UNIVERSITY OF CALIFORNIA
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No. 37

ITS SPECTROSCOPY AT THE NICKEL TELESCOPE

R. P. S. Stone
Steven A. Grandi
and
Fred Walter

This manual is intended to be used
in conjunction with the
Nickel Telescope Users Manual (LOTR 36)

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Preface

This manual is **not** completely self-contained. It doesn't tell you how to operate the telescope and TV system, nor does it contain everything you need to know about the ITS system. On the other hand, most of what is presented here is not to be found anywhere else. Directions for using the telescope, which is an equally complicated system, may be found in Lick Observatory Technical Report No 36. It is intended that these manuals be used together.

The main aspect of the ITS system that is **not** fully covered here is the software, which has already been partially documented elsewhere. You should definitely read LOTR No. 14, **The Scanner Data Taking Program Users Manual.** This manual was written for the 120-inch ITS system. Although it is mostly directly applicable to the 1-meter ITS, there are a few non-essential exceptions, such as lack of a grating rocker and no auto spectrograph setup at the 40 inch.

Two operating systems exist for the ITS, known as the 8K and 32K systems. The data formats are different, so be sure that you have facilities available to read the data from whichever system you choose. The systems are pretty similar, generally, but the 32K system has some extra refinements. LOTR No. 14 describes the 8K system, and Section VI of this manual describes the aspects of the 32K system which are different from the 8K.

Chapter V consists of Fred Walter's privately circulated notes on use of the ITS at higher dispersions, and Chapter VI is excerpted from Steve Grandi's notes on the 32K system. In each case I have made minor updates, so errors are no doubt my own. Finally, I thank Reginald Dufour and Eileen Friel for numerous useful comments.

Chapter I. Introduction

The ITS spectrograph at the Nickel Telescope is a complex system, and for the first few nights you'll probably feel quite busy. Most sub-systems available at the 3-meter are available at the 1-meter, but at the 3-meter there's a Telescope Assistant to absorb some of the work load, whereas at the 1-meter you'll be on your own after the initial check out. Therefore, although it is not absolutely required, it is **very** strongly recommended that before trying to observe alone at the 1-meter, you get some experience with the Lick ITS system. This is usually accomplished by accompanying an experienced ITS observer on a Lick 3-meter or 1-meter run, or to the 60-inch at Mount Lemmon. If it is really impossible for you to arrange that sort of prior exposure, then having an observing partner along on the first run would definitely make some things easier. Many people prefer to observe in pairs all the time.

If you do come to the 1-meter to get experience by helping someone else, both of you should know that it is long-standing Lick policy that, at the smaller telescopes, observers may not check out new observers. Checkout may be done only by the Lick person in charge of a telescope or his/her specifically designated representative. The reason for this is of course that the equipment is often very vulnerable to misuse as well as very expensive to fix or replace. Therefore we strongly prefer that you request an official checkout on your **first night** at the telescope. This will make you more useful to your observing partner as well. **Any person who has not been officially checked out *may not* operate the telescope or spectrograph or TV, but they may help with the computers or routine guiding (only!), under the supervision of the assigned observer.**

No consistent convention for naming the spectrograph in question has arisen. Therefore we will refer to the Robinson-Wampler Image Tube/Image-Dissector Spectrograph as the ITS (Image Tube Scanner) usually. Other common variants are IDS, Robinson-Wampler scanner, Super-Scanner, or just scanner. Kitt Peak's IIDS was copied from ours, with yet another name.

A very nice conceptual overview of the system may be found in Robinson and Wampler, P.A.S.P., **84**, 161, 1972.

Here is a very brief description of the system. The telescope is focussed on aluminized two-hole apertures mounted in a wheel at the top of the spectrograph. Below the apertures, the light may pass through order separating and/or neutral density filters, then it goes through a hole in the downward-looking grating in order to reach the collimator, which is at the bottom of a long pipe at the bottom of the spectrograph. The collimated beam goes back up to the grating, is dispersed, then is folded into the camera by a flat, where it is refocussed onto the first image tube. The spectra (object + sky, and sky) are amplified by a chain of three image tubes, and the result is "stored" for a few milliseconds on the slowly decaying phosphor of the image dissector until it can be read. The output of the dissector is amplified and sent to the scanner memory in the readout room, where the spectra signals are accumulated during the preselected integration time. A real time display of the scanner memory contents allows continuous examination of the accumulated spectra. At the conclusion of the data-taking cycle, the data is moved to a floppy disk or 9-track tape. Buffers in the data-taking computer allow for sky subtraction and adding successive scans.

The image tube chain is cooled by ethanol in order to reduce thermal counts. The ethanol is pumped through a closed system, and is cooled by passing through copper tubing in a dewar filled with a dry-ice/isopropyl slurry. The image tube chain is also continuously flushed with dry nitrogen in order to exclude moisture, which would otherwise condense on the cold face of the first image tube.

The following two sections of the manual give step-by-step instructions for setting up the spectrograph followed by a section of information required to set up a good observing plan. A lot of details are mentioned, not so the manual can substitute for a formal check out, but so it will serve as an adequate source to refer back to at a later date if you have become hazy on any aspects of ITS use. Of course, if you have read this manual prior to your check out, it will go much faster and easier.

Appendix A consists of a checklist for checking the instrument, setting it up for observations, and then shutting down at the end of the night/run. It will probably be useful to have a Xerox of the checklist in your observing kit when you come to the mountain. To some extent the checklist parallels the next couple of sections, but of course it is greatly abbreviated.

If you have not used this telescope for a long while and feel rusty and/or uncertain about using it safely, **please** request a refresher check out. It is free.

Chapter II: Start-up and System Check

A. Set up

1. Have a look at the User's Log and the Trouble Log in order to see if any system changes have been made since you last used it, and to see what has been causing trouble recently.

2. Thoroughly clean the dry-ice/isopropyl dewar of any residue. Neglect of this step will significantly degrade the cooling efficiency and lead to increased dark current.

3. Check that the following cables and hoses are connected to the instrument:

a. Dry nitrogen (N_2, surgical rubber hose)

b. 110 V to amp/disk power supply, supply switched on

c. Signal-out coaxial cable from amp/disk to memory (in control room)

d. Solid coax (signal from dissector to amp/disk)

e. Dissector HV cable (with rectangular filter box)

f. Sweep cable (grey 1/2" cable with three serrated rings on connector)

g. Image tube HV plugged into top of voltage divider

h. Four soft white cables (and associated ground wire from voltage divider to back of dissector).

i. Alcohol cooling lines connected betwixt dewar and ITS

4. Remove small screw from brass outlet at bottom of dissector and purge tube with N_2 for 30 minutes or more before cooling, to flush out any moist air. Normally, it will only be necessary to set the timer by the low-pressure regulator at the base of the telescope (just above the observing floor). Set it counter-clockwise to

"hold," and leave it pressurized throughout your run. Expect 5" H_2O pressure. Also, there is a small valve on the ITS camera which should remain locked open. **Check the brass outlet, at the bottom of the dissector, to be sure N_2 is flowing!**

B. Checkout

While the tube is purging and before icing, performance of the following steps will detect any serious problems while the image tubes are warm and maintenance can still be performed expeditiously.

1. Check dark slide closed.

2. Press "reset" on junction box at south pier.

3. Check both image tube and dissector power supplies off.

4. Turn on real time display oscilloscope. Move center display button out to observe sweep loading in Step 9 below. Check that every button marked with a black sticker is pushed in, and no others.

5. Turn on rate meter crate (at top of telescope control rack).

6. Turn on scanner memory. On the scanner memory box, press START, STOP, and ERASE, and check that traces can be seen on the oscilloscope. NOTE: Switching the scanner memory power off and on can wipe out the computer program. Always bootstrap after switching power on the scanner memory.

7. Load the Data Taking System (SDTS): Turn on the computer, check TTY on-line, caps lock button down and bootstrap the computer (procedure is posted on the front of the computer) with an SDTS disk in unit 0.

8. In preparation for step 9, Start Data Taking with switch (1,1) and (8K system) after answering the questions, set "More Goodies" switch to "Load Sweeps" or (32K system) stop at the "Fast Sweep Load" question.

9. Turn on sweep power. Load sweeps from the disk (any sweeps will do) to avoid possible overheating of sweep circuits. The SDTS disk nearly always has somebody's old sweeps stored on it as sweep #1. On the real time display, verify that the sweeps look reasonably flat; i.e., there should be no large discontinuities if they are loaded properly.

10. On the real time display scope, push center display button in to display data from the scanner memory. Also on the center display module of the scope, push in the 10 mV vertical sensitivity button. This will enable you to see individual counts and verify that the dissector is alive in the next step. On the scanner memory box, press start, check the counting light on and set the display scale to 2^8.

11. Turn on the dissector power supply, and slowly set it to the "best value" (755) written near the 10-turn pot. The actual voltage is not important since it will be adjusted for best focus, and the knob value is more accurately resettable than the

meter. At this point, if the cables are connected properly, you should occasionally see single counts in the display. After verifying this, reset real time scope to 100 mV vertical sensitivity for normal operation.

12. Next turn on the image tube power supply and set it slowly with reference to the dial, not the meter. Around 15 kV noticeable dark current should appear on the real time display. (If not, something is disconnected.) At about 20 kV bright "ion spots" may appear in the display. If so, stop raising the voltage and let them cook for a while; temporarily exposing the tube to room lights may speed the demise of the spots. Do not allow the dark current to exceed 20 kHz on the rate meters as you set the voltage; if it exceeds this value without exposure to light, something is wrong. Finally, set to the recommended value written on the power supply panel (normally 24 kV).

13. As a final check of the system, set sweeps by mapping the tube. Use the neon lamps as a light source. Set the diagonal mirror to the field viewing position, pull the dark slide, set the grating to 217.5 and try 1 count per dot. "Counts per dot" determines how many counts will produce one dot on the memoscope, so 1 count per dot is max sensitivity. The light may not illuminate the slits uniformly, so just establish that sweeps **can** be set and that the system responds to light. Observe the neon spectrum with a rough camera focus value $\sim$ 959 and verify that the focus is good enough to ensure that no major disaster has occurred. At the conclusion of the sweep setting routine the computer will ask for the "left slit channel offset." This parameter slides one slit spectrum with respect to the other so wavelengths will be the same along the two slits. This is important for sky subtraction, for example. You can determine it yourself later (see Chapter III, paragraph 11), but for now just use the most recent value from the Observers' Log.

14. Finally, if everything looks good, ice up. Be **sure** the red thumbscrew at the top of the image tube chain is loose (see next paragraph), replace the small purging screw in the brass connector at the bottom of the dissector, and turn the alcohol pump on. Be sure there is enough **isopropyl** in the dewar to cover the copper tubes in the bottom when the telescope is vertical (about 1 1/2" of it) and that the pump reservoir is full of **ethanol**. Do **not** substitute one for the other. Fill up the dewar with dry ice, and mix it well with the isopropyl to make a good wet slurry.

The top of the image tube chain is held in place by a sleeve which is in turn held by two Allen-head set screws and a red thumbscrew which screw radially in through the top of the image tube chain casing. If these screws are tight when cooling is initiated, as the chain contracts slightly the image tubes may be pulled apart. Conversely, if the chain is allowed to warm up with the set screws tight, the slight thermal expansion may result in a damaged image tube. Thus, it is **essential** that the red thumbscrew be loose during any cooling or warming of the image tube chain. The obvious corollary of this is that the tube must not be allowed to warm up inadvertently, that is, we cannot allow it to run out of ice or alcohol.

The observer will be fully responsible for maintaing the ice and alcohol in the system. If for any reason you will be unable to be **certain** of keeping the system iced, all you need do is **loosen the red thumbscrew.** It is a small matter to retighten it and reset sweeps. It is essential that this thumbscrew be loosened at the end of each night's observing as normal procedure. "Loose" for the red thumbscrew means just half a turn; "tight" means tightly finger tight.

Chapter III: Prepare to Observe

1. Ensure a sufficient supply of dectapes, floppy disks, or 9-track tapes are on hand. (To the data taking system, Dectapes and floppies are logically equivalent.) They may be obtained from the TA's at the 3-meter if needed. Of course you will be charged for them.

Be sure your floppy disks are formatted. If necessary to format, load the L.O.E.L. Maintenance disk, bootstrap, and type MARK (return). Prompts from the TTY will guide you from there. It is most convenient to do this before starting the data taking system, since the procedure will lose the data system initialization parameters.

2. Be sure you have logsheets on hand. There may be some in the dome or you can get them from the 3-meter night assistant, or you can copy them from Appendix E.

3. Check the N_2 supply at the tank (300 lbs. minimum for a night) and the pressure at the low pressure regulator at the base of the telescope ($\sim$ 5 inches of water pressure).

4. When the tube is fully cooled (that is, iced down for two hours or more), **tighten the red thumbscrew** at the top of the image tube chain.

5. Top off the ice. To be certain the cooling is working, check that the brass cooling lines going into the image tube housing are frosty.

6. Turn on the real time data monitor, memoscope and TTY (check TTY on "LINE").

7. Check that the discriminator level is set as desired; usually this will be the value written on the unit near the knob. Recheck image tube HV set as desired.

8. Set the aperture carefully. Use high speed to get near the desired aperture, then low speed to set (with short jabs of the button) so the light **just** comes on. An aperture of 4 arcsec is best for setting sweeps and focussing.

9. Open the dark slide and set sweeps. If the apertures were very carefully set, one sweep setup should work for all apertures. Set the grating to $\sim$ 217.5, use the continuum lamp source or room lights, diagonal mirror out, and try one count per dot. Use joystick switch (3,11) to mark the sweeps, or switch (3,12) to return to "counts

per dot." If the cursor on the memoscope screen "creeps," use the small black serrated tab next to the joystick to eliminate the creep. Note that you must set the top (right!) sweep first, or the data will end up reversed in all your scans. Do not attempt to set sweeps with the joystick without answering "Y" to "map tube?," or the Y-offset for the sweeps will be lost, even though they will look good on the memoscope.

10. Focus the spectrograph. Use an aperture size of 4 or 8 arcsec and set the grating to 217.5 units; the neon doublet at 6400 Å will be approximately centered. The focus program is largely self-explanatory. If you use the 32K system do not use the "collimator" option, as it requires computer control of the spectrograph which is not available here. Simply use the "dissector" option for both dissector and camera focus. You may prefer to focus manually. A quantitative focus parameter is F^4 (Famous Faber Focus Factor), which is the height of the valley between the two lines of the 6400 doublet when the right hand peak just reaches 40 units above the "continuum" just redward of the right-hand peak, on the real time scope. Adjust the dissector voltage for the best split of the doublet, then adjust the camera focus knob on the spectrograph itself for the best split. You may wish to repeat this procedure with lines moved to the sides of the spectrum. The best center and edge focus may not occur at the same values, so compromise may be necessary.

11. Occasionally you may wish to check the left slit channel offset (usually rather stable). Use the line lamps to run a short scan and use option 1 of the peak finding routine to see if the current offset is satisfactory. If you find a new offset is better, change the value by using the set sweeps routine, and note the new value in the User's Log.

12. Determine the grating settings and filters to be used. Color filters will normally only be needed for order separation (to supress second order blue contamination when observing in the first order red). See Appendix D.

13. Initialize data taking.

14. If safe to do so (good weather, no possibility of water dripping onto the telescope), remove the plastic telescope cover.

15. Do calibration ("quartz") scans for each decker setting to be used later to remove small scale irregularities in the tube response. Be sure it is dark enough to preclude solar lines in the continuum. A possible scheme for these scans is to do a 16-minute scan with the telescope pointed at the white patch on the back of the shutter or at the windscreen. Try quartz lamp on 2, grating 228. Of course, the mirror cover, dark slide and diagonal mirrors must all be out of the way. Use ND filters as necessary for large apertures. They are not flat, but they vary smoothly, so the channel-to-channel calibration should be unaffected. Try for 1% or better at the lowest counting channels of interest ($\gtrsim$ 40K counts). Some observers prefer to add quartz scans taken at two or three grating tilts in order to get good statistics all across the tube. The disadvantage is that the sum may contain inflection points where the

added scans had very different slopes.

16. Use the appropriate routine ("Load calibration buffer" [8K] or "calibration setup" [32K]) to add, normalize and store the calibration scans in the calibration buffer.

17. Take short scans of the emission-line comparison lamp sources for wavelength calibration. Normally do this **after** the continuum to avoid line lamp afterglow in the quartz scans. However, if there is too much sunlight in the dome for the quartz scans, maybe you can do these calibrations first; then the afterglow can be going away while you are waiting for it to get darker. Use neon for $\lambda \geq 5800$, helium-cadmium-argon and/or mercury for shorter wavelengths. All three lamps contain argon and will provide argon lines in the red and IR. See Appendix C for sample spectra. To avoid afterglow, do not expose the ITS to the comparison lamps longer than necessary. At the time of writing, the Hg lamp is much brighter than the other two - use a 2.5 mag neutral density filter.

18. When ready to observe, remove the RA locking bar and open the mirror cover. Check to be certain the primary is still present. If not, anticipate lower counting rates.

19. Because the telescope is operated remotely, there is a significant hazard of inadvertently running it into objects on the dome floor. When you leave the dome to begin observing, be certain to move ladders, chairs, etc. against the wall. Also, when you begin your first setting of the telescope, be sure to ask yourself once again if the floor is really clear.

Chapter IV: Observing Considerations

1. **Limits.** Observing limits are 5-1/2 hours East and West, $-39\overset{\circ}{.}5$ and $+67\overset{\circ}{.}5$ in dec, and 13° elevation. The top of the slit obstructs the telescope when within 4° of the zenith.

2. **Image Tube Response.** Only one tube chain is available at the 40 inch. It corresponds to the "red" tube at the 120 inch. Tube response extends **roughly** from λ3600 to λ8800.

3. **Gratings.** Three gratings are available. They are all 600 line/mm; the "standard" one is blazed for 5000 Å in the first order. The others are blazed for 7500 Å and 1μ in first order. The efficiencies of the 7500 Å and 1μ gratings are very poor, relative to the standard grating; however, see Chapter V. If you wish to use a grating other than the standard one, you must be checked out on the procedure by Rem Stone. A rough calibration of grating readout versus central wavelength is given in Appendix B. Expect a bit less than 1.2 Å per channel or about 2400 Å in a first order spectrum. There is some degradation in quality near the ends, so try to keep important features in the middle 80% or so. There is a great deal of backlash in

the grating movement. The difference between setting clockwise or anticlockwise to a particular tilt value is about 75 channels in wavelength, so it is essential to set in a consistent sense; clockwise setting is assumed in the tilt vs. wavelength chart. To reach a particular setting, always go past it by 20.0 dial units (or more) than come back to it in your consistent direction to eliminate backlash. With care, you can reset to ± 2 channels. Maximum channel shift due to flexure/position effects is also about ± 2 channels. Be sure to unlock the grating before attempting to move it, and lock it afterward.

4. **Grating Changes.** If you wish to change gratings, you **must** be checked out on the procedure by Rem Stone. As described below, access to the grating could be disastrous for the spectrograph. Still, the procedure is briefly described here as a reminder for those who have been checked out. **First, the high voltage to the image tubes must be turned off.** Access to the grating tray is via two hatches on the sides of the spectrograph which have red warning lables saying "do not remove". Removal of the cover plates allows light to enter the spectrograph below any dark slide protection. With the image tube voltage off and the cover plates removed, rotate the grating tray until you can carefully insert the plastic grating cover into its slot in the grating carrier. You may need to look around to find the cover; it might be on the shelves with the tools, or loose in the grey cabinet in the hall or even (as it should be) in the red storage box for the grating. In any case, **do not** remove the grating without first having its protective cover inserted. To remove the grating, reach in through the round access port and loosen the two thumbscrews **only 1/2 turn.** If they are loosened too far, they may fall out and fall down the collimator pipe. Then turn the grating until it is lined up with the rectangular access port, and carefully slide the grating out. Store it carefully in its box and store the box in the steel grey cabinet. Since the cabinet is in a public access area, be absolutely certain you leave it locked. Install the new grating, tighten both thumb screws, **only then** remove the grating cover, replace both access panels, and **only then** turn the high voltage back on. It will be necessary to reset sweeps.

5. **Apertures** are mounted in a wheel which is rotated by buttons on the black ring at the top of the spectrograph. The wheel has eight positions. At the time of writing, 5-8 are blocked, and positions 1 through 5 contain apertures of sizes 3.7, 8.1, 14.8, 26.3, and 8 x 16 arcsec, respectively. Two LED's mounted near the aperture buttons indicate when an aperture is in position. Only position one is uniquely identified, by **both** LED's lighting up. The yellow button rotates the wheel in the forward direction; the blue, reverse. It is worth setting the apertures carefully. If this is done, one set of sweeps will work for all aperture sizes; and if the aperture wheel is moved accidentally and reset carefully, it will not be necessary to reset sweeps. To set them carefully, then, set close to the desired position at fast speed, then set the toggle switch to slow speed and use the shortest possible jabs of the **forward** button until

the light **just** comes on. You will find that the sweep setting is very sensitive to the aperture position, so set it carefully. If using a very large or very small aperture, you may need to adjust the light level for quartz calibration scans, or the integration time for wavelength calibration scans. In general it is best to do calibrations with the same setup as is used for observing, but a large aperture will degrade the line lamp spectra so badly they may become useless.

6. **Dark Slide.** The dark slide is a small black knob in the black collar at the top of the spectrograph, just to the right of the aperture setting buttons. It pulls out about 1" to open.

7. **Filter Wheels.** The filters are accessed via a door on the west side of the black collar at the top of the spectrograph. An alarm will sound if you attempt to open the door with the dark slide open. There are two filter wheels which each carry eight filters. The left (upper) filter wheel contains a selection of order separators, and the right (lower) wheel contains neutral density filters. The contents of each location in the filter wheels is written on a card on the west side of the spectrograph body below the filter access door, and in Appendix D of this manual.

The filters must be changed manually. When changing filters, touch only the outside rim of the filter wheel. The filters themselves sit exposed just behind the numbered tabs on the wheel, so if you let your fingers stray in there you will leave fingerprints on the filters. The maintenance crew, as a simple reminder, will merely locate the offending finger and keep it. When changing filters, be careful not to jiggle the aperture wheel gears, or you may need to reset the aperture again.

8. **Order Separators.** In general, you will only need an order separator if the longest first order wavelength of interest, divided by (higher order number), results in a wavelength that falls within the spectral sensitivity of the ITS. The very blue end of the ITS is $\lambda3500$ or more, so you will only need an order separator to suppress 2nd order blue at 3500 if you wish to observe in 1st order at 7000 Å.

9. **Neutral Density Filters and Peak Count Rate.** A neutral density filter may be required for objects brighter than about 7th or 8th magnitude. Five densities of quartz substrate filter are available, providing 1.75, 2.5, 5, 7.5, and 10 mags of attenuation. The limiting factors for brightness are the paired-pulse correction due to deadtime in the amp/disk, and afterglow (the latter effect is discussed in the following paragraph). The paired pulse correction is reasonably well known for counting rates up to one megahertz, but becomes increasingly uncertain for higher counting rates. Consideration of the number of channels to be counted (2048 per slit x 2 slits), the flyback time for the dissector (300 μsec) and the memory cycle clock rate (1 MHz) leads to the result that the peak count rate through the amp/disk is 4400 x peak channel counts sec^{-1}. If the peak rate is to be 10^6 then the peak channel should be no more than 227 counts sec^{-1}. At the telescope, you may estimate this by setting the display scale to $2^{11} = 2048$, and looking for a peak channel folding time of about

9 seconds. If this rate is exceeded, use a neutral density filter for best results.

10. **Afterglow.** While you are thinking about bright objects, be aware that they will cause a lingering afterglow in the ITS, so don't plan to observe faint objects right after bright ones. It is hard to quantify this afterglow, but I would guess that an 8th mag star might leave some residual glow for half an hour and the room lights might last even longer (depending on aperture size). The decay time depends on **how long** the ITS is exposed to the source, in addition to how bright the source is. You can check for afterglow by opening the gate on the memory box (that is, press START) and looking at the real time display with the memory display gain all the way up and the dark slide closed. An absence of spectral features or continuum shape combined with a low count rate on the rate meters ($\leq$ 200 counts) will assure you the afterglow is gone. Prudence (that is Prudence Townsend of Hyannisport, the well known ITS observer) would of course suggest that you plan your observing program so you don't have to be concerned about this. In particular, do not do quartz calibration scans soon after wavelength calibration lamps or bright stars! The spectrograph will not be harmed by exposure to room lights, although afterglow may be a problem. But **never** expose it to a daylight sky or shine a flashlight directly on the aperture wheel.

11. **Audio Rate Meter.** An audio rate meter is available which is a nice aid to guiding. It produces a tone whose pitch is proportional to the rate meter output, so a drop in the tone indicates a loss of light and the need for guiding. To use, turn on the toggle switch on the speaker grill in the rate meter crate, and adjust the rate meter scale switches to a range appropriate for the signal being detected. If the rate meter is allowed to saturate (too high a sensitivity selected) it will no longer trigger on each arriving pulse and the tone will be lower than expected and may deceive you.

There are two ways to use the audio rate meter. These are with gated or ungated output, and are selected by moving a coax between the gated and ungated connectors on the front of the sweep box. Usually gated output is nicest, because the data gate automatically controls the tone from the audio rate meter. This way you can be certain when data taking is underway, or e.g. if "pause" has worked. However, if your object is **very** faint and hard to see on the TV, switching to ungated output will enable aural feedback when a scan is **not** in progress, so you can use the audio rate meters for centering the object in the apertures.

12. **Spectrograph Flexure.** Max channel shift due to flexure is usually about two channels. Thus if maximum accuracy is required in the wavelength calibration, you may wish to do a lamp calibration at the position of your object. Remember that the zero point can usually be adjusted from night sky lines anyway.

13. **Sweep Oven.** From time to time during the night, check the oven temperature on the sweep box. The oven is to maintain stable sweeps, and the game is to find a combination of the temperature selector and fan (on/off) which will cause the oven to cycle on and off at the ambient temperature prevailing in the computer

room. If the oven light on the panel is cycling from time to time, you've hit it. On a summer night you may need to set the oven to a low temperature and leave the oven fan on. A cold winter's eve may require the room heater, oven heater on max and no fan.

14. **Counts per Photon.** The scanner produces about 4 counts for each incident photon. Since the accuracy of the observation depends on the number of photons counted, not counts, don't forget to divide by 4 when predicting signal/noise.

15. **Alcohol.** When the system is first iced, 1-2" of isopropyl should be in the dewar. Thereafter it is **not** ordinarily necessary to add alcohol to the dewar. In fact, too much alcohol will increase the sublimation temperature of the dry ice and lead to less efficient cooling. It is only necessary to mix the dry ice well with the alcohol already in the system.

16. **Memoscope Care.** Observers are requested **not** to adjust the memoscope. The reason is that the phosphor may be burned rather easily, and these large storage scopes are a rarity in the world of electronics in that they are getting more, rather than less, expensive as time goes on. It has been carefully adjusted for the best performance and a long phosphor life; please do not change it. A corollary consideration is to erase the display whenever it is no longer needed, and turn it off in the morning, even if the computer is left on.

17. **Telescope Balance.** Avoid anything which will change the balance of the telescope, such as adding or changing equipment on it. If necessary to rebalance, call telescope maintenance. You may rotate the tub to change the position angle of the spectrograph if necessary. At present, this is the only instrument for which the tub has been balanced for rotation. Do it carefully, don't pull out any cables, and be sure to relock the tub.

18. **Sky Subtraction.** It has been found that sky subtraction is markedly superior if, for observations totalling more than just a few minutes, the observations are made so as to obtain symmetry in the observations for both slits about a central time. For example, 2 minutes with the object in the left slit, 4 minutes right, then 2 minutes left will provide better sky subtraction then 4 left and then 4 right. Also, in general, it is better to switch the object between the slits at **least** every eight minutes.

19. **Telescope Focus.** Focus the telescope on the spectrograph by adjusting the secondary mirror while looking at the apertures with the TV (5th mag or fainter, of course). The aperture inserts are tilted in order to reflect the beam to the periscope and then to the TV, so focus on a line between the apertures to ensure that the focal plane will intersect the apertures. It is sometimes the case that the best focus for the apertures does not quite coincide with the best focus in the full field (diagonal mirror in) mode. In this case it is usually convenient to just leave it at the best aperture focus.

20. **Do Not Defocus.** Do not attempt to observe bright objects by defo-

(for page 15)

21. <u>DEC Computer Escape</u>. If you find yourself in an undesirable mode with the PDP-8I that you can't exit gracefully (-1 in response to a prompt will often work), then use Ctrl-C ~~(return)~~. Remember that you enter the data taking programs by making a selection from switch (1,1) on the switch panel, then typing G (return). If you want to make another ~~selection~~ selection from (1,1), exit the current program by typing Ctrl-C.

cussing them. We have found that for objects which are out of focus and off axis (to avoid the shadow of the secondary) the response of the system changes drastically and in a complex way. These difficulties may be avoided simply by keeping objects in focus and using the neutral density filters when necessary.

21. **DEC Computer Escape.** If you find yourself in an undesirable mode with the PDP-8I that you can't exit gracefully (−1 in response to a prompt will often work), then use Ctrl-C. Remember that you enter the data taking programs by making a selection from switch (1,1) on the switch panel, then typing G (return). If you want to make another selection from (1,1), exit the current program by typing Ctrl-C.

22. **TV Caution.** The most vulnerable part of the spectrograph is the TV. Please read that section of LOTR No. 36 again, and **be careful with it!.**

Chapter V: On Using the 40 Inch at High Dispersion
(by Fred Walter)

For the past year I have shunned the standard grating on the 40 inch ITS, to work in second and third order at Hα and Ca II H+K. In 2nd order at Hα, one can get $\sim$ 2 Å resolution, and at 3rd order near 4000Å , one can get $\sim$1.5 Å resolution. This is adequate for resolving the Ca II H+K emission cores in relatively weak chromospheric emitters such as ξ Boo A and σ CrB B (see figures).

TABLE 1

λ_c	Order	Grating Tilt	Filter	Reciprocal Dispersion at Center
4000	2	250	5 (BG 38)	.57 Å channel
4100	3	332	6 (blue dichroic)	.33 Å channel
6500	2	350	4 (GG 495)	.49 Å channel

The settings I have used are given in Table 1. The dispersions are measured from the lines in HM Sge in the blue, and from the calibration lamps in the red. The reciprocal dispersion as a function of first order wavelength is given by

$$D = 1.369 - 3.2\text{E-}5\lambda \text{ Å /channnel}$$

λ as a function of grating tilt is well approximated by the following linear relation, to at least a grating tilt of 350, for both the 7500 Å and 1μ gratings.

$$\lambda_c = 4000 + (\text{Grating tilt - 170}) \times 50 \text{ (first order)}$$

The 7500Å grating is the best to use in 2nd order blue. It is more efficient than the 1μ grating at 4000Å, and the two are comparable at 4500Å.

TABLE 2
Efficiency of 1μ Grating Relative to 7500Å Grating

λ	λ_{order}	Grating Tilt	$\eta_{1\mu}/\eta_{7500}$
4000		170	<0.1
5600		202	~0.3
6000		210	~0.3
6500		220	~0.5
8000	4000/2	250	~0.5
8800	4400/2	250	~1.0
12300	4100/3	332	~3.0
13000	6500/2	350	10.0

The 1μ grating must be used for 2nd order red and 3rd order blue (see Figure 1 for Ne+(He-Ar) calibration lines at 2nd order red). At first order centered at Hα, the 1μ grating is a factor of 2 slower than the 7500Å grating; at 6000Å it is about a factor of 3 slower. These 2 gratings also have far fewer fingerprints than does the standard (5000 Å) grating.

Note that filter 5 is probably not a BG38, because there is no first order light leak from 7000-9000Å. The BG38, as described in a Kodak manual, has 80% transmission at 8000Å. Filter 6, an interference filter supplied by Steve Vogt, cuts off completely between 5400Å and 7300Å , with 85-90% transmission from 3870Å to 5000Å (except for ripples at ~4650 and 4900Å which go to 81 and 71%) - see Figure 6 for transmission curve. This filter is excellent for work at 3rd order blue.

The IDS on the 40 inch, because of its good intrinsic resolution (4-5 channels), can be a very useful instrument for work at moderate (2Å) resolution, with a limiting magnitude at 4000Å of ~13 (~1 hour exposures).

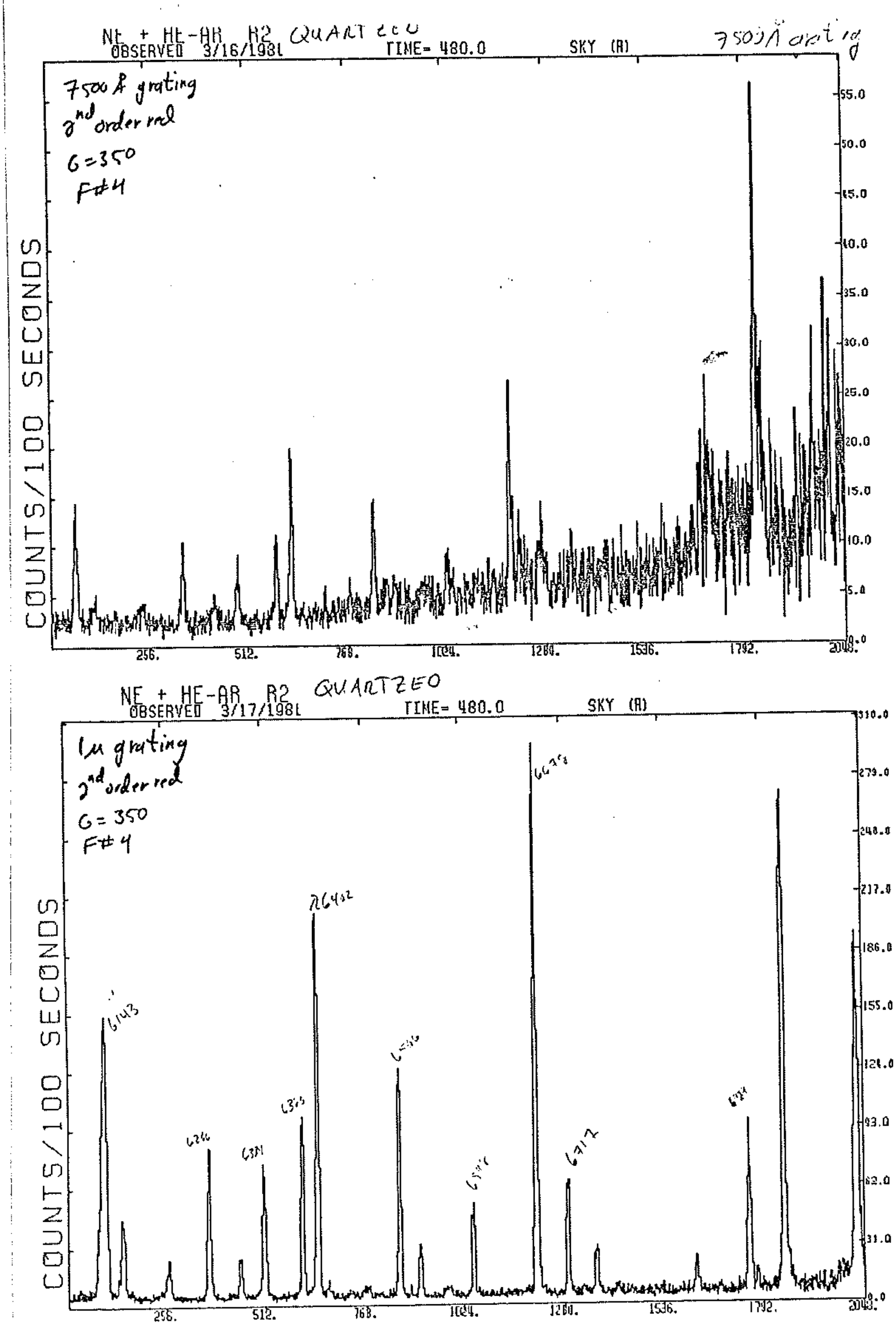


Figure 1. Calibration lamps centered at 6500 Å, second order for the 7500 and 1 μ gratings. The data have been quartzed. Both scans are 8 minutes. The 1 μ grating is far superior. Note the separation of the λ6383 and λ6402 focussing lines.

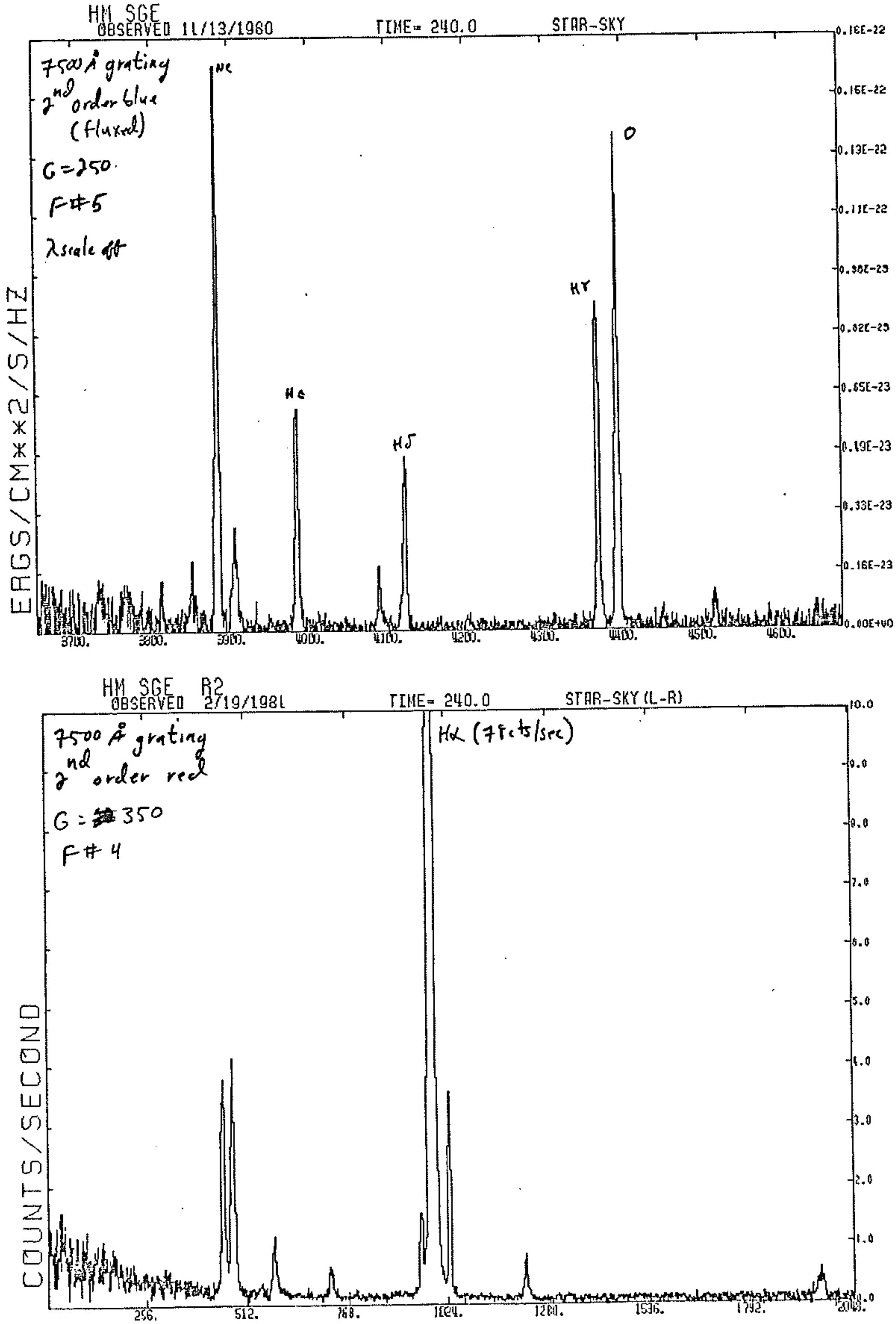


Figure 2. HM Sge, a good cosmic calibration line source, demonstrating the capabilities of the IDS at second order red and blue.

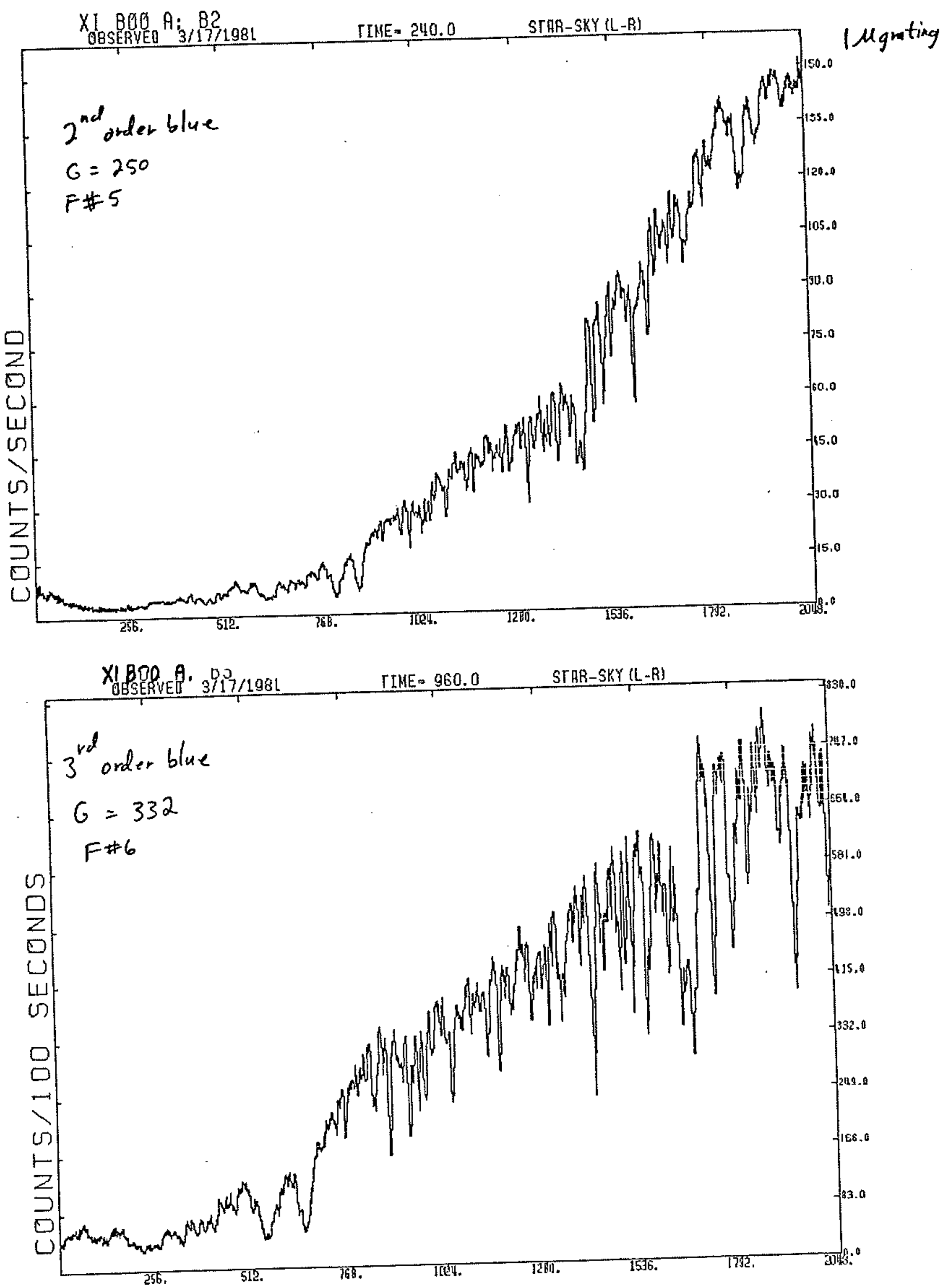


Figure 3. Spectra of ξ Boo A (G8V) at second and third order in the blue. The relative count rates are misleading because the third order spectrum was obtained through clouds.

1u grating

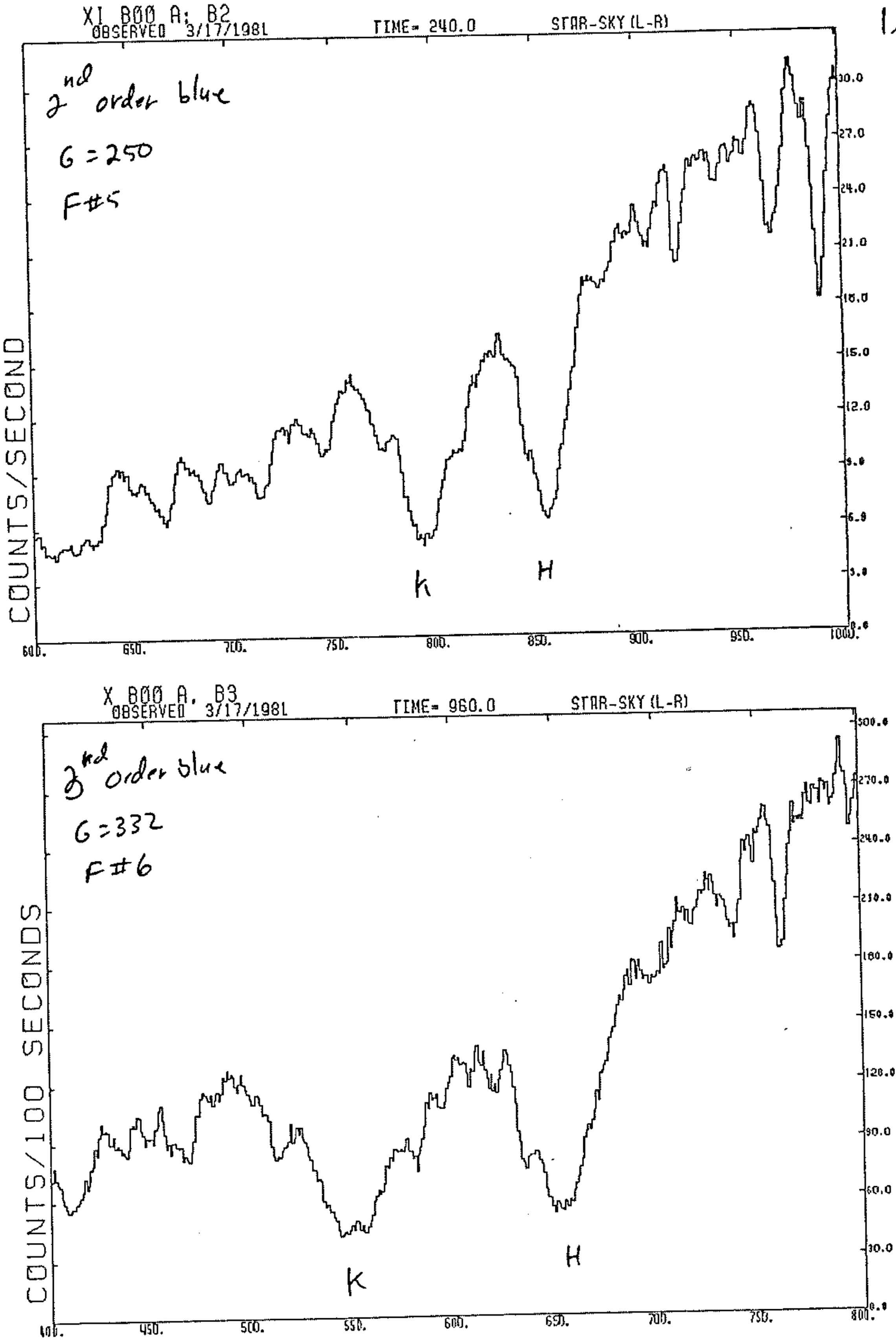
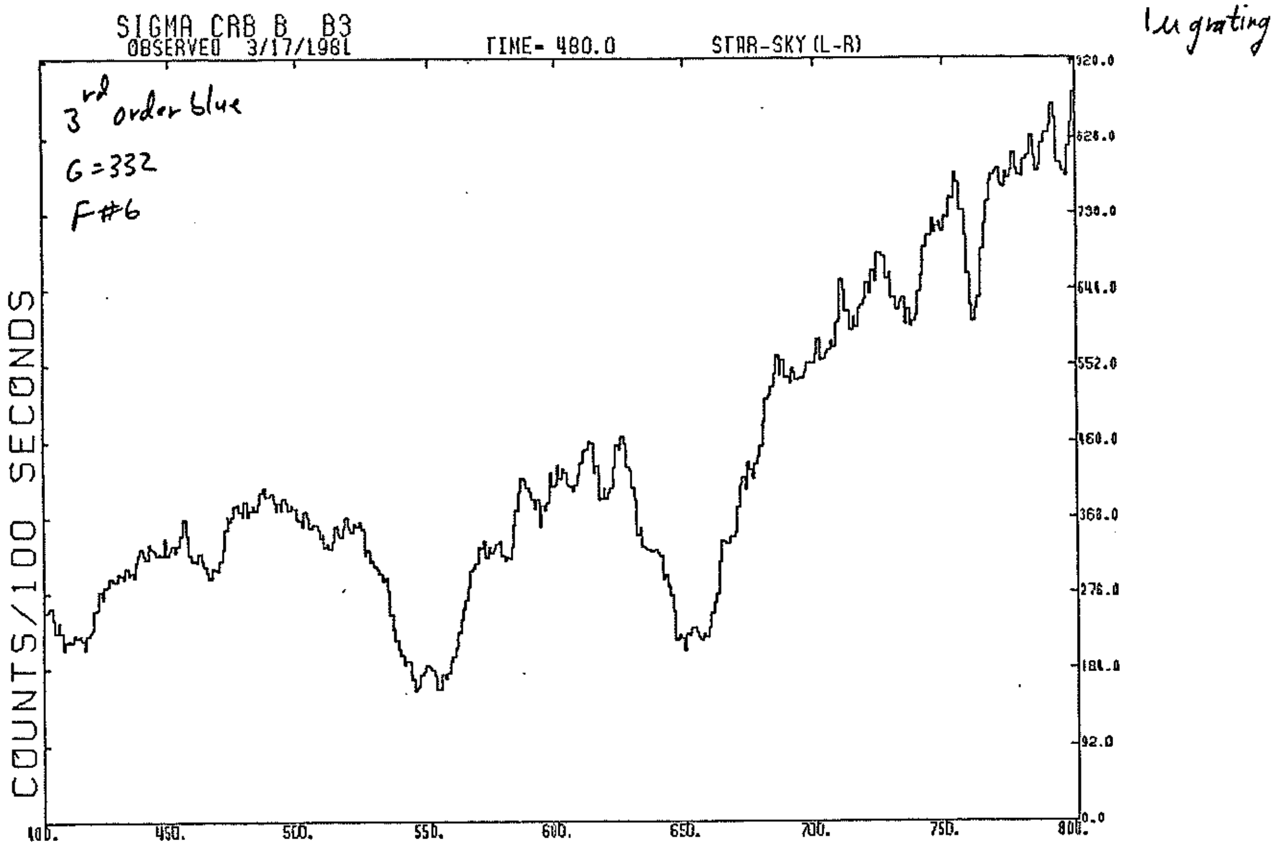


Figure 4. A blowup of the spectra in Figure 3 to detail the improvement in resolution in 3rd order. The Ca II K emission core is obvious.



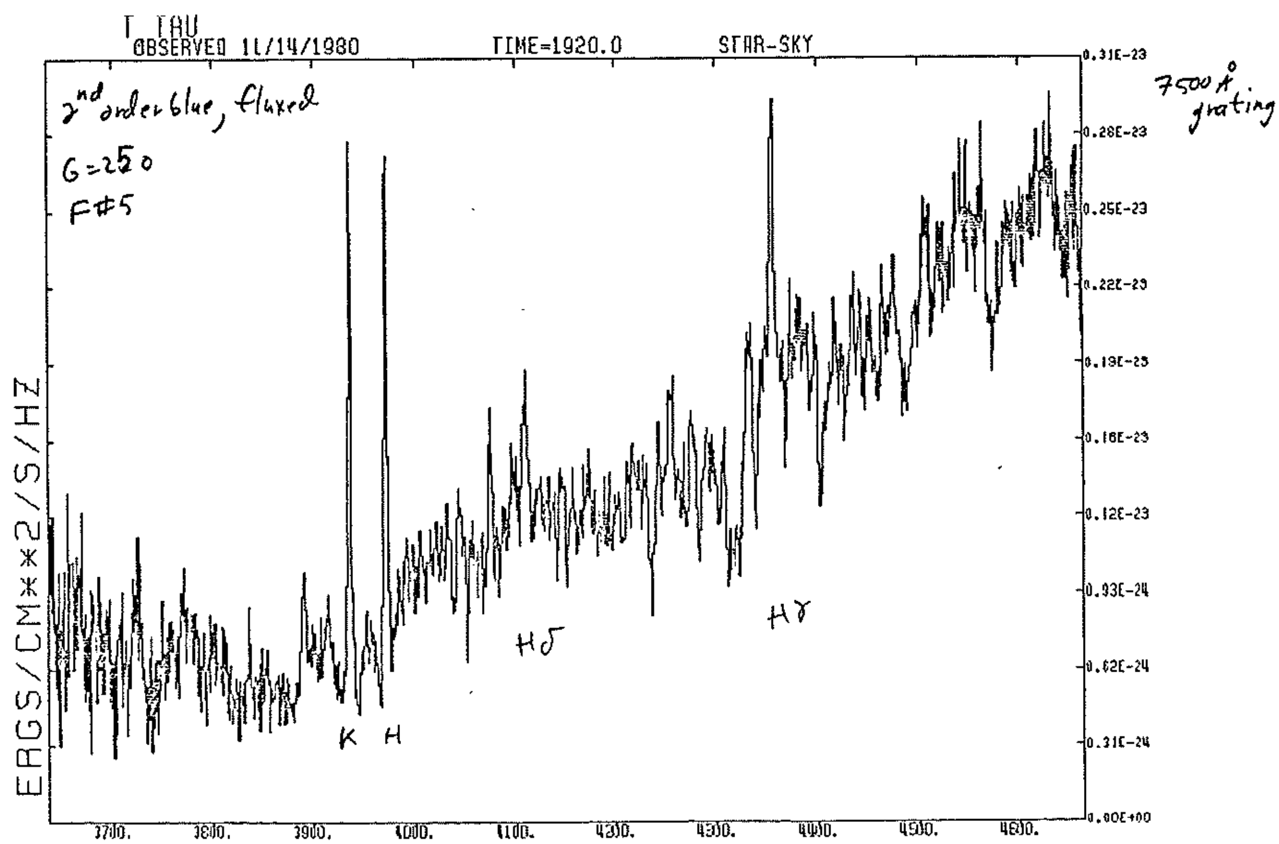


Figure 5. More examples: The Ca II H+K emission cores of σ CrB B in 3rd order, and a fluxed 2nd order spectrum of T Tauri.

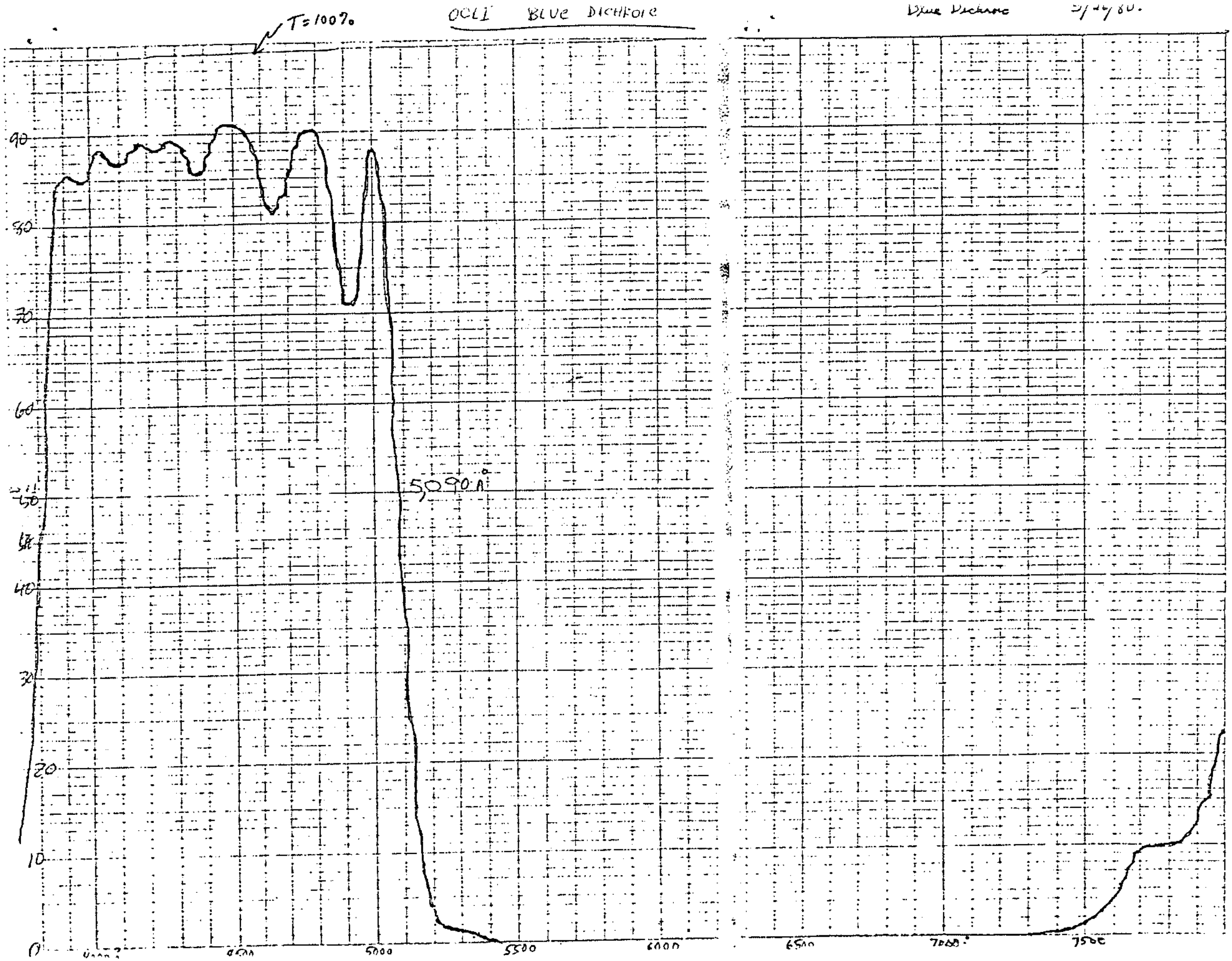


Figure 6. Transmission of filter 6 (blue dichroic).

Chapter VI: Notes on the 32K Scanner Data Taking System
(by Steven A. Grandi)

These notes are designed to acquaint experienced users of the standard 8K Scanner Data Taking System (SDTS) with the new "2-slit" 32K-SDTS written by Bob Kibrick (with additions by Alan Koski). Much of the information in LOTR No. 14 on 8K SDTS still applies fo 32K-SDTS. Among the new features in 32K-SDTS are: support of 9-track tape as a data output medium, support of the area scanner memory (32K memory) in the 2-line mode, a vastly improved wavelength calibration system capable of fifth-order fits and lots of bells and whistles. In the following numbered notes, I will summarize these changes.

1) Different switch labels are required for 32K-SDTS. These labels are annotated "32K" and are kept in the front of the disk notebook. Note that the two buttons below the joystick are important in 32K-SDTS: Switch 3,11 should be labeled "CHANGE COUNTING TIME" and switch 3,12 should be labeled "TROUBLE RESET/ABORT PLOT." The switch locations in 32K-SDTS have been given a more logical arrangement - - the location of the toggle switches that activate the "SPECIAL FUNCTIONS," "MORE GOODIES," and "STILL MORE STUFF" functions now corresponds spatially to the respective rotary switches.

2) 32K-SDTS supports the 32K area scanner memory for use in the "normal" 4K 2-slit mode (although I personally have never so used it). When using this mode of data taking, the real time scope will look a bit odd: eight sweeps will be seen instead of the normal two. However, the bottom six sweeps are duplicates of the top two; so an adjustment of the real time scope controls will make the display look "normal." Note that the counting statistics obtained using the area-scanner in the 2-line mode should be better than those obtained with the 4K memory since each channel is sampled by the image dissector more frequently.

The user must tell the program which scanner memory he/she is using during initialization. The old scanner memory is called the "regular" or "4K" memory. Note that when using the area scanner memory, the sweep box must be set for eight lines of data as well as the memory box.

3) Data can be written to 9-track, IBM-compatible tape instead of, or in addition to, Dectape/floppy disk. The resulting 800 or 1600 BPI 9-track tapes can be run through the IBM Scanner Data Reduction System (see LOTR No. 15 and No. 26) and they can be read by UCLA-FSDRS. More details about the tape format can be obtained from Bob Kibrick.

Several nights' worth of data can be put on one reel of tape by using different files, normally one file per night. The Tape file is specified in the initialization process. (You have to remember how many scans are contained in the existing files, however.)

The IBM tape can be safely rewound by dialing "IBM TAPE" on "STILL MORE STUFF". You will have to "START DATA TAKING" to add data to the rewound tape. IBM tape reels are also given six-characater names during initialization.

Several error-checking features have been included in 32K-SDTS. First of all, simultaneous data recording on both IBM tape and dectape/floppy disk is possible in 32K SDTS. Second, an initial check of the proper functioning of the IBM tape is made during initialization (The program types "IBM DRIVE IS NON-FUNCTIONAL" and quits if the tape-drive is broken. Take data on floppies only!) Finally, after each scan is written on the IBM tape, the IBM tape scans are reread, the sum of all the channels is computed and compared to the sum of the channels in the last-run buffer. If they don't agree, a message is printed - - but no further action is taken to correct the error.

Most SDTS functions ("LOG-LIST," "RECALL A RUN," etc.) can obtain data from either the dectape/floppy or IBM tape. However, "TAPE I/O," "LOG EDIT" (the IBM tape is a sequential medium - - you cannot replace existing records), "LAMBDA CALIBRATION," "CALIBRATION SETUP" (to sum quartz scans) and others require input scans to be on dectape/floppy.

4) The dectapes produced by 32K-SDTS are in a different format ("new style") from those produced by 8K SDTS ("old style"). In addition, 23 scans (numbered 0-22) are written per dectape by 32K-SDTS rather than 18 (numbered 0-17) as are written by 8K SDTS. The new UCLA-FSDRS (Fortran Scanner Data Reduction System) will read both new- and old-style dectapes. Several of the utility programs on the 32K SPECIAL tape (LOTR No. 26) will properly access either style of dectape. New log sheets have been created for the 32K-SDTS (see the Appendix). Dectapes are identified by a dectape number; the initial dectape number of the night (1052, for example) is specified during SDTS initialization.

5) 32K-SDTS uses a running scan number that is different (in principle) from the scan number on the output dectape. The output dectape scans are referred to by slot number (0-22 on a single tape). Thus, the program might print out: "SCAN 76 on DECTAPE (4,7)" which means scan number 76 was written on dectape 4, slot 7. When the program asks for a **slot** number, respond with the position on a dectape and not with the running scan number.

6) Sweep setting is different in 32K-SDTS from that in 8K-SDTS, but it is straightforward. However, automatic sweep setting is unavailable. A choice is given when mapping the tube between the normal display and a display without the 4X vertical magnification ("full" display). The program will print "SET LINE/SWEEP COUNT SWITCHES TO 2 ON 4K and SWEEP BOX" when using the normal scanner memory or "SET LINE/SWEEP COUNT SWITCHES TO 8 ON AREA SCANNER AND SWEEP BOX." These adjustments should have already been made by the electronics crew. When the sweeps are marked as **not** OK, the sweepsetter is given the option of retracing only one of the two sweeps. (Indicate that the sweep is to be set by

the joystick, specify whether one or two sweeps are to be traced, then specify which sweep.) The "copy boxes" allow one to copy a previous sweep and move it (preserving the shape). I have never used this feature, however.

7) Initializing data-taking is a more complicated process with 32K-SDTS than with 8K-SDTS but again it is straightforward. **Follow instructions!** Basically, the user must configure the data-taking system to correspond to the hardware actually in use. Thus, operating at the 40-inch, or when a device such as the clock is broken is simply a matter of flipping the appropriate toggle switch. If you are observing on the 120-inch, are using the normal 4K scanner-memory and everything is working, just hit the carriage return without flipping any switches. (As of mid-1984, at the 40-inch the following are unavailable: x-y stage (switch 4, 11); spectrograph control (4,12); time standard (4,7); tub (3,2); and since one usually uses the 4K scanner memory, one marks as unavailable the area scanner memory (switch 3,3). The "quickstart" feature immediately after startup can be used to save time on later initializations.

8) To construct summed quartz scans for use as calibration buffers is an easy process with 32K-SDTS. Merely dial up "CALIBRATION SETUP" on "STILL MORE STUFF" and follow directions. Note that the acceptable calibration buffers are 1-6.

9) The LED readouts now display the time left in the scan instead of the time elapsed in the scan. Also, the display is updated while plotting or while waiting for a keyboard response.

10) The number of counts in the left and right channel is no longer written on the terminal when a scan is written to IBM tape, only when it is written to dectape. If the program detects a problem when it **reads** the tape after the data are written, the channel sums are typed out. Note that even when the program **thinks** it has found an error, it just may be another episode of flakiness. I haven't lost any data yet.

11) In addition to the "AUTO SLIT CHANGING" function, 32K-SDTS has an "AUTO START" function which will not only change slits but also start a new scan without any operator intervention. (The slit code is automatically changed and typed out as well.) Since the telescope is moved between slits before the previous scan is written onto tape, a minimum amount of observing time is lost. Remember to turn this switch off during the last scan of a sequence.

I use this feature routinely and I have found that the auto-slit changer is quite accurate in 32K-SDTS.

12) 32K-SDTS attempts to catch errors in entering slit codes. If a previous scan had a slit code of L or LN, and the slits were changed under PDP-8I computer control, then 32K-SDTS expects a slit code of R. If R was not entered, "???" will be typed as a reminder and a new code is requested. (Any code will be accepted now, however.) Conversely, if the computer did **not** change slits for you, the program expects the same slit code as before. Hence, if you start in the Left slit, move manually

to the Right slit, the program will respond with ??? to the entered R slit code. Just enter R a second time and the program will believe you.

The program also checks, after the completion of a scan, whether the star channel had more counts than the sky channel. If not, a message is typed.

The program also has a feature so that it will not wait forever for the user to enter the slit code and/or name. Thirty (30) seconds after the scan ends, the computer gives up and tries to deduce a slit code as best it can. A missing name is set to blanks.

13) An auto-scaling feature is available for plots. Place the "OFFSET" switch on its top ("AUTO-SCALE") position, and the highest point in any plotted scan will be placed at full scale. (An offset of 50 is used in the auto-scaling mode.)

14) The "COMMENTS" switch can also be used to change the slit code or name of an **in-progress** scan. Note that it is impossible to log-edit a scan after it has been written onto 9-track tape. (The new FSDRS will allow later editing of mag tape data, however.)

15) There is an interlock built into 32K-SDTS to prevent certain conditions, such as the needed replacement of a dectape/floppy disk, scans taken with the dark slide closed, sweep diaster, etc., from being ignored. When such a condition is detected, the trouble light is lit and no data will be written until the TROUBLE RESET button (below the joystick) is pushed. (The trouble light will then be extinguished.)

16) The "CHANGE COUNTING TIME" function is now invoked by switch 3,11 (below the joystick). The new counting time is entered in minutes (< 32), and will show up immediately on the LED display.

17) 32K-SDTS does not (yet?) include the following 8K SDTS functions: the ability to scrunch or smooth scans; a programmed sequence facility; or the ability to do simple precessions without the "set telescope" corrections.

18) The lights on the switch panel have new meanings in 32K-SDTS. The two leftmost lights are "idle" lights and alternately flash when the program is waiting for a command. Note that the flashing frequency of these lights drops when "ENABLE AUTO-SLIT CHANGE" or "ENABLE AUTO-START" is left on. The "trouble" light was discussed in note 15. The "busy" light is on when the program is reading and processing a scan. The "paused" and "counting" lights are obvious.

19) A FOCAL listing of 32K-SDTS may be obtained by accessing the "SUB-SYSTEM"position of the "SPECIAL FUNCTIONS" switch and requesting option 2.

20) If you took data on floppies and decide to carry your data home on a reel of IBM tape, initialize 32K-SDTS (with output to "IBM TAPE ONLY") and call up "SUB-SYSTEM" on "SPECIAL FUNCTIONS." Option 4 is a dectape/floppy-to-IBM copying utility. The user specifies the beginning and ending slot number for each volume (presumably 0 and 22, except for the last dectape/floppy). The scans are copied to IBM tape in the same format and with the same error checking procedures

as described above. It is advised that the user finish the job by doing a "LOG-LIST" of the IBM tape. It will take about 5 minutes per floppy.

21) The IBM tape drive still exhibits occasional episodes of flakiness; specifically, it seems to get lost and slips one record. This only happens when you are moving backwards and forwards on the tape (doing log lists, recall runs, etc.). My advice: after you have completed the tape moving exercise, do a log-list of the **last** scan on the tape. This should straighten things out. If you do find a problem (the usual symptom is a message saying, "wrong length record detected - - -"), unload the tape with "IBM TAPE" and restart data taking. My final advice: always do a complete log-list of the IBM tape at the end of the night. You can always restore the tape from your backup dectapes/floppies in case of disaster.

APPENDICES

Appendix A: 40 Inch ITS Checklist

I. Setup

1. You will need 9-track tape and/or **formatted** floppy disks, and logsheets. If you still need to format your floppies, do it now.

2. Turn on nitrogen to "hold" (check 5" water pressure at N_2 regulator and check tank quantity in round room); remove screw from brass purge fitting on dissector. Press "reset" on junction box at south pier.

3. Turn on computer, teletype, memoscope and real time scope. Bootstrap and load data taking system. Start data taking program. If 32K, stop at fast sweep load.

4. Turn on rate meter crate.

5. Turn on scanner memory.

6. Turn on sweep box. Load sweeps from disk, and watch them load on the real time scope so you know it is working.

7. Set up the scanner memory with gate open and max gain, then

8. Set dissector voltage while watching the real time scope memory display. Should see negligible counts at full dissector voltage.

9. Set image tube voltage (24 kV). Pause at 15 kV and verify visible dark current, but only a little. More or less may indicate a malfunction.

10. Set sweeps (just to be sure it works, that light is reaching the tube, etc.) Try grating 217.5, diagonal mirror in, neon lamp, no filter, aperture 4 or 8 arcsec, 1 count/dot, dark slide open.

11. Turn off lamps, close dark slide open.

12. If everything looks OK so far and tube has purged for **at least** 30 minutes, replace purge screw.

13. Check the red thumbscrew loose, check the alcohol levels, turn on the pump and ice up.

II. Start

1. Two hours or more after icing, tighten the red thumbscrew.

2. If the weather looks good, remove the plastic cover from the telescope. Once the cover is off, **you** are responsible for replacing it in a timely manner so as to protect the telescope and instruments from moisture.

3. Remove and stow RA locking bar.

4. Set aperture carefully. Suggest 4 arcsec aperture for steps 5 and 6 below.

5. Set sweeps (for real). Use secondary or room lights, point telescope to white spot on shutter or white windscreen. Try grating 217.5, no filter, 1 count/dot. Dark slide open, diagonal mirror out.

6. Focus dissector and camera. Use same setup as above, but neon lamp on, diagonal mirror in.

7. Do a continuum ("quartz") calibration. Use secondary lights on white spot or windscreen, aperture size you plan to observe with. Set grating to ~ 228, open mirror cover, diagonal mirror out. Use ND filter if necessary for a large aperture.

8. Load calibration buffer.

9. Do wavelength calibration (diagonal mirror in).

10. Being very careful of any weather threat, open the dome to cool, if desired. Open mirror cover. Do not allow sunlight to hit telescope. Do not allow ITS to see bright sky (dark slide closed)!

11. Turn on and load the PET computer and telescope control monitor.

12. Check time and date on Telco, and load if necessary.

13. When ready to observe, check dome floor clear, lights off.

14. Turn on auto dome and track; check and reset dome centering.

15. Set to an Ephemeris star and visually check coordinates with finder first night or after power interruption.

16. You may use the TV without a neutral density filter beginning 45 minutes before the end of astronomical (18°) twilight and up to 45 minutes after astronomical dawn. Remember: 5th mag max.

III. End of Night

1. Turn off TV (gain to minimum, integration to minimum, integration and store switches off, shutter closed, camera control off, sync generator off, monitors off).

2. Auto dome and track off.

3. Close dome.

4. Do wavelength and quartz calibrations as necessary.

5. Line lamps, continuum sources off, close dark slide.

6. Close mirror cover.

7. Dome stows with slit east (align arrows on wall and dome).

8. Re-ice (this is required every 8-10 hours).

9. **Loosen red thumbscrew.** Once again, do not let the tube warm up inadvertently with that thumbscrew tight!

10. Cover telescope and stow near north limit (winter) or at zenith (summer).

11. Install RA locking bar.

12. Press "panic" button on junction box at south pier.

13. Take a final look around the dome for anything else you forgot. Turn off lights. Lock dome door.

14. Remove disk. Turn off the PET computer and telescope control **monitor**. (Leave Telco on!)

15. Remove disks. Turn off the DEC computer, real time scope, memoscope, decwriter.

16. Fill out logbooks. Try to be complete and precise in your comments. Also report problems to the 120 inch (ext. 51).

17. Insure that both doors are locked before you leave.

IV. End of Run

1. If possible, coordinate with the following observer to keep things on and cold. In the absence of an **explicit** arrangement with such an observer, do the following in addition to the End of Night list above:

2. Gradually turn the image tube power supply to zero and turn off the power switch.

3. Do the same for the dissector supply.

4. Turn off the rate meter crate, memory box and sweep box.

5. Turn the nitrogen timer to 4 hours (at the south base of the telescope).

6. Check again that the red thumbscrew at the top of the image tube chain is loose.

7. Turn off the alcohol pump.

8. If you used other than the standard grating, **replace standard grating.**

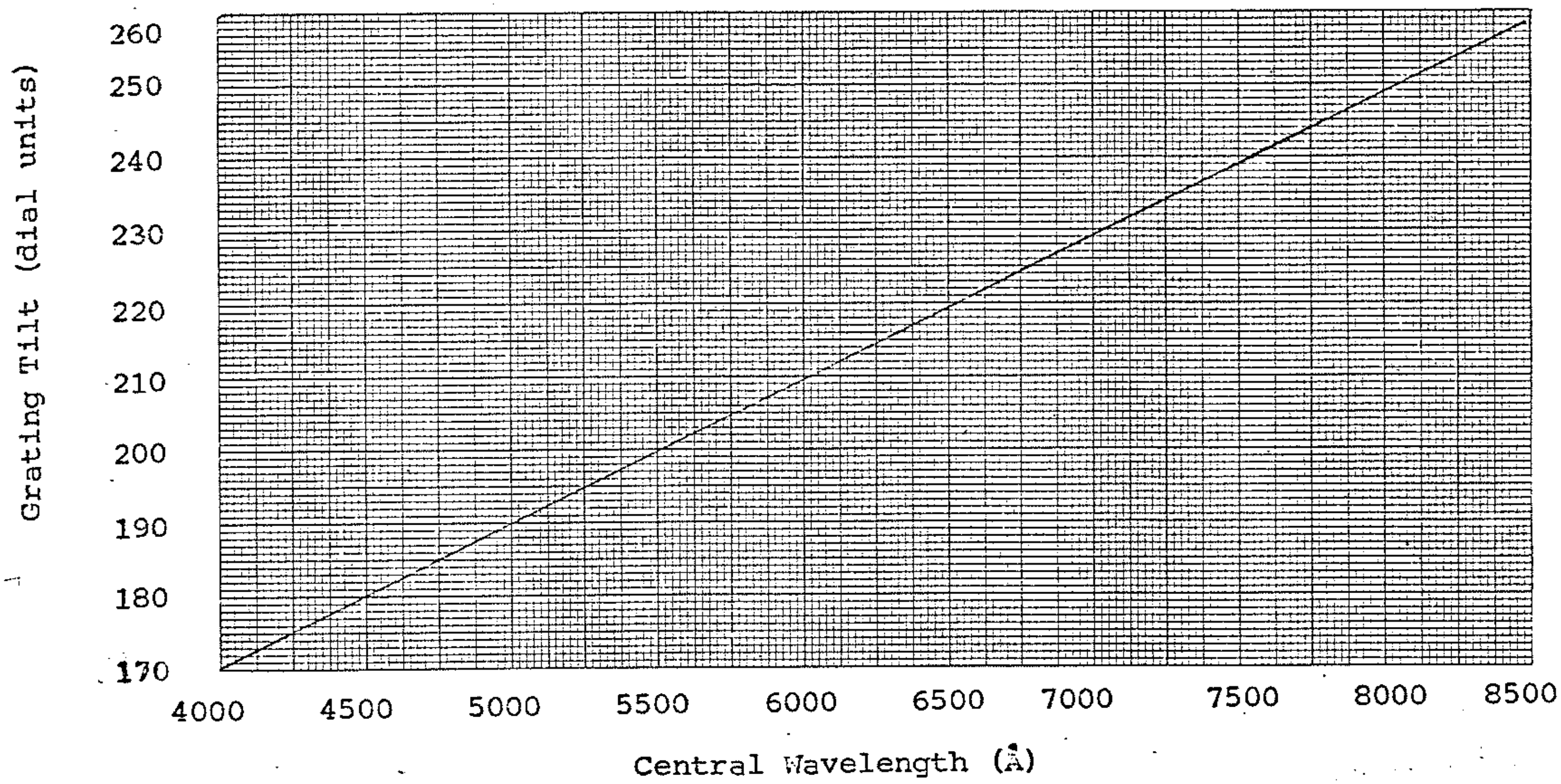
9. Store all system disks properly in the storage binder.

10. Clean up the readout room.

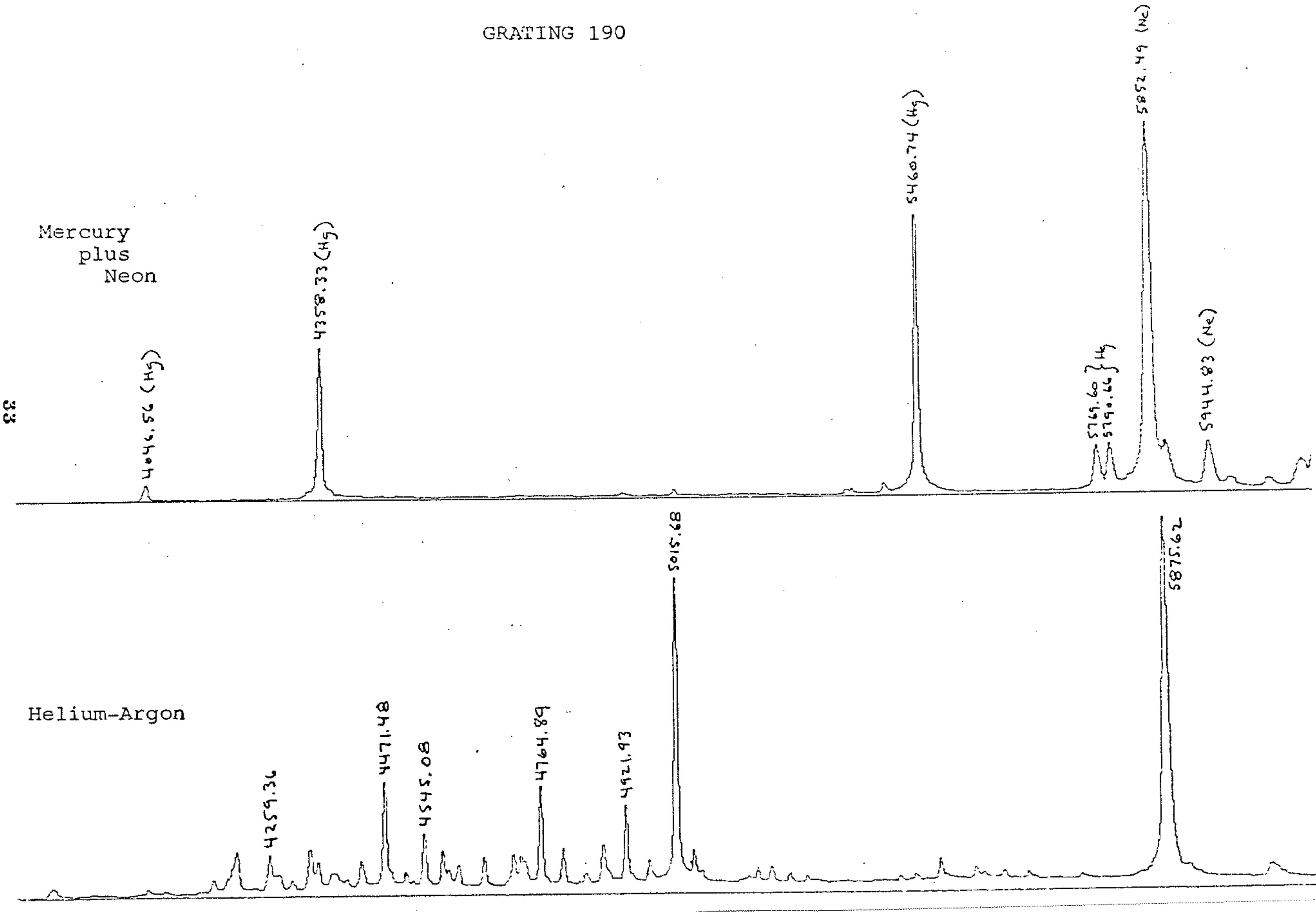
11. Lock doors.

Appendix B: Grating Tilt versus Central Wavelength

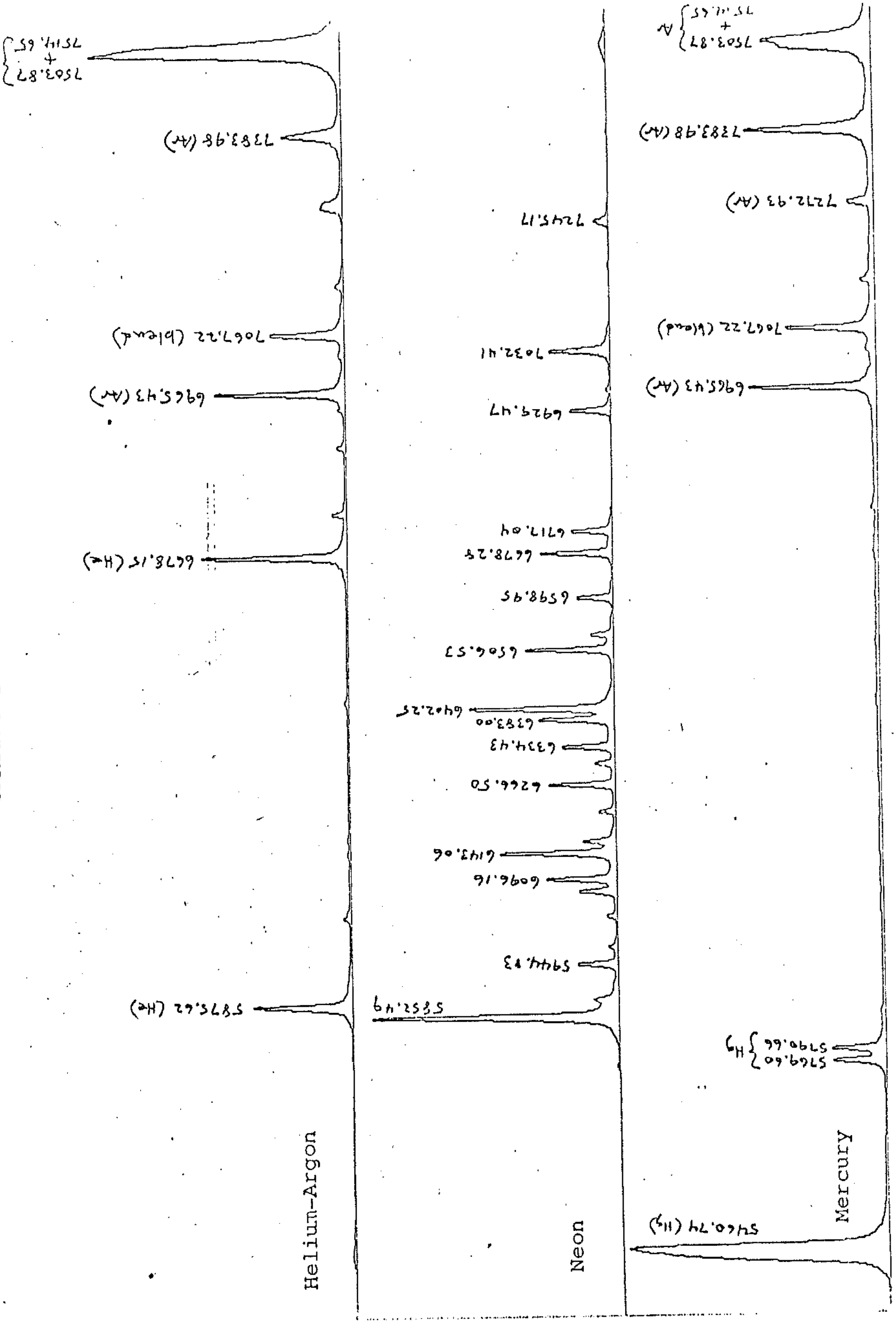
This chart assumes all grating settings are <u>clockwise</u>; that is, lower to higher.



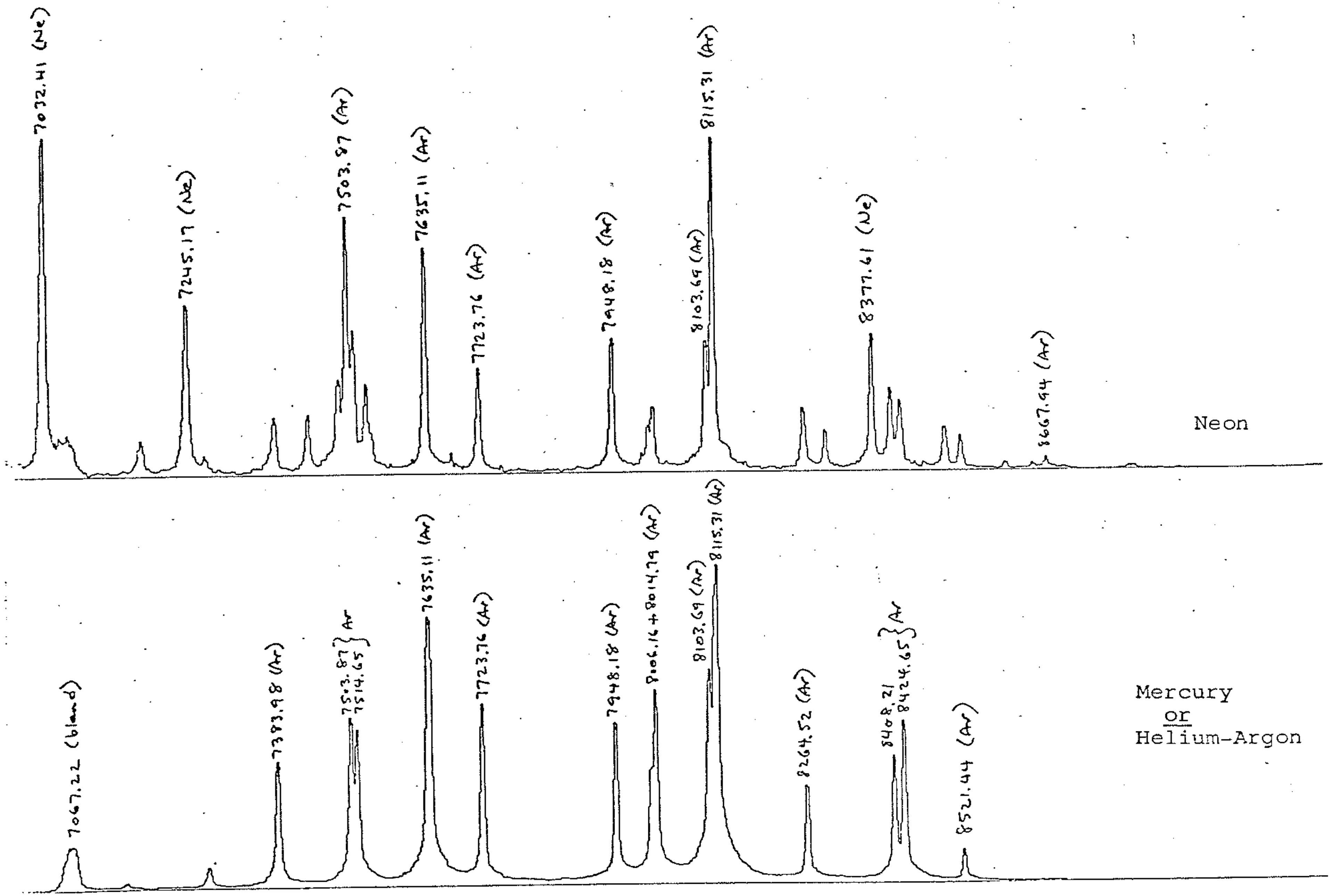
GRATING 190


Mercury
plus
Neon
4046.56 (Hg)
4358.33 (Hg)
5460.74 (Hg)
5769.60
5790.66 Hg
5852.49 (Ne)
5944.83 (Ne)
Helium-Argon
4259.36
4471.48
4545.08
4764.89
4921.93
5015.68
5875.62

GRATING 220


Helium-Argon
7503.87 + 7514.65 Ar
7383.98 (Ar)
7067.22 (blend)
6965.43 (Ar)
6678.15 (He)
5875.62 (He)
Neon
7245.17
7032.41
6929.47
6717.04
6678.28
6598.95
6506.53
6402.25
6383.00
6334.43
6266.50
6143.06
6096.16
5944.83
5852.49
Mercury
7503.87 + 7514.65 Ar
7383.98 (Ar)
7272.93 (Ar)
7067.22 (blend)
6965.43 (Ar)
5769.60 5790.66 Hg
5460.74 (Hg)

GRATING 250


7032.41 (Ne)
7245.17 (Ne)
7503.87 (Ar)
7635.11 (Ar)
7723.76 (Ar)
7948.18 (Ar)
8103.69 (Ar)
8115.31 (Ar)
8377.61 (Ne)
8667.94 (Ar)
Neon
7067.22 (blend)
7383.98 (Ar)
7503.87
7514.65
Ar
7635.11 (Ar)
7723.76 (Ar)
7948.18 (Ar)
8006.16 + 8014.79 (Ar)
8103.69 (Ar)
8115.31 (Ar)
8264.52 (Ar)
8408.21
8424.65
Ar
8521.44 (Ar)
Mercury
or
Helium-Argon

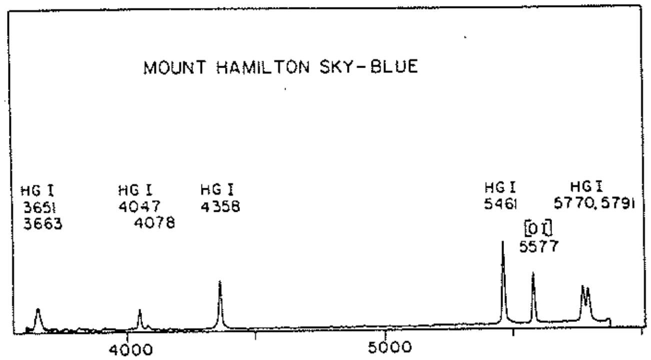


FIG. 1—The blue region of the night-sky spectrum observed from Mount Hamilton on 1975 August 2/3. The exposure was 64 minutes centered about 23:37 PST at a mean zenith distance 19° and azimuth 130° ($\alpha = 21^h22^m$, $\delta = +25°$; $\ell = 75°$, $b = -18°$). The relative flux per unit frequency interval is plotted against wavelength to the same scale as Figure 2.

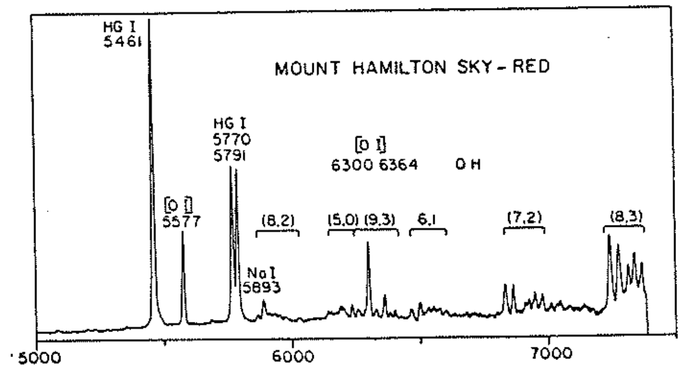


FIG. 2—The red region of the night-sky spectrum observed from Mount Hamilton on 1975 August 2/3. The exposure was 48 minutes centered about 21:50 PST at a mean zenith distance 53° and azimuth 248° ($\alpha = 15^h14^m$, $\delta = +70°$; $\ell = 10°$, $b = +50°$). The relative flux per unit frequency interval is plotted against wavelength to the same scale as Figure 1.

This figure is from Osterbrock, Walker and Koski, P.A.S.P. 88, 349 (1976). Since these figures were generated, extensive installation of low pressure sodium lights in Santa Clara valley has resulted in Na D becoming the strongest night sky feature.

APPENDIX C

Appendix D: Filters

The filters and positions shown here are as of mid-1984. The most likely change is just to add filters not listed here. However, there is nothing sacred about these lists and the actual contents of the filter wheels at any time will be found on the filter position list, on the spectrograph below the filter access door.

Position	Filter	Position	Filter
1		9	QND 1.75 mag
2	GG 385	10	QND 2.5 mag
3	GG 455	11	
4	GG 495	12	QND 5 mag
5	BG 38 (4mm)	13	QND 7.5 mag
6	Blue dichroic ($\lambda\lambda$3700-5150)	14	QND 10 mag
7		15	
8		16	

Note: Filters prefixed GG are Schott numbers for order separation. The three digits indicate the cutoff wavelengths; GG 455 cuts off at $\sim$ 4550 Å . QND means Quarts Neutral Density.

IMAGE TUBE SCANNER

Date ______________ Image Tube ____________ Volt. _

Observer ________________ Assistant ________________ Tape ________ of ____________ Dissector Volt. ________

Collimator Focus ______________

an	Object	Slit	H.A. Start	Int. Time	P.S.T. Start	Seeing	Slit Width Set.	″	Decker Set.	″	Gr.	Swp.	Gr. Set.	Tilt λ_c/Order	Corr	Upper Filt Set.	I.D.	Lower Filt Set.	I.D.	ID No.	Remarks

9-TRACK ______

IBM FILE ______ DISC: ______

IDS OBSERVATIONS

Observer: ______ Ass't: ______ HV: ______ Focus: ______ Date ______ 19 ___ UT

Tube: Corr:

SLOT	SCAN	Object	RA	DEC	AP	SLIT	DECK	Filt. U	Filt. L	Gr. Tilt	Gr.	Int. Time	H/A Start	PST	Remarks
0															
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															
11															
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14															
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17															
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19															
20															
21															
22															

Appendix F: Telescope Limits

Wind: Steady at, or significant gusts over 50 mph.

Humidity: Close if relative humidity exceeds 95%, or as necessary to exclude moisture. Please note that it takes special effort to keep aware of changes in the weather when you are observing remotely from the control room. Nevertheless, you will be the responsible person if you fail to protect the telescope and equipment from moisture. Be aware of trends in the weather, and look or go outside as often as necessary.

Telescope Position Limits Hour angle: $5^h\ 30^m$ E or W

Declination: $+67\overset{\circ}{.}5$, $-39\overset{\circ}{.}5$. Slew is disabled and set speed only is available north of +65°.

Elevation: 13°

Zenith: Partial occultation by dome at <4°

TV: 5th magnitude maximum