MASSACHUSETTS INSTITUTE OF TECHNOLOGY

APOLLO

GUIDANCE AND NAVIGATION

E-1432

GSE FAMILIARIZATION MANUAL

October, 1963

MIT INSTRUMENTATION LABORATORY

CAMBRIDGE 39, MASSACHUSETTS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

APOLLO

GUIDANCE AND NAVIGATION

Approved: Milton B. Trageser Date: 2/3/64
Milton B. Trageser, Director
Apollo Guidance and Navigation Program

Approved: Roger B Woodbury Date: 2/4/64
Roger B. Woodbury, Deputy Director
Instrumentation Laboratory

E-1432

GSE FAMILIARIZATION MANUAL

January 1964

MIT INSTRUMENTATION LABORATORY
CAMBRIDGE 39, MASSACHUSETTS

COPY # 47

ACKNOWLEDGMENT

This manual represents the joint effort of MIT/IL, resident and non-resident members of AC Spark Plug, Raytheon Co., Kollsman Instrument Co., and WESCO.

This report was prepared under the auspices of DSR Project 55-191, sponsored by the Manned Spacecraft Center of the National Aeronautics and Space Administration through contract NAS9-153.

ABSTRACT

This publication describes the Apollo Ground Support Equipment (GSE) which is the complex of units designed to be used in the performance of pre-flight checkout of the Apollo Guidance and Navigation Equipment (G&N) in its various system and subsystem configurations.

This publication has been divided into four general sections as follows:

A. Section I - General
B. Section II - AC Spark Plug Furnished Equipment
C. Section III - Raytheon Furnished Equipment
C. Section IV - Kollsman Furnished Equipment

Within each of these sections the particular equipments being manufactured or procured by the participating contractors are described.

Section I contains the Equipment Family Tree of the major components described in following sections, a list of the applicable Mechanization Drawings and an illustration of the present breadboard GSE.

TABLE OF CONTENTS

SECTION I

1.1 GSE FAMILY TREE, TOP ASSEMBLY LEVEL

1.2 MECHANIZATION DRAWINGS

1.3 PHOTOGRAPH OF GSE BB, AND IMU ON ROTARY TABLE

1.4.1 TYPICAL LAYOUT OF A SINGLE G & N UNIVERSAL TEST STATION

1.4.2 DESCRIPTION OF A G & N UNIVERSAL TEST STATION

SECTION 2

AC SPARK FURNISHED EQUIPMENT

OPTICS INERTIAL ANALYZER, NO. 1900004

2.1.1 ILLUSTRATION OF OPTICS INERTIAL ANALYZER

2.1.2 DESCRIPTION OF OPTICS INERTIAL ANALYZER

2.1.3 OPTICS INERTIAL ANALYZER CAPITAL EQUIPMENT SPECIFICATIONS

2.1.4 OPTICS INERTIAL ANALYZER EQUIPMENT LIST

OSCILLOGRAPH CONSOLE, NO. 1900000

2.2.1 ILLUSTRATION OF OSCILLOGRAPH CONSOLE

2.2.2 DESCRIPTION OF OSCILLOGRAPH CONSOLE

2.2.3 OSCILLOGRAPH CONSOLE CAPITAL EQUIPMENT LIST

2.2.4 OSCILLOGRAPH CONSOLE EQUIPMENT LIST

G & N COOLANT AND POWER CONSOLE, NO. 1900145

2.3.1 ILLUSTRATION OF G & N COOLANT AND POWER CONSOLE

2.3.2 DESCRIPTION OF G & N COOLANT AND POWER SUPPLY

2.3.3 CAPITAL EQUIPMENT SPECIFICATION

2.3.4 G & N COOLANT AND POWER CONSOLE EQUIPMENT LIST

GSE - J - BOX OVERHEAD, NO. 1900433

2.4.1 ILLUSTRATION OF OVERHEAD J - BOX

2.4.2 DESCRIPTION OF OVERHEAD J - BOX

ROTARY TABLE, NO. 1900006

2.5.1 ILLUSTRATION OF ROTARY TABLE

2.5.2 DESCRIPTION OF ROTARY TABLE

ROTARY TABLE CALIBRATION KIT, NO. 1900810

2.6.1 ILLUSTRATION OF ROT. TABLE CALIBRATION KIT

2.6.2 DESCRIPTION OF ROT. TABLE CALIBRATION KIT

IMU MOUNTING FIXTURE, NO. 1900012 AND IMU MTG FIXTURE ALIGNMENT SET, NO. 1900800

2.7.1 ILLUSTRATION OF IMU MOUNTING FIXTURE

2.7.2 DESCRIPTION OF IMU MOUNTING FIXTURE AND ALIGNMENT SET

DEGAUSSER, NO. 1900299

2.8.1 ILLUSTRATION OF DEGAUSSER

2.8.2 DESCRIPTION OF DEGAUSSER

FILLING AND PURGING FIXTURE, NO. 1900803

2.9.1 ILLUSTRATION OF FILLING AND PURGING FIXTURE

2.9.2 DESCRIPTION OF FILLING AND PURGING FIXTURE

BELLOWS, IMU SNAP-ON, NO. 1900802

2.10.1 ILLUSTRATION OF BELLOWS, IMU SNAP-ON

2.10.2 DESCRIPTION OF BELLOWS, IMU SNAP-ON

IMU PRESSURE SEAL TESTER, NO. 1900804

2.11.1 ILLUSTRATION OF IMU PRESSURE SEAL TESTER

2.11.2 DESCRIPTION OF IMU PRESSURE SEAL TESTER

INERTIAL COMPONENTS TEMP. CONTROLLER, NO. 1900342 (NO. 1900496, NO. 1900011)

2.12.1 ILLUSTRATION OF PORTABLE TEMPERATURE CONTROLLER

2.12.1.1 PORTABLE TEMPERATURE CONTROLLER WITH COVER OPEN

2.12.1.2 PORTABLE TEMPERATURE CONTROLLER, FRONT VIEW

2.12.1.3 ILLUSTRATION OF BATTERY POWER PACK

2.12.2 DESCRIPTION OF ICTC

IMU SHIPPING CONTAINER, NO. 1900010

2.13.1 ILLUSTRATION OF IMU SHIPPING CONTAINER

2.13.2 DESCRIPTION OF IMU SHIPPING CONTAINER

PSA MOUNTING FIXTURE, NO. 1900606

2.14.1 ILLUSTRATION OF PSA MOUNTING FIXTURE

2.14.2 DESCRIPTION OF PSA MOUNTING FIXTURE

GSE-PSA JUNCTION BOX, NO. 1900268

2.15.1 ILLUSTRATION OF GSE-PSA JUNCTION BOX

2.15.2 DESCRIPTION OF GSE-PSA JUNCTION BOX

PSA TRAY EXTENDER SET, NO. 1900805

2.16.1 ILLUSTRATION OF PSA TRAY EXTENDER SET

2.16.2 DESCRIPTION OF PSA TRAY EXTENDER SET

LOAD & SIGNAL SIMULATOR SET NO. 1900797 (NO. 1900798, NO. 1900799)

2. 17. 1 ILLUSTRATION OF LOAD & SIGNAL SIMULATOR SET

2. 17. 2 DESCRIPTION OF LOAD & SIGNAL SIMULATOR SET

OPTICS/NAV BASE MOUNTING FIXTURE NO. 1900013

2. 18. 1 ILLUSTRATION OF OPTICS/NAV BASE MOUNTING FIXTURE

2. 18. 2 DESCRIPTION OF OPTICS/NAV BASE MOUNTING FIXTURE

REMOTE OPTICS CONTROLLER, NO. 1900491

2. 19. 1 ILLUSTRATION OF REMOTE OPTICS CONTROLLER

2. 19. 2 DESCRIPTION OF REMOTE OPTICS CONTROLLER

G & N MOUNTING FIXTURE, NO. 1900014

2. 20. 1 ILLUSTRATION OF G & N MOUNTING FIXTURE

2. 20. 2 DESCRIPTION OF G & N MOUNTING FIXTURE

G & N HARNESS SHIPPING FIXTURE, NO. 1900811

2. 21. 1 ILLUSTRATION OF G & N HARNESS SHIPPING FIXTURE

2. 21. 2 DESCRIPTION OF G & N HARNESS SHIPPING FIXTURE

G & N TRANSPORT CART, NO. 1900009

2. 22. 1 ILLUSTRATION OF G & N TRANSPORT CART

2. 22. 2 DESCRIPTION OF G & N TRANSPORT CART

SECTION 3

RAYTHEON FURNISHED EQUIPMENT

COMPUTER TESTER ASSY. NO. 1014156

3.1.1.1 ILLUSTRATION OF COMPUTER TESTER ASSY.

3.1.1.2 PHOTOGRAPH - FRONT VIEW OF COMPUTER TESTER ASSY. BREADBOARD

3.1.1.3 PHOTOGRAPH - WIRING OF COMPUTER TESTER ASSY. BREADBOARD

3.1.2 DESCRIPTION OF COMPUTER TESTER ASSY.

3.1.3 LIST OF COMPUTER TESTER ASSY. CAPITAL EQUIPMENT

3.1.4 PANEL LIST OF COMPUTER TESTER ASSY.

AGC/CTS OPERATION CONSOLE, NO. 1014465

3.2.1 ILLUSTRATION OF AGC/CTS OPERATION CONSOLE

3.2.2 DESCRIPTION OF AGC/CTS OPERATION CONSOLE

3.2.3 AGC/CTS OPER. CONSOLE CAPITAL EQUIPMENT SPECIFICATION

COMPUTER CALIBRATION SYSTEM CONSOLE, NO. 1014217

3.3.1 ILLUSTRATION OF COMPUTER CALIBRATION SYSTEM CONSOLE

3.3.2 DESCRIPTION OF COMPUTER CALIBRATION SYSTEM CONSOLE

3.3.3 LIST OF DRAWERS OF COMPUTER CALIBRATION SYSTEM CONSOLE

COMPUTER SIMULATOR DRAWER, NO. 1014061

3.4.1.1 PHOTOGRAPH OF COMPUTER SIMULATOR, FRONT PANEL

3.4.1.2 PHOTOGRAPH OF COMPUTER SIMULATOR DRAWER

3.4.2 DESCRIPTION OF COMPUTER SIMULATOR DRAWER

AGC SHIPPING CONTAINERS AND HANDLING FIXTURES

3.5.1 AGC SHIPPING CONTAINER AND HANDLING FIXTURE FAMILY TREE

3.5.1.1 ILLUSTRATION OF AGC HOLDING FIXTURE

3.5.2 DESCRIPTION OF AGC SHIPPING CONT. AND HANDLING FIXTURES

SECTION 4

KOLLSMAN FURNISHED EQUIPMENT

PRECISION TEST FIXTURE, NO. 1016910

4.1.1 ILLUSTRATION OF PRECISION TEST FIXTURE

4.1.2 DESCRIPTION OF PRECISION TEST FIXTURE

FUNCTIONAL TESTER, NO. 1016949

4.2.1 ILLUSTRATION OF FUNCTIONAL TESTER

4.2.2 DESCRIPTION OF FUNCTIONAL TESTER

SHORT PERISCOPE, NO. 1016911

4.3.1 ILLUSTRATION OF SHORT PERISCOPE

4.3.2 DESCRIPTION OF SHORT PERISCOPE

5 IN. AUTOCOLLIMATOR, SCT NO. 1017410

4.4.1 ILLUSTRATION OF 5 IN. AUTOCOLLIMATOR

4.4.2 DESCRIPTION OF 5 IN. AUTOCOLLIMATOR

4.4.3 5 IN. AUTOCOLLIMATOR SPECIFICATIONS

2 1/2 IN. AUTOCOLLIMATOR, SCT NO. 1017435

4.5.1 ILLUSTRATION OF 2 1/2 IN. AUTOCOLLIMATOR, SCT

4.5.2 DESCRIPTION OF 2 1/2 IN. AUTOCOLLIMATOR, SCT

4.5.3 2 1/2 IN. AUTOCOLLIMATOR SPECIFICATIONS

2 1/2 IN. AUTOCOLLIMATOR, SXT NO. 1017448

4.6.1 ILLUSTRATION OF 2 1/2 IN. AUTOCOLLIMATOR, SXT

4.6.2 DESCRIPTION OF 2 1/2 IN. AUTOCOLLIMATOR, SXT

0^{o} AUTOCOLLIMATOR PLATE, NO. 1017380

4.7.1 ILLUSTRATION OF 0^{o} AUTOCOLLIMATOR PLATE

4.7.2 DESCRIPTION OF 0^{o} AUTOCOLLIMATOR PLATE

45^{o} AUTOCOLLIMATOR PLATE, NO. 1017381

4.8.1 ILLUSTRATION OF 45^{o} AUTOCOLLIMATOR PLATE

4.8.2 DESCRIPTION OF 45^{o} AUTOCOLLIMATOR PLATE

THEODOLITE, NO. 1017447

4.9.1 ILLUSTRATION OF THEODOLITE

4.9.2 DESCRIPTION OF THEODOLITE

SECTION 4 (CONT.)

ALIGNMENT MIRROR ASSEMBLY, NO. 1016951
4.10.1 ILLUSTRATION OF ALIGNMENT MIRROR ASSEMBLY
4.10.2 DESCRIPTION OF ALIGNMENT MIRROR ASSEMBLY

ADJUSTABLE MIRROR, NO. 1017377
4.11.1 ILLUSTRATION OF ADJUSTABLE MIRROR
4.11.2 DESCRIPTION OF ADJUSTABLE MIRROR

SHAFT ACCURACY TESTER, NO. 1017378
4.12.1 ILLUSTRATION OF SHAFT ACCURACY TESTER
4.12.2 DESCRIPTION OF SHAFT ACCURACY TESTER

G & N INSTALLATION QUALIFICATION FIXTURE, NO. 1017383
4.13.1 ILLUSTRATION OF G & N INST. QUALIF. FIXTURE
4.13.2 DESCRIPTION OF G & N INST. QUALIF. FIXTURE

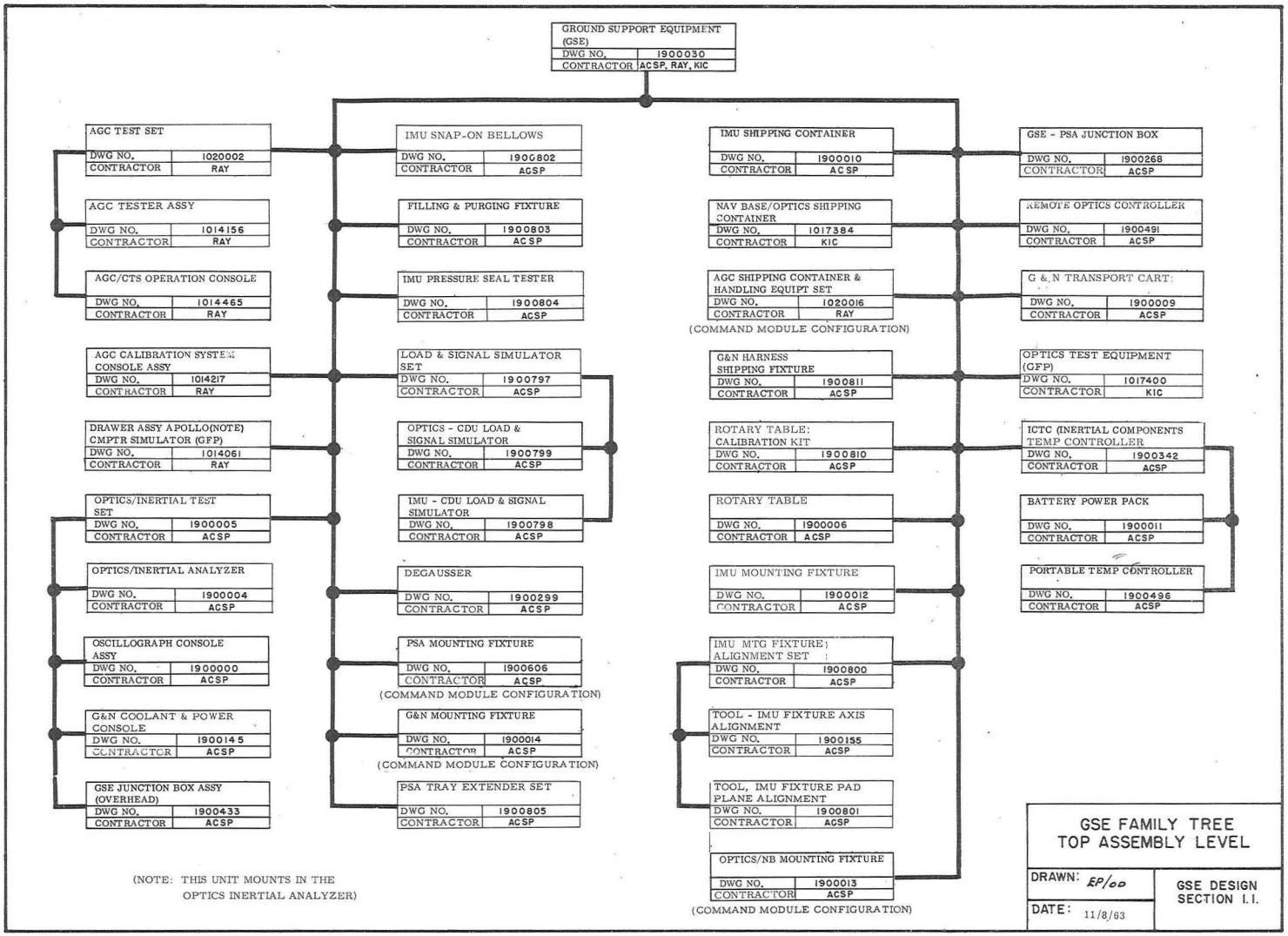
AZIMUTH REFERENCE FIXTURE, NO. 1017382
4.14.1 ILLUSTRATION OF AZIMUTH REFERENCE FIXTURE
4.14.2 DESCRIPTION OF AZIMUTH REFERENCE FIXTURE

WEDGE, VARIABLE DEVIATION, NO. 1017376
4.15.1 ILLUSTRATION OF WEDGES
4.15.2 DESCRIPTION OF WEDGES

MAP & DATA VIEWER TESTER, NO. 1016948
4.16.1 ILLUSTRATION OF MAP & DATA VIEWER TESTER
4.16.2 DESCRIPTION OF MAP & DATA VIEWER TESTER

OPTICS/NAV BASE SHIPPING CONTAINER, NO. 1017384
4.17.1 ILLUSTRATION OF OPTICS/NAV BASE SHIPPING CONTAINER
4.17.2 DESCRIPTION OF OPTICS/NAV BASE SHIPPING CONTAINER

OPTICS SHIPPING CONTAINER, NO. 1019700
4.18.1 ILLUSTRATION OF OPTICS SHIPPING CONTAINER
4.18.2 DESCRIPTION OF OPTICS SHIPPING CONTAINER

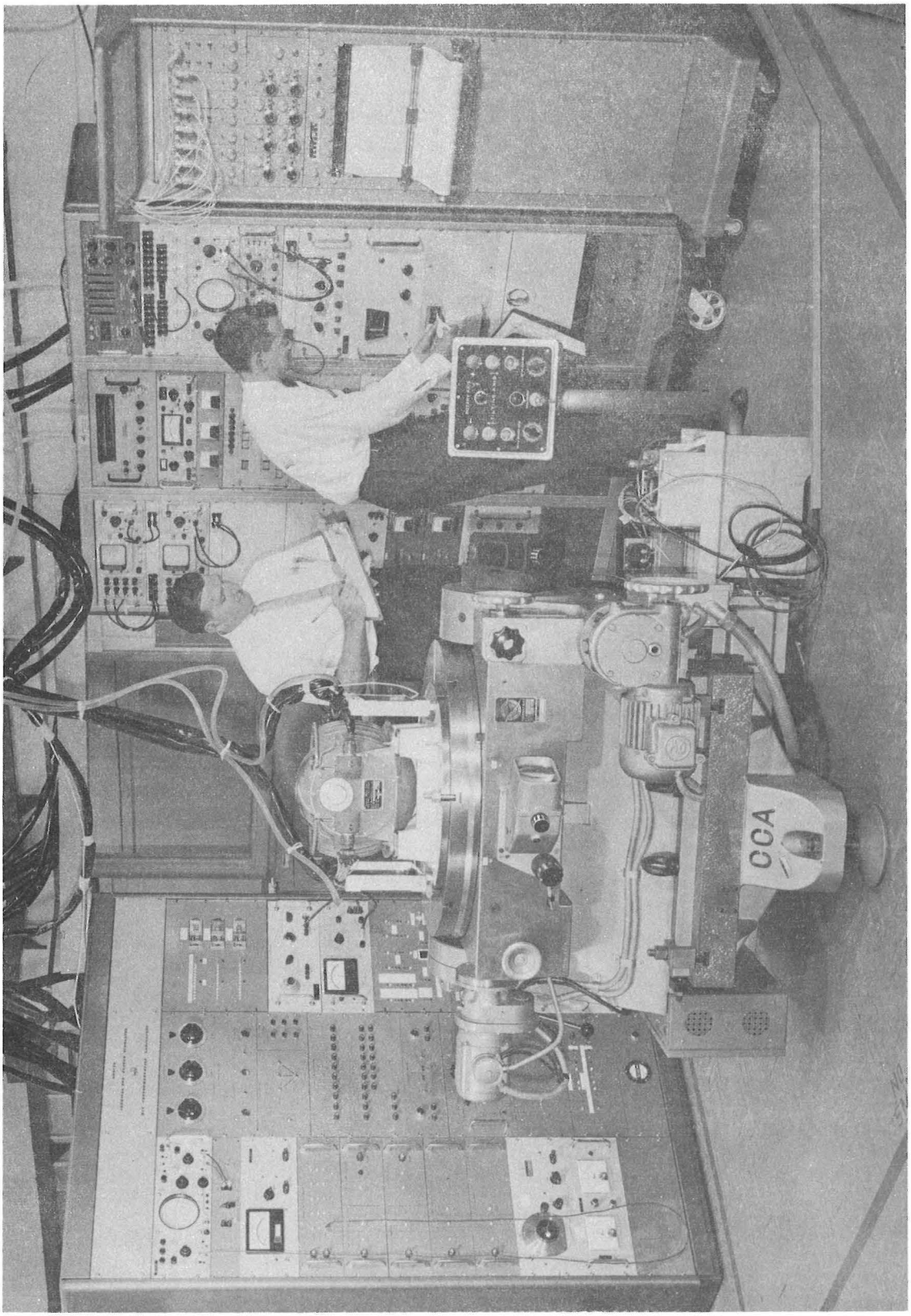

GROUND SUPPORT EQUIPMENT (GSE)
DWG NO. 1900030
CONTRACTOR ACSP, RAY, KIC
AGC TEST SET
DWG NO. 1020002
CONTRACTOR RAY
AGC TESTER ASSY
DWG NO. 1014156
CONTRACTOR RAY
AGC/CTS OPERATION CONSOLE
DWG NO. 1014465
CONTRACTOR RAY
AGC CALIBRATION SYSTEM CONSOLE ASSY
DWG NO. 1014217
CONTRACTOR RAY
DRAWER ASSY APOLLO(NOTE) CMPTR SIMULATOR (GFP)
DWG NO. 1014061
CONTRACTOR RAY
OPTICS/INERTIAL TEST SET
DWG NO. 1900005
CONTRACTOR ACSP
OPTICS/INERTIAL ANALYZER
DWG NO. 1900004
CONTRACTOR ACSP
OSCILLOGRAPH CONSOLE ASSY
DWG NO. 1900000
CONTRACTOR ACSP
G&N COOLANT & POWER CONSOLE
DWG NO. 1900145
CONTRACTOR ACSP
GSE JUNCTION BOX ASSY (OVERHEAD)
DWG NO. 1900433
CONTRACTOR ACSP
(NOTE: THIS UNIT MOUNTS IN THE OPTICS INERTIAL ANALYZER)
IMU SNAP-ON BELLOWS
DWG NO. 1900802
CONTRACTOR ACSP
FILLING & PURGING FIXTURE
DWG NO. 1900803
CONTRACTOR ACSP
IMU PRESSURE SEAL TESTER
DWG NO. 1900804
CONTRACTOR ACSP
LOAD & SIGNAL SIMULATOR SET
DWG NO. 1900797
CONTRACTOR ACSP
OPTICS - CDU LOAD & SIGNAL SIMULATOR
DWG NO. 1900799
CONTRACTOR ACSP
IMU - CDU LOAD & SIGNAL SIMULATOR
DWG NO. 1900798
CONTRACTOR ACSP
DEGAUSSER
DWG NO. 1900299
CONTRACTOR ACSP
PSA MOUNTING FIXTURE
DWG NO. 1900606
CONTRACTOR ACSP
(COMMAND MODULE CONFIGURATION)
G&N MOUNTING FIXTURE
DWG NO. 1900014
CONTRACTOR ACSP
(COMMAND MODULE CONFIGURATION)
PSA TRAY EXTENDER SET
DWG NO. 1900805
CONTRACTOR ACSP
IMU SHIPPING CONTAINER
DWG NO. 1900010
CONTRACTOR ACSP
NAV BASE/OPTICS SHIPPING CONTAINER
DWG NO. 1017384
CONTRACTOR KIC
AGC SHIPPING CONTAINER & HANDLING EQUIPT SET
DWG NO. 1020016
CONTRACTOR RAY
(COMMAND MODULE CONFIGURATION)
G&N HARNESS SHIPPING FIXTURE
DWG NO. 1900811
CONTRACTOR ACSP
ROTARY TABLE: CALIBRATION KIT
DWG NO. 1900810
CONTRACTOR ACSP
ROTARY TABLE
DWG NO. 1900006
CONTRACTOR ACSP
IMU MOUNTING FIXTURE
DWG NO. 1900012
CONTRACTOR ACSP
IMU MTG FIXTURE; ALIGNMENT SET
DWG NO. 1900800
CONTRACTOR ACSP
TOOL - IMU FIXTURE AXIS ALIGNMENT
DWG NO. 1900155
CONTRACTOR ACSP
TOOL, IMU FIXTURE PAD PLANE ALIGNMENT
DWG NO. 1900801
CONTRACTOR ACSP
OPTICS/NB MOUNTING FIXTURE
DWG NO. 1900013
CONTRACTOR ACSP
(COMMAND MODULE CONFIGURATION)
GSE - PSA JUNCTION BOX
DWG NO. 1900268
CONTRACTOR ACSP
REMOTE OPTICS CONTROLLER
DWG NO. 1900491
CONTRACTOR ACSP
G & N TRANSPORT CART
DWG NO. 1900009
CONTRACTOR ACSP
OPTICS TEST EQUIPMENT (GFP)
DWG NO. 1017400
CONTRACTOR KIC
ICTC (INERTIAL COMPONENTS TEMP CONTROLLER
DWG NO. 1900342
CONTRACTOR ACSP
BATTERY POWER PACK
DWG NO. 1900011
CONTRACTOR ACSP
PORTABLE TEMP CONTROLLER
DWG NO. 1900496
CONTRACTOR ACSP
GSE FAMILY TREE
TOP ASSEMBLY LEVEL
DRAWN: EP/00
DATE: 11/8/63
GSE DESIGN SECTION I.I.

GSE Mechanization Drawings

The Apollo GSE Inertial Test set has been designed based on the following:

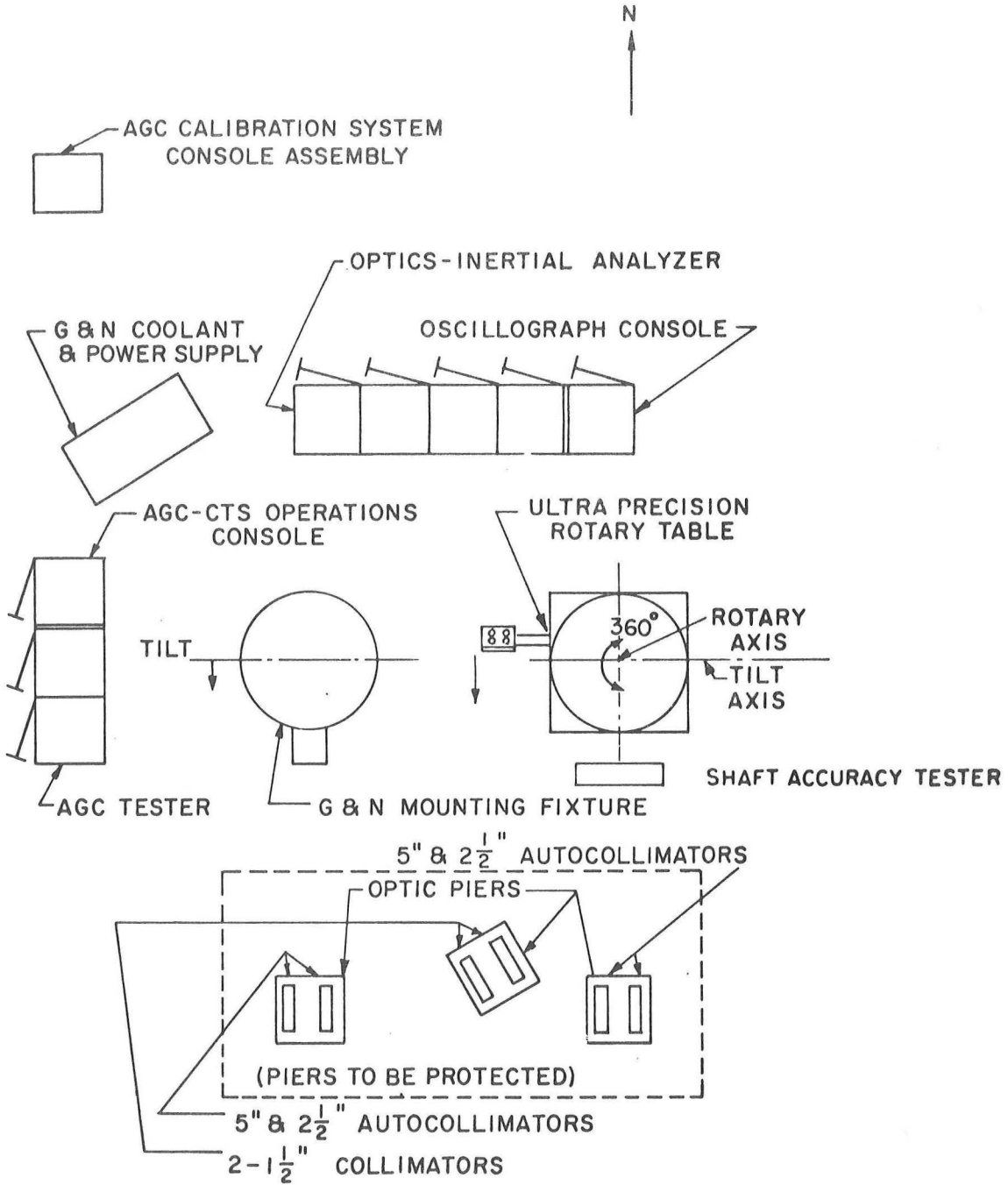
MECHANIZATION DRAWINGS

SIGNAL SELECTION	1900066
POWER CONTROL	1900144
DISPLAY AND MONITOR	1900089
SUBSYSTEM INTERFACE	1900262
TEST CONTROL	1900258
COUNTER SWITCHING AND UTILIZATION	1900077
GROUNDING	1900065
OPTICS TEST	1900100



Photograph of GSE Breadboard and IMU on Rotary Table

Typical Layout of a Single G&N Universal Test Station

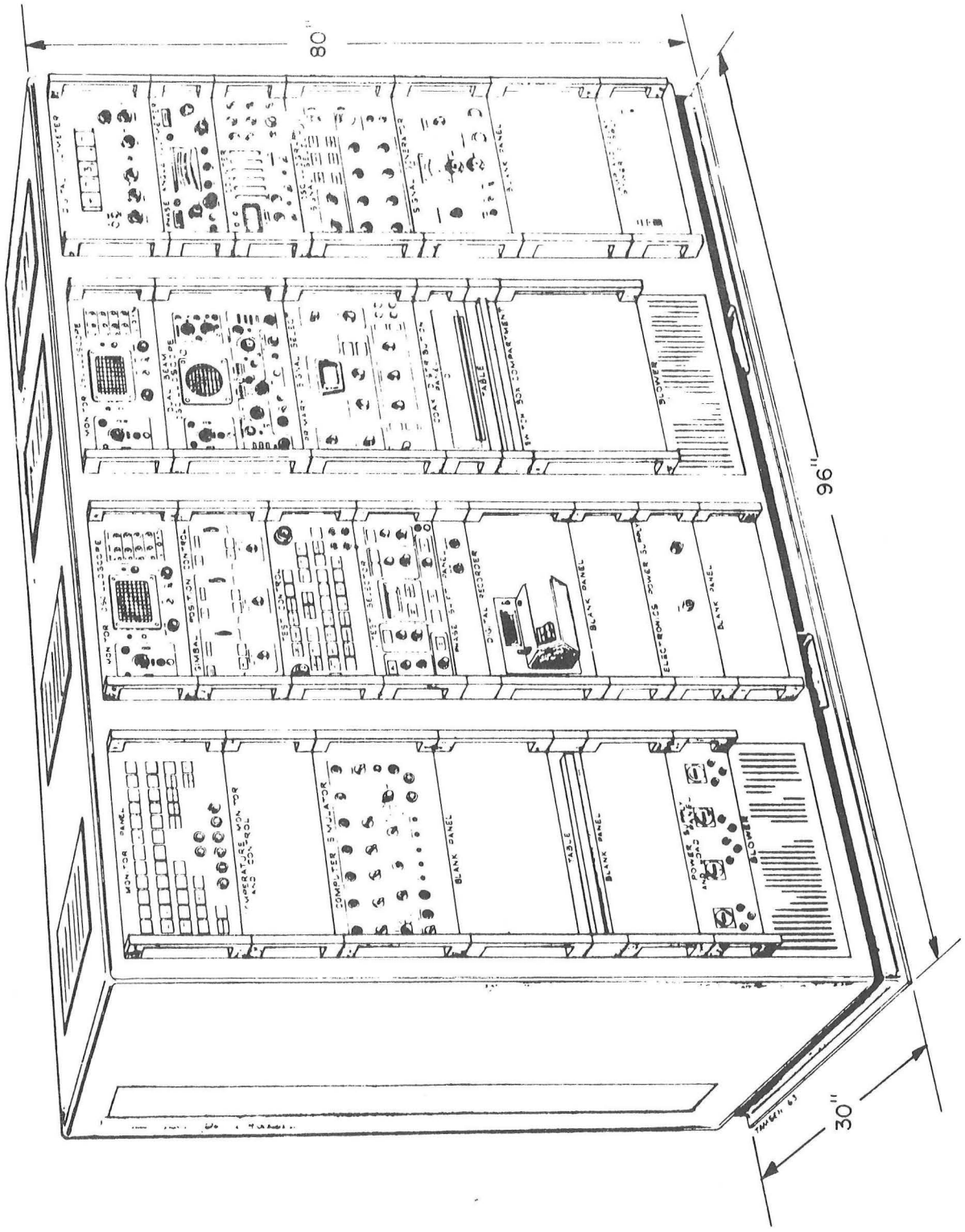


Description of a G & N Universal Test Station

The sketch in section 1.4.1 shows a layout of a single G & N Universal Test Station, with all its major pieces of equipment placed in their approximate positions.

The G & N Mounting Fixture will have all airborne components in SC configuration mounted on it during system checkout, and will sit on an isolation pad or an equally stable floor. The Ultra-Precision Rotary Table with its associated holding fixtures will be used to hold the Optics and Inertial Subsystem airborne components during subsystem checkout; it is also supported by the isolation pad (stable floor).

The OIA Console, AGC Tester, and G & N Coolant and Power Console are located around the isolation pad to provide convenient cabling from the overhead J-Box. The AGC Calibration System Console is provided with casters and will be rolled up if required. The Optics Piers (or stands) for mounting the collimators are located south of the Ultra-Precision Rotary Table and G & N Mounting Fixture. They are set on the isolation pad, if the site is provided with one, or on an equally stable floor.



Optics-inertial Analyzer

Description
of
Optics Inertial Analyzer

The Optics Inertial Analyzer is a four-bay test equipment console. It provides output stimuli and control signals to the airborne equipment. Another function of the OIA is to monitor airborne signals or route airborne signals to the Oscillograph Console. The OIA has provisions to enable the determination of:

1) Inertial System
   a) IMU alignment
   b) Gyro and accelerometer scale factors and coefficients
   c) Servo loop dynamic and static performance
   d) Temperature control calibration and performance
   e) Operational moding

2) Optical System
   a) Trunnion and shaft accuracy
   b) Servo loop dynamic performance
   c) Operational moding

3) Spacecraft interface load and display simulation

All the airborne signals to the Optics Inertial Analyzer feed into a distribution bay in the rear of the console. From the distribution bay all critical signals are wired to the Coax Distribution Panel. (Critical signals are those signals whose characteristics would be altered by switch networks). These signals are brought out on the front of the panel. By the use of short coax jumper cables, signals to be checked are sent to the Dual-Beam Oscilloscope Panel.

The signals to be monitored on the Counter are wired to

the Counter signal select switches on the Primary Signal Selector Panel. The signals to be monitored on the Oscillograph Console are wired to the Oscillograph Signal Selector Panel. At this panel, up to eight signals at a time will be selected for monitoring on the oscillograph. Signals to be monitored on the Dual-Beam Oscilloscope, Phase Angle Voltmeter, and the Digital Voltmeter are first routed to the cross-bar switch in the Switch Box Compartment. With the use of the cross-bar switch, any one of a hundred groups of two signals each, are selected and routed to the Primary Signal Select Panels. At the Primary Signal Select Panel, signals from the cross-bar switch and the means of monitoring the signals are selected.

Some component drawers contain commercial test equipment that has been modified for use in the analyzer. A computer simulator will be supplied by the AGC manufacturer for installation in the Optics Inertial Analyzer. The remaining drawers are contractor-manufactured.

2.1.2.1 Monitor Panel. The Monitor Panel is a malfunction indicator. It contains error bit monitor circuitry, level detectors for airborne power supplies, and the frequency detector for 3200-cycle ducosyn suspension voltage. Malfunction indicator lights for CDU FAIL, IMU FAIL, ACCELEROMETER FAIL and their lower level tributaries are provided.

The Monitor Panel also contains the control display and alarm system, including audible alarms and alarm indicators for coolant temperature, coolant flow, ducosyn excitation, G & N power, etc.

2.1.2.2 Temperature Monitor & Control. This panel provides an auxiliary heat capability for airborne inertial components, continuous alarm monitoring of inertial component temperature (i.e., IRIG, PIPA), continuous meter monitoring during periods

of airborne control and a test moding, and stimuli for airborne heater controller checkout is also provided.

Apollo Computer Simulator. (Raytheon Furnished)
The Computer Simulator produces drive-rate outputs identical with those of the AGC by generating a two-phase clock frequency, dividing it, and modifying the results to produce the desired outputs. Load simulation for the normal inputs to the AGC are provided by the Computer Simulator. The panel contains its own power supplies.

2.1.2.3 Power Supply and Load Panel. The Power Supply and Load Panel contain two power supplies and several dummy loads. One 115-volt, 400-cps power supply provides power for the lamps on the Airborne Display and Control Panels. The second power supply provides a 2-volt, 3200-cps output for the magnetic suspension of the PIP and IRIG ducosyns. The dummy loads simulate airborne loads which are not present in the test area. The loads vary from simple resistors to precision resistor-reactor networks.

2.1.2.4 Monitor Oscilloscope. There are two Monitor Oscilloscopes mounted in the Optics Inertial Analyzer. They are used to monitor the IRIG and PIP output signals during system checkout and troubleshooting. These oscilloscopes are modified commercial equipment.

2.1.2.5 Gimbal Position Control. This panel contains control circuits capable of precisely positioning each of the three IMU gimbals, to facilitate IMU alignment verification, resolver zeroing, and inertial component coefficient and scale factor tests. Readouts are provided to indicate the individual gimbal angles. Gyro protection circuits, which monitor the gimbal motor voltages and disable the control loops to prevent gimbal runaway, are also incorporated into this panel.

2.1.2.6 Test Control. The Test Control Panel contains controls for operational moding and power turn-on sequencing of the G & N system. It also provides control for test moding of Optics and inertial dummy loads, and of wheel power, and it enables by-pass of the D & C IMU control panel.

Some of the operational moding controls are: Zero Encoder, Coarse Align, Fine Align, Manual CDU, Entry and Attitude Control. Special test moding controls associated with inertial subsystem testing are provided to allow disabling of the gimbal stabilization loops, gyro caging loops, and accelerometer control loops.

2.1.2.7 Test Selector. Test Selector panel enables selection of test sequences that may be performed in conjunction with appropriate moding selection in the test control panel. The major test selector sequences are:

IRIG Test
CDU Test
Gimbal Servo Test
Optics Test
Failure Indicator Test
Alarm Test

In addition to the G & N system test modes above, a special selector test mode is implemented which provides self test of the analyzer's safety alarms and failure indicators.

2.1.2.8 Phase Shift Panel. The Phase Shift Panel is used to shift the phase of the G & N 3200-cps voltages that are used as a reference for Monitor Oscilloscopes. This compensates for phase shift in PIP and IRIG signals that are being monitored so that Lissajous patterns may be continuously observed.

2.1.2.9 Digital Recorder. The Digital Recorder consists of a commercial digital printer and banks of reed relays for input

data switching. The printer is capable of recording binary-coded decimal inputs. The normal input sources of data for the Digital Recorder to print will be from the Digital Voltmeter, the Counter, the CTS and the positional information from the Switch Box Compartment.

2.1.2.10 Electronics Power Supply. The Electronics Power Supply panel contains two identical power supplies connected to produce +30v dc and -30v dc. These supplies produce the B+ and B- power for the Optics Inertial Analyzer electronics.

2.1.2.11 Dual-Beam Oscilloscope. The Dual-Beam Oscilloscope is used in system and subsystem calibration and checkout to observe nulls, to check noise on power supplies, and to observe waveforms. It is also used to determine phase relationships between floating isolated pulses as well as between the output of power supplies and their driving pulses. Monitoring airborne signals selected by the Coax Distribution Panel is another function of this panel.

2.1.2.12 Primary Signal Select. The Primary Signal Select panel is used to route various airborne signals to their appropriate monitoring instruments. This panel contains the control for the Switch Box Compartment.

2.1.2.13 Coax Distribution Panel. Critical airborne signals that might be affected by routing them through switches are fed to the Coax Distribution Panel. These signals will be routed to the Dual-Beam Oscilloscope for monitoring via short coaxial jumpers on the front of the panel.

2.1.2.14 Switch, Crossbar. This compartment contains a crossbar switch which will select any one of a hundred groups of two signals each to be sent to the Primary Signal Select Panel.

2.1.2.15 Digital Voltmeter. The Digital Voltmeter is the primary voltage-measuring device in the OIA. Its input comes

from the crossbar switch through the Primary Signal Select Panel. It is used to measure the magnitudes of a-c and d-c supplies and signals of the airborne systems.

2.1.2.16 Phase Angle Voltmeter. This panel will be used to measure both phase angles and in-phase voltages between the signals and their respective references during all phases of testing. It will also be used to measure servo error signals and power supply voltages.

2.1.2.17 Counter. The counter has many uses during all phases of testing. It is used to count time per unit event, event per unit time, event per unit event, or forward-backward pulses. There is a plus or minus sign presentation to indicate forward-backward counting. Four inputs are provided to the counter, three from the Primary Signal Select Panel and one from a remote clock. Outputs from the counter are to the Digital Recorder and to the remote Readout Counter (in Oscillograph Console).

2.1.2.18 Oscillograph Signal Selector. At this panel, up to eight signals at a time will be selected for monitoring at the Oscillograph Console. Eight rotary switches, 16 positions per switch, are used to accomplish this selection. Up to six (6) ac or six (6) dc signals may be monitored simultaneously. Section 2.2.2 describes this in more detail.

Two selector switches are provided for selection of critical signals to be routed to scope "B."

Two Phase Generators are provided to shift the monitor scope references for proper signal presentation.

2.1.2.19 Signal Generator. The Signal Generator is used to supply sinusoidal inputs of various frequencies to the Inertial Subsystem stabilization loops to determine the closed-loop frequency response.

2.1.2.20 Relay and Lamp Power Supply. This panel supplies 28v dc to operate various GSE relays and lamps. A circuit breaker and "Power On" light are provided on the front of the panel.

2.1.2.21 Blowers. Two blowers for cooling, one each in the first and third equipment bay, are provided.

Optics Inertial Analyzer Capital Equipment Specification

GENERATOR, SIGNAL P/N 1900043

Modified Hewlett Packard Model 202AR to Drawing 1900022

1.	Accuracy	3% from 0.008 to 0.012 cps
		2% from 0.012 to 0.120 cps
		2% from 0.120 to 1200 cps
2.	Stability	1% Minimum
3.	Output voltage	0 to 30 volts P-P into 4K ohms
4.	Internal Impednace	40 ohms
5.	Distortion	1% MAXIMUM

VOLTMETER, PHASE ANGLE P/N 1900036

Modified Gertsch Model PAV-2B to Drawing 1900050

1.	Accuracy	±2%
2.	Reference	
	a. Input voltage	1 to 125 volts
	b. Impedance	100 K ohms
	c. Frequency Range	800 and 3200 cps
3.	Signal	
	a. Voltage Range	1 mv to 300v
	b. Impedance	10 Meg ohms
	c. Frequency Range	10 cps to 50 Kc

OSCILLOSCOPE, DUAL BEAM P/N 1900037

Modified Tektronix Model RM 565 to drawing 1900026 with modified Model 2A63. Differential Amplifier to drawing 1900028 and modified Model 3 A1 Dual Trace.Amplifier to drawing 1900027

1. Amplifier 2A63

a. Frequency Range	Dc to 3000Kc
b. Rise Time	1 μsec
c. Input Impedance	1 Meg shunted by 47 pf
d. Sensitivity	1 mv/cm to 20 v/cm

2. Amplifier 3A1

a. Frequency Range	Dc to 10 Mc
b. Rise Time	35 nano seconds (approx.)
c. Input Impedance	1 Meg shunted by 47 pf

3. Horizontal Sweep — 1 μ sec to 5 sec/division

4. Delay Interval — 1 μsec to 50 sec calibrated and continuously adjustable

OSCILLOSCOPE, MONITOR P/N 1900038

Modified Tektronix Model RM 561 to drawing 1900024 with modified Model 2A63 Differential Amplifier to drawing 1900028 and Modified Model 3A74 Four Trace Amplifier to drawing 1900025.

1. Amplifier 3A74

a. Frequency Range	Dc to 2 Mc
b. Input Impedance	1 Meg shunted by 47 pf
c. Sensitivity	20 mv/cm to 10v/cm

VOLTMETER, DIGITAL P/N 1900042

Modified Electro-Instruments Model 850 to drawing 1900018.

1. Dc Accuracy	±0.01% of reading and 1 digit
2. Dc Range	±0.0001 to ±999.9 volts
3. Input Impedance, dc	1000 Meg to ± 10 volts 10 Meg to ±1000 volts
4. Ac Accuracy	±0.1% of reading and 1 digit
5. Ac Range	0.0001 to 999.9 volts
6. Input Impedance, ac	1 Meg shunted by 45 pf

COUNTER P/N 1900041

Modified Beckman Model 3350/6-3 to drawing 1900032

1.	Internal Clock Accuracy	3 parts in 10^7/day
2.	"A Input"	
	a. Sensitivity	100 mv rms
	b. Input Impedance	1 Meg shunted by 75 pf
	c. Counting Rate	DC coupled 0-2 Mc, ac coupled 10 cps to 2 Mc maximum
3.	"B" Input, same as "A Input" except	
	a. Couting Rate	DC coupled 0-100Kc, ac coupled 10 cps to 100Kc maximum
4.	"C" Input	
	a. Minimum Amplitude	3 Volts rms
	b. Impedance	2.2K ohm
	c. Counting Rate	10 cps to 100 Kc
5.	"D" Input	
	a. Input Characteristics	Same as "B Input"

PRINTER

Modified Berkeley Model 1453 to drawing 1900063

1.	Printing Rate	3 Lines/sec
2.	Accuracy	Same as data source
3.	Input Code	10 line decimal and BCD 8421
4.	Print Command	Manual and Automatic

OPTIC INERTIAL ANALYZER EQUIPMENT LIST

A. OPTICS INERTIAL ANALYZER, P/N 1900004-011
Cabinet Electrical Assembly, P/N 1900031

a. Monitor Panel, P/N 1900055-011
Spec: ATP-1900055

b. Temperature Monitor and Control, P/N 1900058-011
Spec: ATP-1900058
Schem: 1000255

c. Computer Simulator, P/N 1014061
Spec: FTM 1014061
Schem: Refer 1014203

d. Power Supply and Load Panel, P/N 190060-011
Spec: ATP-190060

e. Oscilloscope, Monitor Assembly, P/N 1900038 consisting of:
Oscilloscope, Monitor P/N 1900024
Four Trace Amplifier, P/N 1900025
Differential Amplifier, P/N 1900028
Spec: ATP-1900024
(2 each)

f. Gimbal Position Control, P/N 1900054-011
Spec: ATP-1900054
Schem: 1900455

g. Test Control, P/N 1900059-011
Spec: ATP-1900059
Schem: 1900649

h. Test Selector, P/N 1900082-011
Spec: ATP-1900082
Schem: 1900692

i. Phase Shift Panel, P/N 1900163-011

A. OPTICS INERTIAL ANALYZER (cont'd)

Spec: ATP-1900163
Schem: 1900431

j. Digital Recorder, P/N 1900052-011
Printer, P/N 1900063
Spec: ATP-1900063
Schem:

k. Power Supply, Electronics, P/N 1900035
Power Supply, Electronics, P/N 1900029
Spec: ATP-1900029

l. Oscilloscope, Dual Beam Assembly, P/N 1900037 consisting of:
Oscilloscope, Dual Beam, P/N 1900026
Dual Trace Amplifier, P/N 1900027
Differential Amplifier, P/N 1900028
Spec: ATP-1900026

m. Primary Signal Selector, P/N 1900057-011
Spec: ATP-1900057
Schem:

n. Coax Distribution Panel, P/N 1900166-011
Spec: ATP-1900166
Schem: 1900266

o. Switch Box Compartment, P/N 1900309-011 consisting of:
Switch, Crossbar Assembly, P/N 1900048
Switch, Crossbar, P/N 1900061
Spec: ATP-1900061
Schem: 1900078

p. Voltmeter, Digital Assembly, P/N 1900042
Voltmeter, Digital, P/N 1900018
Spec: ATP-1900018

q. Voltmeter, Phase Angle Assembly, P/N 1900036

A. OPTICS INERTIAL ANALYZER (cont'd)

Voltmeter, Phase Angle, P/N 1900050
Spec: ATP-1900050

r. Counter Assembly, P/N 1900041
Counter, P/N 1900032
Spec: ATP-1900032

s. Oscillograph Signal Selector, P/N 1900056-011
Spec: ATP-1900056
Schem: 1900648

t. Generator, Signal Assembly, P/N 1900043
Generator, Signal, P/N 1900022
Spec: ATP-1900022

u. Power Supply, Relay and Lamp Assembly, P/N 1900049
Power Supply, Relay and Lamp, P/N 1900023
Spec: ATP-1900023

v. Blower, P/N 1900350-011
Spec:
Schem:
(2 each)

w. Ac Power Protection Panel, P/N 1900075
Spec: ATP-1900075
Schem: 1900397

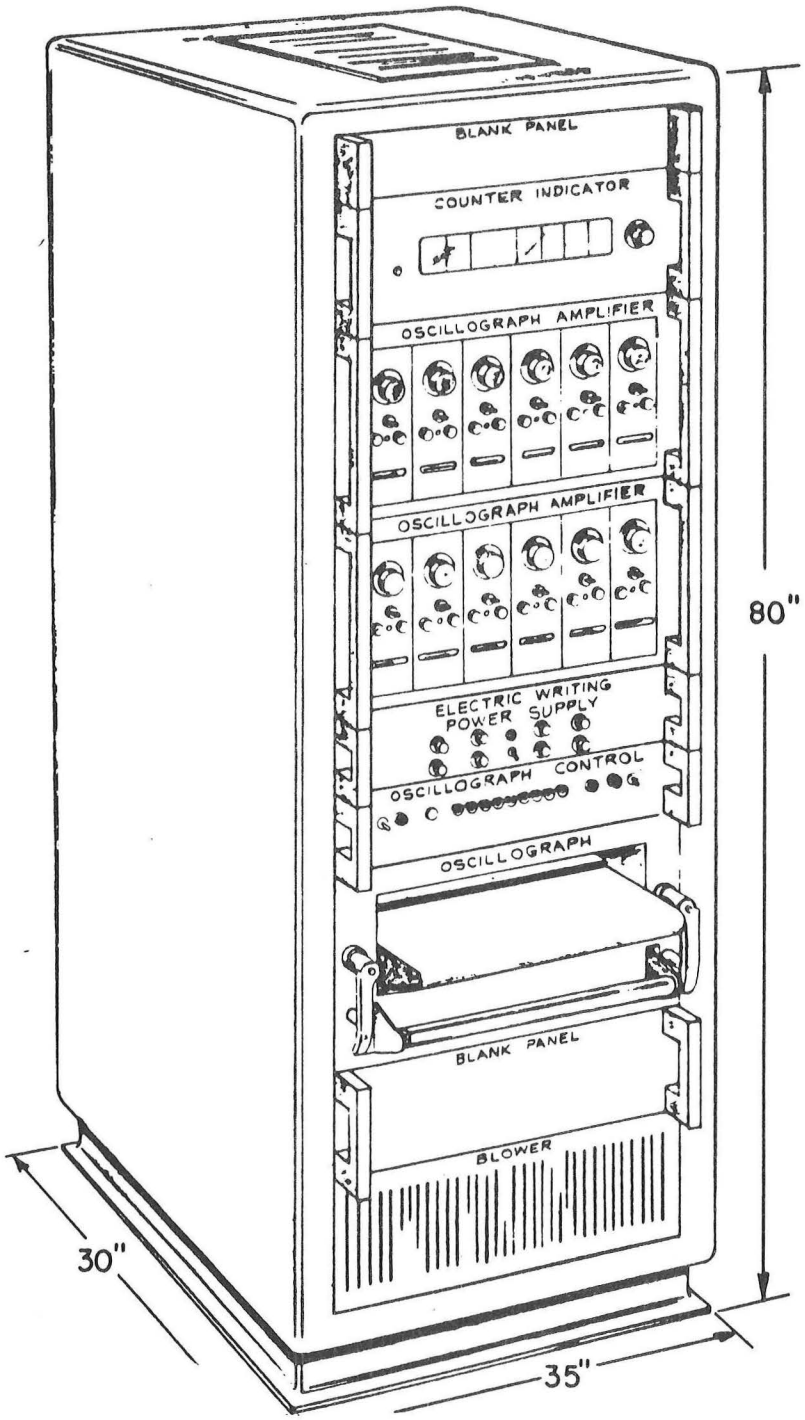
x. Table, Writing, P/N 1900345-011*

y. Table, Writing, P/N 1900345-021*

*one of these tables will have provision for chart storage of signal selection.

z. Storage Drawer P/N
(2 each)

Oscillograph Console



Brief Description of Oscillograph Console

The Oscillograph Console is a one-bay test equipment console. It is used to give a permanent record of signals selected by the Oscillograph Signal Selector panel in the Optics Inertial Analyzer. It has the capability of providing a graphic rectilinear presentation in ink or by electric writing. Selection of the type of recording technique is accomplished by replacement of pens and paper.

The oscillograph has eight recording channels. Twelve preamplifiers (6 ac & 6 dc), however, are furnished in the console, and by the use of a preamplifier selection scheme, the number of ac and dc signals that can be monitored may be selected. A maximum of 6 dc and 2 ac or 6 ac and 2 dc channels can be recorded simultaneously. The selection scheme is implemented by using the four middle channels via a relay control that is operated from the Oscillograph Signal Selector panel in the Optics Inertial Analyzer. No warm-up time is required when switching from one preamplifier to the other because B+ and filament voltages are not switched.

2.2.2.1 Indicator, Counter, Remote. Indicator, Counter, Remote will give the operator a readout of the Counter panel in the Optics Inertial Analyzer. This panel will make use of an in-line Nixie type readout as compared with the column-type readout of the Counter panel. The readout will consist of six digits and a plus or minus sign, indicating forward or backward counting.

2.2.2.2 Oscillograph Amplifier Panels. There are two Oscillograph Amplifier panels in the Oscillograph Console. One panel contains four dc and two ac preamplifiers; the other panel contains four ac and two dc preamplifiers. Each panel will contain four driver amplifiers, one for each pen channel, and relays to perform

the various preamplifier selection functions. The desired preamplifier combinations will be selected from the Oscillograph Signal Selector Panel in the Optics Inertial Analyzer.

2.2.2.3 Oscillograph Electric Pen Control. The purpose of this panel is to provide power to the electric pens used for writing on eight-channel electric recording paper.

2.2.2.4 Oscillograph Control. This panel is used to control the Oscillograph. It contains the Oscillograph master power switch which provides 115-volt, 60-cps power to the Oscillograph Amplifier drawers, electric pen control, and to the Oscillograph. It also has a control to vary the chart speed, an event marker button, and a light indicator to indicate when the chart paper is low. The Master Control knob provides an intensity adjustment for the electric pens.

2.2.2.5 Oscillograph. The Oscillograph contains the paper to be used for recording and the paper drive motor. It also contains the pens used for writing and eight pen motor assemblies to which the writing pens are attached. One pen motor assembly has two pens. The ninth pen provides one-sec timing marks.

OSCILLOGRAPH CONSOLE CAPITAL EQUIPMENT LIST

The Oscillograph Console contains an eight-channel oscillograph recorder similar to a Massa Model BSA-860A, a remote counter readout similar to a Beckman Model 5926, and a blower for cooling.

2.2.3.1 Amplifier Racks, P/Ns 1900044 & 1900045

2.2.3.1.1 Dc Channels, similar to MASSA DR 201

a. Input Range: 5 mv to 200 volts

b. Impedance: 10 Megohms

c. Input: Floating and shielded

d. Sensitivity: 1 mv/mm to 20 v/mm

e. Stability, Zero: 0.5% full scale for 10% line change
Gain: 0.5% full scale for 10% line change

f. Bandwidth: 0 to 120 cps, 3 db down

g. Step Response: 70% in 5 milliseconds

2.2.3.1.2 Ac Channels, similar to MASSA DR 500

a. Input range: 40 mv to 40 v

b. Impedance: 100K ohms

c. Input: Floating and shielded

d. Sensitivity: 1 mv/mm to 1 v/mm @ 100K INPUT Z
: 10 mv/mm to 10 v/mm @ 1 M

e. Stability, Zero: Less than 0.2 mm/hr drift
Gain: Less than 10% full scale

f. Reference Voltage: 10 to 130 volts

g. Reference Frequency: 60 cps to 5 KC

h. Reference Input: Floating and shielded

i. Reference Input Impedance: 100K ohms

2.2.3.2 Oscillograph, P/N 1900047

a. Writing method: Electric rectilinear or ink
b. Chart Speed: 0.5 to 200 mm/sec
c. Response: See dc Channels (2.2.3.1.1, f and g)

2.2.3.3 Counter Readout, P/N 1900039

The remote counter readout affords an in-line counter readout with numerals two inches high for improved readability.

OSCILLOGRAPH CONSOLE EQUIPMENT LIST

A. OSCILLOGRAPH CONSOLE, P/N 1900000-011

a. Indicator, Counter Remote Assembly, P/N 1900039
Indicator, Counter Remote, P/N 1900020
Spec: ATP-1900020

b. Amplifier Oscillograph Assembly, P/N 1900045 consisting of:
Amplifier, Oscillograph, P/N 1900071
Rack, Oscillograph, P/N 1900161
Amplifier, Driver, P/N 1900069 (4 each)
Preamplifier, dc, P/N 1900074 (4 each)
Demodulator, Phase Sensitive, P/N 1900068 (2 each)
Preamplifier Selector, P/N 1900162

c. Amplifier, Oscillograph Assembly P/N 1900044 consisting of:
Amplifier, Oscillograph, P/N 1900070
Rack, Oscillograph, P/N 1900067
Amplifier, Driver, P/N 1900069 (4 each)
Preamplifier, dc, P/N 1900074 (2 each)
Demodulator, Phase Sensitive, P/N 1900068 (4 each)
Preamplifier Selector, P/N 1900162

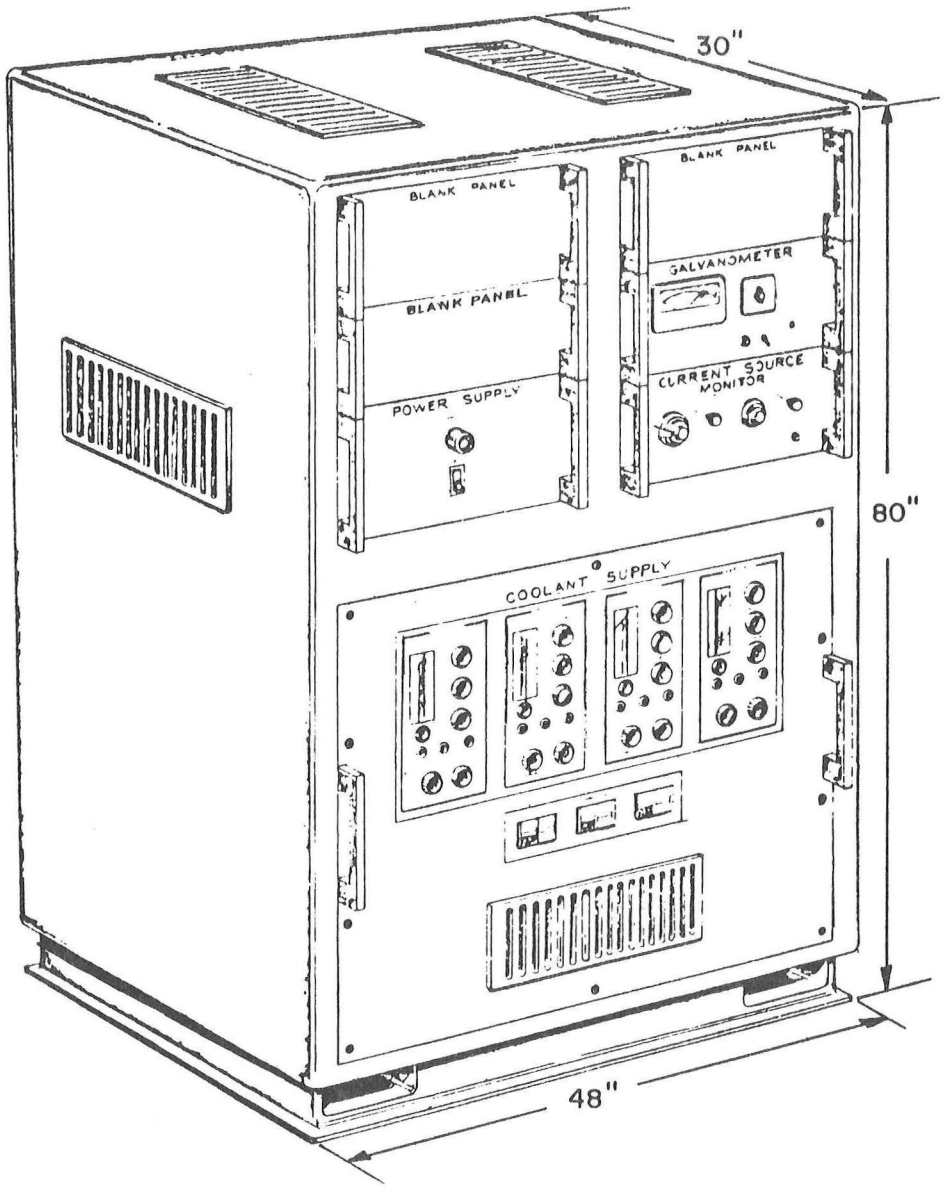
d. Control, Electric Pen, Oscillograph Assembly, P/N 1900164
Control, Electric Pen, Oscillograph, P/N 1900165

e. Control, Oscillograph Assembly, P/N 1900046
Control, Oscillograph, P/N 1900072

f. Oscillograph Assembly, P/N 1900047
Oscillograph, P/N 1900073
Spec: ND-1002205 (Test Specification for Oscillograph Group)

g. Blower, P/N 1900350-021

AGE Coolant and Power Console



Description
of
G & N Coolant and Power Console

The G & N Coolant and Power Console performs three major functions during Optics Subsystem, Inertial Subsystem, and G & N System checkout.

(1) It supplies prime power for the airborne equipment.

(2) It provides the equipment necessary for airborne equipment testing.

(3) It contains the equipment necessary to monitor the PIPA control loop precision voltages.

The following panels will perform these functions in this console.

2.3.2.1 Current Source Monitor. The Current Source Monitor is used to monitor the precision reference current in the PIPA and IRIG torquer windings. A standard cell is used to standardize the output of the Precision Voltage Reference (PVR). Both of these units are located in this drawer. The ground support PVR output is then compared with the airborne PVR output. The output of the Current Source Monitor is checked by a micro-voltmeter on the Galvanometer-Voltmeter panel.

2.3.2.2 Galvanometer-Voltmeter. The Galvanometer-Voltmeter is a sensitive dc voltmeter that will operate primarily in the microvolt range. Its prime function will be to act as a null-meter for the Current Source Monitor.

2.3.2.3 Guidance System Power Supply. This power supply is used to provide the prime 28 v dc power for the airborne electronic packages when the Optics Subsystem, Inertial Subsystem, and the G & N System are being tested. It is capable of a 50-amp output,

adjustable for use in power margin testing, and includes remote sensing provisions.

2.3.2.4 Coolant Supply (PS-1900098). The coolant supply circulates a temperature-controlled solution of ethylene glycol and water for cooling the Apollo Guidance and Navigation System during testing.

Operating power for the pumps, motors, and other coolant supply equipment is 115 ± 10v ac, line to neutral, 60 ± 5 cps, 3-phase 4-wire, Y-connected.

The pumping system supplies coolant at 40 psig (60 psig max) throughout the flow range at flow rates within ±5% at any point within the range of each circuit. Temperature is controlled within 2° F of the desired temperature range of each circuit.

There are four circuits in the distribution system, each of which is capable of providing sufficient control within the following ranges, when measured at the outlet of the coolant supply:

	Circuit 1	Circuit 2	Circuit 3	Circuit 4
Temperature ($^{\circ}$F)	20 to 65	40 to 100	40 to 100	40 to 100
Flow Rate (lb/hr)	25 to 100	8 to 50	25 to 180	25 to 180

Satisfactory operation of the coolant supply will be assured at temperatures of 50° F to 85° F ambient at air pressures of 24 to 32 inches of Hg.

The following indicators and alarms are provided:

a. Input power applied.

b. Refrigeration unit power ON.

c. Pump power ON.

d. Four inlet temperature gauges, 20° to 120° F range.

e. Four outlet temperature gauges, 20° to 120° F range.

f. Outlet pressure gauge on pump, 0-100 psi range.

g. Four flowmeters.

h. Tank level indicator.

i. Four adjustable low flow rate alarms, audible and flashing light.

j. Four adjustable high-pressure alarms, audible and flashing light.

k. Four adjustable high-temperature alarms, audible and flashing light.

The coolant is: a water-glycol solution with inhibitors corresponding to the Spacecraft coolant (approximately 62.5% by weight of glycol and 37.422% by weight of distilled water).

The coolant will be filtered by a 10-micron (nominal) filter and contained in a 2-gal. storage tank, designed for a 40-psig operating pressure (90 psig min. burst pressure).

A relief valve is adjusted to prevent pressures in excess of 60 psig.

Capital Equipment Specification

GALVANOMETER P/N 1900034

Modified Hewlett-Packard Model 425 AR to Drawing 1900062

a. Accuracy ±3% of full scale

b. Input Impedance 1 Megohm

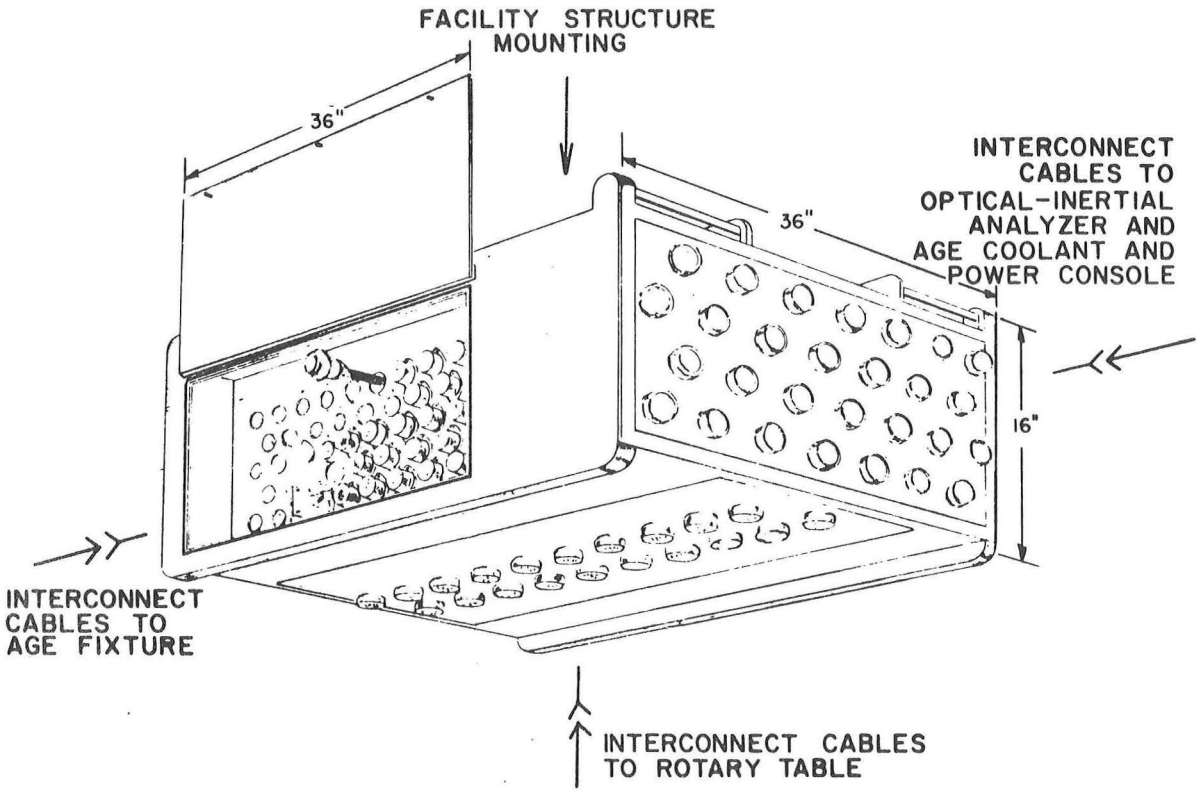
c. Voltmeter Range 10 mv to 1 volt full scale (plus & minus)

POWER SUPPLY, GUIDANCE SYSTEM P/N 1900021

Modified Trygon Model C36-50 to drawing 1900021

a.	Voltage Range	0-36 v dc
b.	Current Range	0-50 amp
c.	Ripple	Less than 10 mv rms
d.	Regulation	
	1. Line	0. 1% for line change from 105 to 125 volts
	2. Load	0. 1% from no-load to full-load
e.	Output Impedance	0. 002 ohm max dc to 1 kc 0. 5 ohm max 1 kc to 100 kc
f.	Stability	Output varies less than 28 mv for 8 hours after warm-up
g.	Recovery Time	100 μsec max for change from no-load to full-load

GSE Junction Box



Description of
GSE J-Box (overhead)

The GSE overhead J-Box provides for test cabling interconnection between the GSE and G&N equipment in the system and optics or inertial subsystem test configurations. It includes relays that are remotely controlled by the GSE Optics Inertial Analyzer for special test sequencing and interconnections. The J-Box is suspended from the test facility ceiling mounting structure to allow cable play during orientation of the G&N equipment on the Rotary Table or in the G&N System Mounting Fixture.

Illustration of Rotary Table

See Section 1. 3

Description of Rotary Table

The purpose of the Rotary Table is to provide a means for the mounting and precision orientation of various guidance and navigation component assemblies, subsystems, and combinations of subsystems. The Rotary Table, when used with the appropriate GSE Test Consoles, will provide inertial and optical subsystem test capability.

The Rotary Table is a precision device that has the capability of having its upper surface moved about its vertical and horizontal axes. It is capable of rotating 360^{o} and tilting 90^{o} with 2^{o} of overtravel at each end about its tilt axis. There are limit switch interlocks to prevent actuation of the tilt drive beyond permissible limits.

Manual operation and motor drive capabilities are available at both axes with a fine vernier manual control on the rotary axis. Hand brakes are provided on both axes with a mandatory lockout of the master drive if the associated hand brake is not fully released. The nominal rate of rotation about the tilt and rotational axes is approximately 1 rpm, the drive motor having a slow start capability.

2.5.2.1 The table top has a diameter of 32 inches with 8 T-Slots for accepting ASA standard 5/8-inch T-Bolts for mounting test fixtures.

2.5.2.2 A rigid, stable, cast iron base supports the table top and houses the readout and drive accessories. A three-point support system enables levelling of the table to within 1 arc-sec along either horizontal table axis.

2.5.2.3 Over-all table repeatability with a 200-pound load and maximum moments of 1500 in-lbs and 720 in-lbs about the tilt and rotary axes, respectively, is ±2 arc-sec. Indication of position on both axes is by means of optical (optigon) readouts. (Maximum allowable table load is 500 pounds.)

2.5.2.4 A pendant type control station is provided on the right-hand side of the Rotary Table to provide:

a. Key-operated power switch,

b. On-off and brilliancy controls for each optigon light,

c. Push-buttons for positive and negative tilt rates,

d. Spring-return rotary switch for positive and negative rotary rates,

e. Indicator light, POWER ON.

Illustration of Rotary
Table Calibration Kit

(Not Available)

Description of Rotary Table Calibration Kit

The purpose of the Rotary Table Calibration Kit is to provide a means of calibrating the arc-sec scales of the table axes and adjusting the table level to allow for periodic table calibration and inspection. Rotary axis calibration is accomplished at both the zero and 90^{o} tilt positions.

The calibration equipment consists essentially of the following:

2.6.2.1 Tilt and Rotary Axis Calibration.

a. Autocollimator, 30-minute field of view (Leitz Type AADHM/GAATN, or equivalent)

b. Autocollimator stands with tilt plates

c. Twelve-sided polygons, glass (Hilger-Watts Type HW P/N TP-122)

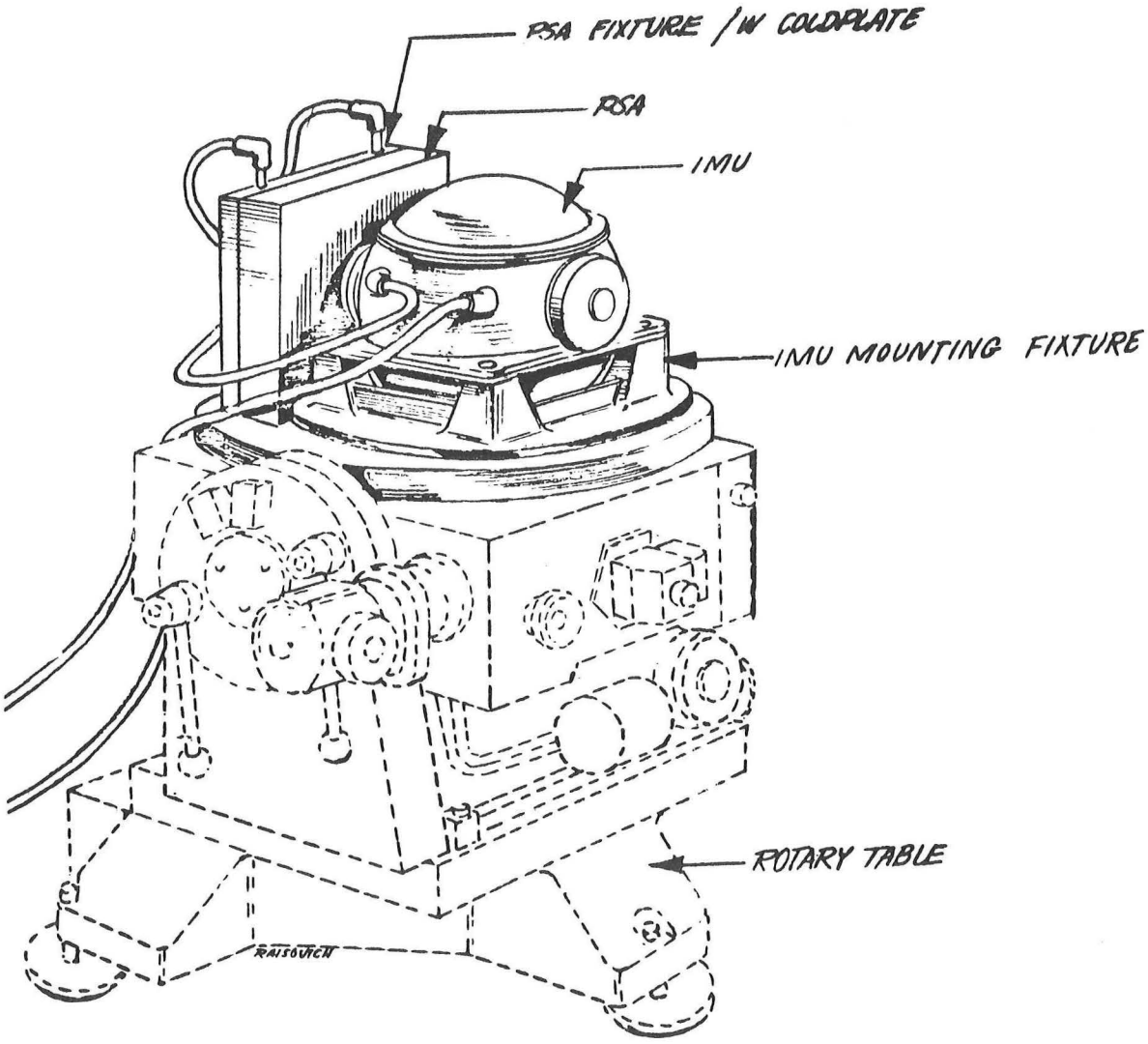
d. Tilt-axis and rotary-axis table mounting adapters to allow mounting of the polygon to the table rotary axis.

2.6.2.2 Level Adjustment

a. Pendulous Device (Taylor-Hobson "Tallyvel" or equivalent)

b. Single-Channel Portable Recorder (Varian G-11A, Type B-1, 4-speed, motor drive option, or equivalent.)

Inertial Subsystem Test Configuration



Description of IMU Mounting Fixture and Alignment Set

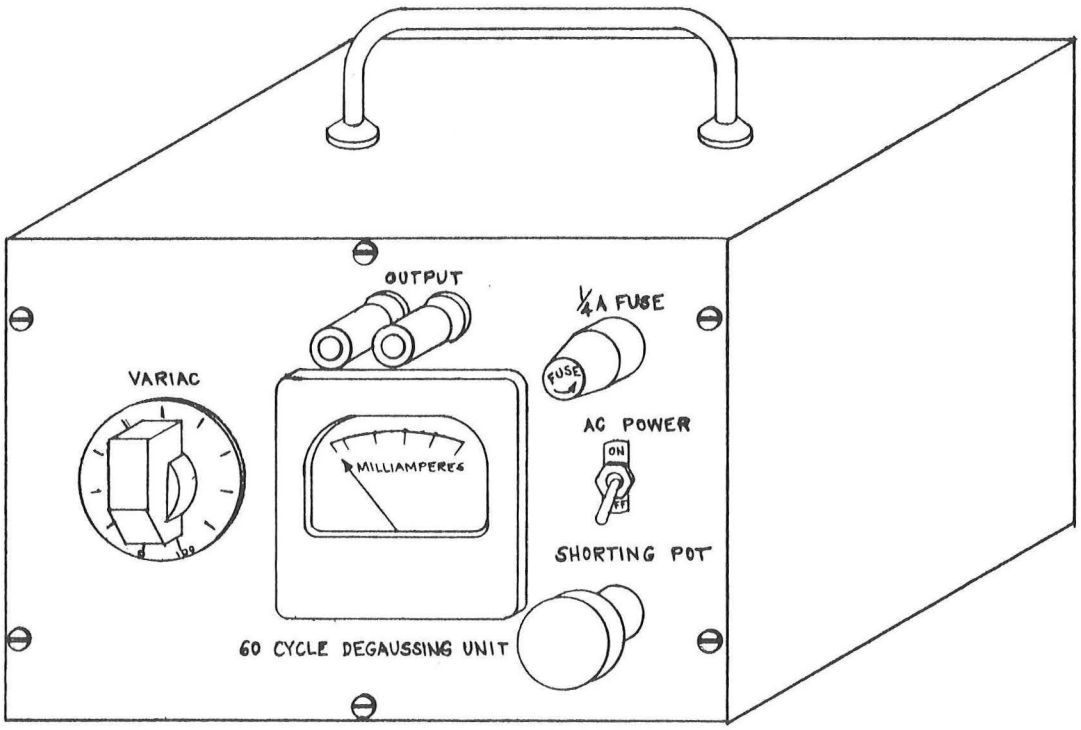
The purpose of the IMU Mounting Fixture is to accurately support and position the IMU on a rotary tilting table during alignment tests.

The fixture orients the IMU mounting pad surfaces parallel to the rotary table surface. Locating pins, mating with the locating holes in the IMU flange, are provided to assure proper fixture/IMU orientation with respect to the table's tilting axis.

With the table tilted at or near 90^{o}, the locating pins must be aligned parallel to the table tilt axis within 2 arc-sec by positioning the table about its rotary axis. To facilitate this requirement special alignment tools are furnished.

Detailed information on surface finish accuracy, etc. is contained in NASA Specification ND 1002072.

Degausser


OUTPUT
¼A FUSE
FUSE
VARIAC
AC POWER
ON
MILLIAMPERES
SHORTING POT
60 CYCLE DEGAUSSING UNIT

Description of Degausser

The degausser, a portable unit approximately 12 inches square, allows demagnetization of inertial component torquers without Inertial Measurement Unit disassembly. The unit operates from 115-volt 60-cps line voltage. The unit can be used in the laboratory or in the spacecraft and operates independent of the Optics Inertial Analyzer.

Illustration of Filling
and Purging Fixture

(not available)

Description
of
Filling and Purging Fixture

This equipment will be used at the factory and at the field sites in conjunction with the AGE Coolant and Power Console. Initially, it will be used to fill the heat exchanger of the IMU at the factory and later to refill the exchanger in the event of leakage that is field-site repairable. It includes provisions for purging and drying the heat exchangers and coldplates as well as evacuating and filling them with the water-glycol solution.

Illustration of Bellows, IMU Snap-On

(not available)

Description
of
Bellows, IMU Snap-On

The Snap-On Bellows mount to the IMU quick-disconnect couplings. They are designed to accommodate the expansion and contraction of the coolant fluid while the IMU is being transported.

Illustration of IMU
Pressure Seal Tester

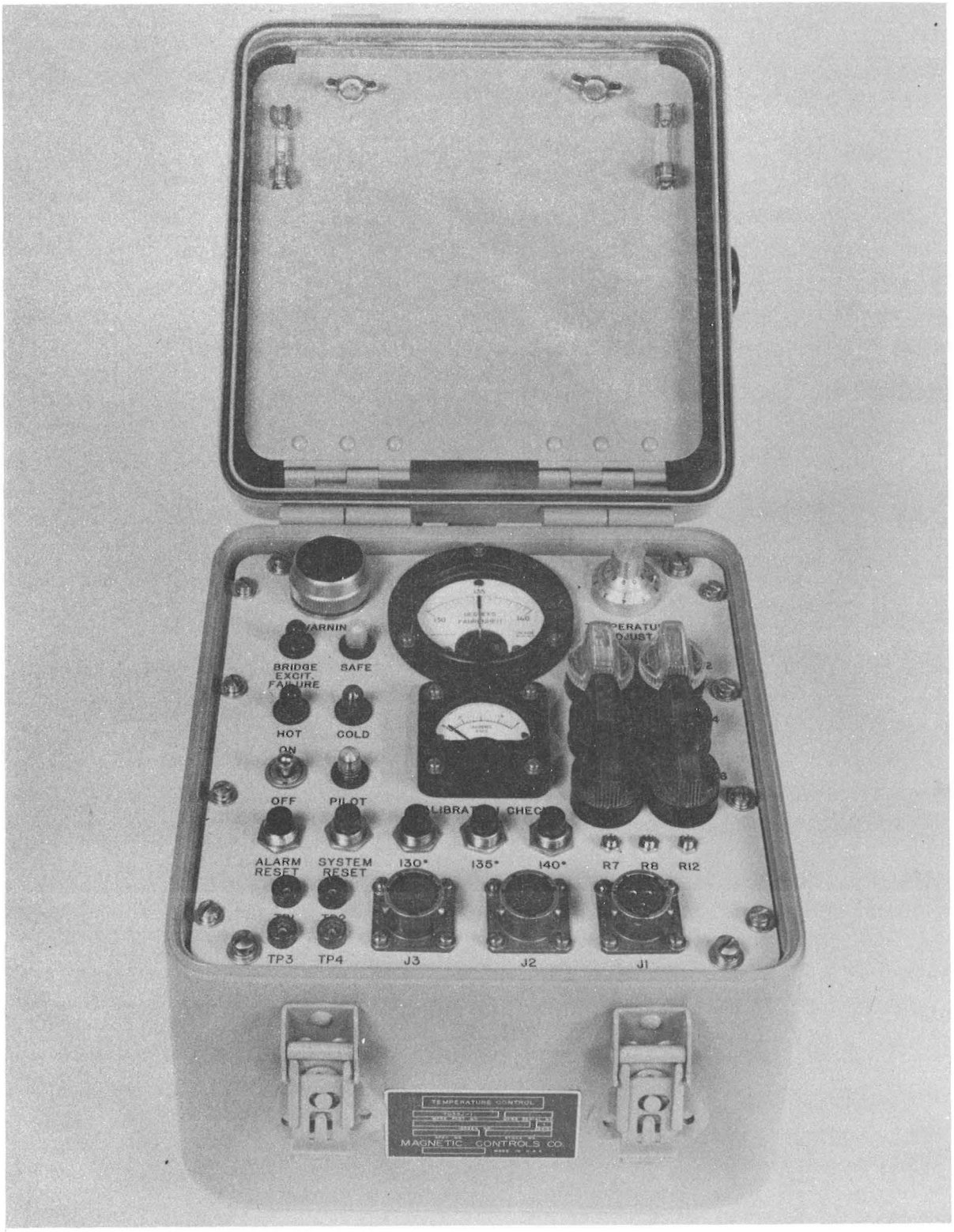
(not available)

Description
of
IMU Pressure Seal Tester

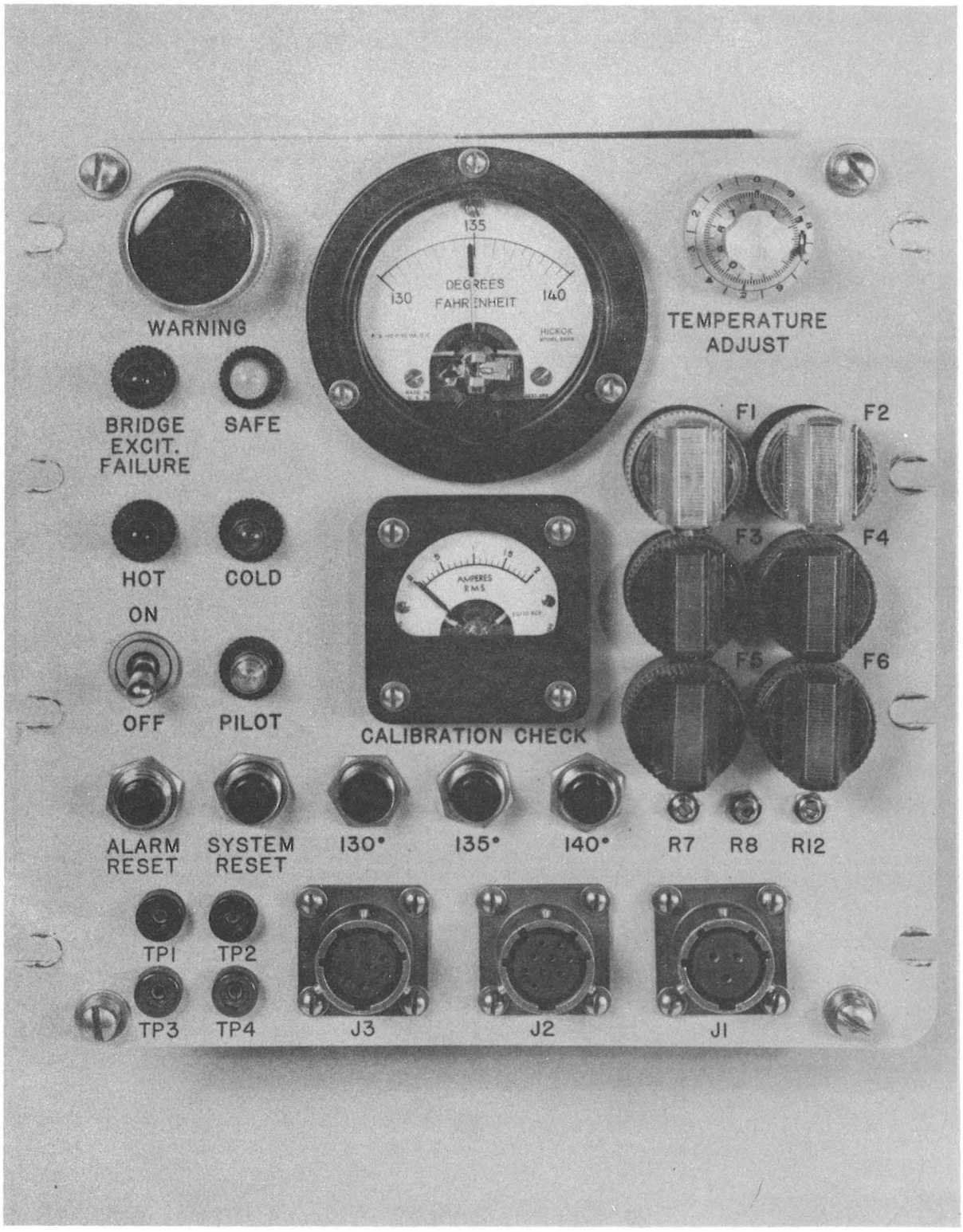
This equipment is applicable for use at both the factory and the field sites.

It will be used to determine if the gas pressure in the IMU is within specification, by checking the IMU pressure seals prior to installation and after final placement of the covers.

Portable Temperature Controller

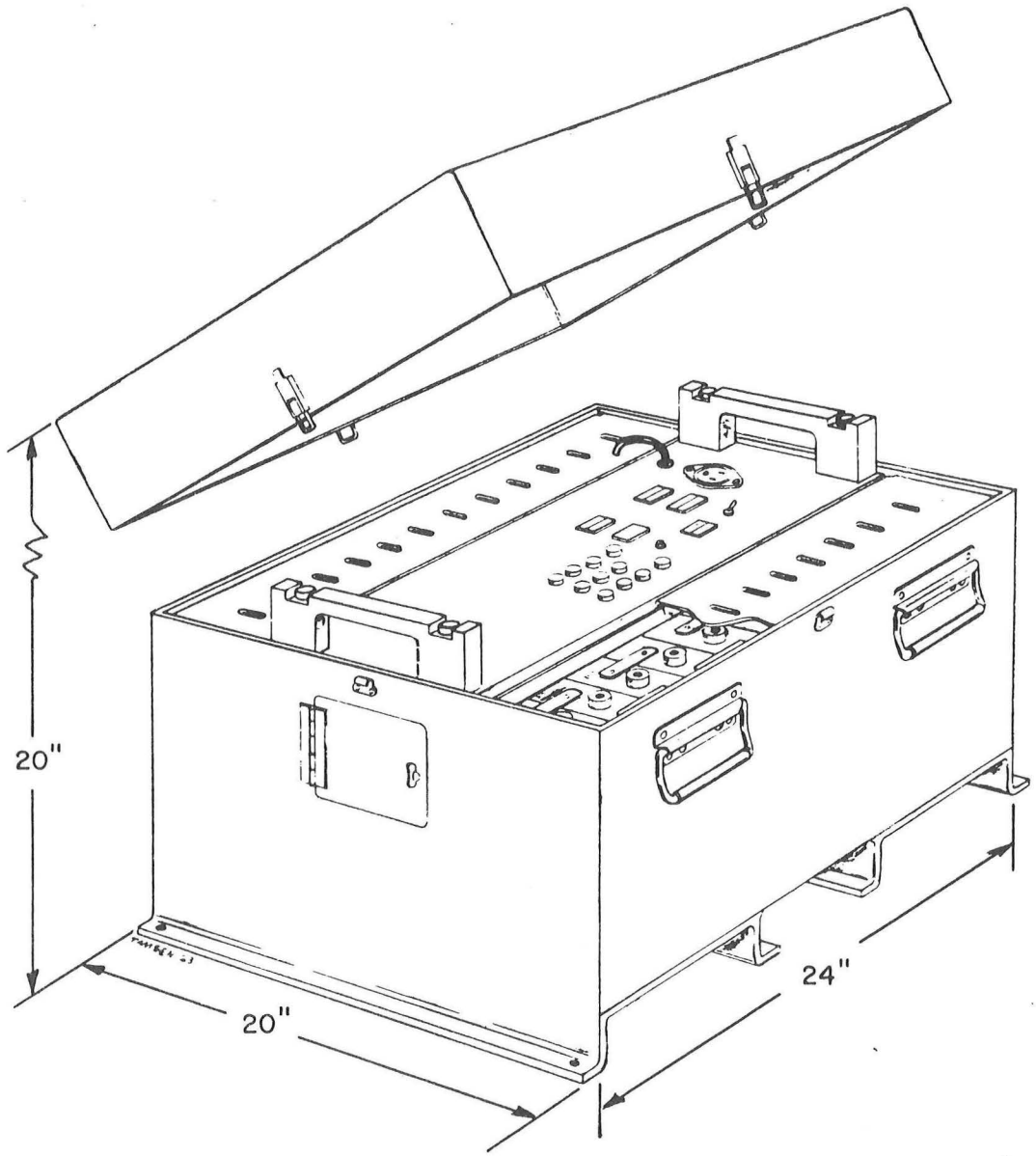


Portable Temperature Controller With Cover Open



Portable Temperature Controller, Front View

ICTC Battery Pack



Description of Inertial Components
Temperature Controller

The purpose of the Inertial Components Temperature Controller (ICTC) is to maintain the temperature of the IMU inertial components at $135^{o} \pm 5^{o}F$ during all phases of storage and transportation, except when the temperature controller located in the OIA or in the PSA has control.

The ICTC consists of two separate units, an IMU Portable Temperature Controller and a Battery Power Pack.

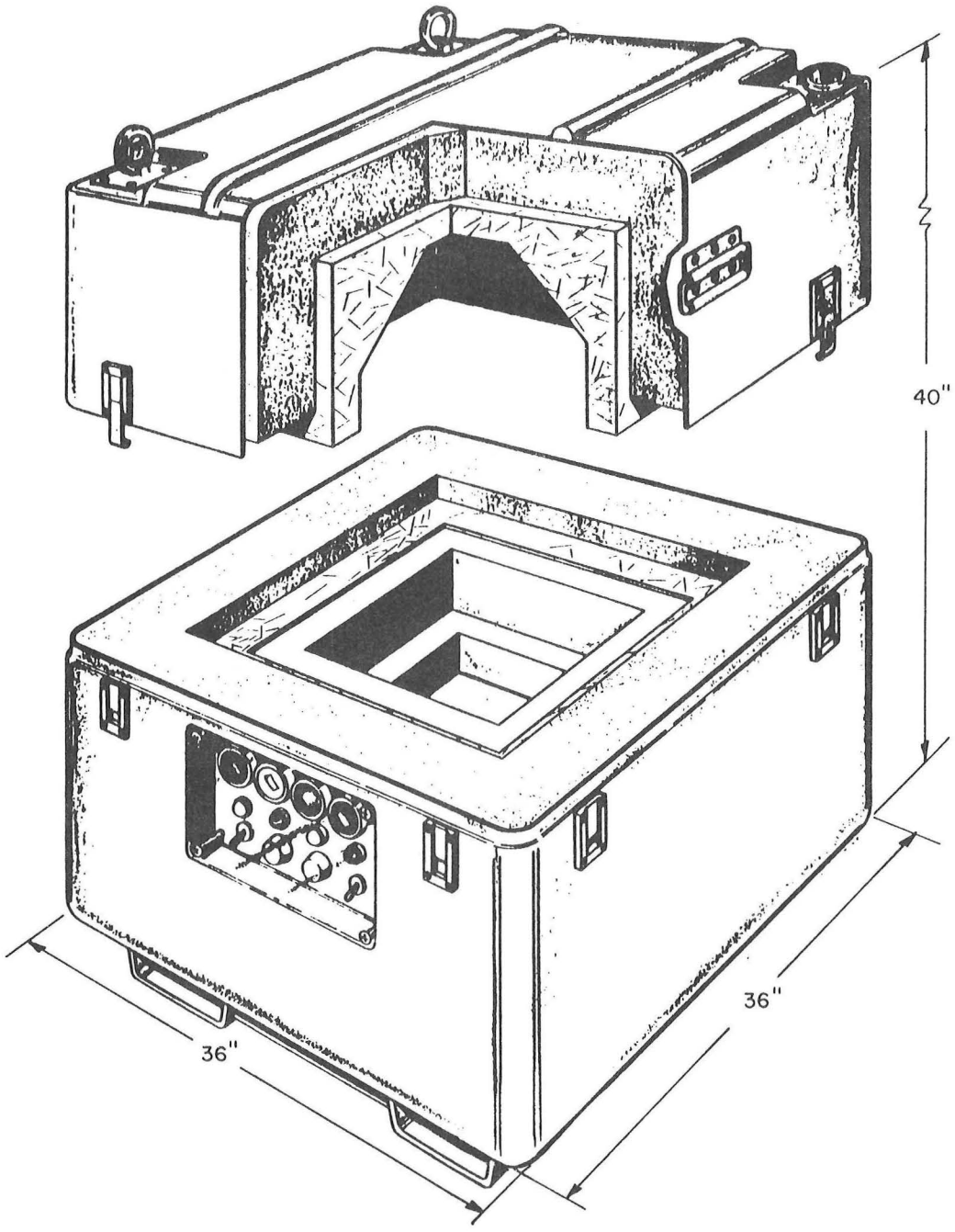
2.12.2.1. IMU Portable Temperature Controller (PTC)

The PTC contains thermal sensing and amplification circuitry and is capable of supplying 0-30 volts at 60 cps to the inertial components heaters. Maximum power output is 60 watts. It also includes internal and remote alarm switching that operates when the temperature tolerance exceeds $135^{o} \pm 5^{o}F$ or when power failure occurs. Normal power input is 115 volts ±10%, 60 cps. In the event of 60-cps wall power failure, the PTC is automatically transferred to operate from the Battery Power Pack.

2.12.2.2 Battery Power Pack

The Battery Power Pack houses a 28-volt nickel-cadmium battery, a battery charger, an inverter, and temperature control failure alarms. It will supply 100VA maximum for a period of at least 6 hours. An auxiliary battery can be connected to the Battery Power Pack to allow for 12-hour operation when necessary.

IMU Shipping Container



Description of IMU Shipping Container

The purpose of the IMU Shipping Container is to provide environmental control while the IMU is being transported and stored. It will also provide shock and vibration isolation. A temperature control system will maintain the internal temperature of the container between 120° and 140° F. With external power removed, the temperature control system will store sufficient energy to maintain the internal temperature between 120° and 140° F for approximately 100 hours. The temperature control system has two a-c heater elements. The two heater elements are connected so that either may be operated by a switch located on the control panel. The container provides visual indications under the following conditions:

a. An indicator will illuminate when input power is applied.

b. An indicator will illuminate when current is flowing through the primary a-c heater element.

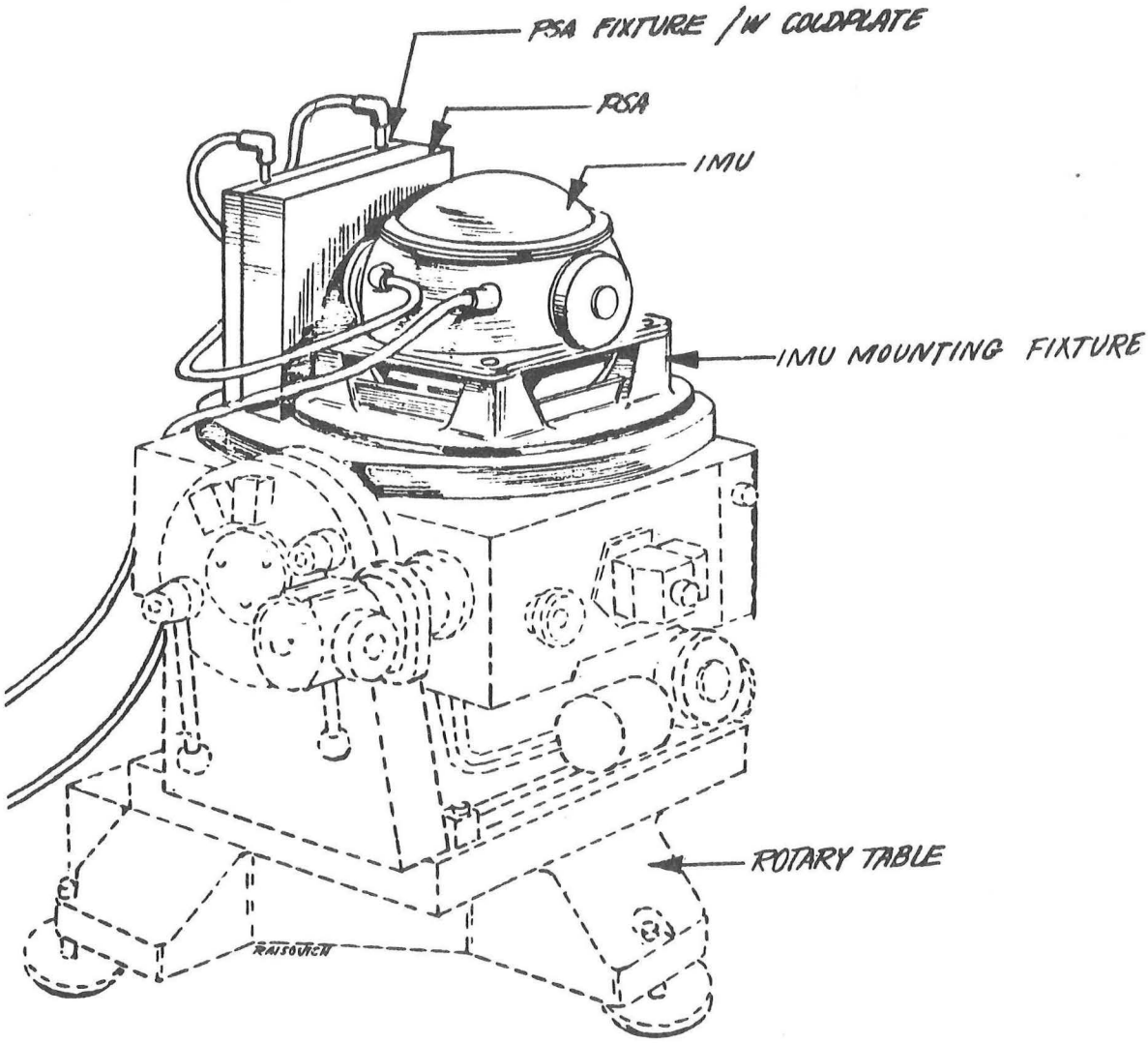
c. An indicator will illuminate when current is flowing through the secondary a-c heater element.

d. An indication of the internal temperature of the container is provided.

e. An indicator is provided that signals whether the internal temperature of the container has been lower than 120° F or higher than 140° F at any time while the container was in transit or storage.

f. A resettable thermal fuse and indicator are also provided. The fuse will open if the temperature in the container exceeds 145° F. An indicator will illuminate when the fuse is open.

Inertial Subsystem Test Configuration



Description
of
PSA Mounting Fixture

The PSA Mounting Fixture supports the PSA during the Inertial Subsystem test. It is hard-mounted to the Rotary Table.

The PSA mounting fixture allows the necessary close proximity of the PSA to the IMU during Inertial Subsystem testing.

The fixture includes the GFP cold plate which provides the necessary coolant interface for PSA thermal heat transfer.

Illustration of G&E-PSA Junction Box

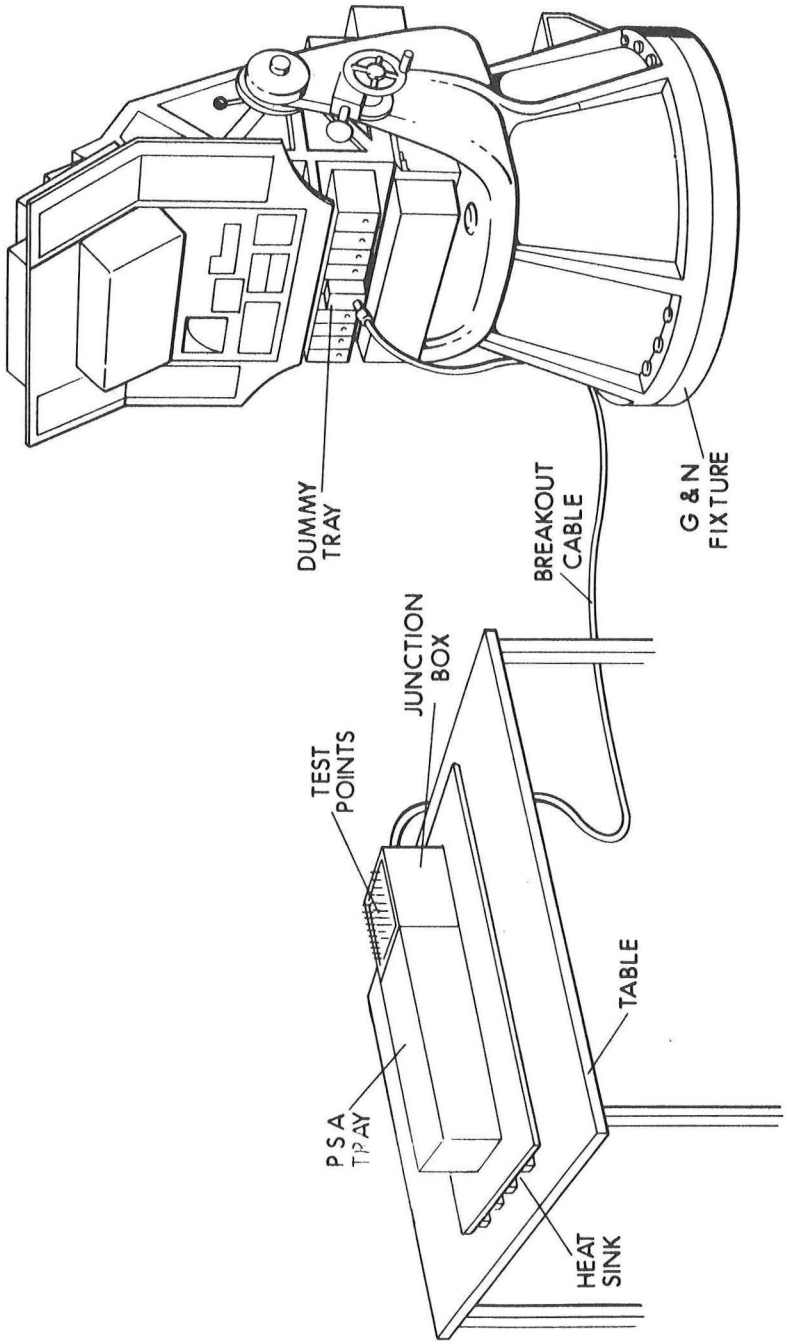
(not available)

Description
of
GSE-PSA Junction Box

The GSE-PSA Junction Box will provide for re-routing intertray wiring for overhead "J" box access, and GSE switching control.

The "J" Box mounts to the PSA Mounting Fixture

PSA Tray Extender Set



Description of PSA Tray Extender Sets

The PSA Tray Extender Sets are used for system and subsystem malfunction localization and system test verification of Tray 2 failure indicators P/N 1007051. The Tray Extender Set enables the removal of a tray from the PSA end connector assembly with the tray operating, and provides access via test points for comprehensive trouble shooting. The set consists of:

a. Dummy trays compatible with the 84-pin and 105-pin rear connector tray configurations, respectively.

b. Adapter connectors and mount to allow interconnection of the trays to the PSA end connector through a breakout cable and the dummy trays for both the 105 and 84-pin tray configurations. The cable length is approximately 5 feet, and the adapter includes test point access to each signal routed through the tray end connector. The adapter includes a heat sink to accommodate tray dissipation.

A special adapter to enable implementation of system failure circuitry indicator verification for PSA Tray 2 is provided. The adapter includes appropriate mechanical keying to assure that no other tray can be connected to this adapter. The adapter allows verification of the IMU FAIL, ACCELEROMETER FAIL, CDU FAIL, and error detect circuitry. "Press to test" switches are used to exercise each of these circuits.

Illustration of Load and Signal Simulator Set

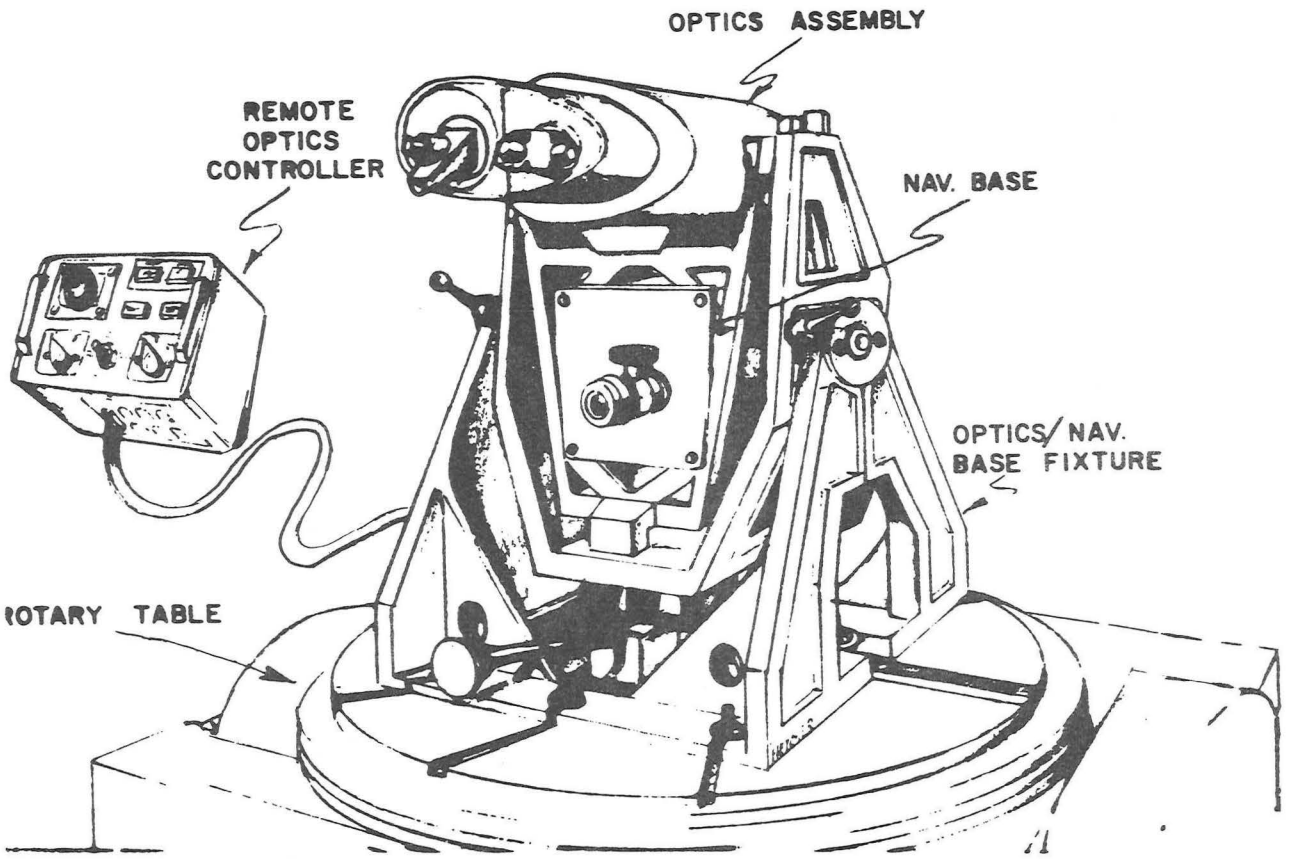
(not available)

Description of Load and Signal Simulator Set

The load and signal simulator set enables continuity checks of the harness, power supply, and verification and PSA phasing checks. This is accomplished by reducing prime powers to signal levels and measuring the response at test points on the units. Power supply loads are simulated.

The IMU-CDU and OPTX-CDU load and signal simulators are portable and operate independent of each other or of any other Ground Support Equipment. The physical size and cables allow the use of these items in the spacecraft.

Optics Nav. Base Fixture

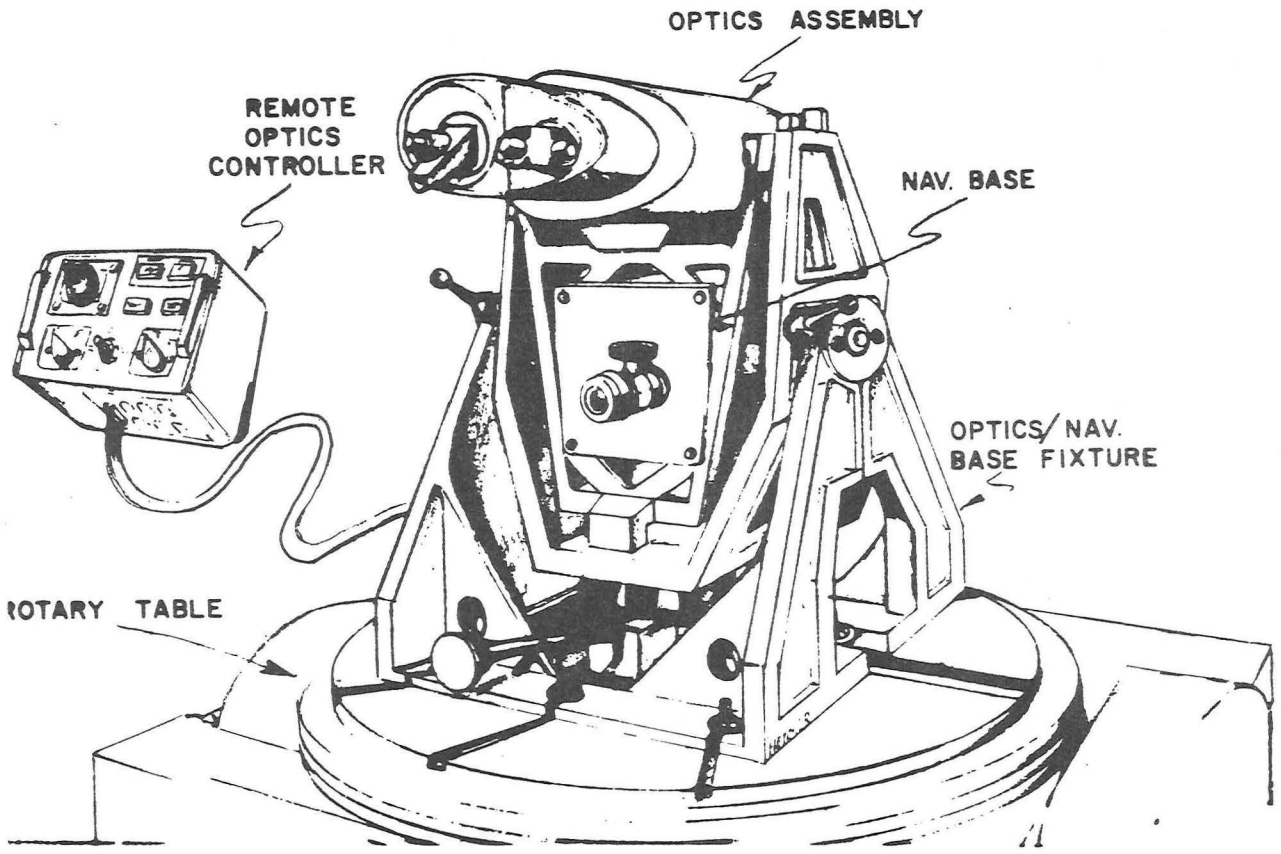


Description of the Optics-Nav Base Mounting Fixture

The purpose of Optics-Nav Base Mounting Fixture is to support the Optics-Nav Base Assembly during subsystem testing of the optics. It consists of a cast meehanite base and cradle. The base is hard-mounted to the rotary table by means of eight T-Head bolts. The cradle accepts the Optics-Nav Base Assembly via Kinematic Mounts and is adjustable within $\pm 2^{o}$ about the Y-axis of the Nav Base. Stability of setting is within 2 arc-sec for one hour.

Approximate weight of the fixture is 450 pounds.

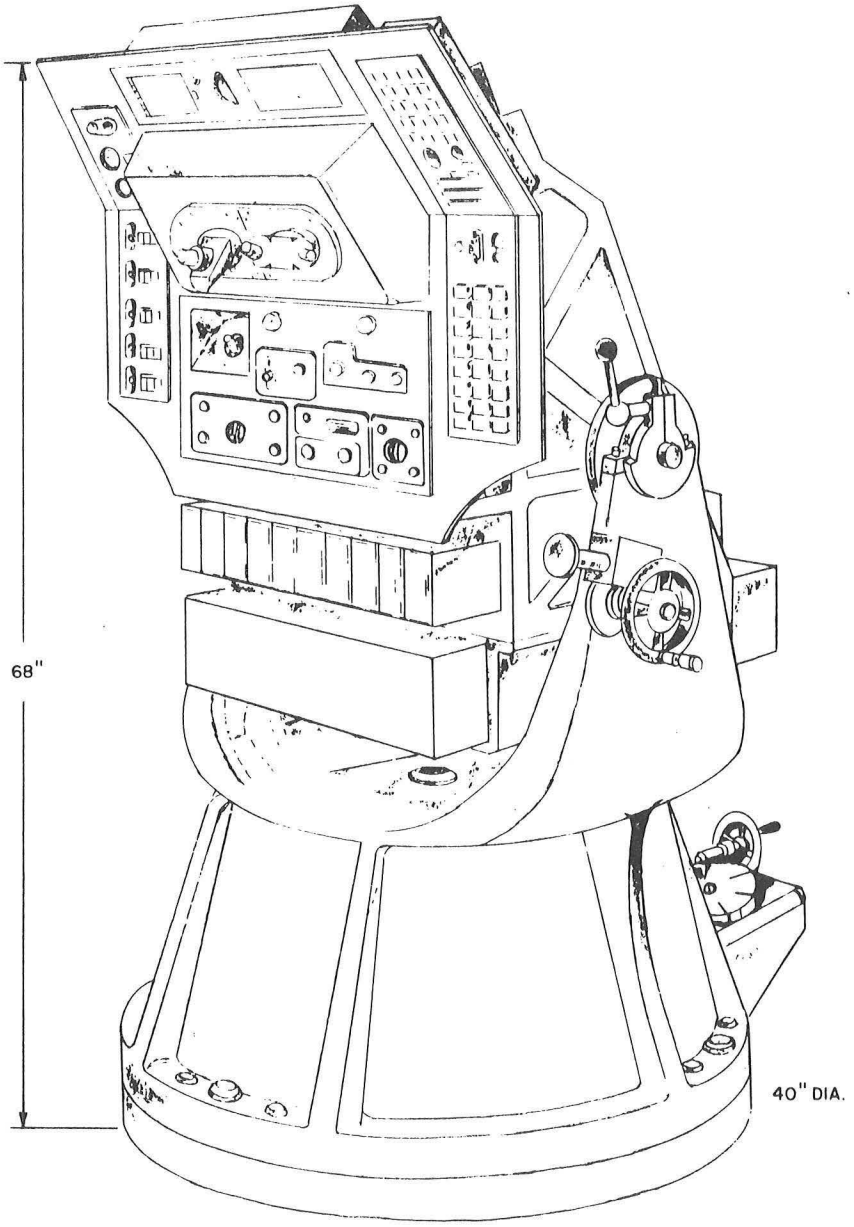
Optics Nav. Base Fixture



Description
of
Remote Optics Controller

The Remote Optics Controller duplicates the G&N system D&C Control panel moding and hand controller drive provisions. It is used to facilitate Optics Subsystem Testing when the Optics-Navigation Base assembly is mounted on the Rotary Table.

G&N Mounting Fixture



Description of G & N Mounting Fixture

The G & N Mounting Fixture enables final system acceptance testing in the spacecraft harness configuration. It includes complete mounting provisions for the entire G & N System equipment compliment (IMU-Optics-Nav Base Assembly, PSA, AGC, D&C, etc.) and incorporates coldplates with convection-isolating shrouds for thermal test simulation.

It consists of a base, cradle, and G & N mounting structure. The mounting structure pivots in the cradle to allow adjustment of the structure about the Nav Base Y-axis (Optics SXT-Trunnions Drive Axis). The base incorporates leveling features that allow leveling of the Nav Base Y- and Z-axes (SXT-land mark line of sight) over a range of 2 degrees with a resolution of ± 10 min of arc.

Mounting structure orientation is accomplished through coarse and fine manual gear drive controls located on the cradle assembly. The drive enables adjustment about the Nav Base Y-axis so that the Z-axis can be positioned to the following three test configurations (Y-axis maintained level):

a. Optics to IMU Stable Member Alignment - Space Craft Configuration at 32.5° from horizontal.

b. Optics parallelism and trunnion accuracy tests - Z-axis horizontal.

c. Optics Shaft axis design configuration testing - Z-axis vertical at 90° from horizontal.

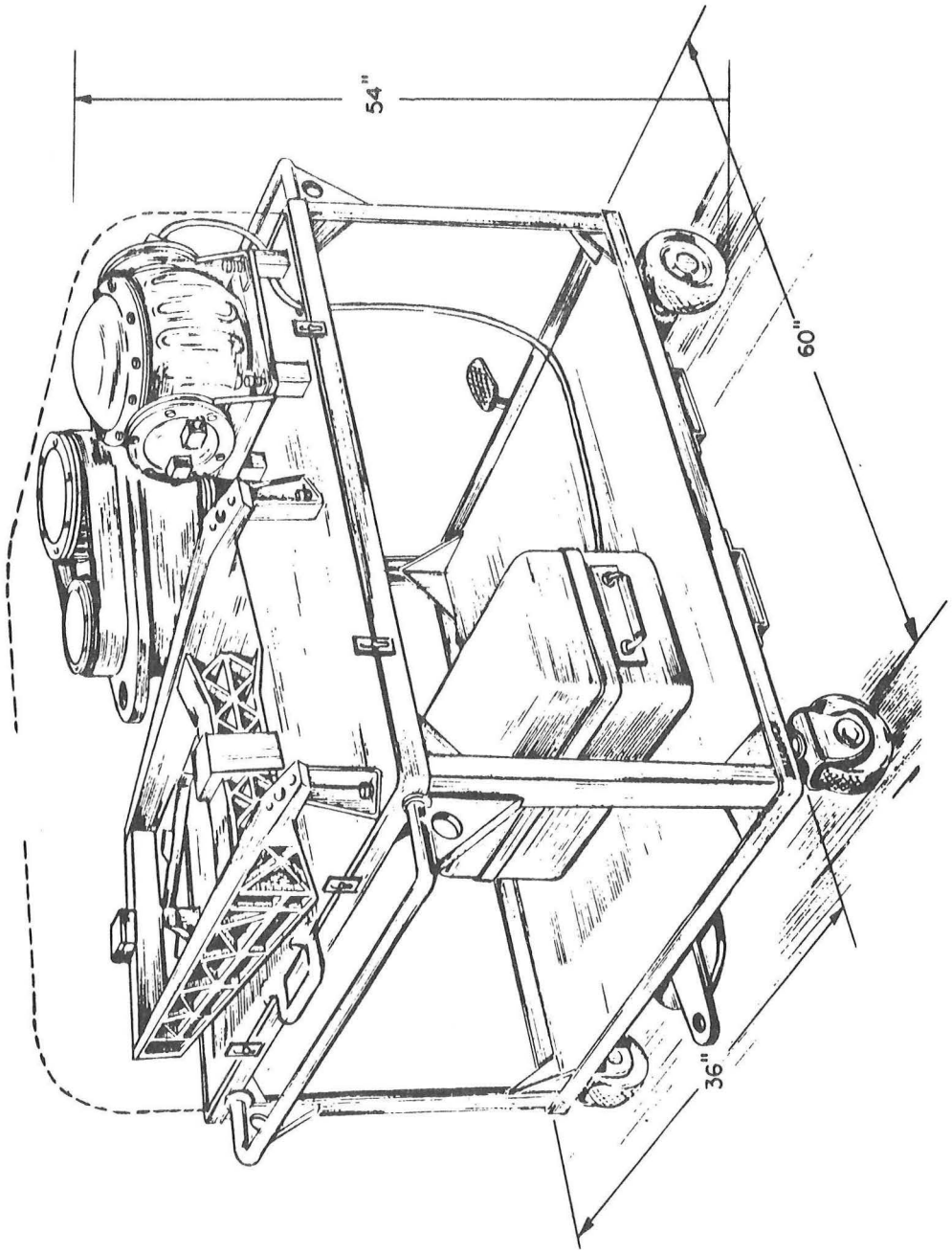
The fixture adjustment resolution about the Y-axis is within 2 arc-sec. To assure test integrity, extremely rigid torsional fixture stability requirements have been implemented (i.e., Nav Base Z-axis in horizontal configuration, above Y-axis stability 2 arc-sec/5 minutes; Z-axis stability 10 arc-sec/5 minutes; X-axis stability of 2 arc-sec/hour).

Illustration of G&N Harness Shipping Fixture

(not available)

Description of
G&N Harness Shipping Fixture

The purpose of the G&N Harness Shipping Fixture is to house the G&N Harness including the PSA end connector (J-Box) and to minimize wear and flexure of the harness during handling and shipping. It consists of a rigid frame that facilitates handling via handles (manually) or by hoist. It also provides a supporting mount that is used on the G&N Transport Cart as well as the harness shipping container.



G&N Transport Cart

Description of G&N Transport Cart

The G&N Transport Cart has the capability of handling the entire G&N, which is accomplished on a two-trip basis. The IMU, Nav Base Assembly and AGC are moved on the first trip and the D&C, PSA including G&N Harness, and the Map and Data Viewer on the second. The G&N Cart has provisions for the Inertial Component Temperature Controller (Portable Temperature Controller and Battery Power Pack).

The maximum dimensions, in inches, of the cart are 36 wide by 60 long by 54 high (including a protective cover). Shock isolation provisions include semi-pneumatic caster type wheels and individual shock mounts for each G&N unit. The cart conforms to MIL-M-8090 Mobility Requirements, Ground Support Equipment.

Apollo Computer Test Set

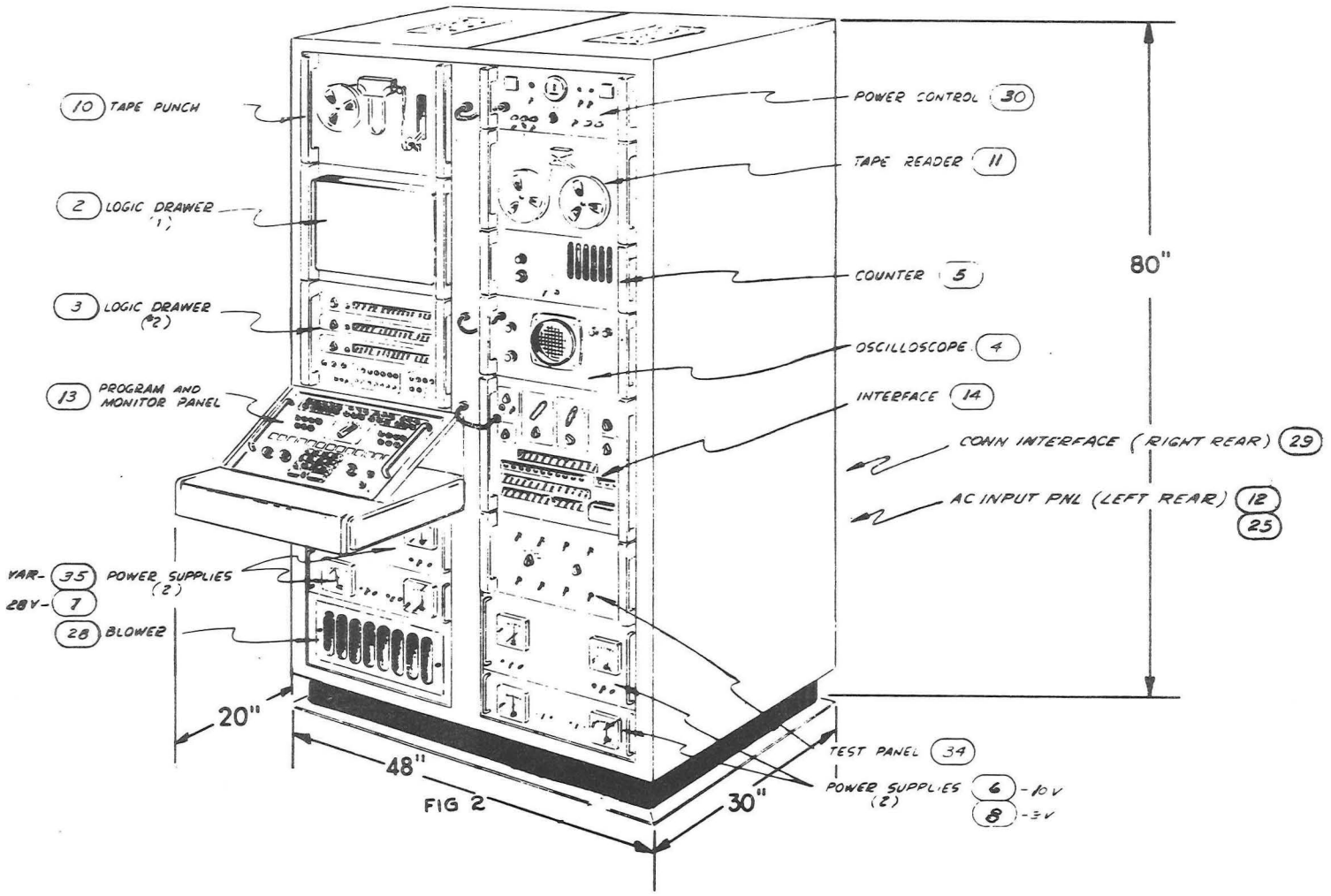
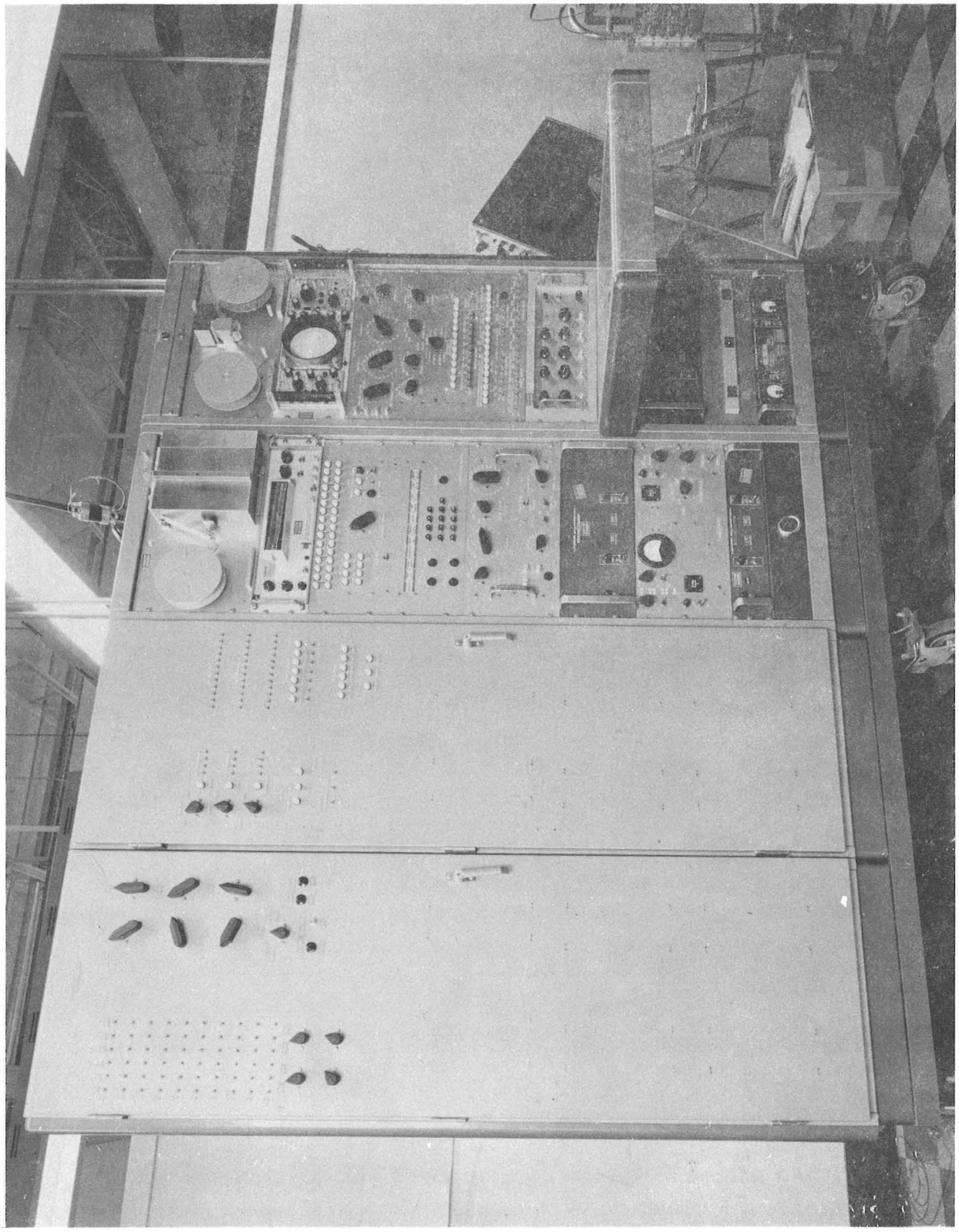
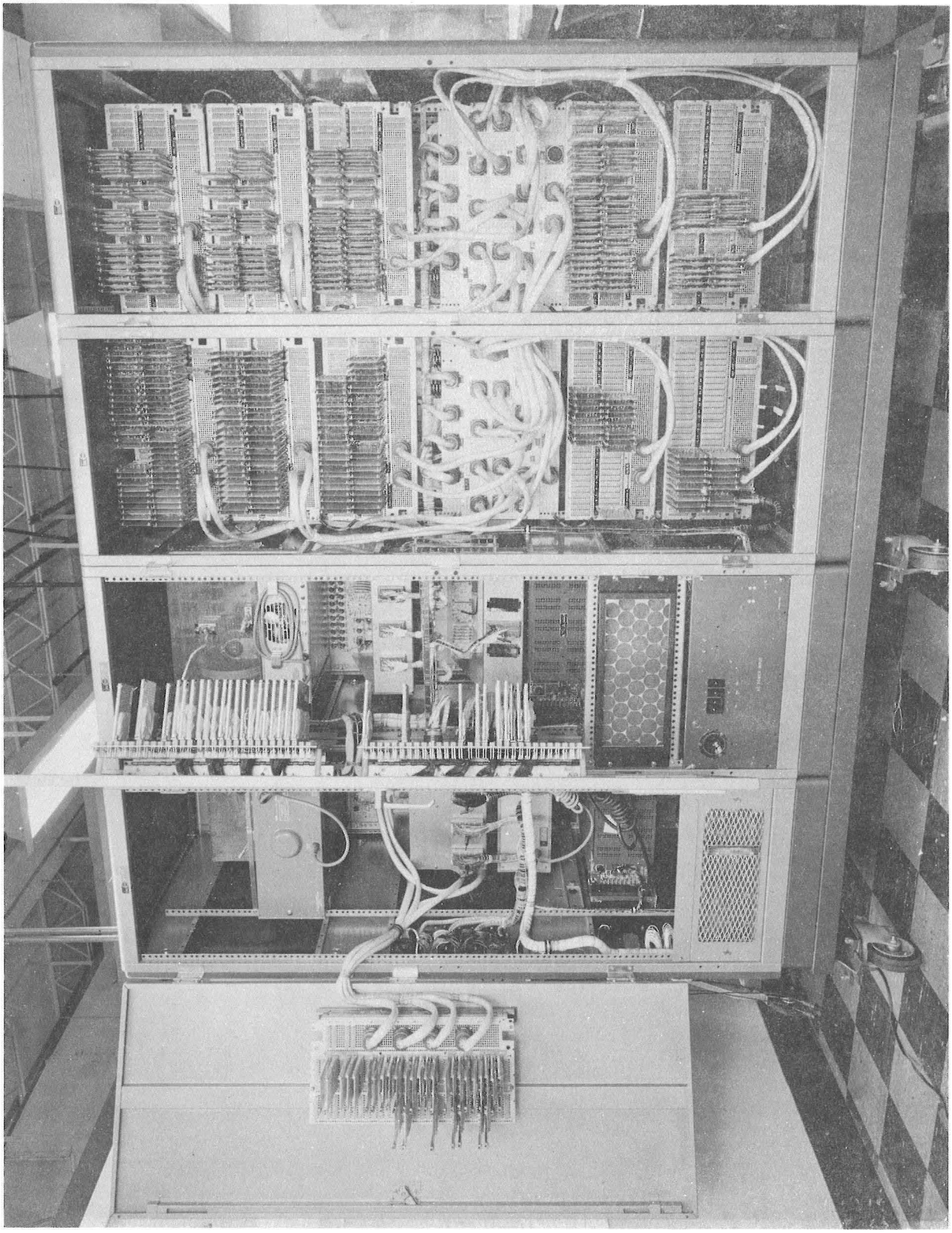


FIG 2



Computer Test Breadboard, Front View



Computer Tester Breadboard Internal Wiring

Description of Apollo Guidance Computer Tester Assembly

The AGC Tester consists of a two-bay Test Console and a single-bay Operating Console. Together, these units comprise a system for checkout of the AGC as a separate subsystem. The Test Console provides special communications via the AGC test connector for the reading and writing of the central processor and memory registers in the computer and the monitoring or commanding of the sequence control logic of the computer. In addition, the test set connects to the AGC interface connectors for the purpose of verifying the operation and performance of the AGC interface circuits and logic and programs associated with the interfaces.

A description of the panels of the AGC Test Set and their functions gives an insight to the means and methods of AGC check-out.

3.1.2.1 The Programmer and Monitor, ND 1014309.

This equipment provides displays and controls for selection of the particular mode of operation of the test set from the following twelve selectable modes:

Monitor	Transfer Control	Tape Prepare
Keyboard Load	Read AGC	Tape Duplicate
Tape Load	D/A Chart Display	Tape Verify
Up-link (test) Tape	Self Test	Up-link (test) Manual

In addition, it provides a display of the contents of the remote Z-register (RZ) and one other remote register, selectable from the following: RA, RB, RG, RQ, RX, RY, RS or RLP. Minor display registers, Bank, Staging, Branch, and Sequence, give additional information about addresses and microprogram status.

The keyboard is used to enter information into the two test set registers displayed on the Program and Monitor panel.

For Example, in KEYBOARD LOAD mode, the AGC address to be modified is loaded into the Remote Z register (RZ) and the data to be entered are loaded into the Remote Accumulator register (RA), and observed on the upper and lower binary lamp registers, respectively. Having verified that the appropriate information has been assembled, the operator depresses the ENTER button, loading the AGC with the contents of A, CA, at address S = CZ. The keyboard is also used to prepare tape for repeated or high-speed entry of bulk data into the AGC. Special program controls, FRESH START and PROCEED, are used to start initially, to get the computer out of loops, and to resume processing after a stop.

EXECUTE is used to command fetching of the contents of a specified address from the AGC and displaying this data in Read AGC mode, to "execute" Transfer Control in TCSA mode, or to effect data entry in Keyboard Load mode. The two Up-Link buttons are used in the Up-Link Manual Test Mode for separate simulation of the serial one and zero Up-Link codes.

Logic Drawers numbers 1 and 2 contain the logic modules which comprise the mode logic, counters, registers, agreement logic, digital to analog converters, and other logic, lamp drivers, and gates. Together, these drawers form the heart of the Computer Test Set.

3.1.2.2 Logic Drawer Assembly Number 1, ND1014124

In this assembly the controls and features relate to the Data Record Mode (also called D. to A.) operation of the Computer Test Set. A single-card manually loaded IBM card reader is used to select up to 6 registers of the AGC for display on punched tape and oscillographic recorders (either oscilloscopes or a multichannel strip chart recorder). Seven-bit digital to analog converteres with individual 9-bit scaling selection switches allow each DAC to be scaled from 1 to 256 AGC bits per bit.

To standardize the DAC outputs, depressing MAX and MIN CAL buttons forces the inputs of all DAC's to all 1's and all 0's,respectively, so that recorder gains and zero settings may be adjusted appropriately. The repetition rate of sampling and recording of "Record Mode" data by the puched tape scanner and tape punch are governed by the group of controls called TIMING which provide for punch-out of specified addresses at the operator's discretion by depressing the manual button, at either of three selectable punching rates, or upon command of an external rate generator via the EXT input jack. Two groups, A and B, of three registers each may be programmed to read standard addresses or specific increment (counter associated) addresses, and the length of the scanning cycle for the timing counter is varied from one to six words per cycle according to the setting of the WORDS OUT selectors.

3.1.2.3 Logic Drawer Assembly Number 2, ND1014125

This assembly contains agreement toggle registers, counter stop, and increment displays and controls. The test set can be programmed to stop or scan (store in display register on the Program and Monitor panel without stopping) upon agreement of either of two addresses or the contents of the Accumulator, or upon the coincidence of the agreement of a specific address and accumulator contents. Parity lights indicate the state of the parity bit read from memory and the state of the generated parity bit in the central processor parity tree. The Inhibit Interrupt toggle and light enable the operator to over-ride any interrupts which might be stuck on in a malfunction, to allow uniterrupted operation of a particular program for special effects. The specific increment categories are tied to increment display lights, and an INCREMENT INHIBIT toggle allows the operator to prevent incrementing, should this be desired, for instance, in a situation where a counter input is incrementing continuously at a rate so rapid as to impair machine operation.

3.1.2.4 Systems Interface Panel Assembly, ND101495

This assembly provides for the simulation and monitoring of the interfaces of the AGC. The AGC will be programmed to perform these functions systematically and stop upon failure. In a manual mode of operation, various groups of signals can be selected and displayed on the 2-channel oscilloscope for waveform and timing evaluation, or these outputs can be applied to the Frequency Counter for verification of program or logic functioning. Counter drivers, DSKY lights, IMU DC inputs, Optics DC inputs, - ERRUPT (error interrupt) inputs, and discrete inputs (events) are provided to simulate the occurrence of these stimuli and waveforms as in normal AGC system operation. In addition, margin testing can be performed by switching the INPUT VOLTAGE SELECT to marginally low voltages LO 1, or LO 2, and noise sensitivity can be calibrated by inserting noise modulation upon the computer inputs at either of two predetermined levels, Noise 1 and Noise 2. The AGC Down-Link can be exercised by the Down-Link Test section of the panel. A program loads the Down-Link register with a particular word, and a set of start, stop, and bit sync signals applied to the telemetry interface read out the contents of the Down-Link register. With a single simple word and an oscilloscope observation, the Down-Link could be verified for gross operation. More sophisticated dynamic programmed tests can be performed by a closed loop mode of operation where Down-Link is closed back on Up-Link and the computer logic is made to verify that returned data compares with transmitted data.

3.1.2.5 The Power Control Assembly, ND1014130

This assembly contains a voltage monitor meter for display of the Test Set power supply voltages as selected, the main POWER ON switch, and voltage test terminals and Test Set operating time counter.

3.1.2.6 The Connector Interface Assembly, ND1014298

Located on the rear of the Test Set, this panel containing four groups of MS-3119 type quick-disconnect connectors identified with cabling to the PSA, System and Spacecraft, DSKY's, Programmer, and Monitor.

3.1.2.7 The A-C Input Panel, ND1014136

This panel, located on the rear of the test set, contains the main power line connector and Test Set circuit breakers.

Description of Computer Tester Capital Equipment

3.1.3.1 Oscilloscope - Measures pulse characteristics in the megacycle range with rise time of less than 0.2 μ sec.

Modified DuMont - Fairchild #767 (Rack Mount)

Specifications:

Dual Trace	
Sensitivity	5 mv/cm
Bandwidth	25 MC
Rise Time	14 μ sec
Sweep Rate	0.05μ sec/cm to 2 sec/cm
Power Input	115 VAC/60 cps at 2 amps

3.1.3.2 Frequency Counter - Measures frequency of all pulse outputs and counts number of pulses of programmed controlled pulse outputs during system test.

Modified Computer Measurements Company Model #727BND (Rack Mount)

Specifications:

Frequency Range	0 cps to 13 MC
Input Sensitivity	0.1 volt rms or DC-coupled
Input Impedance	1 megohm - 30 pf shunt
Gate Times	1μ sec to 10 sec (7 decade steps)
Oscillator Accuracy	5 parts in 10^8, short term; 2 parts in 10^7 from 15 min to 3 hrs or 5 parts in 10^7/ week
Readout	7 decades
Power Input	115/230 vac ±10%, 50-60 cps at 1 amp

Power Supplies - Supply power to the AGC during subsystem test with the capability of supplying isolated, noise free power during system test.

3.1.3.3 Power Supply - Supplies power to Computer Test Set Lamp driver and tape driver.

Modified Lambda - LE-103 (Rack Mount)

Specifications:

Output	0-36 volts at 0-15 amps
Power Input	105-135 v ac at 16.1 amps 45-66 cps
Regulation	Less than 0.05% or 8 mv for line change between 105-135 v ac. . Less than 0.05% or 8 mv for load variations from NL to FL
Ripple	Less than 0.5 mv rms

3.1.3.4 Power Supply - Supplies variable power to Computer Test Set Interface Transformer Drivers.

Modified Lambda LE-105 (Rack Mount)

Specifications:

Output	0-18 volts at 0-8 amps
Power Input	105-135 v ac at 6.3 amps 45-66 cps
Internal Power Dissipation	236 watts

3.1.3.5 Power Supply - Supply power to the Computer Test Set Logic

Modified Lambda LE-109 (Rack Mount)

Specifications:
(Same as LE-103 except as follows)

Output	0-9 volts at 0-10 amps
Power Input	105-135 v ac at 6.3 amps, 45-66 cps

3.1.3.6 Paper Tape Reader - Loads test programs during subsystem and system tests.

Modified Tally Reader #424 PRF 48-6 (Rack Mount)

Specifications:

Channel Capacity	8 channels
Tape Width	1 inch
Tape Handling	6 inch reel-fan fold
Input	60 characters/sec max
Drive Motor	105-125 volts, 60 cps at 0.44 amps
Output	Relay closures, one for hole, one for no hole

Reader Drive Unit - Tally #1443 (Rack Mount)

3.1.3.7 Paper Tape Perforator - Records data during system test and prepares tape for system and subsystem testing.

Modified Tally #420 PRF 48-6 (Rack Mount)

Specifications:

Channel capacity	8 channel
Rate	60 characters/sec max
Tape Width	1 inch
Tape Handling	6 inch reel - fan fold
Power Input	115 volt, 60 cps at 2 amps
Signal Input	10μ sec pulses approximately 10 volts

Perforator drive unit - Tally #1424A and end of tape sensor

PANEL LIST

Apollo Guidance Computer Tester Assembly

Rack I

1. Punch Assembly ND 1014142
2. Logic Drawer Assembly Number 1 ND 1014124
3. Logic Drawer Assembly Number 2 ND 1014125
4. Programmer and Monitor Assembly ND 1014309
5. Auxiliary Outlet Assembly ND 1014339
6. Power Supply ND 1006936
7. Blower Fan ND 1006897
8. Air Filter, RFI ND 1006918

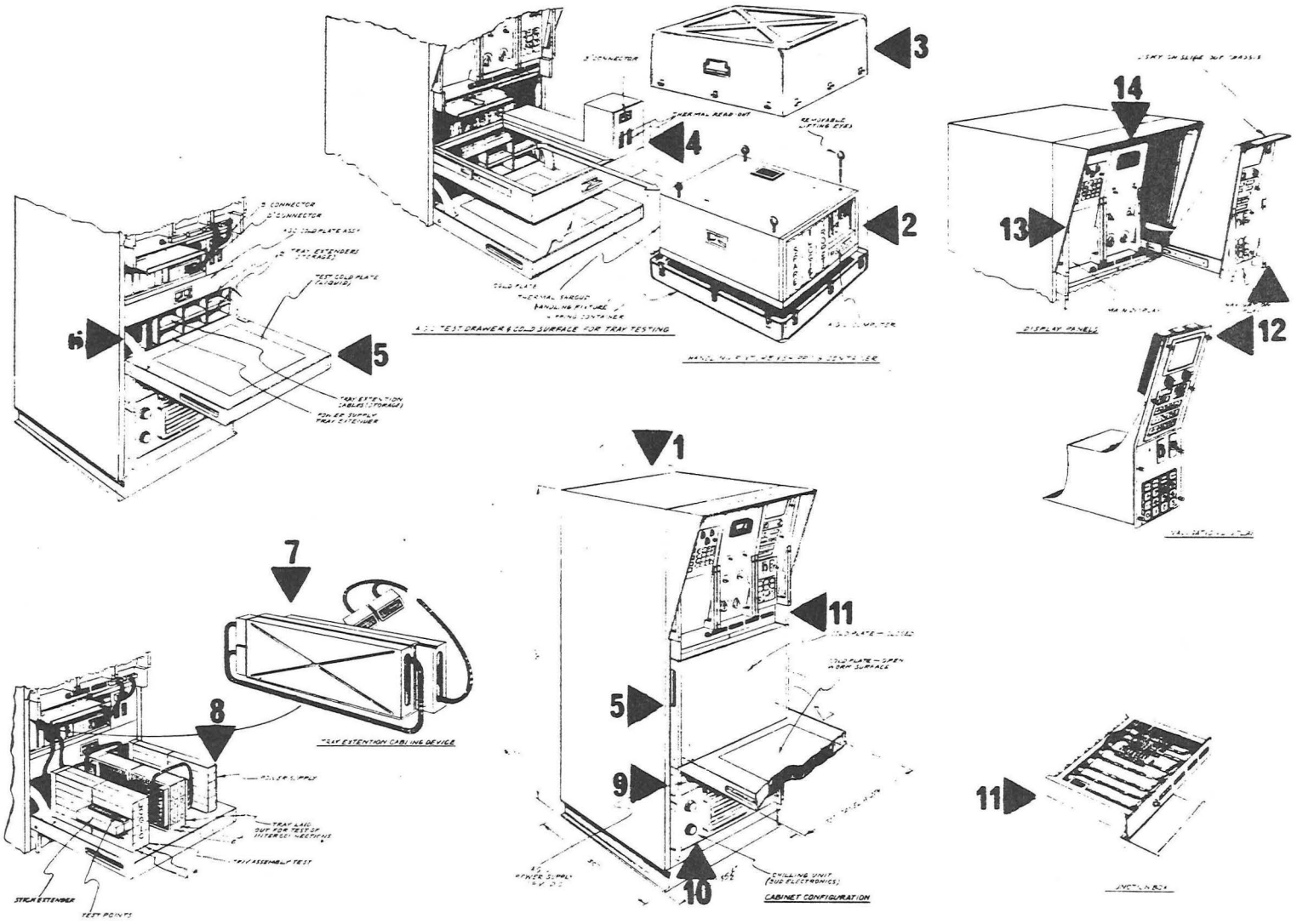
Rack II

1. Power Control Assembly ND 1014139
2. Tape Reader Assembly ND 1014141
3. Counter, Frequency ND 1006934
4. Oscilloscope ND 1006937
5. System Interface (Test) Assembly ND 1014295
6. Test Panel ND 1014380
7. Power Supply, Variable ND 1006931-1
8. Power Supply, 3-volt ND 1006931-2

Rear

1. Conn. Interface, ND 1014298
2. A-C Input Panel, ND 1014136

AGC/CTS Operation Console



Description of The AGC/CTS Operation Console

The Operating Console is a single-equipment rack which contains mounting provisions for the AGC and the AGC Display and Keyboard assemblies (DSKY's), a coolant supply, fold-out coldplate work surface, and a 28-volt d-c power supply.

In normal operation the AGC in its holding fixture is installed on a special shelf located in the midsection of the rack, the DSKY's are installed in the upper section of the rack next to the Power Control Panel, and the coldplate work surface is folded upward covering the AGC shelf.

Should a fault develop which requires work internal to the AGC, the coldplate work surface is folded down and any or all of the trays of the AGC may be operated on extended cables. Sticks may be operated on extenders also for more detailed investigation within trays. The oscilloscope and counter in the Computer Test Console can be used to assist in such detailed trouble shooting. A power supply is provided to supply d-c power to the console. The coolant supply uses Spacecraft specification glycol-water coolant. Cooling is accomplished by an R-12 or R-22 charged refrigerating system driving a liquid heat exchanger. Should heat input be required, an immersion resistance heater is provided. Coolant temperature is adjustable over the range from 45^{o} to 105^{o}F, while flow rate is adjustable over the range from 25 to 80 pounds per hour.

AGC/CTS Operation Console Capital Equipment Specifications

Power Supply

Modified Lambda LE-102 (Rack Mounted)

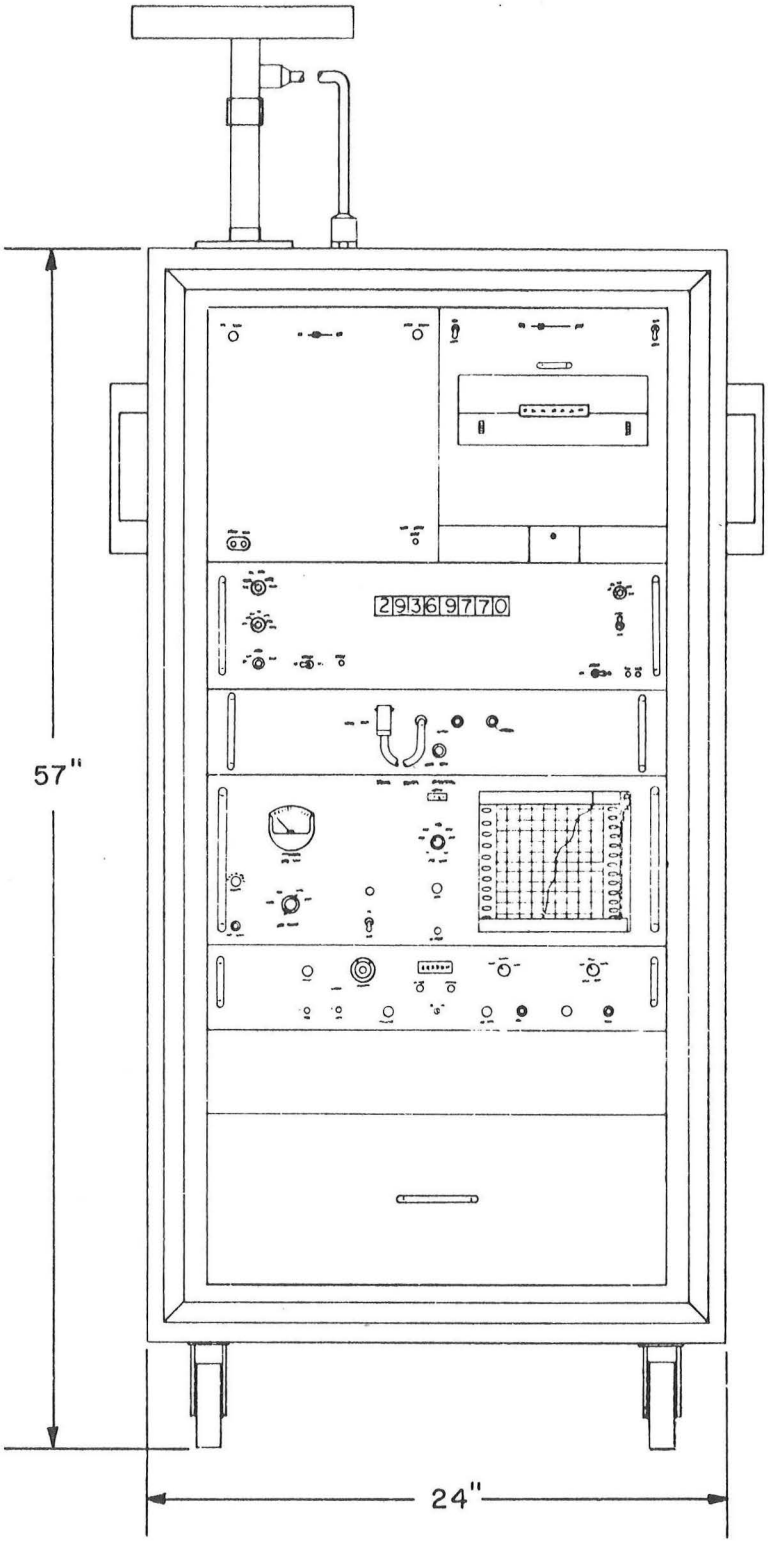
Specifications:

Output	0-36 volts at 0-10 amps
Input	105-135 v ac, 45-66 cps, at 11.3 amps
Regulation	Less than 0.05% or 8 mv for line change of 105-135 v ac or load variation of NL to FL.
Ripple	Less than 0.5 mv rms.

Coolant Supply

Size (inches)	30 wide x 12 1/4 high x 22 deep
Temp. Control	45^{o} to $105^{o}F \pm 3^{o}$
Flow Rate	25 to 80 pounds per hour
Pressure Drop	10 psig max
Head Load	280 W max
Ambient Temp.	50^{o} to $100^{o}F$
Rel. Humidity	100% max
Power Input	110 v ac, 60 cps, 13.5 amps, 35 amp surge

AGC Calibration System Console Assembly



Description of Computer Calibration System Console

A system for the calibration of the crystal oscillator of the Apollo Guidance Computer is contained in the Computer Calibration System (Console Assembly) ND-1014217. In addition, this system provides for the self-calibration of its internal ultrastable oscillator. Designed to make convenient periodic measurement of frequency, the calibrator contains a VLF Receiver/Frequency Synthesizer/Phase Comparator unit, a Local Frequency Standard crystal oscillator, EPUT Counter, and Digital Printer. In operation the printer presents a numeric record of computer frequency, as measured by the counter, under timing gate control from the local standard oscillator. Measurement of frequency to an accuracy of up to 1 part in 10 billion is practical when the local standard crystal oscillator has been calibrated against the Bureau of Standards signals broadcast on VLF. This calibration is accomplished by the Receiver/Synthesizer/Phase Comparator unit.

Description of Computer Calibration System Console

A system for the calibration of the crystal oscillator of the Apollo Guidance Computer is contained in the Computer Calibration System (Console Assembly) ND-1014217. In addition, this system provides for the self-calibration of its internal ultrastable oscillator. Designed to make convenient periodic measurement of frequency, the calibrator contains a VLF Receiver/Frequency Synthesizer/ Phase Comparator unit, a Local Frequency Standard crystal oscillator, EPUT Counter, and Digital Printer. In operation the printer presents a numeric record of computer frequency, as measured by the counter, under timing gate control from the local standard oscillator. Measurement of frequency to an accuracy of up to 1 part in 10 billion is practical when the local standard crystal oscillator has been calibrated against the Bureau of Standards signals broadcast on VLF. This calibration is accomplished by the Receiver/Synthesizer/Phase Comparator unit.

AGC Calibration Equipment
Capital Equipment Specifications

1. Printing Recorder ND 1006965
   Hewlett Packard Printer Model HP 562
   Printing rate: 4 lines per second
   Input: parallel data encoded 1248 BCD
   Column capacity: 11
   Printing Wheels: 12-position: 0 thru 9, -sign, and blank
   Power requirements: 110 v ac, 60 cps

2. Counter, Electrical ND 1006962
   Computer Measurements Corporation Model 706B
   Frequency Range: dc to 5MC
   Accuracy: ± (1 count ± time base accuracy)
   Gate Time: 1 μsec to 1000 sec
   Input Impedance: 1 Megohm, 30 pf Shunt C
   External Standard Input: 1 MC, 1 volt rms, minimum
   Power Requirements: 110 volts, 60 cps, 56 watts

3. Calibrator, Frequency ND 1006963
   Frequency Standard Model RD180-A Manson
   Output Frequency: 100 KC, 1 MC
   Frequency Aging: 5 parts in 10^{10}/day, decreasing to less than 2 parts in 10^{10}/day within 6 months
   MIL Specified, Specification # MIL-E-16400
   Power Requirements: 110 volts, 60 cps, 25 watts
   Battery Supply: In-Built, 40 hours operation

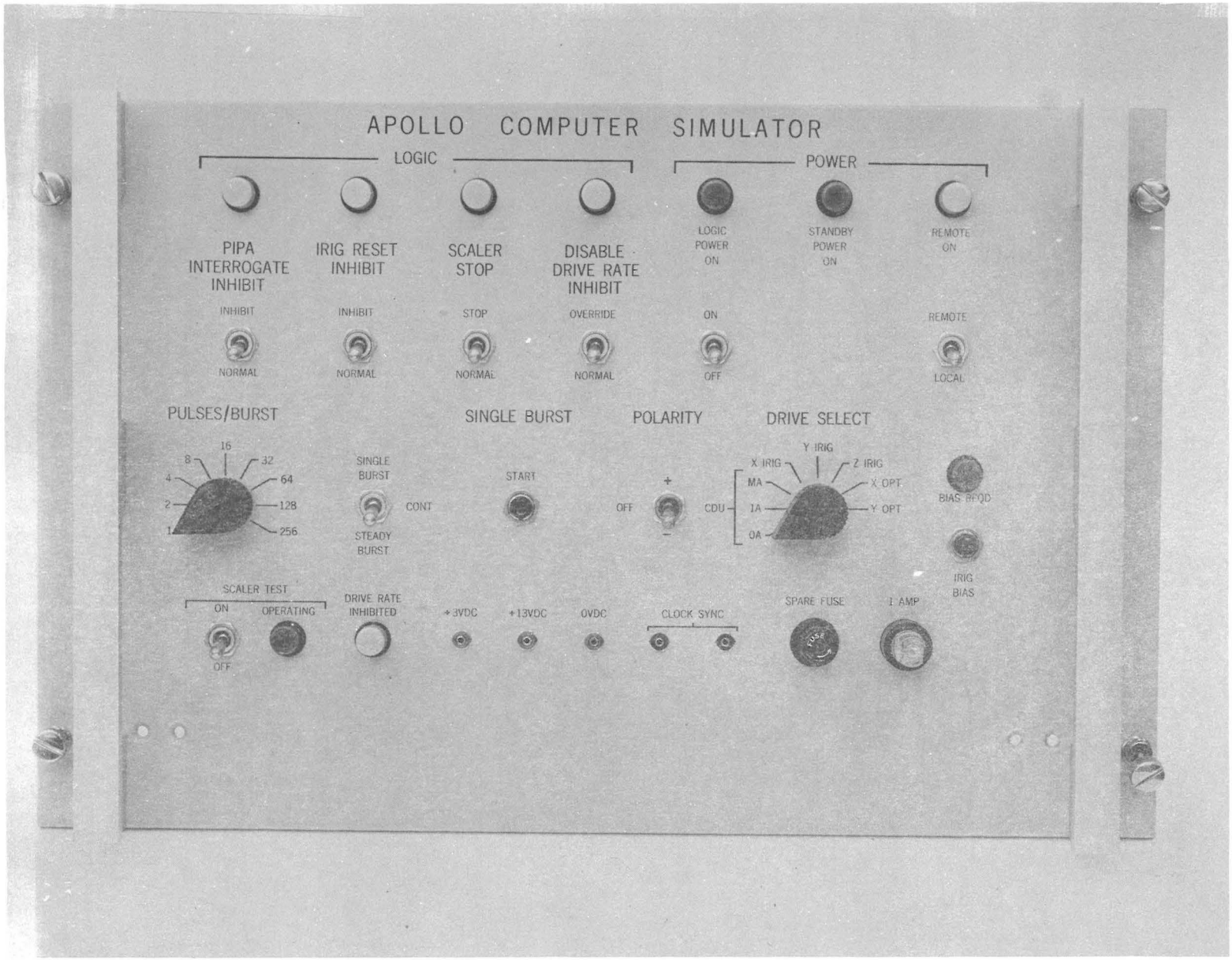
4. Receiver, Phase Comparator (VLF) ND 1006961
   VLF Phase Comparison Receiver, Gertsch PCR-1
   Frequency: As desired by plug in module selection
   18 KC, 20 KC and 22.3 KC specified
   Sensitivity: 0.1 microvolt
   Standard Frequency Output: 100 KC 0.1 volt rms
   Chart Recorder: 100 μsec full scale

Speed: 1, 2, 3, 6, or 4 inches per hour

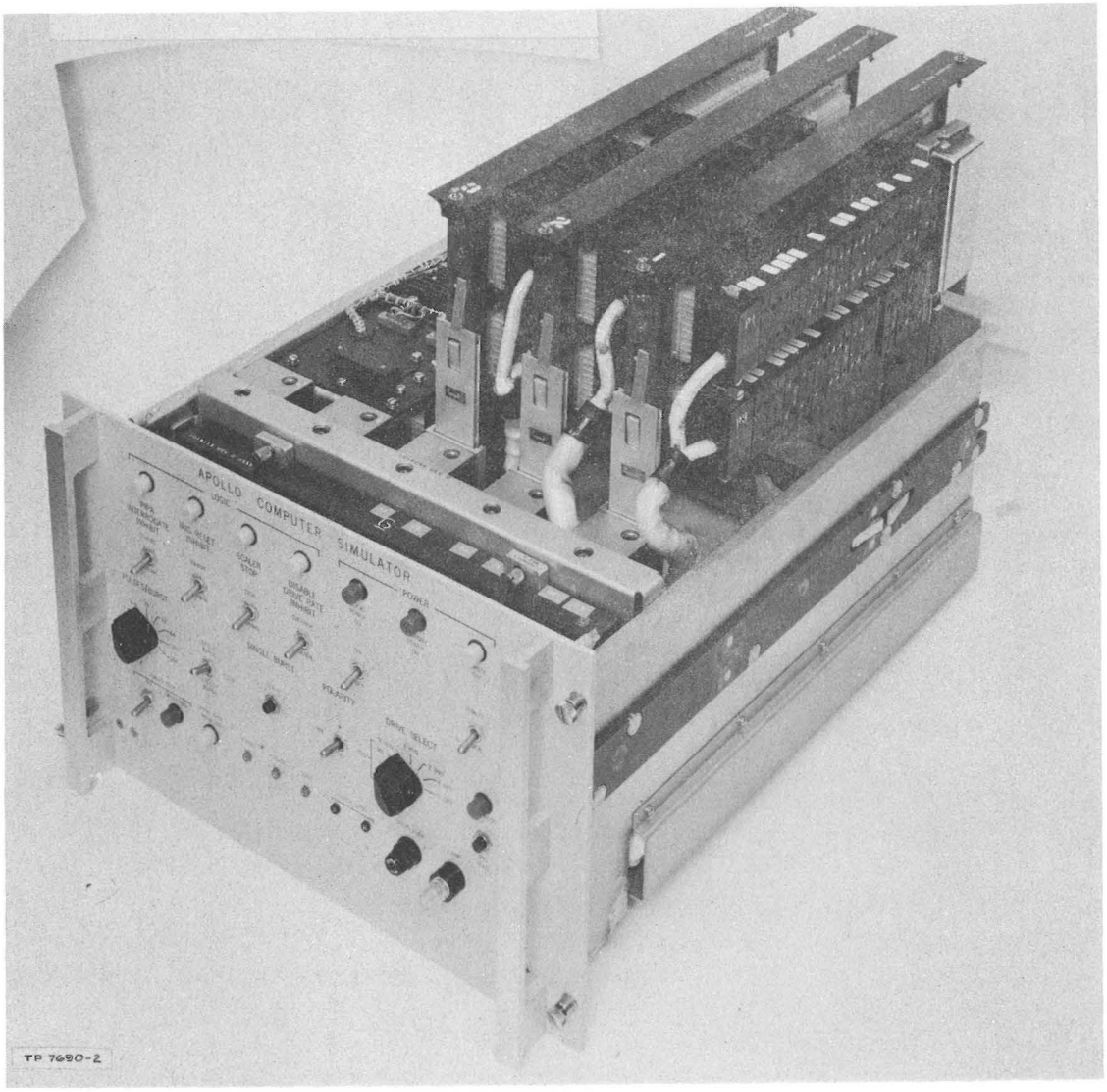
Paper: Pressure sensitive

Comparison inputs: 100 KC or 1 MC 0.5 to 5 volts

Power Requirements 100 v ac, 60 cps, 40 watts



Apollo Computer Simulator



Computer Simulator Drawer

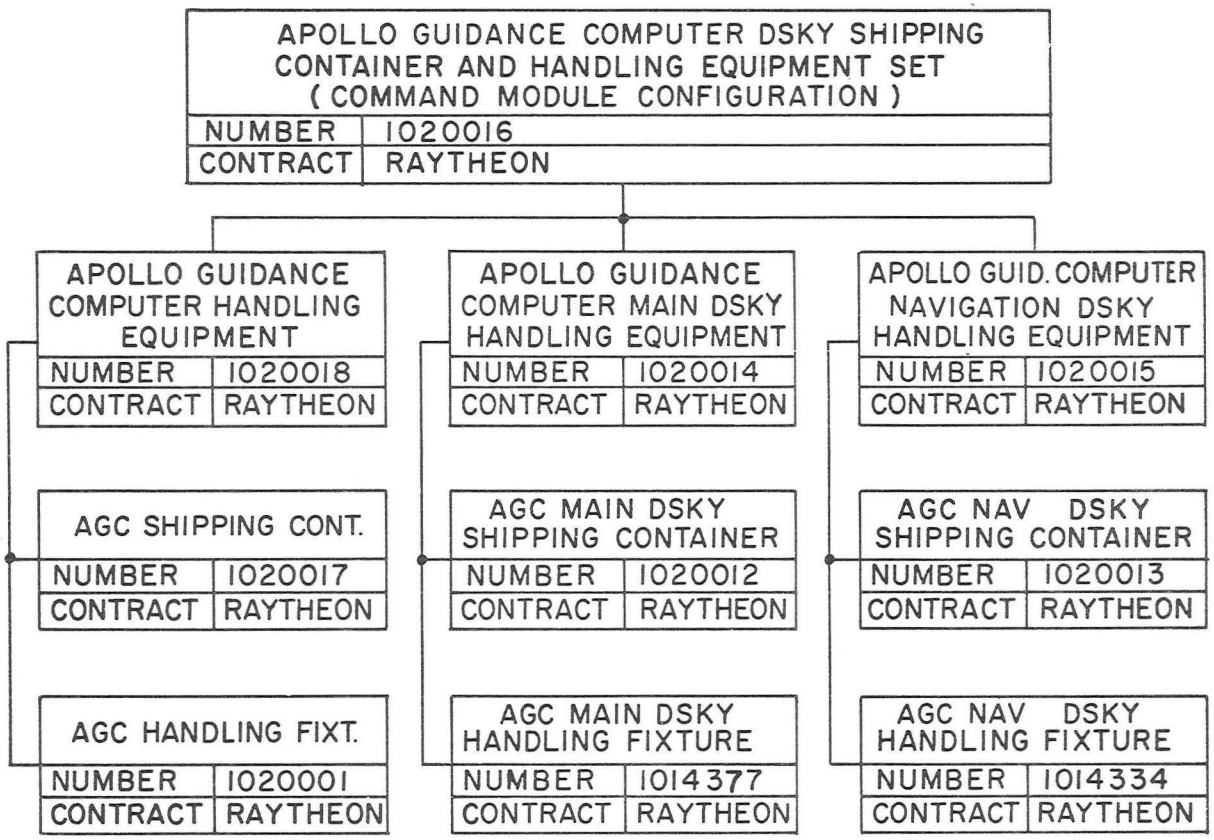
Description of Apollo Guidance Computer Simulator

During Optics and Inertial Subsystems Test when no AGC is present, a computer simulator satisfies the digital interfaces essential for subsystem operation.

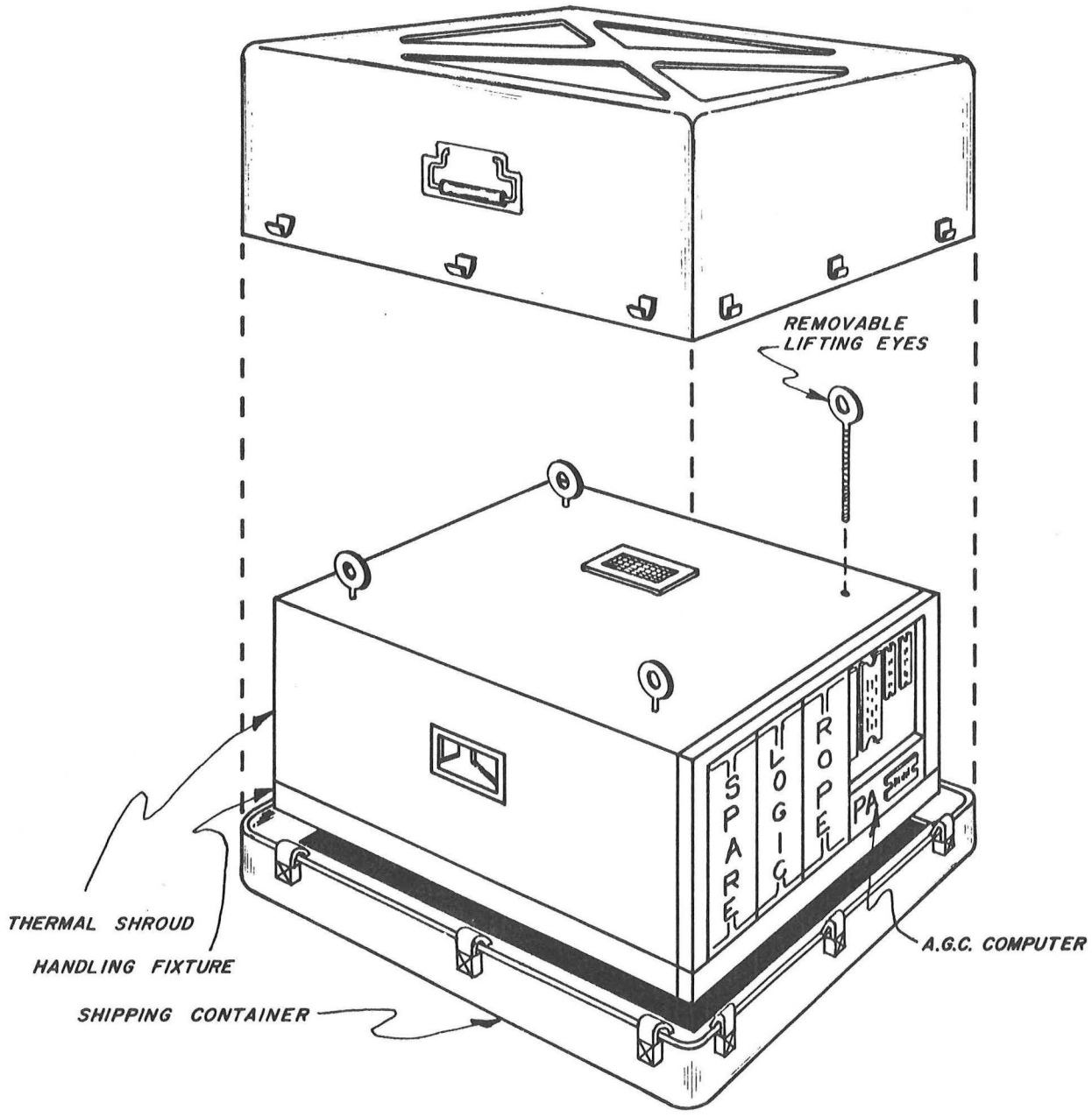
The simulator provides synchronization pulse drivers to power supplies, timing pulse drivers to PIPA and IRIG electronics, programmable pulse drivers to IRIG's and CDU's, and pulse receivers from PIPA's and CDU's.

The computer simulator is a 12 1/4-inch x 19-inch x 24-inch rack-mounting drawer assembly which normally mounts in the Optics Inertial Analyzer Console. The unit derives its power from a 115-volt, 60-cycle standby line at approximately 1 amp. Front panel controls allow a choice of special modes of operation and selection and control of pulse drive commands to either CDU or IRIG electronics, one axis at a time.

Apollo Guidance Computer Shipping Container and Handling Equipment Set Family Tree



AGC Handling Fixture & Shipping Container



Description of
AGC Shipping Container and Handling Equipment Set

3. 5. 2. 1 AGC Handling Fixture and Shipping Container

The AGC Holding Fixture is a structure whose principal purpose is to hold and protect the AGC mounted upon its NAA coldplate. The outer casing of the fixture serves as a convection insulating shroud to simulate the anticipated AGC thermal environment. Clearance, access, and mounting provisions for the interface cables and coolant lines have been allowed to facilitate installation of the AGC/Holding Fixture assembly in subsystem and system operating locations. Mounting points on the bottom of the fixture allow mounting the AGC/Holding Fixture assembly in the AGC Operation Console, the G&N Operating Fixture, the AGE Transportation Cart, and the AGC Shipping Container.

The shipping container houses the AGC mounted on its holding fixture and is designed to enable shipment of the AGC in accordance with environmental requirements of the Apollo Environmental Criteria Spec., NASA/MSC March 25, 1963.

The container will be used for transport of the AGC from Raytheon to the various field sites.

3. 5. 2. 2 DSKY Handling Fixtures and Shipping Containers

The AGC-DSKY Handling Equipment consists of a handling fixture and shipping container for each DSKY.

The Handling Fixtures, ND1014337 and ND1014334, are utilized to mount, support, protect, and facilitate handling of the AGC Main Panel DSKY and the Nav Panel DSKY, respectively. The fixtures serve multiple purposes and serve as:

a. Holding and supporting structures during carrying or working on DSKY's on the bench.

b. Sliding chassis for convenient installation of the DSKY's in the AGC/CTS Operation Console.

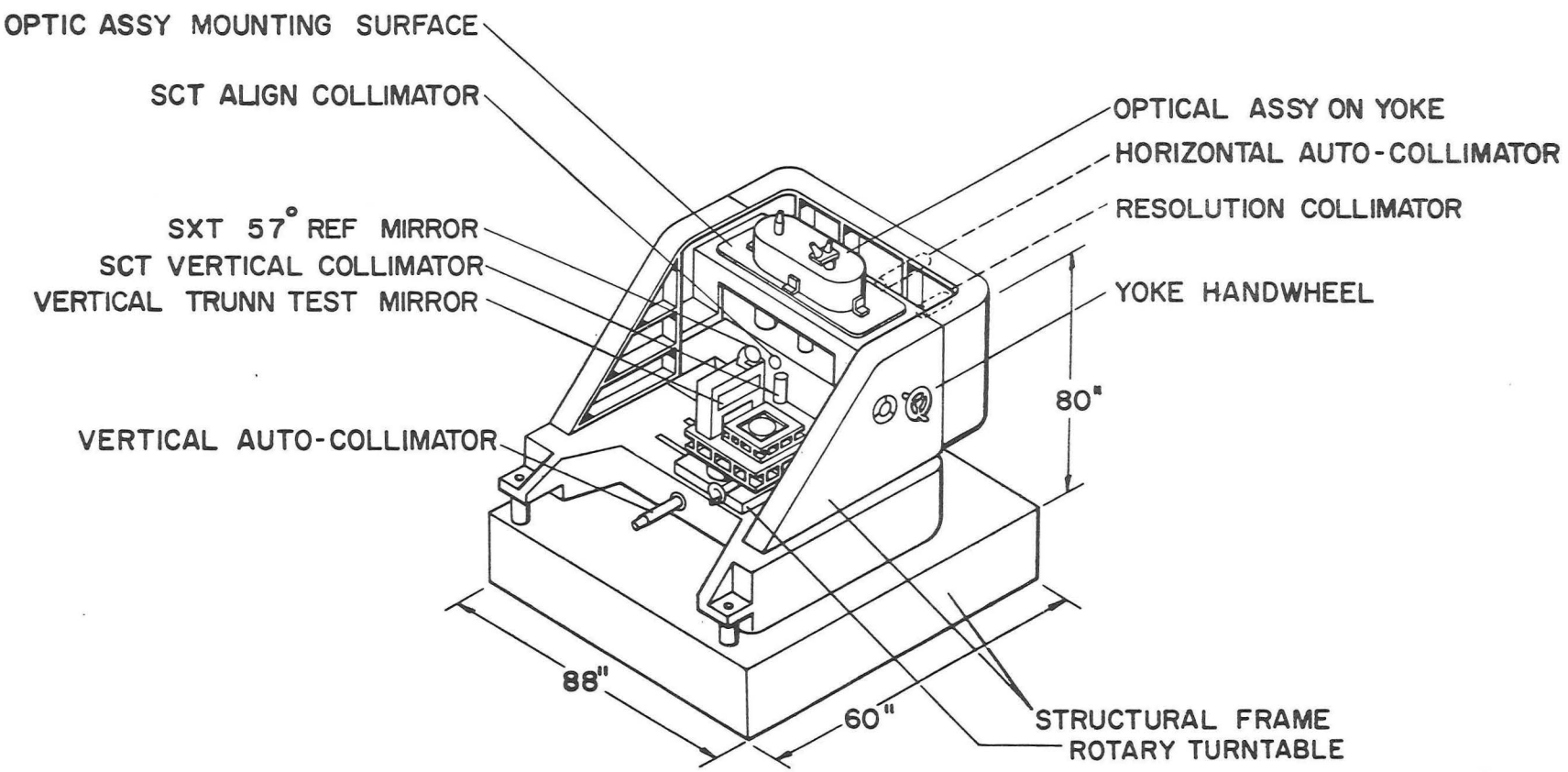
c. Adapter framework to the DSKY shipping containers.

These functions account for the greater portion of life between the manufacture and the installation in the space craft. Therefore, it is expected that the fixtures will minimize wear and tear on the DSKY's by eliminating mechanical mounting and dismounting operations during the interim period.

The DSKY Shipping Containers are assemblies of standard modular metal frames with removable sideplates. The containers are designed to accommodate the Nav Panel DSKY, and the AGC Main Panel DSKY in their handling fixtures. Shock mounts are provided between the containers and the fixtures to protect the payload from handling and shiiping shock.

IV KOLLSMAN

Precision Test Fixture



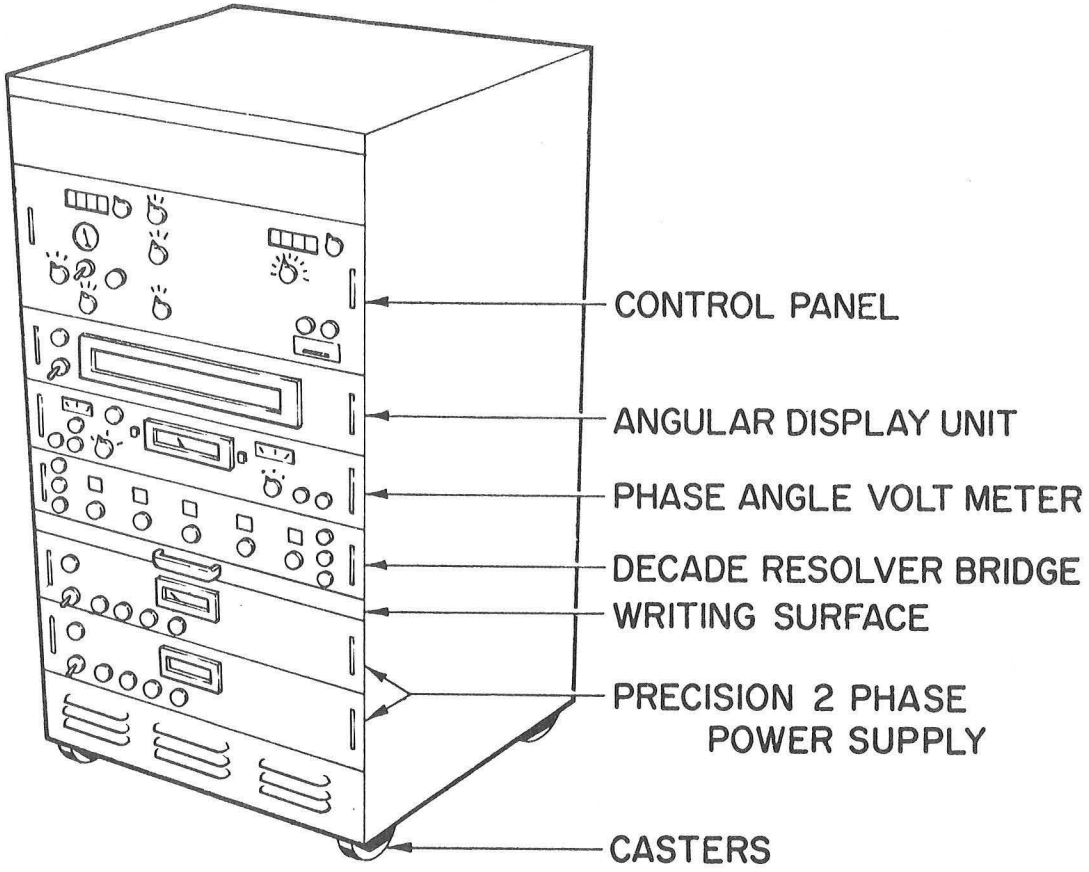
Description of Precision Test Fixture

The Precision Test Fixture is used in conjunction with the Functional Tester to perform the final acceptance test on the Optics Assembly.

The Fixture consists of a rigid frame, a precision turntable, two autocollimators, several flat mirrors, a resolution collimator, and (not an integral part of the rigid frame) a functional (electrical) tester.

The optics system will be mounted on the rigid frame of the test fixture in two orientations, horizontal and vertical. By use of the autocollimators, the precision turntable, and the flat mirrors, wobble test and resolution tests will be accomplished on the entire optics system (sextant and telescope). Electrical tests are accomplished by means of the functional tester.

Optics Functional Tester



Description of Functional Tester

The purpose of the Functional Tester, in conjunction with the Precision Text Fixture, is to provide the electronics necessary for testing the Optics Assembly. The following functions are provided by the tester:

a. Commands for driving the shaft and trunnion drives of the Scanning Telescope and Sextant.

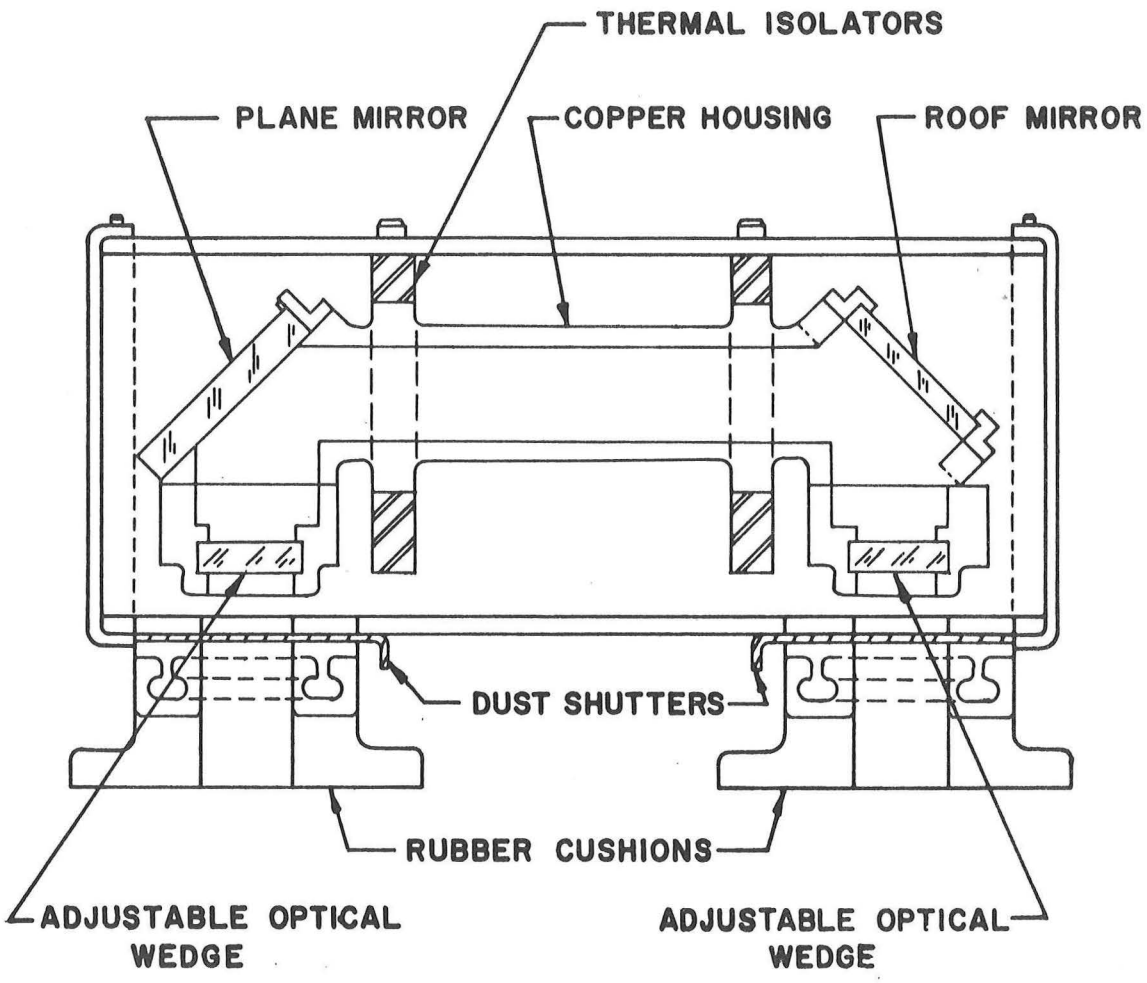
b. Angular position read-out of the optical assembly sextant 16- and 64-speed resolvers.

c. Measurement of breakaway and running voltages of Optical Assembly gear boxes.

d. Measurement of generator output and resolver null voltages.

The tester is equipped with manually positioned resolver transmitter units that provide the commands for shaft and trunnion drives of the SCT and SXT, bridge type readout of 16- and 64-speed resolvers, a variable voltage source and meters for measurement of breakaway and running voltages, a phase-sensitive voltmeter for measuring tachometer output and resolver null voltages, and power to the collimator control box on the Precision Test Fixture.

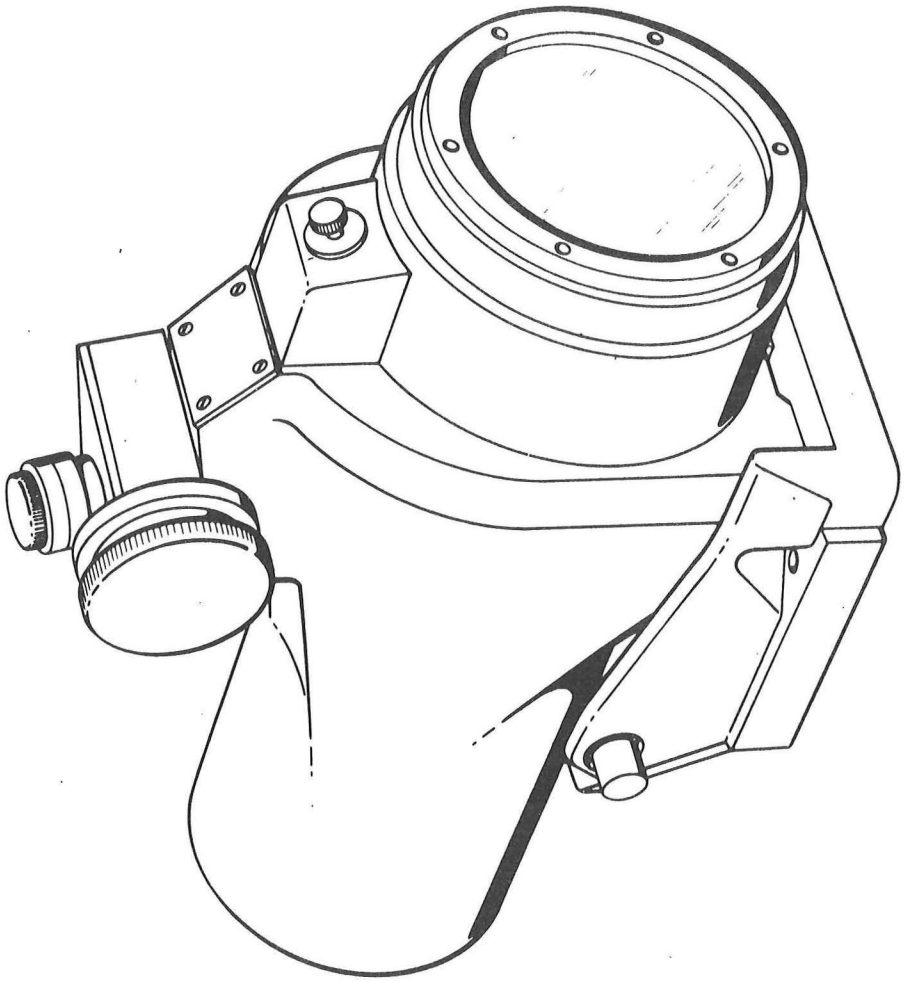
Short Periscope



Description of Short Periscope

The short retroreflecting periscope consists of a "split" retroreflecting prism and a suitable lens system mounted rigidly in a tube in such a manner that a ray of light entering one end of the tube will be parallel to itself upon exiting at the other end of the tube.

With the short retroreflecting periscope held over both the sextant and scanning telescope, parallelism checks may be made at several trunnion angle positions by using the illuminated sextant reticle and checking for superposition of images.



Coordinate Autocollimator

Description of 5-Inch Autocollimator

The 5-Inch Autocollimator measures angular displacements from which straightness, flatness, alignment, angular rotation, and small linear displacements can be determined. In addition, the 5-Inch Autocollimator incorporates a resolution pattern for determining resolution capability of the SXT and SCT and a sufficiently large aperture for checking parallelism between the SXT STLOS and SXT LLOS.

5-Inch Collimator Specifications

1. Range = ±10 min total field.
2. Reading repeatability better than 0, 250 sec of arc.
3. Reticle Pattern, annular pattern plus resolution chart to be per drawing No. 1017410 sht 2 of 2.
4. Measuring accuracy over the total range shall be better than 5 sec. Measuring accuracy within center 2 min to be better than 1 sec.
5. Glass filter reticle to be Tiffen filter No. 58 or equivalent (5000 A - 5800 A).
6. Unit to be supplied with objective and eyepiece protective covers.
7. The unit shall comply with the following requirement. The unit at full aperture shall be autocollimated off a flat mirror for original setting. A diaphragm of one quadrant opening shall be placed over objective, deviation from original setting not to exceed ±1 sec.
8. Second scale = graduated in half seconds, one revolution equal to one min.
9. Minute scale - counts the revolutions of the seconds scale graduated from 0 through 20 min.
10. Eyepiece - 20 X magnification.
11. Operating distance = 35 feet ±1 min at full range capability.
12. Elevation adjustment = $\pm 2^{o}$.
13. Azimuth adjustment = $\pm 2^{o}$.
14. Mounting hole size = (3) 1/4 -28NF.
15. Light source = transformer and rheostat for 115-volt, 60-cycle operation. Lamp - GE #328, 6-volt.
16. Over-all dimensions: length 18 inches; width 9 inches; height 12 inches.
17. Weight = approx 50 lbs.
18. Finish: Gray enamel per spec. (Pending)

19. Unit shall be stable when mounted on an inclined shelf pointing down.

20. Reticle centering is to be checked in accordance with the following procedure:

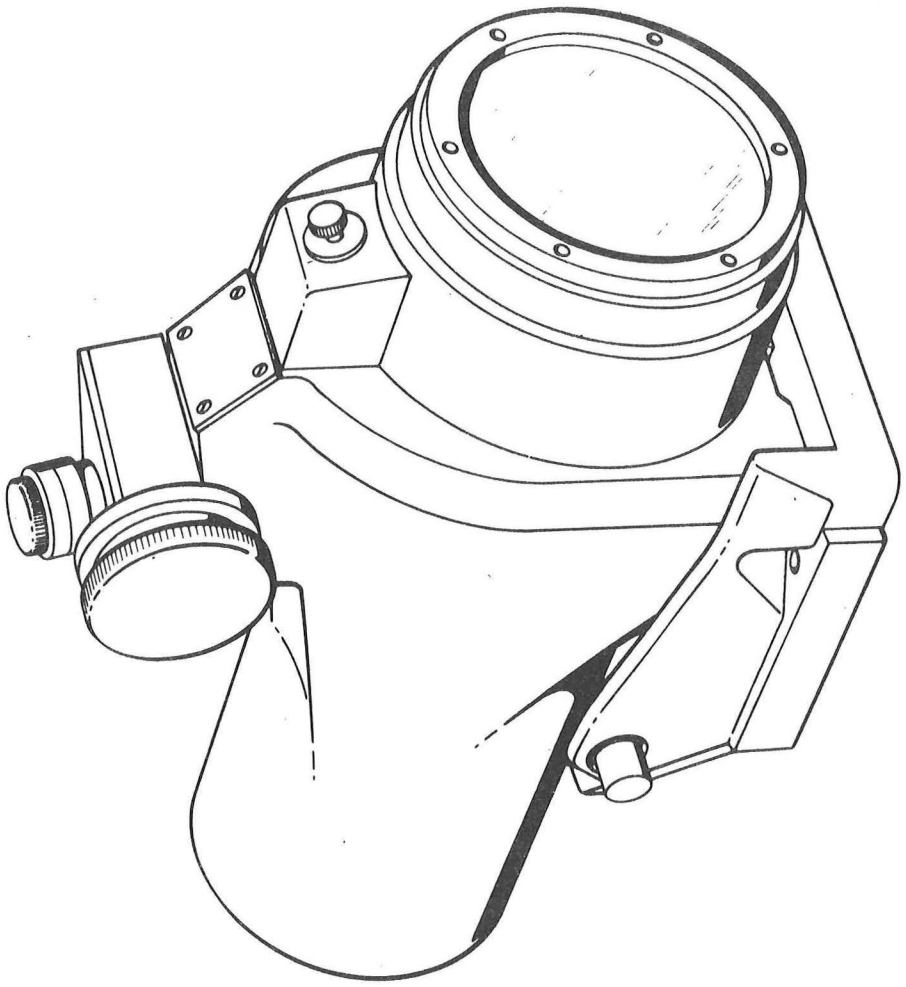
    Autocollimate off a precision flat mirror, the filar reticle to be superimposed on return image of the fixed reticle. The filar eyepiece then to be rotated and exhibit no deviation in excess of one second of arc from superpositioning on the return image of the fixed reticle.

    Position and align an autocollimator to view the objective reticle plus the backlighted filar reticle; deviation between filar and fixed reticle from superposition as viewed in the autocollimatore shall not exceed 0. 75 sec of arc.

21. Package for shipment per spec. (Pending)

22. 25. 625-inch focal length.

23. Lab environment - interior use, temperature range $70^{o} \pm 5^{o}$F.



Coordinate Autocollimator

Description of
2 1/2 Inch Autocollimator - SCT

The purpose of the 2 1/2 inch Autocollimator - SCT is to provide a precision optical reference for SCT testing during optical subsystem and G&N System Testing.

The Autocollimator is a precision optical target incorporating a two and a half inch aperture and a resolution and reticle pattern suitable for performing SCT testing.

2 1/2-Inch Collimator Specifications

1. Range = ±10 min total field.
2. Reading repeatability better than 0. 250 sec of arc.
3. Reticle Pattern, annular pattern plus resolution chart to be per drawing No. 1017435 sheet 2 of 2.
4. Measuring accuracy over the total range shall be better than 5 sec. Measuring accuracy within center 2 min to be better than 1 sec.
5. Glass filter reticle to be Tiffen filter No. 58 or equivalent (5000^{o} A - 5800^{o} A).
6. Unit to be supplied with objective and eyepiece protective covers.
7. The unit shall comply with the following requirement. The unit at full aperture shall be autocollimated off a flat mirror for original setting. A diaphragm of one quadrant opening shall be placed over objective, deviation from original setting not to exceed ±1sec.
8. Second scale = graduated in half seconds, one revolution equal to one min.
9. Minute scale counts the revolutions of the seconds scale graduated from 0 through 20 min.
10. Eyepiece - 20 X magnification.
11. Operating distance = 35 feet ±1 min at full range capability.
12. Elevation adustment = $\pm 2^{o}$.
13. Azimuth adjustment = $\pm 2^{o}$.
14. Mounting hole size = (3) 1/4 - 28 NF.
15. Light source = transformer and rheostat for 115-volt, 60-cycle operation. Lamp GE #328, 6-volt.
16. Over-all dimensions: length 12 3/4 inches; width 6 inches; height 8 3/4 inches
17. Weight = approx 21 lbs.
18. Finish - Gray enamel per spec. (Pending)

19. Unit shall be stable when mounted on an inclined shelf pointing down.

20. Reticle centering is to be checked in accordance with the following procedure:

    Autocollimate off a precision flat mirror, the filar reticle to be superimposed on return image of the fixed reticle. The filar eyepiece then to be rotated and exhibit no deviation in excess of one sec of arc from superpositioning on the return impage of the fixed reticle.

    Position and align an autocollimator to view the objective reticle plus the back-lighted filar reticle; deviation between filar and fixed reticle from superposition as viewed in the autocollimator, shall not exceed 0.75 sec of arc.

21. Package for shipment per spec. (Pending)

22. 20-inch focal length.

23. Lab environment - interior use, temperature range $70^{o} \pm 5^{o}$F.

Illustration of 2 1/2 - Inch Autocollimator

(see Sec. 4. 5. 1)

Description of
2 1/2 Inch Autocollimator - SXT

The purpose of the 2 1/2 inch Autocollimator - SXT, is to provide precision optical references for SXT trunnion accuracy tests during G&N System Testing.

The Autocollimator is a precision optical target with a two and a half inch aperture and a reticle pattern suitable for performing SXT testing.

Illustration of 0^{o} Autocollimator Plate

(not available)

Description of
0^{o} Autocollimator Plate

The purpose of the 0^{o} Autocollimator Plate is to hold and position the optical references during the optical subsystem test and the G & N System Tests.

This device is basically a rigid mounting plate supporting a 5 inch autocollimator, a 2-1/2 inch autocollimator (SCT) and an adjustable mirror.

Illustration of 45° Autocollimator Plate

(not available)

Description of

45^{o} Autocollimator Plate

The purpose of the 45^{o} Autocollimator Plate is to position and hold the optical references during the G & N System Test.

This device is basically a rigid mounting plate supporting two 2-1/2 inch autocollimators (SXT), and an adjustable mirror.

Illustration of T-3A Theodolite

(not available)

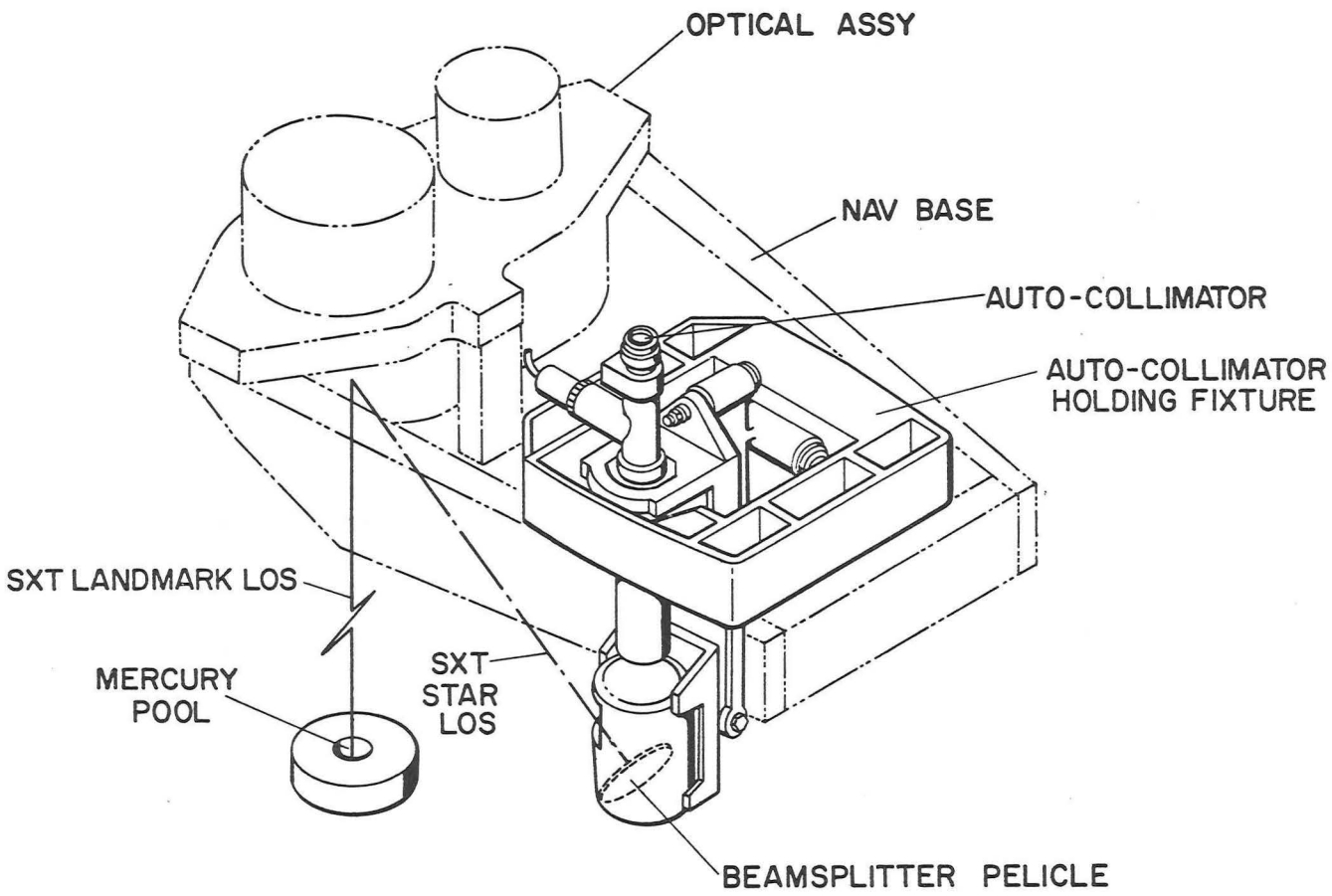
Description of Theodolites

Theodolites are used as facility tools for obtaining A_z with references for alignment of rotary table, mounting fixtures, and optical targets. Similarly they will serve if required during optical testing as secondary targets for additional random test points for trunnion axis accuracy verification.

The T-3A theodolite is a highly precise optical instrument incorporating a wide aperture and an autocollimating feature. In addition, the reticle pattern is calibrated to angular readout scales on the theodolite and therefore may be utilized as a precision target.

The theodolites will be indexed to a known azimuth and then "sighted in" several times with the optics system. The optics angles will then be fed to the computer, the IMU aligned, and all pertinent data recorded. Calculations will then provide an IMU drift check and an IMU to Optics alignment check.

Alignment Mirror Assembly



Description of Alignment Mirror Assembly

The Alignment Mirror Assembly consists of a precision autocollimator, a holding fixture, mercury pools and an adjustable base.

Its function is to measure azimuth relationship of the IMU pads and pins of the Navigation Base with respect to the optics, and parallelism between the Navigation Base "Z" axis and the Optics LLOS.

Illustration of Adjustable Mirror

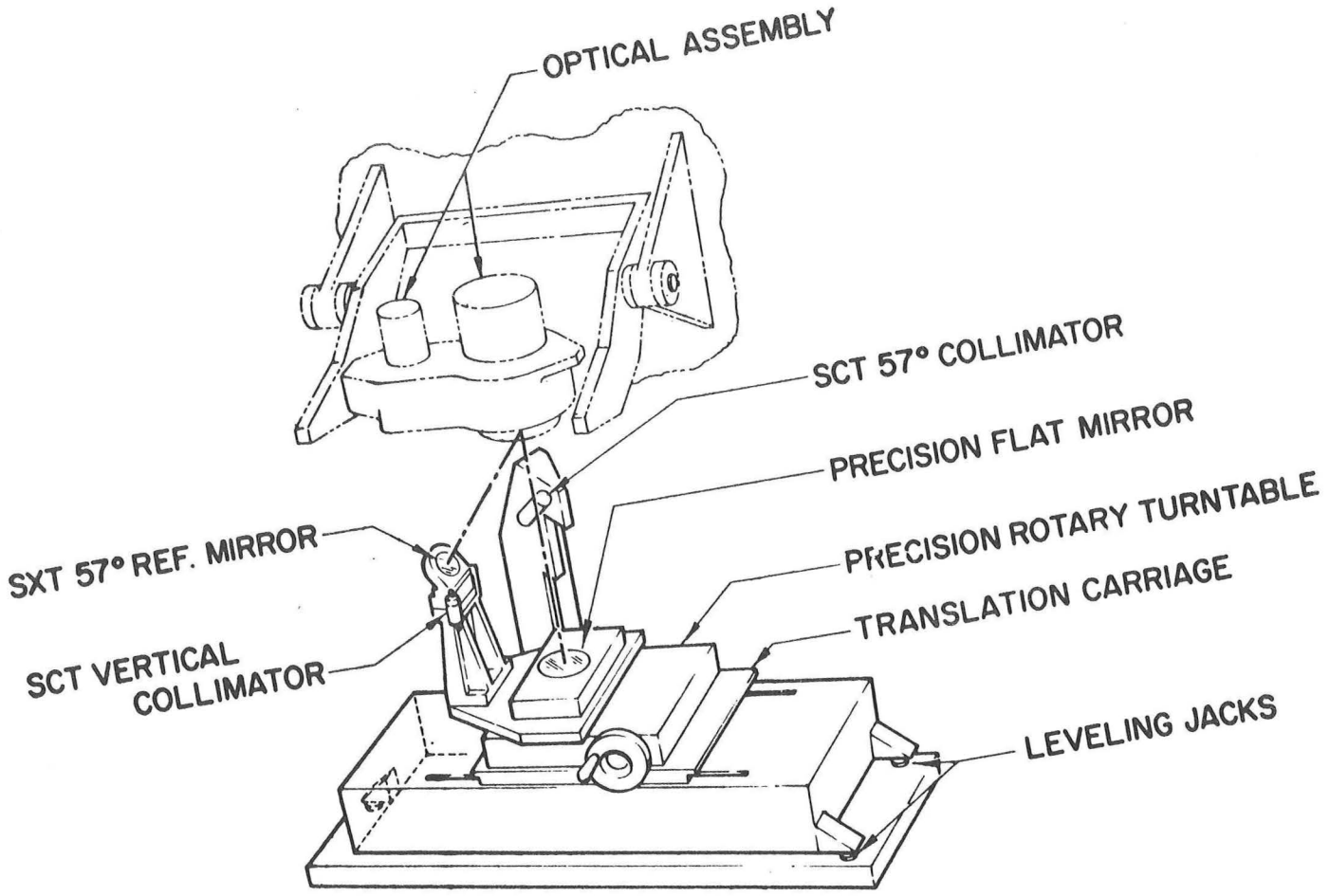
(not available)

Description of Adjustable Mirrors

The Adjustable Mirrors are used in conjunction with a theodolite to establish additional reference angles for checking SXT-SCT trunnion accuracy during system-level testing.

The Adjustable Mirror is glass, flat (for example - 1/10λ), front mirrored, and positioned on a stand that has capability of adjustment.

Shaft Accuracy Tester, Precision Rotary Table

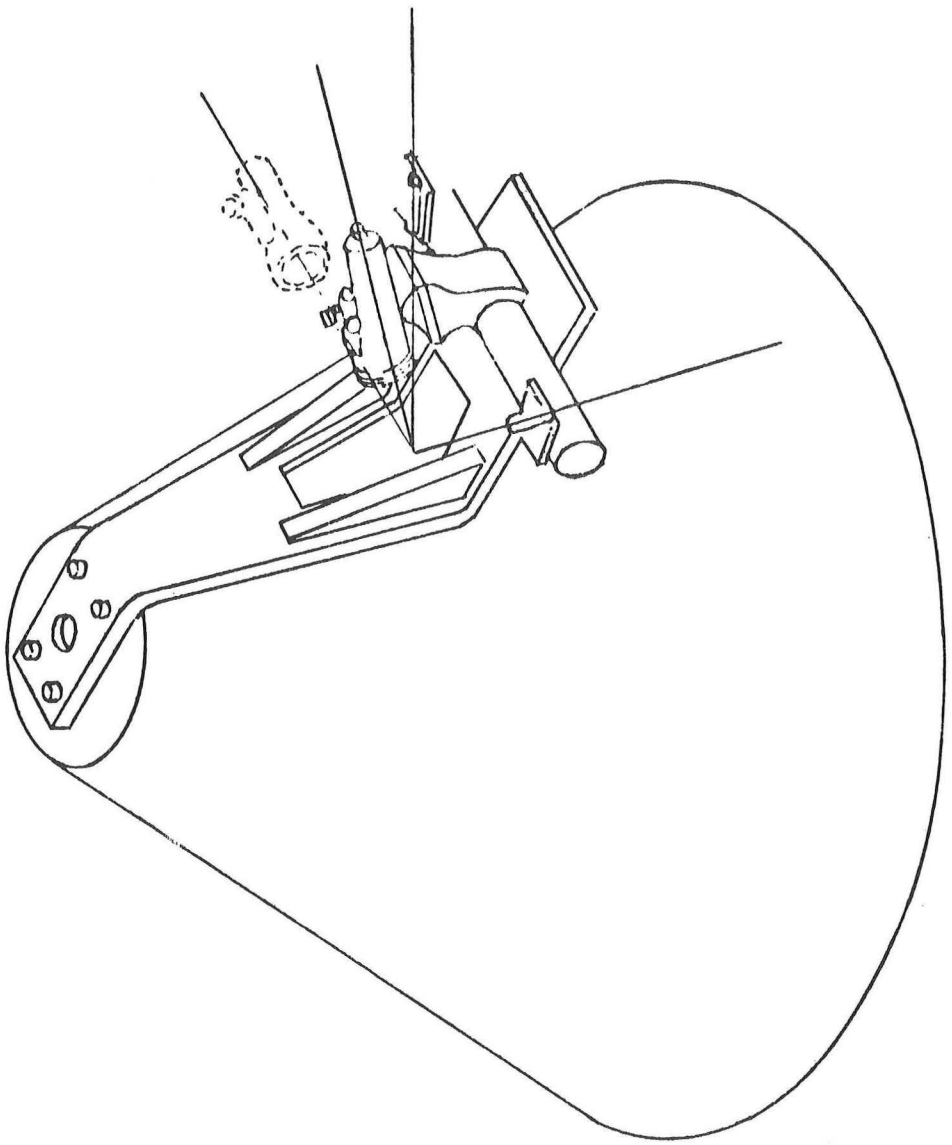


Description of Shaft Accuracy Tester, Precision Rotary Table

The Shaft Accuracy Tester is used in Optics Subsystem testing. It provides a means for the SXT and SCT shaft axis accuracy tests. The Tester consists of an instrument rotary table with a collimator and mirror mounted to the table. The table mounts onto a base frame possessing level adjustment capability. Translation freedom to enable tests of both the SXT and the SCT shaft axis is incorporated in the base. Table readout accuracy is 2 arc-sec.

Testing is performed in conjunction with the Precision Rotary Table to which the Nav Base Optics Assembly is mounted. The rotary table is tilted to position the optics shaft axis line of sight down toward the Shaft Accuracy Tester.

G & N Installation Qualification Fixture



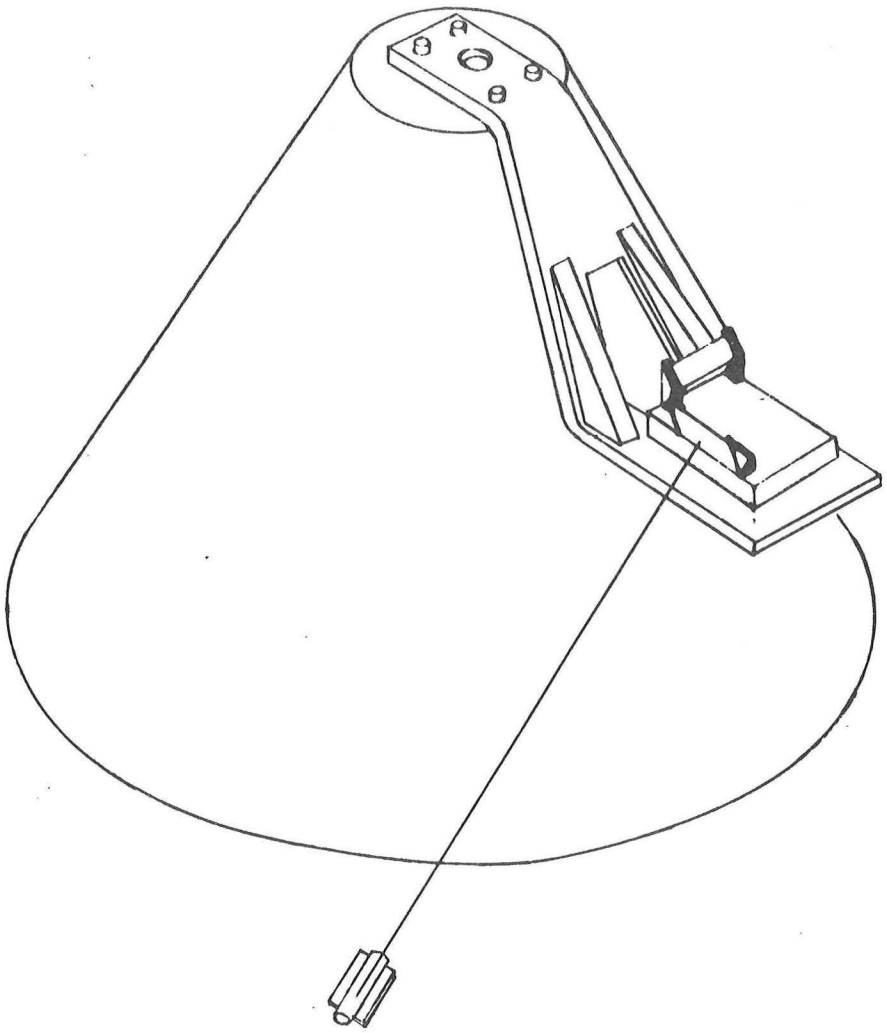
Description of

G & N Installation Qualification Fixture

The G & N Installation Qualification Fixture is used for Optics-to-IMU alignment verification, parallelism checks of both SXT lines-of-sight at trunnion angle = 0^{o}, trunnion angle linearity tests, optics resolution tests, and possible optical scatter tests.

The fixture consists of a rigid holding fixture, a 5-inch autocollimator, and two autoset level collimators.

Azimuth Reference Fixture



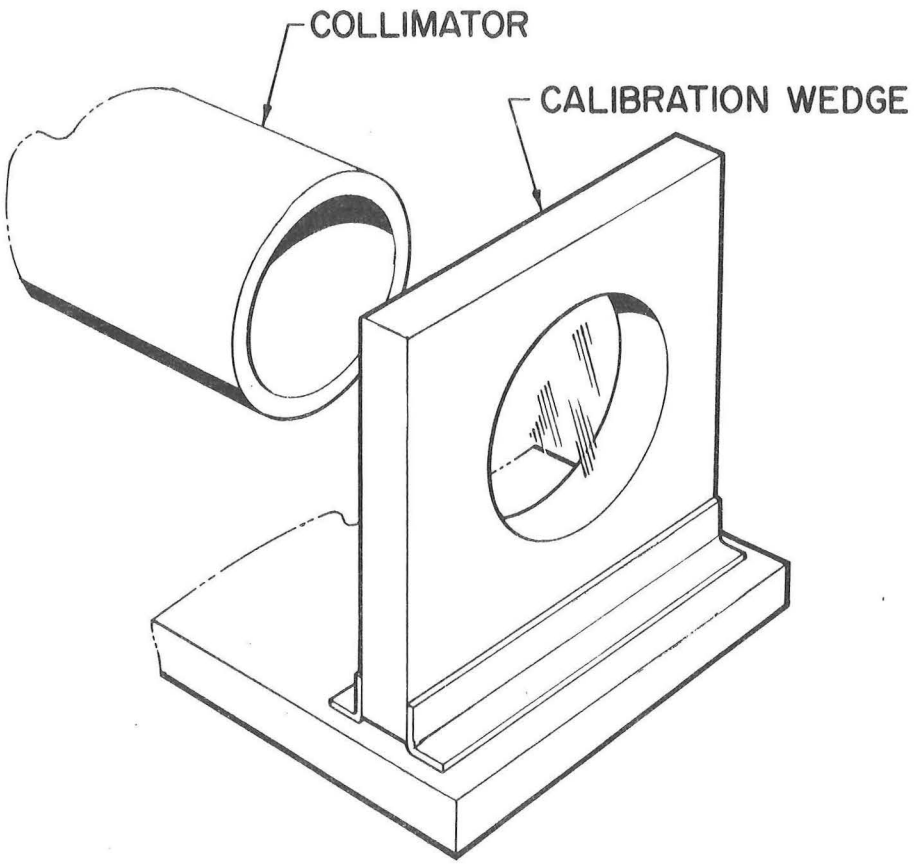
Description of

Azimuth Reference Fixture

The purpose of the Azimuth Reference Fixture is used to provide an azimuth reference (within ± 30 sec) to the optics for performing IMU drift tests.

The fixture consists of a rigid frame type holding fixture and two prisms.

Calibrated Wedge



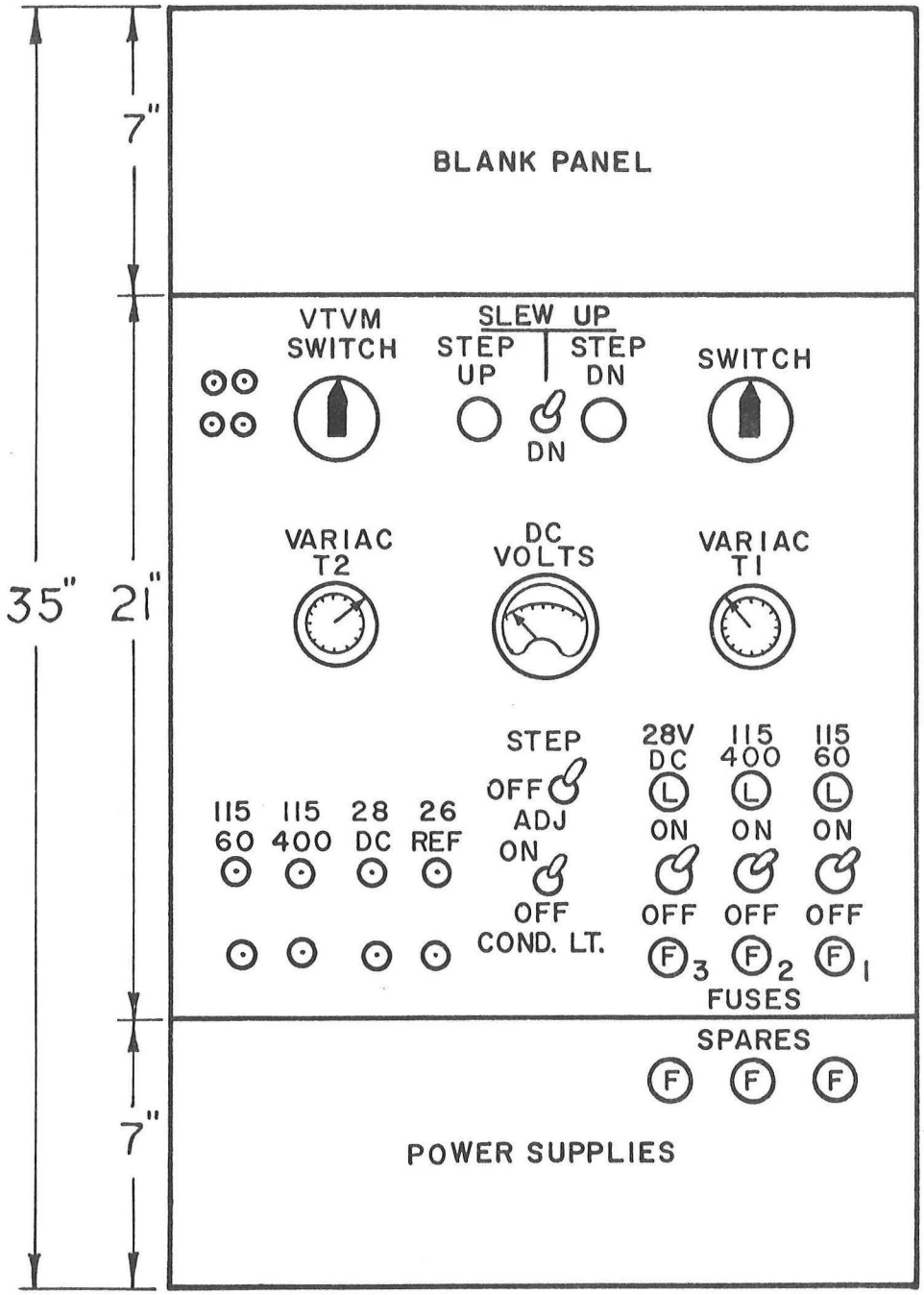
Description of Optical Wedge Set,

Variable Deviation

Optical Wedges are made from high-quality glass or quartz and are used for deviating a beam of light through known angles.

Optical wedges will be utilized at various stages of optics testing to perform checks of the Sextant Trunnion incremental angular accuracy.

Map & Data Viewer Tester



Description of Map and Data Viewer Tester

The MDV Tester, has the capability of determining whether or not the MDV unit is in an operational status.

The MDV Tester contains all the controls necessary for proper system operation in the manual, step and slew modes. It also supplies the MDV with the power required to energize the unit. The input and output signals fed to the MDV are monitored by utilizing a built-in d-c voltmeter in conjunction with external test points which are available for use with a site-supplied oscilloscope and VTVM. The condition lights are checked by the use of a switch which energizes each light in the MDV.

Illustration of Optics/Nav Base Shipping Container

(not available)

Description of Optics-Navigation Base Shipping Container

The Optics-Navigation Base Shipping Container is now undergoing preliminary layout design. This container will be capable of shipping either of the two following configurations:

1. The Optics Assembly, a dummy Navigation Base, a holding cradle, and a handling fixture.
2. The Optics Assembly, the Navigation Base, a holding cradle, and a handling fixture.

The first configuration will be utilized for shipping Optics Assemblies from Kollsman. The second will be utilized for shipping the Optics-Navigation Base Assembly from AC Spark Plug.

The holding cradle which will serve a dual function will be utilized during shipping to protect the Navigation Base mounts and it will be used after shipping to contain the Optics-Navigation Base Assembly in the G & N Transportation Cart.

The handling fixture, also serving a dual purpose, will be utilized during shipping to protect the IMU pads and pins of the Navigation Base, and after shipping for transferring the Optics-Navigation Base Assembly from the cradle and Transportation Cart to test fixtures or into the Command Module.

Illustration of Optics Shipping Container

(not available)

Description of Optics Shipping Container

The purpose of the Optics Shipping Container is to provide interim optics protection during handling, storage and shipping from Kollsman to various guidance sites until the Optics-Nav Base Shipping Container becomes available.

The container consists of an inner and outer member. The optics assembly is shock mounted to the inner container and sealed in an inert atmosphere. The inner container is suspended on shock mounts within the outer container in a filtered and a humidity controlled atmosphere.

E-1432

DISTRIBUTION LIST

Internal

R. Alonso
J. Arnow (Lincoln)
R. Battin
W. Bean
E. Berk
P. Bowditch
A. Boyce
R. Boyd
P. Bryant
R. Byers
G. Cherry
E. Copps
S. Copps (MIT/ASCP)
R. Crisp
W. Crocker
G. Cushman
J. Dahlen
O. De Tommaso
E. Duggan
J. Dunbar
K. Dunipace (MIT/AMR)
R. Euvrard
P. Felleman
S. Felix (MIT/S & ID)
J. Flanders
J. Fleming
L. Gediman
J. Gilmore
F. Grant
D. Grief
Eldon Hall
I. Halzel
D. Hanley
W. Heintz
E. Hickey
D. Hoag
A. Hopkins
F. Houston
M. Johnston
B. Katz
A. Koso
M. Kramer
W. Kupfer
A. Laats
D. Ladd
A. LaPointe
L. Larson
J. Lawrence (MIT/GAEC)
T. Lawton
D. Lickly
R. Magee
G. Mayo
J. McNeil
R. McKern
R. Mudgett
James Miller
John Miller
J. Nevins
G. Nielson
J. Nugent
E. Olsson
C. Parker
W. Patterson
J. Potter
K. Samuelian
P. Sarmanian
R. Scholten
J. Sciegienny
D. Scolamiero
N. Sears
D. Shansky
T. Shuck
W. Stameris
E. Smith
W. Smith
W. Tanner
R. Therrien
W. Toth
M. Trageser
R. Weatherbee
R. White
L. Wilk
R. Woodbury
W. Wrigley
D. Yankovich
Apollo Library (2)
MIT/IL Library (6)

External

(ref. APCAN; 2 July 1963)

P. Ebersole (NASA/MSC)		(2)
W. Rhine (NASA/RASPO)		(1)
S. Gregorek (NAA S & ID/MIT)		(1)
T. Hueurmann (GAEC/MIT)		(1)
AC Spark Plug		(10)
Kollsman		(10)
Raytheon		(10)
WESCO		(2)
Capt. W. Delaney (AFSC/MIT)		(1)
NAA RASPO:	National Aeronautics and Space Administration Resident Apollo Spacecraft Project Office North American, Inc. Space and Information Systems Division 12214 Lakewodd Boulevard Downey, California	(1)
CAPE:	National Aeronautics and Space Administration Kennedy Space Center Cape Kennedy, Florida Attn: Mr. B. P. Brown	(3)
HDQ:	NASA Headquarters 1520 H Street Washington, D. C. Attn: Mr. G. M. Low, M. A. P.	(6)
AMES:	National Aeronautics and Space Administration Ames Research Center Moffett Field, California Attn: Library	(2)
LEWIS:	National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio Attn: Library	(2)
FRC:	National Aeronautics and Space Administration Flight Research Center Edwards AFB, California Attn: Research Library	(2)
LCR:	National Aeronautics and Space Administration Langley Research Center Langley AFB, Virginia Attn: Mr. A. T. Mattson	(2)

GSFC:	National Aeronatuics and Space Administation Goddard Space Flight Center Greenbelt, Maryland Attn: Manned Flight Support Office code 512	(2)
MSFC:	National Aeronautics and Space Administration Geroge C. Marshall Space Flight Center Huntsville, Alabama Attn: R-SA	(2)
GAEC:	Grumman Aircraft Engineering Corporation Bethpage, Long Island New York Attn: Mr. A. Whitaker	(1)
NAA:	North American Aviation, Inc. Space and Information Systems Division 12214 Lakewood Boulevard Downey, California Attn: Mr. R. Berry	(1)
GAEC RASPO:	National Aeronautics and Space Administration Resident Apollo Spacecraft Project Officer Grumman Aircraft Engineering Corporation Bethpage, L. I. , New York Attn: Mr. Jack Small	(1)
WSMR:	National Aeronautics and Space Administration Post Office Drawer D White Sands Missile Range White Sands, New Mexico	(2)
MSC:	National Aeronautics and Space Administration Manned Spacecraft Center Apollo Document Control Group (SPID) Houston 1, Texas	(45)