several precautions:

1. Keep plates dry. Baked plates tend to break less. Breakage is always higher in times of high humidity.

2. Use only plates that have smooth edges after cutting, as breaks tend to occur at chips and bumps.

3. Prestress the plates in the bender in the loading room for several hours before use.

The original plateholder is marked "20". There is a newer one, "20B", having a slightly different curvature, that reportedly gives superior definition in the central 500-600 Å, but the old plateholder is better toward the edges. The 20 holder is made of aluminum while 20B is made of stainless steel and hence is much heavier.

There is a plane-parallel compensator available for exposures longward of about 5500 Å that will fit only the "20" holder. It contains a GG-14 filter.

The focus control is directly behind the plate toward the grating. The height control is on the support structure at the top of the camera, while the tilt control is a metric micrometer to the east of the height indicator. The radius of the tilt motion is 291 mm.

Multiple exposures can be made on a single plate by varying the height. Make the first exposure at height = 25.00 and put on the calibration. Use a decker setting no greater than 18mm. Set the height at 23.30 for a second exposure and at 26.50 for a third. Do not put on the calibration for either of these, and do not use a decker setting greater than 18 mm.

40-inch Camera

Before lowering this camera into position,be sure that the 20-inch camera is fully raised. Change the corrector plate. The focus control is on the optical axis of the mirror and faces the grating. The height indicator is similar, is located above and to the west of the focus indicator, and faces west. The tilt control is a metric micrometer to the west and above the focus indicator. The radius of the tilt motion is 343 m

Two exposures can be made on one plate. Set the height at 30.00 for the first exposure, which should include the calibration. Set the height at 27.50 for the second exposure, but do not put on any calibration.

Only one set of "S" calibration strips can fit on the one inch plates. With the height set at 30.50, all the odd strips are in the clear region of the plate. If one wishes to have the even strips appear, set the height at 21.00.

80-inch Camera

Both the 20- and 40-inch cameras must be fully raised to use this

camera. The focussing mechanism for the 80-inch camera is part of the 40-inch mirror cell. The focus and tilt controls are as for the 40-inch. The height control is directly above the focus indicator. Switch the calibration system so that the (inner) L deckers are used (see section on calibration.) The focus of the 80-inch is temperature dependent. The radius of the tilt motion is 343 mm.

160-inch Camera

Both the 20- and 40-inch cameras must be fully raised to clear the light path to the 160-inch mirror. No corrector plate is necessary if the 6.5-inch collimator is used. Since the optical axis for this camera is inclined to those for the shorter focal length cameras, the grating settings used are different. As with the 80-inch, use the (inner) L deckers in the calibration mechanism. The plateholder for this camera is stored in a box beneath the counter in the loading room. Either one or two 2 x 10-inch plates can be used, depending on the spectral coverage desired. The plate tilt is set permanently. There is a strong temperature dependence of the focus; see table 8 (appendix).

8-inch Camera

To use this camera, prepare the optics as for the 160-inch camera, and set the 160-inch focus at 24.50. There is a 2 x 24-inch flat mirror that mounts in the focal plane of the 160-inch to deflect the light to the 8-inch.

Users of this device are warned that the mechanisms are very delicate; nothing must ever be forced. Get thorough instruction from Mr. Harlan before using this camera on your own.

Both the focus and tilt for this camera are very stable and ordinarily should not need changing. Controls for the camera are located in the slit room. The camera cover and comparison firing can be controlled from inside the spectrograph room if the toggle on the electronics in the slit room is switched to REMOTE.

The plateholder has some slight light leaks and should be loaded in the darkroom with the red lights on. The camera cover should not be opened unless all lights are off.

20-inch with Varo Mark II

The 40 mm. Varo model 8605 image intensifier reduces the scale by a factor of approximately 0.94, hence the dispersion is lowered somewhat. Both the dial indicators on the Newtonian flat that directs the beam to the Varo should always be at 0.00. Two screws hold the Varo to a flat plate below the 20-inch mirror and Newtonian flat. One has a red pl head and screws in behind the flat plate; the other is an Allen screw with washer that goes in the lower front. Back off the push screw opposite the tilt micrometer before mounting or dismounting the Varo, and be sure that t Varo is tightly seated against the flat plate. There are two dial indicato for focus and height. The focus is generally very stable. The height is changed only if a new tube is installed or if a tube defect is to be avoide but check the setting. It is usually better to change the grating setting to avoid a tube defect, as changing the height can result in a curved spectrum.

Connect the high voltage probe to the east side of the camera. Near it are connections for the temperature probe and dry air line; connect them also. Turn up the air pressure to 5 to 8 pounds; this provides dry air across the face of the Varo to prevent fogging of the cold field flattener. The dessicant envelope inside the camera should be changed daily or when tube noise appears on plates; unscrew the four screws holding the PVC plate atop the box.

The high voltage power supply is located in the slit room around the corner from the desk. Be sure the power is off before changing plates or turning on the room lights. The settings on the power supply should be as follows:

Voltage: Medium Polarity:+ Current: Low
Trip Controls: voltage:8 current:1 (i.e. trip will release if voltage rises above 0.8 of full scale).

To activate the tube, push HIGH VOLTAGE ON (black button); you'll hear a popping sound. Then turn up the HV with the large black knob to 11 to 13 kV, depending on the level of tube noise tolerated. Turn down the voltage before turning off the tube with HIGH VOLTAGE OFF (red button).

Cold boxes are bolted onto a copper plate on the west side of the Mark II Varo camera box. These cold boxes are made of plastic with one copper face and are kept in the left freezer in room 287 upstairs. The temperature readout on the floor beneath the slit area indicates the te

of the cathode and suggests when the cold box needs to be replaced. How long they last depends on the temperature in the spectrograph room; generally an hour or so is typical. One may wish to replace the cold box before starting a long exposure.

2. COMPARISON SPECTRA

A hollow cathode("HC") iron-neon lamp is used to impose a comparison spectrum on the plate via the comparison prisms. The prisms are adjusted periodically so that the same area on the grating is illumianted by each prism as by the starlight. Care should be taken in handling the prisms to avoid changing this alignment. The small alignment screws behind each prism bracket should never be touched. Lower the prisms to the slit carefully.

Just in frontof the HC (about one foot up from the slit) is the filter wheel with six filters as follows:

filter number	name	properties
1	-	empty
2	Wr 2A	UV absorber, opaque below 4100 Å
3	λ5550	interference filter: 5460-5740
4	Wr 12	transmits beyond 5000 Å
5	Wr 44	transmits 4350 to 5500 and beyo
6	Wr 40	transmits 4650 to 5800 and beyo

The latter two filters are to minimize the strong neon line at 5852 Å The Wr 44 is particularly effective for this.

Just down from the filter wheel are two slots in the ray-gun. The up one should always contain a piece of milled aluminum with a 6 mm hole. Th aperture is imaged on the collimator by optics in the ray-gun. The lower can contain various filters, all 38 by 52 mm:

1. fine-ground UV transmitting Plexiglas ("ordinary diffuser")
2. clear Plexiglas, absorbs below 3450 Å
3. same as #2 with one side fine-ground
4. 2 mm NG-9, both sides polished
5. 2 mm NG-9, one side fine-ground
6. BG-38 (not in metal holder) transmits (T >10%) 3400 to 6700 Å

These filters are kept in paper envelopes in the desk in the slit roo

Procedure for Use

1. Select ray-gun filter and insert into slot.

2. Select filter-wheel filter by pushing the appropriate button unde the comparison timer. The yellow light to the left of the buttons will co on and stay on while the filter-wheel is in motion. When the filter is in place, the light goes out.

3. The power supply for the HC is below the comparison timer. There are two meters (current and voltage), a big black knob, and a toggle switc Be sure the black knob is turned all the way down (counterclockwise), then turn on toggle switch; a small yellow light will glow.

4. After a few seconds turn up the black knob slowly until the tube fires: the current meter will suddenly jump up. Reduce the current to

the desired value: 10 ma and 50 ma are standard.

5. Select the desired exposure time (up to 60 seconds) on the comparison timer. A button on the timer activates it and it resets itself.

6. After completing the exposure, turn down the black knob to zero before shutting off the HC power.

DO NOT RUN THE HOLLOW CATHODE TUBE UNNECESSARILY. It is easy to replace but difficult to realign (this is done by Mr. Harlan).

It is conventional to divide the comparison exposure into two halves, one near the beginning and one near the end of the stellar exposure to average out any progressive movement of the spectrum.

The shutter behind the slit (controlled by the slide on the west side of the slit pedestal) must be open while the comparison exposure is being made. There is an interlock shutter that protects the integrator while the comparison shutter is open, hence the integrator does not count during that time.

Symptoms of HC Failure

Notify Mr. Harlan if any of the following symptoms appear when using the HC so that it can be replaced without loss of observing time:

1. Fe spectrum weakens relative to Ne. As a result the color of the discharge changes from orange to pink.

2. Unusually high voltage required to ignite HC.

3. Current unstable once ignited: keeps dropping.

3. CALIBRATION

This system imposes a series of calibration strips of known relative intensity on the plate parallel to the stellar spectrum. There is a small wavelength shift between the two, typically 40 Å. The light is passed through two stepped slits of known dimensions, producing 14 strips in all, 7 on one side of the spectrum (the "odd" strips) and 7 on the other (the "even" strips). The outer "S" deckers are used with the 20- and 40-inch cameras; these two strip stacks are numbered 1 to 14. For the longer focal length cameras (80-, 160- and 8-inch cameras) the inner "L" deckers are used. These strips are numbered 21 to 34.

As noted, all the odd numbered strips occur on one side of the spectr all the even numbered strips on the other. Strip 1 (or 21) is the densest strip, and are the farthest of their stack from the stellar spectrum. Str 2 (or 22) is the next densest and occurs next to the stellar spectrum.

To change the deckers, there is a slide beneath the calibration box inside the spectrograph room.

Two light sources are available. An incandescent source is usually used to somewhat below 4000 Å. The Xenon source is (as of June, 1976) abo six times brighter than the incandescent at 4000 Å; this factor becomes much larger at shorter wavelengths. To the left of the calibration timer side the slit room is a box with toggle switches to choose between the two When they are switched to INCANDESCENT, the source comes on when the timer is turned on and goes out when the buzzer sounds or the timer is turned of To use the Xenon source, set the switches on XENON, set the timer to the d sired time, turn on the timer, then push the firing button until the tube ignites as indicated by the meter above the firing button which responds to a photocell in the Xenon box. The tube will shut itself off when the buzzer sounds.

When setting the timer, always approach the desired time in a clock- wise direction, otherwise the timer will run about two minutes longer than indicated.

Since the calibration system is far behind the slit, the shutter beh the slit need not be open during the calibration exposure.

Calibration Filters

1. Wavelength selection:

   a. UV absorbing (Wr 2A)
   b. Blue (Corning 5850)
   c. Yellow (Corning 3384)
   d. Wr 89B

2. Neutral density: 2X, 9X, 4X and 50X.

The 4X, 50X and 89B filters are inserted into the light beam from inside the spectrograph room; there are plungers on top of the calibration box. They can be removed from the beam by pulling up on those plungers, or from the slit room by means of the B, Y and UVA filter plungers. Since the 4X is located in the same slide as the B filter, it will be pushed out of the beam if one depresses the B plunger, then pulls it back out again. The UVA controls the 50X filter similarly, and the Y filter controls the 89B.

RELATIVE INTENSITIES OF STRIPS

S Deckers 20- and 40-inch Cameras

strip number	log I	strip number	log I + constant
1	2.404	2	2.255
3	2.105	4	1.955
5	1.803	6	1.656
7	1.495	8	1.350
9	1.183	10	1.027
11	0.839	12	0.752
13	0.399	14	0.332

L Deckers 80-, 160- and 8-inch Cameras

strip number	log I	strip number	log I + constant
21	2.405	22	2.256
23	2.108	24	1.957
25	1.809	26	1.661
27	1.510	28	1.356
29	1.223	30	1.046
31	0.935	32	0.778
33	0.653	34	0.377

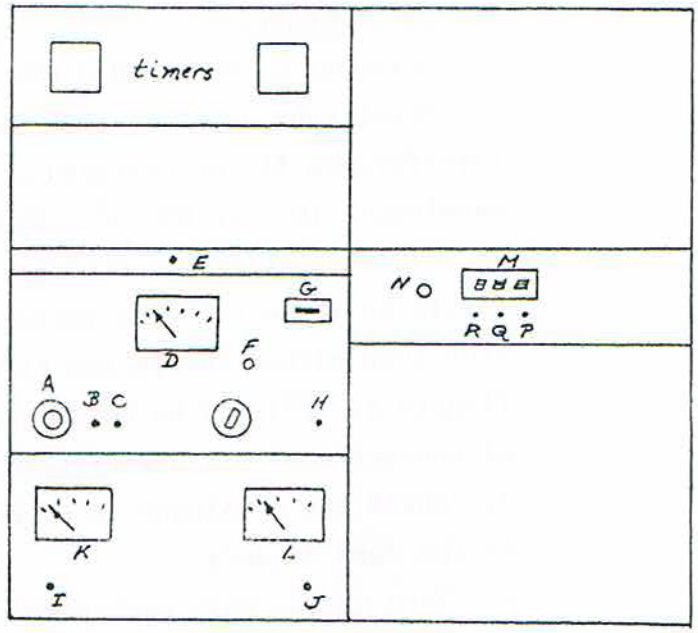
The even strips differ from the odd strips by a constant factor because the light paths are not identical.

Note that with the 40-inch camera only one set of strips will fit on a plate.

If it is so desired, the deckers can be replaced with a rectangular aperture to check the uniformity of the illumination; consult Mr. Harlan.

Warning: on early Varo plates (before EC-10123 or EP-370, i.e., before 1/1/72) the odd strips are vignetted; only the even strips should be used.

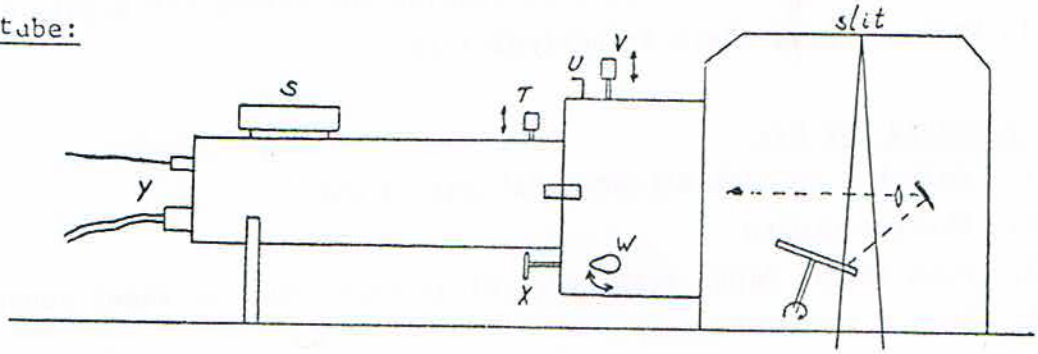
4. EXPOSURE INTEGRATOR



Switches and meters:

A: Dark balance adjust
B: DARK BALANCE/ZERO BALANCE
C: Shutter: OPEN/CLOSE
D: Meter indicating accumulated charge
E: Main power switch for rack
F: RESET; red button to reset needle D
G: counter
H: integrator ON/OFF
I,J: Power switches for HV supply
K,L: current and voltage meters for HV supply
M: digital readout
N: dimmer for digital readout
P: RESET; resets counter to zero
Q: STOP; prevents digital readout from displaying further counts
R: START; must be pressed if readout is to work, otherwise it will ignore counts

Phototube:



S: Dessicant cannister; unscrews. Replace when crystals become pink.
T: Filter slide (red tube only)
U: Decker selector; use LONG if decker setting is more than 6 mm
V: Filter slide; in for yellow (Y), out for blue (B)
W: Shutter indicator; indicates if safety shutter is opened or closed but does not control shutter. Do not try to turn this manually; use switch C.
X: Propeller on/off. If pulled out the propeller deflects 8% of the light to the phototube, if pushed in that 8% is saved. An interlock prevents the propeller from stopping in the light path.
Y: Cables for HV and signal

Set-up Procedure

1. Switches C, H, I and J OFF, B to ZERO BALANCE.
2. Mount tube desired; blue or red. The red tube has two filters; an interference filter centered at 6470 Å and a RG-9 filter whose effective wavelength is near 8000 Å. These filters are denoted in the log by "R" and "I" respectively. When using the red tube the filter slide "V" should be in so that the yellow filter is in place. When using the blue tube either the yellow filter (logged as "Y") or blue filter (logged as "B") may be used. Their transmission is close to that of conventional B and V filters.
3. Check the dessicant to be sure crystals are blue. Spares are in the desk drawers.
4. Turn on the main rack power "E".
5. Turn on H, I and J. Set the voltage "L" to 1400 V for the blue tube, 1175 V for the red tube.
6. Let the system warm up for at least one hour to stabilize the dark current.
7. Set "B" to ZERO BALANCE. Adjust zero balance knob so meter D is on zero.
8. Switch B to DARK BALANCE and multiplier switch to 1X. Adjust dark balance knob A (it looks like a combination lock) until the needle stops drifting. This will need readjusting during the night, especially in warm weather; check it periodically.

Procedure for Use

1. Switch B on DARK BALANCE, "X" pulled out.
2. Shutter CLOSED
3. Push RESET, STOP, START (P,Q,R) in that order to reset counter.
4. Push F to reset meter.
5. Switch C up; shutter OPEN
6. Open the slit and start the exposure.

Note: push in "X" before turning off power to avoid having the propeller stopping on the beam.

5. MISCELLANEOUS

a. Filters Over and Under the Slit

In the pencil tray in the desk in the slit room is a shaft about 0.2 by 5 inches with a mushroom-shaped knob. It inserts into a hole under the slit on the west side of the slit pedestal and screws into the under-slit filter slide. The positions available are:

1. slide fully in: no filter
2. one click out: 1 mm, UG-11, transmits below 3900Å, with a peak at 3300Å
3. two clicks out: 3 mm, C9863, transmits below 3900
4. three clicks out: Wr 89B (gelatin), transmits redward of 7000Å
5. fully out: full aperture is clear

It is recommended that the filter slide be fully OUT unless one of the filters is being used.

In paper envelopes in the slit room desk are kept various filters that can be secured to the filter holder that swings into the beam above the slit. They should be cleaned only with lens tissue. All filters are two inches square unless noted:

1. NG-4 2 mm, T about 12% longward of 4000 Å
2. NG-3 1 mm, T about 12% from 4000 to 6500, 15 to 20% above 7200
3. GG-11 2 mm, transmittance greater than 10% above 4800 Å
4. GG-495 2 mm, essentially the same as the GG-11
5. Plexiglas UVA absorbs below 3450Å
6. Wr 2A transmits redward of 4200 Å
7. RG-2 77 x 90 x 2 mm, transmits redward of 6300 Å

b. Rocker

This is a 25 mm quartz block that oscillates so as to trail the star along the slit. To use:

1. Bring device into position over the slit. Be careful not to strike the filter holder.

2. Slide back the upper and lower covers and secure them with tape to prevent their closing unnoticed. If the block needs cleaning, be sure to use only lens tissue and be careful not to use any pressure.

3. Turn on power in right-hand electronics rack opposite the slit. Push ROCKER selector, be sure MOONLIGHT ELIMINATOR is off.

4. Set sweep to desired value, e.g. 8 mm. Set the sweep rate, e.g. 2 sec/mm.

5. Set NORMAL/FAST RETURN to NORMAL. (If FAST RETURN is selected, block returns at maximum speed, 1 mm/sec).

6. Push STOP, RESET, GO. Turn on small toggle switch; this will start motor going. Turn it off when the indicator beside the

block reaches half of the desired sweep (in this case 4 mm).

7. Reverse the direction of travel. Push STOP, RESET, GO. Turn small toggle switch back on. The block should now sweep between the desired limits.

Anytime a parameter is changed, be sure to push RESET; otherwise the rocker will take up where it left off but with the new parameter.

If the rocker gets jammed at the limits, grasp the knurled stepping motor shaft with the fingers, turn it in a direction that takes the block away from the limits until the stepping motor takes over.

c. Moonlight Eliminator

This device is kept in a small box in the metal cabinet in the dark room over by the 120-inch shops. It is delicate, and should be handled with care, especially when being installed over the slit, when a slip could do damage. The long guide pins are to protect the slit plate. Replace the light sealing plate with the red screw head after removing the eliminator. There is a cable stowed above and east of the slit pedestal that connects to the moonlight eliminator.

The electronics for the Moonlight Eliminator are the same as for the rocker. To activate, push the MOONLIGHT ELIMINATOR button. The moonlight eliminator may be run with or without the rocker.

Three apertures are available to fit over the slit; their sizes are 1.5, 2.5 and 3.5 arc seconds.

d. Image Rotator

This device can only be used with the 120-inch telescope because of its placement in the light beam. Inside is a fused silica Dove prism that reverses the field, producing a rotation of the image that is twice that of the prism.

Alignment of the device is sensitive; if it is seriously out of alignment refer the problem to Mr. Harlan. The image rotator degrades the definition somewhat, and so should not be used if the desired resolution along the slit is to be better than about 2 arc seconds.

The device is swung into the beam by holding down the IMAGE ROTATOR switch on the side of the electrical cabinet toward IN until the motor stops. The horrendous noise is normal. Screw the knurled knob at the end of the arm all the way in to seat the device properly.

Set the outer ring to the hour angle supplied by the night assistant, then choose the position angle with the inner ring. The

rotation of the device is started with the IMAGE ROTATOR switch between the two timers in the electronics rack. The green light will glow when the device is running.

After use, unscrew the knurled bolt fully, then hold the IMAGE ROTATOR switch on OUT until the motor stops. If the device gets stuck in the IN position, try holding down the limit switch until the motor starts. If the problem persists, call Mr. Harlan.

e. Zeeman Unit

This device is described in a separate publication available from Drs. Herbig or Kraft.

6. BOOKKEEPING

Please try to make the entries legible since they must be copied by personnel unfamiliar with astronomy as well as other astronomers unfamiliar with your work. In the past, many entries have been completely unreadable; this propagates misinformation. Spare log sheets, as well as envelopes for your plates, are kept in the coude darkroom. Most of the entries are obvious, except perhaps:

Page 1, cols. 5,6: celestial coordinates. Be sure to enter 1900 coordinates since these are necessary for computing the heliocentric correction and eventually for filing and cataloguing the plates.

Page 1, col. 10: seeing conditions. Enter the size of the seeing disk in arc seconds (and so indicate) OR use the numerical code as follows:

0	disk larger than 10"
1	5" to 10"
2	1".5 to 5"
3	1" to 1".5
4	0".5 to 1"
5	disk smaller than 0".5

Page 2, col. 2: camera focal length. Enter "20" if old 20-inch plateholder was used, "20 B" if new plateholder used. Note if plane-parallel compensator was used with 20-inch camera. Note if 9.5-inch collimator was used.

Page 2, col. 10: integrator reading. Example: B10X130. Blue tube with blue filter used, multiplier switch on 10X, 130 counts accumulated during exposure.

Page 2, col. 12: new observers should identify the initials they will use

The heliocentric Julian Dates, velocity correction for the earth's motion, etc. are computed regularly at Santa Cruz and can be obtained from Ms. Toepfer, ext. 2201.

TABLE 1

Slit Settings to Produce a 20 Micron Projected Width

a. with 6.5-inch Collimator

	Camera					
grating tilt	20"	40"	80"	160"	8"	20+Varo*
20°	24.4	12.2	6.1	3.1	62	26
22°	24.9	12.4	6.2	3.2	63	26
24°	25.4	12.7	6.4	3.2	64	27
26°	25.9	13.0	6.5	3.2	65	28
28°	26.5	13.2	6.6	3.3	66	28
30°	27.0	13.5	6.8	3.3	67	29
32°	27.6	13.8	6.9	3.4	67	29
34°	28.2	14.1	7.1	3.4	68	30
36°	28.8	14.4	7.2	3.5	69	31
38°	29.5	14.8	7.4	3.5	71	31
40°	30.2	15.1	7.6	3.6	72	32
42°	31.0	15.5	7.7	3.6	73	33
44°	31.8	15.9	8.0	3.7	74	34

b. with a 9.5-inch Collimator

34°	28.2	14.1	7.0	3.4	68	30
36°	28.8	14.4	7.2	3.4	69	31
38°	29.4	14.7	7.4	3.5	70	31
40°	30.1	15.1	7.5	3.5	71	32
42°	30.8	15.4	7.7	3.6	72	33
44°	31.6	15.8	7.9	3.7	73	34
46°	32.4	16.2	8.1	3.7	74	34
48°	33.3	16.6	8.3	3.8	76	35
50°	34.2	17.1	8.6	3.9	77	36
52°	35.3	17.6	8.8	3.9	79	38
54°	36.4	18.2	9.1	4.0	81	39
56°	37.7	18.8	9.4	4.1	83	40

*assuming a tube demagnification of 0.94

TABLE 2

Dispersions (Ångstroms mm^{-1}) at Blaze Wavelength

Grating	Order	True Blaze Wavelenths (Å)							
		20-,40-,80-inch	160-,8-inch	20-inch	40-inch	80-inch	160-inch	8-inch	20+Varo*
II	1	7218	7391	32.8	16.4	8.2	4.1	--	35
	2	3609	3696	16.4	8.2	4.1	2.1	41	--
III	1	10971	11235	32.7	16.4	8.2	4.1	--	--
	2	5485	5617	16.4	8.2	4.1	2.0	--	17
	3	3657	3745	10.9	5.5	2.7	1.4	27.3	--
V	1	3753	3843	48.3	24.1	12.1	6.0	121	--
VII	1	12557*	12811	20.5*	10.3*	5.1*	2.5	--	--
	2	6279*	6406	10.3*	5.1*	2.6*	1.2	--	11*
	3	4186*	4270	6.8*	3.4*	1.7*	0.8	16.4	--
	4	3139	3203	5.1	2.6	1.3	0.6	12.3	--

*using 9.5-inch Collimator

**assuming tube demagnification of 0.94

all other values assume use of 6.5-inch Collimator

TABLE 3

Settings for Grating II with 6.5-inch Collimator

λcentral	order	20,40,80,Varo	160,8
3600	2	28.88	22.57
3800	2	29.61	23.28
4000	2	30.34	23.99
4200	2	31.09	24.72
4400	2	31.84	25.45
5500	1	25.78	19.54
5800	1	26.32	20.07
6000	1	26.69	20.43
6350	1	27.32	21.05
7250	1	28.97	22.65
8200	1	30.72	24.36

TABLE 4

Settings for Grating III with 6.5-inch Collimator

λcentral	order	20,40,80,Varo	160,8
3700	3	36.15	29.65
3800	3	36.72	30.21
4000	3	37.87	31.32
4200	3	39.03	32.45
4800	2	33.91	27.47
5000	2	34.07	27.63
5500	2	35.96	29.47
5700	2	36.72	30.21
6350	2	39.23	32.65
7100	2	42.18	35.51
7300	2	42.98	36.29

TABLE 5

Settings for Grating V with 6.5-inch Collimator

λcentral	order	20,40,80,Varo	160,8
3800	1	20.43	14.32
4000	1	20.67	14.55
4200	1	20.91	14.79
4400	1	21.15	15.02
4600	1	21.39	15.26
6350	1	23.36	17.97

TABLE 6

Settings for Grating VII

λcentral	order	20,40,80,Varo w/9.5-inch Coll.	160,8 w/6.5-inch Coll.
3800	3	47.21	41.27
4000	3	49.12	43.13
4200	3	51.07	45.02
4400	3	53.08	46.97
4600	3	55.14	48.96
5000	2	42.90	37.07
5500	2	45.96	40.06
6000	2	49.12	43.13
6560	2	52.81	46.71
7000	2	55.84	49.64
7500	2	59.46	53.13
7500	1	35.58	29.93
8000	1	37.01	31.33
8500	1	38.46	32.74

TABLE 7

camera	approx. focus	approx. focal tolerance	tilt	height setting	plate size	plate thickness
20-inch	8.36	0.01 mm	5.70	25.00	1 x 6	0.030
40-inch	14.31	<0.05 mm	10.56	30.00*	1 x 8	0.040
80-inch	14.20	.05 mm	9.70	25.0	1 x 10	0.040
160-inch	24.50**	0.1-0.2 mm	--	25.00	2 x 10	0.040
8-inch	12.31*	0.01 mm	....	940**	1 x 2	0.040
20+Varo Mk II	.794	0.001 in	0.495		2 3/8 x 3	0.040

*Star spectrum decentered. See notes for 40-inch camera.

**Temperature dependent -- see Table 8.

*Set 160-inch focus at 24.50.

**940 on slit room console, zero on camera itself.

TABLE 8

Temperature Dependence of Focus, 160-in Camera

T(°F)	Δf	T(°F)	Δf
40°	0.00 mm	60°	+0.74
42°	+0.07	62°	+0.81
44°	+0.15	64°	+0.89
46°	+0.22	66°	+0.96
48°	+0.30	68°	+1.04
50°	+0.37	70°	+1.11
52°	+0.44	72°	+1.18
54°	+0.52	74°	+1.26
56°	+0.59	76°	+1.33
58°	+0.67	78°	+1.41
60°	+0.74	80°	+1.48