

<p align="center">AC SPARK PLUG DIVISION General Motors Corporation Milwaukee, Wisconsin</p>	<p>XDE 34-T-504</p>	
<p align="center">ASSEMBLY AND TEST PROCEDURE FOR THE OPTICS SUBSYSTEM</p>	<p align="center">ENGINEERING DESIGN INFORMATION EXHIBIT</p>	
	<p>By R. Erickson</p>	<p>Date Orig. 12/26/62</p>

1.0 INTRODUCTION

1.1 SCOPE - This document establishes the operating characteristics, test requirements to be demonstrated and unique alignment procedures necessary to test the Optics Subsystem.

1.2 COMPONENTS - The Optics Subsystem shall consist of each of the following assemblies:

- a) Optical Assembly
- b) Power & Servo Assembly, Blocks 6, 7, 8 and Associated Power Supplies
- c) G&N Indicator Control Panel
- d) Coupling Display Units (2)
- e) Navigation Base

1.3 PRECAUTIONS - Not applicable

1.4 APPLICABLE DOCUMENTS

1.4.1 The following documents of the issue in effect on the date of issue of this Test Procedure form a part of this Test Procedure.

- 1.4.1.1 DRAWINGS - NASA No. 1015100 Optical System Functional Diagram
- NASA No. _____ Optical Inertial Analyzer
- NASA No. _____ Computer Simulator
- NASA No. _____ Power Supply
- NASA No. _____ Optics - Nav. Base to Rotary Table Mounting Fixture

2.0 ASSEMBLY REQUIREMENTS - To be defined

2.1 ASSEMBLY PROCEDURES - To be defined

3.0 TEST REQUIREMENTS

3.1 PRIOR COMPLIANCE - The components of Para. 1.2 shall have successfully completed assembly level testing prior to subjecting the Optics Subsystem to the requirements of this document.

3.2 TEST CONDITIONS

APPROVED BY: *R J Poplar*

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3.2.1 ENVIRONMENTAL - The Optics Subsystem shall be tested in the following environment:

- a) Class F Clean Room Conditions

3.2.2 ELECTRICAL - The following electrical power shall be provided to the Optics Subsystem:

- a) 28 VDC +2, -3 volts, 230 watts
 b) 115 V \pm 11.5 volts, 400 cycles, 30 watts

3.2.3 DETAILED TEST EQUIPMENT - The equipment specifically required for Optics Subsystem testing is as follows:

3.2.3.1 One (1) Optical-Inertial Analyzer, NASA Dwg. (Part) No. _____, of which the following equipments are to be utilized:

3.2.3.2 One (1) Computer Simulator, NASA Drawing (Part) No. _____.

3.2.3.3 One (1) Power Supply of 6 ± 0.6 volts (rms), 400 ± 40 cps capacity, 10 amps, NASA Drawing (Part) No. _____.

3.2.3.4 One (1) Prime Power (for Optical-Inertial Analyzer Operation) of $115 \pm$ volts (rms), 60 ± 3 cps, capacity _____ amps.

3.2.3.5 One (1) Precision Rotary Table, (vendor) Part No. _____.

3.2.3.6 One (1) Optics - Nav. Base to Rotary Table Mounting Fixture, NASA Drawing (Part) No. _____.

3.2.3.7 One (1) 5" Precision Collimator, Vendor's Part No. _____.

3.2.3.8 One (1) 2.5" Precision Autocollimator, Vendor's Part No. _____.

3.2.3.9 One (1) Target Collimator, Vendor's Part No. _____.

3.2.3.10 One (1) Pendulus Mirror (Tentative).

3.2.3.11 One (1) 15 Sided Polygon, Part No. _____.

3.2.3.12 One (1) C_K Alignment Fixture, Part No. _____.

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3.2.3.13 TEST EQUIPMENT CALIBRATION - Commercial test equipment shall be calibrated as per the applicable calibration specification. Special manufactured test equipment shall be calibrated as per the design or manufacturing agency specification for each equipment.

3.2.4 TEST SET-UP - See Appendix I.

3.2.5 INTERFACE

3.2.5.1 LOADING - The AGC inputs listed below must be provided with simulated loads as listed herein.

AGC Input

Trunnion Decoder +
Trunnion Decoder -
Shaft Decoder +
Shaft Decoder -
Trunnion Zero
Shaft Zero
Trunnion Failure
Shaft Failure

Load Characteristics

Approx. 1.4 K Ω watt at 6 V in,
to 1.1 K Ω , 1 watt at 14 V in.

3.2.5.2 GUIDANCE REFERENCE CLOCK SIMULATION - Each of the Optics Subsystem power supplies shall be supplied by simulations of the Guidance Reference Clock synchronized pulses as specified below.

- a) Output Impedance - Approx. 2K Ω
- b) Pulse Amplitude - 5 V PP
- c) Rise Time - (10%-90%) - 0.2 μ secs
- d) Frequency -
25.6 KCSP - Encoder excitation supply only
800 cps - 28 VAC 1% and 5% supplies only
- e) Pulse Width -
25.6 KCSP - 20 μ secs
800 cps - 3 μ secs

3.2.5.3 THERMAL INTERFACE - To be defined.

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3.2.5.4 DIGITAL TO ANALOG INPUTS - To be defined.

3.2.5.5 TRACKING INPUTS - To be defined.

3.2.6 TEST VALUES - All values given in Section 3 herein are absolute and do not include instrumentation tolerances.

3.2.7 TEST DATA - All data generated while performing the requirements of this document will be recorded and forwarded with the tested subsystem to the next receiving agency.

3.3 OPERATING CHARACTERISTICS

3.3.1 POWER - The following power shall be available within the Optics Subsystem:

VOLTS	FREQ (CPS)	SYNC %	UNSYNC (%)
2.5 \pm 0.02 VAC	25.6 K	\pm 0.1	-0, +10
28 \pm 0.28 VAC	800	\pm 0.1	-0, +10
28 \pm 1.40 VAC	800	\pm 0.1	-0, +10
-28 \pm 2.8 VDC			
28 \pm 2, -3 VDC			
6 \pm 0.6 VAC	400		

The Optics Subsystem shall be capable of meeting all test requirements within the range of operation above.

3.3.2 RELAY AND MANUAL INPUTS OPERATION - All Optics Subsystem mode relays and manual inputs shall be exercised to insure proper operation.

3.3.3 ZERO OPTICS

3.3.3.1 With the 2X Trunnion CDU in the Zero Mode, the 2X Trunnion CDU readout shall indicate 000.000 \pm .001 and the ST LOS and SCT LOS shall be parallel to the LLOS in the $X_{NB}Z_{NB}$ or $Y_{NB}Z_{NB}$ plane within 25 min.

3.3.3.2 With the Shaft CDU in the Zero Mode, the Shaft CDU readout shall indicate 000.000 \pm .001 and the Trunnion Drive Axis (TDA) of the SXT and SCT shall be parallel to $+Y_{NB}$ within 30 min.

3.3.4 LOS PARALLELISM - The LLOS and the STLOS shall be parallel in the $X_{NB}Z_{NB}$ plane within 10 sec and parallel in the $Y_{NB}Z_{NB}$ plane within 20 sec with the 2X Trunnion CDU 16X resolver null less than 10 mv after the CDU has been commanded to zero, and the Optics Subsystem subsequently set to the Normal Mode.

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3.3.5 SXT-SCT TRUNNION AND SHAFT LOS LIMITS - The limits shall be as follows:

	+0	+5
SXT Trunnion LOS	0 -5	+90 -0
SXT Shaft LOS	$\pm 270 \pm 5$	
SCT Trunnion LOS	Continuous	
SCT Shaft LOS	Continuous	

3.3.6 SXT-SCT Optical Centerline Parallelism - The optical centerline of the SXT ST LOS and SCT shall be parallel in the $X_{NB} Z_{NB}$ plane within 26 min and in the $Y_{NB} Z_{NB}$ plane within 1 min with $A_S = 0^\circ$.

3.3.7 OPTICS ASSEMBLY TO IMU MOUNTING PAD ALIGNMENT - With the Optics Subsystem in the "Zero" mode and subsequently set to the "Normal" mode, the 2X Trunnion and Shaft CDU 16X resolver outputs shall be less than 10 mv rms, and the optical centerline of the SXT shall be aligned to the planes formed by the IMU mounting pads and alignment pins as follows:

- The SXT lines of sight shall be parallel to the Z_{NB} component of the IMU mounting pads to within 26 secs at any given shaft angle.
- The SXT trunnion drive axis at $A_S = 0$ shall be parallel to the Y_{NB} component of the IMU mounting pads to within 30 secs.

3.3.8 SXT-SCT CONTROL STICK OPERATION

3.3.8.1 With the control stick at mechanical null, the electrical null shall be 0 ± 5 mv rms in phase, 10 mv rms total. The deadzone switches shall actuate to the "off" state when the output voltage of the control stick is less than 750 mv with an attenuation of 1:1.

3.3.8.2 The output voltage range with an attenuation of 1:1 shall be from zero to 10 v rms. The maximum output and phase at the control stick physical limits shall be -

Left 10 ± 1 v rms $0 \emptyset$	Up 10 ± 1 v rms $\pi \emptyset$
Right 10 ± 1 v rms $\pi \emptyset$	Down 10 ± 1 v rms $0 \emptyset$

3.3.8.3 The output voltage shall be attenuated by ratios of 1:1, 10:1 and 100:1 $\pm 10\%$.

3.3.8.4 In the Resolved Mode, the Up-Down or Left-Right control stick motion shall result in Up-Down or Left-Right image motion respectively to within 10 degrees for trunnion angles of 5 degrees or greater. The image rates shall remain constant at a rate of 1° per second for an initial shaft angle of 90°

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and trunnion angles in the range of 5-45 degrees.

3.3.9 POSITIONAL ACCURACY - The shaft and trunnion of the SXT-SCT shall be capable of being positioned to any angle within the range of operation listed in Para. 3.3.5 and repeatable to that angle to within the tolerances listed in Table II as indicated by encoders and CDU readouts. The rms values of all SXT trunnion angular errors generated shall not exceed 8 secs. The rms values of all SXT shaft angular errors generated shall not exceed 19.2 secs.

TABLE II

FUNCTION	POSITION TOLERANCE	
	ENCODER BITS	CDU (DEG)
SXT Shaft	+ 3	+ 0.018
SXT Trunnion	+ 3	+ 0.008
SCT Shaft	+ 45	+ 0.500
SCT Trunnion	+ 158	+ 0.420
*SCT Trunnion	+ 79	+ 0.420

* When operating with the SCT only

3.3.9.1 DECODER BIT CHARACTERISTICS - The decoder bits of the command servo shaft and trunnion gear trains to the AGC shall have the following characteristics:

- The rise and fall time shall be less than 20% of pulse width, measured at 10% to 90% amplitude.
- The amplitude shall be 10 + 4 volts PP with respect to reference lead.
- The pulse width shall be 0.5 to 8 μ sec at 90% amplitude.
- The noise level shall be \leq +2 volts peak.

3.3.9.2 ENCODER GRANULARITY - The granularity of the trunnion encoders shall be equivalent to .0479 milliradians or 9.8877 secs per pulse. The granularity of the shaft encoders shall be .1918 milliradians or 39.5508 secs LOS per pulse. When operating with the SCT only the Trunnion encoder granularity shall be .0958 milliradians or 19.7754 secs.

3.3.9.3 CDU FAILURE INDICATION - The Shaft and Trunnion Failure indication shall be present at the AGC interface under any one of the following conditions.

- 25.6 KC supply below _____ v
- CDU motor excitation below _____ v
- CDU motor control voltage above _____ v

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3.3.9.3.1 The CDU Failure Indication has the following characteristics:

Frequency	102.4 KC \pm 2 ppm
Amplitude	6 \pm 3 v p-p
Pulse Width	0.5 to 8.0 μ sec at 90% of the amplitude
Rise Time	20% of the pulse width at 10% to 90% of the amplitude
Fall Time	same as rise time
Noise Level	\leq 1 v p-p

3.3.10 SERVO CHARACTERISTICS

3.3.10.1 The steady state null of the trunnion command servo loop shall be less than 1 v rms in phase as measured at the motor control winding. The steady state null of the shaft command servo loop shall be less than 1 v rms in phase as measured at the motor control winding.

3.3.10.2 RATE - The maximum and minimum drive rates of the command servo as measured at the one speed shaft shall be as follows with the command servo driving in either direction:

FUNCTION	MAX (DEG/SEC)	MIN (SEC/SEC)
Shaft and Trunnion	\geq 17	\leq 50

3.3.10.3 LINEARITY - The command servo drive rate shall be linear over the entire range of command input to within 10% of full scale at 1:1, 10% at 10:1, 10% at 100:1 at \geq 10 rpm at motor shaft.

3.3.10.4 SENSITIVITY - The sensitivity of the command input to LOS output shall be 0.04 rad/sec/volt \pm 10%.

3.3.10.5 DYNAMIC RESPONSE - With a step input of 1.5 v, (at time t_0) to the command servo, the tachometer output of the SXT Shaft and Trunnion CDU's shall be 1.27 \pm 0.13 v in less than 1 sec after t_0 . At time t_1 the step input shall be removed and the tachometer shall return to null within 1 sec after t_1 .

3.3.10.6 VELOCITY ERROR

3.3.10.6.1 SXT TRUNNION - For a steady state rate command into the 2X Trunnion CDU of 3 deg/sec (LOS) the velocity error shall be less than 1 min at resolver output.

3.3.10.6.2 SXT SHAFT - For a steady state rate command into the Shaft CDU of 3 deg/sec (LOS) the velocity error shall be less than 1 min at resolver output.

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3.3.10.6.3 SCT TRUNNION - For a steady state rate command into the 2X Trunnion CDU of 3 deg/sec (LOS) the velocity error shall be less than 1 min at resolver output.

3.3.10.6.4 SCT SHAFT - For a steady state rate command into the Shaft CDU of 3 deg/sec (LOS), the velocity error shall be less than 1 min at resolver output.

3.3.11 TIME TO ZERO

3.3.11.1 The Shaft CDU shall zero \leq 1 min from the 270° limit after the zero command is given. The Trunnion CDU shall zero \leq 15 sec from 45° after the zero command is given.

3.3.11.2 The SXT shaft shall zero \leq 70 sec from the 270° limit after the zero command is given. The SXT trunnion shall zero \leq 20 sec from the 90° LOS limit after the zero command is given.

3.3.11.3 The SCT shaft shall zero \leq 90 sec from a 360° limit after the zero command is given. The SCT trunnion shall zero \leq 90 sec from a 360° LOS limit after the zero command is given.

3.3.12 TRACKER CHARACTERISTICS - To be defined.

3.3.13 25° OFFSET - The SCT LOS shall be capable of being automatically offset to a trunnion LOS angle of $25^\circ \pm 15'$.

3.3.14 COMPUTER INPUT CHARACTERISTICS - To be defined.

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<p>4.0 TEST PROCEDURES</p> <p>4.1 CLASSIFICATION OF TESTS - The inspection and testing of the Optics Subsystem shall be classified as follows:</p> <p>a) Acceptance Tests</p> <p>4.2 TEST CONDITIONS</p> <p>4.2.1 ATMOSPHERIC CONDITIONS - All testing of the Optics Subsystem shall be performed under the following atmospheric conditions:</p> <p>a) Temperature $75^{\circ} \pm 4^{\circ}$</p> <p>b) Relative Humidity 50% or less</p> <p>4.2.2 TEST POWER - The Optics Subsystem shall be tested while supplied with the following power:</p> <p>a) 28 + 2 vdc, 230 watts</p> <p>b) 115 v 400 ~ 1 phase, 30 watts</p> <p>4.2.3 TEST CONFIGURATION - See Appendix I.</p> <p>4.2.3.1 CERTIFICATION OF TEST SETUP - The relative alignment of the test setup shall be verified prior to the testing of each subsystem.</p> <p>4.3 ACCEPTANCE TESTS - All Optics Subsystems shall be subjected to the following individual acceptance tests:</p> <p>a) Prefunctional</p> <p>b) Functional</p> <p>4.3.1 TEST SEQUENCE - The sequence of testing shall be as indicated in this document.</p> <p>4.4 DETAILED TEST PROCEDURES</p> <p>4.4.1 PREFUNCTIONAL TESTS - The prefunctional tests shall be performed with all switches in their "off" or initial positions and no power applied to the subsystem.</p>						
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4.4.1.1 VISUAL MECHANICAL - The Optics Subsystem shall be visually inspected for presence of dust, gear damage, broken glass, damaged wires, bent pins or other physical damage.

4.4.1.2 GROUND ISOLATION - The separation of independent ground systems in the Optics Subsystem shall be measured as follows:

- To be determined.

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<p>4.4.2 FUNCTIONAL TESTS</p> <p>4.4.2.1 OPTICS ASSEMBLY TO IMU MOUNTING PAD ALIGNMENT (Reference Paragraph 3.3.7 a) and b)).</p> <p>The SXT ST LOS parallelism to the Z_{NB} component of the IMU mounting pads is checked by installing the C_K fixture on the IMU mounting pads and sighting through the autocollimator in the C_K fixture and the SXT respectively into mercury pools. By adjusting the Navigation Base about its axes, the ST LOS can be made to autocollimate off of its mercury pool. The non-parallelism can then be determined by sighting through the C_K fixture autocollimator and directly reading the X_{NX} and Y_{NB} misalignment components of Z_{NB}. The misalignment in the X_{NB} direction shall be less than 26 $\widehat{\text{secs}}$ and in the Y_{NB} direction less than 30 $\widehat{\text{secs}}$. The misalignment magnitude and direction shall be recorded as ϵST_X for X_{NB} misalignment, and ϵST_Y for Y_{NB} misalignment. The sign of the misalignment shall carry the sign of the respective axes.</p> <p>The alignment of the Trunnion Drive Axis with $+Y_{NB}$ (which defines $A_s = 0$) can be determined by commanding the Shaft CDU to zero, nulling the SXT 16X resolver and sighting through the C_K fixture autocollimator into the SXT. The misalignment read through the C_K fixture autocollimator shall be less than 20.6 $\widehat{\text{secs}}$. If the misalignment exceeds 20.6 $\widehat{\text{secs}}$ but is less than 29.4 $\widehat{\text{secs}}$, adjust the null of the SXT shaft fine resolver by substituting null shift resistors into the fine resolver null trim circuit until the misalignment is minimized and less than 20.6 $\widehat{\text{secs}}$. The C_K fixture can then be removed from the Navigation Base and the remainder of the subsystem tests performed.</p>						
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4.4.2.2 INITIAL ALIGNMENT - The Optics Assembly is aligned to Collimator #1 through the L LOS. This alignment will provide a basis from which all angular measurements are made when using the Rotary Table. Through this procedure, SXT to NB, NB to mounting fixture and mounting fixture to rotary table interface misalignments which directly affect the optical tests are discounted.

- a. Set the Controller Mode selector to "Direct"
- b. Set the Slave Telescope switch to "STAR LOS"
- c. Set the Optics Mode selector to "Zero"
- d. Set the Optics Power switch to "ON"
- e. Set the SXT Power switch to "ON"
- f. Set the Controller Speed selector to "Hi"

NOTE: (Wait fifteen minutes and then set the Optics Mode Selector to "Normal". Perform Step g. in the interim).

g. Sight through the SXT LLOS into Collimator #1 and bring the collimator reticle image and the SXT reticle into coincidence by adjusting the Navigation Base mounting fixture about its Y axis and by adjusting the rotary table in azimuth. Record the rotary table azimuth angle. The elevation angle shall be at its calibrated zero angle. The recorded angles of step g shall be known as the Zero Reference Point (ZRP) and shall be referred to as such hereafter.

4.4.2.3 SXT LOS Parallelism, SXT-SCT Optical Centerline Parallelism - (Reference Paragraphs 3.3.4, 3.3.6 and 3.3.7a). SXT LOS Parallelism is determined by comparison of alignment of the LLOS and STLOS to the LOS of Collimator #1. Upon determination of the magnitude and direction of misalignments, LLOS alignment to the Z_{NB} axis can be calculated. The STLOS is then compared to the SCT LOS through Collimator #1 and Autocollimator #2 to determine the SXT-SCT Optical Centerline Parallelism.

- a. Set the Optics mode selector to "Normal".
- b. Monitor the 2X Trunnion CDU 16X resolver error output at J _____ pin _____ and J _____ pin _____.
- c. The 16X resolver error shall be $0 \pm$ _____ mv and shall not change during the performance of Step d.

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4.4.2.3 (Continued).

- d. With the Optics Control Stick, position the STLOS until the Shaft CDU indicates (-90.000°) 270.000° . The reticle image of Collimator #1 shall be visible through the SXT STLOS.
- e. Sight through the SXT STLOS into Collimator #1 and bring the collimator reticle image into coincidence with the SXT STLOS reticle by adjusting the rotary table in azimuth and elevation.
- f. Record the change in azimuth from the ZRP of Para. 4.4.2.2 Step g as eL_Y . The sign of eL_Y shall be determined as follows:

Increasing azimuth (-), decreasing azimuth (+). Record the elevation angle.
- g. The change in azimuth eL_Y shall be 0 ± 10 secs, and when algebraically added to eST_X from Para. 4.4.2.1 $eL_Y + eST_X$ shall not exceed 26 secs.
- h. Sight through the SCT LOS into Autocollimator #2 and bring the autocollimator reticle image into coincidence with the SCT LOS reticle by adjusting the rotary table in azimuth and elevation.
- i. Record the change in azimuth and elevation. The azimuth and elevation changes shall not exceed 26 min and 1 min respectively.
- j. Set the rotary table angles to the ZRP recorded in Para. 4.4.2.2 Step g.

4.4.2.4 OPTICS SUBSYSTEM POWER - The power requirements of Para. 3.3.1 shall be checked as follows:

- a. Apply power as required in Para. 3.2.2 to the Optics Subsystem.
- b. Monitor the power outputs listed in Para. 3.3.1 with the appropriate test equipment (AC, DC voltmeters, phase sensitive voltmeter, EPUT meter).
- c. Set Optics Power switch to ON.
- d. The voltage at J ____ Pin ____ shall be 2 ± 0.02 VAC.

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- e. The sync frequency shall be 25.6 KCPS \pm 25.6 cps.
- f. Switch out the Guidance Reference Clock Input simulation.
- g. The unsync frequency shall be 25.6 KCPS + 2560 cps, -0 cps.
- h. The voltage at J ___ Pin ___ shall be 28 \pm 0.28 VAC.
- i. The voltage phase shall be known as 0° phase and shall be used as the phase reference for Step n.
- j. The unsync frequency shall be 800 \sim + 80 cps, -0 cps.
- k. Switch in the Guidance Reference Clock Input simulation.
- l. The sync frequency shall be 800 \sim \pm 0.8 cps.
- m. The voltage at J ___ Pin ___ shall be 28 \pm 1.4 VAC.
- n. The voltage phase shall be 90° \pm ___ with reference to the voltage phase of Step i.
- o. The sync frequency shall be 800 \sim \pm 0.8 cps.
- p. Switch out the Guidance Reference Clock Input simulation.
- q. The unsync frequency shall be 800 \sim + 80 cps, -0 cps.
- r. Switch in the Guidance Reference Clock Input simulation.
- s. The voltage at J ___ Pin ___ shall be 28 +2, -3 vdc.
- t. The voltage at J ___ Pin ___ shall be -28 \pm 2.8 vdc.
- u. The voltage at J ___ Pin ___ shall be 6 \pm 0.6 VAC.
- v. The frequency shall be 400 \pm 40 cps.

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4.4.2.5 SXT-SCT Control Stick Operation - (Reference Para. 3.3.8).
The Control Stick maximum voltage, phase, mechanical null, electrical null,
output attenuation and resolution are checked as follows:

- a. Set the Optics mode selector to "Zero".
- b. Monitor the output of the Control Stick and the output of the deadzone switch.
- c. Set the Controller Speed selector to "Hi".
- d. With the Control Stick centered, the output voltage of the Control Stick at J Pin and J Pin shall be equal to or less than 5 mv rms in phase, 10 mv rms total.
- e. Position the Control Stick to its respective limits, Left, Right, Up, Down and record the output voltage and phase at J Pin and J Pin .
- f. From each limit, position the Control Stick to its mechanical null, while monitoring the output voltage of the Control Stick and deadzone switches.
- g. The deadzone switches shall change state when the Control Stick output is less than 750 mv rms.
- h. The voltage and phase indications of Step e. shall be:

Left $10v \pm 1.0 v \ 0 \ \emptyset \text{ rms}$

Right $10v \pm 1.0v \ \pi \ \emptyset \text{ rms}$

Up $10v \pm 1.0v \ \pi \ \emptyset \text{ rms}$

Down $10v \pm 1.0v \ 0 \ \emptyset \text{ rms}$
- i. Set the Controller Speed selector to "Med" and repeat Step e.
- j. The voltage and phase indications of Step e. shall be:

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EXHIBITASSEMBLY AND TEST PROCEDURE FOR
OPTICS SUBSYSTEMBy
R. EricksonDate
12/26/62Left lv $\pm 0.1v$ 0ϕ rmsRight lv $\pm 0.1v$ $\pi \phi$ rmsUp lv $\pm 0.1v$ $\pi \phi$ rmsDown lv $\pm 0.1v$ 0ϕ rms

k. Set the Controller Speed selector to "Low" and repeat Step e.

l. The voltage and phase indications of Step e. shall be:

Left $0.1v \pm 0.01v$ 0ϕ rmsRight $0.1v \pm 0.01v$ $\pi \phi$ rmsUp $0.1v \pm 0.01v$ $\pi \phi$ rmsDown $0.1v \pm 0.01v$ 0ϕ rms

m. Set the Optics mode selector to "Normal".

n. Using the Control Stick, drive the Shaft CDU to an indicated angle of 270.000° .o. Using the Control Stick, drive the 2X Trunnion CDU to an indicated angle of 10.000° .

p. Set the Controller Speed selector to "Med" and the Controller mode selector to "Resolved."

q. Sight through the SCT LX eyepiece and simultaneously start a timer and displace to Control Stick to its upward limit.

r. When the reticle image origin of Collimator #2 leaves the 60° field of view, stop the timer and release the Control stick.s. The reticle image origin of Collimator #2 shall appear to move vertically $\pm 10^\circ$ of the SCT reticle and the timer indication shall not exceed 30 seconds.

t. Set the Controller Mode selector to "Direct".

u. Repeat Steps m and n and drive the 2X Trunnion CDU to an indicated angle of 90.000° .

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- v. Set the Controller mode selector to "Resolved".
- w. Repeat Steps q through t.
- x. Set the Optics mode selector to "Zero".

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4.4.2.6 CDU Decoder Bit and Failure Indication Characteristics
(Reference Para. 3.3.4.1 and 3.3.4.3) - The characteristics of the trunnion and shaft decoder bits as well as the CDU Failure indication characteristics are checked as follows:

- a. Monitor the plus trunnion decoder outputs at J ___ Pin ___ and J ___ Pin ___ with an oscilloscope.
- b. Set the Optics mode selector to "Zero", wait one minute.
- c. Set the Optics mode selector to "Normal".
- d. Set the Controller Speed selector to "Low".
- e. Provide a 0.1v input to J ___ Pin ___ from the GSE.
- f. Synchronize the output pulses on the oscilloscope.
- g. The pulse amplitude shall be 10 ± 4 volts p-p with respect to the reference at J ___ Pin ___.
- h. The pulse width shall be 0.5 to 8 microsecs at 90% of the amplitude.
- i. The pulse rise and fall time shall be less than 20% of the pulse width measured at 10% to 90% of the amplitude.
- j. The noise level shall be 2v p-p or less between pulses.
- k. Monitor the minus trunnion decoder outputs at J ___ Pin ___ and J ___ Pin ___ with an oscilloscope.
- l. Repeat Steps b. through j.
- m. Monitor the plus shaft decoder outputs at J ___ Pin ___ and J ___ Pin ___ with an oscilloscope.
- n. Repeat Steps b. through j.
- o. Monitor the minus shaft decoder outputs at J ___ Pin ___ and J ___ Pin ___ with an oscilloscope.

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<p>p. Repeat Steps b. through j.</p> <p>q. Monitor the CDU Failure indication at J ___ Pin ___ and J ___ Pin ___.</p> <p>r. Remove the 2v 25.6 KC voltage supplied to J ___ Pin ___.</p> <p>s. Adjust the oscilloscope to synchronize the 102.4 KC signal monitored at J ___ Pin ___ and J ___ Pin ___.</p> <p>t. The pulse amplitude shall be a positive 6 ± 3 v p-p.</p> <p>u. The pulse frequency shall be 102.4 KC.</p> <p>v. The pulse width shall be 0.5 to 8.0 μsec at 90% of the amplitude.</p> <p>w. The rise and fall time of the pulse shall be less than 20% of the pulse width from 10% to 90% of the amplitude.</p> <p>x. The noise level shall be less than 1v p-p.</p> <p>y. Apply the 2v, 25.6 KC voltage supplied to J ___ Pin ___.</p> <p>z. Remove the 28v 5% 800 ~ voltage supplied to J ___ Pin ___.</p> <p>aa. The CDU Failure indication shall be present.</p> <p>ab. Apply the 28v 5% 800 ~ voltage supplied to J ___ Pin ___.</p> <p>ac. Repeat Steps b. and c.</p>						
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4.4.2.7 Trunnion Accuracy and Limits - (Reference Paragraphs 3.3.4 and 3.3.4.2) - The SXT and SCT trunnion accuracy is determined for positive angles of 20° , 40° and 57° . The rotary table is positioned to the above angles and the SXT and SCT lines of sight are then commanded to backsight through the rotary table angle until the collimator reticle image and SXT or SCT reticle is coincident. The encoder output and CDU readout are thus checked against a precision optical angle to determine their accuracy. The SXT trunnion limits at 0° and 90° are checked by noting the increased output of the SXT 1X resolver as the SXT trunnion engages its limit stop.

- a. Monitor the trunnion decoder outputs at J ___ Pin ___ and J ___ Pin ___ with the Fwd-Bwd counter.
- b. Set the rotary table azimuth $-20^{\circ}00'00''$ from the ZRP recorded in Para. 4.4.2.2 Step g.
- c. Set the Optics mode selector to "Zero" and wait one minute.
- d. Set the Optics mode selector to "Normal" and insure that the 2X Trunnion CDU readout indicates 000.000° and that the Fwd-Bwd counter indicates zero.
- e. Use the Control Stick to position the STLOS until the Shaft CDU readout indicates 270.000° .
- f. Use the Control Stick to drive the STLOS until the center of the reticle image of Collimator #1 is coincident with the central vertical line of the SXT reticle.
- g. Record the Fwd-Bwd counter and 2X Trunnion CDU readout indications.
- h. Sight through the SCT eyepiece and adjust the SCT LOS using the 2X Trunnion CDU thumbwheel until the SCT reticle is coincident with the reticle image of Autocollimator #2.
- i. Record the Fwd-Bwd counter and 2X Trunnion CDU readout indications.
- j. Repeat Steps c. through i. five times.

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<p>k. Each Fwd-Bwd counter and CDU readout indication recorded in Step g. shall be 7282 ± 3 bits and $40.000^\circ \pm .008^\circ$ respectively.</p> <p>l. Each Fwd-Bwd counter and CDU readout indication recorder in Step i shall be 7282 ± 158 bits and $40.000^\circ \pm 0.420^\circ$ respectively.</p> <p>m. Set the rotary table azimuth angle $-40^\circ 00' 00''$ from the azimuth angle recorded in Para. 4.4.2.2 Step g.</p> <p>n. Repeat Steps c through j.</p> <p>o. Each Fwd-Bwd counter and CDU readout indication recorded in Step g shall be 14563 ± 3 bits and $80.000^\circ \pm .008^\circ$ respectively.</p> <p>p. Each Fwd-Bwd counter and CDU readout indication recorded in Step i shall be 14563 ± 158 bits and $80.000^\circ \pm 0.420^\circ$ respectively.</p> <p>q. Set the rotary table azimuth angle $57^\circ 00' 00''$ from the azimuth angle recorded in Para. 4.4.2.2 Step g.</p> <p>r. Repeat Steps c. through j.</p> <p>s. Each Fwd-Bwd counter and CDU readout indication recorded in Step g. shall be 20753 ± 3 bits and $120.000 \pm 0.420^\circ$ respectively.</p> <p>t. Each Fwd-Bwd counter and CDU readout indication recorded in Step i shall be 20753 ± 158 bits and $120.000^\circ \pm 0.420^\circ$ respectively.</p> <p>u. Set the 2X Trunnion CDU readout indicator to a nominal 180° using the Control Stick.</p> <p>v. Sight through the SXT eyepiece and bring the SXT reticle and the SXT autocollimated reticle image to coincidence by using the 2X Trunnion thumbwheel.</p> <p>w. The 2X Trunnion CDU readout and Fwd-Bwd counter readout indication shall be $180.000^\circ \pm .008^\circ$ and 32768 ± 3 bits respectively.</p>						
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<p>x. Monitor the SXT 1X resolver error output J ___ Pin ___. The voltage shall be less than ___ mv rms.</p> <p>y. Using the 2X Trunnion CDU thumbwheel, drive the SXT ST LOS until the error voltage at J ___ Pin ___ begins to maintain a static error voltage of greater than ___ mv. The 2X Trunnion CDU readout shall indicate between 180.000° and 190.000°.</p> <p>z. Set the Optics mode selector to "Zero", wait one minute.</p> <p>aa. Set the Optics mode selector to "Normal". The voltage at J ___ Pin ___ shall be less than ___ mv rms.</p> <p>ab. Repeat Step y. except that the 2X Trunnion CDU readout shall indicate between 000.000 and 350.000°.</p> <p>ac. Square and add each deviation from the 18 nominal Fwd-Bwd counter indications recorded in Step f.</p> <p>ad. The sum of the 18 squares shall not exceed 12.</p>					
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<p>4.4.2.7.1 SCT TRUNNION ACCURACY AND LIMITS - (Reference Para. 3.3.9 and 3.3.13). - The SCT Trunnion accuracy is checked -60°, $+25^{\circ}$, $+60^{\circ}$, checking optical angles against decoder outputs and CDU readouts. The 25° offset function is also checked.</p> <ol style="list-style-type: none"> a. Monitor the trunnion decoder outputs at J ___ Pin ___ and J ___ Pin ___ with the Fwd-Bwd counter. b. Set the rotary table azimuth $+60^{\circ} 00' 00''$ from the azimuth angle recorded in Para. 4.4.2.2 Step g. c. Reset the Fwd-Bwd counter to zero. d. Set the SXT Power switch to "OFF". e. Set the Optics mode selector to "Zero", wait one minute. f. Set the Optics mode selector to "Normal". g. Set the shaft angle to 270.000° as indicated on the Shaft CDU readout. h. Use the Control Stick to drive the SCT LOS until the vertical reticle image of Autocollimator #2 is coincident with the vertical reticle of the SCT. i. Record the Fwd-Bwd counter and 2X Trunnion CDU readout indications. j. Repeat Steps e. through i. five times. k. Set the rotary table azimuth to the azimuth angle recorded in Para. 4.4.2.2 Step g. l. Set the Slave Telescope selector to "Landmark LOS 0°". The SCT LOS shall drive until the LOS looks into Autocollimator #2. m. Sight through the SCT 3X eyepiece and adjust the rotary table in azimuth until the vertical reticle image of Autocollimator #2 is coincident with the vertical reticle of the SCT. n. The change in azimuth shall not exceed ___ min. 								
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<p>o. Set the rotary table azimuth $-25^{\circ} 00' 00''$ from the azimuth recorded in Para. 4.4.2.2 Step g and record.</p> <p>p. Set the Slave Telescope selector to "Offset 25°". The SCT LOS shall drive until the LOS look into Autocollimator #2.</p> <p>q. Sight through the SCT 3X eyepiece and adjust the rotary table in azimuth until the vertical reticle image of Autocollimator #2 is coincident with the vertical reticle of the SCT.</p> <p>r. The change in azimuth from that recorded in Step o. shall not exceed 15 min.</p> <p>s. Set the rotary table azimuth $-60^{\circ} 00' 00''$ from the azimuth angle recorded in Para. 4.4.2.2 Step g.</p> <p>t. Reset the Fwd-Bwd counter to zero.</p> <p>u. Set the Slave Telescope Selector to STAR LOS.</p> <p>v. Repeat Steps e. through i. six times.</p> <p>w. Each Fwd-Bwd counter and 2X Trunnion CDU readout indication recorded in Step i. shall be 10922 ± 79 bits and $240.000^{\circ} 0.420^{\circ}$ respectively.</p> <p>x. Each Fwd-Bwd counter and 2X Trunnion CDU readout indication recorded in Step u. shall be 10922 ± 79 bits and $120.000^{\circ} \pm 0.420^{\circ}$ respectively.</p> <p>y. Use the Control Stick to drive the SCT LOS 300° as indicated by the 2X Trunnion CDU readout indication passing through 360° and around again to 000.000°.</p> <p>z. Set the rotary table azimuth to the angle recorded in Para. 4.4.2.2. Step g.</p> <p>aa. Sight through the SCT 3X eyepiece and using the Control Stick, drive the SCT LOS until the vertical reticle image of Autocollimator #2 is coincident with the vertical reticle of the SCT.</p>					
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- ab. The Fwd-Bwd counter and 2X Trunnion CDU readout indications shall be 65535 ± 79 bits and $000.000^{\circ} \pm 0.420^{\circ}$ respectively.
- ac. Set the Optics mode selector to "Zero".
- ad. Set the SXT Power switch to "ON".

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4.4.2.8 **SHAFT ACCURACY AND LIMITS** (Reference Para. 3.3.5, 3.3.9) - The SXT and SCT shaft accuracy is determined by mounting a 15-sided polygon on the SXT or SCT shaft drive axis and monitoring it with an autocollimator. The accuracy and repeatability is checked at 48° increments as follows:

SXT Shaft Accuracy and Limits:

- a. Monitor the plus Shaft decoder output at J ___ Pin ___ and J ___ Pin ___ with an appropriate Fwd-Bwd counter.
- b. Set the rotary table azimuth and elevation angles to the values recorded in Para. 4.4.2.2., Step g.
- c. Set the rotary table azimuth angle to $+90^{\circ} 00' 00''$.
- d. Install the polygon on the SXT shaft axis.
- e. Set the Optics mode selector to "Zero", wait two minutes and then to "Normal".
- f. Position the polygon such that Autocollimator #2 will autocollimate off of the 0° reference face.
- g. With the Control Stick, position the shaft angle in a positive direction in a nominal 48° increment.
- h. With the Shaft CDU thumbwheel, position the shaft angle, until Autocollimator #2 autocollimates off of the polygon face.
- i. Record the Shaft CDU readout indication and the Fwd-Bwd counter indicatiin.
- j. Compensate the indications in Step i. if the calibration data for the polygon indicates that the deviation from the nominal 48° increment exceeds 20 secs.
- k. The Shaft CDU readout shall indicate $48.000 \pm 0.018^{\circ}$ and the Fwd-Bwd counter shall indicate 4369 ± 3 bits.
- l. Repeat Steps g. through j.
- m. The Shaft CDU readout shall indicate $96.000 \pm 0.018^{\circ}$ and the Fwd-Bwd counter shall indicate 8738 ± 3 bits.

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<p>n. Repeat Steps g. through j.</p> <p>o. The Shaft CDU readout shall indicate $144.000 \pm 0.018^\circ$ and the Fwd-Bwd counter shall indicate 13107 ± 3 bits.</p> <p>p. Repeat Steps g. through j.</p> <p>q. The Shaft CDU readout shall indicate $192.000 \pm 0.018^\circ$ and the Fwd-Bwd counter shall indicate 17476 ± 3 bits.</p> <p>r. Repeat Steps g. through j.</p> <p>s. The Shaft CDU readout shall indicate $240.000 \pm 0.018^\circ$ and the Fwd-Bwd counter shall indicate 21845 ± 3 bits.</p> <p>t. Monitor the SXT Shaft 1/2X resolver (E8) error output at J ___ Pin ___.</p> <p>u. With the Control Stick, position the shaft angle until the Shaft CDU readout indicates 270.000.</p> <p>v. The Fwd-Bwd counter indication shall be 24576 ± 3 bits.</p> <p>w. With the Shaft CDU thumbwheel, position the shaft angle in a positive direction until the voltage at E8 exceeds ___ \pm ___ mv.</p> <p>x. The Shaft CDU shall indicate $270.000 \pm 5^\circ$.</p> <p>y. Set the Optics mode selector to "Zero", wait 2 minutes.</p> <p>z. Set the Optics mode selector to "Normal".</p> <p>aa. Repeat Step f.</p> <p>ab. With the Control Stick position the shaft angle in a negative direction in a nominal 48° increment.</p> <p>ac. Repeat Steps h. through j.</p> <p>ad. The Shaft CDU readout shall indicate $312.000 \pm 0.018^\circ$ and the Fwd-Bwd counter shall indicate 4369 ± 3 bits.</p> <p>ae. Repeat Steps ab and ac.</p>					
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<p>af. The Shaft CDU readout shall indicate $264.000 \pm 0.018^\circ$ and the Fwd-Bwd counter shall indicate 8738 ± 3 bits.</p> <p>ag. Repeat Steps ab. and ac.</p> <p>ah. The Shaft CDU readout shall indicate $216.000 \pm 0.018^\circ$ and the Fwd-Bwd counter shall indicate 13107 ± 3 bits.</p> <p>ai. Repeat Steps ab. and ac.</p> <p>aj. The Shaft CDU readout shall indicate $168.000 \pm 0.018^\circ$ and the Fwd-Bwd counter shall indicate 17476 ± 3 bits.</p> <p>ak. Repeat Steps ab. and ac.</p> <p>al. The Shaft CDU readout shall indicate $120.000 \pm 0.018^\circ$ and the Fwd-Bwd counter shall indicate 21845 ± 3 bits.</p> <p>am. With the Control Stick, position the shaft angle until the Shaft CDU readout indicates 90.000°.</p> <p>an. The FWD-Bwd counter indication shall be 24576 ± 3 bits.</p> <p>ao. With the Shaft CDU thumbwheel, position the shaft angle in a negative direction until the voltage at E8 exceeds _____ \pm _____ mv.</p> <p>ap. The Shaft CDU shall indicate $90.000 \pm 5^\circ$.</p> <p>aq. Repeat Steps f. through s. and y. through al. two more times.</p> <p>ar. Remove the polygon from the SXT shaft axis and install the polygon on the SCT shaft axis.</p> <p>as. Repeat Steps e. and f.</p> <p>at. Set the SXT Power switch to "OFF".</p> <p>au. Repeat Steps g. through s. three times with the exception that the tolerances for Shaft CDU readout indication and Fwd-Bwd counter indication shall change to $\pm 0.500^\circ$ and ± 45 bits respectively.</p> <p>av. With the Control Stick, position the shaft angle in the positive direction until the Shaft CDU indicates 5°.</p>						
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<p>aw. Repeat Steps y. through al. with the exception that the tolerance for the Shaft CDU readout indication and Fwd-Bwd counter indication shall change to $\pm 0.500^\circ$ and ± 45 bits respectively.</p> <p>ax. With the Control Stick, position the shaft angle in the negative direction until the shaft CDU indicates 355°.</p> <p>ay. Repeat Step y.</p> <p>az. Square and add each deviation from the 30 nominal Fwd-Bwd counter indications recorded in Step i. for the SXT.</p> <p>ba. The sum of the squares shall not exceed 69.</p> <p>bb. Set the Optics mode selector to "Zero".</p> <p>bc. Remove the polygon from the SCT Shaft.</p> <p>bd. Set the SXT Power switch to "ON".</p>						
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4.4.2.8 TRUNNION SERVO TESTS (Reference Para. 3.3.10) - The following servo tests of steady state null, maximum and minimum rate, linearity, sensitivity, dynamic response and velocity error for the Trunnion servo loop are performed as follows:

Trunnion Servo Tests

- a. Monitor the trunnion decoder outputs at J ___ Pin ___ and J ___ Pin ___ on the Fwd-Bwd counter.
- b. Monitor and identify the following signals on the pen recorder.

NOTE: See Appendix II for signal identification.

<u>Signal Location</u>	<u>Channel</u>	<u>Range (+ 20 MM)</u>
E6 J ___ Pin ___	1	.1 V/MM
E5 J ___ Pin ___	2	.1 V/MM
E9 J ___ Pin ___	3	.1 V/MM
E3 J ___ Pin ___	4	.1 V/MM
E1 J ___ Pin ___	5	

- c. Set the pen recorder channel 5 range to .001 V/MM and the paper speed to 10 MM/sec.
- d. Start the pen recorder and allow to run for 10 sec.
- e. The steady state null of E1 shall be ___ mv + ___ mv rms.
- f. Set the Optics mode selector to "Zero", wait one minute.
- g. Set the Optics mode selector to "Normal" and insure that the Controller Speed selector is set to "Hi".
- h. Set the pen recorder channel 5 range to 20 V/MM.
- i. Apply a 1.5 volt signal to a switch in the GSE which will switch the voltage to J ___ Pin ___ when required.
- j. Start the pen recorder at a paper speed of 100 MM/sec.

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- l. Switch the 1.5 volt signal to J ___ Pin ___ for a period of 10 sec after which stop the pen recorder.
- m. The Fwd-Bwd counter shall indicate 10922 ± 1092 bits.
- n. The signal E3 shall rise to a voltage of $1.27 \pm .13$ V rms within 1.30 MM (1.3 secs) after the step input is applied, and shall drop to a voltage of .005 volts or less within 100 MM (1 sec) after the step input is removed.
- o. The steady state error voltage of E6 shall be ___ + ___ V rms.
- p. The steady state error voltage of E5 shall be ___ + ___ V rms.
- q. The steady state error voltage of E9 shall be ___ + ___ V rms.
- r. Set the Optics mode selector to "Zero", wait one minute.
- s. Set the Optics mode selector to "Normal".
- t. Apply a 10 volt signal to J ___ Pin ___.
- u. Start the pen recorder at a paper speed of 100 MM/sec.
- v. Switch the 10 volt signal to J ___ Pin ___ for a period of 3 sec after which stop the pen recorder.
- w. The steady state voltage of E3 shall be equal to or greater than 8.4 volts rms.
- x. Repeat Steps r. and s.
- y. Set the pen recorder channel 4 range selector to .25 V/MM.
- z. Apply a 1 volt signal to J ___ Pin ___.
- aa. Start the pen recorder at a paper speed of 10 MM/sec.
- ab. Switch the 1 volt signal to J ___ Pin ___ for a period of 10 sec after which stop the pen recorder.
- ac. The steady state voltage of E3 shall be $.84 \pm 0.08$ volts rms.

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<p>4.4.2.8 Continued.</p> <p>ad. Repeat Steps r. and s.</p> <p>ae. Set the pen recorder channel 4 range selector to .001 V/MM.</p> <p>af. Apply a 8 mv signal to J ___ Pin ___.</p> <p>ag. Start the pen recorder at a paper speed of 10 MM/sec.</p> <p>ah. Switch the 8 mv signal to J ___ Pin ___ for a period of 10 sec after which stop the pen recorder.</p> <p>ai. The steady state voltage of E3 shall be .7 mv + .7 mv rms.</p>						
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4.4.2.9 SHAFT SERVO TESTS - (Reference Para. 3.3.10) - The following servo tests of steady state null, maximum and minimum rate, linearity, sensitivity, dynamic response and velocity error for the shaft servo loop are performed as follows:

- a. Monitor the Shaft decoder outputs at J ___ Pin ___ and J ___ Pin ___ on the Fwd-Bwd counter.
- b. Monitor and identify the following signals on the pen recorder.

NOTE: See Appendix II for Signal Identification

<u>Signal Location</u>	<u>Channel</u>	<u>Range (+ 20 MM)</u>
E8 J ___ Pin ___	1	.1 V/MM
E7 J ___ Pin ___	2	.1 V/MM
E10 J ___ Pin ___	3	.1 V/MM
E4 J ___ Pin ___	4	.1 V/MM
E2 J ___ Pin ___	5	

- c. Set the pen recorder channel 5 range to .001 V/MM and the paper speed to 10 MM/sec.
- d. Start the pen recorder and allow to run for 10 sec.
- e. The steady state null of E2 shall be ___ mv + ___ mv rms.
- f. Set the Optics mode selector to "Zero", wait one minute.
- g. Set the Optics mode selector to "Normal" and insure that the Controller Speed selector is set to "Hi".
- h. Set the pen recorder channel 5 range to 20 V/MM.
- i. Apply a 1.5 volt signal to a switch in the GSE which will switch the voltage to J ___ Pin ___ when required.
- j. Start the pen recorder at a paper speed of 100 MM sec.
- l. Switch the 1.5 volt signal to J ___ Pin ___ for a period of 10 sec after which stop the pen recorder.

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4.4.2.9 Continued.

- m. The Fwd-Bwd counter shall indicate 2730 ± 273 bits.
- n. The signal E^4 shall rise to a voltage of $1.27 \pm .13$ V rms within 1.30 MM (1.3 secs) after the step input is applied and shall drop to a voltage of .005 volts or less within 100 MM (1 sec) after the step input is removed.
- o. The steady state error voltage of E^8 shall be $\text{---} \pm \text{---}$ V rms.
- p. The steady state error voltage of E^7 shall be $\text{---} \pm \text{---}$ V rms.
- q. The steady state error voltage of E^{10} shall be $\text{---} \pm \text{---}$ V rms.
- r. Set the Optics mode selector to "Zero", wait one minute.
- s. Set the Optics mode selector to "Normal".
- t. Apply a 10 volt signal to J Pin .
- u. Start the pen recorder at a paper speed of 100 MM/sec.
- v. Switch the 10 volt signal to J Pin for a period of 3 sec after which stop the pen recorder.
- w. The steady state voltage of E^4 shall be equal to or greater than 8.4 volts rms.
- x. Repeat Steps r. and s.
- y. Set the pen recorder channel 4 range selector to .25 V/MM.
- z. Apply a 1 volt signal to J Pin .
- aa. Start the pen recorder at a paper speed of 10 MM/sec.
- ab. Switch the 1 volt signal to J Pin for a period of 10 sec after which stop the pen recorder.
- ac. The steady state voltage of E^4 shall be $.84 \pm 0.08$ volts rms.
- ad. Repeat Steps r. and s.
- ae. Set the pen recorder channel 4 range selector to .001 V/MM.

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af. Apply a 8 mv signal to J ___ Pin ___.						
ag. Start the pen recorder at a paper speed of 10 MM/sec.						
ah. Switch the 8 mv signal to J ___ Pin ___ for a period of 10 sec after which stop the pen recorder.						
ai. The steady state voltage of E ⁴ shall be 7 mv \pm .7 mv rms.						
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4.4.2.10 TIME TO ZERO - (Ref. Para. 3.3.11) - The following is a check on the ability of the Optics Subsystem to zero from any angle within a specified period of time.

- a. Set the Optics mode selector to "Normal".
- b. Set the SXT Power switch to OFF.
- c. With the Control Stick, drive the SCT LOS until the Trunnion CDU readout indication increases to 360° , and through 0° to 0° again.
- d. Using the Fwd-Bwd counter as a timer, simultaneously set the Optics mode selector to "Zero" and start the Fwd-Bwd counter.
- e. When the zero indication is given, stop the Fwd-Bwd counter.
- f. The Fwd-Bwd counter shall indicate 90 sec or less.
- g. Sight through the SCT eyepiece and adjust the rotary table in azimuth until the SCT reticle and the reticle image of Collimator #2 are coincident.
- h. The change in rotary table azimuth angle shall be 1 min. or less.
- i. Set the Optics mode selector to "Normal".
- j. With the Control Stick, drive the SCT LOS until the Shaft CDU readout indicates 360° .
- k. Repeat Steps d. through i.
- l. Set the SXT Power switch to ON.
- m. With the Control Stick, drive the ST LOS about the shaft axis to a Shaft CDU readout indication of $+270^{\circ}$.
- n. Monitor E7 on the pen recorder and the zero indication.
- o. Start the pen recorder at 10 MM/sec.
- p. Using the Fwd-Bwd counter as a timer, simultaneously set the Optics mode selector to "Zero" and start the Fwd-Bwd counter.

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4.4.2.10 Continued.

- q. When the voltage E7 indicates 20 mv or less, stop the Fwd-Bwd counter and the pen recorder.
- s. The Fwd-Bwd counter shall indicate 70 sec or less and the zero indication shall be present.
- t. Set the Optics mode selector to "Normal".
- u. Monitor E5 on the pen recorder and the Zero indication.
- v. Using the Control Stick, drive the ST LOS until the Trunnion CDU readout indicates 180°.
- w. Start the pen recorder at a paper speed of 10 MM/sec.
- x. Simultaneously set the Optics mode selector to "Zero" and start the counter.
- y. When the voltage E5 indicates 10 mv or less, stop the counter and pen recorder.
- z. The counter shall indicate 20 secs or less and the zero indication shall be present.
- aa. Set the SXT Power switch and Optics Power switch to OFF.

APPENDIX I

SXT LOS TO IMU MOUNTING PAD ALIGNMENT TEST SET-UP

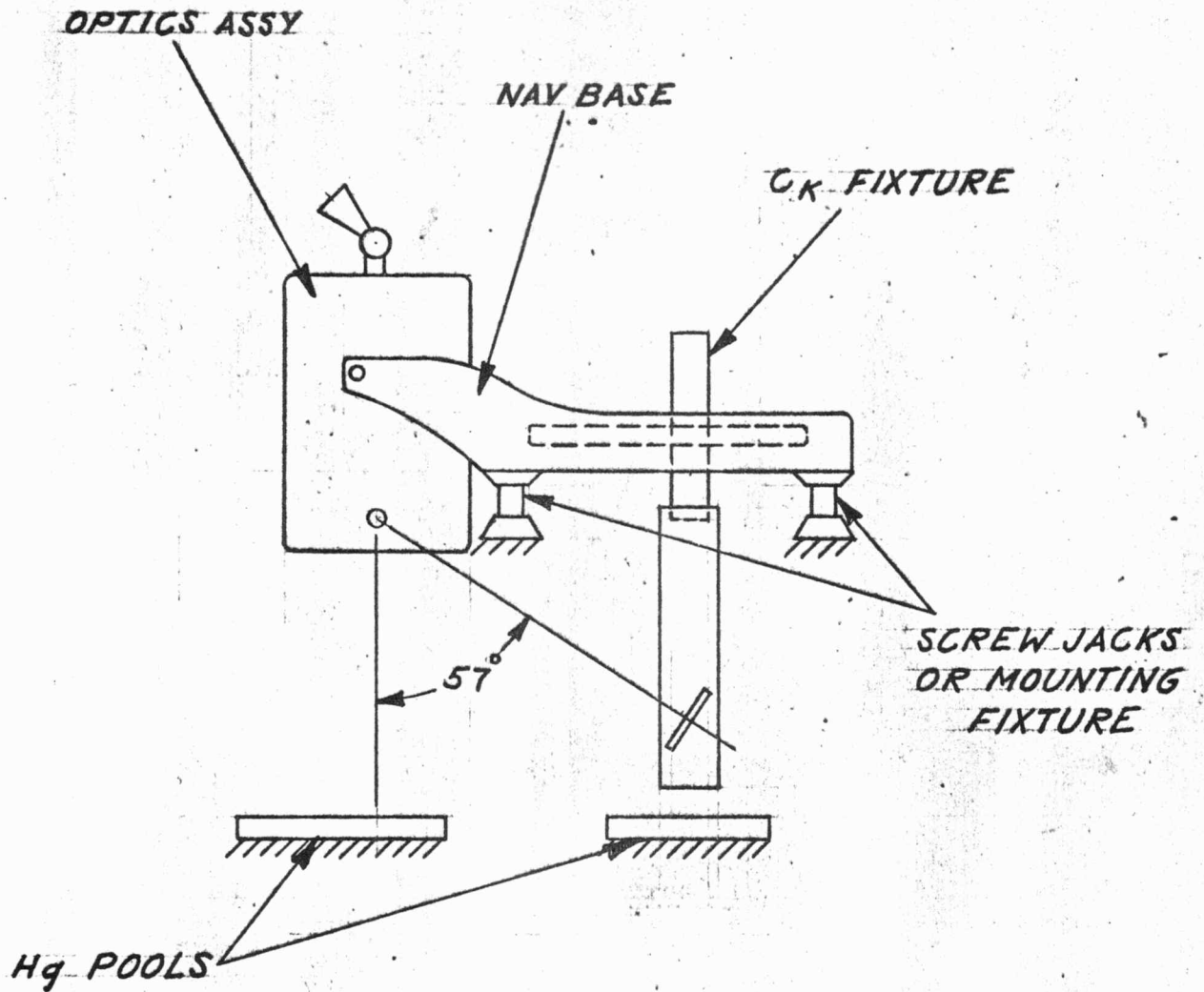


FIGURE I

APPENDIX I
OPTICS ASSY POSITIONAL ACCURACY TEST SET-UP

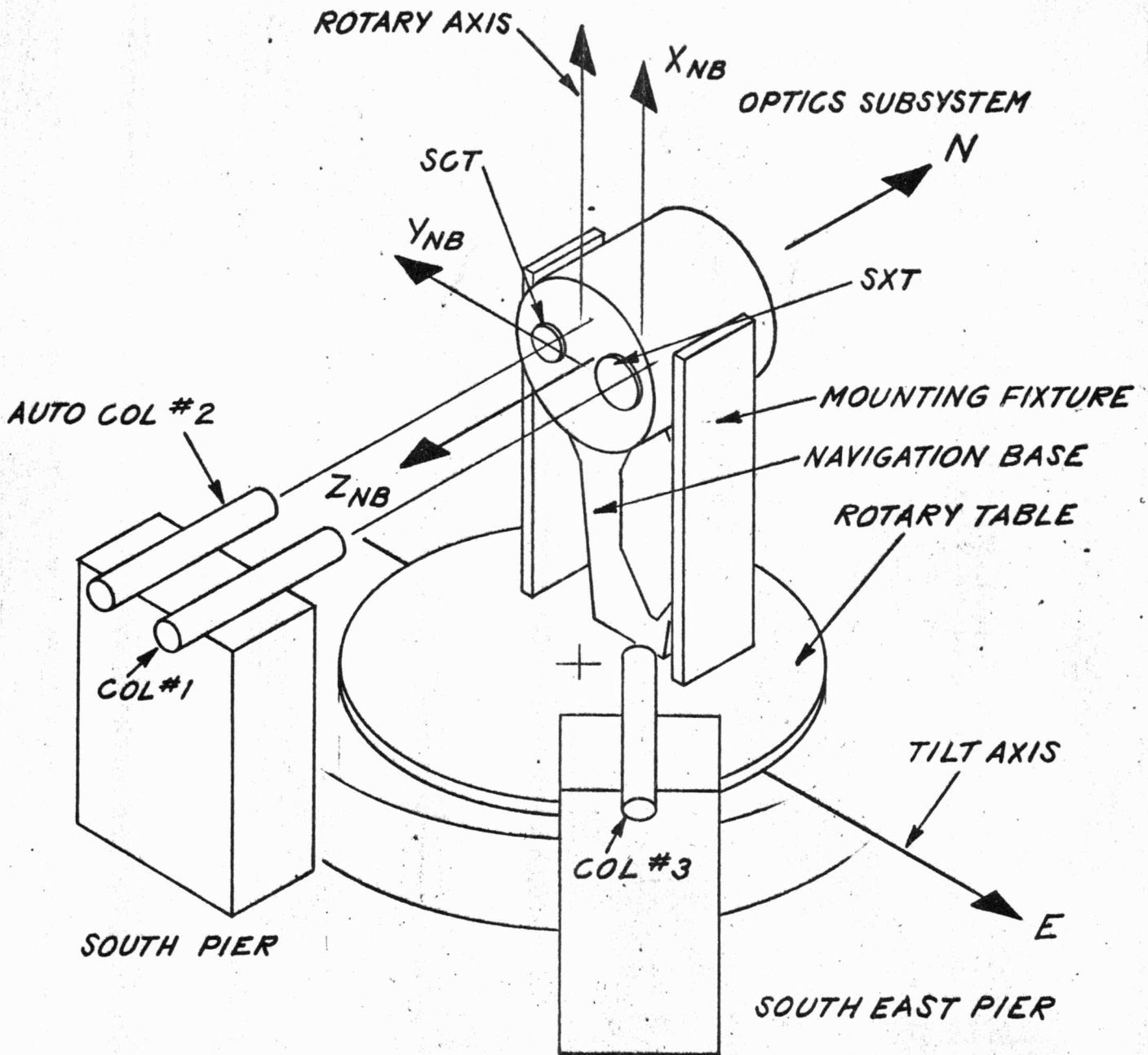


FIGURE II

APPENDIX I

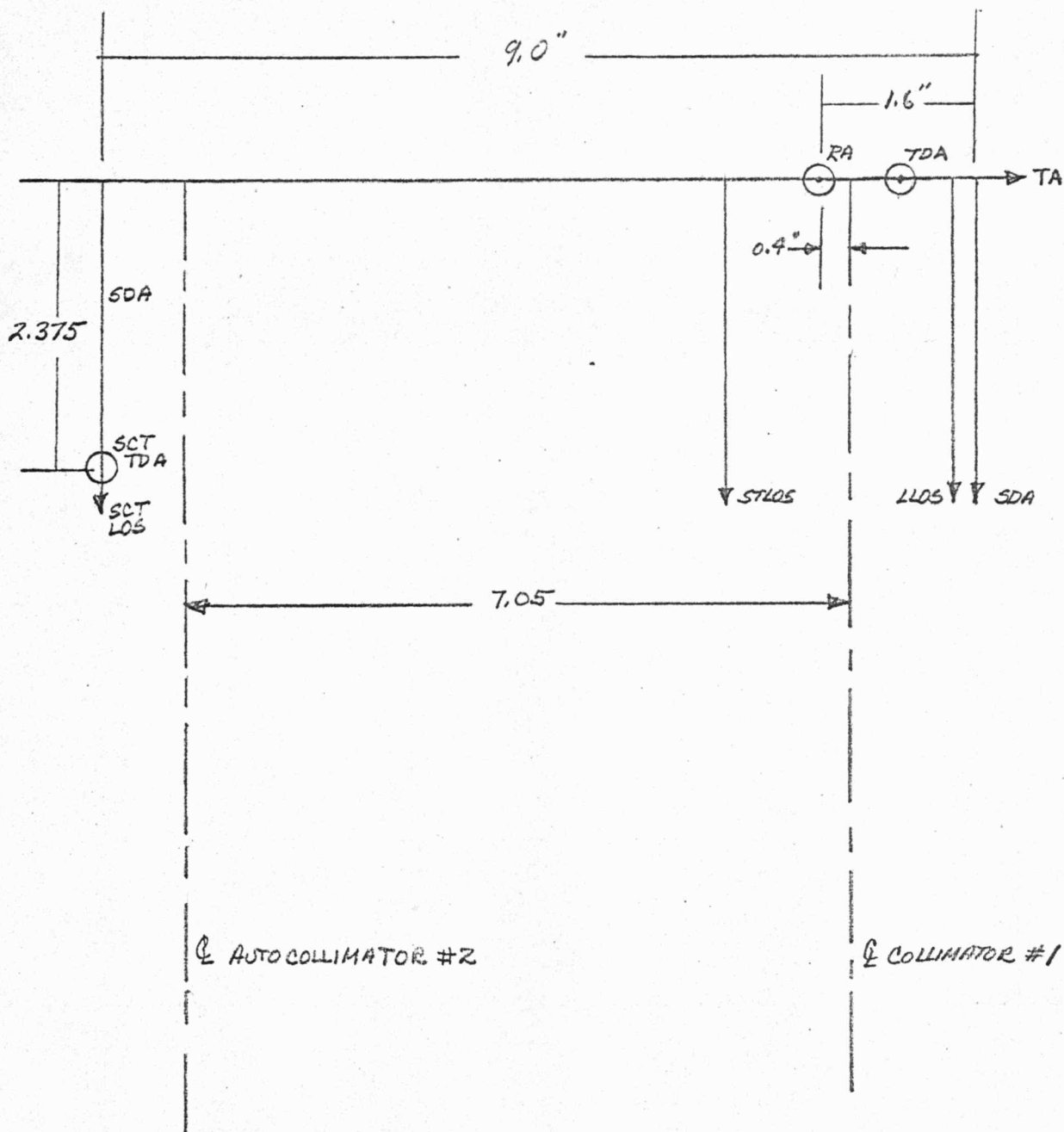


FIGURE III

PLAN VIEW OF OPTICAL TARGET AXES AND SXT-SCT AXES
RELATIVE TO THE ROTARY TABLE AXES

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APPENDIX II

SIGNAL IDENTIFICATION

- E1 2X Trunnion CDU motor control winding.
- E2 Shaft CDU motor control winding.
- E3 2X Trunnion CDU tachometer output.
- E4 Shaft CDU tachometer output.
- E5 SXT Trunnion 1X resolver error signal.
- E6 2X Trunnion CDU 16X resolver error signal.
- E7 SXT Shaft 1/2X resolver error signal.
- E8 Shaft CDU 16X resolver error signal.
- E9 SCT Trunnion 1X resolver error signal.
- E10 SCT Shaft 1/2X resolver error signal.
- E11 2X Trunnion CDU 1/4X resolver sine output.
- E12 Shaft CDU 1/2X resolver sine output.
- E13 Trunnion plus decoder output.
- E14 Trunnion minus decoder output.
- E15 Shaft plus decoder output.
- E16 Shaft minus decoder output.
- E17 Up-Down Control Stick output.
- E18 Left-Right Control Stick output.
- E19 Up-Down deadzone switch output.
- E20 Left-Right deadzone switch output.