MULTIPLE MIRROR TELESCOPE OBSERVATORY

Smithsonian Astrophysical Observatory *and* Steward Observatory, University of Arizona

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MMTO Tech Memo 84-8
From: D. Blanco, W. Goring, C. Janes, C. Poland, J. Montgomery
Subject: THE MMTO TOP BOX

I. Summary: The top box is a two level optical bench that resides between the beam combiner and the focal plane on the telescope. It is attached to the instrument rotator ring. It houses acquisition and seeing TV cameras, comparison sources, and associated mirrors, lenses, prisms, shutters, and electronic controls. The new top box is being prepared to add the following features not available in the existing top box:
1. Remote control for more functions such as focus and camera select, etc.
2. Additional functions such as offset guiding, more comparison sources, and more cameras.
3. Sufficient ports, connectors, space, and other provisions for the additional features.

II. Description:

A. The top level of the top box provides the following features:
1. Two acquisition TV cameras, one more sensitive than the other for work on faint objects. Both cameras have intensifier stages and shutters controlled by handpaddles at the operator's station. The camera not used for faint objects may be rotated under computer control by a 100 steps per revolution stepping motor geared 360:1 to provide a step increment of $.01^{\circ}$. This rotation maintains the telescope images constant with respect to the camera photocathode, thus keeping constant the distortion effects of the camera. The full range of motion is 540°. The angular position of the camera is displayed on the operator's control panel.

A third camera can be mounted at a side port to permit viewing the slit while the acquisition camera field of view is offset for autoguiding.

Each acquisition TV has a focusing lens. The lenses may not be remotely focused since focusing is provided by the Beseler lens.

2. Two steering mirrors mounted on a sliding stage so that the optical beam from the bottom level can be reflected to one or the other of the intensified TV cameras. The mirrors must be adjusted by hand, but are mounted kinematically to maintain stability of the adjustments. The mirror assembly is moved under remote control by a torque motor; the positions are encoded by microswitches. The stage can be stopped at any of three positions. The two positions occupied by mirrors are located with hard stops and are repeatable to $\pm$ .0005" (design estimate). The third position is clear and need only repeat to $\pm$ 1/8". This function is also referred to as the "camera select".

One or both of the mirrors may be replaced with a dichroic or beamsplitter to permit splitting the optical beam between the acquistion TV camera and a slit-viewing camera. The third "clear" position of the slide permits the entire beam to be reflected to what is referred to here as the slit-viewing camera position.

3. A revolving assembly of four pupil wheels known as the "pupil select", located at the pupil image in the optical path between the steering mirror and the acquisition camera driven under remote control by a 200 steps per revolution stepping motor geared 96:1 for a step increment of .02°. Each of the four pupil wheels can be revolved precisely into the optical axis, by means of a coarse index on the pupil revolver, a fine index on the motor shaft, and phase information from the stepper motor logic. This assures location on the unique step. Two additional bits are encoded on the pupil revolver to identify which pupil wheel is in place. These two bits and the coarse and fine indices are determined by opto-interrupters used to sense holes in disks attached to the pupil revolver and motor shaft.

All four pupil wheels rotate together, driven by a single 100 step per revolution stepping motor geared 36:1 for a step increment of .1°. The angular position of the wheels is determined by counting steps from the home position. A unique "home" index is established for the four wheels to a one-step accuracy using the same method as on the pupil select. The pupil wheels are rotated under remote control. One pupil wheel houses six wedge prisms. The prisms cause the six star images to be displayed separately on the acquisition video. The wheel is rotated to keep the prisms constant with respect to the pupil image when the top box derotater is in motion. The purpose of all this is to permit the TCS computer to measure the individual star image positions for use in autoguiding. The common motion of the star images is used to correct the OSS while the differential image motions are used to correct the secondaries.

4. An assembly of 2 achromatic wedge prisms on the same optical axis as the pupil wheel permit a radial and angular displacement of the acquisition TV camera field of view so that any part of the 4 arc minute telescope field of view can be displayed on the acquisition video. The wedge prisms are rotated by 200 steps per revolution stepping motors geared 180:1 for a step increment of .01°. This translates to a resolution of .01° for "θ" and to be determined for "r" on the sky. The prisms are manually controlled remotely for acquiring an offset guide star for automatic guiding. "θ" and "$\Delta\theta$" positions are displayed on the operator's control panel.

B. The bottom level of the top box provides the following features:

1. A Beseler lens to collimate the optical beam reflected from the focal plane. The lens is moved along the optical axis by a torque motor with a resolution of $\pm$ .01". The motion is encoded with a linear-wipe potentiometer and a readout at the operator's station so that the operator can easily repeat selection of Beseler lens position. This motion provides focusing of the optical beam to the various detector positions in the top level.

2. An integrating sphere to provide a uniform beam from any of several comparison sources. Each of the sources feeds light to the sphere by means of individual fiber optic links. Fiber optics may be used to feed light to the sphere from sources external to the the top box, such as the sun. The sphere exit port feeds a light beam through a filter wheel assembly and a Hartman wheel assembly to optics on a sliding stage.

3. An 8 position filter wheel assembly in the comparison source beam path driven by a 200 steps per revolution stepping motor geared 24:1 for a step increment of .075°. A coded disk and optical interrupter assembly plus electronics to return to the same phase of the stepping motor permit selection of filter positions accurate to 1 step of the stepping motor. Seven neutral density filters from .15 to 3 permit various attenuations of the comparison source beam. The 8th position is clear. The wheel is moved under remote control.

4. An 8 position wheel assembly provides the selection of 7 different Hartmann wheels or clear. The wheel assembly is identical to the filter wheel. The Hartmann wheels are used to mask the spectra from the comparison sources. The wheel assembly is moved under remote control.

5. A 3-position sliding stage on which is mounted optics to deflect the comparison source beam. The stage is identical to the steering mirror sliding stage and is driven by a torque motor to any of three positions. The 2 positions occupied by mirrors are located with adjustable hard stops and microswitches for a repeatability of $\pm$ .0005" (design estimate). The third clear position need only repeat to $\pm$ 1/8". A double-sided mirror at one position images the integrating sphere aperture onto the telescope focal plane while simultaneously deflecting the telescope beam to a detector which may be located at the bottom level. The second position holds a mirror to deflect the beam to a position the use of which is to be determined, while the third position is clear.

6. An I-CCD TV camera to view the telescope field for seeing tests.

7. A removable optic assembly used when the user's

instrument does not have a mirror located at the telescope focal plane or when no instrument at all is mounted on the top box. A mirror, a beamsplitter, or a dichroic may be used with the assembly. The mirror is pierced with an aperture so that light from the observed object passes through to the user's instrument while the remainder of the field is reflected to the acquisition TV. The dichroic passes red light through to the user's instrument while reflecting blue light to the top box, while the beamsplitter passes 80% of the light to the user's instrument.

III. Mechanical configuration:

1. Outside dimensions are 38 1/2" x 38 1/2" x 23 1/2" high. Material is anodized aluminum.

2. The box is divided into upper and lower levels by a 1/2" thick shelf. The 10" tall lower level is further divided into north and south compartments by a segmented wall. The south compartment houses control electronics and comparison lamps. The division prevents dissipated heat from disturbing the optics in the north compartment.

3. Four removable access panels are provided on each side of the top box. Two large (9 1/4" wide by 16 3/8" tall) panels access both upper and lower levels, while two small (7" wide by 6" tall) panels access one or the other level. The top of the box is also provided with hinged and/or removable panels in a to be determined configuration. Some of these panels may be used to hang special electronics or connectors, or to attach optical instruments.

4. At every possible detector location the floor or shelf of the box is drilled and tapped with mounting holes in a standard optical bench configuration (1/4-20 holes on 1.000 inch centers). This provides easy installation of various detectors, pickoff mirrors, and other optics.

5. Various popular bolt circles are provided in the bottom plate of the box for mounting instruments. Bolt holes are reinforced with threaded steel inserts. A bullseye pattern of contrasting color is inscribed in the bottom plate to aid alignment of instruments during mounting.

6. The quasi-cassegrain focus of the MMT is located 9.00 ± 0.02 inches below the bottom plate of the top box.

7. Instruments which make use of the top box functions must provide a reflective aperture or semi-reflective surface at the MMT focus to feed the top box optics. Alternately, the instrument may make use of the removable optic assembly described in Section II B, paragraph 7.

8. Nominal values for the position and angle of the mirror which feeds the top box optics were given in MMTO Technical

Memorandum 83-13, and are summarized here:

a. Mirror intersects z axis (telescope pointing direction) 9.00 $\pm$ 0.02 inches below bottom plate of top box.

b. Slits or holes should be within 0.02 inches of the z-axis intersection.

c. Mirror is tilted 12.50 $\pm$ 0.04 degrees about the north-south axis. Mirror is inclined down towards the west.

d. Mirror is not tilted more than 0.04 degrees about the east-west axis.

IV. Remote Control

The top box functions are controlled remotely from a control panel at the operator's station or from a computer. Throughout this write-up, remote control refers to either computer control or the control panel. A manual switch at the operator's station permits control exclusively from the manual control panel, or from the manual control and the computer together. In the latter case, control signals from the manual control pass to the computer so that the computer can keep track of the status of every function.

All top box features which rotate as a function of position angle (camera rotator, pupil wheels, and AWPS) are controlled by interfaces in the mount computer expansion chassis. Other functions are controlled by interfaces in the TCS computer expansion chassis.

Spectrograph functions that reside in the top box (Hartmann wheel, filter wheel, comparison sources, and comparison mirror) are remotely controlled by the instrument controller if one is connected. Status of these functions is provided to the control panel at the operator's station. The instrument controller connection to the top box has provisions for jumpers that will prevent certain comparison sources from being used when that controller is connected.

The four features with a continuously controlled motion as a function of position angle are the AWP's (2), camera rotator, and pupil selection. These motions are controlled by generating a serial pulse train in the remote control, one pulse per step. One step represents a motion of .01 deg; the maximum slew rate of position angle is 2 deg/second so that the maximum step rate is 200 Hz. In addition to 1 step command line per motor, there is a direction command line, an enable line, and a "go home" control line. "Go home" is a 1 usec pulse that is latched in the top box electronics to force the motor to slew to a "home" position. Three status lines return to the remote control from the top box for each function, "step loss", "step", and "home". "Step loss" occurs when the step count is not equal to the number of steps between the motor index position, or some integer multiple thereof, indicating an error in positioning the motor has occurred. "Step loss" is reset when the step count is correct at the motor index position. This can be accomplished by going to the home position. The "step" line indicates when a step command takes place to provide a motion indication to the operator's control panel. "Home" indicates when the motor has successfully reached the home position.

The two sliding stages (comparison mirror and camera select) and the pupil select are controlled by the TCS computer. A separate signal line exists for each position of each of the three different functions. Position information from the microswitches on the sliding stages is returned to the remote control. The motor and opto-interrupters for the pupil selector are turned off after positioning so that position information must be determined from the previous command. All three functions are commanded to a "default" position on power up by the top box electronics. When all three functions are at the default position, a "park" signal is returned to the remote control. A "Busy" status line from the top box from each of the three functions indicates when a function is in motion. The direction for the two sliding stages is always defined so that moving to an undesired position can be avoided.

The Beseler lens is positioned manually from the operator's control panel only. A potentiometer permits indication of position on the operator's control panel.

The filter wheel, Hartman wheel, and comparison sources are controlled only by the instrument control box, though the status of all three functions is returned to the TCS computer and to the manual control. The comparison mirror is controlled by the instrument control box only when the instrument control box is connected; otherwise, control reverts to manual or computer control. Status is always returned to both the computer and the manual control.

Features discussed but not provided as of this writing.

1. A "de-stacker" assembly of six wedge prisms to bring into coincidence images which are stacked in a line at the main focus for high resolution spectroscopy. A spare position in the pupil wheel is set aside for the addition of this feature at a later date.

2. A six hole baffle to eliminate background light at the TV when using unbaffled IR optics. Again, a spare position has been set aside in the pupil wheel for the addition of this feature.

3. Sets of six Hartmann biprisms to aid in focusing of the indiviual images.

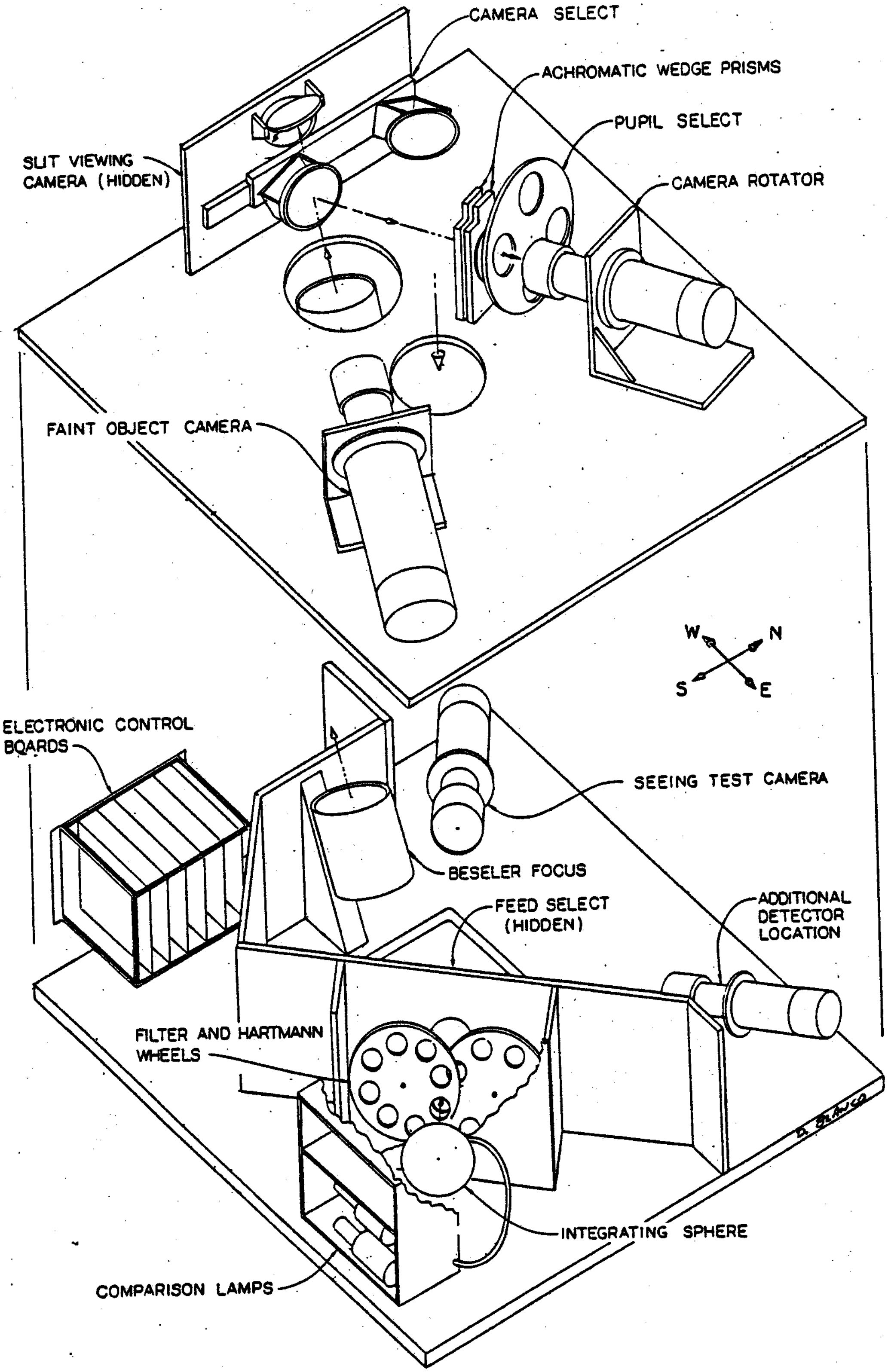
4. A mask which transmits only one of the 6 pupils. A spare position in the pupil wheel may be used for this purpose.

5. A device to eliminate the overlap of the sky background

in the 6 star images. An attempt was made to implement this feature using a set of 6 lens pairs, but the lenses received proved to be of insufficient quality. There may be a way to do it using optics at the focal plane.

6. A shutter to protect an instrument attached to the bottom of the top box.

7. Lightproofing and shutter at top entrance to permit flatfielding with chamber lights on.



CAMERA SELECT
ACHROMATIC WEDGE PRISMS
PUPIL SELECT
SLIT VIEWING CAMERA (HIDDEN)
CAMERA ROTATOR
FAINT OBJECT CAMERA
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ELECTRONIC CONTROL BOARDS
SEEING TEST CAMERA
BESELER FOCUS
FEED SELECT (HIDDEN)
ADDITIONAL DETECTOR LOCATION
FILTER AND HARTMANN WHEELS
INTEGRATING SPHERE
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