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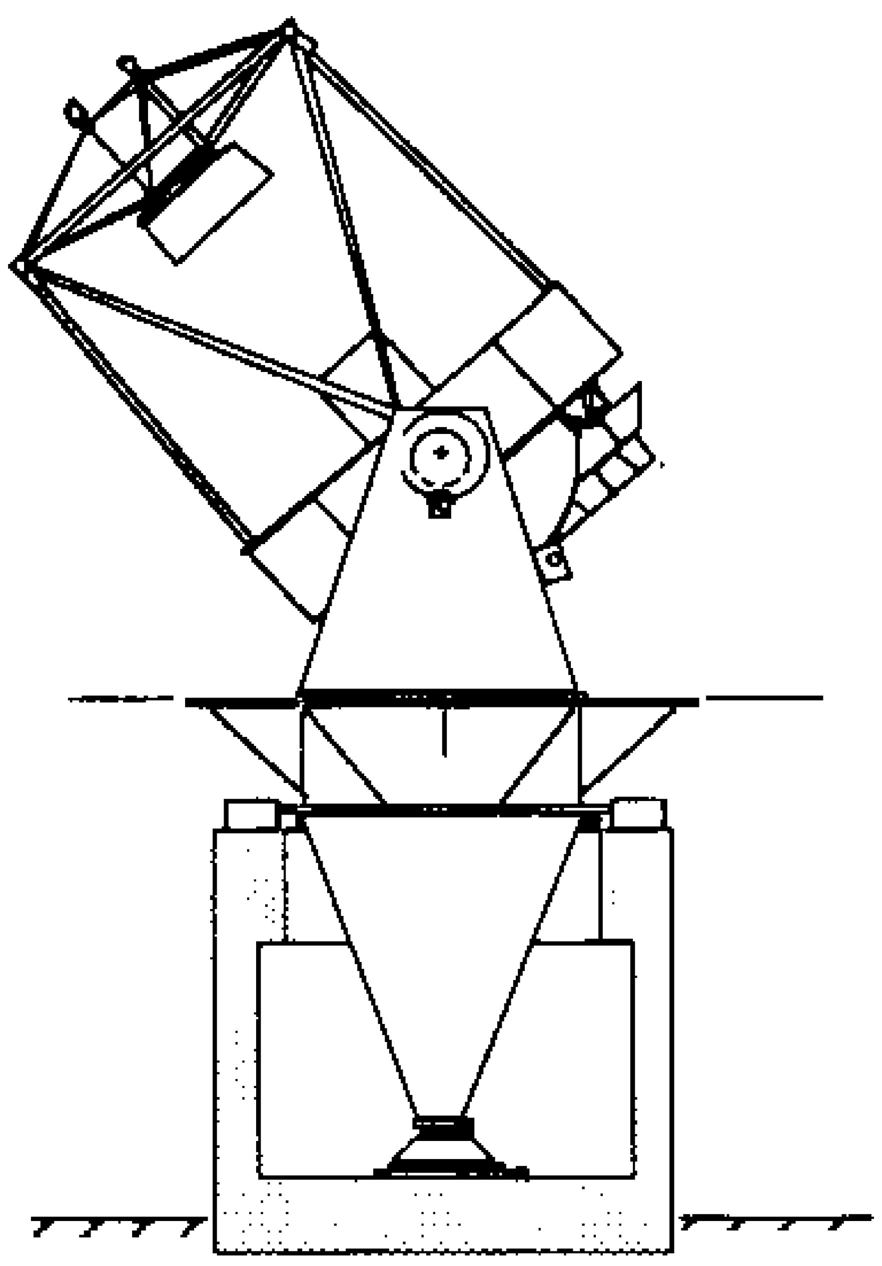

3.5 Meter Telescope

Secondary Mirror Subassembly

Design Requirements for the WIYN 3.5 Meter Telescope

WODC 01-13-02

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Title: Secondary Mirror Assembly Design Requirements for the WIYN 3.5 Meter Telescope

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1. Purpose and scope

This document describes the performance requirements for the secondary mirror subassembly for the WIYN telescope. The secondary mirror is housed in a support cell which attaches to the vane and cage assembly of the OSS. The optical design of the telescope (WODC 02-01) calls for a convex hyperbolic secondary 1.2 meters in diameter. It will be made of low expansion glass in a lightweight honeycomb configuration weighing approximately 250 lbs. (see NOAO drawing number 3506.0003960E sheets 1 through 3).

The mirror support cell performs eight functions:

a) provides rigid spatial definition for the mirror with respect to the vane and cage assembly under all pointing conditions;

b) provides controlled movement of the secondary mirror in three degrees of freedom (tip, tilt, and focus) with minimum hysteresis;

c) supports the secondary mirror with minimum distortion of the optical surface;

d) protects the secondary from damage in use,

e) allows for the safe removal and reinstallation of the secondary;

f) allows the secondary to be installed on the telescope in several alternate positions clocked about the optical axis;

g) Accommodates manual adjustment during initial collimation.

h) provides a mounting surface for the secondary baffle.

A design goal of the secondary and support cell is to minimize contribution to seeing internal to the telescope. Low mass, lightweight designs and low power dissipation are consistent with this goal.

2. System description

A mirror support scheme similar to that proposed for the Magellan[1] f/6.5 and the MMT Conversion[2] f/9 secondaries has been selected for supporting the WIYN secondary. An assembly is shown in NOAO drawing number 3501.0003994E.

The mirror is kinematically defined to its cell at three points spaced 120° apart and located near the 70% full radius from center. These three points define a plane in space establishing the secondary's pointing and axial position, but do not define the mirror laterally.

Lateral definition is provided by a central hub flexure located at the CG point of the mirror.

A tangential strap flexure will define the mirror in rotation about its axis.

When the telescope is zenith pointing the secondary mirror is supported by air pressure over its face. This is done by forming a pneumatic seal between the mirror and cell at the mirror circumference and evacuating the space between the mirror and its support cell. The vacuum is regulated to about 0.13 psi below ambient air pressure to balance the weight of the mirror against gravity.

FEA studies of the WIYN secondary indicate that an image blur of 0.43 arcseconds FWHM results when the full weight of the mirror is suspended from its three defining points. Scaling indicates that up to 30 lbs may be taken on the defining points (10 lbs per point) and still meet the image specification. The vacuum system must regulate to better than 12% of full load in order to maintain this condition.

At horizon pointing the full weight of the mirror is carried by a central diaphragm flexure located at the cg point of the mirror. FEA studies indicate this will contribute .03 FWHM at horizon pointing without refocus or recollimation. Since the horizon pointing aberration is primarily comatic, it may be possible to improve this somewhat by active collimation.

The mirror and cell are kinematically registered to the secondary cage assembly in a similar manner. Three actuator motors located on the secondary cage provide collimation and focus adjustments by moving the mirror and cell in tip/ tilt and focus.

3. Envelope

No part of the secondary assembly can protrude beyond the central obscuration diameter of the well baffled telescope (described in WODC 00-01).

4. Focus motion

Focus travel is provided to find the "best" focus position during initial collimation, to accommodate any variation in the focal plane position between various instruments, and to actively compensate for thermal and gravitational deflections in the telescope. The ratio of secondary focus travel (dS) to image plane focus motion (dZ) is given by $dZ = m^2 dS$. For the WIYN telescope m = 3.597.

The requirements for dynamic secondary focus travel are:

range: +/- 5 mm (corresponds to +/- 64.7 mm at image plane)
resolution: 5µ minimum (corresponds to .1 arcsecond image enlargement)
speed: 1.5 mm per minute maximum (corresponds to about 0.5 arcseconds per second image "bloom")

Focus motion of the secondary should not cause any notable image degradation due to vibration from starting, stopping or running motors.

Focus motion must not cause more than 0.05 arcseconds of image motion due to "drunken helix" or similar systematic errors.

In addition to its dynamic focus travel range, allowance will be made for additional static adjustment of +/- 10 mm in focus. The static focus adjustment will be done during initial collimation only.

5. Tip and tilt

A finite element model of the WIYN telescope structure[3] predicts the secondary package will tilt about one half arcminute as the telescope tracks from zenith to horizon. Rotations of this magnitude may introduce noticeable miscollimation aberrations to the image field. Hence it may be necessary to tilt the secondary package during observations to actively collimate the telescope compensating for thermal and gravitational tilt deflections.

Tilt of the secondary causes image motion at the focal plane. The image motion per step must be small enough to be unnoticeable during observations.

The requirements for the tip/tilt motion are:

range: 1 degree minimum (corresponds to 35 arcminutes of image motion on the sky)
resolution: 0.04 arcsecond (corresponds to 0.025 arcseconds of image motion on the sky
repeatability: 0.08 arcseconds (corresponds to 0.05 arcseconds image motion on the sky

All axes of motion will be provided with limit switches and safety restraint clips to prevent catastrophic failures.

6. Centration

Allowance will be made for manually centering the secondary and its cell +/- 1.5 mm with respect to the secondary cage in any direction in the plane of the secondary square frame. The centration shall be repeatable so that the secondary may be removed and re-registered in its previous position.

7. Mirror support tolerance

An overall budget for image degradation due to various sources was presented in WODC 00-01-02. The allowance for image degradation due to secondary support errors is 0.05 arcseconds FWHM at zenith pointing. When the telescope is pointing at an arbitrary zenith angle the error allowance increases as $(\cos z)^{-3/5}$ where z is the zenith distance. This implies the following error allowances:

Zenith distance	Image allowance (arcsec FWHM)
0°	0.050
20°	0.052
40°	0.059
60°	0.076

7. Thermal image degradation

The allowance for image degradation due to thermal effects of the secondary and support cell is 0.07 arcseconds FWHM at zenith. In order to meet this budget the support system will be designed to dissipate minimum heat. A reasonable goal for powered motors and controllers resident on the secondary mirror subassembly is no more than 10 Watts total power dissipation under normal conditions.

All surfaces exposed to the night sky will be covered with low emmissivity tape. Any other prudent precautions will be taken to promote the rapid thermal equilibration of the secondary and its support package to the ambient air temperature.

8. Removal and installation.

The secondary cell will be removed from the telescope on an annual or semi-annual basis for realuminizing the secondary mirror. The design will allow for safe removal or installation in 2 hours or less. An overhead crane with 1/2 ton capacity may facilitate this process.

The mounting cell will be designed to safely support the mirror in the event of accidental bumps and jars (approximately 1.3 G accelerations) during handling.

A cover will be provided to protect the secondary during handling and for temporary storage.

9. Environmental

The secondary support cell will meet specifications under the following conditions:

Temperature	0° to 100° F
Humidity	98% non-condensing
Altitude	6838 ft.

1. Eric Melsheimer, "Preliminary design of the f/6.5 optical secondary", Magellan Project Report No. 20, June, 1990

2. Dan Blanco, "Support and thermal analysis of the f/9 secondary" Memorandum to the MMT Conversion Committee, October 23, 1990

3. Engineering Report - "Preliminary design study for the WIYN 3.5 meter telescope" by L&F Industries, June 1990