Stanford University
W.W. Hansen Experimental Physics Laboratory
Gravity Probe B Relativity Mission
Stanford, California 94305-4085

GP-B Telescope "Assemble Base Plate/Tertiary Mirror/Primary Mirror Assy. and Corrector Plate/Secondary Mirror Assy." P0361 Rev -

September 15, 1995

Prepared: _____ Date _____
Jason Gwo, Telescope Assembly

Prepared: _____ Date _____
Ken Bower, Telescope Assembly

Approved: _____ Date _____
John Lipa, Telescope Manager

Approved: _____ Date _____
John Turneaure, Hardware Manager

Approved: _____ Date _____
Ben Taller, Quality Assurance

ASSEMBLE BASE PLATE/TERTIARY MIRROR/PRIMARY MIRROR ASSY. AND CORRECTOR PLATE/SECONDARY MIRROR ASSY.

- for SUGP-B dwg#'s 25087 and 25088
- also use *GP-B Telescope Image Divider Assembly (IDA) General Alignment and Bonding Procedures* (SUGP-B P0282) for procedures concerning safety; personnel; work area requirements; fixture cleaning and acceptance; flight part inspection, handling, storage, and cleaning; redline authority; and sign-off and recording requirements.

CAUTION:

- The flight parts used in this operation may be heavy, delicate, and somewhat irreplaceable with multiple critical surfaces that can be easily damaged or contaminated by normal handling. Compliance with the above defined safe handling practices is critical.

CAUTION:

- If at any time during this procedure flight hardware is not live monitored, verify that all flight hardware is seismically secured and protected against airborne contamination.

WARNING:

- Some of the solvents, detergents, and/or bonding agents used in this procedure may be flammable, toxic, or reactive. Consult P0282 for information about specific chemicals.

Table of Contents:

1 SURFACE CLEANING OF TELESCOPE FUSED QUARTZ PARTS

1.1 Where:

Class 100 clean bench in Telescope clean room (Class 1000). Preferably two and NO more than three people are allowed in the clean room.

1.2 General Cleaning Schemes

In order of increasing time, effort, and effectiveness**:**

1.2.1 DI-air cleaning
--- Baseline process after locking the part on centering fixture
1.2.2 Solvent touch off (plus (A))
--- Baseline process after locking the part on centering fixture

1.2.3 Snow/air cleaning
--- Baseline process *before* locking the part on centering fixture
1.2.4 Spin cleaning (in Telescope clean room)
--- GO's proprietary
--- Stanford has the capability of cleaning parts with only one critical surface.
1.2.5 GO cleaning (In Telescope clean room or at GO)
--- GO's proprietary
--- Default process conducted by General Optics before shipping
--- Stanford has the facility except the cleaning chucks for parts with two critical surfaces.
--- To be performed only by experienced technicians from GO because of the high danger to parts and personnel.

1.3 DI-AIR CLEANING

1.3.1 Use De-Ionized air cleaning gun supplied with PPE Grade Nitrogen gas to gently blow off particulates.
--- Avoid blowing particles into upstream of laminar flow air.
--- Avoid contacting the part with the air gun.
--- Be patient; lightly charged particulates may take several seconds of blowing before their charge dissipates enough for them to be blown off.

1.4 SOLVENT TOUCH OFF

1.4.1 Use low acetone grade Methanol (<1ppm residue after evaporation) moistened Technicloth (low particulate Polyester; i.e VWR TWTX604 or -609) wipe or small alpha swab (woven polyester tip; i.e VWR TWTX742B) to touch off particulate.

1.5 SNOW/AIR CLEANING PROCEDURE:

1.5.1 Snow/air clean (i.e. (a) CO_2 snow cleaning and (b) DI-N_2 purging immediately after (a)):
* the cleaning compartment in the clean bench,
* gloves and sleeves,
* all surfaces of the cleaning chuck located in the compartment:
* the microscope, and
* the cold-light illuminator

1.5.2 Roughly snow/air clean Side B of the part when *firmly* held by two hands on the non-bonding surfaces.
--- Make the snow jet approximately in the same direction as the laminar flow.

1.5.3 Lock the part in position, with Side A exposed, on cleaning chuck.
--- Cushion the part with particulate free orange polyester shim stock.

1.5.4 Snow/air clean all exposed surfaces of the part.
--- Make the snow jet approximately in the same direction as the laminar flow.

1.5.5 Check the bonding surface and its chamfer under strong cold-light illumination with 7X microscope for any visible-light scattering center.
--- (NO picture-taking for surface cleanliness documentation)

1.5.6 Iterate Steps (1.5.4) and (1.5.5), if necessary.

1.6 SPIN CLEANING

Proprietary General Optics Process. Refer to General Optics (554 Flinn Ave. Moorpark, CA 93021) for procedures.

1.7 GO CLEANING

Proprietary General Optics Process. Refer to General Optics (554 Flinn Ave. Moorpark, CA 93021) for procedures.

2 PRE-BONDING CLEANING/INSPECTION

2.1 When:

After alignment is made with the alignment/bonding fixture, and right before bonding

2.2 **DI-air clean** (above, section 1.3) the part for loose particulates; solvent touch off (above, section 1.4) for relatively tenacious particulates.
--- Keep nothing, including hands, in the upstream of the laminar flow.
--- If unsuccessful, perform snow/air cleaning

2.3 **Check the bonding surface** and its chamfer under strong cold-light illumination with 7X microscope for any visible-light scattering center.
--- (NO picture-taking for surface cleanliness documentation)

2.4 **Iterate** Steps (2.2) and (2.3), if necessary, for both bonding surfaces.

3 ALIGNMENT AND BONDING

3.1 Where:

Class 100 clean bench in Telescope clean room (Class 1000) unless otherwise stated

3.2 General Scheme:

3.2.1 Align and bond Baseplate (SUGP-B dwg#25077) and Tertiary Mirror (SUGP-B dwg#25080). (Wait at least 24 hours before starting (3.2.2).)
3.2.2 Align and bond Baseplate/Tertiary Mirror assy. and Primary Mirror (SUGP-B dwg#25081)
3.2.3 Align and bond Secondary Mirror (SUGP-B dwg#25079) and Corrector Plate (SUGP-B dwg#25060). (Independent of (3.2.1) and (3.2.2).)

3.3 Assembly Procedure:

3.3.1 Freon clean alignment fixtures in SIA clean room (Class 1000):
--- After cleaning, carry them to the gowning area of Telescope clean room with snow cleaned container. (Follow *snow/air cleaning procedure* (above, section 1.5).)
--- Only the fixtures (not the container) are taken into the class 100 clean area.

3.3.2 Visually inspect all parts for shipping damage:
--- Follow *pre-bonding cleaning/inspection procedure* (above, section 2*)*, for both flight parts and their protective covers as necessary.
--- Put shipping cover(s) back on immediately after inspection/cleaning

3.3.3 Prepare environment in Telescope clean room:
--- Preferably two and NO more than three people in the clean room for better cleanliness (Observers are welcome to look through window.)
--- Everyone gowned for Class 100 or cleaner environment (bouffant cap, face mask, coverall, shoe covers, and gloves required)
--- Snow clean bench, gloves, all components, tools, and fixtures in the clean bench and ductless fumehood. Snow clean the strength tester and weights. (Follow *snow/air cleaning procedure* (above, section 1.5*)*.)
--- Count particles inside and outside the clean bench to ensure Class 100 and 1000 environment (or better), respectively.

3.3.4 Prepare bonding solution
--- See *Bonding Procedure for Fused-Quartz Components* (SUGP-B 0218)
--- Verify solution by bonding two 1" o.d. flats together.

3.3.5 Snow clean all surfaces of flight parts
--- Follow *snow/air cleaning procedure* (above, section 1.5).

3.3.6 Lock BP (or CP) on alignment fixture
--- Protect the lower surface with a cushion (kapton tape) on the part supports.

3.3.7 Inspect/clean the bonding surface of BP (or CP) to TM/PM (or SM):
--- Follow *pre-bonding inspection procedure* (above, section 2).
--- Follow *surface cleaning of telescope fused silica parts* (above, section 1), if any scattering center is found.
--- After cleaning, put the part in a snow-cleaned storage compartment.

3.3.8 Inspect/clean the bonding surface of TM (or PM or SM):
--- Follow *pre-bonding inspection procedure* (above, section 2).
--- Follow *pre-bonding cleaning procedure* (above, section 1), if any scattering center is found.
--- After cleaning, put the part in a snow-cleaned storage compartment.

3.3.9 Iterate Steps (3.3.7) and (3.3.8) until both bonding surfaces are free of visible-light scattering centers.

3.3.10 Center the top piece on BP (or CP)
--- Follow the *standard centering procedure* (below, section 4).

3.3.11 Inspect/clean bonding surfaces again
--- Repeat (3.3.9).

3.3.12 Bond
--- See *Bonding Procedure for Fused-Quartz Components* (SUGP-B P0218)
--- Have a second set of micro-pipettes ready.
--- Before bonding PM/BP, put plastic protection cover on TM

3.3.13 Cure bond for at least 24 hours.

3.3.14 Check centering.
--- After checking, snow clean both assembly and its protection covers if necessary.
--- Put on protection covers.
--- Document centering readings (attach copy of lab notes to sign-off sheet from P0282).

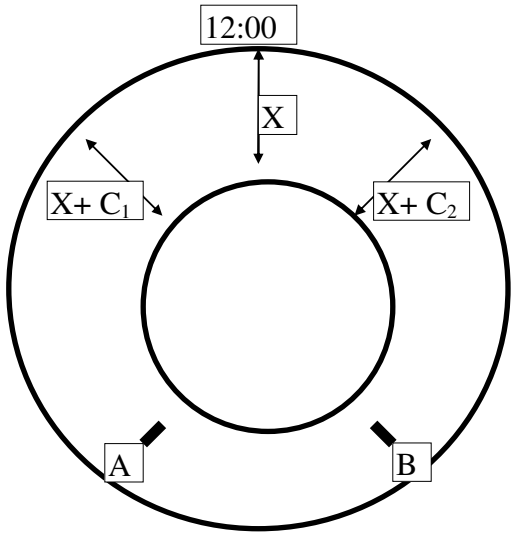
3.3.15 Perform qualification shear test (in Telescope clean room).

--- Shear load corresponds to 7.5 G of the lighter piece.
--- Protection covers remain on the assembly.

3.3.16 Recheck centering
--- (Same as (3.3.14))

3.3.17 Store assembly in flight part container.

4 STANDARD CENTERING OF TELESCOPE MIRRORS



SUGP-B P0361 Rev -
J. Gwo, K.Bower

4.1 SET-UP

4.1.1 Install the Baseplate or Corrector Plate in the Centering fixture such that the top of the part is parallel to the top of the fixture to within 0.010". Secure the part by tightening the locking screws such that the opposing spring clips are compressed until they nearly create a hard contact.

4.1.2 Place one piece (~10 sq.cm) of orange polyester shim stock on the center of the part for the tertiary mirror or three pieces distributed evenly over the mirror's footprint for the primary and secondary mirrors.

4.1.3 Place the mirror on top of the protective shim stock.

4.1.4 Place the indicator jig onto the fixture using care to avoid contact with all bonding and coated surfaces. Bring the jig into five point contact with the fixture and part.

4.1.5 Adjust and secure the articulated arm of the indicator jig such that the indicator tip contacts the sidewall of the mirror at the same height as A and B.

4.1.6 Temporarily move the jig out of the way as required for safety during any future steps.

4.2 COARSE PHASE

4.2.1 Move the mirror by hand until it appears to the eyes to be centered with respect to the other part.

4.2.2 Adjust screws A and B until they both contact the mirror. Sweep the indicator jig around at least ninety degrees of the part's diameter and take readings at about 1:30 and 10:30 to determine C_1 and C_2. Adjust screws A and/or B such that C_1 appears to be equal to C_2 (as well as you can tell with the range of the indicator).

4.2.3 Adjust screws A and B as required by amounts approximately equal to C_1 and C_2 until they can be measured by sweeping the dial indicator over ninety degrees of range (around 0.003" or less).

4.2.4 Adjust screw A or B such that $C_1 = C_2$ (hereafter referred to as C). Repeat this step as required during the fine phase.

4.3 FINE PHASE

4.3.1 Use the micrometer on the indicator jig to zero the dial indicator in the 12:00 direction

4.3.2 Measure C by sweeping the indicator jig.

4.3.3 Adjust both A and B by 2.415 x C (watch for sign error - if C is positive, unscrew).

4.3.4 Rezero the indicator at 12:00.

4.3.5 Remeasure C
- if C is larger than before, you have made a sign error; reverse adjustments to screws A and B
- if C_1 is not equal to C_2, adjust screw A or B until it is and repeat fine phase
- if C >0.0003" then repeat fine phase and you'll probably do better
- if C <0.0001" then you probably can't get any better

4.3.6 Check solid for contact of all parts; tighten clamps on screws A and B; and reverify that C <0.0002".

4.4 GENERAL RULES AND PITFALLS

4.4.1 For bonding, all centering should be conducted by a single person in the laminar flow area of the class 100 clean bench.

4.4.2 Whenever screw A or B are adjusted, assure that the mirror is in firm contact with both screws A and B before continuing

4.4.3 For fine phase, slightly tighten the clamps on screws A and B.

4.4.4 During the fine phase, apply a *constant* 5-10 lbs. of force to the indicator assembly towards the center to overcome any 'spring slop' in the system whenever measuring and make sure that the articulated arm of the indicator jig is tightly locked.

4.4.5 Periodically check to make sure that no particles are building up in any critical contact point (the five contact points of the indicator jig and screws A and B). Clean contacts with *solvent touch off* (above, section 1.4) as required.

attachments: SUGP-B dwg#'s 25087, 25077, 25080, 25081, 25088, 25060, 25079.