UNIVERSITY OF CALIFORNIA

LICK OBSERVATORY TECHNICAL REPORTS

No. 61

NICKEL TELESCOPE USER'S MANUAL

R.P.S. Stone

It is intended that this book be used
in conjunction with one for the instrument
you intend to use

Santa Cruz, California

July, 1992

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Many shall run to and fro, and knowledge shall be increased.

Daniel XII, 4

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I. Introduction and General Remarks

The 1-meter Anna L. Nickel Telescope was placed into operation in 1979. It is housed in the dome at the north end of the Main Building, which was formerly occupied by Lick's first permanent telescope, an Alvan Clark 12-inch refractor. The Nickel telescope was designed and built by Lick personnel, drawing heavily on accumulated spare materials (hence one nickname, the "Spare-parts Telescope"). At the time of construction, it was estimated that a commercial 1-meter telescope with a dome at this site at the same time, with no instrumentation, would have cost about $750,000. It is quite remarkable then that the telescope was placed into service with an image-dissecting spectrograph for a cash outlay of only $28,000. Thus, the telescope is a tribute not only to the generosity of Anna L. Nickel, but also to the very clever engineering staff at Lick Observatory.

The 40-inch is a highly automated, complex, modern telescope. It is suggested that this manual be read rather completely in order to speed up the checkout process. An additional advantage to reading the manual is that if you have a problem or question, you'll probably know where in the manual to find the answer.

A. Visitors

It is not permitted for observers to bring friends in for night-time sightseeing. Even daytime visits to Lick telescopes must generally be approved in advance by the Director or the mountain Superintendent, and by the observer scheduled to use the telescope you wish to visit. The reasons for this long-standing policy are 1) that observers should be serious about observing and make the most of assigned observing time, and 2) to avoid the abuse of the telescopes and equipment by casual and perhaps inadequately supervised visitors. Once an observer has carefully set up the equipment, that person should be able to feel confident that nothing will be changed without permission. Consider how you would feel if you set up, and then someone's friend casually twiddled a knob so that you observed for one or more nights with a setup different from that which you had so so carefully prepared.

B. Observer Checkout

Observers may not check out new observers. To insure that our telescopes and equipment will be used correctly, new observers must be checked out by the appropriate Lick staff member. All it takes is to indicate the need on your time request. Once you've all been checked out, then you may of course work out variations of the normal observing procedure with your colleagues.

If you have not observed with the 40-inch for some time and feel uncertain about using it safely and effectively, you are urged to request refresher instruction in your time request. It is best for everyone concerned to be conservative about this. If you are going to be checked out, please call the person who will conduct the checkout a day or two in advance in order to arrange a time and place to meet.

C. First Night

If it's your first night ever on Mt. Hamilton, stop first at the diner to check in.

For any run, try to arrive early (perhaps for lunch) on the first day in order to check out the equipment, especially if you are the first observer after an instrument change. This will give some time to correct any problems while the daytime maintenance crew is still on duty, thereby helping to reduce unnecessary overtime as well as increasing your chances of getting started on time.

D. Scheduling

The Nickel telescope is scheduled on a quarterly basis. For changes, contact Burt Jones at UCSC ((408) 459-2384).

E. Security

Access to the 40-inch and its control room is through the Main Building, which is open to the public. For this reason, it is particularly important to be security conscious. If the building is open, keep the yellow rope up across the bottom of the stairs to discourage visitors from wandering up (some fraction of people will always ignore the "Staff Only" sign). When you're actually on hand working, you may find it convenient to keep the dome and control room doors unlocked. Push the buttons in the door jamb just below the latch to enable/disable the automatic locking. When you leave the area, please be particularly certain to leave the doors locked. When the building is not open to the public, be particularly certain that the outside doors are properly locked. One does occasionally find visitors wandering through because an outside door was not properly closed. There is too much irreplaceable equipment in the building to allow people to wander around unsupervised.

Here's a small point of personal preference and the reason for it. Once when I believed I was alone in the building at night and I had the radio on loudly, I suddenly realized someone was standing just behind me whom I had not heard come in, and it was a real shock. I now keep the control room door closed and locked, just so anyone coming in will have to make some noise and I'll know they're there. Similarly, if you're going in to see someone, it's considerate to call first if convenient, and then stomp up the stairs and rattle the door, just so they'll know you're coming.

F. Telephones

The 40-inch control room can be direct dialed from other mountain or UCSC phones at ext. 5940, or from outside phones dial (408) 459-5940. Another line (5941) is in the dome itself (a wall phone just to the left of the doorway), and after a few rings calls are automatically forwarded from the control room to the dome.

If you make any calls other than to UCSC or Mt. Hamilton, please sign for them on the phone list hanging on the wall of the control room, so you can be recharged, unless of course you charge it to your own account in some other way.

II. Dome

Please take a look at Figure 1 (following page) for the general layout of the dome.

A. Dome pointing

Observing is done remotely at the 40-inch. That is, observations are conducted from the control room, so the observer is only on the dome floor during instrument setup periods. For this reason the dome must be positioned automatically to the position angle dictated by the telescope pointing. The dome slit has been enlarged beyond the original two feet or so used for the 12-inch refractor, as you can see by the laminated bridge on the left side of the slit; but still the new slit is barely large enough to accommodate the 40-inch, allowing only a couple of inches of clearance on each side when the telescope is centered. Dome pointing is achieved by the telescope controller (Sec IV). There is a track fixed to the bottom inside diameter of the dome, and an infrared sensor mounted on an arm extending from the north pier of the telescope detects reflective marks on the track to determine the position angle of the dome. Operation of the dome is automatic, and requires only that the "auto dome" switch on the telescope controller be turned on.

B. Occultation

There are a couple of points to be aware of in actual operation. First, visually check the dome centering whenever it's convenient, and particularly at the beginning of your run. On rare occasions you may find it necessary to adjust the zero point through telco as discussed in Section IV.

Second, the top of the dome slit occults the telescope when it is pointed within 6.25 degrees of the zenith. The maximum occultation is about 40%. A red warning light on the telco panel lights when this occurs. Of course, this is only really critical if photometric results are desired.

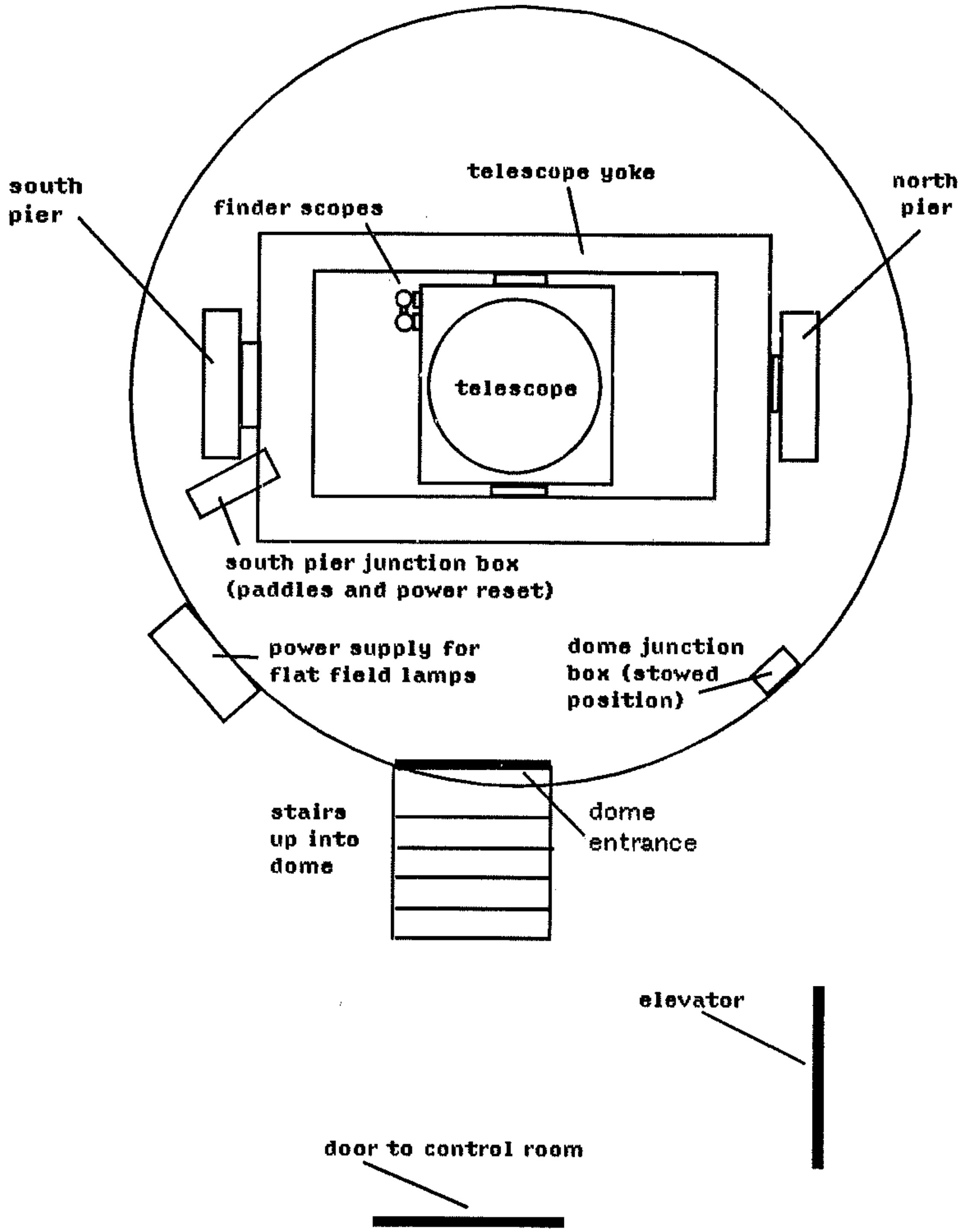


Fig. 1: Dome Layout

C. Manual Operation

The dome may be operated manually by a rocker switch mounted on a small blue box on the end of a long cable, normally found hanging from a hook near head level at the corner of the south pier platform nearest the door. If auto dome is selected on the Telco panel, the dome will still respond to the manual rocker switch; but in this case as soon as you release the manual switch, the auto feature will recenter the dome slit on the telescope.

D. Stow Position

The dome is stowed with the slit facing roughly northeast. There is a large black arrow on the white junction box which moves with the dome, which should be lined up with the similar arrow on the wall of the dome to the right of the north pier. The reason for having a preferred position angle for stowing the dome is that this seems to be where the dome leaks least during bad storms.

E. Shutter Switch

There are three switches that you will need on the white dome junction box. The shutter switch is a rocker switch which opens and closes the shutter. Press the spring-loaded switch and let go - if you hold it down the shutter will reclose when it reaches the end of its travel. Movement is ended automatically when limit switches are encountered. Once the dome is open, **you are responsible for protecting the telescope** from any weather threat which may arise.

F. Dome Lights

By the door there is a switch for a white light and a dimmer for a red light, but the main dome lights are controlled by a toggle on the white dome junction box. This switches four white lights mounted on the dome itself.

G. Windscreen

The windscreen is controlled by a three position toggle switch on the white dome junction box. Strangely enough, up moves the windscreen up, down moves it down, and the middle position is off. The telescope controller does not know where the windscreen is, and since one is not normally on the dome floor while observing, the usual thing is just to stow it all the way down. Fortunately the telescope is fairly stiff, and in most cases if the wind is shaking the telescope significantly, the wind will be at or above the limit anyway. If you must observe close to a strong wind you may wish to use the windscreen, but bear in mind that it will not follow the telescope's motion, and the only way to move the screen is to go out onto the dome floor.

In any event, at all seasons and regardless of your personal expectations of the weather, stow the windscreen all the way up at the end of the night, as it helps to protect the telescope from moisture.

Notice that the last three switches are mounted on the white junction box, and the box is attached to and moves with the dome, but they will always be a few feet to the left of the dome slit, wherever that may be.

H. Limits

The dome must be closed whenever any of the following limits are reached:

1. Humidity. 95%, or as necessary to exclude moisture from the dome. As you probably know, it's generally good practice to let the telescope and mirror reach ambient temperature before observing in order to let the mirror figure stabilize, and to minimize focus changes during the night. This is especially important for direct imaging. Therefore you may wish to open the dome in the afternoon, position it so the sun will not strike any portion of the telescope, open the mirror cover, and expose the mirror to the sky. If you do so, be very certain to be alert for any sudden weather changes. Fog can form very suddenly over Mt. Hamilton, so be alert for this possibility at any season. In particular, don't open up the telescope and then go take a nap! The humidity gauge is in the right-most window of the control room, opposite the door.

2. Wind. Close the dome whenever the wind velocity exceeds 50 mph. The gauge is on the wall of the control room opposite the door. This limit requires reasonable interpretation. If the wind is steady at 50 mph or above, of course close. But what if it is generally 40, gusting occasionally to 50 or 55? Then keep going if you wish, but watch it closely. If it is generally 40 but gusting frequently to 60 or 70, then close up. But as you can see, all possible variations can't be covered, so the ultimate rule is, close at 50, and interpret that in a reasonable and prudent way.

3. Forest fires. In the summer and fall it is not uncommon to have forest fires in the general area. Even if the fire is miles away, the mirror surfaces must be carefully protected from any windborne ash from the fire. The reason is that ash plus moisture forms acids which can actually **etch the glass**, so please do everything possible to protect the mirrors. Usually in such a case the telescope technicians at the 120-inch will be monitoring the situation closely, so if they ask you to close up you must do so immediately, and don't reopen until they tell you it's ok. On the other hand, if you have reason to suspect ash fallout, please close up immediately and then tell the people at the

120-inch in case they are not aware of it yet. Thank you!

I. Alarm

There is only one alarm which might sound in the dome, which indicates the ion pump is off. Pressing the start button on the ion pump power supply is usually sufficient to restart it. But that's an instrument related topic, covered in a different manual.

III. Telescope

A. Configuration and Optics

It's worth noting two unusual aspects of the construction of the telescope. First, the yoke is a simple rectangle. This requires giving up the option of observing close to the pole, but it is a fairly stiff structure, and was very much less expensive to build than the alternatives. Second, there is no right ascension gear. Instead, the telescope is driven in R.A. by a roller pressed against a smooth, hardened disk. Again, this resulted in a considerably less expensive telescope.

The Ritchey-Chretien optics utilize an f/5.3 primary mirror of 38-1/2" diameter, and a secondary providing an f/17 cassegrain focus with an approximate scale of 12.25 arcsec/mm. About 12% of the light is blocked by the secondary.

B. Locking Bar

Whenever the telescope is stowed, the R.A. motion is locked by the "R.A. locking bar." This is a long aluminum pole (actually a spinnaker pole from a sailboat) which goes from a tab on the southeast corner of the yoke of the telescope to a fastening point under the floor, via an access panel. If you walk straight ahead when you first enter the dome, you will probably break your toe on it. The purpose of the bar is to keep the telescope from exceeding its limits in case of a power failure. It may be convenient to remove the bar when you come in to set up, but in any case you must of course remove it before making any motion in R.A. To do so, pull out the T-handled pin at the yoke end, move the bar away from the yoke tab and immediately replace the pin in the bar so it won't get lost. Then reach down below the floor level and pull the spring-loaded locking pin in the bar upwards (parallel to the axis of the pole), and move the bar off of the sub-floor fastening point. Meanwhile, be careful not to let the upper end of the locking bar bang into anything. Cover the hole in the floor with the floor panel, and stow the locking bar on the floor along the wall where it'll be out of the way.

C. Mirror Cover

The mirror cover is opened and closed pneumatically. The control for this is a black-knobbed lever on the inside surface of the yoke above the south polar axle. Pull the handle down to open the two halves of the mirror covers. Movement of the covers may not be complete for 5 seconds or so after the handle is moved.

D. Tub Rotation

The tub of the telescope (that is, the bottom-most round section, just below the mirror level and of slightly smaller diameter than those above it) can be rotated, for example to place an instrument at different position angles with respect to the sky. The usual case, however, is that the position angle for a given instrument is fixed by the dome crew when the instrument is mounted, and in general the tub should not be rotated by the user, since the telescope is not usually balanced to allow for rotation. If you anticipate a need to rotate the tub, check with the dome crew to be sure it has been specially balanced.

If your configuration has been approved for rotation, notice the three gold anodized locking handles at 120 degree intervals around the tub where it is attached to the telescope above. Turn the handles counterclockwise (looking up) to unlock, turn the tub by hand, and relock the three handles. The tub may be difficult to turn - a smaller person may well need help. Turn it slowly and carefully, and be particularly careful not to snag and pull out cables as you turn it.

E. Power Reset and Panic

Before any of the paddles, the tracking, or the diagonal mirror will work, power to the telescope must be enabled by pressing the power "reset" button. This is one of two buttons on the south side of the large junction box which is mounted on the east side of the south pier of the telescope. It is easy to find - all the telescope paddles hang on the front of this large junction box. Just press the reset button and you'll hear a "thunk" as a major power relay is activated in the junction box. At the end of the night be sure to press the "panic" button next to the reset button to disable telescope power (particularly a good move in case you forget to turn off the drive)!

F. Paddles

1. <u>Focus paddle</u>.

There are three paddles hanging on the junction box. The focus paddle has a potentiometer on the face and a black switch sticking out of the top, and it is not normally hooked up at all except for rare visual observing. Focus is normally done remotely from the control room and is discussed below.

2. Slew paddle.

The two remaining paddles may be used to move the telescope during setup (telescope motions during observing are made remotely from the control room.) The slew paddle is the aluminum one with four black buttons on the face. The directions are marked on the paddle, but usually it is sufficient to press a button and see if it does what you want.

3. Set/guide paddle.

The blue anodized paddle with the joystick is the set/guide paddle. Motions are made with the joystick, and aural feedback is provided (one click/stepping motor step.) If you hear any stepping motor clicks when the joystick is neutralized, you can probably eliminate them with the two trim tabs next to the joystick; if that doesn't work, press "restart" on telco (see Sec IV below).

The guide paddle has three slide switches on it at the top. The "dis/ena" switch should always be in the ena(ble) position on this dome paddle. This switch allows computer controlled movements of the telescope, which will be discussed in greater detail later. The "set/norm" switch is used to choose set or guide ("norm") speeds. The last switch, labeled "R.A. norm/reverse" is used to reverse the sense of the joystick in R.A., if desired.

G. Rain Screen

A white rain screen is mounted half way down the telescope tube. It operates like a roller blind. The cord is on the north side of the telescope. Always cover the telescope with the rain screen when it is stowed or when the weather is threatening.

H. Finder Scopes

There are two finder scopes on the south side of the telescope. It will usually be necessary to find a bright star with which to reset the telescope coordinates after an instrument change or a power failure (not uncommon during the winter months.)

The field of the smaller 2-inch finder is in excess of four degrees, and that of the 3-inch finder is about 44 arcmins. Normally one uses only the 3 inch scope. The 3-inch finder has an illuminated reticle grid, and each square of the grid is about 2-3/4 arcmin on a side.

The illumination intensity is controlled from a box mounted on the telescope a foot or so to the left of the finders (follow the wires from the finders if it's not obvious). Usually it's convenient to leave the switch on, and just use the pot to control the illumination. Turn the reticle lights off when not in use, either with the pot or the switch.

The procedure for resetting the coordinates is to put a bright star with well-known coordinates at a known location on the finder grid, center the star on the acquisition TV in the control room, and then reset the coordinate readouts. The desired location on the finder grid varies from instrument to instrument, and will change for a given instrument if the tub is rotated (because the TV is in the tub). Look in the User's logbook for a diagram of the proper grid position by a recent user of your instrument. Please do not reset the finder scopes!

Notice that there is a lens cover for the larger finder. To open the cover, pull the white cord down and latch the knot in the cord in the slot through which the cord runs. Be sure to re-cover it when you're done. We found this scope full of water once, so covering it is important.

I. Flat Field Lamps

There are two lights mounted high on the telescope truss members that may be used for flat fielding. Either the white windscreen or a white patch painted on the inside of the shutter may be used as a flat white surface to illuminate.

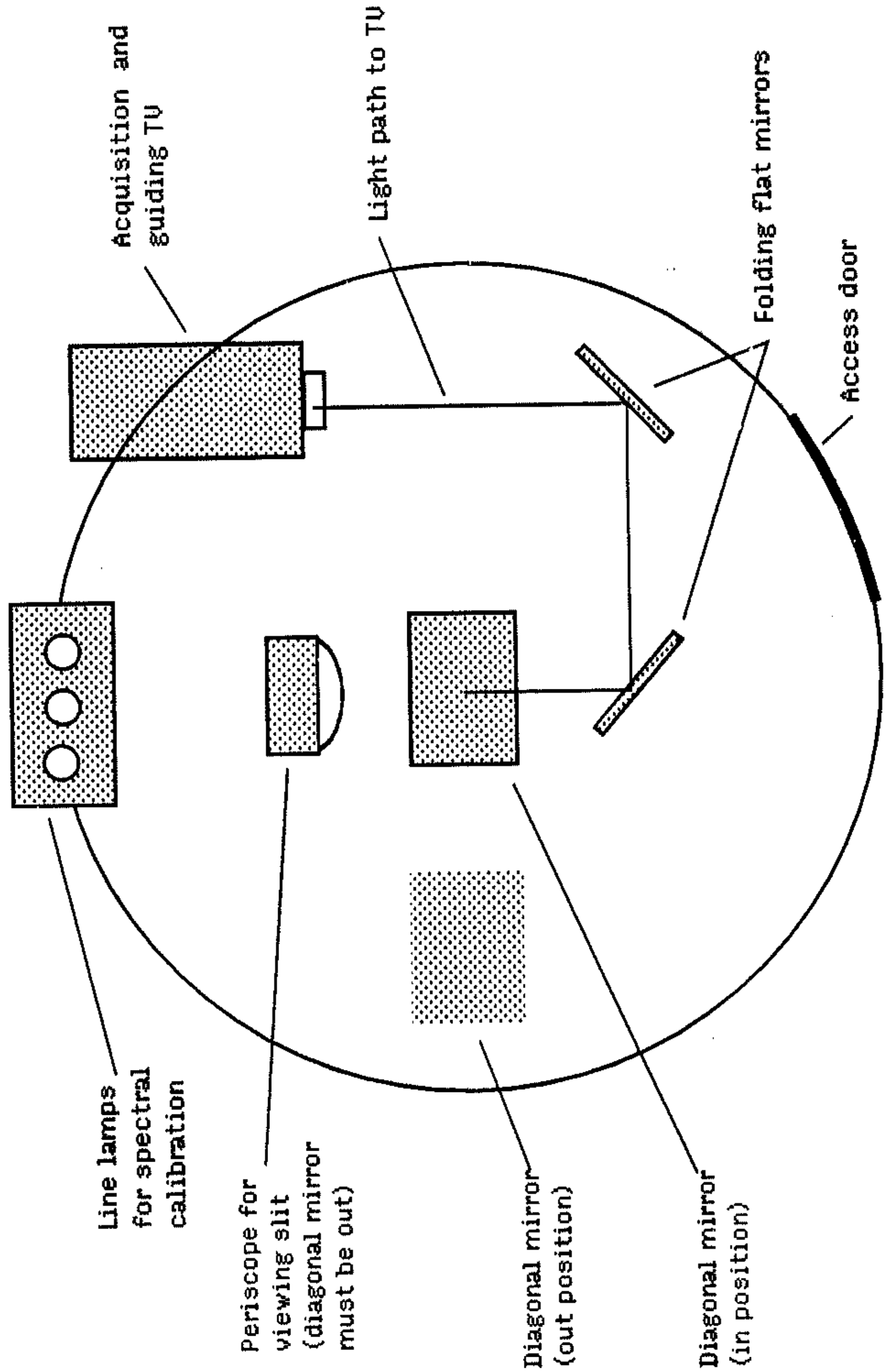
The power supply for the lamps is at the bottom of a small rack in the cubbyhole between the dome door and the south pier. Adjust the intensity as needed, but please do not exceed 12 volts or the lights will burn up quickly.

The lights must be hooked up to the power supply. There is a small, cylindrical two prong connector which usually hangs near the southeast corner of the yoke of the telescope, which plugs into a similar connector which comes from the power supply. You can leave it plugged in all the time. If it snags on anything, it'll just pull easily apart.

J. In the Tub

The layout of the tub contents is illustrated in Figure 2 (following page).

As has been mentioned, the instrument tub can be rotated, so positions of items on or in the tub will be described with respect to the TV camera case, the aluminum back of which protrudes from the side of the tub.



TELESCOPE UTILIZATION BIN (TUB)

Looking down from the top

Figure 2

1. Access.

Users generally do not need to get into the tub except perhaps to check things as described below. There are three black access plates on the bottom of the tub. Each is held on by two captive thumbscrews. If you have occasion to take off more than one at a time, notice that they are not interchangeable. Each one is stamped with a (hard to see) number, and a corresponding number is stamped on the lower outside rim of the tub. There is a small black hatch in the side of the tub just opposite the TV camera.

2. Light paths.

It is necessary for the TV to be able to view both the telescope field and (in some cases) an instrumental focal plane, for example spectrograph slit jaws. To view the telescope field for object identification and centering, light from the telescope secondary is deflected by a diagonal mirror onto a pair of folding flat mirrors, and then into the TV (see figure 2). To look at the instrumental focal plane, the diagonal is removed, and the light then passes on down to the focal plane.

In the case of the spectrograph, the aluminized entrance apertures are tilted, so that portion of the light which does not go through the slit is reflected back up through a periscope, which feeds the light to the folding flats and thence to the TV for guiding. See the spectrograph manual for a fuller discussion.

3. Diagonal mirrors.

Only one diagonal is mounted at a time, depending upon the instrument in use. The on-axis diagonal mirror is inserted into or removed from the telescope beam pneumatically. Its position is controlled by a switch in the control room.

For some instruments, an off-axis diagonal is used. The object is then acquired on the off-axis mirror, and the entire telescope is then offset so that the object will move off of the mirror and onto the telescope optical axis, and thus to the detector or instrument aperture. Guiding is then accomplished on whatever is available in the field from the off-axis diagonal. The TV is fixed in the tub, so one may not move it with respect to the telescope and detector.

4. Folding flats.

The two folding flat mirrors can be moved together on a screw, to accommodate various focal distances corresponding to various instrumental focal planes. The folding flats will usually be set up for the correct focal distance by the telescope maintenance crew. If you need to move them, you can get access to the inside of the tub by the small side door just opposite the TV. Just inside the door at the top, you'll see a red button in the middle of a black handle between the folding flats. If you push the red button it releases the flats from the screw on which they move so you can slide the mirrors rapidly along their track to a new position. For fine adjustments, the screw is turned by a knurled thumbwheel at the end of the screw inside the tub just above the door.

There is a scale for the flat mirrors mounted inside the tub on the roof of the tub compartment. In order to see it, you'll probably have to take off one of the three black cover plates on the bottom of the tub. The one to remove is the one to your left as you face the access door for the folding flats.

5. Comparison lamps.

A foot or so to the right of the TV camera on the outside of the tub you'll see a black box mounted which contains the emission lamps for wavelength calibrations. It contains three individually selectable lamps. They are turned on and off from the data taking terminal in the control room. To use the lamps, the diagonal mirror must be in the "in" position. Then the light from the lamps will bounce off of a white card mounted on the back of the diagonal mirror, and go down to the spectrograph aperture.

K. Infrared Facilities.

1. Prep Room.

A prep room is nearby (down the stairs, turn right down the main hall, first door to your right), where you can keep your cryogens and find a few tools, as well as a vacuum pump and leak detector.

2. Chopping Secondary.

An f/17.5 chopping secondary may be mounted. Please request this in advance on your time request.

The direction of the chop is always at position angle 45°. The range may be varied from zero to about 3 arcmins, and the rate may be adjusted from zero to 8 Hz. The precision of an offset is about 1% of the throw.

The secondary can run in automatic mode, where the chopping rate is provided by an internal oscillator, or (the more usual case) in manual mode where the nod is initiated by a TTL pulse from the observer's equipment.

The controls and connectors for the chopping secondary are at the top of the rack in a recess of the southeast wall of the dome, above the flat field lamp power supply.

Connectors on the panel are:

PMON - position monitor (mirror position feedback)

DMON - drive monitor (drive signal to mirror)

TTLIN - TTL trigger input

ANALOG OUT - output from shaper card
ANALOG IN - input to driver card

Controls are:

TRIG INT/EXT switch - selects internal oscillator or external trigger
FREQ pot - adjusts internal oscillator frequency
RAMP pot - adjusts ramp speed of mirror motion
DAMPING pot - damps the stopping of the mirror
OFFSET pot - moves zero point of the mirror motion
AMP pot - adjusts amplitude of the chop

A scope is required to set up the chop; one is nearly always readily available on the dome floor. Connect the scope to the PMON connector on the chopper control panel. The scope will then show the feedback from the position sensor on the mirror. The various adjustments will affect the appearance of the waveform on the scope. When correctly set, the waveform will be nearly a square wave, symmetrical and without overshoot.

To assure the best mean collimation of the secondary, the offset control should be set so that the waveform is centered around the DC zero. The AMPlitude control sets the throw of the chopping motion. The slope of the sides of the wave may be adjusted with the ramp control. As the slope is increased the mirror may tend to overshoot, and it will be necessary to adjust the damping so as to avoid this. The corners of the waveform should be as square as possible.

3. Autoguiding.

Although we have not yet discussed the autoguider, there is a special consideration for it's use with the chopping secondary. As we said, the chop is only accurate to about 1%, so each chop will be close to the desired position but may not be quite exact. In normal use, if the joystick is used to touch up the telescope position after a chop, the autoguider will reinitialize, but in the chopping mode the constant reinitialization is undesirable, since it's not the autoguiding which is at fault. It is possible to turn off the reinitialization feature, although at present this is quite awkward, and can only be done by Bob Kibrick (UCSC, 459-2262). We hope this will soon be available more easily to the user.

L. Visitor's Equipment

If you have an experimental instrument package or wish to hang any additional equipment on the telescope, please discuss your needs with Burt Jones in Santa Cruz, and then coordinate closely with the telescope maintenance personnel on Mt. Hamilton (ext. 5954).

IV. Control Room

A. Telescope Control

Refer to Figure 3 (following page) for an approximate view of the contents of the electronics racks in the Control Room.

1. Dew sensor.

At the top of the third rack from the left you will find a CAMAC crate, and sitting inside it is the small controller for the dew sensor. It is very important to ensure that it is on (never turn it off!), that the sensitivity is set to 25, and that the audio is on.

A limitation of the sensor is that it operates only above freezing. If the outside air temperature is 32 degrees or below, then one must rely on periodic outside checks, and the old humidity gauge mounted in the right hand window of the east wall, and close at 95% or as necessary to exclude any precipitation.

The dew sensor has been found to be quite accurate, and if it goes off, you must close the mirror cover and the dome immediately. The dome must remain closed until the dew sensor dries out and the alarm turns off.

The audible alarm is quite loud. If it sounds, sanity may require that you turn it off and rely on the warning light and outside examination as indications of humidity level. However, if you turn it off, be absolutely certain that you turn it back on as soon as the humidity drops, or if you leave the dome. Think how totally unfair it would be if your failure to turn the audio alarm back on means someone else unwittingly lets it rain on the mirror two weeks later. Similarly, I suggest that you check to be sure the dew sensor is properly set up first thing when you walk in the dome, so if someone else turned it off last week and forgot to turn it on, you won't get blamed.

2. Slew.

About midway up the third rack from the left is a rack panel which contains the four white telescope slew buttons. Directions are labeled. Let the telescope come to a complete stop before moving in the opposite direction.

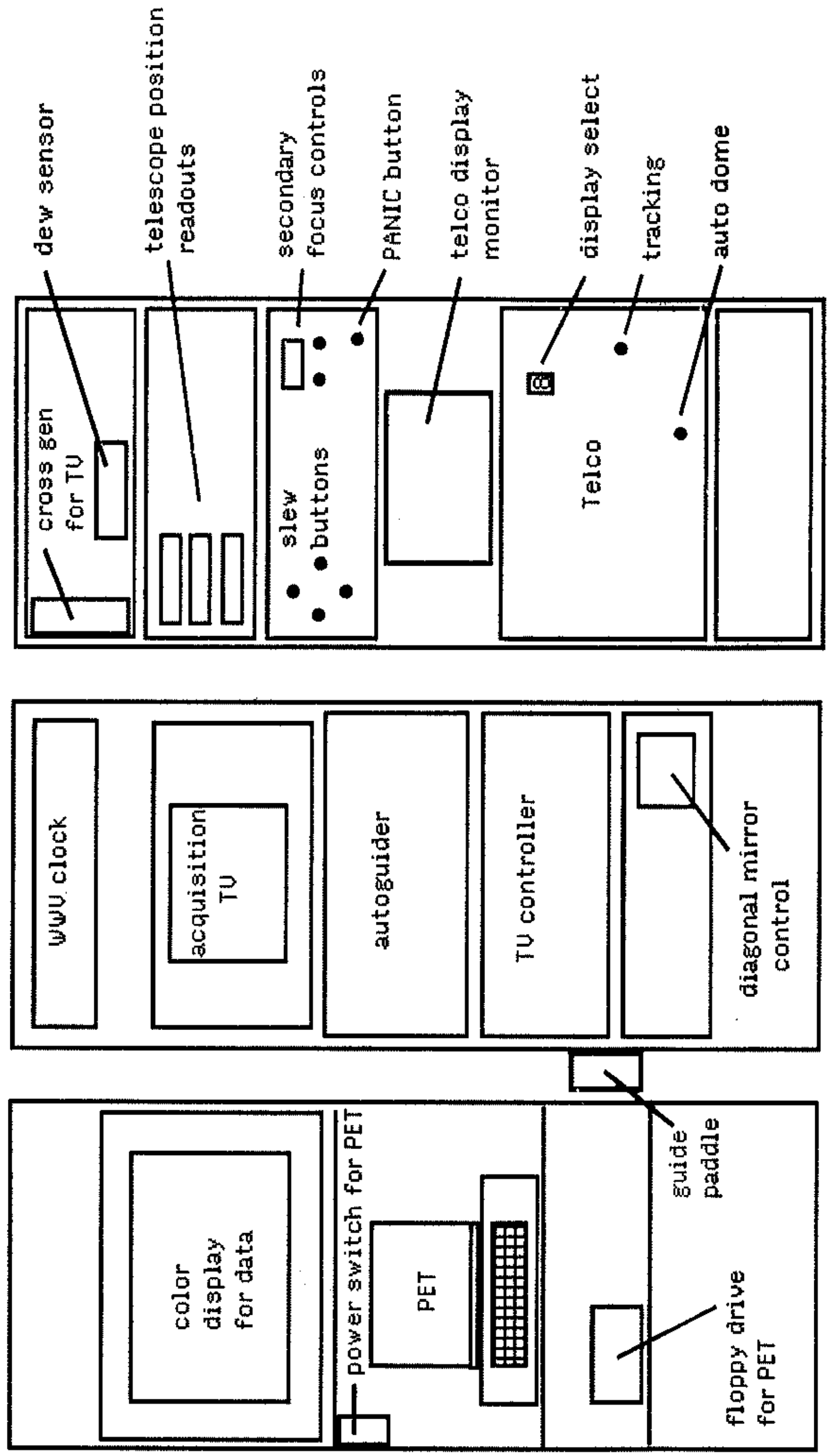


Fig. 3: Layout of Control Room Electronics

Before attempting to move the telescope, be <u>especially sure the dome floor is clear</u>. That is, move everything well back against the dome walls. Since most telescope movements are done remotely, they are also done blindly, so it is important that there be nothing on the floor that the telescope can run into.

3. <u>Guide paddle</u>.
The guide paddle is identical to the one on the dome floor, described above in Sec. III.F.3.

4. <u>Focus</u>.
On the right-hand side of the same panel as the slew buttons are the telescope focus controls, with a digital readout of the secondary mirror position in arbitrary units. The knob functions as a rate control (from negligible to slow), and the spring loaded toggle switch actuates the motor.

5. <u>PANIC</u>.
This same slew/focus panel contains another very important button in the lower right corner, to whit, the red panic button. This button will kill the telescope power, and may be useful in case of a telescope malfunction. Keep it in mind.

6. <u>Position display</u>.
Above the slew buttons is the digital telescope position display. Hour angle, R.A. and dec are shown. The displayed positions may be reset with the remaining switches. The pointer is confusingly labeled "hrs, mins, secs, trim", but think of it as a rate selector; "hrs" is fast, "trim" is slow. The toggle selects the direction of change, and the black buttons actually cause the readouts to change as selected. Due to the limited precision of the dec encoder, the minimum dec readout change is two arcsecs. Normally one sets to a bright star with known coordinates at the beginning of the night, centers it on the detector, then resets the readouts to the correct position.

7. <u>Telescope controller (Telco)</u>.
a. <u>Power.</u> The nerve center of the telescope is the black-paneled Telescope Controller, which is usually referred to simply as "Telco". Since the controller is busily keeping various clocks up to date, it is normally never turned off.
b. <u>Lights and limits</u>. There are a lot of pretty lights on Telco, and you can usually ignore most of them. Pay attention to the red ones, though. The zenith warning will remind you when the telescope is being partially occulted near the zenith. The limit lights indicate which limit has been reached, so you

know which way to drive the telescope to get off the limit.

c. Monitor and display select. The display select thumbwheel in the upper right corner of the telco panel is used to select what data are sent from the controller to the telescope control display monitor. The telco monitor is in the rack above the controller, and normally only needs to be turned on (rocker switch inside door on front of monitor, at bottom).

There are only two display select positions normally used now. If display select on the controller is set to 8, information displayed on the monitor will be for the current position of the telescope. Useful information displayed includes coordinates, hour angle, zenith distance, telescope azimuth, dome azimuth, PST, UT, ST and airmass.

Display select 13 will present autoguider information, which is discussed further in Sec. IV.

d. Auto dome and auto slew. There are two switches at the bottom center of the telco panel. The one labeled auto slew is not functional at the time of writing. The auto dome switch enables telco control of the dome, and should be turned on when you're ready to observe, and off at the end of the night.

e. Tracking. Telescope tracking is enabled with the toggle so labeled at the right side of the telco panel. Turn it and auto dome on and off at the beginning and end of observing.

f. Track rates. The track deviation thumbwheels are used to trim the telescope track rate. A typical value for the R.A. rate within 30 or 40 degrees of the zenith is -0.04. This may vary a bit, and will vary more at large zenith distances. Increasing the number increases the rate; i.e., drives the telescope faster to the west. The dec rate is set with the other thumbwheels; a plus rate drives the telescope north, and a typical value is zero. The tracking switch only turns off the R.A. rate, so if you've entered a non-zero dec rate, you must remove it at the end of the night, or it will just keep going all day. Again, do not turn off power to the controller.

g. Error messages. Telco may display various useful error messages to you on the monitor. For example, if it knows it doesn't know the correct time and date, it will ask for it; if the hour angle, sidereal time and right ascension are inconsistent with one another it will require you to reset them (and also suggest what to set them to - usually one sets R.A. from a star and then corrects the hour angle as necessary); and it will inform you if the dome encoder appears to be slipping (in recent years these messages appear to be of no significance, but it wouldn't hurt to check the dome alignment just to be sure).

h. Shutdown. An extreme case you're not very likely to see is when telco shuts down entirely. Only the red "shutdown" LED will remain lit on the telco panel, and an obnoxious alarm will sound. The most likely time for this to occur is after extended power failures, when the internal batteries have been drained and telco has lost all information regarding the telescope. To recover, first set the telescope position readouts to something reasonable. It doesn't have to be correct, but it does have to be reasonable (e.g., dec = -90 won't do). Then press the red restart button on telco. If that doesn't work, call for help.

8. PET Computer - Talking to Telco.

Many of us would like to see the PET consigned promptly to the nearest landfill, because it has a truly unreliable keyboard. We've expected to see it replaced almost daily - for the last half dozen years! If you do come in and it's not there, chances are it will be replaced by a window on the ISI workstation. Look for an icon called something reasonable, like maybe "telco", and expect to see more or less the same routines as are described below.

The PET computer is used to communicate with telco. To start the PET, first turn on the wall-type power switch just above it to the left. This energizes the computer and it's disk drive. Load the 5-1/4 inch telescope control system disk (almost invariably in the disk drive; if not, check the top right desk drawer), close the disk drive door, and type "shift-run" on the PET. The system will automatically load and run the program. When it is ready (~20 seconds), a menu will be displayed on the PET. These are the routines which are available:

- T - Set time and date
- D - Change dome offset
- Z - Zero track rates
- S - Initialize position changer
  - < - Move to left
  - > - Move to right

a. Set time and date (T). This routine initializes telco's clocks. Proper operation of the precession program requires the correct date, and the correct time is required for telco's calculation of sidereal time, hour angle and airmass. Telco will let you know via a flashing error message on the telco monitor if it has lost the correct time and date. This is usually the result of a power failure.

Notice that telco always requires the PST date and time, and the time must be in 24-hour format. There is a WWV time standard clock at the top of the rack just to the left of the rack telco is in which gives UT, and PST = UT-8 (and PDT = UT-7).

b. Change dome offset (D). The dome offset routine allows you to adjust the zero point of the dome rotation so as to center the dome slit on the telescope. This is critical since there's only a couple of inches of clearance on each side when the dome is perfectly centered. It's a good idea to check the centering at the beginning of the night, perhaps on your focus star.

The routine shows you the current offset and asks for your correction, in centimeters. A positive correction moves the dome to the right as you look out the slit.

c. Zero track rates (Z). Normally the autoguider track rates are set to zero every time you slew to a new object. It rarely happens that for some reason inappropriate track rates are developed by the autoguider, and you wish to reset them to zero and start over, but remain on the same object. This is the routine to use.

d. Initialize position changer (S). This routine lets you set up a computer controlled move between any two positions. The routine asks for input in arcsecs in R.A. and dec, for both a move from A to B and (presumably but not necessarily) from B to A. Very long moves are possible (something like 32,000 arcsecs!), but the rate over long distances would be prohibitively slow.

This is most often used with instruments which use the diagonal with the hole in it. Recall that the telescope is pointed so that the light first falls on the off-axis portion of the diagonal for field identification and object centering, and then the telescope is translated so as to put the light down through the on-axis hole in the diagonal. This routine is the easiest way to do that translation.

The direction of the move required will depend on the tub orientation, which varies with the instrument. Usually one looks in the User's Logbook to find offset values recorded by a recent user with the same tub orientation. A corollary is that if you really must rotate the tub to odd position angles, the offsets between the acquisition TV and your detector will be unknown, and some hassle will be required to discover them.

e. Move telescope to left (<) and to right (>). These commands execute the moves set up with Initialize Position Changer, described just above. The "left" and "right" are arbitrary and do not have anything to do with the actual motion of the telescope; they depend on how you entered the coordinates in the initialization. The acquisition TV is to the right of the monitor used to display the data from the detector, so the way most users set it up, just for mnemonic purposes, is so that "Move to Left (<)" moves the field from the TV to the detector, and vice versa. Again, see the User's Log for recent values.

9. Air Pressure.

On very rare occasions an error message saying "no air pressure" may appear behind the red Lucite panel at the bottom of the rack which contains telco. Air pressure is required for operating the clutches of the telescope drives, as well as for operation of the mirror covers and diagonal mirror. The proper response to this message is to call maintenance at 5954.

B. TV Acquisition, Guiding and Autoguiding.

1. Performance and limitations.

Our marvelous TV cameras are a product of Lloyd Robinson and the Lick shops. (They are described in PASP 99, 1014 (1987)). They are very nearly impervious to abuse. You need not worry about room lights, flashlights, or any celestial object which is up at night. The only limit is, do not point it at the sun! The camera does not have a shutter because it does not need one. It will recover by itself from an overexposure in about five frame reads.

The full field of the camera is about 5'40" x 7'20" (arc). Color sensitivity ranges from below 4000Å to about 1 micron. The integration time may be varied from a minimum of 0.7 sec to about 30 secs. On a clear dark night, this is sufficient to see objects at the limit of the (old) Palomar Sky Survey. The moon and San Jose often mean one cannot see quite so deeply, however.

2. TV power.

The TV controller is in the second rack from the left. Just above it is the autoguider control panel, and above that is the acquisition TV monitor. In order for the TV to work, a number of items must be on. Unexpectedly, power to the TV controller and the autoguider should be left on at all times. The power switches for these units are right there on the panels, so please notice the small labels next to the switches which remind you to "Leave On".

Other items which must be on in order for the TV to work are the Cross Generator and the monitor, which are discussed below.

3. Cross Generator.

This is an odd prerequisite to operation of the TV. I first mention the switch which is least obvious and which you are therefore most likely to forget. At the top of the rack which contains telco, recall the CAMAC crate which has the dew sensor sitting in it. In order to get a video signal to the monitor, power to the CAMAC crate must be on.

Power to the crate is controlled by a small toggle switch in the lower right corner. The reason power here is necessary is that the crate contains and powers the cross generator, located at the extreme left side of the crate, through which the video signal passes. The generator superimposes three +'s on the video field which may be moved around as reference marks. The cross generator has three pairs of knobs, one pair to move each of the three +'s up and down or left and right. A single knob at the bottom of the panel varies the brightness of all three crosses. I emphasize again that if you're not getting a TV image when you think you should be, make certain the power to the CAMAC crate is on.

4. Monitor.

The Conrac monitor in the second rack from the left is used for the TV camera display. Its power switch is inside a small door on the right side of the monitor, along with the usual assortment of monitor controls. Usually no other adjustment is necessary, but I like to see a raster, just so I know for sure the monitor is working, so occasionally I adjust the brightness or contrast a bit.

There is one other important switch on the monitor. This is a toggle labeled "reverse" in the lower right corner of the front panel. Normally this is left in the up (= reverse) position, which puts north either up or left on the monitor for the two most usual tub position angles, but you are of course free to change it as you wish. It flips the picture top for bottom. This switch is rarely changed, so if you do change it, please try to remember to switch it back when you're done.

This brings up a major HINT: If you are really having a hard time identifying your first field on an observing run, double check this switch (or equivalently, double check the sky directions as shown on the TV).

5. TV controls.

I reiterate once more that the power to the TV controller should be left on.

a. Gain. There are no tricks here; just do what you need to do to see what you want to see. Of course, use all the gain available before using any integration. On a dark night, you can see objects fainter than mag 14 with max gain and no integration.

b. Integration. As previously stated, the range is 0.7-30 secs. Start with the integration at minimum, use the gain control, and if you can not see what you need to see with max gain, start increasing the integration. The useful range of the integration control may be limited by moon or bright clouds.

c. Offset. The offset control affects both the zero point and the dynamic range of the TV intensity display. It may usually be simply left at the median position (12 o'clock), but particularly if you wish to see something very faint next to something very bright, you may wish to play with this control.

d. Binning. If every pixel on the CCD is displayed, the image maps onto an area larger than the monitor screen by about 40% or so. The area seen in an unbinned image is about 4 x 4 arcmins. Binning allows you to combine pixels as they are read out so as to see the whole field seen by the TV camera. If you select binning 2, every two rows and every two columns will be combined as they are read off of the chip. This means that the chip can be read out faster, so the display will be updated more quickly. Binning 4 produces an even smaller display, and is not useful.

With binning 2, the entire field may be seen on the monitor which makes field identification easier, but the trade-off is that you will have only half the spatial resolution, so guiding may be less accurate in this mode.

e. Position select. If you are not binning and would like to see different parts of the image, use this switch to select the center (C), or either of the four quadrants, e.g., top left (TL) or bottom right (BR).

6. TV camera filters.

There is a switch selectable 5 mag neutral density filter which may be placed in front of the TV camera. The camera doesn't mind bright objects, so it's not easy to think of any compelling reason to use this filter. However, if you want to use it, it's controlled by the toggle switch on the panel just below the TV controller. If things seem faint to you on the TV, check to be sure this filter is not accidentally in front of the camera.

In addition, you can mount single 2" x 2" filters in a plastic holder which snaps into place on the camera lens. This might be useful, for example, if you wish to set onto H-alpha bright filaments, or if you want to choose objects bright at some wavelength for which you have a narrow band filter available.

7. Diagonal mirrors.

In a recess on the right hand side of the panel just below the TV controller is the switch which controls the position of the diagonal mirror inside the telescope tub. The choices are in (in the beam, full field to the TV), or out (diagonal mirror out of the beam, light goes down to the detector.)

A sliding panel which says "Please do not move diagonal mirror" may be moved in front of the switch by the dome crew. It's rarely used, but if it is blocking the switch, assume it means what it says. There is probably a pellicle in place which the diagonal mirror can run into and destroy. If you need to move the mirror and the panel is closed, please contact maintenance at 5954 for help. Observers should never have occasion to open or close the panel.

Only the solid diagonal (no hole) should be moved with the switch. If the other diagonal is being used which has the on-axis hole, one moves the telescope rather than the mirror.

An important thing to know is that, when you move the diagonal to the out position and look at an aluminized entrance aperture through the periscope, the additional optics flips the image left for right on the TV screen (which affects manual guiding); and the scale is increased by roughly a factor of two, so the field may look somewhat different to you.

8. <u>Manual guiding</u>.

Setting and manual guiding is accomplished with the blue anodized guide paddle which has already been described. The paddle hangs in a bracket near the TV camera monitor.

There are a few things to be aware of. If the tub is rotated, the direction on the TV screen in which an object moves may not be clearly related to how you push the joystick on the paddle. Especially for a long manually guided integration, it will be worth your while to arrange things so that an obvious relation exists between joystick movement and object movement. The most obvious thing to me would be to set it up so that the object moves in the same direction as the joystick moves. You can always achieve this by some combination of rotating the paddle, reversing the effect of the joystick in R.A. with the appropriate paddle switch, and flipping the TV picture with the reverse switch on the TV camera monitor.

The aural feedback from the paddle is often useful. Each click corresponds to one stepping motor step, which is <1/10 arcsec. But it is useful in a less quantitative way; that is, if a bunch of clicks moves the telescope twice as far as you want, then half a bunch back should be about right. For fine guiding, you may get a feel for about how many clicks per minute will keep the object well centered.

There are various aids to guiding. Recall the cross generator with which you may mark objects. Often a grease pencil mark on the monitor screen is useful. On many occasions it is sufficient to guide directly off of the entrance aperture of the instrument.

However, usually the best way to guide is by...

9. Autoguiding.

With the autoguider, life is almost too easy. It has lots of controls and pretty lights, and if you are really into that sort of thing you can read all about them in LOTR 31. Here I try to condense it down to the minimum you need to know to make it work.

a. Description. The idea is simple. The autoguider gets its data from the TV camera image. With the autoguider joystick you position a reticle over the guide star image on the TV monitor. The reticle is divided into four quadrants. The autoguider finds the balance of light between the four quadrants, and guides the telescope so as to maintain that balance.

In normal operation, the autoguider keeps the star positioned at the spot defined by the reticle. If the telescope joystick is used to reposition the star on the reticle, the autoguider will sense that and will assume that the new position is now the correct one, and it will reinitialize on this new star position. Notice that once the correct position is established, it is best not to change that unnecessarily, as the result will be that the autoguider will spend a lot of time reinitializing, and will not gain the experience needed to determine a good set of guide rates. What this means is, if the star wanders a bit, give the autoguider a chance to do the correction by itself; constant interference by a mere human can be self-defeating.

An independently positioned background reticle is used to correct for changes in sky brightness. As the autoguider gains experience, it will gradually adjust the telescope tracking rates so as to minimize the guiding corrections required. This system is designed to provide small corrections at a slow rate. That is, it is assumed the telescope track rates are reasonably close to begin with. If you wish to do something unusual like track a comet, you may need to use the telco drive rate thumbwheels to enter an in-the-ballpark starting rate to enable the autoguider to track adequately.

Because the TV cannot be moved independently of the telescope, on occasion it may happen that there is no object in the field to guide on. This doesn't happen very often because the TV is so sensitive, but when it does it's certainly annoying after being so spoiled by the comforts of observing with the autoguider - sometimes it cuts right into your ability to follow the plot of the late movie. This is more likely to happen when guiding on the spectrograph apertures, because the field size there is relatively small. If this happens to you, the only comfort I can offer is that at least you're not out on a cold dome floor worrying about whether your eyelids will freeze to the eyepiece, and the next field will probably be better.

b. Use (theory). When power is first turned on, the autoguider performs an extensive self-diagnostic routine. If an error is found (not likely), the LED's in the small two-digit "seeing" display in the upper right of the control panel will blink every second or so. If this happens, try pushing the "error reset" button; if that does not help, try recycling the power once. If you still get the error indication, call for electronics help (5952).

Fortunately, there are a number of things on the complicated appearing autoguider panel which you can ignore (again, if you really want to wallow in all of the gory details, see LOTR 31 - the present notes are directed at the normal folks). Ignore the seeing stuff - the seeing reticle, the seeing background reticle, and the seeing LED readout.

To initially set up the autoguider, the first step is (can we presume it?) check the power on. Set the menu select switch to normal. For more info on the menus (diagnostics), see LOTR 31.

Usually, set the side select switch to auto. The side select reflects the fact that the autoguider was first used with a two-slit spectrograph. This option may be useful if you plan to chop back and forth between two nearby positions. It allows you to set up two independent sets of reticles, one for each position, and automatically switch between them.

There are normally two reticles used, the guide reticle and the background reticle. The reticle select switch allows you to select which of the two reticles you wish to adjust. The reticle selected is the one displayed on the TV. In order to avoid getting confused and accidentally setting the background reticle onto a guide star, I suggest always returning this switch to the guide reticle position after the rare occasion when you have to reposition the background reticle. The mark intensity knob controls the intensity of the reticle display. Turn this knob clockwise until you see a black reticle box displayed on the TV.

The function switch allows you to select the reticle attribute to be adjusted; "position" on the TV screen, "size" of the reticle quadrant boxes (the guide and background reticles always have the same size, so it usually makes sense to set the size up on the guide reticle), or "separation" between the boxes (which allows you to place one half of the reticle on each side of a slit, for example). Each of these attributes is varied with the joystick. The "guide lock" position allows you to lock out any accidental motion of the joystick, but since it's well out of the way, I prefer to leave the function switch set to "position", since I know I'll have to use that function for every new guide star.

The sensitivity (or gain) control determines how sensitive the reticle boxes are to the light of the guide star. You need enough signal to guide effectively, but not so much as to saturate the ADC. Two LEDs in the lower right corner will help you with this. The "gain/4" light tells you it's a big signal so it's being divided down to avoid saturation, and yet it's not too big unless the "signal too big" light comes on.

The averaging time knob allows you to determine how many TV frames to average in order to produce a guide signal. The signal the autoguider gets is dependent on the gain and integration time of the TV camera. Once you have adjusted the camera for the best picture, then adjust the averaging time of the autoguider. Generally it is better to have an averaging time at least twice as long as the TV integration time, but if the tracking is very poorly set, that may have to be reduced in order to avoid making the guide corrections too large.

If you choose telco display select 13, the telco monitor will show you what the autoguider is up to. The most useful parts of this display are the bottom few lines, which show the track rates derived by the autoguider and the guide history silos (see LOTR 31, page 33). When the autoguider is guiding, the history silos show you the actual number of stepping motor steps generated by the autoguider in both R.A. and dec. The maximum number of steps per averaging period is 5. A happy guider with good rates will generate mostly zero's with an occasional 1 or 2. All zero's means either that it's a great night so images are steady and the rate is really locked right on, or, more likely, there's some reason it's not guiding. The test, of course, is whether the star stays nicely in the middle of the guide reticle.

If the autoguider is having to work too hard (lots of 4's and 5's in the history silos), you may be able to use the history silo information in order to make a quick thumbwheel rate adjustment, or you may choose to decrease the averaging time. The averaging time is best when not equal to the integration time - half as long or twice as long is better, and if guiding is satisfactory (small automatic corrections), then the longer the better.

As the autoguider builds up experience, it will redetermine the required track rate. The newly derived track rates will be displayed just to the left of the history silos, and will be added to whatever is on the thumbwheels. Thus, in general, do not diddle the thumbwheels while autoguiding, as you will just confuse the autoguider. If you are very far from the required rate, a manual change may help, but be careful, and after your manual change, allow plenty of time for the autoguider to adjust to the new rate.

c. Use (practice). That all sounds a bit forbidding, but in practice the adjustments do not usually seem very critical. Setup on a guide star might typically go like this. Adjust the telescope pointing so the object to be observed is positioned satisfactorily. Set the guide/initialize switch to initialize. Mentally select a guide star. Now position the guide reticle over the guide star; select the guide reticle with the reticle select switch, and move the function switch to position, then use the joystick to carefully center the guide reticle over the guide star. Set the guide/initialize switch to guide enable.

When you start autoguiding, the background reticle will be seen as well as the guide reticle - be sure the background reticle is on a clean piece of sky for each new field, in order to provide a good background reference. At this point you may want to look at the autoguider history silos (telco display select 13) to be sure the autoguider is performing satisfactorily (only if it is not do you need to worry about adjusting the sensitivity and averaging time). If that's all fine, then you can relax, and just glance at the TV from time to time to ensure that all is well.

On occasion, for example if the seeing changes, you may wish to change the reticle size. Typically, a good size is 1.5 - 2 times the size of the star image. This is an empirical setting. You don't want to include too much sky with the object, but if the seeing is very unstable or the telescope is bouncing in the wind, you may need to go larger.

10. Rotation Matrices.

For autoguiding, Telco uses a rotation matrix to compensate for field rotation resulting either from orthogonal changes of tub position angle or differing numbers of reflections in the light path to the TV guide camera. Usually the tub position angle is sensed by Telco and the appropriate matrix is used, but it is possible to manually substitute other values. If autoguiding drives the star off of the guiding reticle, it is probably because such a manual change has been made. To reset, try pressing the red reset button on Telco; if that doesn't work, try turning off Telco power for 30 seconds or so (this will require resetting time and date).

For unusual instrumental configurations you may desire to change the rotation matrix in unexpected ways, so a full discussion of the parameters is given as an Appendix.

V. Troubles and Solutions

These remarks are all directed at problems with the telescope; if you have a problem with an instrument, see the green book for that instrument.

If you've checked below for help with your problem and still can't resolve it, please call for help from a Resident Astronomer or from a duty technician at the 120-inch. A technician is on duty at the 120-inch for just this purpose during the afternoon and evening, and a Resident Astronomer is generally on call. Usually we can resolve problems by phone, but if we cannot, someone will come over to help you.

You might exercise some discretion; if it's 4 A.M. and a lousy night and a problem that probably can't be fixed anyway, then maybe it would be as well to wait for the daytime crew to fix it. But even if it's 4 A.M. and freezing, if it's a great night and it's the last half-hour you need to finish your thesis observations, don't hesitate to ask for the help you need. If in doubt you may wish to discuss it with one of the above mentioned persons to help you decide on a reasonable course of action. Only you can really judge how important it is, but your consideration will be appreciated.

Some typical problems and their solutions follow.

A. Dome does not rotate.

1. Auto dome not enabled on telco.

2. "Dome is stuck" message from Telco. First try cycling the autodome switch on Telco. If that doesn't work, go out and move the dome past the tight spot (you may have to back it up first) with the manual dome switch.

B. Dome slit misaligned with telescope.

Reset dome alignment with PET.

C. Telescope does not slew.

1. Reset telescope power at south pier.

2. Ensure R.A. locking bar is removed.

3. Are you at a position limit? See telco for messages, slew away from limit.

4. Heaven forbid - did you run into anything on the dome floor?

D. Telescope does not track.
1. Check tracking switch "on" on telco.
2. Check everything under C above.
3. Is the telescope out of balance? (Call maintenance.)

E. Telescope tracks poorly.
1. Adjust tracking rates with telco thumbwheels.
2. Is it very windy? Check wind speed, and if legal, choose an object away from the wind, or consider using the windscreen (but don't forget that telco doesn't know it's there so you must position it manually.)
3. If manual tracking adjustments seem to make the tracking worse instead of better, you have almost certainly made the adjustment in the wrong sense. Likely difficulties are:
a. Changing the rate in the wrong sense on telco. More positive R.A. rate causes the telescope to track faster to the west. More positive dec rate causes the telescope to track faster to the north.
b. Confusion about the true directions on the TV. Such confusion may arise as a result of flipping the monitor top for bottom with the reverse switch on the monitor, reversing the sense of the R.A. motion with the R.A. reverse switch on the guide paddle, or the left-right flip of the TV field which occurs when you move the diagonal mirror out of the beam.

A common source of confusion is about whether you are moving the sky or the telescope. If you move the telescope north and east, the stars on the TV (or in the eyepiece) will appear to move south and west. The direction of motion of the telescope is always opposite to the apparent motion of the stars. Just remember that the controls move the telescope across the relatively fixed sky; they do not move the stars with respect to the telescope.

HINT: To be certain of directions on the TV, don't take any switch positions or direction labels for granted. (In the past some perennial turkey has repeatedly scratched incorrect directions into the anodized surface of the set/guide paddle - at this point, I don't even want to know who it was!) Move the telescope with the joystick while watching the telescope position readouts; they are the most immutable references. Move the telescope in R.A. A larger R.A. means the telescope moved east, so mark east on the TV opposite to the direction in which the stars moved (because, again, you did not move the stars, you moved the telescope.) Do the same thing for dec. Only when you are really clear on directions can you make the proper tracking corrections.

F. Cannot move diagonal mirror.

1. If mirror switch is covered by a panel which says don't move the mirror, don't. Call 5954 for help.

2. Reset telescope power at the south pier.

G. No response from the TV.

1. Check CAMAC crate (cross generator) power on.

2. Check TV monitor; power on, brightness and contrast set so you can see a raster with normal intensity (e.g., scan lines seen).

3. Check camera controller; power on, gain up, offset at about 12 o'clock position, binning 1 or 2.

4. Check autoguider power on.

At this point you should definitely see some sign that the TV itself is alive. If it's really totally dead, call for help.

H. No stars on TV.

Ok, the TV is alive, but you can't find any stars. Check everything in G above, then.

1. Try integrating for a frame or two - maybe there are only very faint stars in the field.

2. Move the telescope around a bit in case you're set to a sparsely populated area of the sky.

Ok, so that didn't work. Next, swallow your pride and do the following (don't laugh - once or twice a year I get a call which ends with considerable sheepishness on the part of the caller):

3. Check that the dome is open.

4. Check that the windscreen is down.

5. Check that the rain screen is clear.

6. Check that the mirror cover is open.

7. Check for clouds.

If all that is ok, then a few less obvious things are:

8. Visually check that the diagonal mirror is in. While you're there,

9. Check the folding flat position.

10. Check the telescope secondary focus. If it's way out of focus you may not be able to see stars in the field.

11. If all of the above are ok, try integrating again. If the sky gets brighter as you integrate, try moving the telescope to a different part of the sky. If still no stars, call for help.

I. Cannot identify object field.

1. First see the hint at the end of E above so you are certain of the orientation of the TV image.

2. Be sure the diagonal mirror is in the in position.

3. Check the TV reverse switch. Normally this switch is up, which puts north to the top or to the left, depending on the tub position.

4. Use only coordinates which have been through the set telescope (setel) program on the ISI within the last half hour at most. Remember that the setel program makes a large number of corrections to the coordinates, particularly including sizable flexure corrections which are unique to this telescope (do not try to directly use coordinates precessed elsewhere, since the flexure corrections will not have been included).

5. Double check your inputs to the setel program. They are echoed on the screen so you can see that you entered everything correctly. Double check the epoch for the coordinates you entered. Is the epoch really what you expect from whatever the original source was?

6. Try reentering the coordinates again even if everything looks ok. Do you get the same answer?

7. Compare the telescope coordinates with your input coordinates, paying particular attention to really gross errors like one hour off, or one degree off, or north dec instead of south. Don't say "That could never happen to me", because at 3 A.M. it can happen to anyone.

8. If all else fails, set to a nearby bright star from the ephemeris. If that is not where it should be, reset the telescope coordinates, using the finder if necessary. If things were that screwed up, try setting to another bright star just to be sure that now everything is really ok.

9. If bright stars are ok, set the telescope carefully back to your field. Bear in mind the full CCD field (binning = 2) is about 6 x 7 arcmins, and figure out from the scale of your finding chart what fraction of the chart area you expect to see on the TV. Be dead certain your chart is oriented correctly. Remember that the telescope usually sets to better than 30 arcsecs, so very often the object is right there near the middle but went unrecognized for some reason. Is there something in the field that's a very unusual color so the TV is over or under emphasizing it? Is your chart a blue image of a bunch of cool stars (the TV is very red sensitive)? Is there a nova in the field? Are you looking for a high proper motion star against a crowded field?

10. If you still have no luck, the problem probably lies with your input coordinates (can you check them independently somehow?), or a bad chart (wrong object,

directions mismarked, very inappropriate or unknown scale).

J. Autoguider consistently pushes star out of reticle box.

This happens rarely. Try pushing the reset button on telco, and if that doesn't work, cycle the power on telco (then you'll have to reset the time and date from the PET)..

K. Control room focus does not work.

Check to see that the focus cable is correctly hooked up at the south pier junction box where the paddles hang. There should be a thick gray cable hooked up to the connector labeled "secondary" on top of the junction box, and there should not be anything connected to the right hand connector on the right hand side of the junction box, which would enable the focus paddle on the dome floor. If things are otherwise, remove the cable from the right-hand side connector and connect it to the top connector labeled "secondary" and that should resolve the problem.

VI. Limits

I emphasize again that the weather can change very quickly on Mt. Hamilton, and fog or rain sometimes comes up suddenly and occasionally unseasonably. I once saw a few drops of rain when the humidity gauge read 65%, and on another occasion I was surprised by fog on an otherwise sunny August afternoon. So please stay alert to the weather.

A. WIND: Steady at, or significant gusts in excess of 50 mph.

B. HUMIDITY: Close immediately if the dew sensor sounds. If the outside temperature is below freezing, the humidity limit is 95%, or close 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.

C. TELESCOPE POSITION:
Hour angle: 5h 30m E or W
Zenith distance: 65.5 degrees (= elevation 24.5 degrees)
Occultation near zenith: <=6.25 degrees zenith distance
Declination limits:

a. With other than the spectrograph: North slew limit is +65 degrees. North of +65, slewing is disabled, but setting, guiding and tracking is permitted. North of +67.5, tracking will cease and only motion to the south will work. South slew limit is at -30.17 degrees. If the south limit is exceeded, tracking will cease, and only motion to the north will work.

b. When complete spectrograph is mounted: North slew limit is +58.5 degrees. North of +58.5, slewing is disabled, but setting, guiding and tracking is permitted. North of +61.5, tracking will cease and only motion to the south will work. South slew limit is at -19.5 degrees. If the south limit is exceeded, tracking will cease, and only motion to the north will work.

Spectrograph observers are asked to use particular caution in the vicinity of +61 degrees and -4.1 to -3.5 hours, as the tailpiece of the spectrograph comes perilously close to the R.A. tracking motor.

APPENDIX

PET COMMANDS FOR CHANGING TELCO'S AUTOGUIDING ROTATION MATRIX

By Bob Kibrick

October 20, 1986
Updated for Nickel Telescope November 10, 1989

TELCO uses a rotation matrix to compensate for field rotation when autoguiding. Three different rotation matrices are available, one for each telescope focus: cassegrain, coude', or prime. While there is only a cassegrain focus at the Nickel 1-meter telescope, for software compatibility with the TELCO at the 3-meter telescope, coude' and prime focus rotation matrices are available in the TELCO at the Nickel telescope. While these may seem useless, they may in fact prove useful for various non-standard configurations of instruments.

Three different commands (or "messages") can be used from the PET to select the desired rotation matrix and to adjust its parameters. Message 20 (i.e., MS%=20) is used to activate the rotation matrix corresponding to a given telescope focus, message 18 (i.e., MS%=18) is used to manually specify the position angle for those foci for which the angle cannot currently be obtained automatically (i.e., prime focus), and message 23 (i.e., MS=23) can be used to set the signs of the rotation matrix elements, as well as the sense of the field reversal corresponding to the various positions of the TV diagonal mirror.

The elements of the appropriate rotation matrix are re-computed as necessary for each focus. At cassegrain focus, field rotation is a function of tub rotation angle, and the rotation angle is obtained automatically by reading the output of the tub position encoder. Cassegrain field orientation is also affected by the position of the TV diagonal mirror. At coude' focus, field rotation is a function of hour angle, and the rotation angle is obtained automatically from the telescope position (i.e., hour angle) encoder. Autoguiding at prime focus is not yet available since there is currently no guide camera at that focus, but provision has been made within TELCO for a prime focus rotation matrix as well. In this case, the rotation angle can be set manually using message number 18.

The signs (plus or minus) of the elements of each rotation matrix are stored in TELCO's EEPROM chips and do not need to change, unless the TV camera at a given focus is changed. Should that occur, it is possible to send TELCO a command from the PET to override the rotation matrix element sign values stored in EEPROM, and store into TELCO's RAM a set of substitute values for each matrix. These substitute values will remain active until power is cycled on TELCO, in which case the original EEPROM values will be restored.

The purpose of the PET message for overriding rotation matrix element sign values (i.e., message number 23) is to allow debugging of these values when a new camera is installed. The reason this feature is needed is that a new camera may be installed at a different orientation, or the light path to the new camera may involve a different number of reflections. This PET command will allow one to compensate for orthogonal rotations and reflections. It will not allow one to compensate for camera rotations that are not orthogonal to the original camera orientation. Currently, non-orthogonal rotations can only be corrected by reprogramming of one of TELCO's EEPROMS, or by "misinforming" TELCO that the telescope is being operated in prime focus (using message number 20), in which case a rotation angle can be manually specified from the PET (using message number 18). Once substitute values have been determined for a new camera (more on this below), Bob Kibrick should be informed of the result so that a new EEPROM can be made for TELCO so that the substitute values will become the new power-up default.

The form of the rotation matrices is as follows, where HORIZ represents the horizontal component of the error signal, VERT represents the vertical component of the error signal (with horizontal and vertical corresponding to the horizontal and vertical axes of the video frame), and THETA represents the rotation angle appropriate for the given focus:

```
RA CORRECTION  =
     (SIGN #1)*HORIZ*COS(THETA) + (SIGN #2)*VERT*SIN(THETA)

DEC CORRECTION =
     (SIGN #3)*HORIZ*SIN(THETA) + (SIGN #4)*VERT*COS(THETA)
```

Note that a proper rotation matrix should always have three signs the same and one different, i.e., either 3 positive terms and 1 negative or vice versa. Any other combination of signs will not yield a correct rotation matrix. Also note that a positive RA correction corresponds to moving the telescope East, and a positive DEC correction corresponds to moving the telescope North.

For the CCD TV camera at Cassegrain focus, THETA is computed as 90 degrees minus the tub position angle (in degrees). The default (EEPROM) values for the rotation matrix element signs are:

SIGN #1 = +1 SIGN #2 = +1
SIGN #3 = +1 SIGN #4 = -1

At Cassegrain focus, the sense of the TV image is also affected by the position of the TV diagonal mirror. If the TV diagonal mirror is out (i.e., position #4), the sense of the horizontal error terms (SIGNS #1 and #3) is inverted, while if the TV diagonal mirror is in (i.e., position #0), it is not. (Note: the sense of reversal for a given TV mirror position can be overridden using the PET variables T0% to T5% as illustrated below; the default values are: T0% = +1, T1% = -1, T2% = +1, T3% = +1, T4% = -1, T5% = +1).

Thus, for the CCD TV camera at Cassegrain focus, the rotation transformation when TV diagonal mirror is in (i.e., position 0) is computed as:

RA CORRECTION = + HORIZ * COS(90-TUB) + VERT * SIN(90-TUB)

DEC CORRECTION = + HORIZ * SIN(90-TUB) - VERT * COS(90-TUB)

while for TV diagonal mirror position 4 (i.e., mirror is out) it is computed as:

RA CORRECTION = - HORIZ * COS(90-TUB) + VERT * SIN(90-TUB)

DEC CORRECTION = - HORIZ * SIN(90-TUB) - VERT * COS(90-TUB)

If the active telescope focus is specified as coude, THETA is computed as the hour angle of the telescope. The default (EEPROM) values for the rotation matrix element signs are:

SIGN #1 = +1 SIGN #2 = -1

SIGN #3 = -1 SIGN #4 = -1

Thus, the rotation transformation is computed as:

RA CORRECTION = + HORIZ * COS(HA) - VERT * SIN(HA)

DEC CORRECTION = - HORIZ * SIN(HA) - VERT * COS(HA)

If the active telescope focus is specified as prime focus, THETA is computed 90 degrees minus the "tub" position angle (in degrees). However, when in prime focus mode, automatic reading of the "tub" position angle (from the tub position encoder) is inhibited, and the value of this field can be set manually from the PET using message number 18. In all other respects, the rotation matrix behaves the same as in Cassegrain focus, i.e., it depends on the position of the TV diagonal mirror. This behavior may be changed in the future so that the position of the TV diagonal mirror will be ignored when the active focus is set to prime focus. However, for the present, one must continue to consider the position of this mirror when autoguiding.

Thus, for prime focus, the transformation used when TV diagonal mirror is in (i.e., position 0) is computed as:

RA CORRECTION = + HORIZ * COS(90-TUB) + VERT * SIN(90-TUB)

DEC CORRECTION = + HORIZ * SIN(90-TUB) - VERT * COS(90-TUB)

while for TV diagonal mirror position 4 (i.e., mirror is out) it is computed as:

RA CORRECTION = - HORIZ * COS(90-TUB) + VERT * SIN(90-TUB)

DEC CORRECTION = - HORIZ * SIN(90-TUB) - VERT * COS(90-TUB)

Note that in this case, "TUB" corresponds to the position angle that has been manually set using message number 18.

When installing a new camera, the quickest way to determine if the rotation matrix element signs are correct for that camera is to attempt autoguiding using the new camera, and see if the guider drives the star off the slit. If the star is driven off, then by analyzing the direction in which the star is driven one can determine what adjustments to make to the rotation matrix parameters. If the star is driven off in a horizontal direction, one can use message 23 to adjust the signs of the horizontal terms (signs #1 and #3), while if it is driven off in a vertical direction, one can adjust the signs of the vertical terms (signs #2 and #4). If it is driven off on a 45-degree diagonal (relative to either the horizontal or vertical of the TV frame), then one can use message 23 to adjust a combination of horizontal and vertical term signs. If the star is driven off at an angle which is not a multiple of 45 degrees, then the rotation angle should be adjusted using message 18.

To execute the PET commands, one must exit from the normal PET menu and get back to BASIC. Then, the following variables must be defined. To leave the value of a given rotation matrix element unchanged, set the corresponding PET variable to zero. To make the sign of the element positive, set the corresponding PET variable to +1. To make the sign of the element negative, set the corresponding PET variable to -1.

variable	Meaning
SF%	Sensitivity pot scale factor (Set to zero)
T0%	TV Mirror position 0 sign reversal
T1%	TV Mirror position 1 sign reversal
T2%	TV Mirror position 2 sign reversal
T3%	TV Mirror position 3 sign reversal
T4%	TV Mirror position 4 sign reversal
T5%	TV Mirror position 5 sign reversal
S1%	Cassegrain rotation matrix element 1 sign
S2%	Cassegrain rotation matrix element 2 sign
S3%	Cassegrain rotation matrix element 3 sign
S4%	Cassegrain rotation matrix element 4 sign
U1%	Coude' rotation matrix element 1 sign
U2%	Coude' rotation matrix element 2 sign

U3%	Coude' rotation matrix element 3 sign
U4%	Coude' rotation matrix element 4 sign
P1%	Prime rotation matrix element 1 sign
P2%	Prime rotation matrix element 2 sign
P3%	Prime rotation matrix element 3 sign
P4%	Prime rotation matrix element 4 sign

For example, assume a new camera is installed at Cassegrain focus, and attempts at guiding result in the star being driven off the slit in the vertical axis of the television. This indicates that the signs of the vertical components (SIGN #2 and SIGN #4) of the rotation matrix should be reversed. This would be accomplished by the following PET commands given directly from PET BASIC

```
CLR:          REM-FORCE ALL PET VARIABLES TO DEFAULT TO ZERO
MS%=23:       REM-MESSAGE #23 IS THE COMMAND TO UPDATE ROTATION
MATRIX
S2% = -1:     REM-REVERSE THE SIGN OF SIGN #2 OF CASSEGRAIN ROT
MATRIX
S4% = +1:     REM-REVERSE THE SIGN OF SIGN #4 OF CASSEGRAIN ROT
MATRIX
SYS(40972): REM-TRANSMIT THE COMMAND TO TELCO
```

After issuing this command, check that the transmission was successful and that the command executed correctly by printing out the value of the variables CC% and CS%, i.e.,

```
PRINT CS%, CC%
```

Both of these variables should be zero. Non-zero values indicate an error in transmission or execution. The various error codes are described in the TELCO write-up which explains PET commands and status frames.

To select a different rotation matrix and corresponding source of position angle information, use message number 20 and set the value of the PET variable FF% (focus flag) as appropriate:

FF% = 0 selects Cassegrain focus (power-up default)

FF% = 1 selects coude' focus

FF% = 2 selects prime focus

Thus, to select the prime focus rotation matrix and to allow manual entry of the rotation angle, one would issue the following PET commands directly to PET BASIC:

```
CLR:          REM-FORCE ALL PET VARIABLES TO DEFAULT TO ZERO
MS% = 20:     REM-MESSAGE #20 SELECTS ACTIVE TELESCOPE FOCUS
FF% =  2:     REM-SPECIFY CODE FOR PRIME FOCUS
SYS(40972):   REM-TRANSMIT THE COMMAND TO TELCO
```

To manually specify a rotation angle for prime focus, use message number 20 and set the value of the PET variable TU% ("tub" position angle) as appropriate. Note that the angle is expressed as an integer in units of tenths of degrees. Thus, for example, to set the rotation angle to 12.3 degrees, one would issue the following PET commands directly to PET BASIC:

```
CLR:          REM-FORCE ALL PET VARIABLES TO DEFAULT TO ZERO
MS% = 18:     REM-MESSAGE #18 SPECIFIES "TUB" POSITION ANGLE
TU% = 123:    REM-SET POSITION ANGLE TO 12.3 DEGREES (0.1DEGREE
UNIT)
SYS(40972):   REM-TRANSMIT THE COMMAND TO TELCO
```

Remember that the THETA used in the rotation matrix is in fact 90 degrees minus the value specified in this command. The reason for this is historical, and is for consistency with the 3-meter.

As was the case in the example given on the previous page, one should check for successful completion of the SYS(40972) command by printing out the value of the variables CC% and CS%, i.e.,

```
PRINT CS%, CC%
```

Both of these variables should be zero. Non-zero values indicate an error in transmission or execution. The various error codes are described in the TELCO write-up which explains PET commands and status frames.

Finally, for use by the telescope technicians, the proper setting of the various parameters can be confirmed by examining the hexadecimal display of TELCO's RAM, using display select positions 0 to 7. The location of the relevant parameters is as follows:

BASIC variable	Corresponding TELCO variable	TELCO RAM
FF%	Focus flag (FOCUSF) (0= Cass., 1= Coude', 2= Prime)	9403
TU%	Tub position angle (TUBPOS) (In units of 0.1 degrees)	93FD - 93FE
Cassegrain rotation matrix signs		
S1%	element 1 sign (AGCAAT)	965F
S2%	element 2 sign (AGCAAT+1)	9660
S3%	element 3 sign (AGCCAT+2)	9661
S4%	element 4 sign (AGCAAT+3)	9662
Coude' rotation matrix signs		
U1%	element 1 sign (AGCOAT)	9663
U2%	element 2 sign (AGCOAT+1)	9664
U3%	element 3 sign (AGCOAT+2)	9665
U4%	element 4 sign (AGCOAT+3)	9666
Prime rotation matrix signs		
P1%	element 1 sign (AGPRAT)	9667
P2%	element 2 sign (AGPRAT+1)	9668
P3%	element 3 sign (AGPRAT+2)	9669
P4%	element 4 sign (AGPRAT+3)	966A

EXAMPLE:
SET-UP SUMMARY FOR MOS AT NICKEL 1-METER TELESCOPE

1. Set TELCO to prime focus

```
MS% = 20:  FF% = 2:  SYS(40972)
```

2. Check for successful transmission

```
PRINT CS%, CC%
```

Both should be zero

3. Check for successful readback

```
CLR
SYS(40969)
PRINT FF%
```

Should print out as 2

4. Adjust rotation angle as appropriate (e.g., to 47.6 degrees)

```
MS% = 18: TU% = 476; SYS(40972)
```

The correct value for this angle will need to be determined empirically.

5. Check for successful transmission

```
PRINT CS%, CC%
```

Both should be zero

6. Check for successful readback

```
CLR
SYS(40969)
PRINT TU%
```

Should print out the value that was set in step 4 above (e.g., 476). The tub position angle display on TELCO's TV monitor (i.e., TUB=) should also display this angle, rounded to the nearest degree (e.g., TUB=048)

7. Adjust rotation matrix sign elements if necessary (for example):

```
MS% = 23: P1% = +1: P2% = -1: P3% = -1: P4% = -1: SYS(40972)
```

8. Check for successful transmission

PRINT CS%, CC%

Both should be zero

9. Note: unlike the focus flag and the tub position angle, the rotation matrix sign elements cannot be read back with the PET. To confirm that these have been set correctly, set TELCO's DISPLAY SELECT switch (thumbwheel switch in upper right-hand corner) to position 6; this should display a checkerboard-like pattern of numbers on TELCO's TV display. The display will contain 16 rows of numbers, and each row will contain 16 "boxes"; each box should contain 2 hexadecimal digits, and the boxes will alternate between normal and reverse video. Locate the 7th row down from the top of the screen. Then examine the eighth through eleventh boxes of that row (counting from the left edge of the row). The contents of these four boxes should correspond to the values stored into PET BASIC variables P1% through P4% in step 7. above. Note that a +1 will be displayed as a hexadecimal 01, and a -1 as a hexadecimal FF. In the example given in step 7 above, these four boxes would be displayed as 01FFFFFF.

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LIMITS SUMMARY

Wind: 50 mph

Humidity: When alarm sounds above 0 degrees centigrade, or 95% on the gauge if at or below 0 degrees; or as necessary to exclude moisture

H.A.: ± 5h 30m

Dec :	With spectrograph,	+58.5, −19.5
	Otherwise	+67.5, −30.17

Zenith distance: 65.5