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

GP-B Telescope
"Determine Metering Tube Length"
P0364 Rev -

March 11, 1998

Prepared: _____ Date _____
Ken Bower, Telescope Assembly

Approved: _____ Date _____
Jason Gwo, Telescope Assembly

Approved: _____ Date _____
John Lipa, Telescope Manager

Approved: _____ Date _____
John Turneaure, Hardware Manager

Approved: _____ Date _____
Ben Taller, Quality Assurance

DETERMINE METERING TUBE LENGTH

- for SUGP-B dwg. #25091
- follows *Assemble Baseplate/Tertiary Mirror/Primary Mirror Assy. and Corrector Plate/Secondary Mirror Assy.* (SUGP-B P0361)
- 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 and returning mirror used in this operation are 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.

1) Set-up fixtures.

1.1) Verify cleanliness of all fixtures and tools. Use special care to clean granite surface plate to remove any particulates.

1.2) Inspect the main rail for rust on critical surfaces. If necessary, lightly polish critical surfaces with a gauge block stone and reclean the rail. Place the rail (use normal care, this part is heavy!) on to the surface plate such that the slotted edge is toward you with the slot itself facing up.

1.3) Place the three guide pins in the slot on the rail.

1.4) Place the forward plate fixture on the rail over the middle guide pin. Adjust position and lock in place using the screws provided.

1.5) Place the baseplate fixture on the rail over the left guide pin. Attach the adjusting screw mechanism to it and the left end of the rail.

1.6) Place the knife edge fixture on the rail over the right guide pin. Attach the adjusting screw mechanism to it and the right end of the rail.

1.7) Adjust the three horizontal brass locator screws on the forward plate fixture such that the plane defined by their ends is approximately parallel to the fixture and perpendicular to the rail. Repeat for the baseplate fixture.

1.8) Adjust the two centering brass locator screws on the forward plate fixture such that the 7.25" diameter forward plate assembly will be approximately centered with respect to the fixture and rail when placed against the five brass contacts. Repeat for the baseplate fixture.

1.9) Place the two measurement transfer plates on the surface plate against the closest edge of the rail such that their polished surfaces face left and install the long adjusting rod between them.

1.10) Place the two measurement transfer plate clamps over the rail and into the slots on the plates. Tighten the locking screws on the clamps until the plates are still just able to move against the rail by hand.

1.11) Assemble any remaining parts onto the knife edge fixture (should be preassembled) and install the fiber optic into the fixture. Attach the other end of the fiber to a light source.

1.12) Verify cleanliness of all fixtures and nearby work area.

1.13) Place a small piece of Kapton tape over each brass locating screw which will contact flight or other glassy parts. Use care to prevent the entrapment of any particles or air bubbles under the tape.

1.14) Certification: Date/Time Signature

Work Area _____ _____

Fixture Cleanliness _____ _____

Fixture Set-up _____ _____

Notes _____

_____

_____

2) Install and align flight parts.

2.1) Place the forward plate assembly (SUGP-B dwg. #25088) in the left side of the forward plate fixture with the secondary mirror facing left and the 12:00 o'clock mark approximately up. Place the three spring clamps on to the forward plate such that the plate is secured and no part of the clamps obscures any part of the clear aperture.

2.2) Temporarily tighten the clamp on one of the alignment transfer plates. Place a D-656 2.5" autocollimator to the left of the main rail such that its beam will reflect from both the polished surface of the plate and the surface of the forward plate. Use intermediate mirrors as required.

2.3) Carefully adjust any of the five brass locating screws as desired to improve alignment of the forward plate assembly with respect to the fixtures and verify that the forward plate and reflecting surface of the transfer plate are aligned within 30 arc-seconds. Ensure that the assembly is in solid contact with all five locator screws.

2.4) Place the autocollimator to the left of the main rail such that it's beam will pass through the 3:00 o'clock position of the baseplate (viewed from the top). Align the return image of the autocollimator beam with the forward plate and lock the autocollimator in place.

2.5) Carefully install the large returning mirror in the right side of the forward plate fixture such that the hole in the center approximately aligns with the center of the forward plate. Place the three spring clamps on the returning mirror such that the mirror is secured. Move the knife edge fixture as required to complete this step.

2.6) Adjust the two locating screws on the bottom of the mirror and clock the mirror as required to center the hole in the mirror with respect to the forward plate. Ensure that the mirror is in solid contact with all five locator screws.

2.7) Using the autocollimator, verify that the mirror is parallel to the forward plate within one arc-second. If the mirror is not parallel, recheck the contact points and clamps and shim as required to generate parallelism.

2.8) Place the baseplate assembly (SUGP-B dwg. #25087) in the baseplate fixture with the primary mirror facing right and the 12:00 o'clock mark approximately up. Place the three spring clamps on to the baseplate such that the assembly is secured.

2.9) Carefully adjust the two centering screws on the baseplate fixture such that the baseplate is centered with respect to the forward plate to within 0.02" (the shadow cast by the intersection of the baseplate and the autocollimator beam upon the forward plate makes a good reference for this).

2.10) Using the autocollimator as a reference, carefully adjust the three locator screws on the left of the baseplate fixture such that the bottom of the baseplate is perpendicular to the reference beam to within one arc-second. Verify that the assembly is in solid contact with all five locator screws.

2.11) Certification:

Flight Part Handler _____

	Date/Time	Signature
Fixture Cleanliness	_____	_____
Flight Part Cleanliness	_____	_____
Alignment Verified	_____	_____

Notes _____

_____

_____

3) Establish correct spacing.

3.1) Using the adjusting screw mechanism, adjust the knife edge assembly such that the knife edge is 1.520+/-0.010" from the top (right surface) of the forward plate assembly and lock in place.

3.2) Turn on the light source. Flip the coarse view lens on the knife edge fixture to its on position behind the knife edge. Look through the coarse view lens and adjust the height of the knife edge such that the return image of the light is barely visible. Place a small c-clamp on the knife edge fixture to secure the height adjustment. Only tighten the clamp enough to still allow some future height adjustment.

3.3) Flip the coarse view lens away and hold the fine view lens by hand to view the returned image. This is a difficult step and will require some practice.

3.4) While monitoring the image, raise the knife edge slightly and observe the fashion in which the image becomes dark. Most likely the image will be occluded by the knife edge from top to bottom or bottom to top. If the image became uniformly dark over a very small height adjustment, then the knife edge is located in the Airy disk within the focal depth of the telescope (<0.030") which indicates that the baseplate is within 0.0005" (60:1 lever arm ratio) of the ideal location.

3.5) If the baseplate is not within the desired range, adjust the position of the baseplate fixture by several mils (about 1/2 turn of the adjusting screw) in any direction and repeat steps 3.3 and 3.4. Use care to ensure that the baseplate fixture remains in correct alignment with the guide pin and rail throughout all adjustments. This can also be verified by checking alignment with the autocollimator.

3.6) If the direction of occlusion reversed, the ideal location is between the two baseplate positions observed. If the direction of occlusion did not reverse, the ideal location is past the position which occluded the quickest. Iteratively adjust the position of the baseplate fixture until the ideal location is found.

3.7) Lock the baseplate fixture in place. Verify parallelism of all parts with the autocollimator. Verify correct spacing between the knife edge and forward plate.

3.8) Verify that the baseplate is still in the ideal location by repeating steps 3.3 and 3.4.

3.9) Certification:

Flight Part Handler(s) _____

	Date/Time	Signature
Fixture Cleanliness	_____	_____
Flight Part Cleanliness	_____	_____
Alignment Verified	_____	_____

Notes _____

_____

_____

4) Measure spacing.

4.1) Primary measurement.

4.1.1) Verify the cleanliness of all fixtures and flight parts as required.

4.1.2) Install the dial indicator on to the measurement transfer post. Place the post on to the surface plate against the left surface of the right measurement transfer plate.

4.1.3) Adjust the dial indicator and right measurement transfer plate as required such that the dial indicator reads zero (+/- 0.0001") while the post is in five point contact with the surface and transfer plates and the dial indicator contact point is touching the top (right) surface of the forward plate.

4.1.4) Tighten the clamp to lock the right measurement transfer plate against the rail and repeat step 4.1.3.

4.1.5) Verify the cleanliness of all flight parts as required.

4.1.6) Place the measurement transfer post on to the surface plate against the left surface of the left measurement transfer plate.

4.1.7) Adjust the position of the left measurement transfer plate using the long adjusting rod such that the dial indicator reads zero (+/- 0.0001") while the post is in five point contact with the surface and transfer plates and the dial indicator contact point is touching the top (right) surface of the baseplate.

4.1.8) Tighten the clamp to lock the left measurement transfer plate against the rail and verify correct position established in step 4.1.7.

4.1.9) Place a long (6"+ capacity) depth gauge (i.e. Starrett 445BZ-9RL) in the narrow groove of the left measurement transfer plate with the drive end flush against the polished face.

4.1.10) Build a stack of calibrated gauge blocks tall enough to span from the polished surface of the right measurement transfer plates to within the range of the depth micrometer. Lay the stack on its side on the surface plate against the polished surface of the right measurement transfer plate.

4.1.11) Keeping the head of the depth micrometer flush with the left plate, adjust its length until the end contacts the gauge block stack. Add the reading on the micrometer, the basic length of the micrometer, the sum of the gauge blocks used in the stack, and the negative value of the thickness of the forward plate (from inspection report or independent measurement). This sum is the required length of the metering tube.

4.1.12) Place the measurement transfer post against each transfer plate and verify that the dial indicator readings are still identical when brought into contact with each flight part surface.

4.1.13) Repeat step 4.1.10 using a different configuration of blocks (shuffle and/or substitute).

4.1.14) Repeat step 4.1.11 and compare sums. If the sums are different, repeat steps 4.1.1 through 4.1.13 as required until the variance of sums is at most less than 0.0005" and is preferably less than 0.0002".

4.1.15) Certification:

Flight Part Handler(s)	_____	
	Date/Time	Signature
Fixture Cleanliness	_____	_____
Flight Part Cleanliness	_____	_____
Alignment Verified	_____	_____

micrometer reading	_____	_____	_____	_____
depth gauge length	_____	_____	_____	_____
gauge block stack	_____	_____	_____	_____
<forward plate>	_____	_____	_____	_____

Metering Tube length _____ _____ _____ _____

variance N/A _____ _____ _____

Average _____

Notes _____

_____

_____

4.2) Verification of measurement.

4.2.1) Protect the four contact surfaces of the length transfer rod with Kapton tape as in step 1.13. Verify the cleanliness of all fixtures as required.

4.2.2) Place the height gauge (Starrett model 259-24) on the granite surface plate and verify a correct reading (+/- 0.0005") by comparison to calibrated gauge blocks in both the 0"-1" and 6-12" ranges.

4.2.3) Set the height gauge to the height determined in step 4.1.14. Place the custom adjustable length transfer rod on the surface plate underneath the gauge and adjust the rod as required such that the dial indicator reads zero (+/- 0.0001") when in contact with the bottom of the scriber.

4.2.4) Verify the cleanliness of flight parts as required.

4.2.5) Carefully place the rod between the baseplate and forward plate assemblies and ensure that all three legs of the rod are in solid contact with the baseplate. Depress the plunger of the dial indicator as required during installation to protect the surface of the forward plate.

4.2.6) Repeat step 4.2.5 at two or more other clocking locations between the two flight parts.

4.2.7) Compare the dial indicator readings of the measurements taken in steps 4.2.5 and 4.2.6. If the variance is greater than 0.0005", evaluate and repeat any steps 4.2.1 through 4.2.6 as required.

4.2.8) Compare the measurement taken in step 4.2.7 to that taken in step 4.1.14. If the variance is greater than 0.0015", evaluate and repeat any steps 3.1 through 4.2.7 as required.

4.3) Verification of conditions

4.3.1) Verify that no change in alignment or spacing has occurred by repeating steps 3.7 and 3.8. If changes have occurred, repeat any steps as required.

4.1.15) Certification:

Flight Part Handler(s) _____

	Date/Time	Signature
Fixture Cleanliness	_____	_____
Flight Part Cleanliness	_____	_____
Height Gauge Verified	_____	_____
Alignment Verified	_____	_____

micrometer reading _____ _____ _____ _____

variance N/A _____ _____
_____

Prior Average _____ _____ _____
_____

variance _____ _____ _____ _____

Notes _____

_____

_____

5) If the final measurement taken in step 4.1.14 complies with step 4.2.8, report that measurement to the telescope responsible engineer for application to the final metering tube (SUGP-B dwg. #25061) length.

6) Verify the cleanliness of all flight parts and return them to appropriate storage.

Flight Part Handler(s) _____

	Date/Time	Signature
Flight Part Cleanliness	_____	_____

Notes _____

Attachments: SUGP-B dwg. #'s 25091, 25088, 25087, 25061; Fixture Set-up Sketch.