APOLLO
OPTICAL SUBSYSTEM
AND
LM ALIGNMENT OPTICAL TELESCOPE

FINAL REPORT

VOLUME II
(2 of 2)

February 1970

Prepared For
AC Electronics Division
General Motors Corporation
Milwaukee, Wisconsin

Kollsman Instrument Corporation
Syosset, New York

NASA CR108360

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Subcontract No. FNP 12776
NASA Prime No. NAS-9-497
February 1970

Approved by: Stanley Millman
S. Millman
Program Director

KOLLSMAN INSTRUMENT CORPORATION
Syosset, New York

Section 5

RELIABILITY

5.1 SUMMARY OF YEAR ENDING 31 DECEMBER 1962

5.1.1 Establishment of Standards and Techniques

The function of the Apollo Reliability group at Kollsman was to assure the reliability of the product, by establishing standards of workmanship, techniques of manufacture, techniques and standards for the measurement of achieved reliability, and by indoctrinating project personnel with Reliability concepts and Reliability consciousness.

5.1.2 Preparation of Reliability Plan

During this period the Reliability Plan was prepared, revised and re-submitted to MIT/IL for final approval. In view of the considerably increased scope of work proposed subsequent to that estimated in the initial proposal, a study was initiated to determine what additional facilities and/or equipment were necessary to fulfill the Reliability requirements of the program.

The Reliability Milestone Chart is shown in Figure 5-1.

The Reliability Group's function was a program of determining reliability requirements through reliability analyses, environmental analyses, design review, test planning and selection of parts and materials for the Apollo Optical Subsystem.

5.1.3 Assignments

Work was performed during this period against the following MIT Technical Directives:

TD K3 - Reliability Implementation Plan

TD K-11 - Vendor Reliability and Quality Control

TD K-20 - Failure Reporting System

TD K-28 - Reliability Analysis

TD K-29 - Reliability Test and Evaluation

TD K-30 - Reliability Training

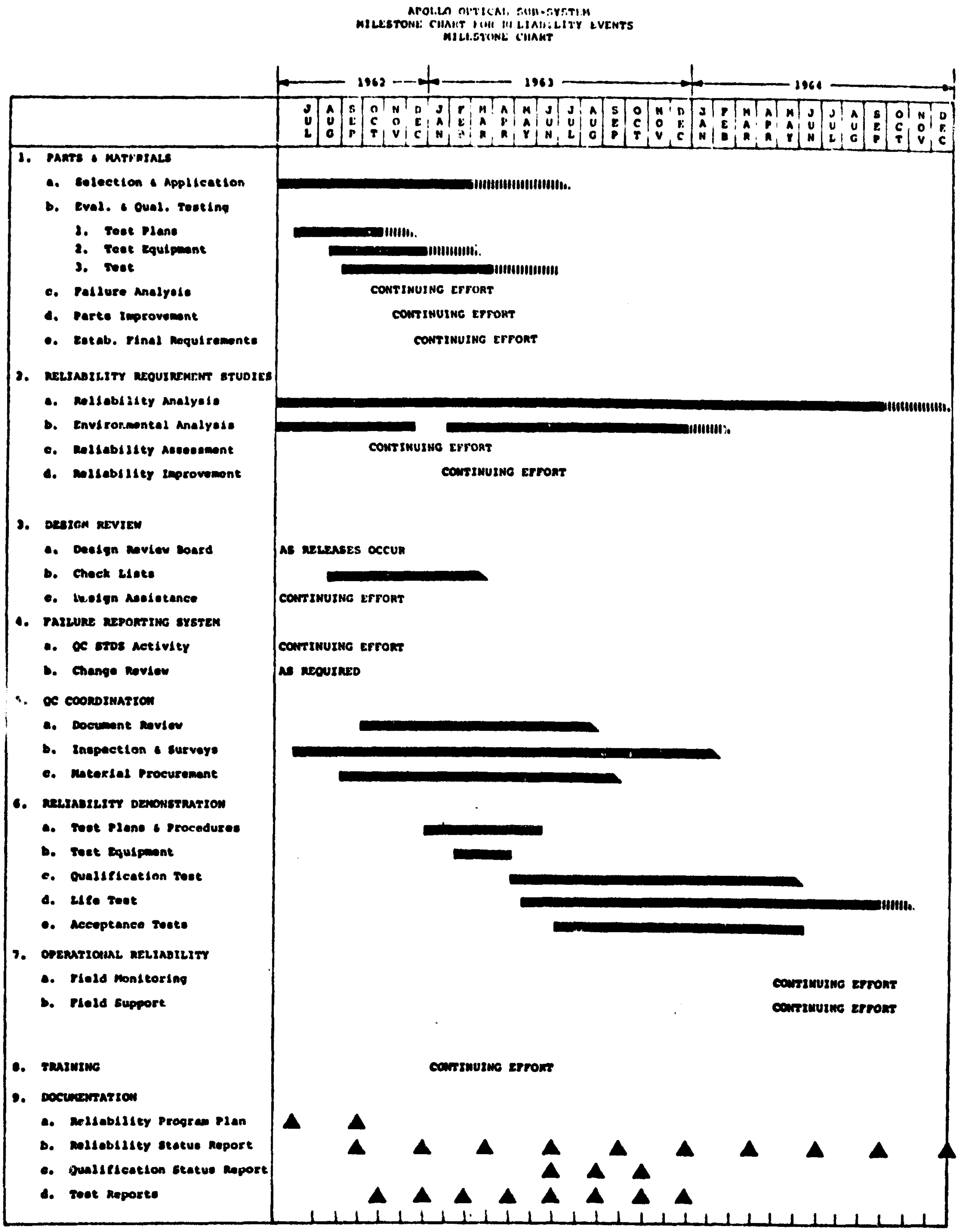


Figure 5-1. Milestone Chart for Reliability Events

The long range effort of the Reliability Group was broken down into the following major categories, projected on the milestone chart (Figure 5-2):

Reliability Program

Parts and materials selection and application

Parts and materials testing

Reliability analysis

Environmental analysis

Design review

Failure reporting

Quality Assurance coordination

Data center

Reliability demonstration

Operational reliability

Training

Progress was made on all phases except Reliability demonstration and Operational reliability which were not due for action until the third quarter of 1963.

5.1.4 Accomplishments

The Reliability Implementation Plan was completed and submitted to MIT for review and approved in accordance with TD K-3. A study was initiated and completed to determine the additional facilities and equipment necessary in view of the increased scope of effort. The reliability work performed was as follows:

1. TD K-11

Training of purchasing department representatives and potential beryllium vendors in reliability requirements was inaugurated through two training sessions conducted in collaboration with the Quality Assurance Department's training program. Promoting better understanding of the high reliability requirements for purchased items increased the overall effectiveness of the procurement program. At the vendor training session 19 vendor representatives covering 9 companies were present.

Three beryllium vendors were surveyed and evaluated favorably: American Beryllium Corporation, Sarasota, Florida, American Precision Industry, Buffalo, New York, and Reeves Instrument Corporation, Garden City, New York. Fish-Schurman, New Rochelle, New York, was approved as a supplier of optical glass. Approval

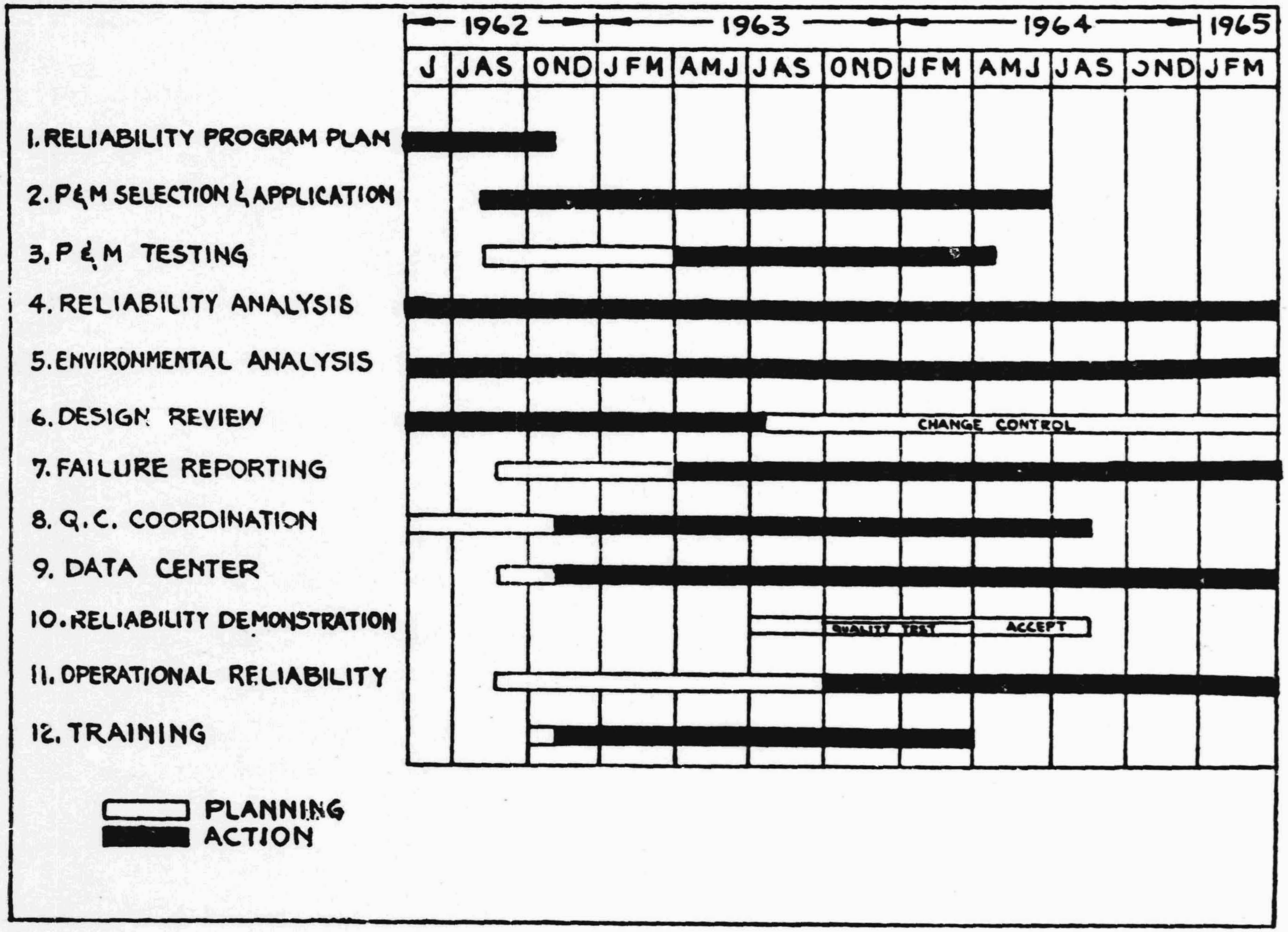


Figure 5-2. Apollo Reliability Milestone Chart

as a processor for vacuum deposition of anti-reflective coatings was withheld from Fish-Schurman because of their reluctance to conform to process control requirements.

Review of problems and requirements in providing a high precision resolver was held at Eclipse Pioneer Division of Bendix Corporation at Teterboro, New Jersey. This resolver was in the breadboard stage. As very little information was available with regard to reliability, a number of Quality problems were quite evident and of great concern.

Qualification testing philosophy was reviewed in detail at a meeting at MIT/IL on December 4, conducted by Mr. G. Mayo. In line with the objective to eliminate duplicate test effort on parts and materials used by more than one participating contractor, Kollsman was assigned the responsibility for drawing up test plans for rotating components, materials and glass. This program utilized results of the environmental studies already conducted and was of great value in planning tests of other portions of the optical subsystem.

Initial test plans for motor-generators were suspended and the purchase order for 12 units recalled when the sextant design was held up. The plans were updated to conform to the latest test plan philosophy and to consider more recent environmental data. The motor generator was retained in the new sextant design and a specification control drawing was completed for the purchase of those motor-generators for qualification testing.

The Reliability Data Center was in operation and contained files of engineering references, specifications, reports and reliability information. The first set of reliability abstracts was received from NASA. A "Reliability Data Summary" form was instituted and maintained in the Data Center as the prime source of reliability information on each part of the optical subsystem (see Figure 5-3).

Coordination with Quality Assurance was maintained on a continuous basis. Noteworthy actions along these lines were coordinated in preparation of the failure reporting system, the purchased items training program, and vendor surveys, conducted primarily by Quality Assurance.

2. TD K-20

The preliminary plan for the Apollo Failure Reporting System was submitted to MIT for review and approval. This plan incorporated aspects of the A.C. Spark Plug failure reporting system that required action by Kollsman as established at a coordination meeting held by ACSP. It also showed the details of the system for reporting failures that might occur at Kollsman and the procedure for obtaining effective corrective action. Kollsman prepared the

Component ______________________ **Sheet** ______ **of** ______

Assembly ______________________ **Signed** ______________

Sub-Assembly ______________________ **Date** ______________

Environment	**Error:**

Item No.	Part Name	Manufacturer and Part Number	NASA Part No.	Part Material	Insulation Class	Temp. Rise °C	Speed RPM	Failure Rate % /1000 HR

Figure 5-3. Reliability Analysis Part Usage and Application Form

internal failure reporting on a report form designed for internal processing. Failures from the field or final acceptance testing were coordinated between ACSP and Kollsman by the ACSP MIL 1352 form.

3. TD K-28

An initial Reliability Analysis of the Sextant was performed utilizing failure rates received from MIT and mechanical failure rates taken from, "Reliability Application and Analysis Guide MI-60-54, Revision 1, July, 1961", The Martin Company, Denver. This analysis resulted in the following reliability estimate for the Sextant:

Operating Mode	Failure Rate %/1000 Hrs.	Reliability for 27 Hr. Oper.
Star	2.32	.99937
Star and Landmark	3.26	.99912

This estimate was revised to reflect the latest redesign in the Sextant. The reliability apportionment for the Sextant and Telescope is .9985 as specified by MIT/IL.

Improved reliability models were developed for the sextant and telescope as additional design data became available (figures 5-4 and 5-5). These models served as a basis for new reliability calculations and were a major consideration in establishing the reliability test program. Possible modes of failure, the effects of failure on operating modes were studied and constituted further factors in test planning and reliability improvement. Included in these studies was an error analysis where the effects on system performance were evaluated as a result of combinations of electrical, mechanical, and optical errors for worst case analysis. A reliability analysis form (figure 5-6) was used for these evaluations.

An outline of environmental influences, to which the Optical S/S was subjected, was based upon existing engineering data for similar spare application and for various published sources. The information was required for use in the selection of materials and parts; the performance of design review; aid to design engineers in application; and to a lesser extent, background data to prospective vendors and suppliers.

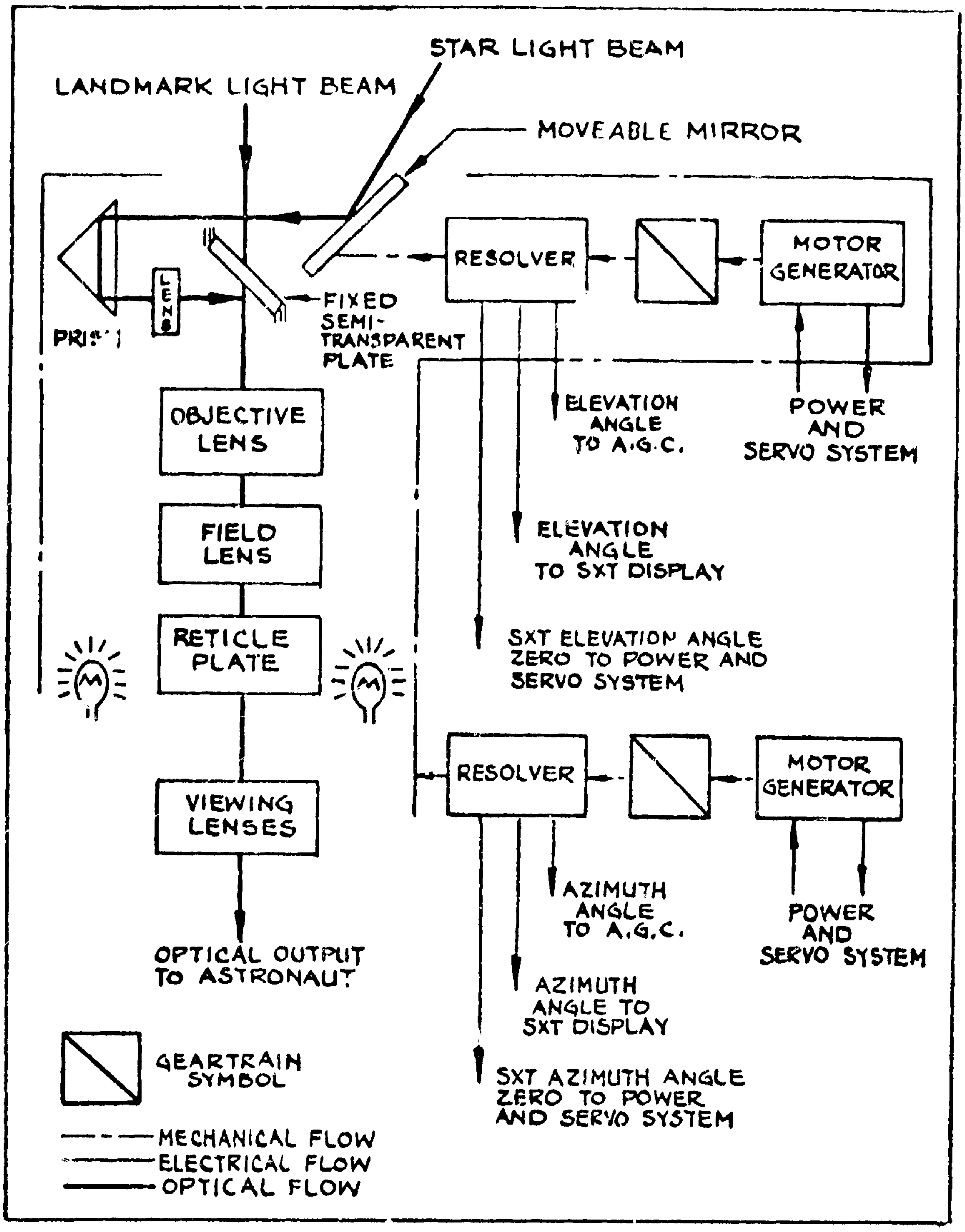


Figure 5-4. Functional Block Diagram
Apollo Optical Subsystem Sextant

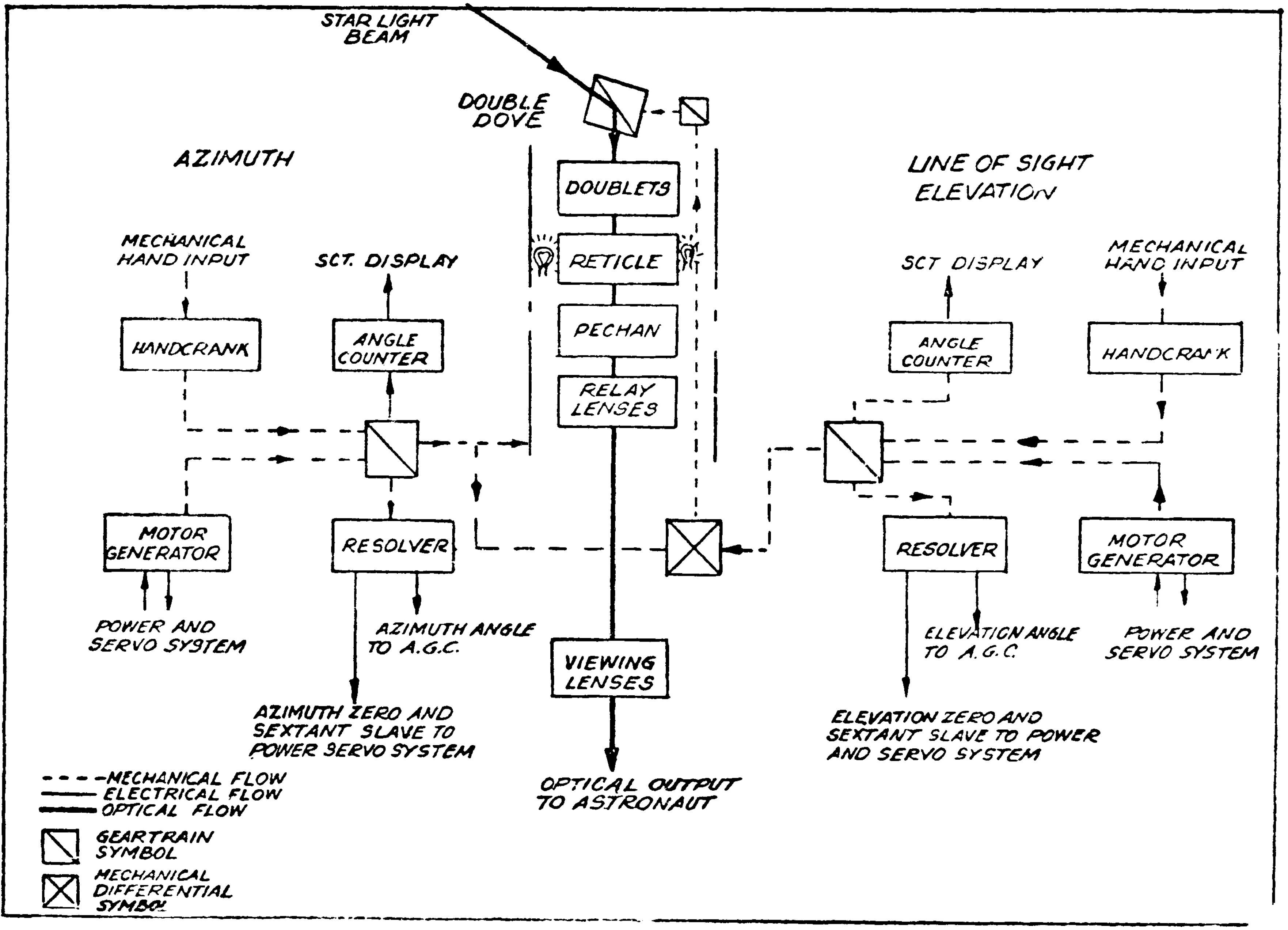
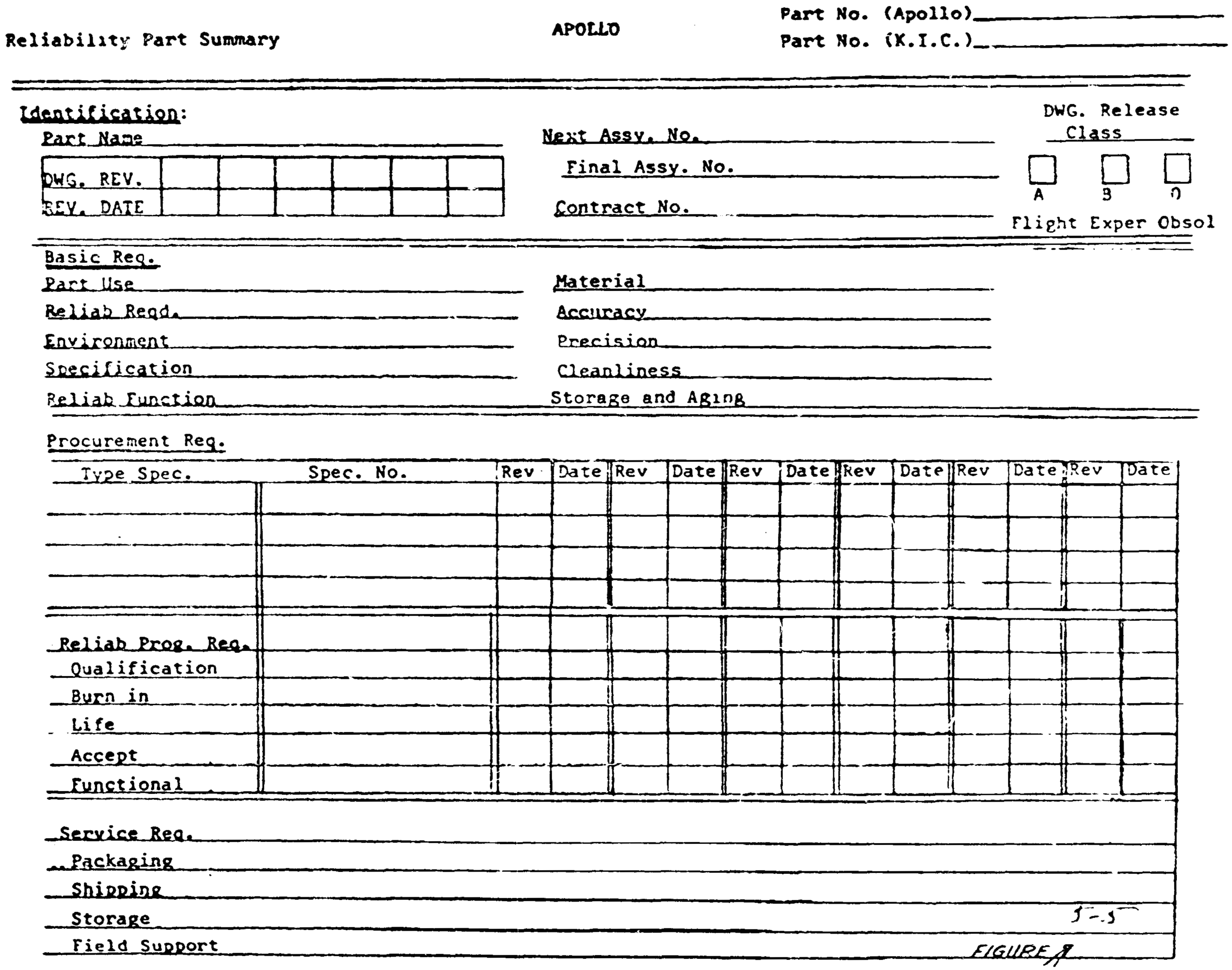


Figure 5-5. Functional Block Diagram Apollo Optical Subsystem Scanning Telescope



Reliability Part Summary **APOLLO**

Part No. (Apollo)__________
Part No. (K.I.C.)__________

Identification:

Part Name __________

DWG. REV.						
REV. DATE						

Next Assy. No. __________
Final Assy. No. __________
Contract No. __________

DWG. Release Class
☐ A ☐ B ☐ O
Flight Exper Obsol

Basic Req.
Part Use __________
Reliab Reqd. __________
Environment __________
Specification __________
Reliab Function __________

Material __________
Accuracy __________
Precision __________
Cleanliness __________
Storage and Aging __________

Procurement Req.

Type Spec.	Spec. No.	Rev	Date	Rev	Date	Rev	Date	Rev	Date	Rev	Date	Rev	Date
Reliab Prog. Req.													
Qualification													
Burn in													
Life													
Accept													
Functional													

Service Req.
Packaging __________
Shipping __________
Storage __________ 5-5
Field Support __________ FIGURE A

Figure 5-6. Reliability Part Summary

An extensive thermal analysis was performed to accurately define subsystem temperature levels and their effects on performance and life characteristics.

The Reliability Group participated in five design review meetings and in engineering planning meetings. Items covered included change in material from A151 416 to A151 440 Stainless Steel, selection of optical glass to resist discoloration from gamma radiation, final packaging of the Optical Subsystem, heat treatment requirements, and dimensional tolerancing. A design review checklist was developed as an aid to design engineers in preparing the original designs and as a further aid in design review. The checklist points out such considerations as corrosion resistance, thermal coefficients of expansion, stress distribution, locking devices, thermal effects, strength and resiliency.

Reliability models and calculations were continued and refined as new design and performance information became available. Error analysis and failure effect analysis were included in the calculations.

The thermal analysis was continued and a detailed study of vibration and acceleration effects was started concurrently with the thermal analysis to facilitate design completion and to determine areas requiring reliability improvement.

The qualification test program was outlined and plans generated for testing of rotary components, materials, and optics.

Vendor indoctrination in reliability followed by vendor surveys evaluations was continued in cooperation with Quality Assurance.

5.2 SUMMARY OF YEAR ENDING 31 December 1963

5.2.1 Assignments

TDK-11	Vendor Reliability and Quality Control
TDK-28	Reliability Analysis
TDK-29	Reliability Test Evaluation
TDK-30	Reliability Training
TDK-42	Design Evaluation and Qualification Test Program
TDK-48	Shipping Container Design
TDK-60	Thermal Analysis
TDK-61	AGE 2 Mechanical Integrity Test
TDK-62	Stress Analysis
TDK-76	Failure Reporting System
TDK-79	AGE 1 and 2 MDV Mechanical Integrity and Thermal Analysis
TDK-80	Part Qualification Test Program (replaces TD's 29 and 42)
TDK-81	Optical Navigational Base Assembly Shipping Container and Cradle
TDK-83	AGE 1 Optical Subsystem Thermal/Vacuum Tests
TDK-103	Fabrication of four OSS Shipping Containers

5.2.2 TDK-11 Vendor Reliability and Quality Control

a. Description of Effort

During the reporting period work continued on this TD, which was initiated in 1962, authorizing work to be performed as support to MIT Design and Reliability in the selection of component parts and materials for the Optical Subsystem. This effort included review of available data, vendor surveys and approval of sources, initial evaluation of parts, determination of inherent weaknesses and/or failure mechanisms of parts, institution of corrective action procedures, recommendations for parts improvement, preparation of procurement specifications and/or SCD's, recommendations for control of critical items, recommendations for burn-in and screening tests, and planning for qualification tests of parts.

b. Accomplishments

Vendor surveys on potential suppliers of parts and materials for the Optical Subsystem continued. As a continuing effort, components furnished by vendors not in accordance with the original drawing specifications were submitted to the Material Review Board (MRB) and reviewed by Reliability in conjunction with Project Engineering and Quality Assurance to determine acceptance or disposition of rejected parts.

Specification changes submitted to MIT via waivers were coordinated and reviewed by Reliability in conjunction with Project Engineering and Quality Assurance to determine the acceptability of the deviations and their effect on other areas.

A comprehensive review of all MIT/IL approved waivers was initiated. The purpose was to institute and effect corrective action in sufficient time for Block II effectivity.

c. Problem Areas

There was a need for additional funding for a Reliability Audit effort. This effort was extremely important in view of the fact that (1) the Parts Qualification Test Program involved various parts, for which quality waivers (to ND 1015404) had been affected, and (2) parts procurement for deliverable and flight hardware were accomplished by separate buys or lots.

5.2.3 TDK-28 Reliability Analysis

a. Description of Effort

This TD initiated in 1962 authorized a reliability analysis to be performed on the Optical Subsystem. This effort included failure effect, environmental studies, design review, reliability predictions and assessments.

b. Accomplishments

A quantitative reliability analysis report for the OSS and MDV was updated to include latest system configuration and included an initial prediction, a maintainability analysis, functional block diagrams for the OSS and MDV, and an appendix which described a method for analyzing the combined statistical behavior of electrical and mechanical parts. Because of significant changes in operating times, checkout policies, and overall repair cycle time, the maintainability and availability results were updated.

Design reviews on the MDV and OSS were attended by Reliability and recommendations were made in accordance with findings from the reliability and environmental analyses.

5.2.4 TDK-29 Reliability Test and Evaluation

a. Description of Effort

Prepared detailed test plans pertaining to reliability tests and evaluations. Submitted completed test plans to MIT/IL for review and approval. Planned and designed test equipment, test fixtures and associated equipment necessary for reliability evaluation and test of optical subassemblies and parts; also for subsequent qualification test of the complete optical system.

b. Accomplishments (see Table 5-1)

Test plans governing the qualification programs for parts and subassemblies were submitted to MIT/IL. Test procedures for qualification testing of the parts, assigned as Kollsman responsibility, were written. The test plans submitted to MIT/IL were used as a basis for the test procedures. Complete sets of test equipment (MDV console and functional tester) were manufactured for Reliability qualification use. An additional total of 23 test fixtures were designed and checked prior to their release for manufacturing.

Four test fixtures which were completed underwent design changes due to a change in test concepts. Designs of cables for environmental chambers (vacuum, humidity, etc.) were completed. In Table 5-1 is a list of the completed overall status of the Reliability Test fixtures.

c. Implementation of TDK-80

TDK-80 (which redefined the qualification test program specified in TDK-42) was submitted to NASA/MSC and MIT for review and approval. The new proposal showed manloading, facility and equipment needs. Each item was treated individually and the effort that was authorized. The revised scope shown in TDK-80 was supplemental to the existing reliability program.

Approval of TDK-80 was required before the end of the reporting period to avoid the following:

a. A duplication of effort in equipment design.

b. Higher costs in piece parts if separate buy orders were required.

c. Unnecessary loss of time in achieving qualification objectives.

d. Additional environmental equipment was required (to supplement KI equipment) to implement the effort specified in TDK-80: They included:three small vacuum chambers, one shock tester, and associated instrumentation.

Table 5-1

Reliability Test Fixture Status

Fixture Numbers	Description	Design		Fabrication	
		IN	Compl.	IN	Complete
10-23330-0091	Thermal Vacuum OSS		X	X	
0111	Humidity - OSS		X		X
0093	Thermal Vacuum- MDV		X		X
0094	Humidity - MDV		X		X
0090	Vibration - OSS		X	X	
0103	Shock (Y-Y Axis) OSS		X	X	
0112	Shock (X-Y Axis) OSS		X	X	
0194	Shock (Z-Z Axis) OSS	X			
0092	Vibration - MDV		X	X	
0117	Shock - MDV		X	X	
0115	Vibration - Fixed Mirror & Beam Splitter		X		X
0113	Shock - Fixed Mirror & Beam Splitter		X		X
0112	Thermal Vacuum - Fixed Mirror & Beam Splitter	X			
0116	Humidity - Fixed Mirror & Beam Splitter		X		X
0118	Vibration - Obj. & Inter Lens Assembly		X	X	
0124	Temperature & Thermal Vacuum0Obj. & Inter-Lens		X	X	
0114	Humidity - Obj. & Inter Lens Assy.		X		X

Table 5-1 (Cont'd)

Fixtures Numbers	Description	Design		Fabrication	
		IN	Comp.	IN	Complete
10-23330-0121	Vibration - Double Dove Assy.		X	X	
0120	Vibration - Trunion Axis Assy.		X	X	
0123	Thermal Vacuum SXT Head Index Assy.		X	X	
0128	Test - Resolver (1 X 64)	X			
0130	Shock - Resolver (1 X 64)	X			
0129	Thermal Vacuum-Resolver (1 x 64)	X			
0082	Vibration - Motor Generator Size 11		X		X
0125	Shock -Motor Generator Size 11		X		X
0126	Thermal Vacuum M-G Size 11		X		X
0127	Humidity-motor gen.size 11		X		X
0095	Vibration-Motor Size 8		X		X
0136	Vibration -Counter Angle		X	X	
0137	Shock-Counter Angle		X	X	
0193	Thermal Vac-Counter Angle		X	X	
0138	Humidity-Counter Angle		X	X	
0135	Adapter-Counter Angle		X	X	
0139	Vibration-Differential	X			

Table 5-1 (Cont'd)

Fixtures Numbers	Description	Design		Fabrication	
		IN	Comp.	IN.	Complete
10-23330-0140	Shock - Differential	X			
0141	Thermal Vac.-Differential	X			
0142	Humidity - Differential		X	X	
0182	Vibration-Slip Clutch		X	X	
0184	Thermal Vac.-Slip Clutch		X	X	
0185	Humidity-Slip Clutch		X	X	
0186	Vibration-Overrunning Clutch		X	X	
0143	Vibration-Proj.Lens	X			
0180	Thermal Va.Proj.Lens	X			
0181	Humidity Projection Lens		X	X	
0109	Vibration-Cartridge Assy.		X	X	
0132	Shock -Cartridge Assy.	X			
0133	Thermal Vac.-Cartridge	X			
0108	Vibration-Resolver Size 5		X		X
0119	Vacuum & Temperature Stand		X	X	
0131	Dummy Sextant Load		X	X	
0190	Adapter for Ultradex Table		X	X	
0190	SXT Head Adapter for Ultradex Table		X	X	
0134	Resolver Holding Fixture		X	X	
0210	Optical Pier for General Use		X	X	

5.2.5 TDK-30 Reliability Training

a. Description of Effort

This TD authorized the establishment of a Reliability Training Program to provide for reliability indoctrination of management personnel and training for engineering, field, quality control, and manufacturing personnel.

b. Accomplishments

The reliability training session for field service personnel was held in two sessions. One day was devoted to an understanding of basic reliability principles and the reliability functions being performed in the Apollo Program. Another day was devoted toward explaining the Failure Reporting and Corrective Action System and the responsibilities of field personnel associated with this system.

A reliability engineer was assigned to represent Reliability in a field assignment. This man received special training to maintain proper reliability cognizance in the field.

5.2.6 TDK-42 Design Evaluation and Qualification Test Program

a. Description of Effort

Design Evaluation and Qualification testing of the Apollo optics, major subsystem elements, and parts and materials defined as a Kollsman responsibility as set forth in R 389A.

The procurement and the fabrication of test articles, test equipment and fixtures pursuant to MIT's review and approval of the test plans, procedures and test equipment and fixture design.

Assistance in the coordination of the Guidance and Navigation System test program and participation in the Test Review Board.

b. Accomplishments

Summary sheets were submitted to MIT/IL, completing the list of all SCD items pertaining to Kollsman parts. Action was taken by MIT/IL on 41 out of a total of 105 summaries submitted by Kollsman. As a result of the review of all summary sheets, MIT/IL recommended a list of additional parts that were to be qualified by Kollsman. When this list was received Kollsman formulated test plans. The qualification of the ball bearings were handled separately and the following ball bearings were selected for test: 1011608-3, 1011608-4, 1011612, and 1011607-2.

There have been five meetings of the Test Review Board todate. Kollsman submitted test plans to MIT/IL covering parts and subassemblies that were designated as Kollsman's responsibility for qualification.

Temperature shock tests were conducted on two double dove prisms. They were tested at -100°F for two hours and within five minutes transfer time, placed in a chamber at +250°F for a two hour period. Three such cycles were completed. The conclusions indicated that an air cured process of the optical cement was not detrimental to bonding of the optical test items.

A total of 13 test fixtures were received and a total of 30 were released to manufacturing.

The thermal vacuum chamber was received at Kollsman and was installed. Acceptance tests on the solar simulator (Kollsman furnished equipment) were completed.

5.2.7 TDK-48 Shipping Container Design

a. Description of Effort

This technical directive authorized the design and preparation for manufacture of shipping containers to protect the Optical Unit and the Map and Data Viewer when exposed to transportation, handling, and storage environment.

Four containers were fabricated for the Optical Unit to meet delivery dates for the first four assemblies. This effort was conducted in conjunction with TDK-81, which authorized the design and fabrication of an Optics-Navigation Base Shipping Container, for shipping the remaining Optical Units.

b. Accomplishments

Procurement specification 1019700 (Optics Shipping Container) and 1019721 (MDV Shipping Container) were approved. Preliminary layout drawings for the Optics container and MDV container were approved. NASA drawings for the Optics container were finalized. Fabrication of MDV containers was completed.

5.2.8 TDK-60 Thermal Analysis

a. Description of Effort

This technical directive authorized the performance of a thermal analysis of the Optical Subsystem to determine temperature conditions of selected critical subsystem elements for hot and cold orbits. In addition, it was intended to provide support for the testing of the AGE-1 Optical Subsystem, and to provide support to MIT/IL for evaluation of certain thermal variables such as form factors and heat exchange between selected surfaces.

b. Accomplishments

The combined steady-state analysis of the Apollo Optical Subsystem was completed and a report written. The detailed transient analysis was started. Negotiations were initiated with a computer facility for solution of the transient equations after all the terms were developed.

The temperature profile resulting from the combined steady-state analysis provided a basis for the selection of finishes for component parts, and for the subsequent detailed analyses for the determination of optical efficiency under extreme environmental conditions.

Temperature nodes were assigned for the detailed transient analysis. All equations were written and approximately 35% of the terms to be entered in the heat transfer equations were developed.

c. Problem Areas

From the resultant temperatures an optical efficiency analysis was performed to determine whether or not the thermal gradients induced an error exceeding the prescribed tolerance. The results of this analysis led to a time dependent mode of operation to limit extreme temperature cycling.

5.2.9 TDK-62 Optical Unit Stress Analysis

a. Description of Effort

This technical directive authorized a vibration analysis of the Optical Unit to determine the dynamic behavior of selected elements of the assembly. In addition, evaluation of unusual and excessive shock loading on the Optical Unit, imposed during earthlanding, were conducted, specifically in terms of the effect on crew safety requirements. These analyses were used to determine critical areas, and aided in dete[illegible] points of measurement for the AGE-2 mechanical integri[illegible]K-61).

b. Accomplishments

Further investigation of the Optical Unit-Navigation Base mounting bolts was conducted. Based upon the results obtained, it was determined that stresses in the bolts during earthlanding would exceed the ultimate stress. Although the analysis was highly conservative, higher strength bolts were indicated. A report on this analysis was prepared.

The following reports were prepared and issued:

1. Natural frequency determination of telescope as a beam.
2. Natural frequency determination of the sextant and telescope, supported by the shaft axis bearing acting as springs.
3. Natural frequency determination of the workshaft on the telescope, and the maximum stresses likely to exist during vibration.

Evaluation of the Optical Unit test conditions continued. Evaluation of test data analysis techniques were initiated. An inertia study of the Optical Unit was completed.

5.2.10 TDK-61 AGE-2 Mechanical Integrity Tests

a. Description of Effort

This technical directive authorized mechanical integrity tests of the AGE-2 Optical Unit. Specifically, the work authorized consisted of preparation of a test plan; design and fabrication of test fixtures; conducting of tests; recording and analysis of data; and submission of final report.

b. Accomplishments

A revised test plan (revision #3) was prepared and submitted to MIT/IL for approval. This document included requirements for steady state acceleration, vibration, shock, and acoustic testing of the Optical Unit, as well as steady sta[illegible]cceleration, vibration, and shock testing of the MDV (as autho[illegible] by TDK-79).

Fabrication of test fixtures and an evaluation of the vibration exciter system and acceleration and strain measuring instrumentation was continued. The detailed test procedure and evaluation of acceleration and strain measuring instrumentation was completed.

5.2.11 TDK-81 Optics-Navigation Base Assembly Shipping and Handling Container

a. Description of Effort

This technical directive authorized the design and manufacture of a shipping and handling container for transporting and storing either the Optics-Navigation Base Assembly and a handling fixture, or the Optical Unit with a dummy navigation base and dummy handling fixture. The container was capable of protecting the Optics-Navigation Base Assembly and other critical items (isolation mounts) from the transportation shipping environments specified in Apollo Environmental Criteria Specification, dated March 25, 1963.

Sixteen containers were built, the first of which was for qualification tests. These containers replaced the ones designed under TDK-48.

b. Accomplishments

Procurement specification 1019720 was approved. Detailed design information (weights, center of gravity, mounting methods, etc.) was determined.

An interface control drawing of the Optics-Navigation Base configuration was prepared and submitted to MIT/IL and ACSP. This drawing presented the outline requirements to ACSP for accommodation of the assembly to the ACSP transportation cart. In addition, the drawing was used as a basis for the design of the shipping and handling containers. A preliminary procurement specification was prepared.

5.2.12 TDK-83 AGE-1 Optical Subsystem Thermal-Vacuum Test

a. Description of Effort

This technical directive authorized design-evaluation testing of the AGE-1 Optical Subsystem, which included thermal-vacuum and humidity.

b. Accomplishments

1. Fixtures

The following fixtures were fabricated.

a) 10-2333-00091 Thermal Vacuum, OSS Holding Fixture

b) 10-2333-00111 Humidity, OSS Holding Fixture

2. Chamber

The chamber was installed in the Kollsman test area under Kollsman and vendor supervision to assure conformance to all design specifications, see photograph in Figure 5-7.

Appropriate revisions in the design of the chamber were evaluated to expand the number of electrical hookup points in two additional ports. Determination of heating and/or insulation of the chamber partition to simulate C/M structural heat input to the OSS was made. Internal and external cable assemblies were fabricated.

The heat exchanger and coolant material, in Kollsman's possession, were awaiting initial trial runs. Cognizant MIT personnel were contacted to provide proper consultation in this area. In addition, appropriate hydraulic lines, used in the AGE-1 test, were designed.

3. Optics and Optical Determinations

Optical equipment, to be used in the thermal vacuum tests, both preliminary (bench evaluation) and final (in test chamber) were acquired. This equipment included five Wild T-2 theodolites, one K & E alignment telescope; two K & E collimators with autocollimation attachments; Beck optical bench and accessories; and two K & E precision theodolite test stands.

Bench evaluation studies established optimum procedures for optical metrology employed in OSS testing were performed, see photograph Figure 5-8.

The detailed test procedure and test set-up was written. The design of the optical piers was completed, approved and fabricated.

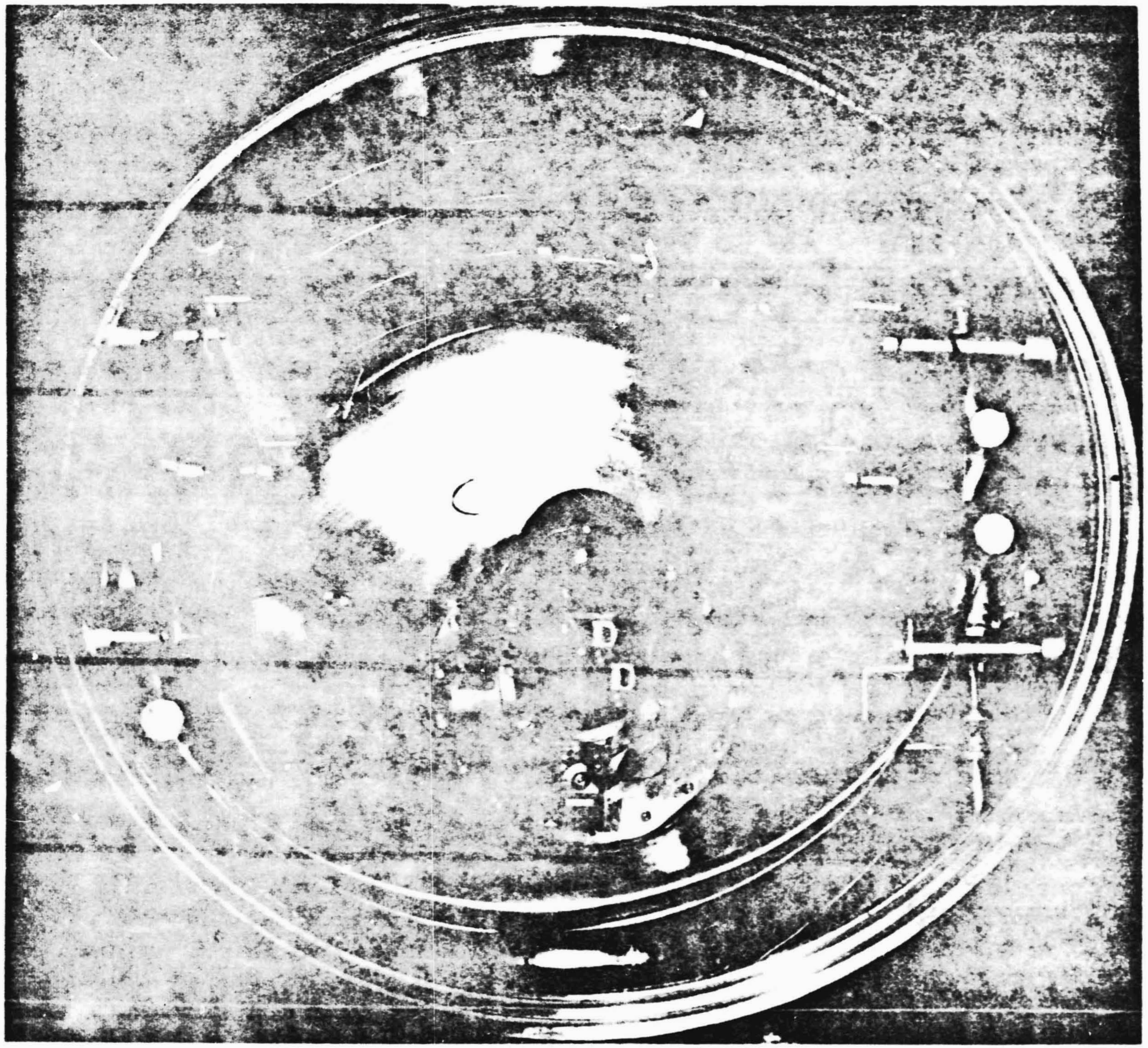


Figure 5-7. Dual Space Chamber

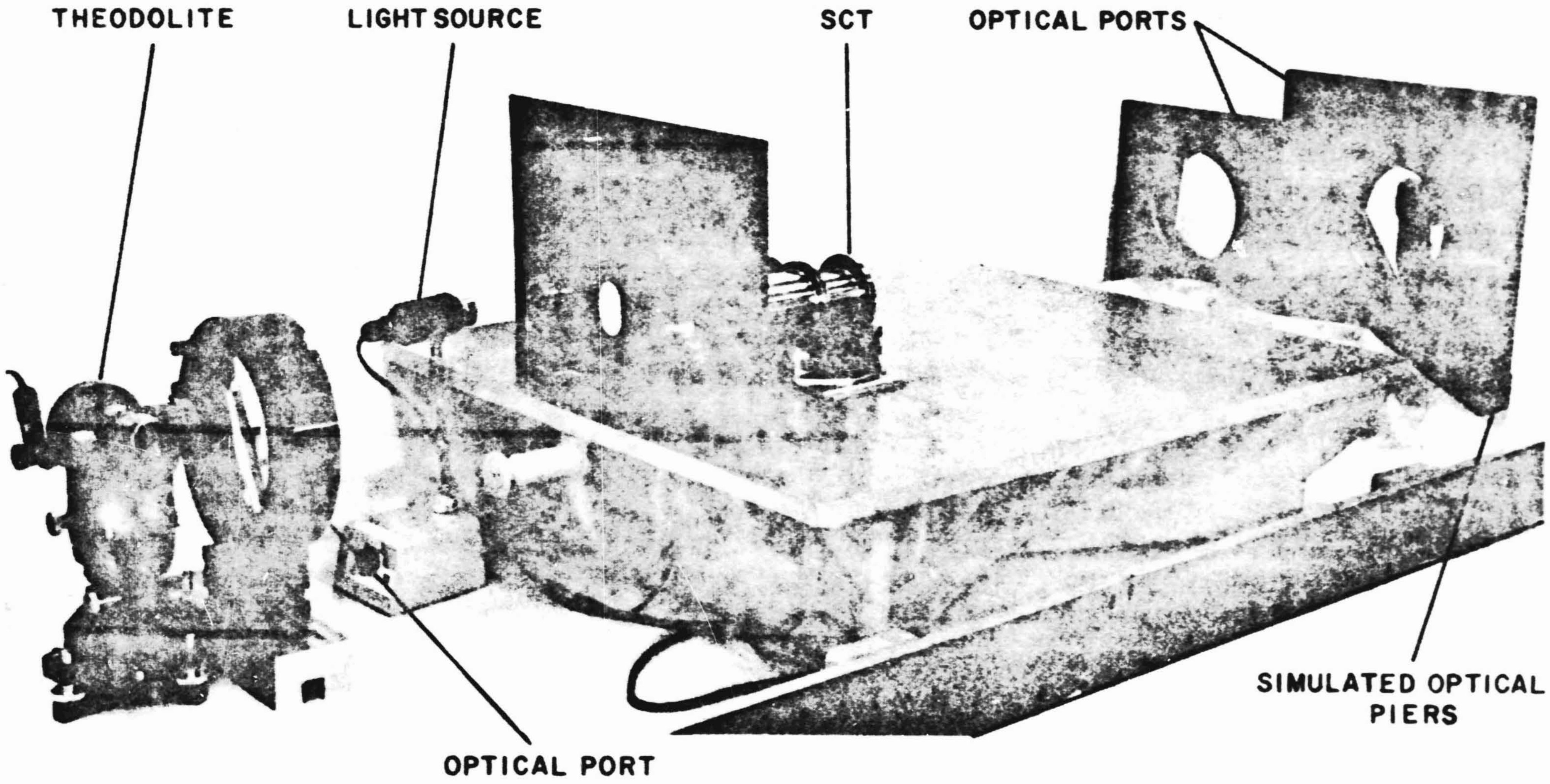


Figure 5-8. Apollo Reliability Optical Test Set-up: AGE-1

The requirement for optical benchmarks was directed toward the incorporation of a sophisticated determination of a precise optical reference. The design of several 12" optical port adapters to be used in the AGE 1 testing was accomplished. The use of the 5" autocollimator was established as an alternate to the SXT theodolite.

A demonstration of the capabilities of the solar simulator was completed. In addition, the calibration of the exposure meter was performed. An investigation of FTE to be used in bench alignment of the OSS was pursued.

Various adhesive samples (used for bonding required sensing devices to appropriate surfaces) were investigated to determine temperatures and deflections were selected as suitable for the contemplated testing. A preliminary investigation of optical methods to establish equipment movement under dynamic equilibrium was made.

5.2.13 TDK-79 AGE-1 and -2, MDV Thermal Vacuum and Mechanical Integrity Tests

a. Description of Effort

This technical directive authorized design-evaluation testing of AGE-1 and -2 MDV which included (a) thermal-vacuum and humidity and (b) vibration, shock, and acceleration.

b. Accomplishments

The design of all fixtures for both design evaluation tests was completed. The fabrication of fixtures listed below was completed.

1. 10-23330-0093 Thermal Vacuum, MDV Holding Fixture
2. 10-23330-0094 Humidity, MDV Holding Fixture
3. 10-23330-0092 Vibration and Acceleration Fixture, MDV and Shock Z-Z.
4. 10-23330-0117 Shock, X-Y, Y-Y axes.

The detailed test procedure for the MDV Thermal Vacuum test was completed. The MDV functional tester was assembled and completed January 15, 1964.

The cables required for hookup between the functional tester and the various test items (AGE 1 & 2, and various subassemblies) were fabricated. Thermocouple wire for use in the thermal vacuum tests was being evaluated for suitability.

5.2.14 TDK-76 Failure Reporting System (Data Center)

a. Description of Effort

This TD authorized the implementation of the failure reporting system and the establishment of a Data Center for acquisition, and processing of all data generated for the Optical Subsystem and MDV.

b. Accomplishments

Failure reporting systems, during both manufacturing and field operation phases, were coordinated by the creation of a failure committee and documented by a Kollsman Apollo Standard Practice Instruction.

To evaluate courses of corrective action, reports on location of all test data and person responsible for currency of data were developed. Other aids were planned.

An EDP tabulation of every part number, next assembly number, quantity/assembly, next higher assembly number, TDRR number, revision letter, proposed change number and reliability data was generated and updated.

5.2.15 TDK-103 FAB. 4 OSS Shipping Containers

a. Description of Effort

This technical directive authorized the fabrication of 4 Optics Shipping Containers designed under TDK-48.

b. Accomplishments

A one-container system (inner and outer containers) was fabricated. Preliminary drop tests were conducted as follows:

1. 17-inch flat drop of containers system on concrete.

   This drop height was approximately twice that specified in MIL-STD-810, Method 516, Procedure III, and produced an impact velocity approximately 40% greater than required. Oscillograph records of the transmitted shock, measured by 2 accelerometers adjacent to the mounting points of the dummy unit on the Ycm axis, showed a peak acceleration of 7g.

2. 27 inch edgewise drop of container system on concrete.

   A 27-inch drop was the maximum obtainable without the container falling over backwards. The peak acceleration; measured by 2 accelerometers located as above, was 5g at the "far" end and 3g at the "near" end.

3. 3-inch edgewise drop of inner container.

   The peak acceleration, measured by 2 accelerometers located as above, was 7g at the "far" end and 4g at the "near" end.

5.3 SUMMARY OF YEAR ENDING 31 DECEMBER 1964

5.3.1 C/M Reliability Plan

Assignment

Work was performed during this period against the following MIT Technical Directives:

TD K-11	Vendor Reliability and Quality Control
TD K-28	Reliability Analysis
TD K-30	Reliability Training
TD K-42	Design Evaluation and Qualification Test Program
TD K-48	Shipping Container Design
TD K-60	Thermal Analysis - Optical Subsystem
TD K-61	AGE-2 Mechanical Integrity Test
TD K-62	Stress Analysis AGE 2
TD K-76	Failure Reporting System
TD K-79	AGE-1 and 2 MDV Mechanical Integrity and Thermal Analysis
TD K-80	Parts Qualification Program (excluding facilities)
TD K-81	Optics-Navigation Base Assembly Shipping and Handling Assembly
TD K-83	AGE-1 Optical Subsystem Thermal/Vacuum Tests
TD K-98	Thermal Analysis - Optical Subsystem
TD K-103	Fabrication of four OSS Shipping Containers
TD K-104	Failure Effects Analysis
TD K-122	LEM Reliability Analysis
TD K-127	Block II Reliability Program

After Novation occurred on the Apollo contract (July 1964), no additional TDK's were issued.

5.3.2 TD K-11 Vendor Reliability and Quality Control

a. Description of Effort

This TD, initiated in 1962, authorized work to be continued thru 1964 in support of MIT Design and Reliability in selecting parts and materials for the Optical Subsystem.

b. Accomplishments

All vendor components submitted to MRB continued to be received by Reliability in conjunction with Project Engineering and Quality Assurance determining disposition of parts. Potential supplier surveys continued.

Reliability reviewed and coordinated all MIT/IL approved waivers as well as specification changes via waivers submitted to MIT.

The following items represent specific accomplishments under TD K-11.

1. The rotors of the Bendix 64 Speed Resolver Assembly, P/N 1011294 in the OSS Sextant Trunnion Axis exhibited cracking or checking of the Randac epoxy coating in the slot openings on the machined O.D. face. In some cases the checking resulted in exposing magnet winding wire. Environmental tests were initiated. The test plan of the subject rotors included baseline test, exposure to vibration, mechanical shock and humidity and then a rerun of the baseline tests to determine the effect on function and determine whether the fissures experienced any growth. Results of these tests were reported as the tests were in progress.

It must be noted that Bendix Eclipse-Pioneer, the vendor, improved the Randac operation and units produced subsequent to 11 June, 1964 were per the E-P Randac Process Operation Sheet which delineated the new process.

As previously reported, lead wire breakage and Hi-Pot failures on the 101137 Resolver (Size 5) were attributed to the brush blocks, procured by the vendor from a lower tier supplier.

Soldering controls, as initiated by Kollsman were established by the vendor over his lower tier supplier. These controls eliminated solder wicking of the lead wire which was the cause of failure.

Hi-Pot failure was caused by a "floating ferrule" condition where the lead wire-brush ferrule was randomly positioned in the mold. Close proximity of the ferrule to the case did occur, thus leading to potential Hi-Pot failure. The vendor's supplier fabricated a positioning fixture Hi-Pot failure. The vendor's supplier fabricated a positioning fixture which contributed to the proper positioning of the ferrule prior to molding. X-rays of each unit was performed by the vendor to verify the proper position of the ferrules. In addition, the vendor provided two insulators at assembly of the resolver, one on either side of the brush block.

2. The Star Tracker and horizon Scanner, which form part of the Block II OSS, required the use of a photomultiplier to perform their function. The photomultiplier chosen was the RCA C70129B, produced for commercial use, by RCA's Lancaster, Pa., tube division. Units

to satisfy Kollsman's requirements were selectively chosen from the production lot. A conference was held at the RCA facility on 16 June 1964 to discuss the Kollsman requirements for the photomultiplier. Included in the discussions were requirements for anode dark current, special conditioning and delivery schedules.

Negotiations with RCA, Lancaster, Pa., on the 1012043 Photomultiplier Electron Tube continued. RCA had not completely satisfied all the technical and quality requirements. Negotiations continued until an impasse was reached, at which time MIT was consulted. KI had attempted to impose welding specifications.

3. Concurrent with release of Block II procurement awards, and recognition of the more stringent requirements of Block II hardware, Q.A. increased its efforts to verify the correctness of all awards, both as to procuring from proper source and in a painstaking review of applicable specifications. The result was an increased awareness by suppliers of their responsibility in discharging their obligations per contract and specifications. This, of course, was also accomplished by field trips to supplier facilities, joint negotiations attended by participating contractors and suppliers, surveillance and audits of suppliers Q.C. systems, and visits by invited suppliers to Kollsman to resolve any areas of doubt or conflict arising from the purchase order and/or applicable specifications.

4. Specification changes submitted to MIT via waivers continued to be reviewed and coordinated by Reliability. A comprehensive review of all MIT approved waivers continued. The purpose of this review was to institute and effect corrective action in sufficient time for Block II effectivity. Additional effort was expended to accelerate the completion of corrective actions as indicated in the waiver requests. In addition, controls imposed by Reliability resulted in a substantial reduction in new waiver requests.

5. Joint contractor negotiations conducted by Utrad Div., Huntington, Ind., revealed that this facility was severely lacking in many aspects of high reliability component manufacture. The vendor was not able to present much of significance in documentation to substantiate process control over the manufacture of transformers. The vendor did not control many raw materials inplant, nor impose any controls over the suppliers. Quality of the item depended solely upon the capability of the operator performing a function. No follow-up survey was conducted to ascertain the effectiveness of the controls that the vendor agreed to establish.

6. Kollsman participated in joint contractor negotiations with Motorola Semiconductor Products, Inc., Phoenix, Arizona. Kollsman negotiated the 1012056 Zener Diodes drawings. The vendor, in Kollsman's opinion, did not comply with the intent of ND 1015404. The vendor's representatives essentially declared all their processes proprietary, including titles and revision status of all controlling documentation. All processes were considered critical by the vendor. The vendor refused to inform the purchaser of any change in a process

unless they deemed it a critical change to that process. The vendor also took exception to the Special Conditioning requirements of the SCD, which was to be negotiated. Kollsman sought another source more inclined to comply with Apollo requirements.

c. Problem Areas

1. One problem area suggested by Kollsman, and reviewed by MIT, was to modify the stringent requirements of ND 1015404, relating to the procurement of simple and inexpensive items. The imposition of this specification on many vendors resulted in an adamant refusal to comply. Kollsman's efforts to secure compliance through personnel contact and negotiations had not been successful. Securing other vendors without regard to the QSL, had not been a successful alternative.

2. Another problem area concerning ND 1015404 on more complex items, was that after extensive negotiations with a vendor, it was not possible to secure full compliance. Many vendors ultimately reduced their objections to ND 1015404 after rapport was established; however, there were some requirements of this document which resulted in an impasse with the vendor. It was suggested that MIT be informed of the specific difficulty a particular vendor had in complying with ND 1015404, where, in Kollsman's opinion, all possible negotiations had been exhausted. Exceptions to ND 1015404 could then be initiated via a TDRR, when all concerned were in agreement that difficulties did indeed exist, in order to finally and permanently resolve the problem.

Furthermore, when a particular member of the G & N team was responsible for the qualification of a part, it was suggested that it be that member's responsibility to negotiate a vendor's exception to ND 1015404 in order to avoid duplication of effort.

There existed a need for an explicit definition on what conditions constitute waiver action, which resulted in a subjective interpretation. This obviously reduced the variance of opinion that currently existed among personnel involved in waiver actions.

5.3.3 TD K-28 Reliability Analysis

a. Description of Effort

The Optical Subsystem reliability analysis, initiated in 1962, continued.

b. Accomplishments

The Block II OSS Star Tracker configuration was reviewed and the error contributed to the system from such sources as the photomultiplier tube, star signal and space-sky background was estimated. A final report covering the results of this analysis was prepared. Results indicated that a second order visual magnitude star could be tracked with a 9.4 arc second error about the null along each axis of a 10 cps system bandwidth was used.

A detailed breakdown of both electrical and mechanical family trees for the Block II OSS was made. Environmental criteria governing the operation of critical components of the Block II OSS configurations were reviewed and finalized. Specifications and Specification Control Drawings for Block II OSS components were reviewed in the course of design review meetings with Project Engineering.

The initial phase in the generation of a reliability block diagram was completed. It consisted of generating family trees of all system elements which are active in the mathematical model and the reliability block diagrams.

Inputs from the Kollsman thermal analysis of the OSS were directed into the component stress analysis to modify failure rates as agreed to by the MIT Reliability Assessment Group and Kollsman.

Design reviews on the OSS and MDV were attended by Reliability personnel and recommendations were made in accordance with findings from the reliability and environmental analyses.

Kollsman reviewed all SCD's for completeness of reliability, environmental and burn-in data.

c. Problem Areas

Definitive system design for the Star Tracker and Horizon Sensor required that certain parameters and values be resolved. Among these unresolved matters were: specification of a system bandwidth, space-sky background effect on system performance, operating temperatures to which photomultiplier will be exposed during the mission and mission duration of operation of the photomultiplier. These problems (especially the last two continued to seriously delay the design until inputs to resolve them were received from MIT/IL.

5.3.4 TD K-30 Reliability Training

a. Description of Effort

Provided for reliability indoctrination of management personnel, reliability training for engineering, quality control, manufacturing and vendors closely associated with the design and fabrication of Kollsman Apollo Prime Equipment. Developed and conducted formal training programs within areas where special skills were employed in the manufacture, inspection and process control of operations and materials.

b. Accomplishments

A review of training and motivation programs was completed. Preliminary copies of this review were submitted to MIT/IL Reliability. Each program was outlined in the following form: Title, length, dates operated, attendees, instructor, syllabus, and training aids.

The motivation program titles were: (1) Reliability for Management, (2) Systems Familiarization Training, (3) Project Management Reports, (4) Overall Apollo Project Reports, and (5) Astronaut Visits.

Training program titles included: (1) Failure Reporting System, (2) Operating Time Logs, (3) Reliability for Field Engineers, (4) Certification Program (implementation of NASA process specifications), (5) Optical Requirements, (6) Clean Room Requirements, (7) Reliability Films, (8) Inspector Training, (9) Quality Requirements for NPC 200-2 and 200-3, and (10) Vendor Orientation.

5.3.5 TD K-42 Design Evaluation and Qualification Test Program

a. Description of Effort

During the year reliability prepared detailed test plans pertaining to reliability tests and evaluations and submitted completed test plans to MIT/IL for review and approval. Reliability also planned and designed test equipment, test fixtures, and associated equipment necessary for reliability evaluation and qualification test of optical subsystem.

b. Accomplishments

The qualification specification ND 1002037 was modified to include parameters established as a result of information gathered during the evaluation of AGE 1 and AGE 2.

The preliminary test plans for the subsystem qualification were modified to include the Tracker, Horizon Sensor and other Block II parts.

Since the qualification system was a Block II system, the planning and philosophy of proper qualification testing were discussed by Kollsman, ACED and MIT/IL.

The Map and Data Viewer AGE-5 was successfully vibrated and accepted in accordance with the FTM 1011559.

A meeting was held between ACED and Kollsman personnel at MIT/IL to formulate a combined OSS and IMU vibration and mechanical shock qualification test plan. A preliminary draft of the combined vibration and mechanical shock test plan was submitted to MIT/IL. These tests were performed at ACSP by Kollsman and ACSP personnel. The plan calls for vibration and mechanical shock testing of the Navigation Base with the IMU and OSS mounted on the Navigation Base simulating end item configuration.

The Qualification Specification ND 1002037 was modified by MIT/IL to incorporate the changes discussed during the last Test Review Board meeting. These changes affected the qualification unit and incorporate more suitable tests.

It was decided by TRB during the earthlanding shock test that simulated internal subsystem components be used with the actual external configuration.

The subsystem qualification test plan was modified to include the Job Description Cards and to show in detail the Final Test Methods and baseline measurements during qualification.

The partial conflict between the qualification document ND 1002037A, (which was modified by MIT/IL) with the Kollsman Work Statement was eliminated.

Details of the functional tests performed on the Optical Subsystem during the various phases of environmental testing was formulated.

Assurance of MIT/IL allocation of enough GSE at ACSP was sought so that the combined tests were accomplished smoothly.

c. Problem Areas

The approval of a TD from MIT/IL to Kollsman authorized the combined vibration and shock tests at ACSP was necessary. The approval of a TD was required to authorize the writing of test plans, procedures and material costs, transportation of personnel, equipment and the optical subsystem and cost of subsistence of Kollsman personnel.

5.3.6 TD K-76 Failure Reporting System

a. Description of Effort

Implementation of the failure reporting systems and the establishment of a Data Center for acquiring, processing, and interpreting of all data generated on the Optical Subsystem and Map and Data Viewer.

b. Accomplishments (Failure Reports)

(1) Prime Hardware Failures - Period ending 23 June 1964

1011371 Resolver 1x - failed 30 December 1963 - open lead entering brush encapsulation - failed at assembly level 1011471.

Corrective Action: Failure analysis requested of Kearfott Division of General Precision revealed: (1) variations in soldering brush leads to resolver leads, and (2) variations in placement of this joint in encapsulation material. To fail, both wicking must be present and wicking must extend from the joint to a point outside the encapsulation. X-ray of 100% of brush blocks, 10% sample distruct test, brush lead pull tests, resolver lead pull tests, and improvement in soldering technique by KD vendor should prevent similar failures in the future. Action complete.

1010610 Motor-generator - failed 3 February 1964 - 4 units due to axis error of 1.7 to 2.4 times maximum allowable - 1 unit due to high starting voltage - failures noted after 50 hour burn-in.

Corrective Action: Kearfott Division of General Precision added an additional test of their own after burn-in to prevent submission of failed units to Kollsman source inspection. Action complete.

1000160 Resolver 16x, failed 10 February 1964 - open winding due to mechanical cut occurring during assembly - failed at assembly level 1011000.

Corrective Action: 50x photograph of location of failure given to Quality Assurance to use as an example of the necessity of improving handling due to the exposed windings of the 16x, 64x, and 1x resolvers. Action complete.

1011369	Clutch, slip - failed 18 February 1964 4 failed due to low or no torque - failed during functional test prior to qualification testing.
1011569	Insert Ball Mount Line - failed 18 February 1964 - fractured during lubricant coating pressing - failed at assembly level 1011739. Corrective Action: Changed coating pressing procedure, changed pressing tools, requested change to reduce stress concentration factor. Action complete.
1011325	Housing of 16x Resolver Stator - failed 24 February 1964 - gear teeth sheared during zero setting - failed at assembly level 1011891. Corrective Action: Changed zero setting procedure and tools. Action complete.
1011373	Clutch overrunning - failed 2 March 1964 - slips intermittently in driving mode.
1011483	Amplifier, Encapsulated - failed 5 March 1964 - variable resistor 1011498 (R13) locked at optimum adjustment by encapsulation material. Previous Waiver K-29 waived reliability and quality assurance provision of ND 1015404. Corrective Action: Waiver K-117 permits use of 1011483 in AGE-2 - appropriate shielding will be evaluated to prevent locking.
1011744	Counter, Angle - Shaft angle counter failed 18 March 1964 and 19 March 1964 - trunnion angle counter failed 19 March 1964 - all failures due to a lack of/or incomplete shade flip. Corrective Action: Immediate action to change shade contour to suit individual counter.
1010341	1X Resolver - failed 21 April 1964 at 1011934 Assembly level of AGE 5 OSS - FR 31 Rotor S_2-S_3 resistance intermittently high.

Corrective Action: Failure Analysis reveals unit had been disassembled and reassembled incorrectly.

1010341 1X Resolver - failed 30 April 1964 FR 35, 36, 37, 38, 39, 40, 41 - Six failed due to accuracy error. One failed due to impedance unbalance. Corrective action: Accuracy error due to lack of ground lead to index stand during last portion of source acceptance test. Impedance unbalance failure reworked cause. Manufacturing error. Action complete.

1011000 Optical Unit - failed 12 May 1964 - FR 1[illegible]2-SCT TDA stiction too high. Corrective action: Same as 1011891 FR 81.

1011281 Differential - failed 25 May 1964 - FR 0054E Unit exceeds total backlash under load of 4 oz. Corrective action: Change proposed to reduce tooth load during backlash measurement to 2 oz, and to increase allowable backlash to 20 min. Action complete.

1011000 Optical Unit AGE 2 - failed 5 June 1964 - FR0056E - Vibration caused loosening of double dove prism within its mounts. Correction Action: 1011197 changed to Revision D per TDRR 08479 to permit use of only one layer of indium foil. Action complete.

1011000 Optical Unit AGE 2 - failed 5 June 1964 - FR0057E - Excessive SCT shaft axis end play. Corrective Action: Changed shim thickness to increase bearing preload. Action complete.

1011000 Optical Unit AGE 2 - failed 5 June 1964 - FR0061E-Inner bearing of 1011744 Angle Counter Shade came apart. Corrective Action: Changed bearing on vendors drawings from angular contact to deep groove to prevent assembly errors. Effectivity to be determined.

MS 122159	Insert, threaded - failed 5 June 1964 on AGE 2 OSS-FR0060E - Improperly tapped hole in optical base caused insert to distort thereby stripping NAS 1352 C08LL12. Corrective Action: Review of inspection procedures of optical base. Action complete.
1000115-2	Insert, threaded - failed 5 June 1964 on AGE 2 OSS-FR0060E - One leg of threaded insert broke during insertion operation to SCT Panel Assembly 1011717. Corrective Action: Review of Process Specification and Inspection Procedure of 1011717 Assembly. Action complete.
1011891	Optical Subassembly Stage III - failed 8 June 1964 - F.R. 80 AGE 5 - Sextant 16X Resolver zero out of specification. Corrective action: Changed zeroing procedure of resolvers to be effective on Revision B of ATP's 1011890 and1011891. Action complete.
1011891	Optical Subassembly Stage 3 - failed 8 June 1964 - FR 81 - SCT TDA stiction reads 3.9v instead of less than 3.6v. Corrective action: Preliminary investigation reveals that 1011193 cam follower assembly spring tension may be too high thus causing the high stiction voltage. Design change under study.
1011891	Optical Subassembly Stage 3 - failed 8 June 1964 - FR 82 - SXT SDA 1/2X Resolver zero out of specification. Corrective action: Same as 1011891 Failure Report 80. Action complete.
1011000	Optical Unit AGE 5 - failed 10 June 1964. 1) FR 83 - Counter shade misaligned. 2) Sextant reticle 40" off center as a result of 1011773-2 set screw loosening during vibration permitting 1011796 to rotate in 1011797 thus changing reticle center. Corrective Action (a) Spring contour is susceptible to change during handling as a part and during assembly operations. Handling fixture for counter and for the SCT gearboxes was evaluated. (b) Inspectors and technicians have been cautioned to give extra attention to vibration proofing of all screws.

1011000	Optical Unit AGE 6 - failed 15 June 1964 - FR 84-Angle counter shade screw worked loose during vibration. Corrective Action: Change proposed to 1011744 drawing to secure all screws with locking compound conforming to MIL-S-22473. Action complete.
1011000	Optical Unit AGE 6 - failed 16 June 1964. FR 108-Sextant reticle 27" off center after acceptance vibration test. Corrective Action: Initial failure analysis revealed no loose parts. Realigned reticle.
1011896	SXT Base Harness Assy - F.R. 109 - AGE 5 OSS Failed 17 June 1964 - Insulation damaged on one wire during vibration. Corrective action: Preliminary failure analysis indicates a design change to reroute harness and clamp more securely.
1011907	Flexprint and Connector Assembly - failed 18 June 1964 in AGE 6 - FR111 - Kinks in flexprint and a cut in one conductor. Corrective action: Same as 1011908 FR 110.
1011908	Flexprint - failed 18 June 1964 - AGE 6 - FR110-Kinked during assembly. Corrective action: Preliminary analysis shows need for several design changes to permit easier installation of the flexprint Final analysis now pending.
1011000	Optical Unit AGE 6 - failed 22 June 1964 - FR 88 - Piece of indium foil partially slipped from between the double dove prism and the double dove prism clamp. Corrective action:
1011000	Optical Unit AGE 5 - failed 22 June 1964 - FR89-SCT TDA 1X Resolver zero out of specifications. Corrective Action: See 1011891 Failure Report 80 Action complete.
1011000	Optical Unit AGE 5 - failed 23 June 1964 - FR 112 - Double dove prism cement appears to have separated on 5% of the cemented surface not in the field of view. Corrective Action:

1011369 Clutch, slip - failed 18 February 1964 - 4 failed due to low or no torque.

1011569 Insert Ball Mount Line - failed 18 February 1964 - fractured during lubricant coating pressing - failed at assembly level 1011739.

Corrective Action: Changed coating pressing procedure, changed pressing tools, requested change to reduce stress concentration factor. Action complete.

1011325 Housing of 16x Resolver Stator - failed 24 February 1964 - gear teeth sheared during zero setting - failed at assembly level 1011891.

Corrective Action: Changed zero setting procedure and tools. Action complete.

1011373 Clutch overrunning - failed 2 March 1964 - slips intermittently in driving mode.

1011483 Amplifier, Encapsulated - failed 5 March 1964 - variable resistor 1011498 (R13) locked at optimum adjustment by encapsulation material. Previous Waiver K-29 waived reliability and quality assurance provision of ND 1015404.

Corrective Action: Waiver K-117 permits use of 1011483 in AGE-2 - appropriate shielding will be evaluated to prevent locking.

1011744 Counter, Angle - Shaft angle counter failed 18 March 1964 and 19 March 1964 - trunnion angle counter failed 19 March 1964 - all failures due to a lack of/or incomplete shade flip.

Corrective Action: Immediate action to change shade contour to suit individual counter.

1010341 1X Resolver - failed 21 April 1964 at 1011934 Assembly level of AGE 5 OSS - FR 31 Rotor S_2-S_3 resistance intermittently high.

(2) Ground Support Equipment Failures - Period ending 16 June 1964.

1017412	Autocollimator - failed 9 March 1964 at ACSP - FR 0767 - Adjustable filar reticle not concentric with autocollimator barrel. Corrective action: Returned to K & E from ACSP. Replaced filar reticle and realigned. Source inspected after repair at K & E by Kollsman. Unit in excellent condition. Action completed 1 June 1964.
1017412	Autocollimator - failed 13 April 1964 at ACSP - FR 1191 E - Light socket shorted; light bulb burned out. Corrective action: Replaced receptacle and lamp on 5 May 1964. Action complete.
1017410	Five-Inch Autocollimator - failed 1 May 1964 at ACSP - Same as 1017410 FR 1510E and FR 1513E plus reticle and filar off 1/2 sec on elevation. Corrective action: Calibrate and use.
1017410	Five-Inch Autocollimator - Two units failed 1 May 1964 at ACSP-FR 1510E, FR 1513E - Numerical markings etched on an angle. Corrective action: 8 June 1964 TWX from A. C. Metzger, RASPO/MIT to A. J. Italiano, ACSP Paragraph 1 directs AC to accept and use units. Action complete.
1017448	2-1/2 Inch Autocollimator - Two failed 1 May 1964 at ACSP - FR 1511E and FR 1512E Reticle and filar alignment off 5 and 2.5 seconds, respectively. Corrective action: Calibrate and use.
1017412	Autocollimator - failed 22 May 1964 at ACSP-FR 1527 E (1) Fixed to filar reticle alignment in excess of specification. (2) Fixed to filar reticles not "square". Corrective action: (1) KIC generating field calibration procedure. (2) Reticles should be adjusted in field. Action complete.

1016951	Alignment Mirror Assembly - failed 28 May 1964 at MIT/IL FR 0961E - Movable pellicle locking pin sheared. Pellicle no longer movable. Locking pin broken.
1016949	Functional Tester - failed 12 June 1964 - FR 0062E - Poor contact in connection of assembly 1017402. Corrective action: Unit repaired.
1016949	Functional Tester - failed 16 June 1964 - FR 0064E Shaft 1019065 seized in housing. Corrective action: .0001" clearance insufficient for lubrication. Shaft honed down from .0005" to .0008" to .1870" +.0000 -.0002.

(3) Table 5-2, provides a detailed summary of internal and external failure reports processed during the period ending 10 September 1964.

Procedures and revisions to E-1322 were reviewed at a meeting with MIT/IL, ACSP, Raytheon and Kollsman participating.

c. Problem Areas

Lack of action by MIT/IL on proposed corrective action, predicated on design changes, was seriously delaying implementation of same. Steps were taken to rectify the situation as soon as possible.

TABLE 5-2

INTERNAL/EXTERNAL FAILURES

INTERNAL FAILURES

Failure Rpt. No.	Date	AGE	Sub-Assembly and Part No.	Part and Part No.
86	7/2/64	20	OSS 1011797	16X Resolver 1000160
199	7/8/64	7	OSS Harness Assy 1011933	1X Frame Size 8 Resolver
119	7/30/64	7	OU Stage III 1011891	1X Frame Size 8 Resolver
153	8/6/64		SXT Telescope Lens - 1011796	Lens Assembly 1011585
152	8/7/64	8	OSS Stage III 101891	Shaft 1011198
157, 8 and 9	8/7/64			Resolver 1010341
133	8/10/64	8	OSS Stage III 1011891	Harness Assembly 1011896
135	8/12/64	8	OSS 1011000	OSS Stage III 1011891
136	8/12/64	8	OSS 1011000	OSS Stage III 1011891
148	8/14/64	8	OSS 1011000	OSS State III 1011891
137	8/17/64	8	OSS 1011000	SCT inner telescope tube assembly 1011724
162	8/17/64		OSS 1011000	SCT inner telescope tube assembly 1011724

TABLE 5-2

INTERNAL FAILURES (Cont'd.)

Failure Rpt. No.	Date	AGE	Sub-Assembly and Part No.	Part and Part No.
141	8/31/64	8	1011891	
163	9/3/64	20	OU Stage III 1011891	Retainer 1011316
142	9/4/64	8	OU State III 1011891	

EXTERNAL FAILURES

Failure Rpt. No.	Date	AGE	Sub-Assembly and Part No.	Part and Part No.
124	7/1/64	6	OSS 1011000	Angle Counter 1011744
120	7/2/64	6	Optical Unit 1011000	
2215	7/6/64	6	Nav Base and Optics 1899950	Optical Unit 1011000
2216	7/6/64	6	Nav Base and Optics 1899950	Optical Unit 1011000
1560	7/6/64	6	OSS 1011000	Optical Base 1011631
1608	7/6/64	6	OSS 1011000	
1609	7/7/64	6	OSS 1011000	Insert Plane 1011567
0074	7/7/64	2	Shaft Axis 1011704	Objective Lens 1011585

TABLE 5-2

EXTERNAL FAILURES (Cont'd.)

Failure Rpt. No.	Date	AGE	Sub-Assembly and Part No.	Part and Part No.
1612	7/8/64	6	OU Stage III 1011890	Bevel Gear 1011356
1561	7/9/64	6	Nav. Base & Optics 1899950	Optical Unit 1011000
1610	7/9/64	6	Shipping Container 1017400	Outer Shipping Container 1019700
1584	7/9/64	6	Nav Base and Optics 1899950	Optical Unit 1011000
1592	7/13/64	5	MDV 1011559	
1593	7/13/64	5	MDV 1011559	
2311	7/13/64	5	MDV 1011559	
1565	7/14/64	6	OSS 1011000	Mirror 1011260
1566	7/14/64	6	OSS 1011000	Double Dove Prism 1011153
1864	7/17/64	6	Optical Unit 1011000	SCT Eyeguard Assembly 1011965
1573	7/23/64	6	OSS 1011000	Angle Counter 1011744
0071	7/24/64	2	Optical Unit 1011000	Ball Bearing 1011602-21

TABLE 5-2

EXTERNAL FAILURES (Cont'd.)

Failure Rpt. No.	Date	AGE	Sub-Assembly and Part No.	Part and Part No.
0372	7/24/64	2	Optical Unit 1011000	Mirror Assembly 1011260
2229	7/24/64	6	Optical Unit 1011000	
2230	7/25/64	6	Optical Unit 1011000	
2201	7/25/64	6	Optical Unit 1011000	
2231	7/27/64	6	Optical Unit 1011000	
2202	7/27/64	6	Optical Unit 1011000	
2203	7/27/64	6	Optical Unit 1011000	
2204	7/28/64	6	Optical Unit 1011000	
2232	7/28/64	6	Optical Unit 1011000	
2233	7/29/64	6	Optical Unit 1011000	
2205	7/29/64	6	Optical Unit 1011000	
2206	7/29/64	6	Optical Unit 1011000	

TABLE 5-2

EXTERNAL FAILURES (Cont'd.)

Failure Rpt. No.	Date	AGE	Sub-Assembly and Part No.	Part and Part No.
2207	7/29/64	6	Optical Unit 1011000	
2208	7/29/64	6	Optical Unit 1011000	
2234	7/29/64	6	Optical Unit 1011000	
2235	7/29/64	6	Optical Unit 1011000	
2236	7/30/64	6	Optical Unit 1011000	
2209	8/4/64	6	Optical Unit 1011000	
2209	8/4/64	6	OSS 1011000	
125	8/6/64	7	OSS 1011744	Angle Counter 1011744
127	8/7/64	7	OSS 1011000	
128	8/8/64	7	OSS 1011000	
129	8/9/64	7	OSS 1011000	
130	8/9/64	7	OSS 1011000	
131	8/9/64	7	OSS 1011000	
1213	8/13/64		GSE	Theodolite DKM-3X S/N 4 1017444

TABLE 5-2

EXTERNAL FAILURES (Cont'd.)

Failure Rpt. No.	Date	AGE	Sub-Assembly and Part No.	Part and Part No.
1214	8/13/64		GSE	Theodolite DKM-3X S/N 4 1017444
0161	8/21/64	2	Optical Unit 1011000	Nut, Locking Rotor 1011311
0181	8/21/64	2	Optical Unit 1011000	Ball Bearing 1101607-2
0182	8/21/64	2	Optical Unit 1011000	Flex Prints 1011907 & -8
0184	8/21/64	2	Optical Unit 1011000	Mounting Bolt MS21250-4028
0185	8/21/64	2	Optical Unit 1011000	Dove Prism Mtg. Assembly 1011197
0186	8/21/64	2	Optical Unit 1011000	Lens Assembly 1011707
0189	8/21/64	2	Optical Unit 1011000	Prisms, Eyepiece 1011269 & 70
139	8/27/64	8	OSS 1011000	
140	8/27/64	8	OSS 1011000	
0190	9/10/64	2	Optical Unit 1011000	Reticle SXT 1011594

5.3.7 TD K-79 AGE-1 MDV Thermal Vacuum and Mechanical Integrity Tests

a. Description of Effort

This technical directive authorized thermal evaluation tests and mechanical integrity tests on the AGE-1 MDV. Specifically, the work authorized consists of preparation of test plans and test procedures, design and fabrication of test fixtures, conducting of tests (thermal vacuum, humidity, vibration, shock and acceleration), recording and analysis of data, and submission of final report.

b. Accomplishments (Mechanical Integrity Evaluation)

(a) All random vibration tests (design evaluation levels) were completed. Evaluation of the data showed accelerations and strains well within allowable limits. A functional check of the unit at the completion of the vibration tests was conducted in accordance with the requirements of the FTM.

Shock fixture evaluation was completed. All fixtures and instrumentions were received. An outline of the Detailed Test Procedure was completed.

The fixtures listed below were fabricated and accepted for design evaluation test:

10-23330-0093 Thermal-Vacuum Holding Fixture
10-23330-0094 Humidity Holding Fixture

The first draft of the detailed thermal-vacuum test procedure was completed. An evaluation study to determine the optimum method of measuring the optical conformance of the projection system with the required standard was completed. The selection and procurement of the optical test equipment to measure the various requirements of the proposed detailed test procedures was completed. Continued thermocouple wire evaluation study. Additional wire was received and underwent laboratory study for utilization in the thermal-vacuum tests. Required electrical cables for the MDV test console connections was completed. Detailed mechanical integrity evaluation test procedures were completed.

The vibration fixture was evaluated for equalization. Sinusoidal vibration tests were conducted on the MDV along the X_{cn}, Y_{cn}, and Z_{cn} axes from 10 to 2000 cps at one-g. Eight accelerometers and eight strain gages were located at various points on the

MDV. The data obtained showed accelerations and stresses within allowable structural limits of the unit. Further evaluations was required to determine the effect of the random vibration environment on the MDV. The lowest resonant frequency of the MDV was found to be approximately 185 cps. This was the beam mode of the MDV front panel, and corresponds with the calculated value. Figure 5-9 shows the MDV in its test fixture, mounted on the C-25 shaker, ready for vibration along the Z_{cn} axis.

Shock tests were conducted at 15, 20, 25, and 30g, 6 ms terminal peak sawtooth shock pulse along the $\pm X_{CM}$ $\pm Y_{CM}$, and $\pm Z_{CM}$ directions.

Functional tests were performed at the conclusion of the shock tests. The results showed satisfactory operation of the MDV, using 15 feet of film in the cartridge, as per Waiver No. K-99.

Constant acceleration tests were conducted at 20, 25, 30, 35, and 40g along the $\pm X_{CM}$, $\pm Y_{CM}$, and $\pm Z_{CM}$ directions.

Functional tests conducted as per Waiver No. K-99, following the acceleration tests, showed satisfactory operation of the MDV.

5.3.8 TD K-48 Shipping Container Design

a. Description of Effort

This technical directive authorized the design and preparation for manufacture of shipping containers for the Optical Unit and the Map and Data Viewer when exposed to transportation, handling, and storage environments. In addition, this TD authorized the manufacture of eight MDV shipping containers.

Note: Technical directive (TD K-103) authorized the fabrication of four shipping containers for the first four Optical Units. The remainder of the Optical Units will be shipped in the Optics-Navigation Base Shipping Container, the design and fabrication of which is authorized by TD K-81.

b. Accomplishments

Design drawings for the Optics and MDV containers were completed. Minor modifications were made for conformance to NASA drawing standards prior to submission for approval.

Qualification tests of the MDV container were completed. The container satisfactorily withstood these tests, and met all the conditions specified in PS 1019721. A report on these tests were issued. Two additional MDV containers were fabricated. A photograph of the container with cover removed appears in Figure 5-10.

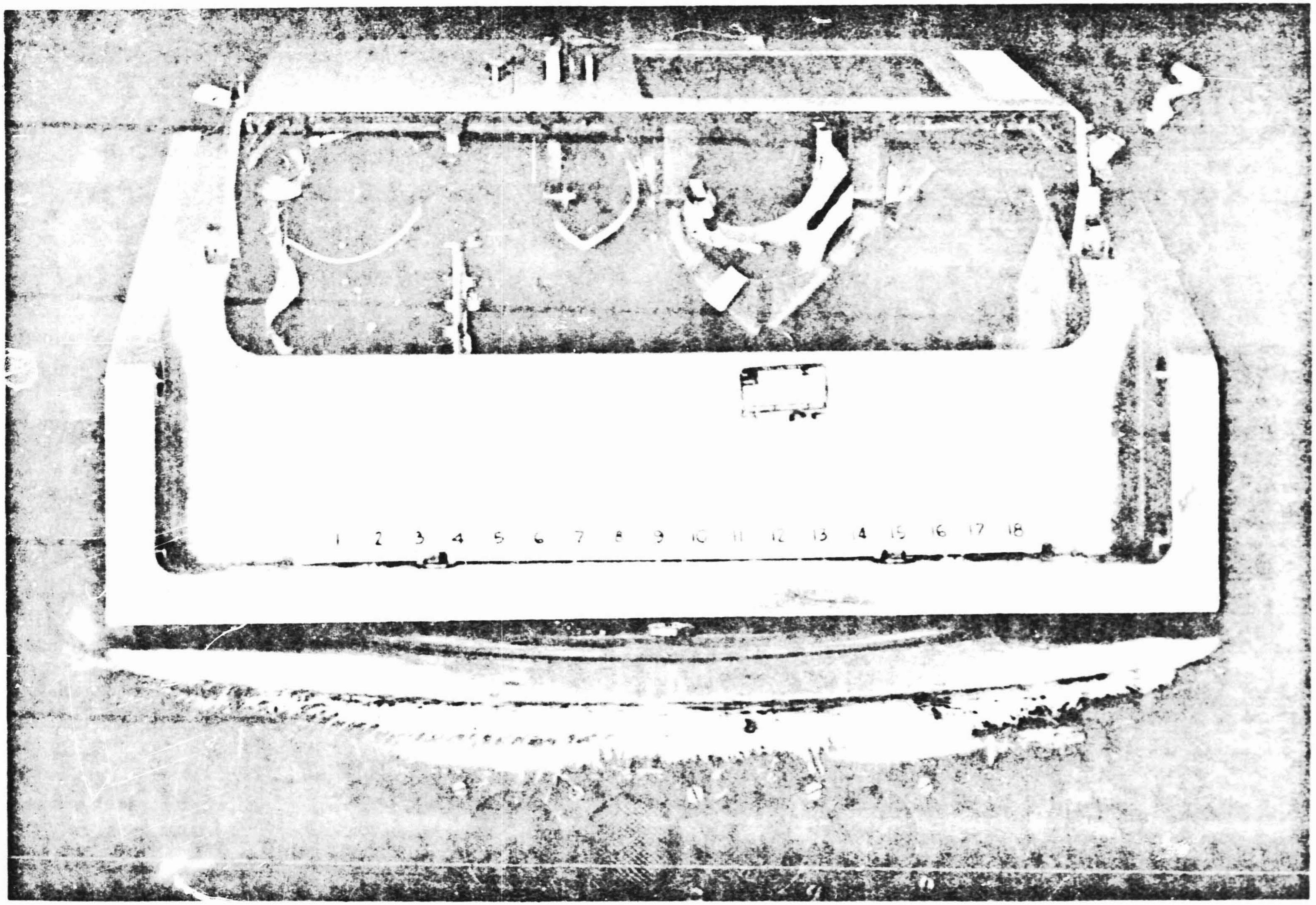


Figure 5-9. MDV Test Setup

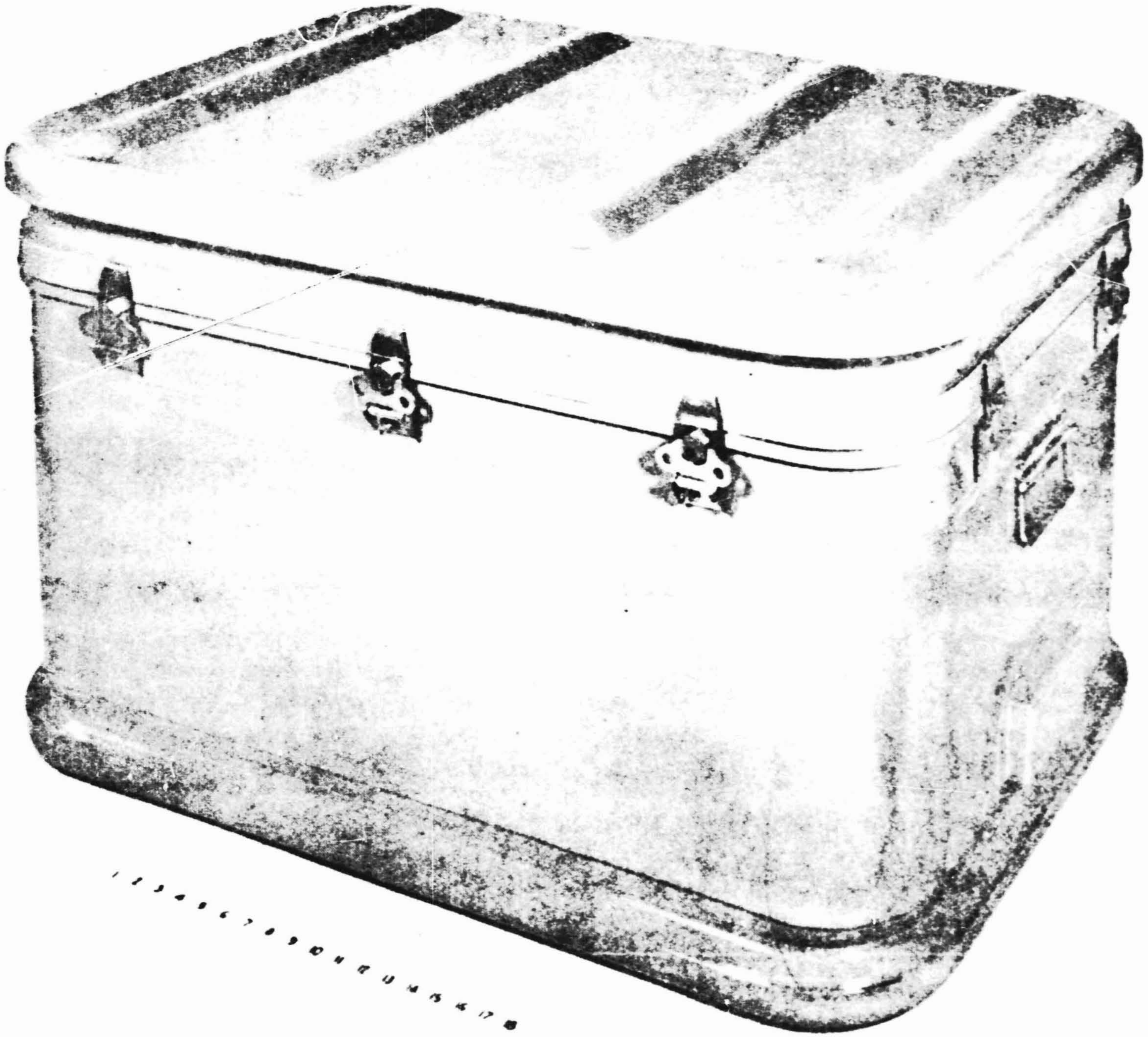


Figure 5-10. MDV Shipping Container

5.3.9 TD K-103 Fabricate Four OSS Shipping Containers

a. Description of Effort

This technical directive authorized the fabrication of four Optical Unit shipping containers, designed under TD K-48.

b. Accomplishments

Qualification tests were completed and a report issued. The container satisfactorily withstood these tests, and met all the requirements specified in PS 1019700. A photograph of the container system, with both covers removed, is shown in Figure 5-11. Two container systems have been fabricated.

5.3.10 TD K-81 Optics-Navigation Base Assembly Shipping and Handling Container

a. Description of Effort

This technical directive authorized the design and manufacture of shipping and handling containers for transporting and storing either the Optics-Navigation Base Assembly and Handling Fixture, or the Optical Unit with a dummy navigation base and dummy handling fixture. The containers must be capable of protecting the Optics-Navigation Base Assembly and other critical items from the transportation shipping environments specified in Apollo Environmental Criteria Specification dated March 25, 1963.

Sixteen containers were built, the first of which was used for qualification tests. These containers replaced the ones being fabricated under TD K-103.

b. Accomplishments

Design drawings have been completed, and reviewed.

5.3.11 TD K-60 and K-98 Thermal Analysis

a. Description of Effort

These technical directives authorized the performance of thermal analyses of the Optical Subsystem and the Map and Data Viewer to determine temperature conditions of selected critical elements for hot and cold orbits. In addition, support was provided for the testing of the AGE-1 Optical Subsystem and Map and Data Viewer,

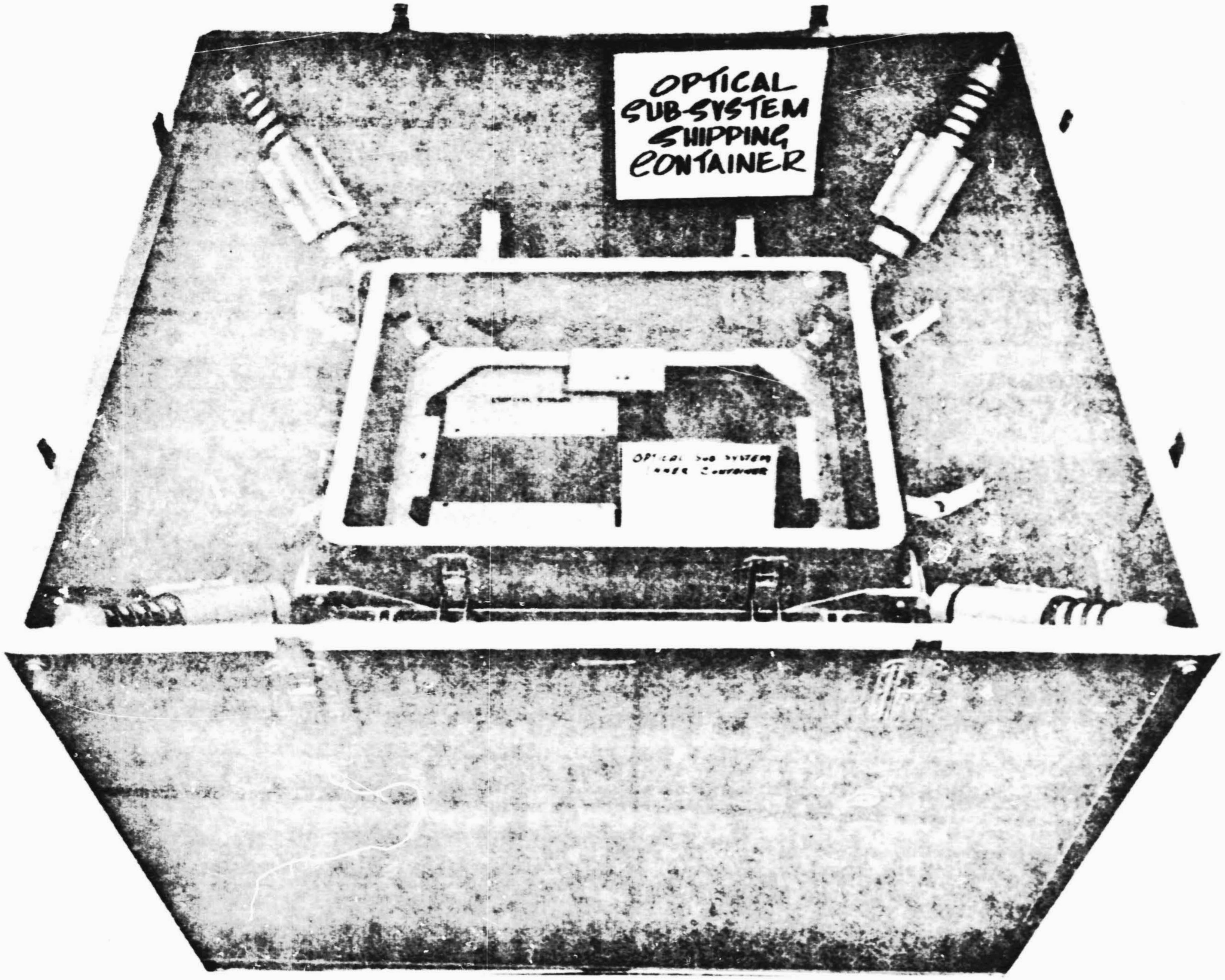


Figure 5-11. Optical Unit Shipping Container

and to support MIT/IL in the evaluation of certain thermal variables such as form factors and heat exchange between selected surfaces.

b. Accomplishments

Detailed transient thermal analyses of the Apollo Optical Unit were conducted for several parametric variations. Temperatures were computed for combination of maximum and minimum temperature conditions, hot and cold orbits, and white painted and bare metal covers.

The Optical Subsystem was divided into 91 temperature modes with temperatures computed for each mode at every 0.1 hour up to 3 hours. Thus, transient profiles were obtained for the various components. Ten of these analyses were conducted and results obtained for the following conditions:

(1) Minimum temperature condition, no solar radiation, collant, white covers.

(2) Minimum temperature condition, solar radiation, coolant, white covers.

(3) Minimum temperature condition, no solar radiation, no coolant, white covers.

(4) Maximum Temperature condition, solar radiation, coolant, white covers.

(5) Maximum temperature condition, no solar radiation, coolant, white covers.

(6) Maximum temperature condition, solar radiation, no coolant, white covers.

(7) Minimum temperature condition, no solar radiation, coolant, bare covers.

(8) Minimum temperature condition, no solar radiation, no coolant, bare covers.

(9) Maximum temperature condition, solar radiation coolant, bare covers.

(10) Maximum temperature condition, solar radiation, no coolant, bare covers.

2

A steady-state thermal analysis of the Map and Data Viewer was conducted. Temperatures were computed for operation under maximum environmental conditions.

The Map and Data Viewer was divided into 36 temperature modes with temperatures computed for each mode at every 0.1 hour up to 3 hours, at which time, steady-state is virtually achieved for these components. The temperatures depict maximum temperature conditions at steady-state.

The Apollo Guidance Equipment Thermal Vacuum Test Chamber was analyzed to determine its temperature profile under three sets of test conditions within the simulated command module chamber. Requirements for thermal insulation to be applied to the bulkhead which divides the test chamber into a command module compartment on one side and a space compartment on the other side were analytically determined. The wattage capacity for heaters to be mounted to the same bulkhead on the command module side was also derived. The heaters provided the simulated mounting temperatures for the Optical Base and for the Scanning Telescope and Sextant Bellows. The thermal insulation prevented inordinate heat loss from the Command Module compartment to the space compartment.

The thermal analyses of the test chamber indicated that the capacity to provide at least 800 watts of heat to the Command Module side of the bulkhead was required. It was recommended that the heaters be located in a six inch annulus directly adjacent to the ring provided for mounting the Optical Unit Test Fixture. It was also recommended that 20 sheets of NRC-2 "Super-insulation" be applied to the space chamber side of the bulkhead. These additions made it possible to simulate normal operating conditions and emergency conditions of cold and hot extremes.

A report was written on the results of the test chamber thermal analyses. A comprehensive final thermal report was written on the analyses of the Optical Unit and the Map and Data Viewer.

Thermocouple temperature readings monitored during the thermal-vacuum test of the Apollo Optical Subsystem were compared with temperature results of the thermal analysis. A correlation analysis between the two sets of data was performed.

Differences in the two sets of data were noted and a basis to define them was established. Primarily, the differences arise from the diverse boundary thermal conditions used in the test and in the analysis. Also, the analysis was fundamentally transient and was terminated at three hours. The test temperatures were monitored for a fifteen hour period. A report was written entitled, Apollo Optical Subsystem, Test and Analysis Correlation of Results", describing the investigation and the conclusions drawn.

5.3.12 TD K-61 AGE-2 Mechanical Integrity Tests

a. Description of Effort

This technical directive authorized mechanical integrity tests of the AGE-2 Optical Unit. Specifically, the work authorized consists of preparation of a test plan, design and fabrication of test fixtures, conducting of tests, recording and analysis of data, and submission of final report.

b. Accomplishments

Concrete base (5' x 5' x 5') for the Shock Machine was installed. The shock machine was assembled, and check out for the various terminal peak sawtooth shock pulses that were required.

Detailed test procedure was completed.

The three coolant hoses (P/N 1001580, 1001581, and 1001582) were leak tested at 60 pse. One hose (P/N 1001580) was found to be unsatisfactory. After examination and investigation, it was learned that this hose was cracked, due to extreme bending during shipment. The remaining two hoses were satisfactory.

Evaluation of the Optical Unit vibration fixture was completed. Evaluation of vibration instrumentation (acceleration and strain measuring devices, tape recorder, analysis filters, curve plotter, etc.) was completed.

Vibration of the Optical Unit along each of the three command module axes was conducted in accordance with the acceptance test vibration specification. Figure 5-12 shows the Optical Unit arranged for vibration along the Y_{CM} axis. Upon completion of vibration, a functional test was conducted in accordance with the FTM. There was no change in performance of the Sextant. There were, however, several discrepancies in the Scanning Telescope.

1. A loosening of the shaft axis approximately .006 inch axially. Complete disassembly of this area indicated improper selection of the spacer for the 1011606 Bearings. An analysis was conducted (TD K-62) to establish a basis for improved assembly methods to prevent this problem from recurring.

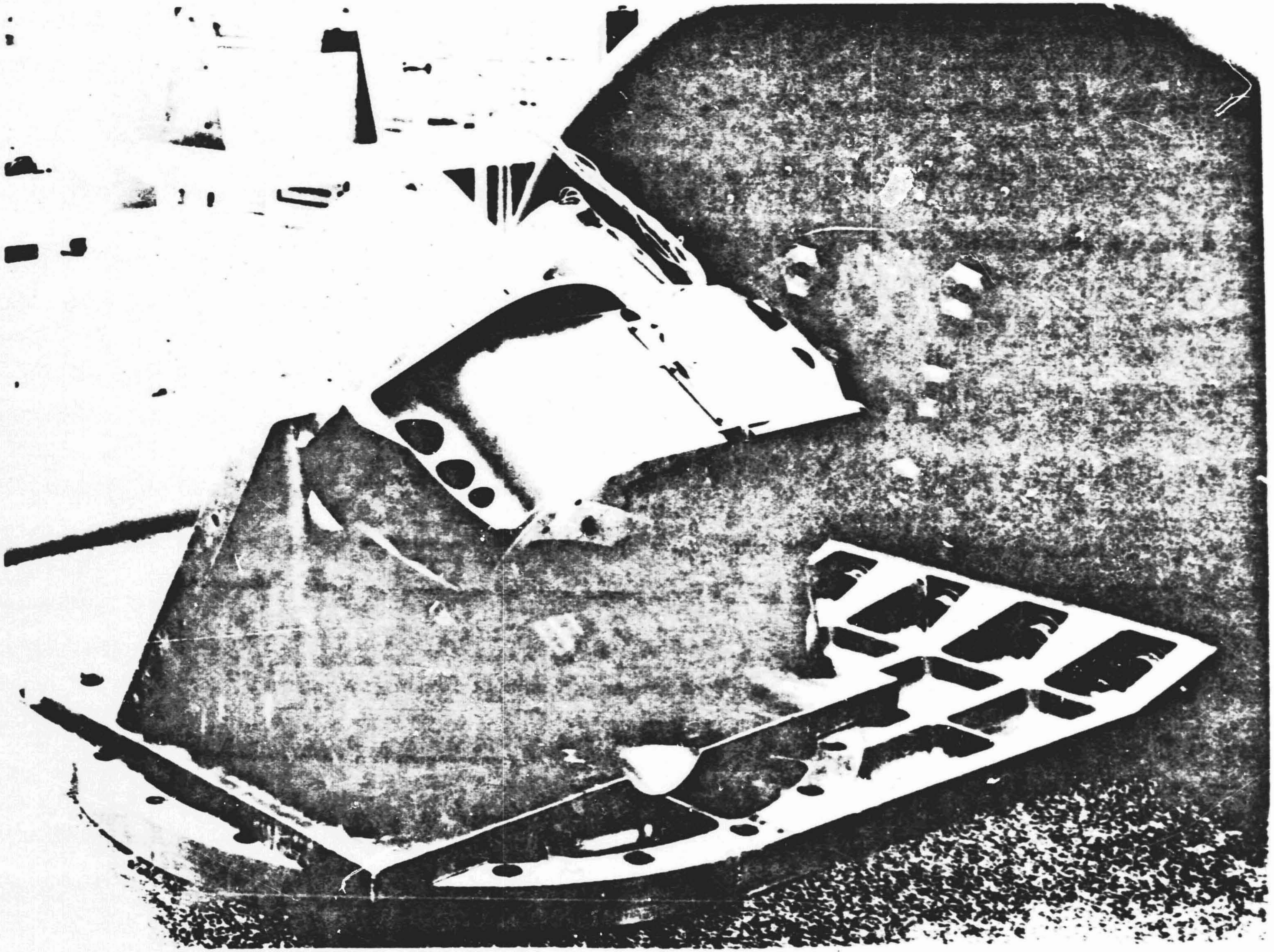


Figure 5-12. Optical Unit Arranged for Random Vibration Along Y_{CM} Axis

2. A loosening of the double-dove prism within its clamps. Evaluation of this situation suggested improper initial selection of clamps and indium foil thickness.

3. Failure of the shaft axis counter bearings. Evaluation indicated that the modified counter used in all Optical Units was not used in the AGE-2 unit.

The unit was reassembled using a proper spacer, proper double-dove prism clamps and indium foil thickness and the modified counters for both the trunnion and shaft axes.

A baseline FTM was performed. Preliminary sinusoidal vibration tests were conducted along the X_{CM}, Y_{CM}, and Z_{CM} axes, at 1 g from 10 to 2000 cps. Oscillograph recordings of the 28 accelerometers and the 19 strain gages were evaluated.

Based upon this evaluation, specific transducers were selected for monitoring during the random vibration tests.

Random vibration tests were conducted in accordance with the Launch and Flight Spectrum, at 25% and 50% of the total g_{rms} level, along the X_{CM}, Y_{CM}, and Z_{CM} axes. Spectral density curves were plotted for the 14 transducers.

An FTM performed following these tests showed an out-of-tolerance reticle eccentricity condition, which was determined to be due to loosening of the objective lens assembly.

No other discrepancies were found.

After correcting the reticle eccentricity condition, random vibration tests were conducted at 100% level (7.2 g_{rms}), along the X_{CM}, Y_{CM}, and Z_{CM} axes. Spectral density curves were obtained and evaluated.

An FTM conducted at the conclusion of these tests yielded the following information:

1. Sextant reticle eccentricity and perpendicularity were out of tolerance.

2. Sextant shaft axis resolver rotated 14 degrees, due to loosening of the locking ring.

3. Sextant shaft axis bearings loosened.

4. Sextant Flexprint, although able to function, was worn due to rubbing against the cover and against an internal wiring harness.

5. Telescope eyepiece prism was chipped slightly in three places. (Eyepiece was not intended to be mounted during this phase of the mission. It was evaluated to determine the effect of accidentally having it secured to the unit.)

6. Optical Unit mounting bolts backed out 1/4 turn.

7. Mounting bolts were scored by the mounting balls.

Repairs were made to the unit, with bearing preload increased to 75 pounds, followed by an FTM to re-establish the baseline.

Based upon the results obtained in the 100% test, accelerometers were located at points considered to be the most critical. Sinusoidal vibration tests were conducted at 1g, from 5 to 200 cps along the X_{CM}, Y_{CM}, and Z_{CM} axes, both with SXT and SCT covers in place and removed. The recorded data was evaluated.

All Optical Unit shock fixtures were evaluated.

c. Problem Areas

A TD was required to cover the repair effort on the Scanning Telescope and any subsequent repair efforts required during the course of the test program.

The evaluation of the AGE 2 Optical Unit suggested that certain subassembly tests be performed. However, Kollsman had no authorization to conduct any tests other than those on the AGE 2 assembly. The following additional investigations were recommended.

1. Evaluation of mounting arrangement (Belleville washers, mounting bolts, mounting bolts, mounting balls).

2. Objective lens assembly.

3. Reticle assembly.

Other investigations were required, based upon additional information that was acquired during subsequent AGE 2 testing.

5.3.13 TD K-62 Optical Unit Stress Analysis

a. Description of Effort

This technical directive authorized a vibration analysis of the Optical Unit to determine the dynamic behavior of selected elements of the assembly. In addition, evaluation of unusual and excessive shock loading on the Optical Unit, imposed during earthlanding, was conducted, specifically in terms of crew safety requirements. These analyses were used to determine critical areas, and aided in determining points of measurement for the AGE-2 mechanical integrity tests (TD K-61).

b. Accomplishments

An analysis was performed, and a report issued on the stresses in the Optics-Navigation Base mounting bolts when exposed to the earthlanding shock environment. As a result of this study, it was recommended that high strength bolts be used. Bolts with an ultimate strength of 300,000 psi were used in place of bolts rated at 180,000 psi.

A "Moment of Inertia Study" was completed and a report issued on the moment of inertia of the Optical Unit about its own axes.

An analysis of the Sextant trunnion axis and shaft axis gear trains, as well as the Scanning Telescope trunnion axis and shaft axis gear trains was made. Results obtained showed that the lowest torsional natural frequency in the Sextant trunnion axis gear train is 645 cps, with the remaining 6 natural frequencies considerably higher (about 4000 cps and up).

An analysis was completed on the natural frequencies of the Sextant and the Telescope, each considered as a rigid body, supported by the shaft axis bearings, considered to be springs. For the Sextant, the two natural frequencies are 1080 cps and 3500 cps; for the Telescope, 2060 cps and 2400 cps.

Lateral vibration of the Sextant and Scanning Telescope was evaluated. Based upon this analysis, it was concluded that the dynamic behavior of these structural elements was satisfactory. A report covering this evaluation was issued.

The torsional vibration analysis of the Sextant and Scanning Telescope gear trains (shaft and trunnion axes) was completed. The results showed that torsional oscillations of the gears is not a problem. A report covering this study was completed.

An analysis of the loads in the eyepiece mounting bolts was completed. The results showed that the bolts will withstand the specified dynamic environment. A report covering this evaluation was completed.

An analysis of the loads on the various lens assemblies in the Optical Unit and the Map and Data Viewer was completed. The results showed that there will be no degradation at the line of contact between the lenses, spacers and housing seats. A report covering this study was completed.

An analysis was performed on the Sextant and Scanning Telescope bearings (1011607-2, 1011606-1 and -2, respectively) to determine possible causes of axial motion of each shaft, and to form the basis for improved assembly methods to eliminate this motion.

An analysis was conducted to determine the dynamic behavior of the eyepieces.

c. Problem Areas

An analytical study of the sextant and scanning telescope shaft axis bearings (1011607-2, and 1011606-1, -2, respectively) was completed and a report was issued. The results showed that higher preloads on the bearings are required, and that an improved method of assembly should be instituted. As a result of this study, the indicated changes were incorporated in the assembly procedures.

An analysis of the dynamic behavior of the eyepieces was completed. The results of this analysis, together with test data obtained under TD K-61, dictated that the eyepieces should not be mounted to the Optical Unit during the more extreme phases of the lunar mission (launch, re-entry, high "Q" abort).

A final report was prepared on all of the analyses performed.

5.3.14 TD K-83 AGE-1 Optical Subsystem Thermal/Vacuum Tests

a. Description of Effort

This technical directive authorized design-evaluation testing of the AGE-1 Optical Subsystem, which includes thermal-vacuum and humidity exposure.

b. Accomplishments

Fixtures

(1) Fabrication of the following fixtures was completed:
10-23330-0091 Thermal Vacuum
10-23330-0111 Humidity

(2) Completed design for vacuum chamber handling fixture for the combined OSS and the 10-23330-0203 was completed and is now in the fabrication stage.

(3) Design of the following fixtures was completed:

10-23330-0201 Coupling Shield (Solar simulator)
10-23330-0202 Optical port covers (Vacuum chamber)

Chamber

(1) The vacuum chamber underwent acceptance tests, conducted jointly by Kollsman and the vendor to assure conformance to all design specifications.

(2) Evaluation studies of the vacuum chamber using theodolites, alignment telescopes and autocollimators to determine the stability characteristics of the mounting partition and the possible effects of transmitted vibration from the pumping gear and other equipment in the environs of the space chamber was completed.

(3) Installation and checkout of the heat exchanger system was completed. Design and fabrication of the appropriate hydraulic lines was completed. Subject system was coupled to the vacuum chamber when the chamber acceptance run was completed.

(4) Installation and checkout of the solar simulation system was completed. A second calibration check using an exposure meter was accomplished. Ducting was installed to vent exhaust gases and to safely dispose of any toxic fumes produced. The radiation projection angle was approximately 12 degrees from the chamber and OSS horizontal axis. Subject run was completed. A Coupling Shield design, 10-23330-0201 was completed.

(5) A "Safety Study" relative to the operation of the solar simulation system was initiated. For personnel protection, protective clothing, eye shields and sunburn ointment were ordered. Safety procedures for the operational area were formulated. An optical part cover, 10-23330-0202 design was completed.

(6) Final determination of heating and/or insulation of the vacuum chamber partition, to simulate C/M structual heat input to OSS was completed.

(7) Compatibility testing and evaluation checkout of the completed functional tests and the auxiliary test panel was completed.

Optics and Optical Determination

(1) Evaluation studies of the optical port flatness characteristics and the effect, if any, on optical metrology procedures was completed.

(2) Fabrication of the Optical Pier, 10-23330-0210, equipped with a dual theodolite mounting was completed.

(3) Fabrication of the two Optical Piers 10-23330-0206 was completed. One was equipped with a reference theodolite, the other with a 45° prism mount (or a precision cube).

(4) An alignment procedure of the three optical piers, referenced in (2) and (3) above, in their respective angular position relative to the vacuum chamber horizontal line-of-sight was completed.

(5) Optical bench evaluation studies of the SCT to establish a secondary method of optical metrology was continued. This alternate method of optical measurement permitted front and rear SCT optical viewing capability.

c. Problem Areas

Evaluation studies of the proposed SCT optical measurement procedure disclosed a suspected problem in viewing through the double dove end with a theodolite mounted outside of the large spool section of the vacuum chamber. The large distance involved negated this form of measurement. It was proposed to have ready at the start of the evaluation test a secondary method of optical metrology, using an alignment telescope. This viewing technique was at the opposite end of the vacuum chamber (small spool area) sighting through the Panel End of the SCT.

The initial alignment procedure involving the three optical piers disclosed a series of problems. The most perplexing problem was the small maneuvering area available for positioning the piers. The desired cube referenced technique requires a larger area than is available. Therefore, concentration was exerted in the use of a right angle mirror technique. The stability of the piers, once aligned, was of paramount importance. Various methods to insure permanent location and stability were under consideration. Present environmental conditions in the optical pier area were not favorable for stability of precision instrumentation (theodolites, alignment telescope and collimators). Various methods to correct this situation were considered.

All items, required for the implementation of the AGE I testing, were acquired or fabricated.

The optical evaluation studies of the Space Chamber were completed. The equipment used was an optically flat mirror (1/4) and an autocollimating theodolite to establish the movement of the partition between the chamber section under the extreme environmental conditions to which the Optical Unit was exposed. A sketch of the test set-up is shown in Figure 5-13. The conditions applied were as follows (see Figure 5-14, "Chamber Schematic"). Chamber B was varied in temperature, from 0° to 160°F and, in pressure, from one atmosphere (approximately 14.7 psi) down to 1 x 10^{-4}mm Hg. Chamber A was varied in temperature from +200° to -250°F and the pressure was brought to and maintained at 1 x 10^{-7} mm Hg. The results of the test indicated that the greatest change in angular displacement of the optical axis of the mirror will never exceed 1 minute of arc with the maximum stress differentials applied across the partition. The maximum stress conditions applied were as follows:

Condition		Chamber B	Chamber A
I.	pressure	1 ambient atmosphere	1 x 10^{-7}mm Hg
	temperature (shroud)	+ 160° F	-250°F
II.	pressure	1 atmosphere	1 x 10^{-7}mm Hg
	temperature (shroud)	-10°F	+200°F

Mylar superinsulation was placed on the chamber partition wall separating Chamber B from Chamber A on the space simulation side. The entire wall was covered with the exception of the 24-inch diameter removable plate. Strip heaters of variable power input (0 to 100 watts each) were mounted to the partition within an imaginary 6-inch annulus around the 24-inch diameter plate circle on the simulated Command side (Chamber B). The above procedure permitted a variable input capability to establish the proper levels of spacecraft structural heat loads.

An initial condensed environmental exposure of the Optical Unit was performed, according to the schedule shown in Figure 5-15. A sketch of the optical test set is indicated in Figure 5-16. The purpose of the test was to establish the extremities to which the

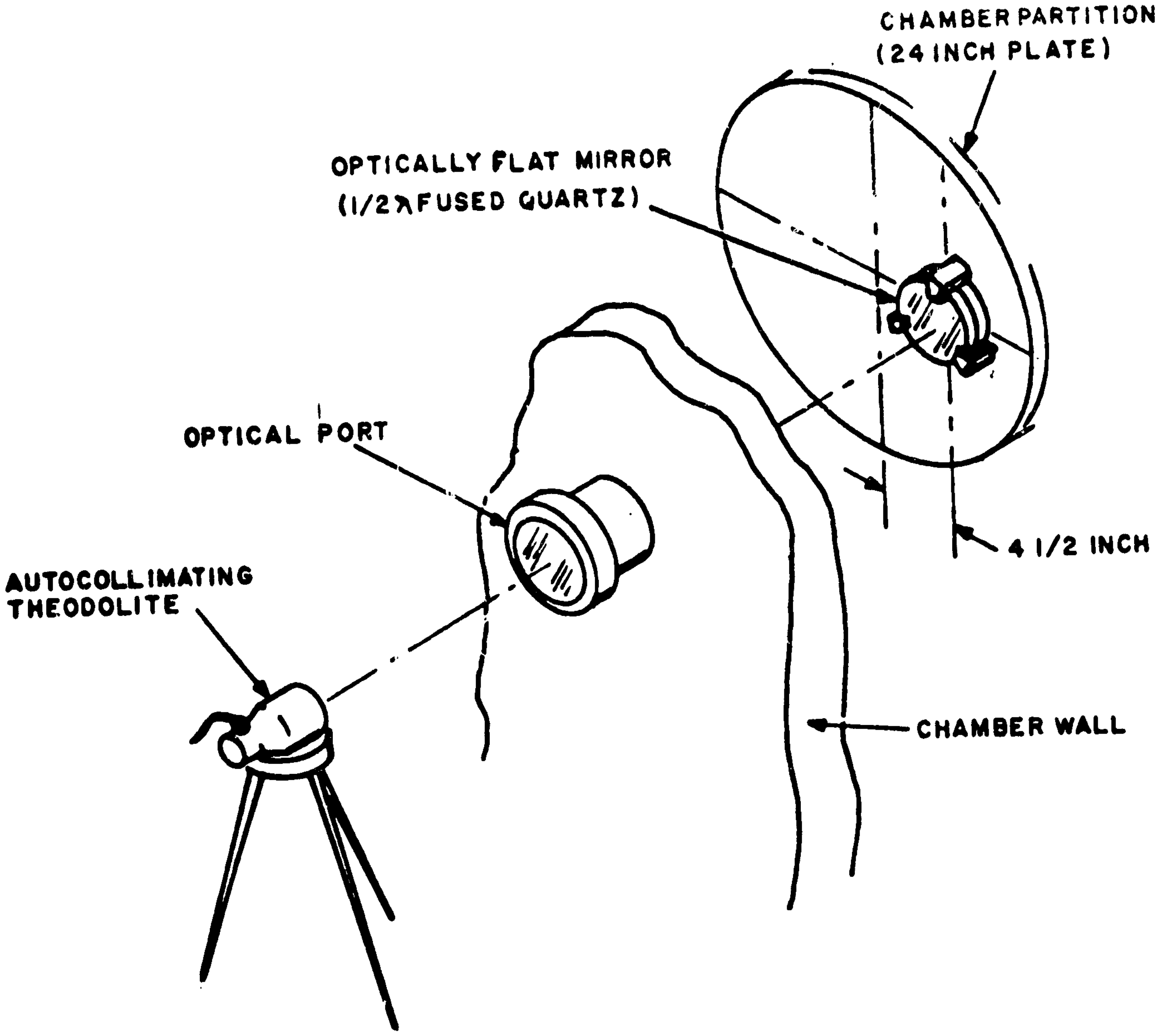


Figure 5-13. Test Set-up for Chamber Partition Movement Evaluation

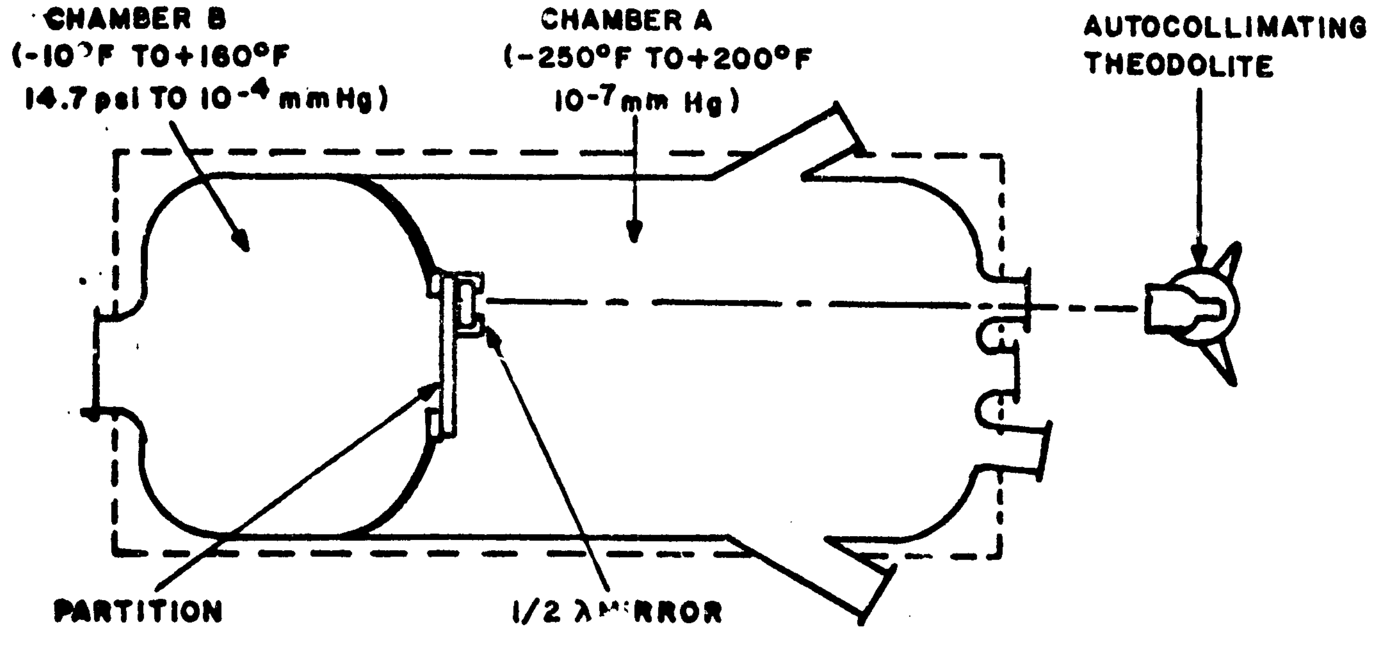


Figure 5-14. Chamber Schematic (Sectional View from Top Looking Down)

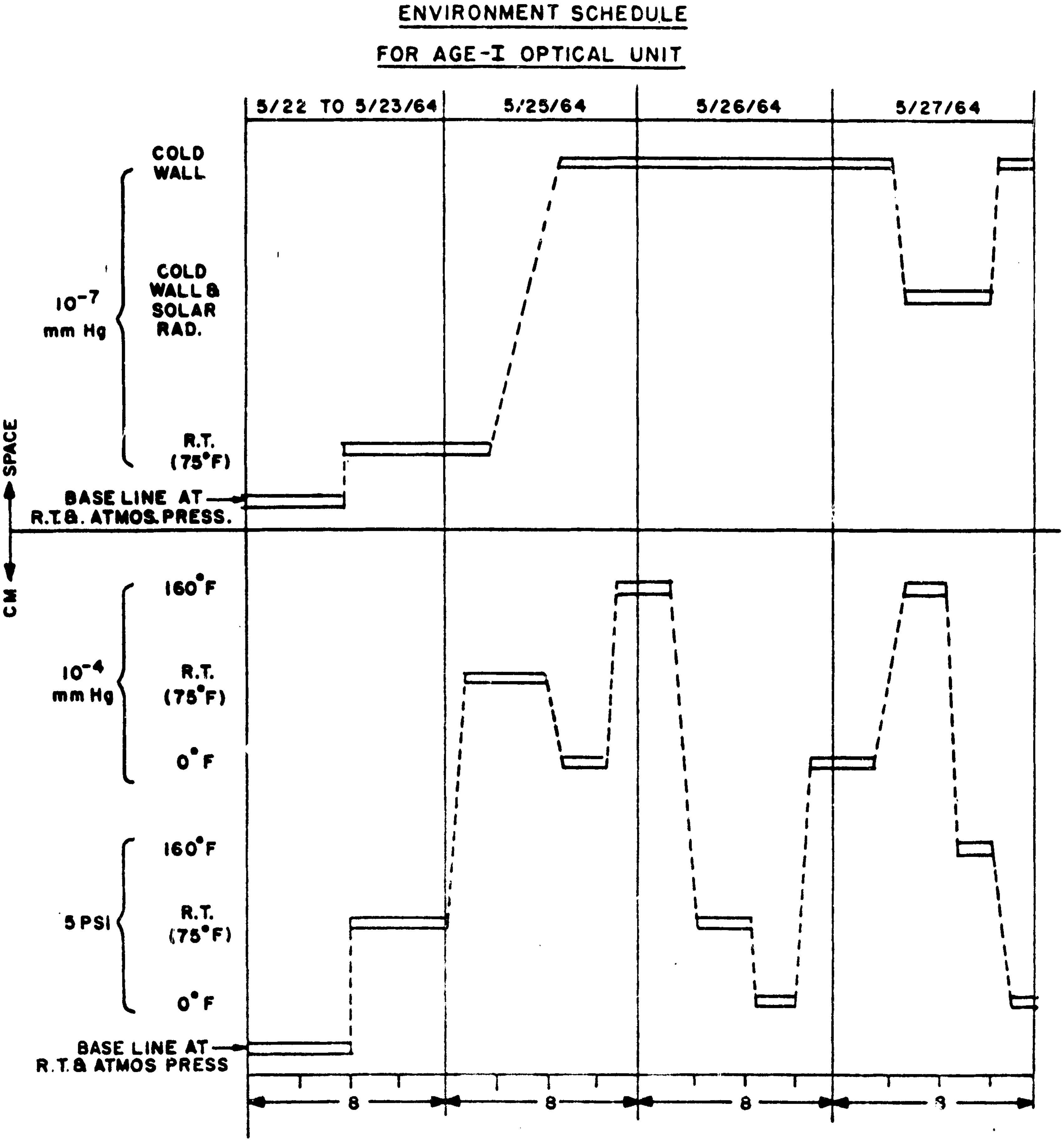


Figure 5-15. Environmental Schedule for AGE 1 Optical Unit

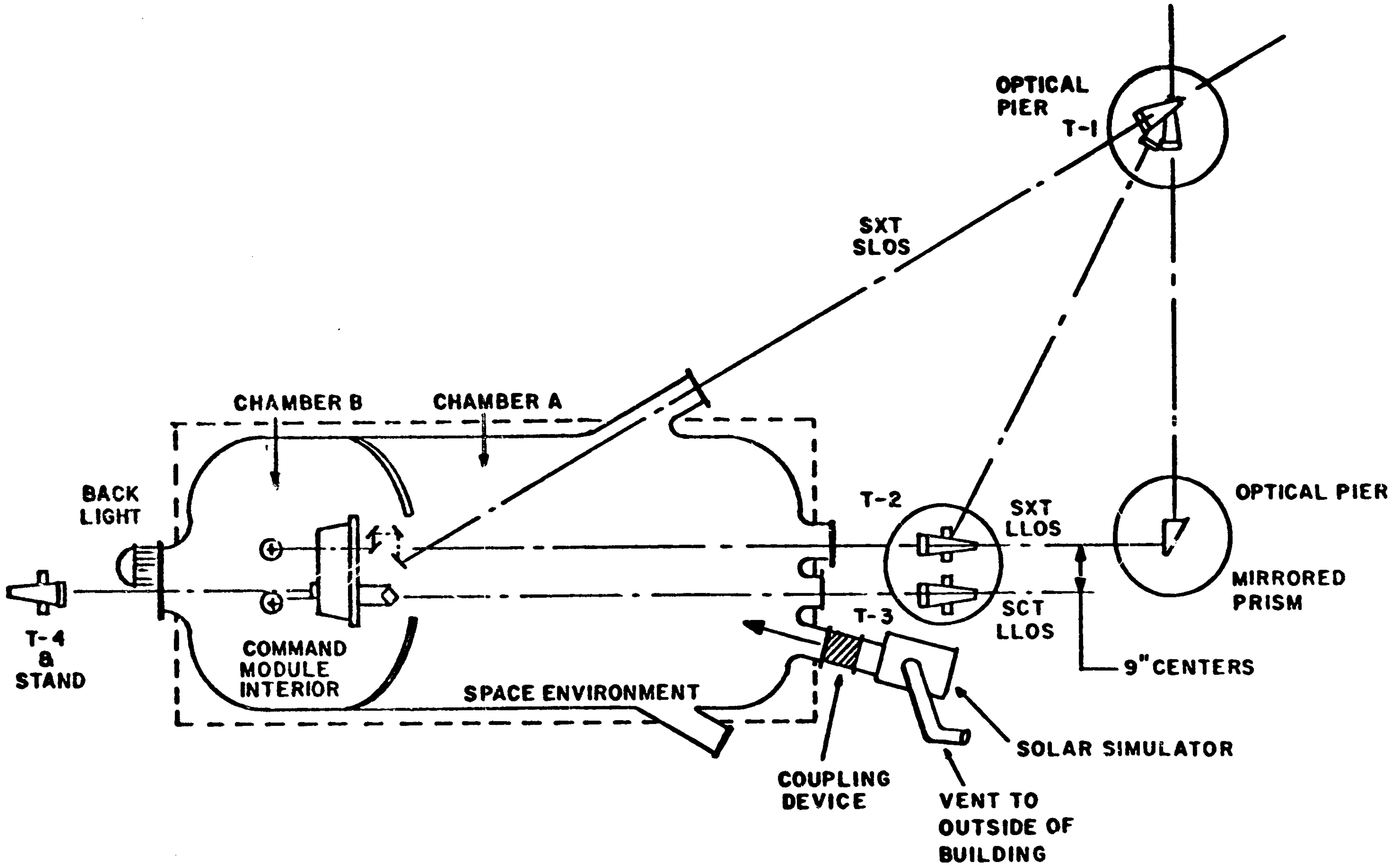


Figure 5-16. AGE 1 Thermal Vacuum Optical Test Layout

Optical Unit would be subjected in the formal extended test. This test determined what areas of testing would require additional observation or monitoring then originally proposed in the preliminary "Detailed Test Procedure". The test data were analyzed and the necessary resulting improvements in instrumentation and operating procedure were instituted prior to the extended run.

1. It was discovered that the Solar Simulator, when energized and directed through the 12-inch optical port in the Space Chamber (see Figure 5-16), caused the reticle images of the SCT and SXT to be obliterated completely. A solution of the problem of reticle obliteration was provided by closing the shutter between the arc and the first condensing lens in the Solar Simulator and, while maintaining back lighting of the Optical Unit, perform the required theodolite readings (SXT LLOS & SLOS).

2. Preliminary reduction of the test data acquired indicated that the displacements observed were of the whole optical base rather than shifts of the components within the SXT or SCT. An additional theodolite, T-5 (see Figure 5-17), was added to the test layout to measure more accurately the pitch and roll attitude of the optical base.

3. During the condensed testing phase only the SXT was energized and maintained at one position (270° LLOS and 34° SLOS) throughout the test. Exercising of the SXT was not attempted. Observations were performed on the basis of any divergence from the baseline conditions initially imparted to the unit. It was observed that there was no change in the zero position of the SCT throughout the test.

4. The Solar Simulator spectrum was analyzed by the use of the MIT Spectrum Analyzer at a distance of 88 inches, and the nominal distance from the solar source to the focal point on the Optical Unit with all equipment in its normal position as indicated in Figure 5-18. It was established that the spectrum of the Solar Simulator conformed well (slightly bluish) to the MIT solar beam spectrum content, i.e., near ultraviolet to infrared. However, the intensity of the beam was found to be deficient. The approximate intensity of the beam was equal to 75% of 1 solar constant. This result was substantiated by the use of the Wollensak Exposure Meter which has been calibrated by the Kollsman's Elmhurst facility (traceable to NBS Standard) for other tests performed recently with the Solar Simulator. The

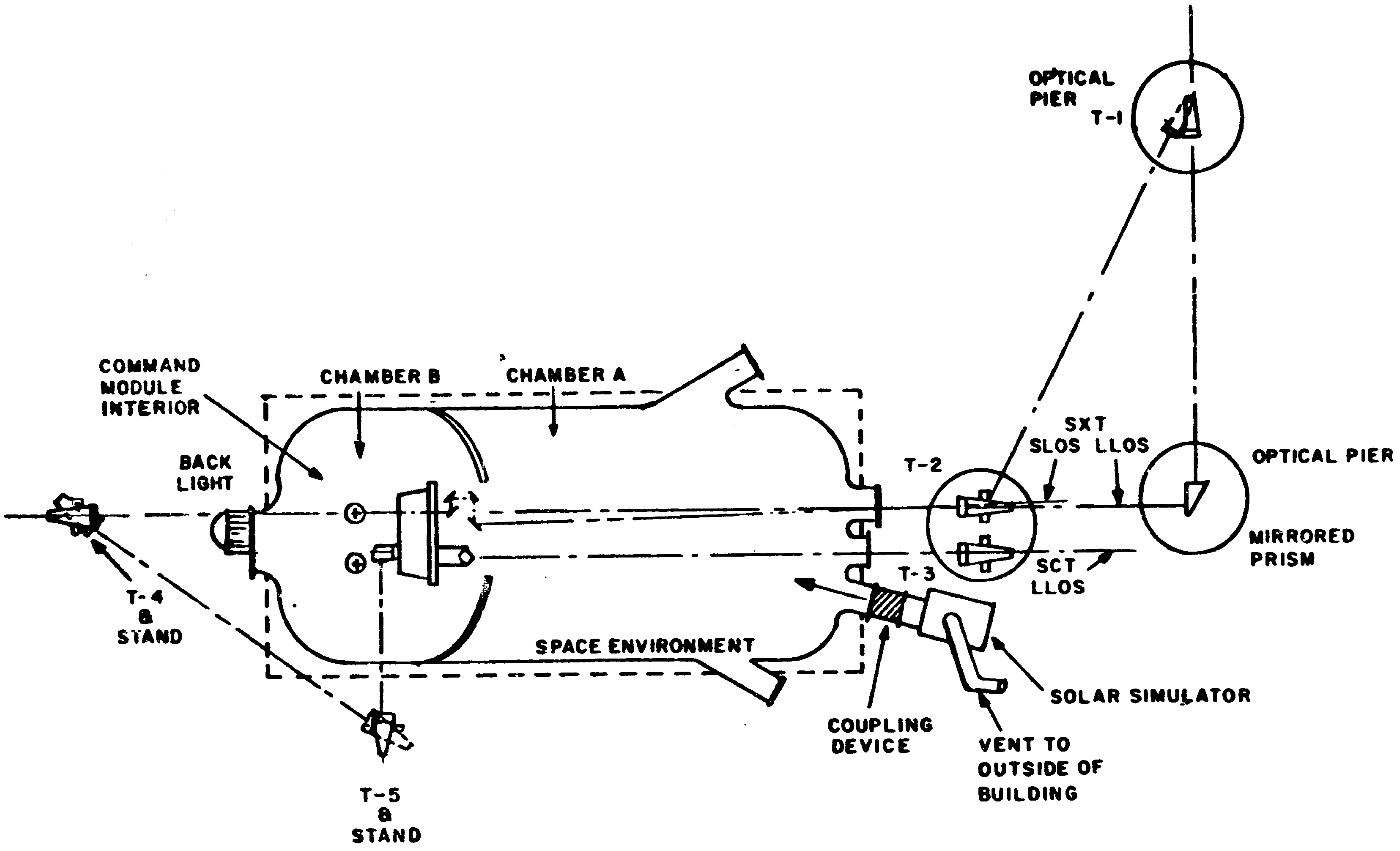


Figure 5-17. AGE 1, Thermal Vacuum Optical Test Layout, Apollo Mission Profile Cycle #1

readings indicated 11/14 or 78% of the required 1 solar constant. Investigation of the findings uncovered a discrepancy in the original Kollsman Solar Simulator calibration tests. It was discovered that the original tests had been performed using a distance of 72 inches between the solar source and the Wollensak Exposure Meter instead of the required 88 inches. Apparently there was a misinterpretation of the test requirements at the time. Fortunately, there was no loss of effort due to this divergence from the original requirements since the test results were extrapolated to the 100% intensity value of the solar beam in the ensuing thermal analyzer.

5. On completing the accelerated test run, samples of the ethylene glycol were obtained and forwarded to MIT for chemical analysis. Fluid samples were as follows:

Sample #1 - From the exchanger line system.
Sample #2 - From the heat exchange accumulator sump.
Sample #3 - From the original 55 - gallon shipping drum.

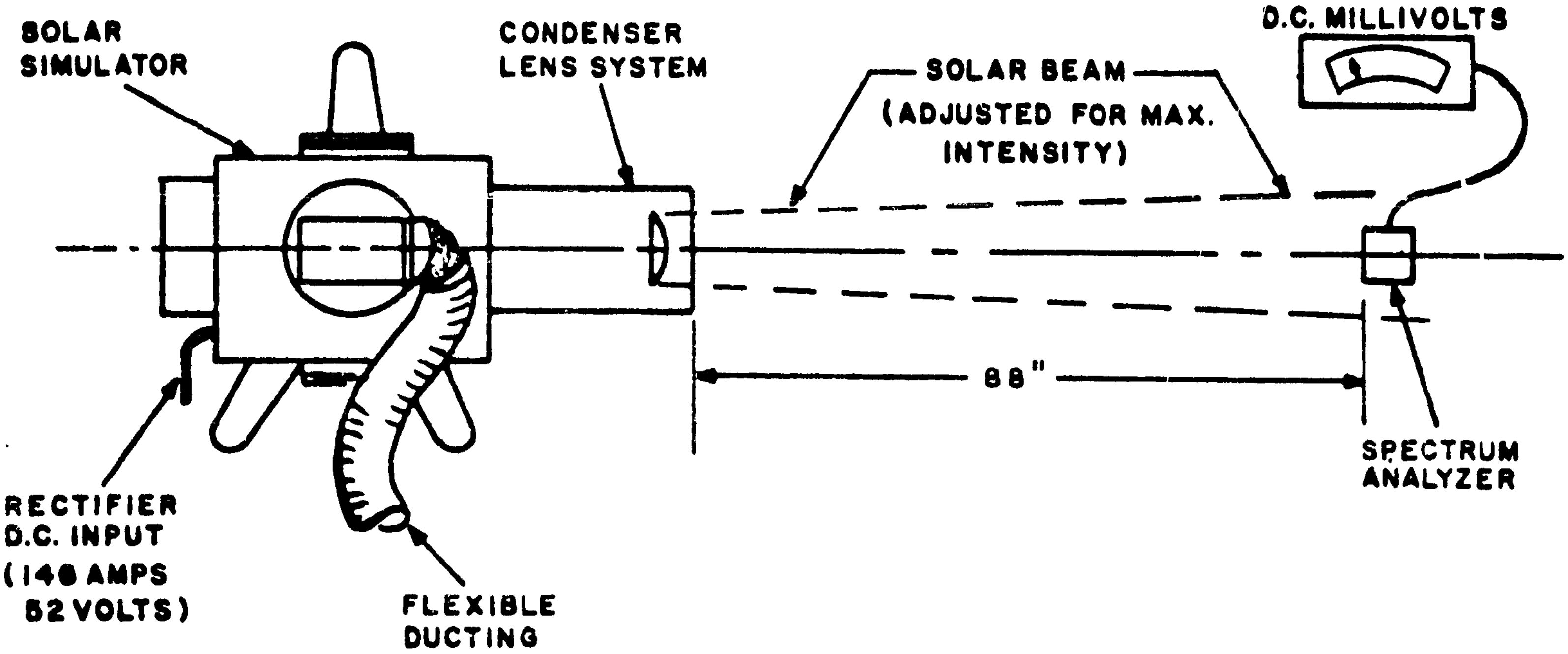


Figure 5-18. Solar Beam Analyzer Test

One complete cycle of the extended thermal vacuum test was performed (see Figure 5-19). The total mission time accumulated was 230 hours with no interruption of operation due to Optical Unit malfunction. The optical test layout is indicated in Figure 5-17. (Note the addition of the T5 theodolite for additional monitoring function.) The test data was reduced and analyzed by MIT and KI personnel jointly.

KI engineering personnel have successfully adjusted the lens system of the Solar Simulator to obtain an intensity of one solar constant.

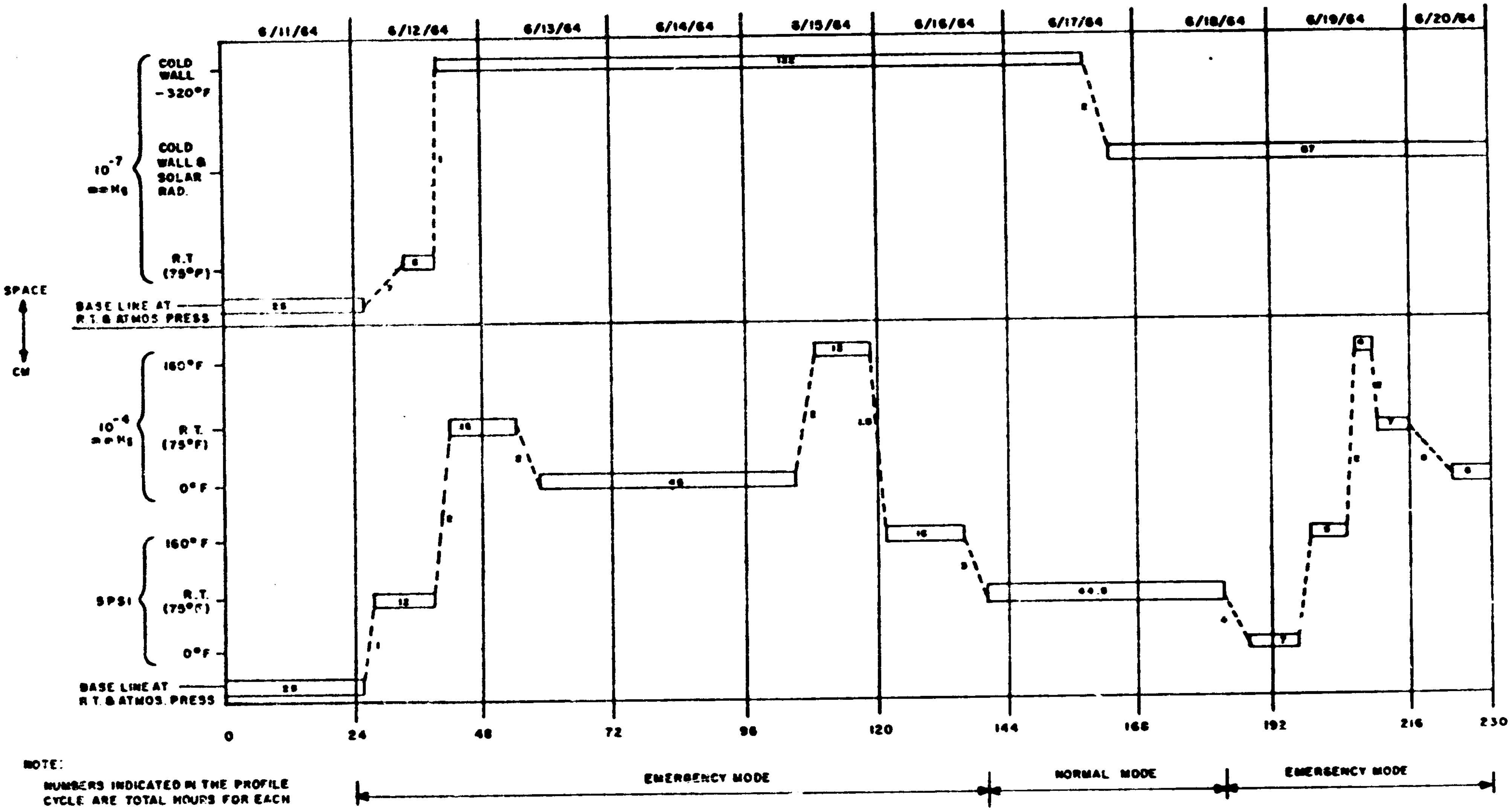
Photographs of the optical unit and environmental area taken before testing are shown in Figures 5-20 and 5-21. Additional photographs are available showing the following views:

1. Close view of SXT Head Showing Thermocouples - Cover Removed. (Figure 3-5, Page 37, Monthly Progress Report No. 16, 31 May 1964.)
2. Close view of SCT Head Showing Thermocouples - Cover Removed. (Figure 3-6, Page 38, Monthly Progress Report No. 16, 31 May 1964.)
3. AGE I Optical Unit Mounted to Chamber, C/M Side (Figure 3-7, Page 39, Monthly Progress Report No. 16, 31 May 1964.)
4. Close view of AGE I mounted to chamber wall C/M side. (Figure 3-8, Page 40, Monthly Progress Report No. 16, 31 May 1964.)
5. AGE I Optical Unit; mounted to chamber - Space side (Figure 3-9, Page 41, Monthly Progress Report No. 16, 31 May 1964.)

5.3.15 TD K-104 Failure Effects Analysis

a. Description of Effort

This TD authorized support and resistance to MIT/IL for failure effect analysis of Command Module Guidance and Navigation Equipment.



NOTE:
NUMBERS INDICATED IN THE PROFILE CYCLE ARE TOTAL HOURS FOR EACH ENVIRONMENT.

Figure 5-19. Environment Schedule for AGE 1 Optical Unit, Thermal Vacuum Apollo Mission Profile, Cycle No. 1

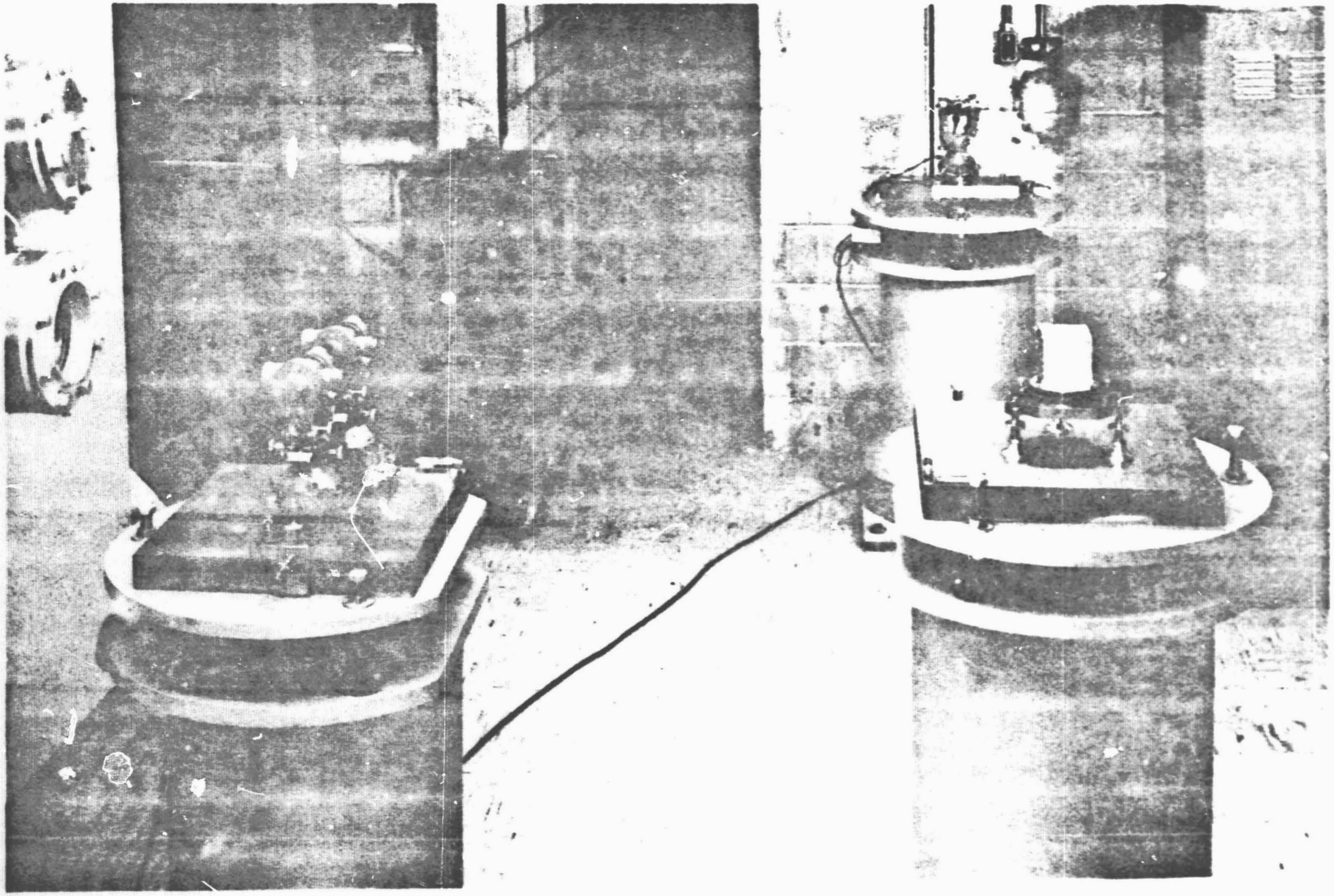


Figure 5-20. Test Layout Showing Positioning of Three Piers Used During Optical Metrology of AGE 1 Testing

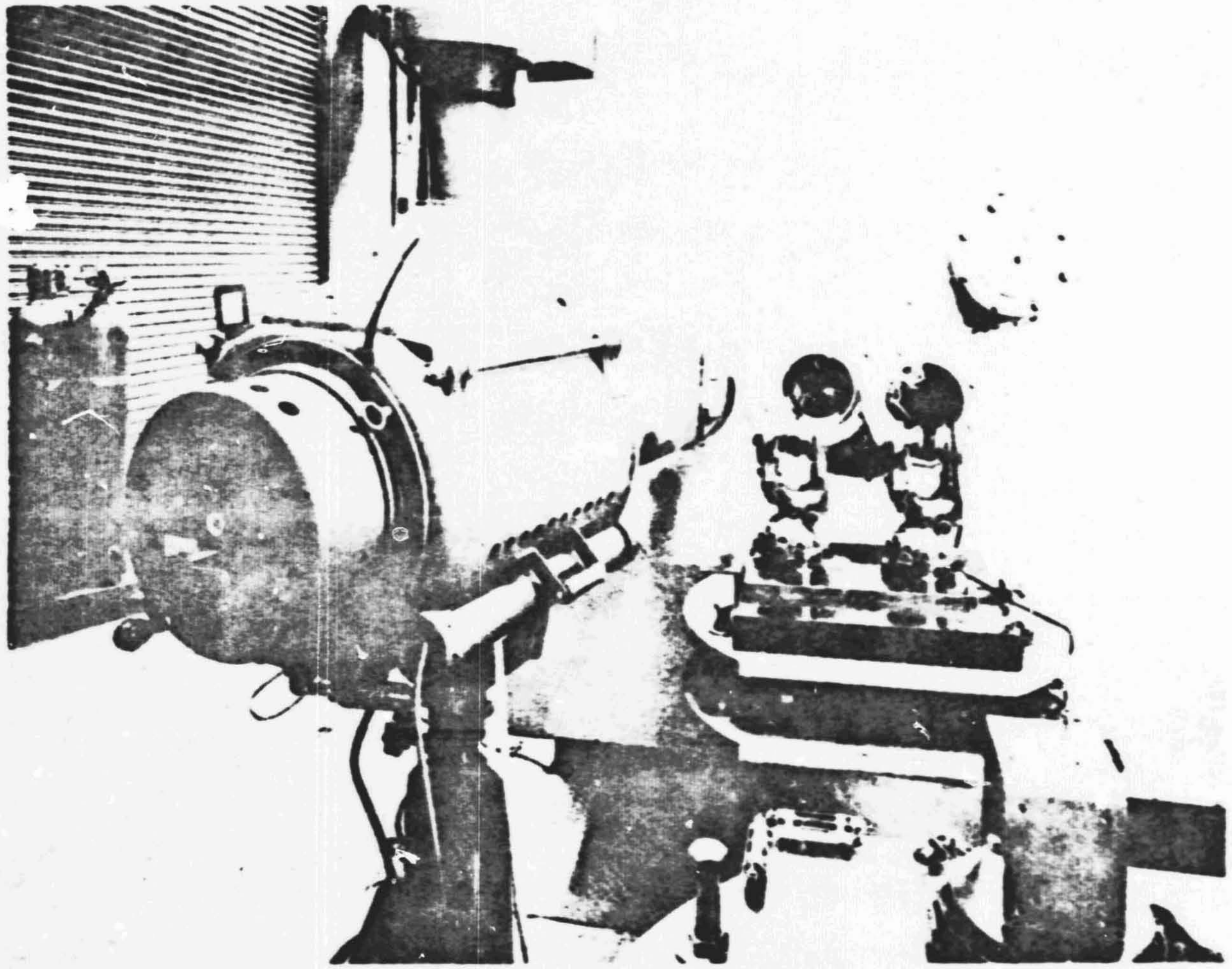


Figure 5-21. Rear of Space Chamber Showing Optical Instrumentation T2 (SXT) and T3 (SCT) In Alignment Position At Start of Evaluation Test. The Solar Simulator is to the Left of the Optical Pier

b. Accomplishments

Kollsman participated in Failure Effect Coordinating Conference with MIT/IL, ACSP, and Raytheon with the following results:

Liaison was established between all contributors to the Apollo G & N failure effects analysis.

The use of NASA approved format for the recording of FEA data was agreed upon.

The need of a mission profile for each flight was stressed in order to delineate an adequate failure effect analysis.

Synthesis of an electrical family tree for the Block II Optical Unit was initiated.

Layout and analysis of interface between KI equipment and ACSP system was investigated.

Classification of failure modes inherent to the OSS and of failure modes pertinent to interface problems, were established

5.3.16 TD K-127 Block II Reliability Program Plan

a. Description of Effort

This TD authorized a revision of the Apollo G & N Reliability Program Plan per the comments received from MSC Reliability and Quality Assurance Division, Houston.

b. Accomplishments

The revised program plan was completed.

5.3.17 TD K-80 Parts Qualification Program

5.3.17.1 Reliability Test and Evaluation

a. Description of Effort

(1) Prepared detailed test plans pertaining to reliability tests and evaluations.

(2) Submitted completed test plans to MIT/IL for review and approval.

(3) Planned and designed test equipment, test fixtures and associated equipment necessary for reliability evaluation and test of optical subassemblies and parts; also for subsequent qualification test of the complete Optical System.

b. Accomplishments

The manufacture for reliability qualification, of the MDV functional tests and cables for space chamber usage were completed. The test procedures for qualification testing of the following parts were completed:

a) Resolver, size 8 (1010341)

b) Resolver, 1X64 (1011294)

c) Motor-generator, size 11(1010610)

d) Motor, size 8 (1011379)

e) Resolver, size 5 (1011371)

f) Flexprint (1011907)

g) Projection Lens (1011374)

h) Overrunning Clutch (1011373)

i) Slip Clutch (1011369)

j) Differential (1011281)

k) Counter Angle (1011744)

l) Connectors (1011499), (1011501), (1011748-1), (1011748-2), (1011747)

m) Cartridge Assembly (1011420)

TD K-80 was amended to include the qualification of resolvers, size 8, by Kollsman. The modification of all test fixtures designed for motor-generator (1010610) were modified so that they can be utilized for resolver, size 8 (1010451).

Preliminary scheduling for the preparation of test procedures for the environmental testing of subassemblies was accomplished.

c. Problem Areas

TD K-80, as approved, made no allowance for the facilities requested by Kollsman. The equipment needed was two (3x3 hermal-vacuum chambers and three (2x2) thermal vacuum chambers along with supporting instrumentation.

Official release of projection lamp (1011413) by MIT/IL was requested so that a plan could be generated by Kollsman. After approval of plan, Kollsman procured parts and wrote a detailed test procedure.

Additional assignment to Kollsman of parts, for qualification by MIT/IL required additional funding. Some of the parts in question were Indicator (1011375), Resistor (1011498), and Microswitch (1011368).

5.3.17.2 Design Evaluation and Qualification Test Program

a. Description of Effort

Design evaluation and qualification testing of the Apollo optics, major subsystem elements, parts and materials defined as a Kollsman responsibility as set forth in R-389A.

This TD authorized the procurement and the fabrication of test articles, test equipment, and test fixtures pursuant to MIT's review and approval of the test plans, procedures, test equipment and test fixture design.

Assistance in the coordination of the Guidance and Navigation System test program and participate in the Test Review Board.

b. Accomplishments

(1) The installation and acceptance of the thermal-vacuum chamber was completed.

(2) The fabrication of environmental test calbes (vacuum, humidity, etc) was completed.

(3) Environmental breadboards for the qualification testing of resolvers were completed.

(4) Test fixtures were released for manufacture as soon as the designs were completed. See Table 5-3 for status of environmental fixtures.

TABLE 5-3

RELIABILITY TEST FIXTURE STATUS

Fixture Number	Description	Design		Fabrication	
		IN	Complete	IN	Complete
10-23330-0121	Vibration - Double Dove Assy.		X		X
0120	Vibration - Trunnion Axis Assy.		X		X
0123	Thermal Vacuum SXT Head Index Assy.		X		X
0200	Shock-Vibration Resolver (1 x 64)		X		
0087	Resolver - Size 8		X		X
0125	Shock - Resolver Size 8		X		X
0126	Thermal Vacuum Resolver Size 8		X		X
0127	Humidity - Resolver Size 8		X		X
0095	Vibration - Motor Size 8		X		X
0136	Vibration - Counter Angle		X		X
0137	Shock - Counter Angle		X		X
0193	Thermal Vac-Counter Angle		X		X
0138	Humidity-Counter Angle		X		X
0135	Adapter-Counter Angle		X		X

TABLE 5-3 (Cont.)

RELIABILITY TEST FIXTURE STATUS

Fixture Number	Description	Design		Fabrication	
		IN	Complete	IN	Complete
10-23330-0139	Vibration-Differential		X		X
0091	Thermal Vacuum OSS		X		X
0111	Humidity - OSS		X		X
0093	Thermal Vacuum - MDV		X		X
0094	Humidity - MDV		X		X
0090	Vibration - OSS		X		X
0103	Shock (Y-Y Axis) OSS		X		X
0112	Shock (X-Y Axis) OSS		X		X
0194	Shock (Z-Z Axis) OSS		X	X	
0092	Vibration - MDV		X		X
0117	Shock - MDV		X		X
0115	Vibration - Fixed Mirror & Beam Splitter		X		X
0113	Shock - Fixed Mirror & Beam Splitter		X		X
0122	Thermal Vacuum - Fixed Mirror & Beam Splitter		X		X

TABLE 5-3 (Cont.)

RELIABILITY TEST FIXTURE STATUS

Fixture Number	Description	Design		Fabrication	
		IN	Complete	IN	Complete
10-23330-0116	Humidity-Fixed Mirror & Beam Splitter		X		X
0118	Vibration-SXT-Telescope Assembly		X		X
0124	Temperature & Thermal Vacuum-Obj. & Inter-Lens		X		X
0114	Humidity-Obj. & Inter-Lens Assy.		X		X
0191	SXT Head Adapter for Ultradex Table		X		X
0134	Resolver Holding Fixture		X		X
0206	Optical Pier		X		X
0210	Optical Pier for General Use		X		X
0183	Adapter - Torque Wrench for Trunnion Axis Assy.		X		X
0204	Vibration-Connectors Size 5		X		X
0205	Life Cycle-Connectors		X		X
0203	OSS Handling Fixture		X		X
0201	Light Cover - Solar Simulator coupling		X		X
0202	Chamber - Optical Port Cover		X		X

TABLE 5-3 (Cont.)

RELIABILITY TEST FIXTURE STATUS

Fixture Number	Description	Design		Fabrication	
		IN	Complete	IN	Complete
10-23330-0410	Chamber Optical Port Cover		X		X
0207	Slip Plate -AGE II		X		X
0199	Adapter Plate - Tie Down -AGE II		X		X
0414	Assy Holding Fixture MDV		X		X
0415	Assy Holding Fixture OSS		X		X
0196	Accuracy - Resolver Size 5		X		X
0140	Shock - Differential		X		X
0141	Thermal Vac. - Differential		X		X
0142	Humidity - Differential		X		X
0182	Vibration - Slip Clutch		X		X
0184	Thermal Vac.		X		X
0185	Humidity- Slip Clutch		X		X
0186	Vibration - Overrunning Clutch		X		X
0188	Thermal Vac. Overrunning Clutch		X		X
0143	Vibration - Projection Lens		X		X

TABLE 5-3 (Cont.)

RELIABILITY TEST FIXTURE STATUS

Fixture Number	Description	Design		Fabrication	
		IN	Complete	IN	Complete
10-23330-0181	Humidity Projection Lens		X		X
0109	Vibration-Cartridge Assy.		X		X
0537	Shock-Cartridge Assy.		X	X	
0108	Vibration-Resolver Size 5		X		X
0119	Vacuum & Temperature Stand		X		X(Rework)
0395	Adapter Plate Shock Machine		X		X
0195	Environmental Fixture		X	X	
0189	Handling Fixture-OSS		X		X
0131	Dummy Sextant Load		X		X
0190	Adapter for Ultradex Table		X		X
0408	Friction Torque - Resolver Size 8		X		X
0411	Resolution -Projection Lens		X		X
0409	Backlash/Torque Fixture Differential		X		X
0405	Drag Torque - Cartridge Assy		X		X
0216	Flexibility - Flexprint		X		X

TABLE 5-3 (Cont.)

RELIABILITY TEST FIXTURE STATUS

Fixture Number	Description	Design		Fabrication	
		IN	Complete	IN	Complete
10-23330-0417	Vibration -Projection Lamp		X	X	
0531	Vibration -Indicator Integrated Readout		X		
0434	Vibration-Objective Lens & Reticle Assy.		X		X
0416	Vibration-Pechan Prism & Relay Lens		X		X
0407	Vibration-MDV Electronic Pkg.		X		X
0433	Vibration-MDV Gear Box		X	X	
0452	Optical Port-AGE I		X		X
0530	Dual Mirror Mount		X		X
0532	Vibration-Eyepiece & Panel Assembly		X	X	
0471	Handling Fixture Space Chamber		X		

(5) Preliminary tests on the slip clutch (1011369) were accomplished.

(6) Status of the Reliability Parts Qualification Program, at the conclusion of this reporting period, is indicated in Table 5-4.

(7) Environmental breadboards for resolvers were designed and fabricated.

(8) Flow charts, Figures 5-22 through 5-24 indicate how three typical parts were processed through qualification tests. These charts indicate when various environmental and test equipments were needed and show the span time for each individual test. Thus, a complete control on the part from the start of testing to the completion of testing was maintained.

(9) The evaluation of the slip clutch test procedure was completed.

(10) Detailed test procedures have been completed for fifteen (15) approved plans and copies of these test procedures were submitted to MIT/IL.

(11) All test plans on subassemblies were completed by KIC and accepted by MIT/IL.

(12) Schedules for subassembly tests, environmental test fixtures, and the preparation of test procedures were prepared.

(13) The test plan for the 1X64 Speed Resolver (1011294) was resubmitted by Kollsman and accepted by MIT/IL. The intention was to qualify six (6) units.

(14) Photographs, showing typical fixtures for Parts Qualification Program, were taken.

(15) The following photographs depict parts undergoing qualification tests:

Figure Number	Title
5-25	Friction Torque Fixture for Resolver Size 8 (1010341)
5-26	Accuracy Testing Fixture for Resolvers 1010341 and 1011371

TABLE 5-4

RELIABILITY PART QUALIFICATION PROGRAM

ENVIRONMENTAL TESTS

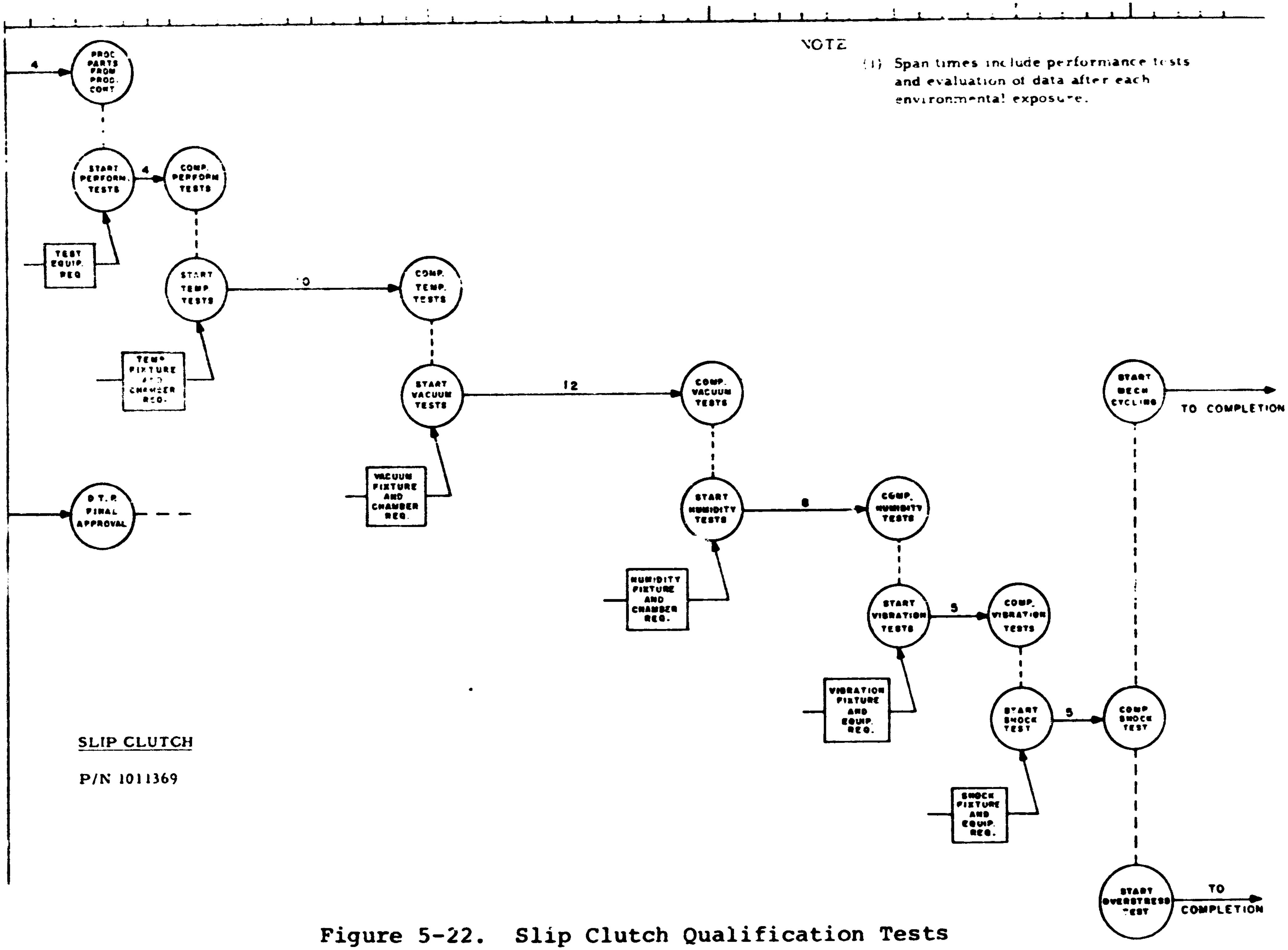
Parts	Qty.	Test Plans	Test Procedures	Functional	Vibration	Mech. Shock	Accel.	Temp. Shock	High Temp.	Low Temp	Thermal Vacuum	Humidity	Remarks
Resolver 1010341	6	X	X	X	X	-	X	X	X	X		X	Tests Stopped Units indicate high nulls and accuracy errors
Resolver 1011371	6	X	X										
Resolver (1x64) 1011294	6	X	In work										
Motor 1011379	6	X	X	X					X	X			
Slip Clutch 1011369	3	X	X	X	X	X		-	-	-		X	Tests Stopped Units to be replaced with 1012144
Overrunning Clutch 1011373	3	X	X						-	-			Tests Stopped Units to be replaced with 1012143
Projection Lens 1011374	3	X	X	X	X		X	X	X	X	X	X	
Cartridge Assy 1011420 C	3	X	X				-	-	-	-			Units being modified to latest change
Indicator Readout Assy 1011375	3	X	X					-	-	-			

TABLE 5-4

RELIABILITY PART QUALIFICATION PROGRAM

ENVIRONMENTAL TESTS

Parts	Qty.	Test Plans	Test Procedures	Functional	Vibration	Mech. Shock	Accel.	Temp. Shock	High Temp.	Low Temp	Thermal Vacuum	Humidity	Remarks
Projection Lamp 1011413	9	X	In Work						-	-			Drawings Released on 9/22/64
Counter Angle 1011744	3	X	X	X	X		X	X	-	-		X	Tests Stopped Bearing Change
Differential 1011281	3	X	X	X	X		X	X	-	-	X	X	
Flexprint 1011907	3	X	X		-	-	-						
Connector 1011748-1	9	X	X	X	X		-	X	-	-		X	
Connector 1011748-2	9	X	X	X	X		-	X	-	-		X	
Connector 1011501	9	X	X	X	X		-	X	-	-		X	
Connector 1011499	9	X	X	X	X		-	X	-	-		X	
Connector 1011747	9	X	X				-		-	-			



NOTE

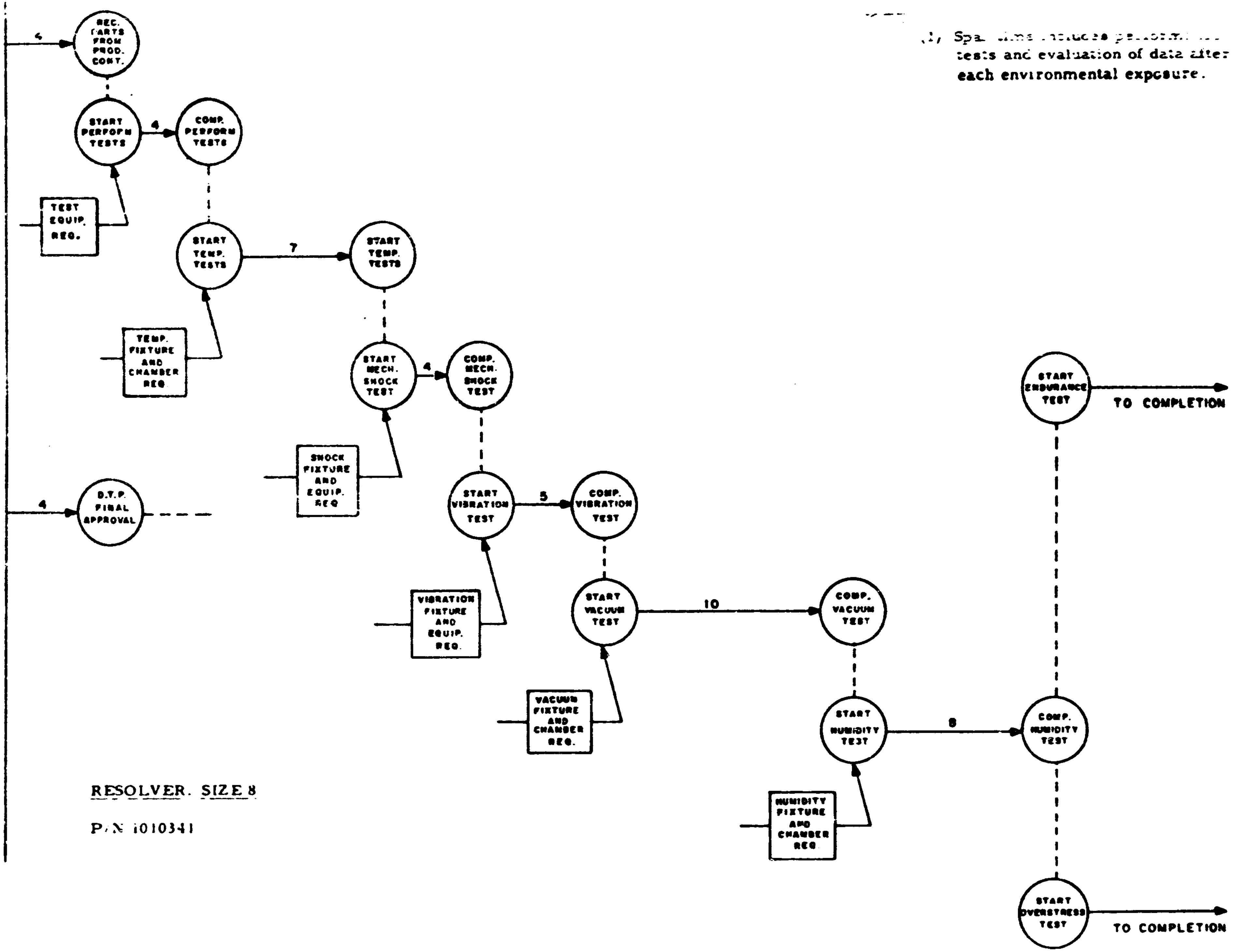
(1) Span times include performance tests and evaluation of data after each environmental exposure.

SLIP CLUTCH

P/N 1011369

Figure 5-22. Slip Clutch Qualification Tests

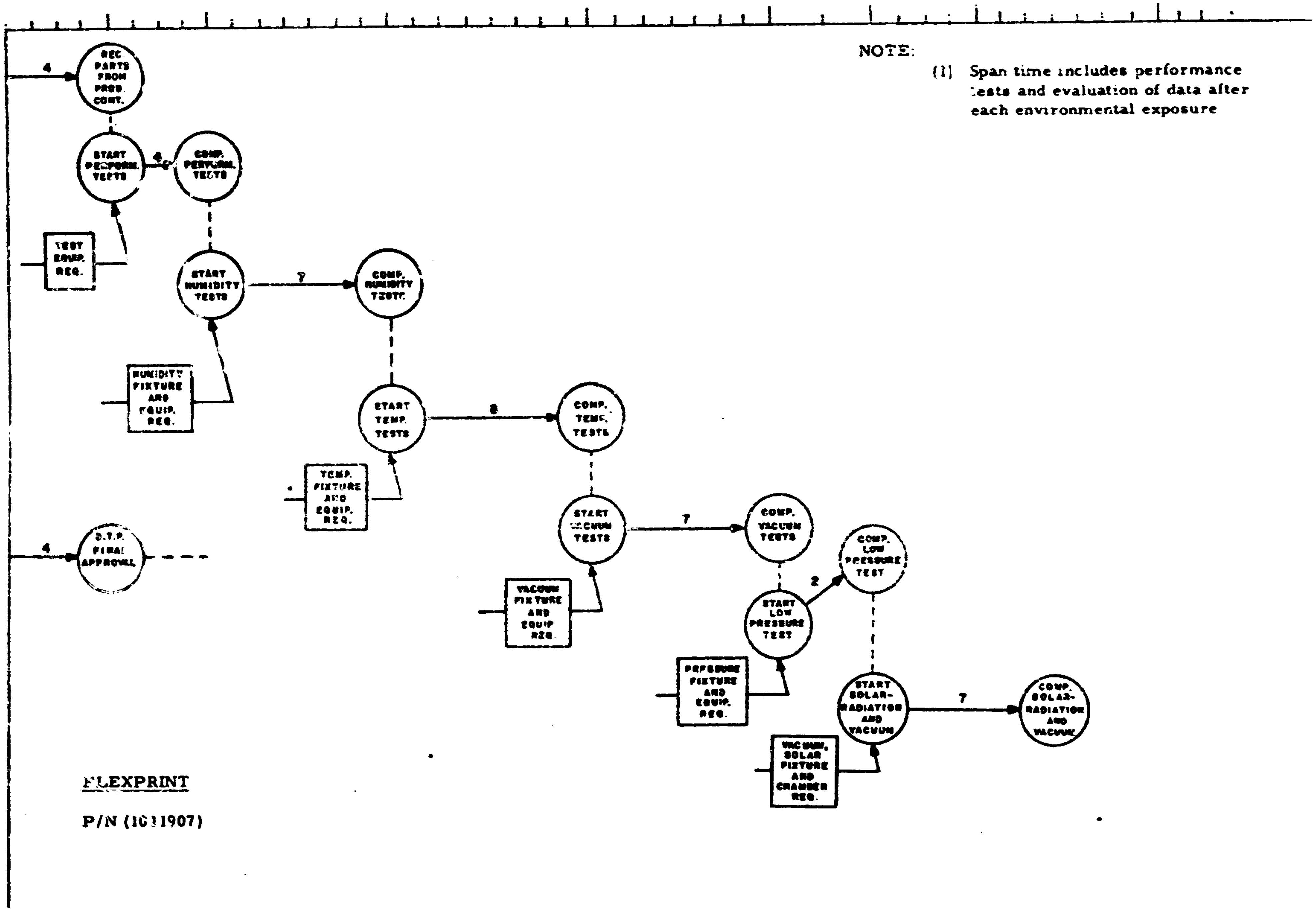
(1) Span time includes performance tests and evaluation of data after each environmental exposure.



RESOLVER. SIZE 8

P/N 1010341

Figure 5-23. Resolver Qualification Tests



NOTE:

(1) Span time includes performance tests and evaluation of data after each environmental exposure

FLEXPRINT

P/N (1011907)

Figure 5-24. Flexprint Qualification Tests

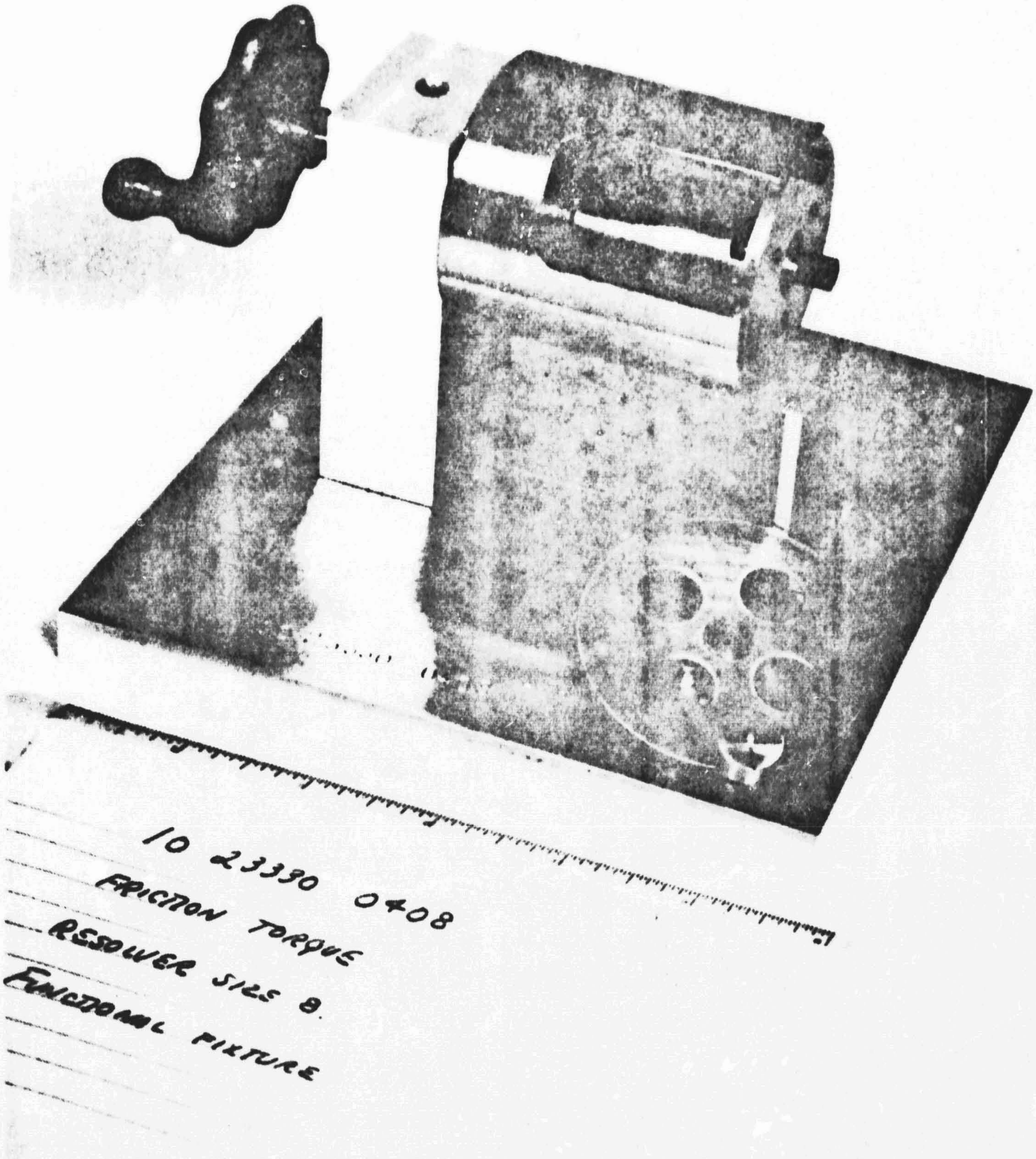


Figure 5-25 Friction Torque Fixture for Resolver Size 8 (1010341)

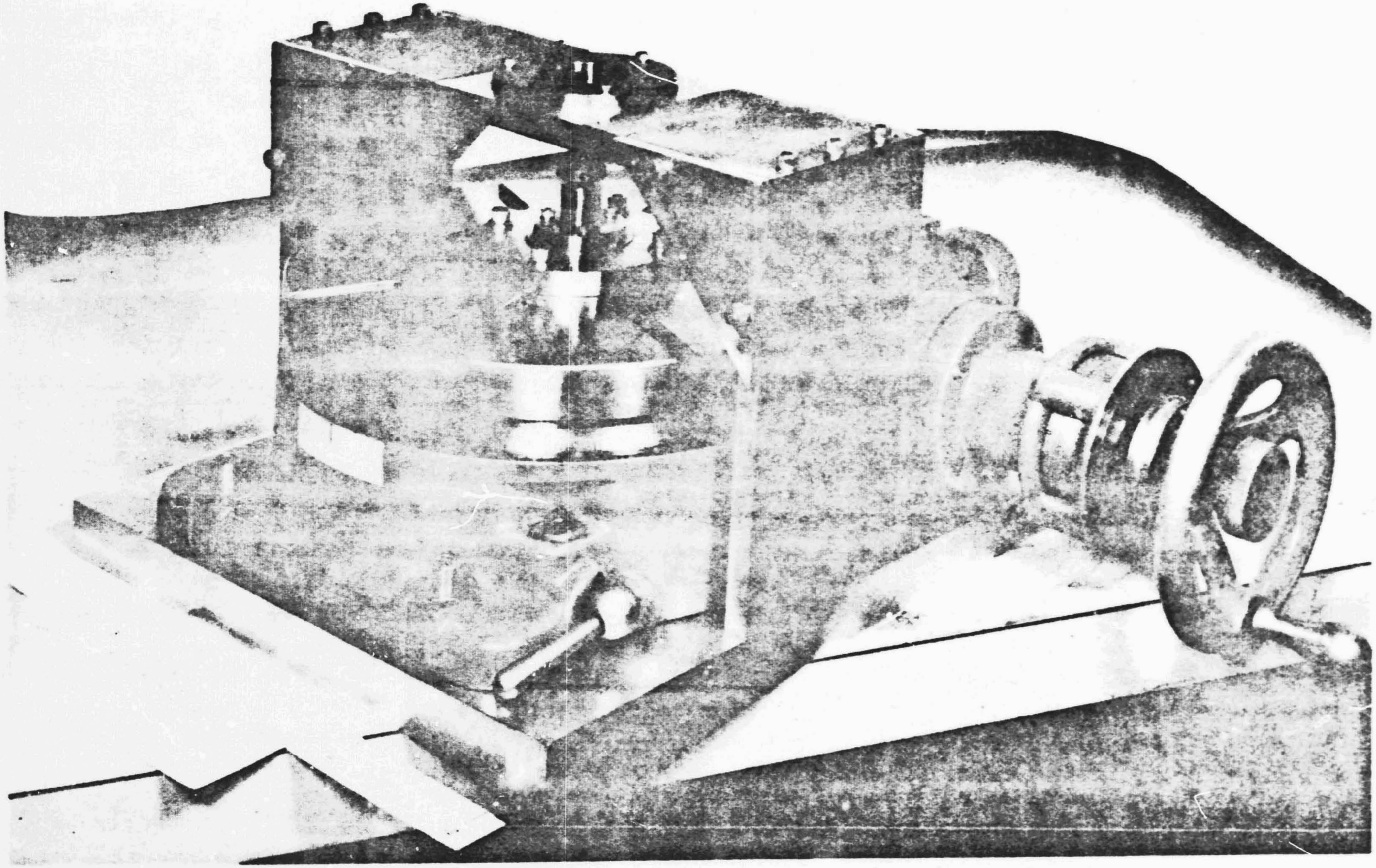


Figure 5-26
Accuracy Testing Fixture for Resolver (1010341 and 1011371)

Figure Number	Title
5-27	Functional Fixture for Projection Lens (1011374)
5-28	Functional Fixture for differential (1011281)

(16) The detailed test procedures for sub-assemblies were revised and re-written to conform to the latest agreements between Kollsman and MIT/IL.

(17) There were thirteen meetings of the Test Review Board to date. The following is a general summary:

(a) Finalization of the test plans for parts qualification was made jointly by KI and MIL/IL.

(b) Updating and revising of the Qualification Status List (QSL).

(c) Review and approval of progress report format, test report format, and progress reports on overall system qualification.

(d) Exchanging of information among contractors and discussion of mutual problems.

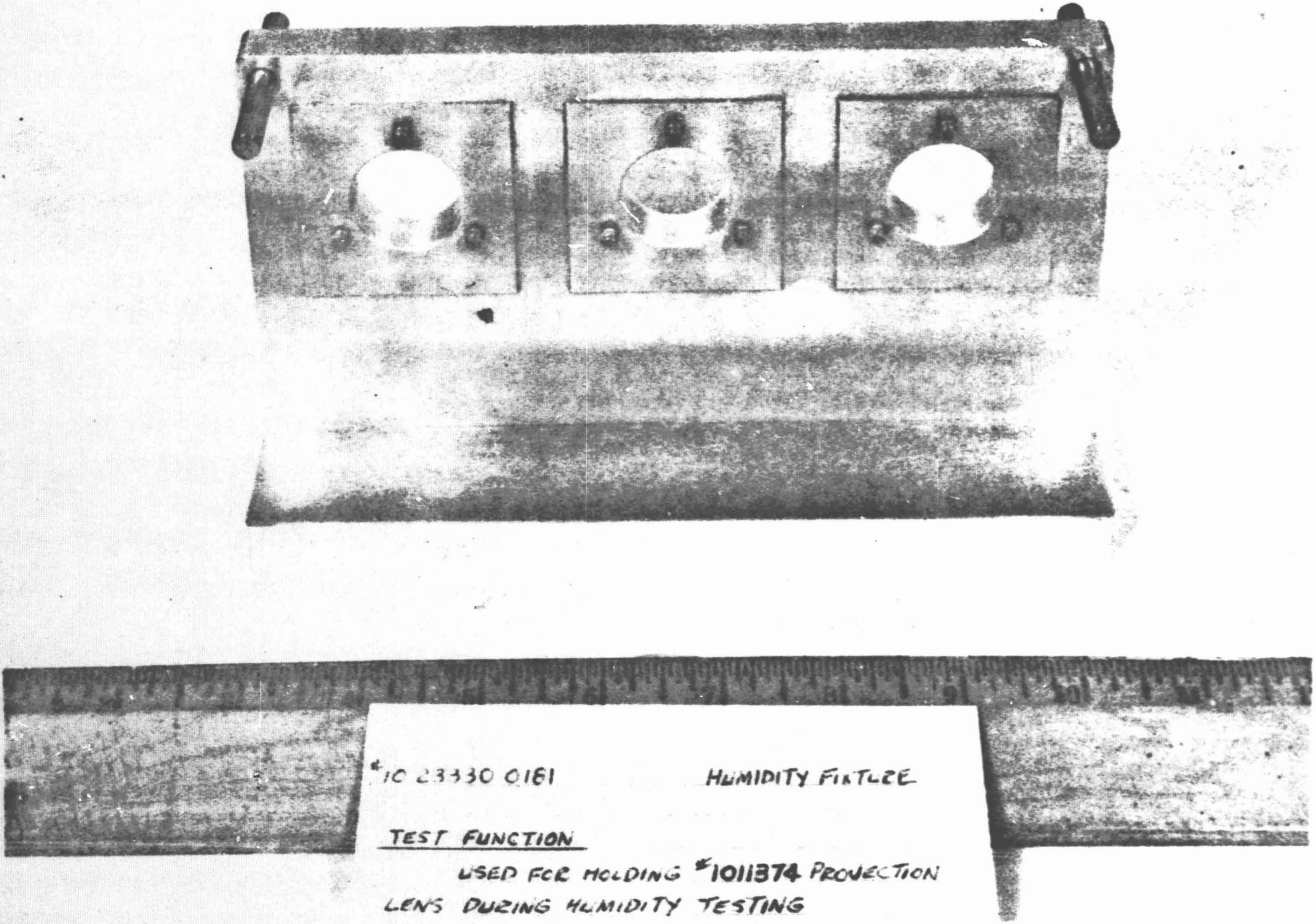
c. Problem Areas

Schedules showed an extended and drawn out qualification program of parts and subassemblies due to the lack of additional thermal vacuum chambers.

The present form of TD K-80 did not approve the required facilities to support the test program. Approval of required facilities had not been received. Since a 6 - 10 week lead time was required for procurement, there was a corresponding delay in the schedules.

Approval of TD K-80 was received. Although Kollsman had anticipated receipt of the supplemental test effort by rearranging and modifying test equipment design (TD-K-29), there was some delay in qualifying certain parts and subassemblies. The major portion of the delay was due to the subassembly program.

The procurement of Class A parts was a major hinderance to the start of the qualification program, since prints were being updated and existing vendor problems were being resolved.



#10 23330 0161 HUMIDITY FIXTURE

TEST FUNCTION

USED FOR HOLDING #1011374 PROJECTION LENS DURING HUMIDITY TESTING

Figure 5-27
Functional Fixture for Projection Lens (1011374)

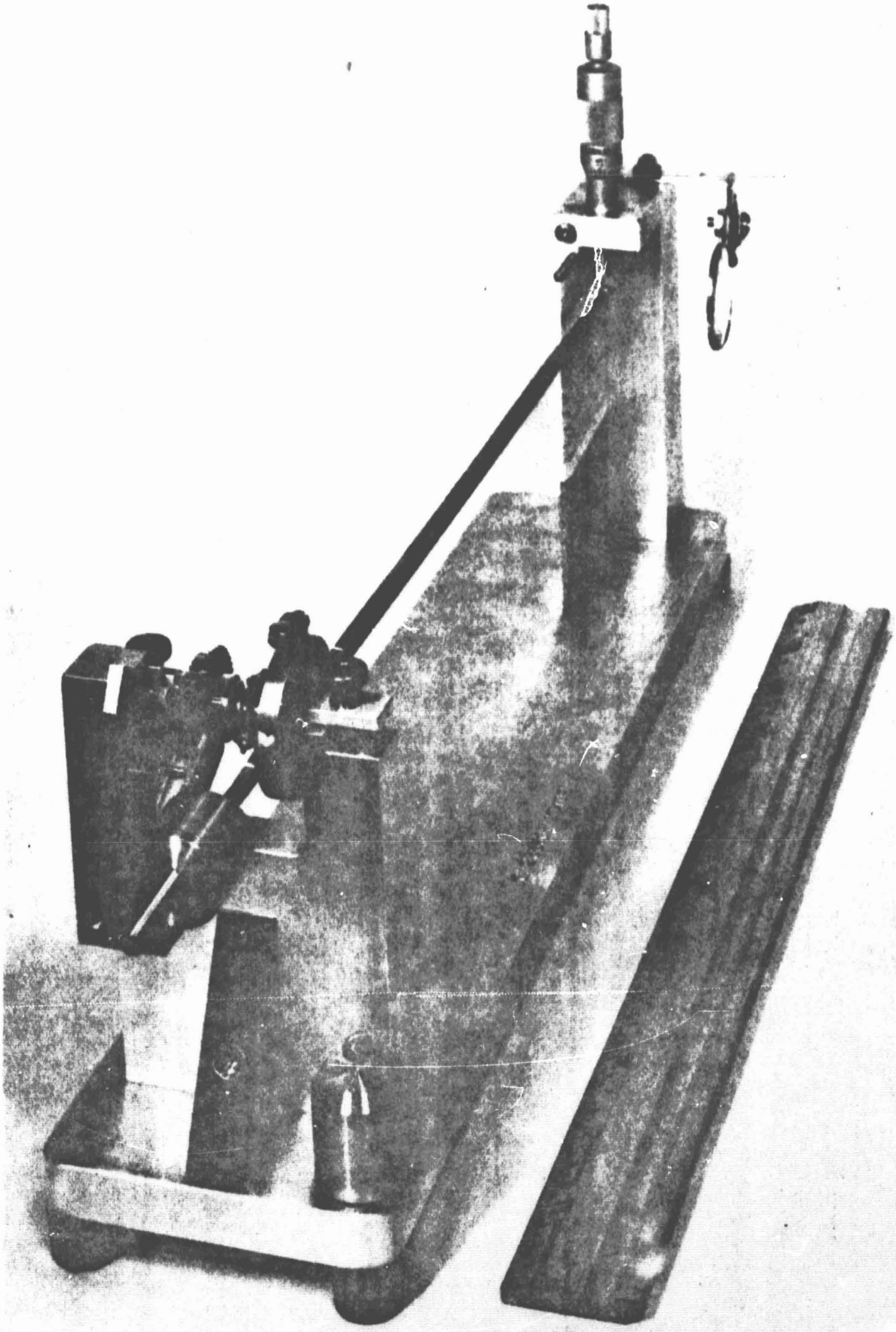


Figure 5-28
Functional Fixture for Differential (1011281)

The Qualification Test Plans for both parts and subassemblies were rewritten as a result of discussions at the monthly test review board meetings.

It was decided at the Test Review Board that ACED will qualify the motor-generator size 11 (1010610) and that Kollsman will qualify the resolver, size 8 (1010341).

MIT/IL and Kollsman concurred on the Kollsman ball bearing test approach. Four types of bearings were tested as suggested in Kollsman letters AR-3-225 and AR-4-235.

Table 5-5 indicates the tests that were to be accomplished for the subassembly test program.

MDV

A problem developed in the design of the over-running clutch test fixtures. In order to get reasonable data, it was necessary that the clutches be installed in the next higher assembly (1011443) and that this entire assembly be qualified. The test fixtures were modified accordingly.

The projection lamp (1011413) was released by MIT/IL Kollsman ordered parts and initiated test procedures, so that qualification tests were started as soon as the parts were received.

Additional funding was needed for changes and retrofits if parts required changes in fixture designs. These parts were purchased and/or modified to the latest revision change for qualification purposes.

	Old	New
Overrunning clutch	1011373	1012143
Slip Clutch	1011369	1012144
Cartridge Assembly	1011420	
Magazine Assembly		1011420C

TABLE 5-5

RELIABILITY SUBASSEMBLY QUALIFICATION PROGRAM ENVIRONMENTAL TESTS

Sub-Assembly	Quantity	Test Procedure	Function	Vibration	Mechanical Shock	Acceleration	Temperature Cycling	Thermal Vacuum	Humidity	Salt Fog
Fixed Mirror & Beam Splitter V	1	X	X	X	X	X	X	X		
SXT Head Assy VI	1	X	X	X	X	X	X	X		
SXT Telescope Assembly V	1	X	X	X						
Shaft Axis & (SXT) Optical Base VII	1	X	X	X	X	X	X	X		
Double Dove Assembly VI	1	X	X	X	X		X	X		
Trunnion Axis With Fixed Worm VI	1	X	X	X	X	X	X	X		
Objective Lens & Reticle Assembly With Lamps V	1	X	X	X	X		X	X		

TABLE 5-5 (Cont.)

Sub-Assembly	Quantity	Test Procedure	Function	Vibration	Mechanical Shock	Acceleration	Temperature Cycling	Thermal Vacuum	Humidity	Salt Fog
Pechan Prism & Relay Lens Assy V	1	X	X	X	X		X	X		
SCT Shaft Axis & Optical Base VIII	1	X	X	X	X	X	X	X		
SCT/SXT Eyepiece & Panel Assembly V	1	X	X	X	X				X	X
SXT Index Head Assembly VI	1	X	X	X	X	X	X	X		
SXT Shaft Axis Assembly VII	1	X	X	X	X	X	X	X		
SCT Trunnion Axis & Shaft Assembly VIII	1	X	X	X	X	X	X	X		
MDV Electronic Package IX	1	X	X	X	X		*	X	X	X
MDV Gear Box Assembly IX	1	X	X	X	X	X	*	X	X	X

* Hi & Lo Temp.

Qualification tests on the following units were stopped for the reasons noted:

1. 1010341 - Resolver, size 8 - High nulls and high accuracy.
2. 1011744 - Angle Counter - bearing change.
3. 1011369 - Slip Clutch - retrofit 1012144.
4. 1011373 - Overrunning Clutch - retrofit 1012143.
5. 1011420 - Cartridge Assembly - new design - Rec. C.
6. 1011274 - Pechan Prism and Relay Lens Assembly - questionable humidity tests preformed.
7. 1011796 - Objective and intermediate lens assembly - too severe thermal shock test performed.

5.3.18 TDK-12L LEM Reliability Analysis

a. Description of Effort

This technical directive authorized assistance to MIT/IL in the assessment and analysis of the LEM equipment to be fabricated by the contractor.

b. Accomplishments

The drawing and data search on LEM AOT Assembly, NASA Drawing No. 6011800 was continued. For this reporting period only preliminary drawings were made available for review.

The generation of a LEM Reliability family tree, Reliability Block Diagram and mathematical model was started upon final release of drawings.

c. Problem Areas

Delay in the release of final drawings was holding up completion of this task. Closer liaison was established and maintained between the design groups and Reliability in order to successfully conclude the effort.

5.3.19 Reliability Report Analyses (ARR-1 through ARR-6)

a. Circuit Analysis for Component Evaluation of Assembly - High Voltage Power Supply (HVPS) Star Tracker P/N 2007032

Reliability Report ARR-1 compiled the results of component reliability analysis calculated under DC conditions and applicable to the capacitors, resistors, general purpose diodes and zener diodes used in the Star Tracker High Voltage Power Supply, P/N 2007032, manufactured by Kollsman. The analysis was performed to determine component reliability data under "worst case" conditions of power, voltage, current and miscellaneous voltages. The evidence indicated that the circuit had to be redesigned to equalize the stress of components.

b. Evaluation of NASA P/N 1012142, Encapsulation in Stycast # 1090.

Reliability Report ARR-2 evaluated the ability of NASA P/N 1012142 to perform when encapsulated in its intended application. The results indicated a sufficiently high degree of confidence in the capacitor end use for which the tested samples were representative.

c. DC Circuit Analysis for Component Evaluation of Assembly. Photometer Head, P/N 2007025

Reliability Report ARR-3 compiled the results of component reliability analysis, calculated under DC conditions and was applicable to capacitors, resistors, general purpose diodes and zener diodes and the photomultiplier tube used in Photometer Head, P/N 2007025, manufactured by Kollsman. The analysis was performed to determine component reliability data under "worst case"conditions of power, voltage, current and miscellaneous ratings. The results of the analysis showed that the resistors, capacitors, diodes and transistors were properly derated, although R19 appeared to be close to design limitations. The photomultiplier tube appeared to be operating in an unstable mode under "worst case" conditions. The biasing on the Q3 stage appeared to be at a relatively low level and could cause clipping for AC signals.

d. Reliability Estimate for Head Electronics Assembly (Photometer) P/N 2007025

Reliability Report ARR-4 investigated relative meantime-between-failure (MTBF) of the Head Electronics Assembly. The component MTBF was typical and not a time indication for the purchased electronic parts used in the assembly. The failure rates used were derived from MIL-HDBK-217. The report did accurately indicate the stress ratios and was a good measure of the relative reliability of parts and modules. The components which should be stress-relieved becomes immediately obvious. The results of the investigation showed that the reliability of the Head Electronics Assembly could be improved by achieving a better balance of component stress ratios. Lowering the numerical values of some components, particularly resistors, would lower the failure rates used in computing the reliability of the assembly.

e. Evaluation of NASA P/N 1006271, Marking Ink

Reliability Report ARR-7 described the investigation of epoxy inks used by Kollsman for identifying Apollo parts and assemblies; the ink hardened too rapidly for hand stamp operation. In addition the transfer from stamp to part was often incomplete. The vendor, Wonow Process Paint Co. advised that the series #50 ink was formulated specifically for silk screen printing, brush on spray operations, and the high percentage of solids and the use of BIS-B-Ethoxyethylether combine to form an ink unacceptable for hand stamp use. The vendor recommended series M spray inks for hand stamping, which is usable for six hours or longer. Amine catalysts are available for surfaces which are heat treated and those which are not heat treated. It was recommended that a new SCD be assigned to these inks.

f. Reliability Estimate for High Voltage Power Supply (HVPS) Star Tracker P/N 2007032

Reliability Report ARR-5 investigated relative meantime-between-failure (MTBF) of the Power Supply Assembly. The component MTBF is typical and not a true indication for purchased electronic parts used in the assembly. The failure rates used were derived from MIL-HDBK-217. The report did accurately indicate stress ratios and was a good measure of the relative reliability of parts and modules. Components which should be stress-relieved became immediately obvious. The results of the investigation showed that the reliability of the assembly could be improved by achieving a better balance of component stress ratios. Lowering the numerical values of some components, particularly resistors, could lower failure rates used in computing the reliability of the assembly.

g. Circuit Analysis for Component Evaluation of Assembly - High Voltage Power Supply (HVPS), Photometer, P/N 2007031

Reliability Report ARR-6 compiled the results of component reliability analysis calculated under DC conditions and applicable to capacitors, resistors, general purpose diodes, zener diodes and transistors used in the Photometer High Voltage Power Supply, P/N 2007031, manufactured by Kollsman. The analysis was performed to determine component rating data under "worst case" conditions of power, voltage, and current. The results of the investigation showed that no parts appeared to be overstressed under extreme conditions.

5.4 SUMMARY OF YEAR ENDING 31 DECEMBER 1965

5.4.1 Introduction

Reliability operations for 1965 are described in the following paragraphs. The main part of Reliability effort during the period was spent on various investigations, initiated when test failures occurred or when a potential failure condition was noted. Shift in emphasis of the reliability effort was dictated by the increased manufacturing activity. Qualification program continued with a target completion date of October 1966. Reliability also assisted vendors in meeting specifications for the parts they supplied; these discussions are also included. Failure Analysis Report and Reliability Reports issued are summarized.

5.4.2 Reliability Activities

IX/64X RESOLVER, P/N 1011294

Meetings were held with Bendix to resolve the problem of cracked impregnation (Randac) on the 64X rotor of the resolver. Acceptable inspection criteria could not be properly defined. At Kollsman's request, Bendix subjected six rotors with cracked impregnation to a two-day humidity cycle, after which hi-pot and megger tests were conducted. One rotor failed, indicating that this test was capable of culling out weak or defective units, and establishing a basis for evaluating cracked impregnation. Kollsman proposed adding a two-day humidity test to the SCD.

MOTOR GENERATOR, P/N 1012156

Several failures of Motor Generators under burn-in were reported by the vendor, Solvere. Due to the gravity of the problem and the impact on schedule commitments, Kollsman sent a team of specialists to the vendor's facility to investigate the failures. The failures were attributed to the bearings. The bearings were analyzed and it was determined that the lubricant was the cause of the failure. The lubrication (ND 1002077) was considered inadequate by Kollsman because the thin film of lubricate was incapable of dissipating the heat generated by the small bearings used in the device. After consultation, MIT/IL revised the SCD to reduce burn-in requirements, over Kollsman's objections. Kollsman countered with a recommendation that the quantity of lubricant in the bearings should be increased, which MIT/IL rejected. Various other recommendations included reduction of the centrifuge requirement from 400 g's to 10 g's, removing the shelf-life requirement and developing a new burn-in procedure.

LUBRICANTS, P/N 1012650, 1012051

General Electric (Waterford, N. Y.) refused to negotiate with Kollsman on the lubricant they were providing. These lubricants are the basic ingredients of ND 1002077, a general specification to the Apollo Program for the lubrication of rotating components and bearings. The problem became apparent with the investigation of motor generator failures. As General Electric was uncooperative, MIT/IL tentatively agreed to "change the source control drawings to information furnished by the vendors".

FLEXPRINTS, P/N 1012519, 1012520, 1012521

Kollsman again reviewed the facility of Sanders Associate to recheck Quality Control. Samples of flexprints were inspected and found to be of poor quality. The vendor was cooperative and claimed progress in upgrading workmanship standards and process controls. As a potential impact on schedule commitments existed, Kollsman requested MIT/IL to add Flexible Circuits as an additional vendor.

EXUDATE AND HAZE INVESTIGATION

An investigation was initiated to discover the cause of the appearance of exudate along the seal area of the OUA and formation of haze on the SXT optics and to find a solution to these problems. Kollsman and ACSP participated in the investigation. A test plan was devised and performed, but the results were inconclusive. It was decided to monitor the SXT optics for haze when exposed to thermal vacuum during final acceptance tests. To solve the exudate problem, it was proposed that the optical base gasket and panel covers should be baked at 375°, 10^{-7} mm/Hg for 40 hours. To solve the haze problem, first a shield was proposed to protect the optics and the window from condensate. When the material left by the haze was identified as talc (which is used as a mould release when manufacturing the "O" ring), it was finally proposed to perform a vacuum bake-out on "O" ring P/N 20123661.

PHOTOTUBE, P/N 1012043

Inspection of the RCA phototube revealed several problems. Lead ends were tinned to increase their diameter so that electrical contact could be made in the test fixture socket. The leads were bent, nicked, gouged and were poorly plated. Holes, machined in the phenolic base were inadequately deburred, a condition which might cause damage to the lead material, especially the gold plating. RCA added a protective tube cover over the leads to prevent damage during handling and shipping, and a socket adapter to protect the leads from bending, and instituted better handling procedures. In addition, RCA eliminated the tinning of leads and deburred the holes in the phenolic base.

BERYLLIUM SEXTANT INDEX MIRROR, P/N 2011259

It was discovered that the mirror was warped up to several wavelengths of light (1/8 wavelength is specified). This was caused, it was found, in the processing of the mirror during coating, which required elevated temperatures. Stress relief of the mirror at lower temperatures proved to be insufficient. The solution to the problem was two heat treating cycles at elevated temperatures. Relapping to required flatness between cycles and after the second cycle was proposed. Complete stability was achieved during mirror coating.

OPTICAL BASE, P/N 2011889

Pre-machined beryllium blocks were found to be pitted and marred when removed from storage. The condition, it was found, was due to improper packing and shipping procedures. Improved procedures were recommended to the vendor.

BALL BEARING CONTAMINATION BY LOCTITE ON EASTMAN 910 ADHESIVES

A New Hampshire Ball Bearing report indicated that contamination might occur on bearing surfaces by vaporization and condensation of uncured Loctite or Eastman 910 adhesives. Investigation of Solvere Motor Generator, P/N 1012156 determined that use of these adhesives did not affect these motor generators

OPTICAL BASE BALL MOUNT, P/N 2011569

Surface cracks on ball mounts were discovered during the surface grinding procedure. The defective parts were scrapped and grinding procedures and inspection procedures were tightened.

POTTING OF ELECTRICAL MODULES

An evaluation of in-house potting procedures was made as a part of a continuing effort to optimize procedural techniques. Procedures were prepared for an overflow reservoir to ensure a 100 percent absence of voids. For the high voltage power supply, it was recommended that a hole should be drilled in the wiring board so that the void within the toroid could be filled with potting material.

PYROFILM RESISTOR, P/N 1010768

It was found that an oxide film was present on leads of resistors received from Pyrofilm. Oxidation occured, it was found, during the stabilization/leak test process. The vendor agreed that these procedures would be separated into two steps: stabilization at 480°C for 18 hours, with components in a sealed, evacuated glass tube, and leak testing at 200°C (a temperature too low for oxidation).

5.4.3 Component Data

The overall effectiveness of vendor compliance with specification requirements was wanting because some vendors omitted certain requirements. Kollsman proposed careful data review studies. The following parts were consistantly and repeatedly accepted:

Resistor (Corning) P/N 1006750, 1006760

Capacitor, Tantalum (KEMET) P/N 1006755

Resistor (pyrofilm) P/N 1010768

Relay (Clare) P/N 1010436

Transistor (Texas Instruments) P/N 1010397

The following parts were conditionally accepted with the stipulation that missing information or explanations would be supplied:

Transistor (General Electric) P/N 1010398

Resistor (Electron) P/N 1010364

Diode (Micro-Semi Conductor) P/N 1012042

Capacitor (Erie) P/N 1012041

Diode (Dickson) P/N 1012056

Capacitor (General Electric) P/N 1010305

Capacitor (Sprague) P/N 1010264

The following parts were rejected:

Diode (General Electric) P/N 1010362

Transistor (General Electric) P/N 1010398

5.4.4 SCD Upgrading

Review studies were performed to upgrade SCD general information either by eliminating descrepancies and incorrect information or by rephasing for clarity. These changes range from overload conditions, wave shapes, voltage specifications to the cancellation of certain military references and standards. MIT/IL specialists were contacted for approval and comment. The following drawings were involved:

1006755	Capacitor, Tantalum (KEMET)
1012043	Phototube (RCA)
1012053	Transformer (Bush)
1012141	Capacitor, Ceramic (Erie)
1012148	Transformer (Bush/Microtron)
1012149	Transformer (Bush/Microtron)
1012502	Capacitor, Tantalum (Mallory)

A conference was held with Dickson Electronics, vendor for zener diode P/N 1012529. An agreement was reached regarding engineering and technical details and the insertion of burn-in information.

A conference was held with Bendix, vendor for resolver P/N 1011294 to advise the vendor of the basic aspects of an SCD in regard to form, fit, function and reliability.

5.4.5 Support of Manufacturing Modified Class A Parts

As a result of schedule commitments, an exhaustive investigation was performed by Kollsman to procure modified Class A parts from vendors who require excessive lead time. This was done to insure that parts, procured in partial non-conformances with SCD requirements, would meet quality and reliability standards. The following requirements were set:

a. ND 1015404 Class 3 in lieu of Class 2.

b. Burn-in for 48 hours in lieu of 240 hours.

c. All lead analysis performed by Kollsman.

d. Complete definition of all deviations from SCD requirements.

e. Performance of EPT when judged necessary.

f. Acceleration of Class A procurement with preferential use over modified parts.

5.4.6 Extended Performance Test (EPT) Program

Criteria and procedures were developed for parts selected for extended performance testing. Test plans were devised for the following parts:

Capacitor, P/N 1006755 EPT-K107

Capacitor, P/N 1010264 EPT-K106

Capacitor, P/N 1012041 EPT-K101

Diode, P/N 1012042, 1012056 EPT-K104

Phototube, P/N 1012043 EPT-K108

Transistor, P/N 1012048 EPT-K105

Transformer, P/N 1012052, 1012148 EPT-K103

Transformer, P/N 1012052, 1012148 EPT-K103

Capacitor P/N 1012142, 1012502 EPT-K102

Originally EPT specifications were intended to apply to an entire group of generally identical components. It was felt that it was more efficient to generate specifications for specific parts so that actual test expenditures could be reduced to a minimum. Drawings were checked to insure compatability with test procedures.

5.4.7 Vendor Design Review

64X/2X/1X RESOLVER ASSEMBLY, P/N 1012065

Kollsman personnel visited the Clifton facility at Clifton Heights, Pa. to review design layouts for resolver assemblies. Kollsman proposed two clamping changes for beryllium parts to insure positive mechanical clamping of the resolver lamination stacks so that there would be no adverse shifts within the resolver assembly. The potting of connectors, assembly marking, tetra etching of lead wires were also discussed.

FLEXPRINT, P/N 1012522

Kollsman personnel visited W. L. Gore, Newark, Del., to review design requirements for the flexprint. Items discussed were: the number of strands, thickness of insulation of primary conductors, type of wire and wrap of shields, thickness of outer teflon insulation, method of terminating shields. More general subjects discussed were: workmanship standards, methods of sealing shields at both connector terminations, soldering and potting connectors, reliable inspection criteria and the use of x-ray at critical points.

CONNECTORS, P/N 1010770, 1010771, 1010772, 1010808, 1010809

Kollsman personnel and ACSP visited Deutsch to discuss design and specification parameters for new Block II connectors. The purpose of the review was to negotiate vendor exceptions to SCD drawings. An additional 7-pin connector was added to SCD 1010771 at the request of MIT/IL. Deutsch was unable to add a 12-position locksmith key way. Various documentation requirements were discussed. MIT/IL expedited a CCB so that the order could be placed on the critical long lead parts list.

RTV, P/N 1012513, 1012515

The elimination of minor discrepancies resolved Dow Corning's exceptions to temperature parameters on the SCD's.

FLEXPRINTS, P/N 1012519, 1012520, 1012521

Preliminary negotiations were iniated with Flexible Circuits, Inc. for flexprints. Close Kollsman reliability design effort was extended to the vendor to assure workmanship and compliance to specifications

TANTALUM CAPACITORS

General Electric supplied Kollsman with redesigned units, which incorporated a double crank at the ends to increase pull strength to approximately 4 pounds.

RESONATOR TUNING FORK, P/N 2007022

Extraneous particles were found on tuning fork tine edges. The vendor reviewed and tightened inspection procedures. Kollsman continued to monitor inspection procedures.

5.4.8 Failure Analysis Reports

APOLLO FAILURE ANALYSIS REPORT NO. 1

LUXORB COATING, P/N 1011778-2 ON SCT OBJECTIVE LENS ASSEMBLY P/N 1011709

Deterioration of the physical properties of the Luxorb coating on the P/N 1011709 assembly occurred during thermal vacuum testing, thereby creating haze. The Luxorb coating became plastic and flowed. Initial corrective action was the replacement of Luxorb with Minnesota Mining and Manufacturing 3M-400 Black Velvet Paint, which did not exhibit the optical properties of Luxorb, but was used successfully under thermal vacuum exposure.

A qualitative comparison with Luxorb, was made of the degree of blackness of American Optical AO OP20, 3M101-C10 Velvet Coating, 3M 400 Black Velvet Paint, India Ink and Egyptian Black. Preliminary findings were inconclusive.

Additional investigation, as reported in AFR 4476 determined that Luxorb was not deteriorating. More thorough cleaning of the optical base and removal of volatiles from the gasket material should prevent further occurrance. Change in gasket material will be considered, if problem is not eliminated.

APOLLO FAILURE ANALYSIS REPORT NO. 2

ELECTRICAL CONNECTOR, P/N 1012151

Twenty-three Deutsch connectors failed dielectric testing at 1500 volts RMS, 60 Hz as per MIL-C-26482. Failure was caused by inadequate hermetic sealing. Two 1/8" pieces of glass (rather than one 1/4" solid glass strip) were fused together to form the seal. The vendor agreed to use one piece hermetic sealing.

APOLLO FAILURE ANALYSIS REPORT NO. 3

SERVO MOTOR TACHOMETER GENERATOR, P/N 1012156

The Solvere servo units were tested for break-away or static friction voltage under a vacuum of 10^{-6} in Hg. Two of the six units failed. It was found that under high temperature conditions, the rotor ball bearings expanded to the extent that the .0002" radial play was insufficient, and therefore, required more torque. It was recommended that radial play should be increased to .0005" to .0008". Increased shaft end play and shaft radial play were also recommended.

APOLLO FAILURE ANALYSIS REPORT NO. 4

AGE 17 - SHAFT AXIS GEAR BOX SCT AND SHAFT ANGLE COUNTER

Excessive friction and binding were noted in the SCT shaft of AGE 17. A running voltage of 39 volts was required as opposed to the specified 37 volts. The gear train was examined for high spots. It was determined that the bevel gears should be paired and lapped, and that a lubrication requirement should be added to ND 1002077.

APOLLO FAILURE ANALYSIS REPORT NO. 5

CAPACITOR P/N 1012142

General Electric capacitors P/N 1012142 failed the pull test, part of Qualification Testing. It was discovered that a designed band in the lead compressed a rubber gasket, which in turn, exerted pressure on the tantalum foil leadbond to the extent that the foil tore. It was recommerded that epoxy (Hysol 12-007A) should be applied at both ends to act as fillets.

APOLLO FAILURE ANALYSIS REPORT NO. 6

HIGH VOLTAGE POWER SUPPLY, STARTRACKER, P/N 2007032

Voltage drift in power supply high voltage output and star presence signal developed as a function of time and temperature. Investigations, using the laboratory breadboard, indicated that the temperature sensitivity of transisotr Q3 (part of the differential amplifier) was the probable cause.

5.4.9 Reliability Report Analyses (ARR-8 thru ARR-47)

INVESTIGATION OF CONTAMINATION OF TELESCOPE PANEL P/N 2011717

Reliability report ARR-8 described the investigation to identify foreign contamination found on inserts in Telescope Panel, P/N 2011717. In addition, the report recommended cleaning procedures and means to prevent re-occurrence of contamination. The result of the investigation indicated that a stainless steel tool should be used in lieu of a cold rolled tool and that leak test should be performed in a clean area.

PACKAGING OF ROUGH OPTICAL BASES

Reliability report ARR-9 investigated means for preventing corrosion during shipment of optical bases. The report recommended that the vendors, Berylco and Brush Beryllium, ship optical bases in sealed polyethyle bags with dessicants.

Note: Reliability report ARR-10 was not issued.

ANALYSIS OF VARIATIONS TO ELECTRO-OPTICAL PERFORMANCE OF PHOTOMULTIPLIER TUBE P/N 1012043

Reliability report ARR-11 analyzed the electro-optical characteristics of an operational Apollo photomultiplier tube to examine its capability to provide reliable performance in star tracking applications. The results evaluated the photomultiplier tube output elect cal signal level and variations produced by the optical star-target light sources when the composit affects of optical collection and efficiency, spectral emission and response, dark currents, signal to noise ratios, and temperature were taken into account. The report was also intended for reference in analyzing additonal operational and performance problems that might be incurred in other parts of the photomultiplier tube and startracker reliability test sub-programs. The results of the investigation showed that the photomultiplier tube was suitable for its intended purpose.

INVESTIGATION OF CONTACT PIN ASSEMBLY LEAD BREAKAGE

Reliability report ARR-12 described an investigation of contact pin assemblies to determine the quality of the solder bond. Radiographic inspection was in accordance with MIL-S-453. The results of the investigation indicated that the beveled pin design decreased the number and size of solder voids within the pin cavity. Mylar sleeving, after application of high temperature, showed evidence of solder running. Specification wire passed an arbitrary 25 cycle flux test. Assembly procedures were revised to avoid excessive fluxing.

CIRCUIT ANALYSIS FOR COMPONENT EVALUATION OF ASSEMBLY - TUNING FORK, PHOTOMETER P/N 2007021

Reliability report ARR-13 described the results of a component reliability analysis calculated under DC conditions and applicable to capacitors, resistors, general purpose diodes and Zener diodes used in the Tuning Fork, Photometer, P/N 2007021, manufactured by Kollsman. The analysis was performed to determine componet reliability data under "worst case" conditions of power, voltage, current and miscellaneous ratings. The analysis showed that all components were stressed properly.

INVESTIGATION OF BERYLLIUM CORROSION UNDER SALT SPRAY ENVIRONMENT

Reliability report ARR-14 described an investigation to determine the effect of salt spray environment upon Beryllium and bimetallic couples of Baryllium and STainless Steel and Baryllium and Aluminum. The investigation was made to determine the effect of thermal vacuum exposure upon various types of protective coating compounds. The results showed that one material, Humiseal 1B15 was the most suitable for use in the projected salt spray test to determine if a coating would isolate beryllium and its bi-metallic couples from the effect of a corrosive environment.

RELIABILITY ESTIMATE FOR TUNING FORK ASSEMBLY, PHOTOMETER, P/N 2007021

Reliability report ARR-15 described the relative mean-time between-failures (MTBF) of the Tuning Fork Assembly. The component MTBF was typical and not a true indication for the purchased electronic parts. The failure rates used were derived from MIL-HDBK-217. The report did accurately indicate the stress ratios and was a good measure of the relative reliability of parts and modules. The components which should be stress-relieved became immediately obvious. The report showed that the reliability of the tuning fork can be improved by achieving better balance of component stress ratios.

EVALUATION OF CONTAMINATED MIRROR HOUSING P/N 6011808

Reliability report ARR-16 described the investigation of contamination found on Mirror Housing P/N 6011808 (S/N 7). The black stains were anodized beryllium, a result of poor masking during the anodizing process. The gray white contamination appeared to be a surface contaminant and not a corrosion product of beryllium.

EVALUATION OF CRACK IN OPTICAL BASE, P/N 2011618

Reliability Report ARR-17 investigated a crack found during leak testing of optical base (S/N 1011). Zyglo penetrant was found in the crack. The optical base was rejected.

CIRCUIT ANALYSIS FOR COMPONENT EVALUATION OF ASSEMBLY - TUNING FORK, TRACKER, P/N 2007022

Reliability report ARR-18 describes the results of component reliability analysis calculated under DC conditions and applicable to capacitors, diodes, resistors and transistors used in Tuning Fork, Tracker, P/N 2007022, manufactured by Kollsman. The analysis was performed to determine component reliability data under "worst case" conditions of power, voltage, current and miscellanous ratings The analysis indicated that components were within specified ratings as to power and voltage.

CIRCUIT ANALYSIS FOR EVALUATION OF ASSEMBLY - HEAD ELECTRONICS, TRACKER, P/N 2007024

Reliability report ARR-19 described the results of component reliability analysis calculated under DC conditions and was applicable to capacitors, resistors, general purpose diodes, zener diodes and the photomultiplier tube used in Head Electronics, Tracker, P/N 2007024, manufactured by Kollsman. The analysis was performed to determine component reliability data under "worst case" conditions of power, voltage, current and miscellaneous ratings. The results of the analysis showed that resistor, capacitor, diodes and transistors were properly derated, although R19 appeared to be close to design limitations. The photomultiplier tube appeared to be operating in an unstable mode under "worst case" conditions. The biasing on the Q3 stage appeared to be at a relatively low level and could cause clipping for AC signals.

CIRCUIT ANALYSIS FOR COMPONENT EVALUATION OF ASSEMBLY - HEAD Y ELECTRONIC TRACKER

Reliability report ARR-20 described the results of component reliability analysis calculated under DC conditions and was applicable to capacitors, resistors, general purpose diodes, zener diodes used in Head Y Electronics, Tracker, manufactured by Kollsman. The analysis was performed to determine component reliability data under "worst case" conditions of power, voltage, current and miscellaneous ratings. The analysis showed that all components were stressed properly.

RELIABILITY ESTIMATE FOR HIGH VOLTAGE POWER SUPPLY (HVPS), PHOTOMETER, P/N 2001031

Reliability report ARR-21 described relative mean-time-between-failure (MTBF) of High Voltage Power Supply, Photometer. The component MTBF was typical and not a true indication for the purchased electronics parts used in this assembly. The failure rates used were derived from MIL-HDBK-217. The report indicated the stress ratios and was a good measure of relative reliability of parts and modules. The components which should be stress-relieved became immediately obvious. The stress ratio of the High Voltage Power Supply appeared to be properly stressed.

ANALYSIS OF VARIATIONS IN OPTICAL-MECHANICAL PERFORMANCE OF TUNING FORK RESONATOR P/N 1012154

Reliability report ARR-22 described an analysis of optical-mechanical characteristics and operations of the double tuning fork scanner assembly to examined its capability to provide reliable performance in the Apollo star tracking application. The results evaluated the interrelationship of scanning aperture size, amplitude of total scan excursion, part tolerances, drive and associated programs and scanning pattern coverage. Every aspect of tuning fork operation was examined on a detailed basis. With respect to optical-mechanical evaluation, the general tuning fork scanner system aspects appeared to meet all requirements.

RELIABILITY ESTIMATE FOR HEAD ELECTRONICS, TRACKER, P/N 2007024

Reliability report ARR-23 described relative mean-time-between-failure (MTBF) of Head Electronics, Tracker P/N 2007024. The component MTBF is typical and not a true indicator for the purchased electronic parts used in this assembly. The failure rates used were derived from MIL-HDBK-217. The report did accurately indicate the stress ratios and was a good measure of the relative reliability of parts and modules. The components which should be stress-relieved became evident. The report showed that reliability might be improved by increasing the voltage rating of R19, but physical size of the substitute resistor was not compatible with the module by increasing the voltage rating of capacitor C2.

CORROSION RESISTANCE OF UNPROTECTED MACHINED BERYLLIUM PARTS

Reliability report ARR-24 investigated the development of corrosion on machined beryllium surfaces under high relative humidity and temperature. Various methods for preventing corrosion were investigated: heat relieving, Zyglo penetration and stripable organic coating were investigated.

BERYLLIUM CORROSION UNDER SALT SPRAY ENVIRONMENT

Reliability report ARR-25 further investigated the effective use of an organic coating for the prevention of galvanic and chemical corrosion of Beryllium in a salt spray environment. The results of the investigation indicated that Humisal 1B15 gave complete protection to Beryllium and its bi-metallic couples in salt spray and humidity environments.

THERMAL VACUUM QUALIFICATION FOR F-50 AND G-300 LUBRICANTS (GENERAL ELECTRIC)

Reliability report ARR-26 described the evaluation of F-50 and G-300 Lubricants in respect to weight loss in thermal vacuum. Kollsman generated a specification for qualifying these lubricants.

AC CIRCUIT ANALYSIS AND EVALUATION OF ASSEMBLY - HIGH VOLTAGE POWER SUPPLY (HVPS), TRACKER P/N 2007032

Reliability report ARR-27 described the results of an analysis of temperature and B+ voltage effects on the operation of the Tracker High Voltage Power Supply, manufactured by Kollsman. The analysis was conducted on a theoretical basis, backed up by actual breadboard results. It was recommended that the regulator portion of the power supply should be redesigned to decrease fluxuations caused by temperature and line voltage. This can be accomplished by adding a feedback from the regulator output, as is done with operational amplifier. In addition, the star presence current should be isolated from the operation of the regulator.

AC CIRCUIT ANALYSIS FOR EVALUATION OF TUNING FORK DRIVE, TRACKER

Reliability report ARR-28 described the analysis of AC characteristics of the tracker tuning fork drive circuitry on a detailed basis to examine its capability to provide reliable performance. The results evaluated the circuit electrical signal level changes, produced by the composite effects of transistor, capacitor, resistor, DC supply voltage and temperature variations. The circuit for the tracker tuning fork drive appeared to be of generally good theoretical design.

PRELIMINARY REPORT ON EXUDATE AND HAZE

Reliability report ARR-29 described the preliminary investigation of the exudate and haze problem, which has developed. It has been established that the exudate was methyl silicone and it was recommended that gasket material should be changed from silicone rubber to Viton. It was established that the haze was a separate problem and the substance was tentatively identified as a halogenated (fluorinated) compound.

DC AND AC CIRCUIT DESIGN, ANALYSIS AND EVALUATION OF ASSEMBLY - HIGH VOLTAGE POWER SUPPLY (HVPS), STAR TRACKER, P/N 2007175

Reliability report ARR-30 described the investigation for redesign of the High Voltage Power Supply as recommended in ARR-1 and ARR-27. The original design exhibited excessive temperature drift characteristics, absence of the star presence current, overstressing of component and operational failures. It was recommended that the design should be modified to incorporate a two part select system for setting the high voltage output and for setting star presence and that a feedback circuit should be added to the DC/AC converter.

FINAL REPORT ON EXUDATE AND HAZE

Reliability report ARR-31 described the results of the investigation into exudate and haze; preliminary findings were described in ARR-29. No definite cause of the haze was found. It was recommended that Kollsman should further study the problem.

ANALYSIS OF THE .34 TO .51 MICRON SPECTRAL CHARACTERISTICS OF TUNGSTEN LAMP (RCA C70048), BLUE LIGHT FILTER (CORNING C55-58) AND PHOTOMULTIPLIER TUBE, P/N 1012043

Reliability report ARR-32 described an investigation of the utilization of an incandescent light bulb as the reference illumination source in factory testing and qualification of the photomultiplier tube. Specifically, the amount of useful energy actually available in the system spectral working region and the capability to continually produce this measurement radiation in a reliable and repeatable basis was investigated. It was concluded that for a constant-radiation, steady-output light source for relative comparison purpose or for use when the time period between tests is comparatively short, the incandescent lamp, at any appropriate level is an excellent light source. Further, it was concluded that when the requirements are for absolute levels of constant radiation for critical measurement, the incandescent lamp must be calibrated and monitored by external instrumentation.

EVALUATION OF BLACKENING COMPOUNDS FOR REDUCING INTERNAL REFLECTIONS WITHIN GLASS COMPONENTS

Reliability report ARR-33 described the evaluation of the relative effectiveness of coating compounds, Black Velvet and Luxorb, to minimize glare when applied to the objective lens assembly. This was accomplished by comparing the intensity of stray light transmitted at the edges of the lens assemblies, coated with these blackening agents, and the intensity of light transmitted along the optical axes of these lenses. Black Velvet proved to be an effective means for reducing the intensity of stray light reflections; it also possessed properties which are compatible with the design and performance of the system.

EVALUATION OF ALLOY 180

Reliability report ARR-34 described the analysis by Kollsman to back up a request to MIT/IL to use Alloy 180 for connector pins in lieu of beryllium copper.

EVALUATION OF TANTALUM CAPACITOR (GE), P/N 1012142

Reliability report ARR-35 described the investigation of qualification failure of tantalum capacitors, manufactured by General Electric. The vendor redesigned the capacitor by increasing the thickness of the tantalum foil from .0005" to .00055".

Note: Reliability report ARR-36 was not issued.

INVESTIGATION OF SIZE 8 RESOLVER (CLIFTON) P/N 1012157
TEST RESULTS

Reliability report ARR-37 described the investigation of excessive angular error after temperature cycling. When resolvers P/N 1012157 were tested, it was concluded that the allowable error in the test procedure could be raised from 2' to 2.5'.

PRELIMINARY TEST REPORT - HIGH VOLTAGE POWER SUPPLY (BREADBOARD)

Reliability report ARR-38 described the preliminary evaluation of the redesigned high voltage power supply in breadboard form. The high voltage output and the star presence signal remained stable over a temperature range of 25°C to 75°C at automatic gain control settings of 2.5V, 2.0V, 1.6V, 1.5V and 1.4V.

EVALUATION OF BLACK STAINS ON STAR TRACKER AND HORIZON SENSOR HOUSING

Reliability report ARR-39 described the investigation of the bleeding of black anodize and finger prints onto unanodized surfaces. It was concluded that the stains were due to poor masking during anodizing and improper handling after cleaning.

Note: Reliability report ARR-40 was not issued.

THERMAL VACUUM EVALUATION OF BLACK DRAG CUP IN MOTOR-TACHOMETER GENERATOR (SOLVERE) P/N 1012156

Reliability report ARR-41 described the investigation into the failure of motor-tachometer generator P/N 1012156 to pass the 10 cycle Thermal Vacuum Speed Conditioning Test. The failure was due to excessive stiction and ball bearing preloading. The vendor proposed blackening the drag cups with Ebonal-C. Units with this modification successfully passed testing.

FINAL REPORT: CORROSION RESISTANCE OF UNPROTECTED MACHINED BERYLLIUM PARTS

Reliability report ARR-42 described the investigation into methods for protecting beryllium parts from corrosion under varying relative humidity and temperature. It recommended more stringent control of the chemistry of beryllium pressing, discouragement of heat-relieving in hydrogen atmosphere, more stringent handling procedures and the use of the beryllium preservation method developed by Berglco. The effect of salt spray was also investigated.

EVALUATION OF TRANSFORMERS, POWER STOP UP P/N 101248 and 101249 (BUSH)

Reliability report ARR-44 compared transformers P/N 1012148 and 1012149 received from Bush Transformer and those rejected by incoming inspection. The report also attempted to estimate empirical limits on expectations of current, switching frequency and electrical wave shape. It was found that construction of the transformer was faulty; there was an increase in current drawn from the power supply, when the transformer is unloaded or loaded, which was caused by a shorted turn in the winding or by inadequate insulation.

ANALYSIS OF TRANSFORMER, POWER STEP UP AS TESTED BY SCD 1012148

Reliability report ARR-43 described the investigation conducted when the Bush transformer did not pass acceptance testing. The investigation included a theoretical analysis of the range of frequencies of output voltages that can be expected from the transformer in production, It took into consideration variations in maximum saturation, flux density, core size and winding turns. It concluded that while SCD 1012148 was correct in its frequency and AC voltage requirements, the test circuit limited unit acceptance.

EVALUATION OF BLACK VELVET 400 IN THERMAL VACUUM ON EPOXY-FIBERGLASS LAMINATE

Reliability report ARR-45 investigated the adhesive properties of Black Velvet 400 in regard to its reliability as a coating for the spray-fiberglass laminate disc (P/N 2008243A) on top of the photo tube shield. Samples primed with strontium chromate performed well. All other samples tested showed tendency toward poor adhesion.

PERFORMANCE TEST: TRACKER HIGH VOLTAGE POWER SUPPLY P/N 2007175

Reliability report ARR-46 described the comprehensive test evaluation of the tracker high voltage power supply production prototype module. The prototype module was fabricated using Class A equivalent parts. Tests were performed after basic cordwood construction, after conformal drip coating and after encapsulation in potting compound. It was concluded that the power supply module was acceptable for its intended use, with the following modifications. To facilitate setting the high voltage output and the star presence signal within specifications, an additional selected resistor would be added to the circuit. To protect transistor Q2B from accidental overload, a 1000 ohm resistor would be inserted between the emitter and Q2B and E12.

SALT FOG TEST OF BERYLLIUM PROTECTED WITH 401-C10 (3M CO.)

Reliability report ARR-47 described the evaluation of 401-C10 (formerly Black Velvet) as a protective coating for beryllium and bi-metallic coupling of beryllium with aluminum or stainless steel. Procedure was in accordance with ND 1002037. It was considered that 410-C10 used with Dupont Line 65 Preparakote Primer did not corrode. Other samples without primer did corrode.

5.5 SUMMARY OF YEAR ENDING 1966

5.5.1 Introduction

OUA Qualification Program was completed on 14 October 1966. Final report KI-AR-FR-100 was submitted on 25 October 1966.

Reliability presentations were made to AC as part of the Apollo Programs presentation on 1 November and 8 December 1966.

Qualification Tests were completed on all multi-speed resolvers and final test reports on 1011294 and 1012065 (CPPC) were submitted.

Temperature-torque tests on AGE 124 were completed.

Data was completed and submitted on the motor-tach temperature gradient evaluation conducted from 27 September - 28 October on a 24 hour, 7 day week basis.

The Final Test Report was submitted on Eyepiece Stowage Container Qualification.

The EPT Program was completed and reports were submitted on P/N 2012497 SXT Reticle, P/N Mirror 2011259 and LEM Mirror, P/N 6011029.

5.5.2 Major Reliability Problems

SOLVERE MOTOR PROBLEM. Since 12 November 1966, Kollsman's Apollo Reliability group was engaged in an intensive program to resolve the contamination and lubrication problem on the Solvere motor, P/N 1012156. This was based upon an analysis of 12 motors at AC. As a result, AC issued a Stop Work Order on OUA production.

AC contended that the high stiction experience in the OUA Qualification Unit, AGE 124 resulted from motor contamination. Kollsman took the position that lack of lubrication was the basic problem.

In Kollsman's judgement, the data presented did not substantiate AC's contention that contamination caused the operating problems experienced in the OUA Qualification Unit, AGE 124. The successful qualification of the motor and its satisfactory operation in OUA units delivered to date offered conclusive proof of the operational capability and the quality of workmanship relative to procurement specifications and intended application.

Over a long period of time, Kollsman had recommended a change to the lubrication specification, originated by MIT/IL under their design responsibility to provide Kollsman Reliability with the necessary updating of requirements for additional lubrication. Kollsman's concern in this area was reflected in Reliability's presentations to AC.

The required degree of reliability at the parts level was achieved through the initiation and evaluation of other changes in the motor design. Under qualification testing, the motors never failed to operate at levels far in excess of requirements imposed upon Solvere in the ND specifications.

In order to investigate motor contamination, eight motors were disassembled at Solvere under controlled conditions. No evidence of contamination was found other than that produced as a result of fabrication or the immediate results of teardown. Kollsman, however, vigorously investigated all areas that could possibly contribute to the alleged contamination problem and implemented corrective action. Detailed rework procedures were generated for recycled and new motors.

Motors required for OUA's were delivered to Kollsman in a manner far exceeding expectations.

THERMAL BLANKET OUA/LEM. The problems encountered with the molding of complex geometric shapes from polyurethane foam resulted in thermal insulation blankets became the pacing item in the fabrication of OUA/LEM eyepieces.

Failure of the vendor to consistently deliver parts to the standards imposed by ND 1002288 resulted in a joint investigation into general polyurethane molding techniques and materials by Kollsman and AC Electronics.

5.5.3 <u>Parts and Materials Program</u>

5.5.3.1 Specifications and Procedures

PROCUREMENT AND TESTING OF ANODIZED SAMPLES - This procedures covered the procurement and testing of anodized test samples. Reference: Apollo Reliability Procedure, No. 56, Procurement and Testing of Anodized Test Samples", dated 1 June 1966.

LOCTITE APPLICATION PROCEDURE FOR OUA/LEM ASSEMBLIES - This procedure optimized the selection, application, and use of Loctite as applied to OUA and AOT assemblies. Reference: Apollo Reliability Procedure, No 53, "Thermal Vacuum Special Conditioning 1012156-1.011 Motor Tachometer Generator. (Reference NASA Part No.

1012156-1)".

PROCESS SPECIFICATION FOR MOLDING WITH POLYURETHANE FOAM - Procedure, ND 1002228, detailed the process by which a vendor manufactures the foam-insulating blanket for OUA eyepieces.

CLEANING, HANDLING AND STORAGE OF BERYLLIUM - This specification established the materials and procedures used in the cleaning, handling and storage of beryllium parts. This was a working process specification based on Apollo Reliability Procedure No. 50. Reference KPS-1003C.701.

GEARS - This specification established the minimum workmanship requirements for handling and assembling gears for OUA and LEM projects. Reference: KPS-1003H.101.

PRECISION BALL BEARINGS - This specification established the minimum workmanship requirements for the handling and installation of precision ball bearings. Reference: KPS-1003H.100.

MODIFICATION OF WIRING HARNESSES AND ASSEMBLIES - This specification established the minimum workmanship requirements for equipment modification. Reference: KPS-10034.102.

SOLVERE MOTOR TACHOMETER GENERATOR - Procedures were established for the teardown, inspection, cleaning, and recycling of Motor Tachometer Generators, PN 1012156.

BLACK VELVET ON GLASS-EPOXY LAMINATE - Thermal-Vacuum properties of Black-Velvet 400, PN 1012543-001, were investigated to determine reliability as a coating on fiberglass epoxy laminate on top of the phototube shield. Reference: Apollo Reliability Report No. 45, "Evaluation of Black Velvet 400, PN 1012543-001 in Thermal Vacuum, on Epoxy Fiberglass Laminate," dated 29 November 1965.

DETERMINATION OF BERYLLIUM ANODIZE THICKNESS - Procedures were developed to measure the thickness of Beryllium anodize. The thickness of the anodic coating on a sample piece representing the first Summit order for panels was measured and conformed to ND 1002127 and ND 1002127 and ND 1002296 and paragraph number 5 on P.O. AS-99179.

WIRE SPLICE EVALUATION - A comparison was made between a ferrule splice (PN 10100952-002) and a Western Electric Splice. The test results indicated that the Western Electric Splice was superior to the crimp type.

THE EVALUATION OF LOCTITE SEALANT UNDER THERMAL VACUUM - The outgassing characteristics of Loctite letter grade sealants were evaluated. Condensible and noncondensible outgassing products were identified by mass spectrometry and infrared analysis. The results of the evaluation are as follows:

a. Cured grade HV Loctite contained a relatively volatile plasticizer which outgasses under reduced pressures.

b. Percent weight-loss in vacuum varies inversely to the holding power of the sealant.

c. Uncured Loctite evaporates under reduced pressure.

d. The condensible gas portion of the outgassing products from uncurred grade HV sealant is composed primarily of the basic Loctite monomer. The plasticizer is present in small quantities.

e. Curing Loctited assemblies in an oxygen-free atmosphere, such as dry nitrogen, increased the total amount of sealant cured.

Reference: Apollo Reliability Report No. 59 "The Evaluation of Loctite Sealant Under Thermal-Vacuum," dated 30 June 1966.

LOCTITE CURING TECHNIQUE - The investigation into the outgassing properties of Loctite Sealant made it necessary to prepare a large quantity of cured sealant. One approach was to cut the samples in a nitrogen atmosphere. By using this technique, Loctite was cured in "Q" primed open aluminum dishes without need of the usual confinement between metal surfaces. The results, using this technique, were so successful that the process was incorporated into assembly procedures. This minimized the inherent danger of outgassing from residual uncured Loctite in mated assemblies. Reference: Apollo Reliability Memorandum No. 86 "Loctite Curing Technique".

THE EFFECTS OF THERMAL VACUUM ON THE BOND STRENGTH OF LOCTITE JOINTS - Color change and loss of fluorescence of cured Loctite, with exposure to thermal vacuum, indicated that evaporation of volatile constituents occurred. Lap shear data obtained indicated that exposure to thermal vacuum had little effect on the bond strength of the Loctite. The large scatter of lap shear results indicated that parameters, such as surface preparation and clamping force during curing, must be closely controlled in order to obtain more uniform results. A direct relationship existed between lap shear strength and breakaway torque of threaded elements. Reference: Apollo Reliability Report No. 54 "Effects of Thermal Vacuum on Loctite".

LUBRICATION FOR OUTER SPACE APPLICATIONS - A state-of-the-art survey was undertaken concerning the nature of lubricants for use in the hard vacuum of outer space. Solid films, plastics, reinforced plastics, soft metals, impregnated bodies, ceramics and cements, and binary alloys were investigated. The most promising types were solid films, reinforced plastics, soft metals, and impregnated bodies. Reference: Special Project Report, "Lubrication for Outer Space Applications", dated 16 September 1966.

LUXORB APPLICATION INVESTIGATION - The investigation of Luxorb application methods indicated that the material was not suitable for OUA/AOT optics. Abrasion resistance, adhesion, and stability in space environments were generally poor, and were not improved by variations in application procedure. Reference: Apollo Reliability Report No. 58 "Luxorb Application Procedure".

RELIABILITY OF GRAY VELVET PAINT 401-B2 AS A PROTECTIVE COATING ON BERYLLIUM - Gray Velvet coating on beryllium specimens (coated and cured in the same manner as the OUA) were intentionally damaged and repaired. Repaired areas appeared to be as good as the original finish. The ease with which damage was inflected indicated that adhesion was poor. As a result, the use of a wash primer undercoat was investigated. Results indicated excellent adhesion. Reference: Apollo Reliability Report No. 55 "Reliability of Gray Velvet Paint 401-132 as a Protective Coating on Beryllium," dated 20 May 1966.

FAILURE OF DEUTSCH CONNECTORS, PN 1010771 and PN 1012151 - Deutsch connectors were under investigation due to numerous failures. (Pin gold flaking, cracked insulation, bent and misaligned pins, improper spring tension, scoring of shell plating, poor chamfer on socket contacts, and rupture of aluminum shell wall). Kollsman integrated failure analysis effort with AC and the Deutsch Company. See "Apollo Failure Analysis Report, No. 5-66-11".

ARALDITE DP-116 - Quick cure catalysts were under evaluation for the purpose of adding a second source vendor to the QSL. Most promising candidate evaluated was Hysol, H-3762. Lap shear specimens were prepared.

WHITE VELVET PN 1012543-002 - Kollsman performed tests to determine loss of reflectance of White Velvet after exposure to solar simulation under thermal vacuum environment. Test specimens were exposed to simulated solar radiation in a thermal vacuum for 11 hours over a 24-hour period and to 200°F. for 16 hours. Reflectance of test specimens was greater than the 85% acceptance level per MIT/IL. Reference: ARR-49, "Reflectivity of White Velvet at Elevated Temperature and Solar Radiation in Thermal Vacuum".

FLEXIBLE CABLES PN 1012519 and 1012520 - Kollsman performed humidity tests to determine quality of adhesive bond of RTV 881 and RTV 60 to FFP and H-Film FEP cable material. Test results showed good adhesion on RTV 60 to pure H-Film sample. Reference: ARR-50, "Humidity Test in Flexible Cables Potted with RTV-60 and RTV-771".

The procurement problem for Flexprints PN 1012519 and PN 1012520-1, -2 was improved by the addition of two new suppliers to the QSL (Garlock Inc. and Electro-Mechanisms) at the request of Apollo Reliability. In addition, Apollo Reliability assisted Manufacturing Engineering in developing a Kollsman capability for potting connectors with acceptable adhesion between the FEP insulation and the potting material.

ECCOBOND 55 PN 1012533 - Eccobond 55 was acceptable to MIT/IL, in place of Cox and Company's 28 proprietary adhesive, for bonding of heater pads to anodized aluminum and polyurethane foam. Emerson and Cummings, the approved vendor for Eccobond 55, was given approval to submit a Certificate of Compliance in lieu of meeting requirements of para. 2.B.2 of SCD 1012533 per Kollsman initiated TDRR.

BERYLLIUM PRISM MOUNT, PN 6011017 - Methylene chloride, recommended by Apollo Reliability as a solvent for Eccobond 55 in removing lens prism from mount; no deleterious effect on beryllium's black anodize finish was observed.

REVISED SHELF LIFE ITEMS - (1) Shelf life of lacing tape, PN 1012507, was changed to six months. Written confirmation from vendor, Guddebrod Bors., was sent to Kollsman. Curing agent, 12-007B, PN 1010297, shelf life was changed to three months. (2) Shelf life of Loctite was changed to indefinite with unopened bottles. Written confirmation was sent from the vendor to Kollsman. (3) Shelf life of Rubber Adhesive EC 1357 and EC 1300L was changed from four months to six months for unopened containers.

LUBRICANT VERIFICATION - The total quantity of lubricant in bearings on PN 1012156-1, S/N's 1129, 1130, 1135 Motor Tachometer was determined. The bearing was randomly selected from a Solvere lot, which had been relubricated by Bearing Inspection Labs, had served to verify the conformance to the alternate Method A procedure of ND 1002077. Reference: Apollo Reliability Report No. 60 "Measurement of Lubricant Weight in Motor Bearing PN 1012156.

NYLON BELTS - The cause of corrosion of OUA Shipping Containers was traced to the Nylon Slings used to remove the inner container from the outer container. Infrared analysis of the carbon tetrachloride extract from the belt identified the corrosive agent as an aromatic sulfonic acid. Reference: Apollo Reliability Procedure No. 61 "Contamination of Nylon Sling".

EYEPIECE THERMAL INSULATION BLANKETS - The fabricato of OUA/AOT eyepiece thermal insulators, had several problems in supplying parts which meet the requirements of the controlling Navigation Document, ND 1002288. The specified urethane foam material, Uralane 577, did not completely lend itself to the molding of complex geometric shapes. Schedule slippage was anticipated. Alternate materials were investigated. Polyurethane foam No. L-131, manufactured by Isocyanate, Inc. showed considerable promise. The fabricator tested the material and requested authority to use the Isocyanate product for all future orders. The material was evaluated and was used by Grumman on the LEM at interface areas. Kollsman requested a formal change to add this material as an option to ND 1002288.

END CAP ROTATION ON RESOLVER PN 1012157 - In order to insure positive locking between the resolver case and the end cap, the following product improvement was accomplished:

A bead of epoxy was added between the case and the end cap assembly.

5.5.4 Reliability Training Program for Personnel Certification

The number of personnel certified and recertified during this reporting period is as follows:

CATEGORY	NUMBER
Welding	50
Crimping and Soldering	140
Potting	35
Plating	32
Loctite	24
Heat Treating	5
Zyglow	10
TOTAL	296

5.5.5 Extended Performance Testing Program

TEST LOTS COMPLETED. For this report period, 87 test lots were completed, bringing the total number of test lots completed to date to 146.

5.5.6 Qualification Test Program

5.5.6.1 Command Module

General - Technical Directive K-80, Amendment 1, was further modified by Amendment 2.

Testing - As indicated in Table 5-8, all parts have completed qualification except PN 1012157 Resolver (CPPC) which was in process.

MILESTONE ACCOMPLISHED. OUA Subsystem, subassembly and ESC qualification tests have been completed.

5.5.6.2 LEM

General - CCRD was tested simultaneously with AOT. CCRD was supplied by AC.

Milestones - Scheduling was based on completion of subsystem testing on 15 February 1967.

Details - Table 5-6 indicates planning for the subsystem.

Table 5-6

LEM SUBSYSTEM QUALIFICATION STATUS

Drawing No.	Test Plan Approval	Qualification Test Start	Qualification Test Complete	Final Report	Remarks
6011000	X	X	027	037	

Vibration and Shock testing was completed at AC and Acceleration testing was completed at Kollsman.

Documentation - Table 5-7 indicates status of Plans, Procedures, and Test Reports.

Table 5-7

LEM DOCUMENTATION STATUS

	Plans	Procedures	Reports
Total Required	4	28	4
Number submitted this report period	1	9	0
Total submitted	4	22	0

Table 5-8

APOLLO PARTS QUALIFICATION STATUS

Drawing No.	Part Type	T. P. and Q. S. S. No. Tr.	Test Plan Approval	Qualification Test		Final Report	Remarks
				Start	Complete		
1010341	Resolver	096-1	X	X	X	X	Complete-Not Qualified
1011281	Differential	003-1	X	X	X	X	Complete-Qualified
1011294	Resolver Ass'y	004-1	X	X	X	X	Complete-Qualified
1011374	Projection Lens	008-1	X	X	X	X	Complete-Qualified
1011499	Connector	012-1	X	X	X	X	Complete-Qualified
1011501	Connector	013-1	X	X	X	X	Complete-Qualified
1011748-1,2	Connector	026-1	X	X	X	X	Complete-Qualified
1012041	Ceramic Capacitor	130-1	X	X	X	X	Complete-Qualified
1012042	Diode Silicon	136-1	X	X	X	X	Complete-Not Qualified
1012043-1,2	Photo Tube	151-1					Tests cancelled
1012048	Transistor Si PNP	150-1	X	X	X	X	Complete-Qualified
1012052	Transformer Audio	145-1	X	X	X	X	Complete-Not Qualified
1012056-1,-11	Diode Zener	137-2	X	X	X	X	Complete-Not Qualified

Table 5-8 (Cont'd.)

Drawing No.	Part Type	T. P. and Q. S.S. No. Tr.	Test Plan Approval	Qualification Test		Final Report	Remarks
				Start	Complete		
1012065	Resolver Ass'y	138-1	X	X	X	X	Clifton-Qualified
1012065	Resolver Ass'y	138-2	X	X	X	X	Reeves-Qualified
1012065	Resolver Ass'y	138-3	X	-	-	-	Bendix (deleted)
1012066	1X, 16X Resolver	141-1	X				(Deleted)
1012142	Capacitor Ceramic	131-1	X	X	X	X	Complete-Not Qualified
1012142	Capacitor Tantalum	132-1	X	X	X	X	Complete-Not Qualified
1012148	Power Transformer	149-1	X	X	X	X	Complete-Qualified
1012149	Power Transformer	159-1	X	X	X	X	Complete-Qualified
1012154	Resonator	153-1					Tests cancelled
1012155	Resonator	154-1					Tests cancelled
1012157	Resolver	143-1	X	X	037	037	Clifton
1012157	Resolver	143-2	X	--	--	--	Kearfott (deleted)
1012502	Capacitor Wet Slug Tantalum	156-1	X	X	X	X	Complete-Qualified

Table 5-8 (Cont'd.)

Drawing No.	Part Type	T. P. and Q. S. S. No. Tr.	Test Plan Approval	Qualification Test		Final Report	Remarks
				Start	Complete		
1012512	Counter Rotating	165-1	X	X	X	X	Complete-Qualified
1012519	Flex Print	170-1	X	X	X	X	Sanders-Complete Qualified
1012519	Flex Print	170-2	X				Flexcircuits (deleted)
1012522	Flex Print (Cable)	169-1	X	X	X	X	Complete-Qualified
2011701	SXT Index Head Ass'y	---	X	--	--	--	Deleted
2007024	Head Elec. Ass'y (Tracker)	601	X	X	X	X	Complete-Not Qualified
2007032	HV Power Supply Ass'y (Tracker)	602	X	X	X	X	Complete-Not Qualified
2007022	Tuning Fork Ass'y	603	X	X	X	X	Complete-Qualified
			APOLLO SUBSYSTEM QUALIFICATION STATUS				
2011000	Subsystem		X	X	X	X	Complete
1021255	Eyepiece Storage Compartment with Eyepieces		X	X	X	X	Complete

5.5.7 Failure Analyses

A summary of Apollo Failure Analyses Reports (AFAR) during the reporting period of 1966 includes:

a. AFAR completed (See Table 5-9 for details)	69

Table 5-9

FAILURE ANALYSIS COMPLETED

Description	Reference
Plate Clutch Deterioration	FR No. 4514
Beryllium Mirror Scoring and Contamination	FR No. 9678
Bowmar Counter on Functional Tester	FR Nos. 8564, 8565, 8568, 8570, 8571, 8573 and 12048
Nyloc Screws, Preforming Methods	Reference: E. Yamic
AGE 202 Contamination	FR No. 9695
Spring Failure	FR No. 1216
Cracked Insert PN 1010771-001, SN 1033	Deutsch Co. Failure Analysis
AGE 1-201 Contamination	FR No. 1136
LEM (601) Contamination	FR No. 9538
Ball Bearing Evaluation	Reference: C. Betancourt
Deutsch Connector	FR No. 1120
AGE 203 Contamination	Reference: Contamination Comm.
AGE 204 Contamination	Reference: Contamination Comm.
Trim Module Failures	FR No. 1164
Feathering on Threads of Manual Adjust	Reference: G. Gruber
Flex-Cable Examination	Reference: S. Brush
Solvent Resistance Test of Optical Coatings	Reference: H. Fistel
Weld-Pak Short Circuit	Reference: H. Fistel
LEM MSC Trainer, SN 6	FR No. 9529
Manual Drive Plugs	FR Nos. 7873, 7876, 9683, 7359
Outer Telescope Tube Assembly Torque vs Strain	Reference: A. Archer

Table 5-9 (Cont'd.)

Description	Reference
Loctite Outgassing	ARR No. 57
Grey Paint Adhesion to Beryllium	ARR No. 55
Nyloc Screw Preform Contamination under Controlled Conditions	Reference: E. Yannic
Purge Valve Evaluation	Reference: E. Winston
Panel Gaskets PN 1011745, SN 1036, 1037, 1039, 1046	Reference: E. Winston
Nicks and Dents in Connector Shell	Reference: FR No. 1120
Nyloc Screw Showing Deformed Nylon after Preform	Reference: G. Gruber
Analysis of Particles Taken From SXT Cavity After Vibration	Reference: FR 1133
Analysis of Particles Taken From Telescope Cavity After Vibration	Reference: FR 1136
Defects on New Nyloc Screws (Nylon and Metal Burrs)	Reference· M. Lionetti
Photographic Evaluation of Cracked Plastics - Avionics Display Systems	Reference: A. Julier, Job No. 398000
X-ray Examination of Ceramic Fracture, PN 2012568	Reference: FR 1164
Photo and Hardness Test of Stainless Steel Balls	Reference: FR 1120

Table 5-9 (Cont'd.)

Description	Reference
Electrical Connector, PN 1001792-001	FR No. 9572
Powerstat, PN 1017484	FR No. 1146
OUA Contamination, PN 2011000	AFAR 6-66-15
Flexprint Assembly, PN 2012519B	FR No. 1150
AOT Foreign Particle Analysis, PN 6011000	AFAR 66-17
Clifton Precision Analysis Report, PN 1012157	AFAR 66-18
AC Bearing and Chemistry Report, PN 101606-1, -2	AFAR 66-19
Differential Failure, PN 1011281	AFAR 66-20
Crack in Shaft, Index Mirror, PN 2011258	AFAR 66-21
Deutsch Co. Analysis-Tech. Report No. 50135	AFAR 66-22
Deutsch Co. Analysis-Tech. Report No. 50134	AFAR 66-23
Deutsch Co. Analysis-Tech. Report No. 50136	AFAR 66-24

Table 5-9 (Cont'd.)

Description	Reference	
	FR No.	AFAR No.
Leak Test Failure of Gasket PN 1011745-4	9537	66-25
Contamination on Reticle-AGE-207, S/N 19	1190	66-26
Electrical Connector, PN 1001792-201	9572	66-27
SXT Eyepiece Assembly, PN 2012699	9498	66-28
Resistor, Variable, Trimmer PN 1010373-17	1196	66-29
Cable Assembly, Special Purpose Electrical, PN 02386910617	1198	66-30
Resolver, PN 1012157	1194	66-31
SCT Eyepiece Assembly, PN 2012719	9873	66-32
Resolver Slip Ring-Brush Contact Resistance, PN 1001801	15935	66-33

5.5.8 Reliability Reports

5.5.8.1 (AAR-48 thru AAR-62)

The following are synopses of the actual Reliability Report Analyses.

EFFECT OF SALT FOG ON BERYLLIUM - Reliability Report ARR-48 described the investigation of the effectivity of various protective coatings in preventing or limiting the corrosion of beryllium under salt fog conditions. Test results indicated that black annodizing and 401-C10 (3M Co.) with an appropriate primer afford excellent protection to beryllium under test conditions.

REFLECTIVITY OF WHITE VELVET AT HIGH TEMPERATURE AND UNDER SOLAR RADIATION IN THERMAL VACUUM - Reliability Report ARR-49 described the evaluation of white velvet coating (3M Co.) at high temperatures and under solar radiation in thermal vacuum. The result indicated that White Velvet met the 85% minimum total reflectance requirement after 16 hours exposure at 200°F. The total reflectance requirement was met after exposure to one solar constant of radiation in thermal vacuum.

HUMIDITY TEST ON FLEXIBLE CABLES POTTED WITH RTV-60 AND RTV-881 - Reliability Report ARR-50 described the evaluation of the adhesion of GE RTV-60 silicon rubber to FEP teflon, FEP teflon covered H-Film and pure H-Film flexible cables and the comparison with cabling potted with RTV-881 silicone rubber. The results indicated that all samples failed the temperature/humidity test except pure H-Film potted with RTV-60, which was considered too severe for the environmental conditions under actual use. Otherwise, all samples exhibited good adhesion characteristics.

TORQUE VS STRAIN IN OUTER TELESCOPE TUBE ASSEMBLY PN 2011722 - Reliability Report ARR-53 described a study of the effects of torque and strain on the alignment of the inter-telescope tube assembly. The following factors were examined:

- To determine whether optical alignment is maintained when a torque of 100 inch/pound is applied to the Lens Locking Ring.
- To determine whether a torque (and resulting strain pattern), lower than that specified, can be applied without disturbing the optical alignment.
- To evaluate strain patterns in the optical system components before and after vibration testing when various torques are applied to the Lens Locking Ring.

- To determine the effectivity of an Experimental Retaining Ring Assembly to maintain optical alignment and low stress level during vibration.

- To determine whether there is deformation of Lens Spacer 2011660 as a result of assembly and vibration.

The following conclusions were reached:

- Using Kollsman assembly procedures, the stress is greater than specified, but after vibration stress is considerably reduced.

- As sufficient torque to prevent optical misalignment developed stress concentration which was improved by vibration, it was recommended that test procedure should be revised to incorporate vibration before inspection of the stress pattern. If stress is to be reduced, means would have to be found to prevent lateral movement of the optical component, so that torque level could be reduced.

- A definitive test should be performed to determine the least torque at which any of the components under stress suffer permanent damage.

- Loctite proved to be an effective protecting agent for the experimental retaining ring. This method applied to the original retainer should be investigated.

- India ink from the bearing surface of the lens assembly was abraded and could contaminate the optical surfaces. Such marking should be restricted to surfaces which do not contact other surfaces.

EFFECTS OF THERMAL VACUUM ON LOCTITE - Reliability Report ARR-54 described a study of the effects of thermal vacuum on Loctite. Color change and loss of fluorescence of cured Loctite indicated that evaporation of volatile constituents occurred when it is exposed to thermal vacuum. Uncured Loctite either cured and/or evaporated during thermal vacuum testing. Lap shear data indicated that exposure to thermal vacuum has little effect on the bond strength of Loctite. There was also evidence the procedural factors such as surface preparation and clamping force during curing must be closely controlled to obtain uniform results. A direct relationship existed between lap shear strength and breakaway torque of threaded elements.

RELIABILITY OF GRAY VELVET PAINT 401-B2 (3M Co.) AS A PROTECTIVE COATING ON BERYLLIUM - Reliability Report ARR-55 described the evaluation of the repairability of Gray Velvet Paint 401-B2 as a protective finish on beryllium. Gray Velvet coated beryllium speciments were intentionally damaged and repaired. The repaired areas appeared to match the original surface. It was noted that the adhesion of the coating to the beryllium surface was poor. The application of a zinc chromate primer produced excellent adhesion.

INVESTIGATION OF LUXORB APPLICATION METHODS - Reliability Report ARR-58 described the investigation of Luxorb application methods. It indicated that the material is not suitable for approved components. Abrasion resistance, adhesion and stability in space environment were generally poor and were not improved by variations in application procedures.

EVALUATION OF LOCTITE SEALANT UNDER THERMAL VACUUM - Reliability Report ARR-59 described the evaluation of Loctite sealants under thermal vacuum. The outgassing characteristics, condensible and non-condensible were identified by mass spectrometry and infrared analyses. Cured grade AV Loctite contained a relatively volatile plasticizer, which outgassed under reduced pressure. Percent weight loss in vacuum varied inversely to the holding power of the sealant. Uncured Loctite evaporated under reduced pressure.

MEASUREMENT OF LUBRICANT WEIGHT IN MOTOR BEARING P/N 1012156 - Reliability Report ARR-60 described the investigation to determine the quantity of lubricant to be applied to the bearing of Motor-Tachometer Connector (Solvere) P/N 1012156. The alternate method A of procedure ND 1002077 was found satisfactory.

CHEMICAL ANALYSIS OF NYLON SLING P/N 1001699 - Reliability Report ARR-61 described an investigation of Nylon Sling P/N 1001699, which was suspected of causing the corrosion of cadmium plated part of shipping container P/N 1019720. Investigation revealed that various chemicals were present in the nylon sling. It was recommended that the nylon sling should be degreased, washed and oven dried to remove contaminants.

GRAY AREAS IN BERYLLIUM ANODIZING - Reliability Report ARR-62 investigated the corrosion resistance of the gray area of an anodized beryllium part. The sample was submitted to two cycles of salt spray testing. The test results indicated that the gray areas are resistant to corrosion.

USE OF CADMIUM PLATING - Reliability Report ARR-62 described the investigation to determine possible consequences of using cadmium plating in space. Cadmium is intrinsically a very volatile metal and under reduced pressure could vaporize, silvering optical parts and contaminating metal parts; cadmium vapors could also be a health hazard to the crew. Cadmium is not suited for use in outer space.

5.6 SUMMARY OF YEAR ENDING 31 DECEMBER - 1967

5.6.1 Introduction

Qualification Tests were completed on the LM AOT (604) 1 February 1967, and the final test report were submitted 15 February 1967. Table 5-10 summarizes these findings.

Reliability presentations were made to AC as part of the Apollo Programs presentation 9 January and 9 February 1967.

Requalification Tests of the OUA with 1012156-4 motors was completed on 23 March 1967. A final report was submitted.

EPT Testing was completed on all six Dove Prisms, PN 2011153, one Beam Splitter, PN 2012222, one Mirror, PN 2011260, and one Reticle (LM) PN 6011430.

5.6.2 Major Reliability Problems

5.6.2.1 Beryllium Corrosion

Beryllium corrosion has been noted on the eloxed and machined interface surfaces of the Optics Base interior.

Analysis indicated the corrosion to be beryllium hydroxide, probably due to carbide inclusions and other impurities on the surface of eloxed walls.

Investigation was made to find a method of removing and inhibiting these contamination sites. Be passivation treatment was subsequently developed to retard this corrosion.

It was also recommended that a periodic nitrogen purge should be performed after OUA delivery.

5.6.2.2 Sextant - Shaft and Trunnion Drive Axes Shifts (OUA)

During vibration tests, there were shifts in the shaft drive axis and in the trunnion drive axis. The shaft drive axis problem was solved by the introduction of an epoxied wedge. The trunnion drive axis problem was minimized by co-planer lapping of mounting pads, extensive cleaning of pads and an increase in spring washer force.

During thermal vacuum tests, there were shifts in the trunnion drive axis. Investigation showed that stresses in the mirror axis cause the shift. New bearings were designed to eliminate stresses. Tests indicated at 0°, 36° and 90°. At AC's direction, the original bearings were re-installed and a new calibration procedure was developed.

Table 5-10

AOT QUALIFICATION FAILURE SUMMARY LM AOT 604 S/N 10

ITEM No.	FAILURE RECORD		FAILURE RECORDED		FAILURE HISTORY			
	Date	R'pt. No. Ext	Environment	Location	Oper. Time	Symptoms	Cause	Corrective Action
1	10/ 8/66	AC 13721	Post IMU/AOT Qual Vibration Testing	ACED Milwaukee		Paint chipped off AOT Housing area where accelerometers were mounted	Paint chipped off when accelerometers were removed	Unit cleaned and reworked following completion of acceleration test at Kollsman Instr. Corp. No further corrective action required since discrepancies were result of special tests performed at ACED, Milwaukee.
2	10/ 8/66	AC 13722	Post IMU/AOT Qual Vibration Testing	ACED Milwaukee		AOT Housing surface dirty. Just external to spacecraft interface.	Cause is unknown. Suspect dry lube film from the ball seats of the Navigation Base.	Same as C/A for AC 13721 Item 1 above.
3	10/ 8/66	AC 13723	Post IMU/AOT Qual Vibration Testing	ACED Milwaukee		AOT Nav. Base Mounting Pads (all four) exhibit scoring.	Suspect condition is caused by low torque value used to mount AOT to Nav. Base. GAEC uses 65±15 in-lbs. Kollsman uses 225 in-lbs.	Recommend increase in torque requirements. ACED/GAEC action.
4	10/12/66	14313	Post IMU/AOT Qual Vibration Testing	Kollsman Instr.		1. Foreign particles on reticle & aspheric lens. Blemish on reticle plane (8) eight times thickness of reticle line. 2. Separation of reticle lamp leads at Lamp Housing Assy with one conductor exposed. 3. Screws on counter cover plate loose.	1. Luxorb flaking off optical elements. 2. Workmanship 3. Workmanship	1. Unit originally sold off with this condition & accepted via Waiver #KIC C-241. TDRR 31700 replaces Luxorb with Black Velvet EFF LGE-605. 2. Additional inspection procedures incorporated for more stringent monitoring during stage. 3. Preliminary design change submitted to AC Electronics.
5	10/28/66	14312	Baseline Test Post IMU/AOT Qual Vibration & Shock Testing	Kollsman Instr.	26	Reticle cursor readout at 90° is 90°2'20"; Initial baseline value was 90°01'08" KIC-C-228. Limit is 90°00'00" ± 60".	Inability of observer to interpolate counter to better than ± 36". Readings to a certain extent are subjective in nature.	ECO 120144-2 Readings to be taken at 15° field of view instead of at 10° because system focus is optimized at 15°. Also, instead of taking (1) one reading, (10) readings will be taken and statistically averaged to eliminate any erroneous readings close out.

Table 5-1(nt'd.)

ITEM No.	FAILURE RECORD		FAILURE RECORDED		FAILURE HISTORY			
	Date	R'pt No. Ext	Environment	Location	Oper. Time	Symptoms	Cause	Corrective Action
6	11/21/66	16202	Post Acceleration Baseline Verification	Kollsman Instr.	36	Precision flanged bushing P/N6011092 located nearest head prism,had burr on its I. D. surface.	1. Bushing hardness was per print but below ND requirement. 2. Burr is probably result of mounting AOT on acceleration fixture.	1. TDRR 31649 adds new note to SCD 6011092 to have bushing heat treated to RC 39-41 per ND 1002114. 2. Change in R&T Coplanarity established after assembly. Close Out.
7	12/16/66	14321	Pre-climatic Baseline	Kollsman Instr.	94	Star LOS "F" detent azimuth difference is 65 sec. Limit ± 21 sec; Elevation difference is + 39 sec. Limit is ± 15 sec.	Possible cause: Relaxation of taper pins.	a. Interim C/A : 1. Added settling vibration EFF. LGE-606. 2. Set bearing preload to high point. b. Failure Analysis requested 1/27/67.
8	1/9/67	14325	Post Ground Temp Baseline Verification	Kollsman Instr.	292	Difference in reticle cursor readout accuracy is 43 sec. Max. allowed is 36 sec.	Out of spec condition caused by improper seating and alignment technique of the plastic aperture stop prior to Functional Test.	AOT 604 is last unit with long eyepiece & plastic aperture stop. As per TDRR31123 AOT 605 and up will have short eyepiece and metal aperture stop with mount. This prevents misalignment of stop which causes parallax and resulting errors.
9	1/9/67	14321-1	Post Ground Temp Baseline Verification	Kollsman Instr.	292	Refer to 14321, Item 7 above.	Refer to 14321, Item 7 above.	Referto 14321, Item 7 above.
10	1/21/67	14233	Post Thermal Vac Baseline Verification	Kollsman Instr.	577	Reticle power match at 22.5° field reticle read 31°55'19'. Reading should be 32°1'52"; + 87, -86 sec.	Out of spec condition caused by improper seating and alignment techniques of the plastic aperture stop. prior to Functional Test.	Same as C/A for 14325, Item 8 above
11	1/21/67	14235	Post Thermal Vac Baseline Verification	Kollsman Instr.	578	Difference in reticle power match readings at 15° field. Before and after thermal vacuum is 41 sec Limit ± 28 sec.		Failure Analysis requested 1/27/67
12	1/21/67	04321-2	Post Thermal Vac Baseline Verification	Kollsman Instr.	578	Refer to 14321, Item 7 above.	Refer to 14321, Item 7 above	Refer to 14321, Item 7 above.
13	1/24/167	14234	Post Cabin Atmosphere Baseline Verification	Kollsman Instr.	613	Counter position at 90° Recorded data is 82.559 deg. Spec. Tol. 82.503 deg to 82.537 deg.	Same as Cause 14325, Item 8 above.	Same as C/A for 14325, Item 8 above.

Table 5-10 (Cont'd.)

ITEM No.	FAILURE RECORD		FAILURE RECORDED		FAILURE HISTORY			
	Date	R'pt No. Ext	Environment	Location	Oper. Time	Symptoms	Cause	Corrective Action
14	1/24/67	14321-3	Post Cabin Atmosphere Baseline Verification	Kollsman Instr.	613	Refer to 14321, Item 7 above.	Refer to 14321, Item 7 above	Refer to 14321, Item 7 above
15	1/24/67	14233-1	Post Cabin Atmosphere Baseline Verification	Kollsman Instr.	613	Refer to 14233, Item 10 above	Refer to 14233, Item 10 above	Refer to 14233, Item 10 above.
16	1/24/67	14235-1	Post Cabin Atmosphere Baseline Verification	Kollsman Instr.	613	Refer to 14235, Item 11 above.	Refer to 14235, Item 11 above.	Refer to 14235, Item 11 above.
17	1/30/67	14236	Post Temp. Humidity Baseline Verification	Kollsman Instr.	677	Foreign Material deposits on: 1. Eyeguard P/N 6011814 2. Reticle Control Knob P/N 6011059 3. Pressure Seal Ring P/N 6011156 4. Worm & Gear Housing Assy. P/N 6011820 5. Lens Housing Threads P/N 6011034 Part No. inking illegible.		
18	1/30/67	14237	Post Temp Humidity Baseline Verification	Kollsman Instr.	677	Rust on: 1. Angle counter worm shaft P/N 6011035C 2. Locking Lever Cam Yoke P/N 6011150	Possible Cause: Galvanic corrosion, dissimilar metal contact, special test fixture to Angle Counter Worm Shaft	
19	1/30/ 7	14238	Post Temp Humidity Baseline Verification	Kollsman Instr.	677	Condensation on inside surface of Angle Counter Window P/N 1012524		
20	1/30/67	14321-4	Post Temp Humidity Baseline Verification	Kollsman Instr.	677	Refer to 14321, Item 7 above	Refer to 14321 Item 7 above	Refer to 14321, Item 7 above
21	1/30/67	14235-2	Post Temp Humidity Baseline Verification	Kollsman Instr.	677	Refer to 14235, Item 11 above.	Refer to 14235, Item 11 above.	Refer to 14235, Item 11 above.

During manual direct mode operation, sextant shaft spring back, up to 0.4°, was observed. Kollsman investigated the problem: spring back was increased with gearbox removed, and did not occur when flexprints were not installed. Kollsman prepared design sketches of various friction drive devices. AC considered a possible electrical control circuit.

When driving at low speed, during system testing, random optical hesitation and speedup was noted. It was found that the 64X resolver lead wind-up force and anti-backlash spring force were about equal at one time and tended to buck each other. After investigation, Kollsman designed a new spring (P/N 2012767), which solved the problem.

5.6.2.3 Evaluation of Thermal Blanket for Sextant Eyepiece

Parameters were established for a thermal blanket to be installed in the sextant eyepiece and the telescope prism housing. No information was available for foam material in an oxygen environment or for burning rate, odor, toxicity, flash and five point outgassing. Vendor samples were unsatisfactory because of internal voids and loose skin. Alternate materials from Isocyanate, Fresman Chemical, NoPco and Product Research were evaluated. Kollsman also investigated solid urethanes.

5.6.2.4 Motor Tachometer Generator (Solvere)

Two failures occurred in testing Solvere motor tachometer generators. S/N 1301 and 1302 showed excessive static friction, S/N 1302 after test equipment failure. After disassembly, scoring proved to be machining marks and not rub marks. On S/N 1302, a soft green deposit was chemically identified, but its source was not found. It was concluded that this deposit had no effect on the problem. There was evidence of contact wear between the retainer and the inner ring. No wear of bearings was noted. It was concluded that the vendor's procedures were satisfactory.

5.6.2.5 Resolver Loading

AC's system test indicated a shift from zero in the 64X resolver. Kollsman checked peak-to-peak values and found significant differences from resolvers with load and those without load. It was found that the 15K ohm shunt on the 5K ohm Fine Resolver Load reduced effective load to 4.8K ohms, but was not critical. Using vendor tests as a standard, connecting the resolver low ends without ground provides the largest peak-to-peak error readings, as much as 8 arc seconds, but not in a consistent pattern. When a ground was connected to the low ends, peak-to-peak voltage was as much as 6 arc seconds with no consistent pattern. It was concluded that the existing JDQ's should be continued as vendor component data is duplicated. It was recommended that the system cabling should be revised for unbalanced capacitive loading.

5.6.2.6 SCT Manual Adjust Knob

When it was discovered that the manual adjust knob occasionally was sluggish or jammed, Kollsman redesigned the assembly by chamfering the "O" ring seat, added a spring washer, modified the spring length.

5.6.2.7 Investigation of Non-Metallic Materials

Kollsman instituted a search for fireproof or fire retardent material in an oxygen environment. Substitute material were considered for

AOT seal P/N 6011143

AOT and OUA Eyeguard P/N 2011879, 2011974

AOT and OUA Insulating Blankets P/N 2012606, 2012687, 2012688, 2012711, 2012714, 2012715, 6011138, 6011139.

5.6.3 Parts and Materials Program

5.6.3.1 Specifications and Procedures

OPTICAL BASE - PN 2012663 - Procedures were established for the handling and cleaning of the Optical Base, primarily for the removal and prevention of corrosion. Reference: Apollo Reliability Procedure, No. 59.

5.6.3.2 Parts and Materials Evaluation

NITRIC ACID AND BERYLLIUM ANODIZE - Flaking of the anodic shell on the seal area of the telescope panel was traced to the nitric acid-ammonium bifluoride solution used by the vendor to clean the chamfer area prior to anodizing. The vendor complied with the recommendation to eliminate the use of this mix.

TEFLON FINISH PN 1010666 & PN 1010667 - Teflon flaking from the SXT Mirror Housing and Eyepiece Assembly, PN 2012719, was caused by poor fusion between the primer and the topcoat. Increasing the cure temperature to 750°F on the initial coat of FEP resulted in a finish with at least 20 times the abrasion resistance previously attained. A change was made to ND 1002067, calling for the 750°F cure temperature. (TDRR 32933)

ANODIZED BERYLLIUM - An investigation was initiated to determine the corrosion resistance of the gray areas frequently found in the recessed areas of anodized beryllium parts. Test results indicated that the gray areas pass the corrosion resistant requirements of ND 1002296. Reference: Apollo Reliability Report, No. 62.

CADMIUM PLATING ON NAS-1394-08 - An investigation was initiated to determine the possible consequences of using cadmium plating on OUA parts. As a result, a recommendation was made that no cadmium or cadmium plated parts should be used in the OUA. The recommended material was passivated stainless steel. Reference: Apollo Reliability Report, No. 63.

FLEXPRINTS PN 1012519, 250-1, 250-2 - Spring back of the SXT shaft was noted during open servo loop operation. Friction of the flexprints against the wraparound cavity was considered as a possible cause. An investigation was initiated to determine the feasibility of lubricating the flexprint but, based on the coefficient of friction between the flexprint itself and various lubricants, it became obvious that rather than improve the lubricity of the flexprint, it would add a possible source of contamination to the flexprint area. Therefore, it was recommended that the flexprint's inherent resiliency be investigated as a contributing factor to the spring back tendency. Reference: Apollo Reliability Report, No. 64.

COVER AND BAFFLE ASSEMBLIES, PN 2012547, 675 and BLACK VELVET PAINT, PN 1012543-001 - Particles of a black contaminant were discovered on the OUA during visual inspection after vibration testing. As a result of an investigation, it was determined that the contamination was Black Velvet paint emanating from the interior painted surfaces of the cover and baffle assemblies. The recommendation was to black anodize the area in lieu of painting. TDRR's 33158 and 33159 served to implement the recommendation. Reference: Apollo Reliability Report, No. 66.

EYEPIECE THERMAL INSULATORS - An evaluation of the molding characteristics of four polyurethane foams and one polyurethane potting compound was undertaken, utilizing a Mutron PN 2012711A mold. Of the materials tested, the most promising was Isofoam L-131. Reference: Apollo Reliability Report, No. 67.

EFFECTS OF 10 PERCENT OXALIC ACID SOLUTION ON SPRAYLOT SC-1071 PROTECTIVE COATING - Chemical removal of corrosion from beryllium surfaces required exposure to a 10 percent oxalic acid solution. This exposure adversely affected certain areas such as inserts and critically machined surfaces. Spraylog SC-1071 proved to be an effective means for masking these critical areas. Reference: Apollo Reliability Report, No. 68.

COMPATIBILITY OF 2.1 PERCENT RIDOLENE SOLUTION WITH GRAY VELVET PAINT, PN 1012543-003 - The use of Ridolene 53 cleaning compound on elementary beryllium presents no difficulty. However, there are many instances where parts have been coated with Gray Velvet Paint and an investigation was initiated to determine the effect of Ridolene on these parts. The conclusion was that Ridolene should not be used on parts coated with organic finishes, notably Gray Velvet Paint. KPS-1003C.7011B lists several alternate methods which may be used depending on the surface finish of the part to be cleaned. Reference: Apollo Reliability Report, No. ARR 70.

LOT EVALUATION REPORT, WIRE, ELECTRICAL, TFE INSULATED, PN 1010789 - The purpose of this test was to verify the acceptability of the following items:

PN 1010789-004D	Lot 10-5-14
PN 1010789-004F	Lot 11-6-12
PN 1010789-003F	Lot 11-6-9
PN 101078-006A	Lot 10-4-49
PN 1010789-012B	Lot 10-4-49

The test was performed in accordance with MIL-W-22759. The results indicated that the wire specimens satisfy the specification requirements. The respective wire spools were rated acceptable for manufacturing purposes. Reference: Apollo Reliability Report, No. 69.

EFFECTS OF 10 PERCENT OXALIC ACID SOLUTION ON THE DIMENSIONS OF BERYLLIUM PARTS - Oxalic acid solution was used to remove corrosion from beryllium parts. The purpose of this evaluation was to determine dimensional loss versus variations in immersion time and solution temperature. After an immersion time of one hour in an oxalic acid solution at a temperature of 50° to 60°C an average of 0.0001 inch was removed from the cylindrical diameter. Reference: Apollo Reliability Report, No. 71.

5.6.4 Reliability Training Program for Personnel Certification

The number of personnel certified and recertified as required during 1967, is listed as follows:

Category	Number
Welding	10
Crimping and Soldering	21
Potting	13
Plating	2
Zyglo	2
Heat Treatings	5
Clean Room Proc.	11
Total	68

5.6.5 Extended Performance Testing Program

TEST LOTS COMPLETED. In 1967, 39 test lots were completed, bringing the total completed to date to 185.

5.6.6 Qualification Test Program

5.6.6.1 Command Module

PLANNING

General. All testing was completed. Submission of the final report on the 1012157 Resolver completed the program.

STATUS

Testing. As indicated in Table 5-11, all parts have completed qualification.

MILESTONE" ACCOMPLISHED. Qualification Testing was completed on all Command Module parts, subassemblies and assemblies.

5.6.6.2 LM

PLANNING

General. Failure analysis was performed on the AOT counter and corrosion problem.

STATUS

Documentation. Table 5-12 indicates current status of Plans, Procedures, and Test Reports.

Testing. Complete - See Table 5-13.

MILESTONES. All LM Qualification Testing was completed. Final reports were submitted.

5.6.7 Design Change Activity

OUA

Table 5-14 shows OUA Design problems, their resolution (Class I or II) and the retrofit effectivity.

AOT

Table 5-15 shows AOT Design problem resolutions (Class I or II) and the retrofit effectivity.

5.6.8 Failure Reports

A summary of reports processed during the reporting period of 1967 is listed as follows:

Table 5-11

APOLLO PARTS QUALIFICATION STATUS

Drawing No.	Part Type	T.P. and Q.S.S. No. Tr.	Test Plan Approval	Qualification Test Start	Qualification Test Complete	Final Report	Remarks
1010341	Resolver	096-1	X	X	X	X	Complete-Not Qualified
1011281	Differential	003-1	X	X	X	X	Complete-Qualified
1011294	Resolver Ass'y	004-1	X	X	X	X	Complete-Qualified
1011374	Projection Lens	008-1	X	X	X	X	Complete-Qualified
1011499	Connector	012-1	X	X	X	X	Complete-Qualified
1011501	Connector	013-1	X	X	X	X	Complete-Qualified
1011748-1,2	Connector	026-1	X	X	X	X	Complete-Qualified
1012041	Ceramic Capacitor	130-1	X	X	X	X	Complete-Qualified
1012042	Diode Silicon	136-1	X	X	X	X	Complete-Not Qualified
1012048	Transistor Si PNP	150-1	X	X	X	X	Complete-Qualified
1012052	Transformer Audio	145-1	X	X	X	X	Complete-Not Qualified
1012056-1,-11	Diode Zener	137-2	X	X	X	X	Complete-Not Qualified
1012065	Resolver Ass'y	138-1	X	X	X	X	Clifton-Qualified
1012065	Resolver Ass'y	138-2	X	X	X	X	Reeves-Qualified
1012142	Capacitor Ceramic	131-1	X	X	X	X	Complete-Not Qualified
1012142	Capacitor Tantalum	132-1	X	X	X	X	Complete-Not Qualified
1012148	Power Transformer	149-1	X	X	X	X	Complete-Qualified
1012149	Power Transformer	159-1	X	X	X	X	Complete-Qualified
1012157	Resolver	143-1	X	X	X	C47	Clifton
1012502	Capacitor Wet Slug Tantalum	156-1	X	X	X	X	Complete-Qualified

Table 5-11 (Cont'd.)

APOLLO PARTS QUALIFICATION STATUS (cont'd)

Drawing No.	Part Type	T.P. and Q.S.S No. Tr.	Test Plan Approval	Qualification Test Start	Complete	Final Report	Remarks
1012512	Counter Rotating	165-1	X	X	X	X	Complete-Qualified
1012519	Flex Print	170-1	X	X	X	X	Sanders-Complete Qualified
1012522	Flex Print (Cable)	169-1	X	X	X	X	Complete-Qualified
2007024	Head Elec. Ass'y (Tracker)	601	X	X	X	X	Complete-Not Qualified
2007032	HV Power Supply Ass'y (Tracker)	602	X	X	X	X	Complete- Not Qualified
2007022	Tuning Fork Ass'y	603	X	X	X	X	Complete-Qualified
		APOLLO SUBSYSTEM QUALIFICATION STATUS					
2011000	Subsystem		X	X	X	X	Complete-Qualified
1021255	Eyepiece Storage Compartment with Eyepieces		X	X	X	X	Complete-Not Qualified

Table 5-12

LM DOCUMENTATION STATUS

	Plans	Procedures	Report
Total Required	1	9	1
Number submitted this report period	0	0	1
Total submitted	1	9	1

Table 5-13

LM SUBSYSTEM QUALIFICATION STATUS

	Test Plan	Qualification Test		Final	
Drawing No.	Approval	Start	Complete	Report	Remarks
6011000	X	X	X	X	

Table 5-14

OUA DESIGN PROBLEM STATUS

PROBLEM	PERFORMANCE	RELIABILITY	RESOLUTION	RETROFIT	OUA-TDRR IN-LINE EFFECTIVITY	CLASS	EFFECTIVE AGE
TDA Shift with Vibration	X		Incorporation of stiffer wave washers and controlled load.	Authorized	None	2	207, 209 and up
Motor-Tach Reliability		X	New -4 motor config. (bearing lube increase)	Authorized	206	1	202, 203, 204, 205, 206 208 and up.
Manual Adjust Knob Failure		X	Incorporated lead-in chamfer, shorter spring and spacer	Authorized	206	1	201, 202, 1-201, 203 and up.
Image Spring Back	X		G and N System Control Change	N/A	N/A	N/A	N/A
SDA Shift with Vibration	X		Installation of be wedges	Authorized	206	1	201A, 202 and up
Eyepiece Vacuum Shim	X		Color coding and position ambiguity	Recommended	Pending	1	–
Be Corrosion		X	Developed be possivation process	As Required	N/A	N/A	As Required
Trunnion Hesitation	X		Incorporation of new trunnion spring assembly	Authorized	206 and up	1	201A, 202 203, 204, 205, 206 208 and up
Resolver Test Modification to include loading	X	N/A	16 x and 64 x zero's checked with load box in test circuit		213 and up	–	–
SXT TDA "O" problem at AC	X		AC Functional Tester presumed to be mal-functioning.	N/A	N/A	N/A	N/A
OUA Perpendicularity Problem	X		Replace eyepiece and lamp with diffused light source for 1 test.	N/A	N/A	N/A	N/A
SXT Limit Stops		X	No problem exists-stops are adequate	N/A	N/A	N/A	N/A
SCT Gear Wear		X		N/A	N/A	N/A	N/A

Table 5-14 (Cont'd.)

PROBLEM	PERFORMANCE	RELIABILITY	RESOLUTION	RETROFIT	OUA-TDRR IN-LINE EFFECTIVITY	CLASS	EFFECTIVE AGE
Eyepiece Redesign and Strain Relief		X	Design study request rejected. No corrective action instituted.	N/A	N/A	N/A	N/A
Non Metallic Mat'l Study		X	New "Viton" insulation blankets for eyepieces in work.	Recommended	N/A	1	ALL

Table 5-15

AOT DESIGN PROBLEM STATUS

Problem	Perf.	Rel.	Resolution	AOT Retrofit	AOT TDRR In-line Eff.	Cl.	Eff. AOT
1. Moisture in winter		X	Hermetic Seal	606-611	612	1	612
2. Poor counter illumination	X		Provide illum.	606-611	612	1	612
3. Loose reticle control knob		X	Incorp. drag in knob	606-611	612	1	612
4. Reticle imperfections visible		X	Change bulbs in reticle lamp ass'y; clear to red	606-611	612	1	612
5. Light leaking thru eyeguard	X		Provide an eyeguard plug	606-611	612	1	612
6. AOT contamination		X	Provide Protector or "boot"	606-609	612	1	611
7. Mech. & Optical axis misaligned	X		Provide objtv. lens centration	606-609	611	2	610
8. Pressure seal flammable		X	Provide flame guards-two versions:				
			a. Heavy weight guards	611	612	1	612
			b. Light weight guards		613	1	610 *
9. Thermal blankets flammable		X	Provide thermostat & reticle lamp ass'ys flame guards	606-612	613	1	613
10. Study light impairs star sightings	X		Provide a sunshade	606-615 **	616 **	1	

* 1st production light weight flame guard delivered in time for AOT 610 retrofit installation in spacecraft.

** Proposed cut-ins.

Figure 5-29 OUA Failure Summary

Figure 5-30 LM Failure Summary

5.6.9 Reliability Report Analyses (ARR-64 thru ARR-78)

a. Lubrication of Flexprints

Reliability report ARR-64 described an investigation of the feasibility of lubricating flexprints. Spring back of the Sextant shaft had been noted during open servo loop operation. Friction of the flexprints against the wraparound cavity was considered as a possible cause. As oils and greases would evaporate under low pressure conditions, a laminar solid, such as molybdenum sulphide was considered. The coefficient of friction of this lubricant proved to be similar to the flexprint itself. The addition of a lubricant to the flexprint did not appear to offer a solution to the spring back phenomenon.

b. Effect of 40% Nitric Acid Solution on Anodized Beryllium

Reliability report ARR-65 described an investigation in regard to loss of adhesion in areas of the telescope panel. It was discovered that the panel had been cleaned with a solution of 40% nitric acid, which contaminated areas of the beryllium surface. Nitric acid should not be used to clean beryllium before anodizing.

c. Contamination of Cover and Baffle Assemblies P/N 2012547, 2D12675

Reliability report ARR-66 described the investigation of black particles discovered on the cover and baffles assemblies after vibration testing. It was found that the particles were Black Velvet paint, from the interior painted surfaces of these assemblies. It was recommended that these surfaces should b black anodized in lieu of painted.

d. Eyepiece Thermal Insulators

Reliability report ARR-67 described the investigation of four polyurethane foam and one polyurathane potting compound, suitable for molding. The material was to be used as thermal insulation for the eyepiece. The most promising material was found to be Isofoam L-131.

e. Effect of 10% Oxalic Acid Solution on Spraylat SC-1071 Protective Coating

Reliability report ARR-68 described investigation of the use of a 10% oxalic acid solution for the removal of corrosion from beryllium surfaces. This exposure adversely affect certain areas such as inserts and critically machined surfaces. Spraylat SC-1071 proved to be an effective means for masking these critical areas.

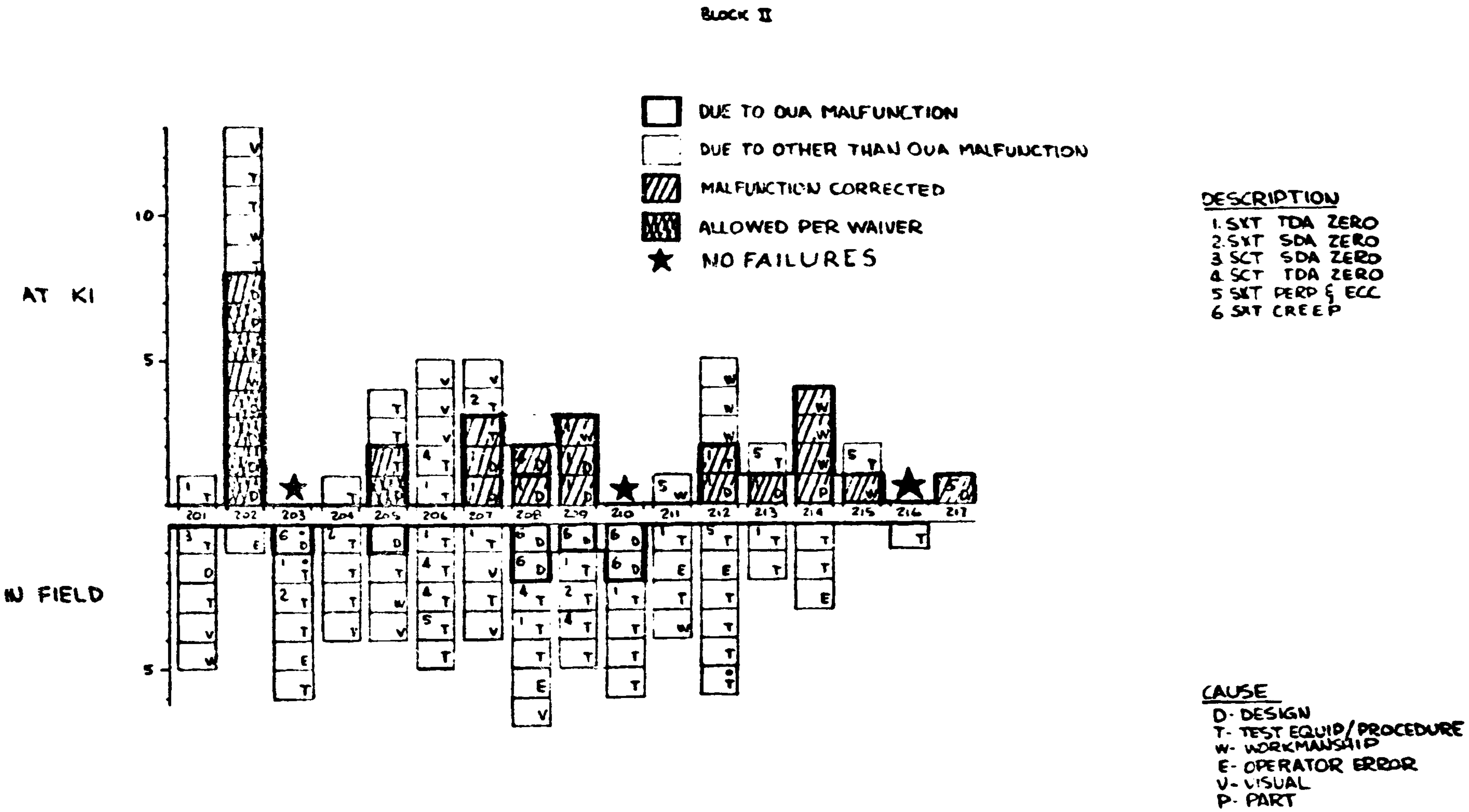


Figure 5-29 OUA Failure Summary

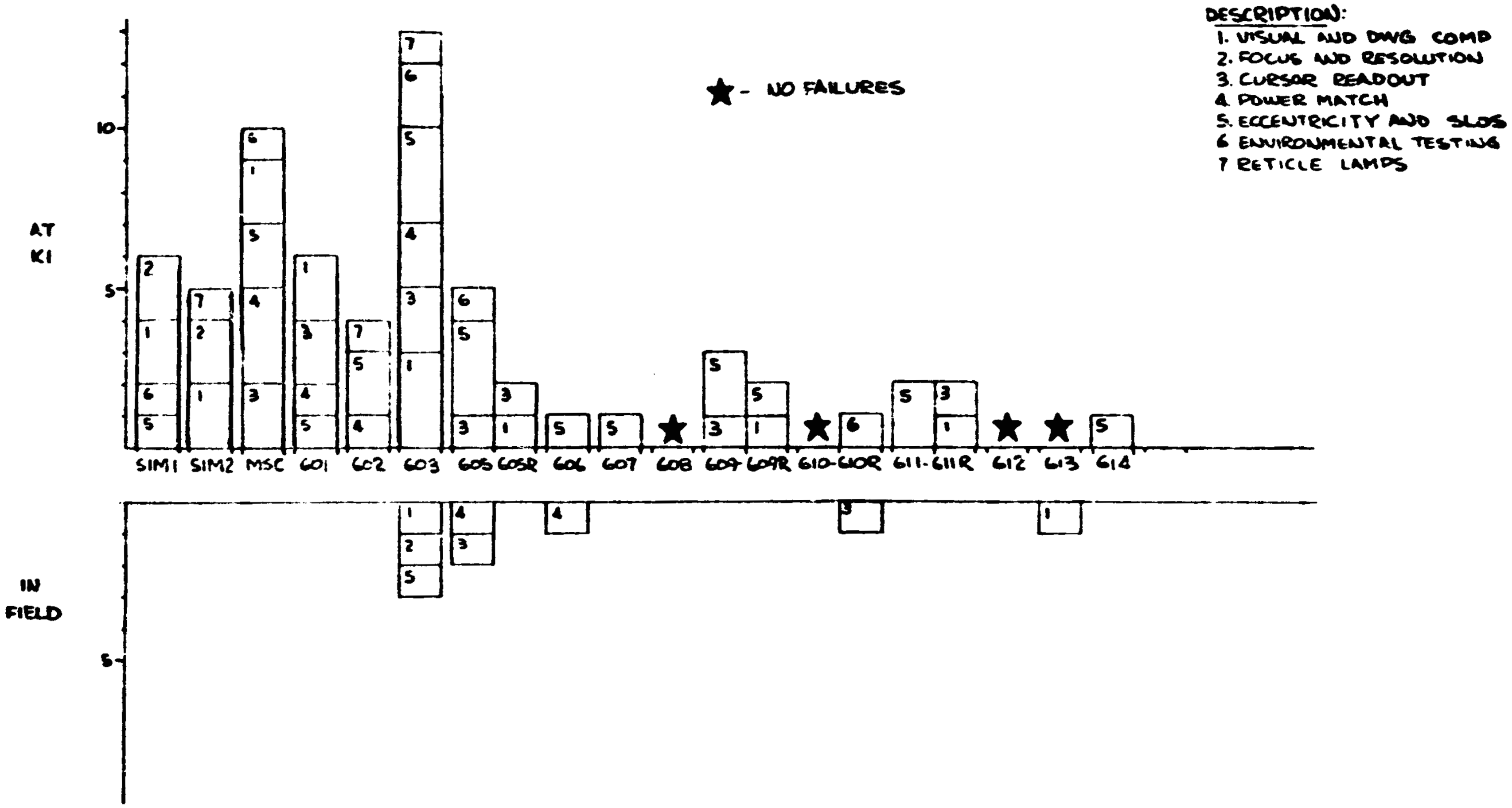


Figure 5-30. LM Failure Summary

f. Lot Evaluation of Electrical Wire, TFE Insulated

Reliability Report ARR-69 described acceptance testing of samples from various lots of electrical wire in accordance with MIL-W-22759.

g. Compatability of 2.1% Ridolene Solution with Gray Velvet Paint

Reliability report ARR-70 described an investigation on the effect of Ridolene solution on parts coated with Gray Velvet. It was found that Ridolene degraded Gray Velvet paint.

h. Effect of 10% Oxalic Acid Solution on the Dimensions of Beryllium Parts

Reliability report ARR-71 described an investigation of the effect of 10% oxalic acid solution, used to remove corrosion, on the dimensions of beryllium parts. It was found that the immersion of a beryllium part for one hour in oxalic acid at a temperature of 50° to 60°C removed an average of 0.0001 inch from a cylindrical diameter.

i. Effects of KI Beryllium Corrosion Pre-treat Solution on the Dimensions of Beryllium Parts

Reliability report ARR-72 described an investigation to determine the effect of KI Beryllium corrosion Pre-treat solution on beryllium parts. This solution is an effective method for removing corrosion from beryllium. It was found that use of the solution resulted in a dimensional loss in beryllium parts.

j. Use of Spraylat SC-1071 as a Masking Agent for Protection of Critical Beryllium Surfaces against Passivation Treatments

Reliability report ARR-73 described an investigation of the effeccivity of Spraylat SC-1071 as a masking agent during passivation. It was found that Spraylat was an effective protective coating against solutions used in passivation treatment at room temperatures.

k. Effect of Berylcoat "D" Passivation Solution on Critical Beryllium Surface Dimensions

Reliability report ARR-74 described tests performed to determine the effect of Berylcoat "D" passivation solution on the dimensions of beryllium parts. It was found that Berylcoat "D" had little or no effect upon critical dimensions when exposed for 30 minutes at room temperature. For 60 minute and 90 minute immersions, the change in dimensions was not critical.

l. Effectivity of Teflon Wire Adhesion to RTV Potting Compounds

Reliability report ARR-75 described an evaluation of the use of RTV potting compounds with teflon wire. Samples of pre-etched wire, wire etched in accordance with ND1002146A, and non-etched wire were prepared and inserted in RTV881 silicon rubber as prescribed. It was found that the pre-etched wire provided the most reliable bonding surface.

NOTE: Reliability Report ARR-76 was not issued.

m. Displacement of Relay Lens Assembly P/N 6011847 (LM)

Reliability report ARR-77 described an investigation to determine the cause of the displacement of the installed relay lens assembly in LM 611. The relay lens assembly had tilted inside of the inner tube P/N 6011804. The assembly is aligned and held in position by means of set screws until it is installed in the inner tube, when epoxy is applied through the six set screw holes. It was felt that epoxy did not supply the support required to hold the assembly in position and that set screws should be used.

n. Hermetically Sealable TFE-FEP Shrink Sleeving

Reliability report ARR-78 described an evaluation of Penntube WTF shrinkable (Teflon) sleeving as a replacement for Kynar shrinkable sleeving. Penntube appeared to be less flammable than Kynar. It was found that Penntube was satisfactory for metal butt type solders, solderless connections or by high temperature solder operation. The limiting factor was the use of low temperature solders which melt and flow during the shrinking operation.

5.7 SUMMARY OF YEARS 1968 - 1969

5.7.1 Introduction

The SXT trunnion failure first reported in January 1968 on AGE 209 and again in June of 1968 on AGE 217 was resolved finally when a redesign of the gearbox was made.

Eyepiece flammability protective covers were designed and fabricated. Corrosion and vibration problems were resolved by redesign.

The AOT sunshade and Radar Shield passed all functional, environmental and qualification testing.

The reliability section of Quality Assurance department continued their efforts on the parts and materials evaluation program.

5.7.2 Major Reliability Problems

5.7.2.1 AGE 220 - OUA Over-vibration

On July 8, 1968, while proceeding through normal sell-off tests, OUA AGE 220 was inadvertently exposed to a random vibration level three times (Figures 5-31 and 5-32) greater than nominal. An extensive evaluation covering visual examination, stress analysis and functional performances was conducted and finalized. (See Tables 5-16, 5-17; Figures 5-33, 5-34, and 5-35)

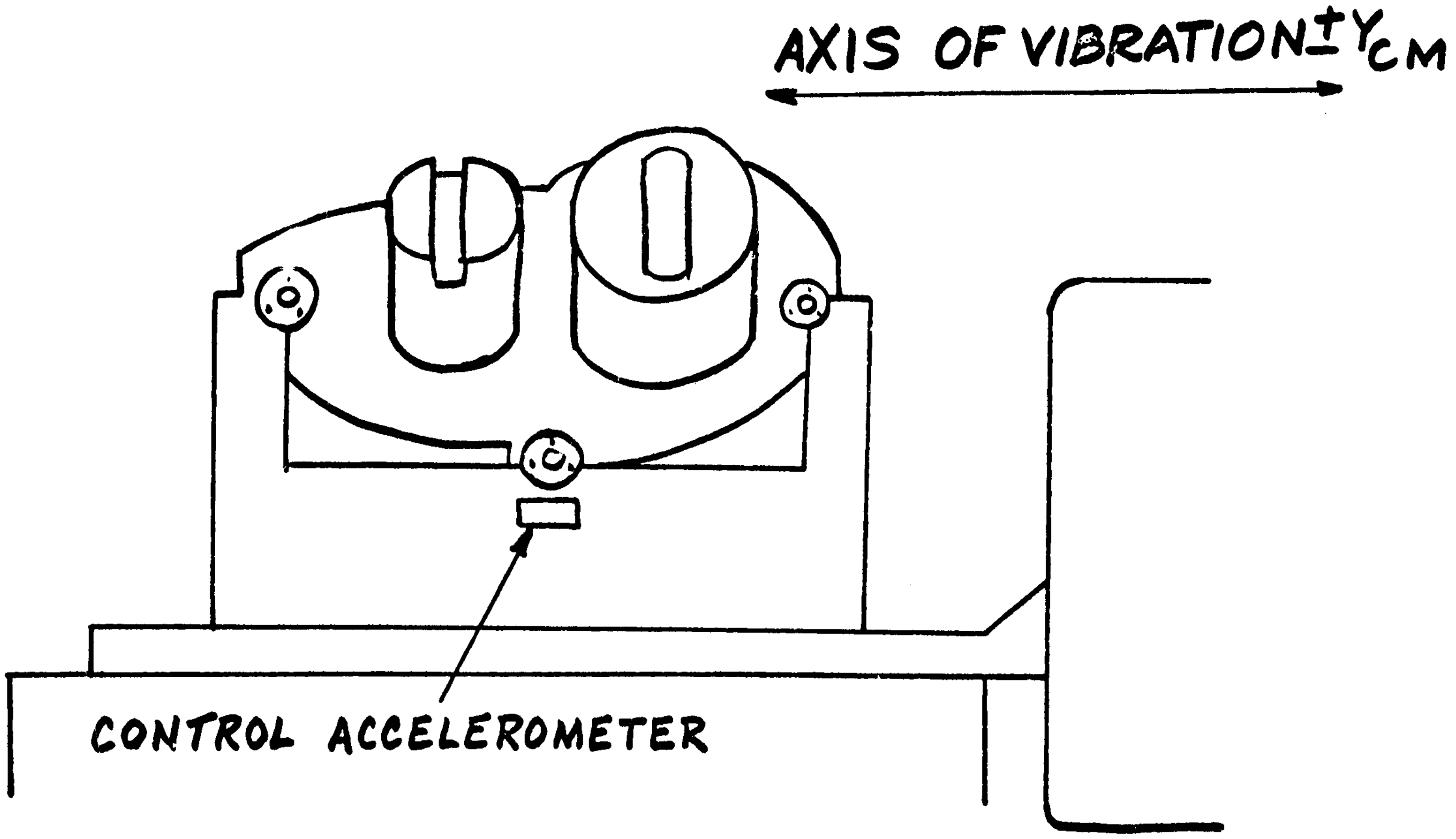
Results of evaluation presented to ACED and NASA personnel at the July 24, 1968 meeting at Kollsman. These failures were detected thru physical examination and functional testing.

- Two spring spacers in SCT field of view
- Both SCT manual drives binding
- SXT TDA 64X Zero error measures 25.2 seconds. Maximum allowable 5.0 seconds.

Various approaches to disposition AGE 220 were considered and reviewed by ACED, NASA, and MIT while the unit was held at Kollsman.

Disposition agreed upon by all parties was to perform a confidence vibration functional test and correlate functional data, after necessary corrective action was completed, to pre-vibration data.

OUA AND CONTROL ACCELEROMETER MOUNTING



ACCELEROMETER S/N 407 ORIGINAL CAL	9.15 MV/g
ACCELEROMETER S/N 407 RECAL	2.85 MV/g

MAXIMUM PROBABLE EXPOSURE	16-17 grms
WORKMANSHIP EXPOSURE	5.3 grms

Figure 5-31. Overstress Condition

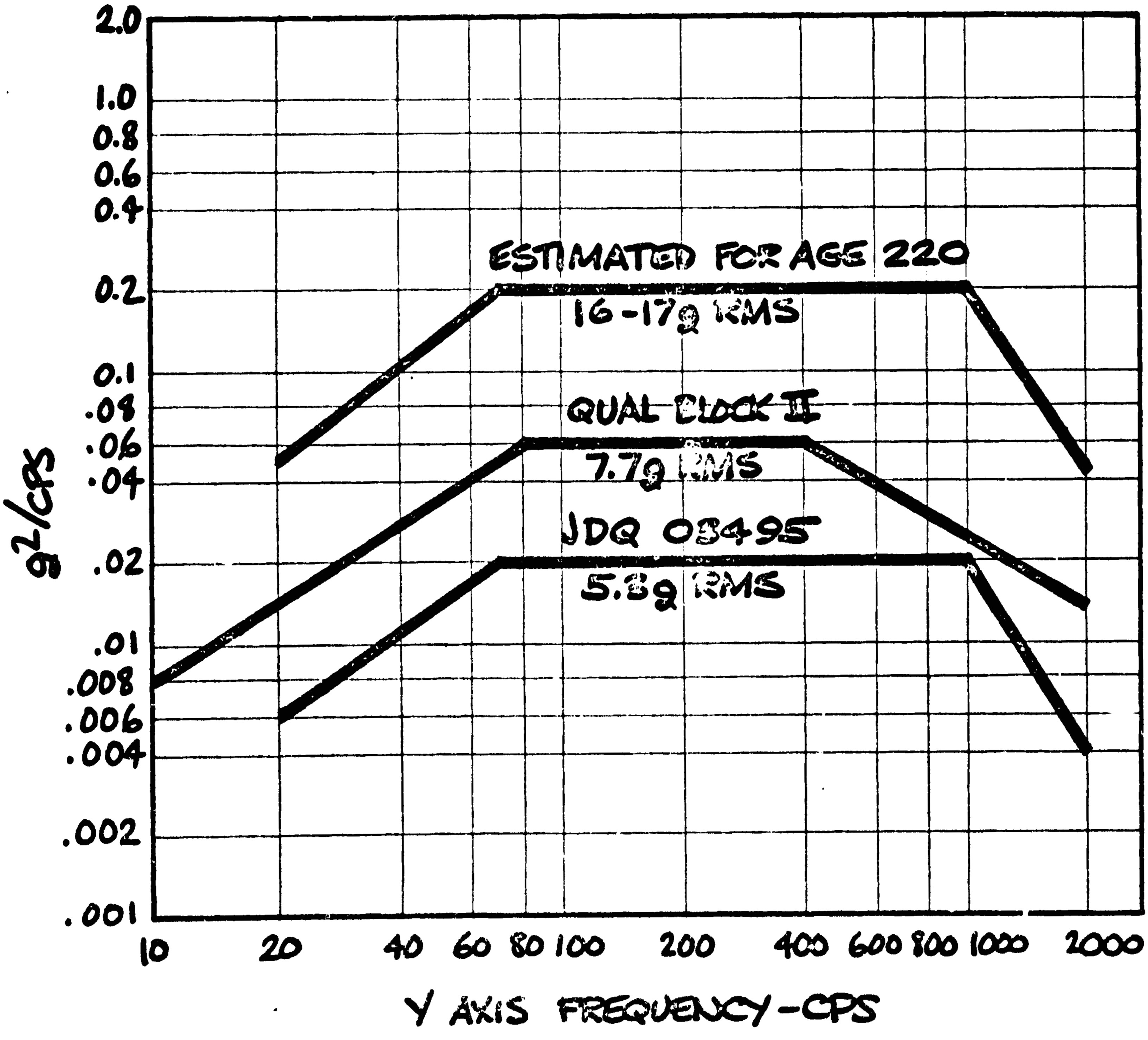


Figure 5-32. Power Spectral Density, Comparison of Levels

Table 5-16

PHYSICAL INVESTIGATION

The following major and subassemblies were visually checked for physical condition:

SCT SIDE: OPTICS

2011153	Prism Assy.
2011724	Pechan Prism Assy.
2011792	Relay Lens Assy.
2011722	Objective Lens & Reticle Assy.
2011732	Relay Lens Assy.
2011784	SCT Panel Window

SXT SIDE: OPTICS

2012735	SXT Index Head Mirrors and Beamsplitter (mirrors were removed and mount surfaces checked for damage)
2011704	SXT Shaft Objective Lens
2011426	Retical Assy.

Table 5-16

PHYSICAL INVESTIGATION (Cont.)

<u>SCT SIDE</u>: MECHANICS

2011215	Trunnion Drive Assy
2011723	Cluster Gear Assy.
2011703	SCT TDA Gearbox
2011702	SCT SDA Gearbox

<u>SXT SIDE</u>: MECHANICS

2011705	Gearbox
2012712	Trunnion Assy.
2012387	Gear and Spring Assy.
2011906	Hsg. and Stator Assy.

Both the SXT and SCT cavities were checked for damage or loose hardware. No damage or loose parts were found.

<u>RESULTS</u>: OPTICS-

No visible evidence of glass fracture were found

MECHANICAL ASSEMBLIES -

Gears, Shafts, Bearings, and Hardware showed no damage.

Table 5-17

STRESS ANALYSIS

ELEMENT	SUMMARY
SCT Shaft	f_n = 4961 Hz > 2000 Hz of exposure max dynamic stress 100 psi
SXT Shaft	f_n = 2316 Hz > 2000 Hz of exposure max dynamic stress 2294 psi allowable yield stress in Be ≈ 30,000 psi
SXT obj. and intermediate lens hsg.(2011796)	f_n > 6000 Hz > 2000 Hz of exposure max dynamic stress 21 psi
SXT Bearings (1012506-2)	at head end-max loading radial load 360 lb < 2191 lb rated radial capac.
SCT Bearings (1011606-2)	radial load 181 lb < 2416 lb rated radial capac.
(1011606-1)	radial load 131 lb < 1933 lb rated radial capac.

Table 5-17

STRESS ANALYSIS (Cont.)

ELEMENT	SUMMARY
Worm Shaft	f_n = 270 Hz Max stress 8150 psi yield strength (8620 steel) 65,000 psi
SCT Relay Lens Assy (2011792)	Typical elements 2011175,172 compressive stress ≈ 500 psi << 50,000 rated compressive stress
SCT Objective Lens Assy	Typical element 2011708 compressive stress ≈ 650 psi << 50,0C0 rated compressive stress

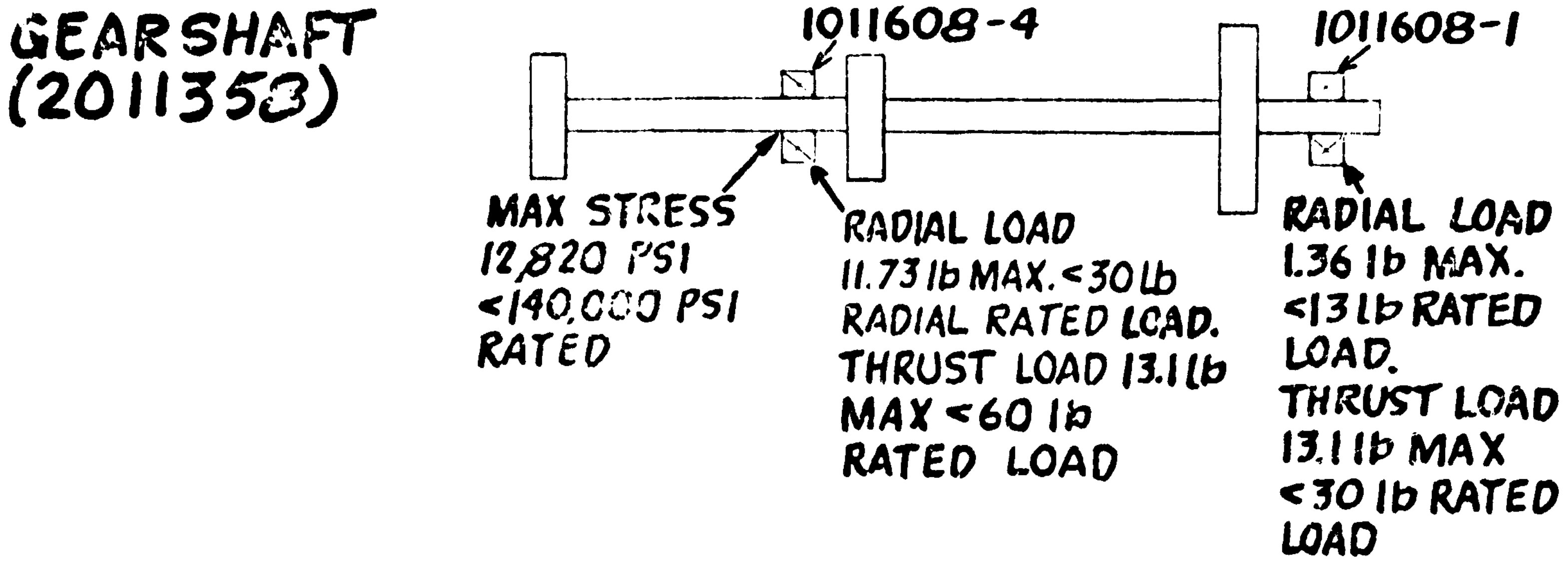


Figure 5-33. "High Mass" Gearshaft

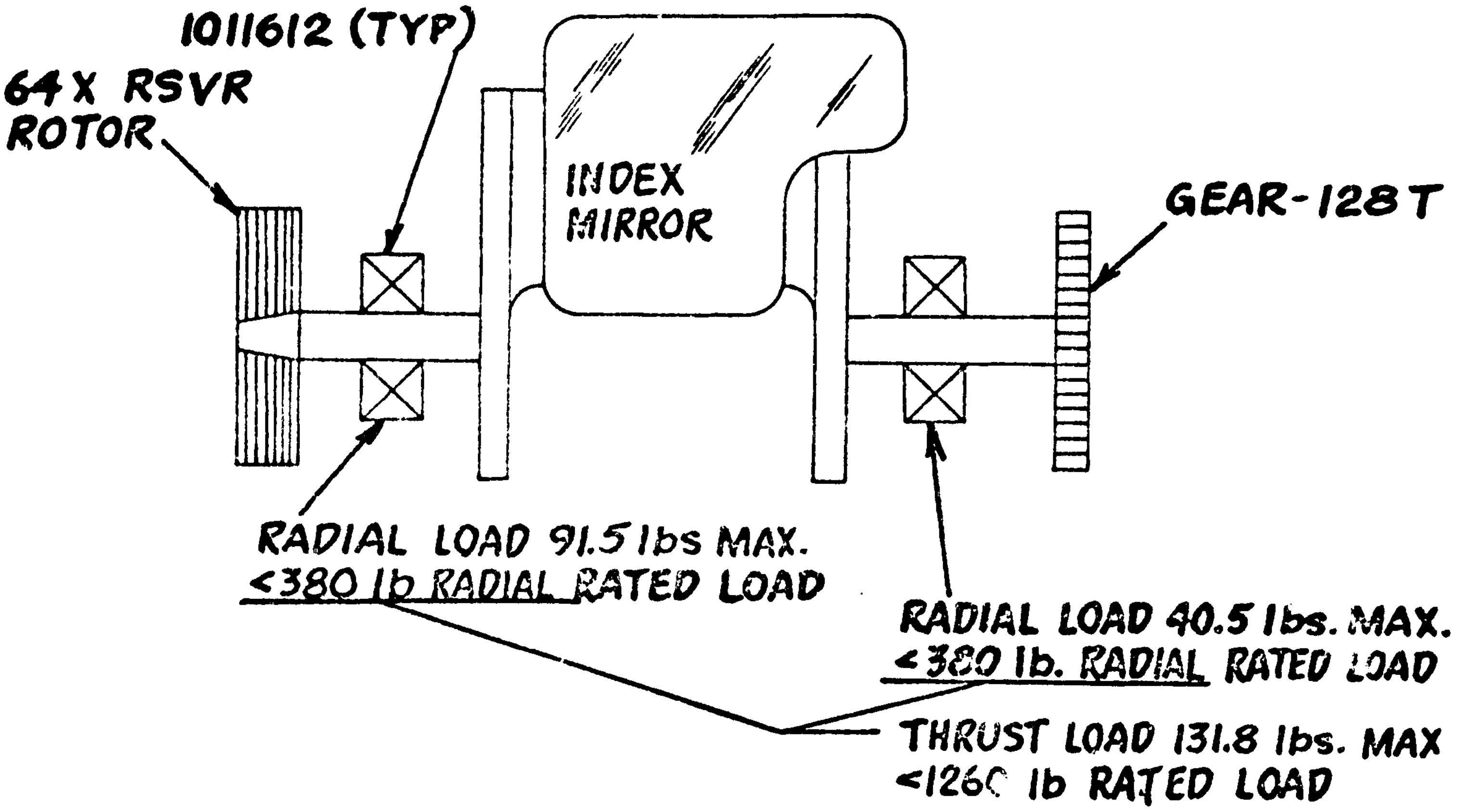


Figure 5-34. Sextant Trunnion

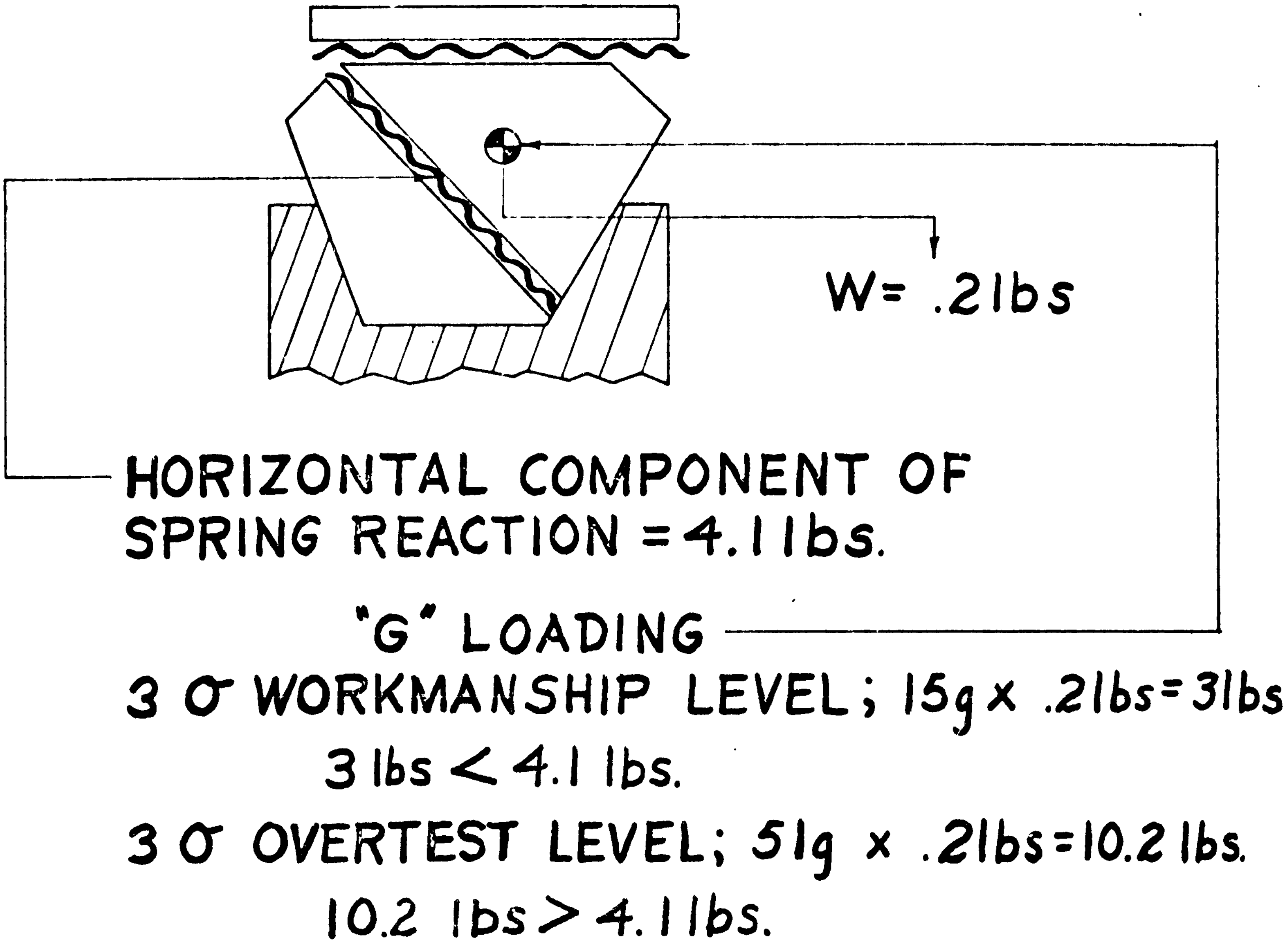


Figure 5-35. Pechan Prism

The SCT inner tube was disassembled, Pechan prism assembly removed, visually examined and spring spacers replaced. The manual drives were reworked to maximum tolerance and relubricated. (This is a chronic problem, not associated with over-vibration.) The SXT head was removed, index mirror and both 45° mirrors removed. Evidence of fretting of mirror mounting pads observed. Pads were cleaned and wave washers were replaced.

All SXT and SCT functional and physical defects after repair, were acceptable and correlated to pre-vibration data before over-vibration.

Final disposition was made to continue and complete FTM. All results were within parameter. Conclusion drawn was that after necessary repairs were made, there were no degradation of optical alignments, resolution, motors, resolvers, counters, gears, bearings and trim modules. AGE 220 was yellow dotted per AC directive and put into non-flying category.

5.7.2.2 OUA AGE 2-6 SCT Shaft Unbalance

In May, 1968, AGE 206 exhibited uncontrolled SCT shaft rate variations during G & N System testing at ACED.

Kollsman personnel visited AC to observe testing of AGE 206. While an internal inspection of SCT revealed no part or workmanship defects, a relationship between OUA orientation and rate deviations was detected. The problem was identified as being the pendulous effect of the shaft unbalance due to the ablative cover. This was affirmed by retesting with Kollsman's aluminum cover containing counterweights, which resulted in the disappearance of the rate variation reported.

Thus, it was recommended that AC decide to evaluate impact of imbalance on System performance and pending results would direct further innovation if required.

5.7.2.3 AGE 204 - SXT Trunnion Failure

A trunnion gear train failure was reported in January of 1968, Kollsman studied the problem and presented an analysis to AC. It was found that the bearing and gear between limit stays and mirror were extensively damaged. The mating corners of the floating dogs were worn in the zero optics direction; the mirror had struck the ablative cover. The redesign of the dogs included reducing the end play and tilt, increasing the surface contact between dogs, and squaring off the corners of the dogs. The spring rate was increased to absorb motor and gear train energy. The ablative cover was machined to assure mirror clearance.

A further problem developed in June of 1968, when the dog limit stop pin in AGE 217 became loose. A redesign of the gear box cover eliminated the potential stop pin problem.

Additional problems, SCT shaft with ablative cover proved to be unbalanced and trunnion instability occurred when slight pressure was applied to the split gear, were to be evaluated at the end of the reporting period.

5.7.2.4 Flammability Protection of OUA Eyepieces

Kollsman was directed to design and fabricate metallic covers for the eyepieces. The new design included a potted adapter and cable to protect the power supply by fusing and to provide strain relief between connector and eyepiece. To solve the vibration proofing problem, Kollsman recommended a wave washer. To solve the problem of corrosion on the plunger (which prevented operation of the quick disconnect), Kollsman recommended fluorinated grease.

Because the torque lead of the eyepiece window cover proved to be high, a stainless steel spray, slightly stiffer than the beryllium-copper spray, was used. Shims were added to standardize the spring loading. The vibration problem was resolved by the addition of two flat washers and a lock washer.

5.7.2.5 AOT Sunshade and Radar Shield

The conical sunshade and radar assembly is a modification to the Alignment Optical Telescope (AOT). The prime purpose of the sunshade is to prevent stray light or light reflected from the lunar module radar gyro from striking the AOT prism. Results of tests conclusively indicated that the sunshade was qualified for space flight. Stresses and strain imposed by the test environment were withstood and structural and dimensional integrity remained intact. Functional check, performed on the AOT, showed that the sunshades did not adversely affect AOT operation.

5.7.2.6 Variable Deviation Wedge

It was discovered that the variable deviation wedges were not specified as to deviate in any particular direction. Kollsman recommended that as the wedges were acceptable as specified, that a decal should be added to show the direction of deviation of each wedge.

5.7.3 Parts and Materials Program

5.7.3.1 Eyepiece Non-metallic Materials

Substitute non-metallic materials and adhesives were selected for eyepiece insulation for use within the cabin environment. SCD's were prepared. Post cure procedures were developed to assure conformance to the test requirements of MSC-A-D-3. Present configurations were evaluated in thermal vacuum. Fire drill samples were prepared for NASA evaluation and Class "A" units were fabricated. Further effort was dependent on results of tests.

NASA reconsidered its position relative to classification of eyepiece insulators in terms of Category B based on results of Fire Drill Test. Effort on the non-metallic material evaluation had been terminated.

5.7.3.2 AGE 203 Be Corrosion

During R&I of OUA AGE 203 corrosion was noted in the SCT and SXT internal cavities. A passivation treatment was developed after analysis and detail tests which would help retard this corrosive process.

5.7.3.3 Hand Held Sextant Non-Metallic Materials

Non-metallic materials used in fabrication of Hand Held Sextant were reviewed to determine sample size and configuration for NASA evaluation to parameters of MSC-A-D-66-3. A report was prepared, including a cost estimate, and submitted to NASA.

5.7.3.4 Stains on P/N 6011105 Gears

The stains on the blackened surface of the P/N 6011105 have been determined to be principally not corrosion. Since the defect is cosmetic, not affecting function, a recommendation was made to release to manufacturing.

5.7.3.5 AGE 205 Internal Corrosion

Investigation completed relative to excessive corrosion on interior of OUA AGE 205. Samples were collected for tests and analysis. X-ray diffraction identified products as beryllium oxide. Be passivation treatment was recommended.

5.7.3.6 Radial/End Play

Radial/End Play fixture identical to Solvere in-line fixture purchased by SK to standardize "in-house" inspection procedures to that of vendor. Fixture was certified by SK Metrology Laboratory.

5.7.3.7 EC-2216 Adhesive Application

Investigation was completed to develop a reliable procedure for the application of EC-2216 adhesive on the P/N 6011809 assembly. Report was issued.

5.7.3.8 AGE 209 Trunnion Limit Stop Failure

An investigation initiated to determine failure mode of limit stop OUA AGE 209 was closed after redesign of gear box necessitated by identical failure occurence in AGE 217, June 1968, was approved and implemented.

5.7.4 Reliability Failure Action Summary

- AFR 9615, AC 1/29/68 SCT TDA Manual Drive. Failure analysis completed. Report was issued.
- AFR 20177, AC 1/14/68 SXT Trunnion Gear Train Failure: Failure analysis determined cause of out of mesh condition between SXT Trunnion Mirror and 2011706 Trunnion Gear Train. Report completed and issued.
- Particle removed from duplex bearing LM-AOT-606 identified as ECCO-Bond 55. Report was completed.
- The particles removed from LM-AOT-609 have been identified by emission spectroscopy. The material is a paint which originated from a source external to the unit. Report was made.
- FR 2018D, AC 1/17/68. Failure analysis completed on SXT Purge Valve. Reported completed.
- The liquid contaminant removed from the outer flange of the worm and gear housing of LM-AOT-607 was identified by infrared analysis as a silicone fluid. Report completed.

5.7.5 Extended Performance Testing Program

EPT:

Test Lots	Tests
In Process	3
Pending	0
Completed this Period	0
Total Completed to Date	185

5.7.6 Design Activity

OUA

OUA Design Problems are listed in Table 5-18, with their resolution and retrofit effectivity.

AOT

AOT Design Problems are listed in Table 5-19, with their resolution and retrofit effectivity.

5.7.7 Failure Report Summary

OUA

Figure 5-36 illustrates the number of failure reports assigned to the optical unit by AGE designation. The failure reports are further classified as to description, cause and disposition.

AOT

Figure 5-37 illustrates the number of failure reports assigned to the AOT by AGE designation. The failure reports are broken down further according to description.

5.7.8 Reliability Report Analysis (ARR-79)

DISPLACEMENT OF OBJECTIVE LENS P/N 6011809 (LM) - Reliability report ARR-79 described an investigation of an apparent displacement of the objective lens in LM 614. It was found that the technique for the application of spray adhesion was adequate, but could be improved. A hypersonic syringe was used to inject a measured amount of adhesive between lens and housing.

5.7.9 Reliability Effort on Rangefinder

A highlight of Reliability effort in early 1969 was the qualification testing of the Rangefinder. These tests, conducted on an around the clock basis, provided the corrective actions that were immediately accomplished on the first flight unit.

RANGEFINDER QUALIFICATION SUMMARY

Environmental qualification testing of an Apollo Rangefinder (ARF), Kollsman P/N 2013250, S/N 002, was initiated on 24 January 1969 and completed on 13 February 1969.

The tests were performed to demonstrate the ability of the ARF to function within required tolerances before, during, and after exposure to the environmental design limit.

Table 5-18

OUA DESIGN PROBLEM STATUS

PROBLEM	NATURE	STATUS	RESOLUTION	OUA RETROFIT	OUA-TDRR IN-LINE EFFECTIVITY	CLASS
SXT TDA Shift with vibration	Performance	Resolved	Incorporate stiffer wave washers and higher screw torqer.	Authorized	207, 209 and up	II
Motor-Tach Failure	Reliability	Resolved	New: -4 Motor configuration (bearing lube increase)	Authorized	206, 209 and up	I
Manual Adjust Knob Lock-up	Reliability	Class II Changes Implemented	Provide lead-in chamfer, shorter spring and spacer. .	Authorized	206	II
			Modify with stainless steel sleeve insert.	As Required	219	II
Image Spring Back	Performance	Resolved	G and N System Control Change	N/A	N/A	N/A
SXT SDA Shift with Vibration	Performance	Resolved	Installation of beryllium wedges	Authorized	206	I
Eyepiece Vacuum Shim, Installation Ambiguity	Performance	Resolved	Designed, Redesignated as GSE.	N/A	N/A	N/A
Beryllium Corrosion	Reliability	Resolved	Developed beryllium passivation process.	As Required	216	N/A
Trunnion Hesitation	Performance	Resolved	Incorporation of new trunnion spring.	Authorized	206	I
Resolver Test Modification to include loading	Performance	Resolved	16X and 64X zero's checked with load box in test circuit.	N/A	213	II
SCT Gear Wear	Performance	Resolved	Improve gear meshing techniques	As Required	N/A	N/A
Heating Cable Strain Relief	Performance	Resolved	Eyepiece redesigned.	Authorized	N/A	I
SXT Limit Stop Override	Performance	Resolved	Redesigned to insure disengagement	Authorized	218 and up	I
Jamming of EP Quick Disconnect	Performance	Resolved	Application of grease to plunger suggested.	N/A	N/A	II
ESU EP Mounting	Reliability	Resolved	Addition of lock washer to thumb screw suggested	N/A	N/A	I
SXT Limit Stop Pin	Reliability	Resolved	Redesign of Gear Box Cover	Recommended	Pending	II

Table 5-19

AOT DESIGN PROBLEM STATUS

	PROBLEM	NATURE	STATUS	RESOLUTION	AOT RETROFIT	AOT-TDRR IN-LINE EFFECTIVITY	CLASS
1.	Moisture in counter.	Reliability	Resolved	Hermetic Seal.	606-611	612	1
2.	Poor counter illumination.	Performance	Resolved	Provide illumination	606-611	612	1
3.	Loose reticle control knob.	Reliability	Resolved	Incorporate drag in knob.	606-611	612	1
4.	Reticle imperfections visible.	Reliability	Resolved	Change bulbs in reticle lamp assembly; clear to red.	606-611	612	1
5.	Light leaking through eyeguard.	Performance	Resolved	Provide an eyeguard plug.	606-611	612	1
6.	AOT contamination.	Reliability	Resolved	Provide Protector or "boot"	606-609	610, 611	1
7.	Mech. and Optical Axis misaligned.	Performance	Resolved	Provide objective lens centration.	606-609	610, 611	2
8.	Pressure seal flammable.	Reliability	Resolved	Provide flame guards, two versions: a. Heavyweight guards b. Lightweight guards	610, 611*	612	1
9.	Thermal blankets flammable.	Reliability	Resolved	Provide thermostat and reticle lamp assemblies flame guards.	606-612	613	1
10.	Stray light impairs star sightings.	Performance	Resolved	Provide a sunshade.	606-617**	618**	1

* 1st production lightweight flame guard delivered in time for AOT 610 retrofit installation in spacecraft.

** Proposed cut-ins.

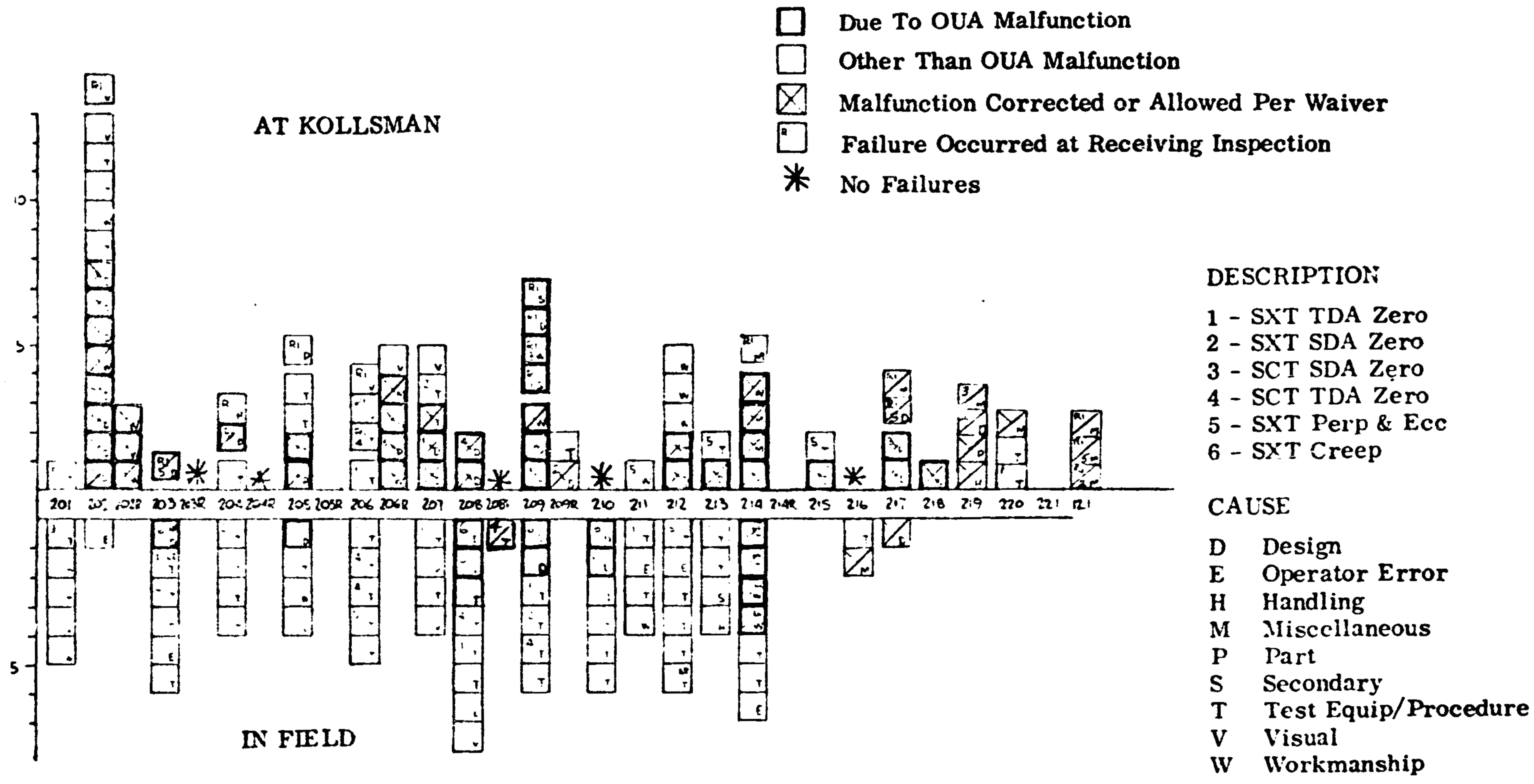
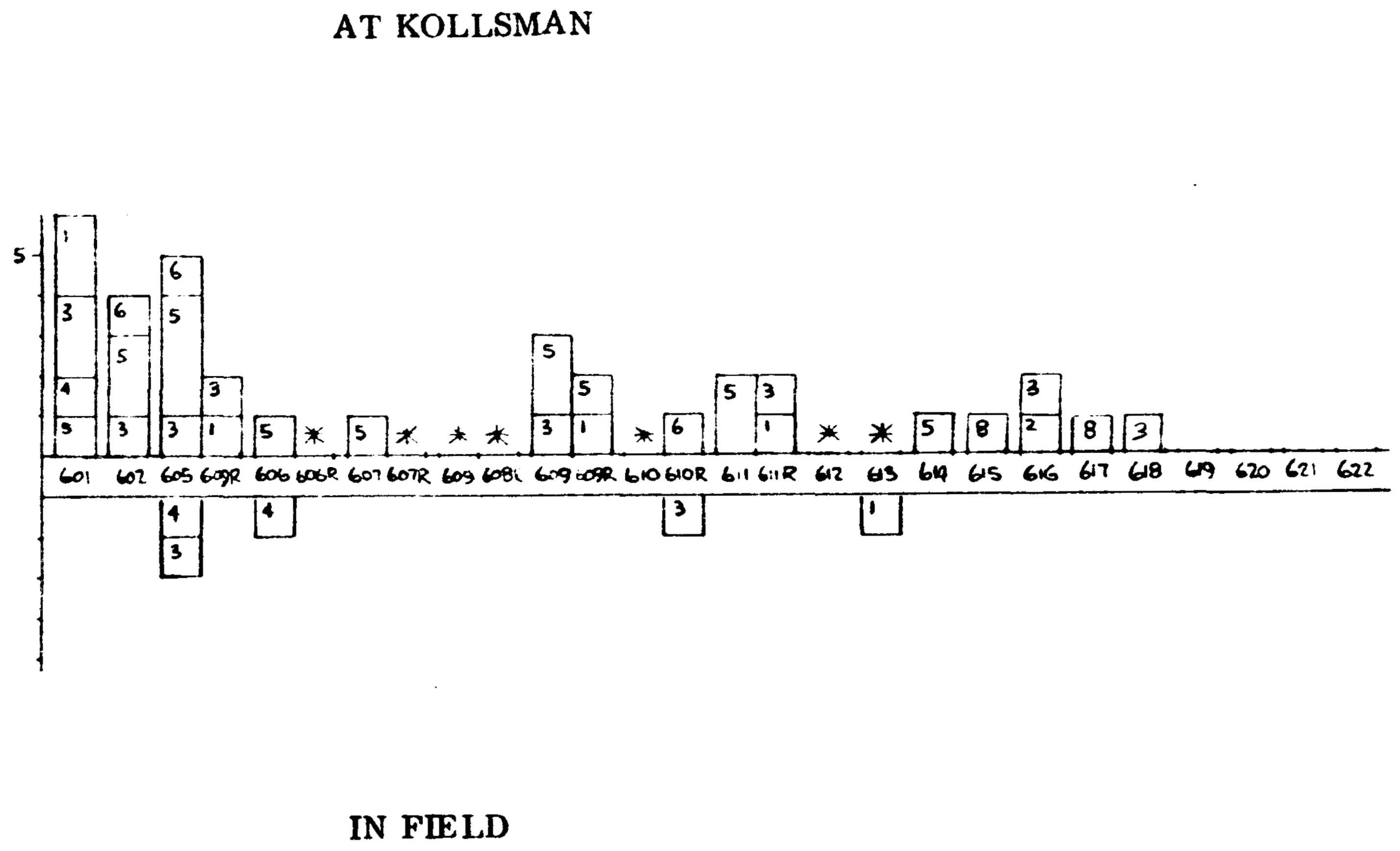


Figure 5-36. Block II, OUA Failure Summary



DESCRIPTION

1 - Visual and Dwg Comp
2 - Focus and Resolution
3 - Cursor Readout
4 - Power Match
5 - Eccentricity and SLOS
6 - Environmental Testing
7 - Reticle Lamps
8 - Miscellaneous

* NO FAILURES

Figure 5-37. LM AOT Failure Summary

Baseline testing was per ITP 01609, part of acceptance test procedure KPS 11K 2013250. The equipment and methods utilized in the acceptance test of the ARF was used in all baseline tests.

The scan control lower limit stop was out of tolerance following the qualification vibration test. The knob assembly was reset to the correct limit positions for continuation of testing, and an engineering investigation initiated. The limit stop failure recurred during the third functional test in the thermal vacuum environment, while the scan control knob was being exercised. A temporary fix was performed consisting of cementing the knob subassemblies. The knob performed satisfactorily during the remainder of the thermal vacuum test, and in the post thermal vacuum baseline. The fix was then removed and the knob assembly modified as redesigned to resolve the slippage problem. Modification consisted of the installation of a set screw to provide a positive locking action while providing for adjustment, in the scanning control knob. Retest in vibration and shock have verified that the redesigned scan control knob assembly is now adequately locked. The limit stop modification necessitated disassembly of the scan control knob. It was found that the deviation wedges and the range scan drum had inadvertantly been thrown out of alignment during the rework. In order to avoid lengthy realignment procedures, which may have required disassembly of the ARF, it was decided that the range accuracy achieved at that point be used as a baseline for the remainder of the test.

In the baseline test following the knob rework, the limit stop positions were checked by different operators, with erratic results. The cause was found to be a shifting condition of the cursor window. It was noted that the cursor glass could be moved as desired by jarring the instrument. The qualification test was continued with the cursor located in a known position, with rework to be performed later, since the remaining test exposures were climatic only. Review of the assembly requirements showed that the window should have been cemented in place. It was determined that ARF serial numbers 003 and 004 had been cemented as required. Following the cabin atmosphere test, the window was secured as specified, and was then subjected to a retest in vibration and shock. Baseline tests results verified that the window does not shift when properly cemented in place.

One of the three locking pins in the eyepiece assembly fell out after the shock test exposure. The pin and its mating hole were measured against drawing requirements; the pin was found to be tapered such that it did not provide a force fit. Replacement with a pin of the correct diameter resulted in an acceptable assembly, which survived all subsequent dynamic tests.

Two of the three eyepiece locking pins were noted to be corroded following the humidity test. (The third pin, which had been previously replaced as described above, was slightly corroded.) The material specified for the subject pins is stainless steel, type 416, which will corrode in a severe environment. The effect of pin corrosion on operation of the ARF was reviewed. It was concluded that the presence of pin corrosion will not affect ARF operation; therefore, the unit will not be modified.

Range drum illumination appeared to be dim after the qualification vibration test. Investigation showed that the illumination level had been normal; and that the apparent cursor illumination is dependent on background light.

One end of the Porro prism was found to be chipped away after the Requalification Vibration test. However, since the prism had successfully undergone initial qualification, the failure is not considered relevant.

5.7.10 Waiver Summary

OUA

Figure 5-38 illustrates the number of waivers assigned to the Optical Unit by AGE designation. The waivers are further classified as to relevant and non-relevant disposition. Star symbols indicate no waivers assigned to that AGE.

AOT

Figure 5-39 illustrates the number of waivers assigned to the Alignment Telescope by AGE designation. The waivers are further classified as to relevant and non-relevant disposition. Star symbols indicate no waivers assigned to that AGE.

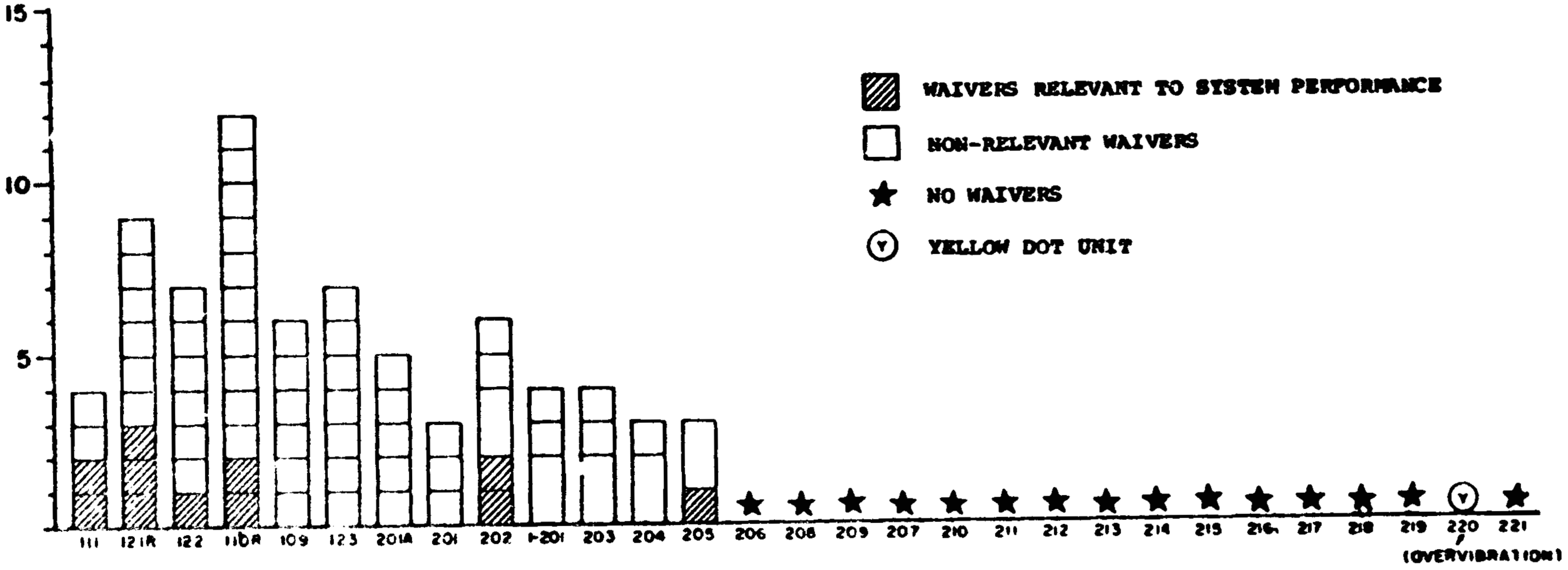


Figure 5-38. OUA WAIVER SUMMARY (BLOCK 100 AND BLOCK II)

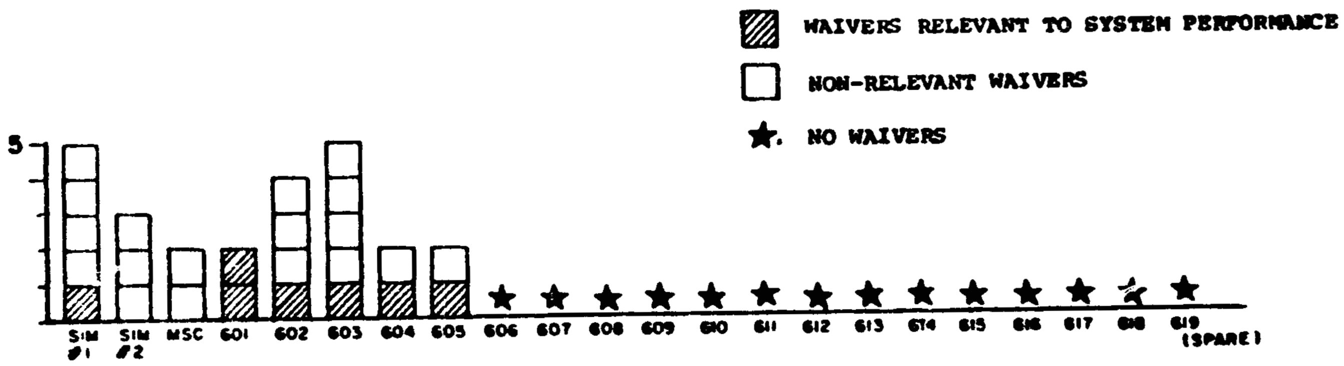


Figure 5-39. AOT WAIVER SUMMARY

Section 6

QUALITY ASSURANCE

6.1 SUMMARY OF THE YEAR ENDING 31 DECEMBER 1962

6.1.1 Program Effort

6.1.1.1 Assignment

Quality Assurance was assigned the responsibility for ensuring the quality of the Sextant (SXT), the Scanning Telescope (SCT), the Map and Data Viewer Display Unit (MDV), and the Ground Support Equipment (GSE) and to assure that the elements thereof are in compliance with NASA Quality Publications NPC 200-2 and NPC 200-3 and MIL-Q-9858 respectively. This included the establishment and monitoring of all controls necessary to fulfill this responsibility.

The Quality Assurance Group worked under T.D.'s K4, K-11 and K-30.

6.1.1.2 Accomplishments

A vendor selection program got underway with quality surveys conducted at the facilities of four prospective Apollo suppliers. The conclusions of these surveys were as follows:

(a) Reeves Instrument Corp - Unqualified approval

(b) American Beryllium Co. Inc. - Unqualified approval

(c) Fish Schurman - Approved as a source for raw glass, but disapproved as a fabrication and/or processor.

(d) American Precision Industries - Approved for general machining, but disapproved for beryllium fabrication.

Preliminary visits were made to D.W. Mann Co., The Barden Corp. and Belock Instrument Corporation to determine the capability of these prospective vendors to produce and inspect the close tolerance items contemplated for their manufacture. In addition, Kollsman evaluated inspection equipment needs to determine the economics of source inspection versus the acquisition of additional capital equipment.

Historical quality information available on prospective sources for rotating components was developed for use by the Reliability group for their evaluation in qualifying parts and vendors.

A comprehensive listing of facilities and equipment required for the quality assurance aspect of the project was developed. These requirements were based upon design information available at the time, and would provide a complete capability of verification, product and process evaluation, and failure analysis.

The document family tree prepared for the Sextant (SXT) and Scanning Telescope (SCT) was reviewed. Inspection and testing requirements were inserted at the proper points. The applicable documentation requirements relating to inspection and testing were also noted at each inspection point. This alerted all project personnel to the need for specific equipment and effort in the respective areas.

Preliminary design reviews were conducted on drawings received from MIT in a pre-Class B (preliminary drawings - released only for breadboard fabrication) state. Review at that point allowed necessary changes to be made at MIT without having to go through a formal change control procedure, and thus reducing possible delays during the formal design review phase.

As per request, an exploratory meeting with Air Force New York Contract Management District personnel was held to discuss the Apollo program at Kollsman, and the Air Force's role as a secondary administrator. An informal presentation was made to the Air Force describing the function and outline design of the Sextant, the Scanning Telescope and the Map and Data Viewer Display Unit.

Presentations were made to Kollsman executive and management personnel describing the role of Quality Assurance on this project, and the responsibilities of the various departments for ensuring complete compliance with NASA Quality Publications NPC 200-2 and NPC200-3.

The proposed NASA Specification ND 1015404, "Configuration, Process and Quality Control Requirements for Suppliers of High Reliability Articles for Use in Spacecraft and Supporting Equipment", was reviewed, and comments were transmitted to MIT.

The Kollsman Apollo Quality Assurance Manual was completed and reviewed; and a list compiled of minor corrections and additions necessary for the efficient administration of the procedures. These refinements were incorporated into the manual during final publication.

A visit was made to Bendix (Eclipse Pioneer Division) regarding a one hundred and twenty-eight pole, ultra-precise resolver, for use on the Sextant.

Fixture requirements to simulate the function of the resolver in the Trunnion Assembly were developed for acceptance testing by Kollsman.

The raw optical glass requirements for the Scanning Telescope were reviewed and grouped according to type and grade. As apart of this review, special instructions were formulated for the inspection requirements of the raw glass melts.

Grumman and Kearfott were visited in a continuing study of clean room operations.

Quality Assurance assisted the Reliability Group in the preparation of an integrated failure reporting system for in-plant and field malfunctions.

Purchase Orders for raw glass, and for components of Factory Test Equipment and GSE were reviewed and approved by Quality Assurance.

6.1.1.3 Major Problems

Preliminary information indicated that MIT intended to place one approved source on some critical drawings. Thus, a change in source would involve a formal engineering change. Should a vendor, realizing that he is the only approved source, refuse to comply with NPC 200-3, difficulty and delay could arise on scheduled deliveries. Clarification of MIT's role in evaluating vendor conformance to the NASA Quality Publications was obtained.

6.2 SUMMARY OF YEAR ENDING 31 DECEMBER 1963

6.2.1 Program Effort

6.2.1.1 Assignments

Quality Assurance was responsible for preparing and implementing the detailed procedures, methods and directives of a Quality Assurance program which is in accordance with the requirements of NASA Quality Publications NPC 200-2 and NPC 200-3.

6.2.1.2 Accomplishments

Selection of procurement sources continued with a two-pronged effort involving both a review of the quality history of possible Apollo program suppliers and a survey of those suppliers' facilities and procedures. Extensive assistance was furnished to potentially desirable suppliers who did not comply fully with all applicable quality requirements. As a result, several of these sources were placed on the list of approved Apollo program suppliers.

A summary of the procurement source evaluation during the year follows:

Pioneer Astro Industries, Chicago, Ill.
Approved for precision machinery including beryllium.

Speeding Corp., Warren, Mich.
Approved for precision machinery including beryllium.

Leemath Inc., Syosset, N.Y.
Approved for precision machinery including beryllium.

B.G. Instrument Corp., Corona, N.Y.
Approved for precision machinery including beryllium.

Beryllium Mfg. Corp., Valley Stream, N.Y.
Approved for precision machinery including beryllium.

Moore Special Tool Co., Bridgeport, Conn.
Approved for non-beryllium precision machinery.

Curtiss-Wright, Electronics Division, East Paterson, N. J.
Approved for electronic, electrical and electro-mechanical life testing.

Miniature Precision Bearings, Inc., Keene, N. H.
Approved for ball bearings.

Split Ball Bearing Division, Lebanon, N. H.
Approved for ball bearings.

New Hampshire Ball Bearing, Peterborough, N. H.
Approved for ball bearings.

Braun Tool & Instrument Company, Hawthorne, N. J.
Qualified approval for precision stampings; will require surveillance.

Barden Ball Bearings, Inc., Danbury, Conn.
Approved for ball bearings.

Beryllium Corp., Nuclear Div., Hazleton, Pa.
Approved supplier of beryllium ingots and rough machined beryllium components; not qualified for heat treatment of beryllium per ND 1002092.

Arwood Corporation, Tilton, N.H.
Approved for non-ferrous investment castings.

Hudson Tool & Die, Inc., Newark, N. J.
Approved for deep draw work;
KI to supply material.

Customatic, Stamford, Connecticut
Approved for F.T.E. only.

Penn-Keystone, Derby, Connecticut
Approved for lighted indicators (Peaklite process)

Meta-Vac, Inc., Flushing, N. Y.
Disapproved for Apollo prime equipment.

Kinney Vacuum, Camden, New Jersey
Approved for optical coatings.

Messinger Ball Bearings, Philadelphia, Pa.
Approved for F.T.E. & G.S.E. bearings only; nothing
smaller than 8" I.D. bore.

Melland Gear Company, Jamaica, New York
Approved for fabrication of gears.

Clifton Precision Products Co., Inc., Clifton Heights, Pa.
Approved for motor generators, resolvers, synchros.

Kaydon Engineering Corp., Muskegon, Michigan
Approved for ball bearings

Newcomb Spring Company, Valley Stream, N. Y.
Disapproved.

Palmyra Foundry, Palmyra, New Jersey
Disapproved.

Eastman Kodak, Rochester, New York
Approved for lenses and optical coatings.

Bausch & Lomb, Rochester, New York
Approved for lenses and optical coatings.

Riley Gear Corporation, N. Tonawanda, N. Y.
Approved for fabrication of gears.

Lee Spring Company, Brooklyn, New York
Approved for springs.

Eclipse Pioneer Division of Bendix, Teterboro, N. J.
Approved for resolvers, synchros, motor generators.

Kearfott Div. of General Aerospace Inc., Asheville, No. Car.
Approved for resolvers, synchros, motor generators.

Sanders Associates, Nashua, N. H.
Approved for flexprint (Flexcable &/or harnesses)

Taylor & Helander Manufacturing Co., Clinton, Conn.
Disapproved.

Continental Connectors, Woodside, New York
Approved for connectors.

Parker Seal Co., Eastern Division, Beria, Kentucky
Approved for 0 rings, rubber seals and sealing devices.

Polacoat, Inc., Blue Ash, Ohio
Disapproved for Apollo prime.

Photronics, Flushing, N. Y.
Disapproved.

F.W. Blanchette Co., Clifton, N. J.
Approved gauge laboratory-mechanical inspection services.

Solvere, Inc., Santa Anna, California
Approved for rotating components.

Stewart Trans Lux Corp., Torrance, California
Disapproved

Parker Seal Co., Western Division Culver City, California
Approved for metal retained seals.

Autotronics, Inc., Florissant, Mo.
Approved for clutches, brakes and for general machining except Be.

K. W. Thompson Tool Co., New Hyde Park, N.Y.
Approved for ferrous and non-ferrous investment castings.

Atlas Pattern and Mold Co., Brooklyn, N.Y.
Conditional approval for sand castings.

La Vezzi Machine Works, Chicago, Ill.
Approval limited to cutting of sprocket teeth only.

Industrial Tectronics, Ann Arbor, Mich.
Disapproved, access denied-awards not permitted.

Astro Gear, Stoughton, Mass.
Approved for gears and gear assemblied (differentials)

D.W. Mann Co., Lincoln, Mass.
Limited approval - optical engraving and assembly only
KI to supply raw material

Polaroid Corp., Polarizer Div., Cambridge, Mass.
Approved for fabrication and process of polarized filters.

Long Island Metal Spinning, Freeport, N. Y.
Disapproved.

Mechanical Rubber Products, Warwick, N. Y.
Approved for processing rubber and rubber products.

General Product and Gear Co., Lynn, Mass.
Disapproved.

Eastern Heat Treat, Glen Cove, New York
Approved for heat treatment of all metals.

Omicro, Inc., Westbury, L. I.
Limited approval - 2 orders max., pending further review.

New Jersey Gear and Mfg. Co., Inc., Hillside, N. J.
Approved for gears.

Optical Coating Laboratory, Inc., Santa Rosa, Calif.
Approved for vacuum deposition of optical coatings.

Davidson Optronics, Inc., W. Covina, California
Approved for manufacture of optical instruments and components.

Vinco Corp., Detroit, Mich.
Approved for gears.

Equitable Engineering Royal Oak, Mich.
Approved for gears, gear masters.

C. B. Kaupp and Sons, Maplewood, N. J.
Approved for deep drawing, hydraform and metal spinning.

Service Machines, Elizabeth, N. J.
Disapproved for Apollo prime.
Requires surveillance all other work.

Greenfield Tap and Die, Greenfield, Mass.
Approved for worm gears only.

General Foundry, Corona, N. Y.
Approved as source for non-ferrous sand castings.

Plainville Casting Co., Indian Orchard, Mass.
Not approved.

Ten Bosch Co., Pleasantville, N. Y.
Not approved for beryllium machining.

Mitron R&D Corp. Walthams, Mass.
Approved for development & mfg. of Apollo containers.

Sigma Instruments; S. Braintree, Mass.
Tentative approval as Apollo supplier pending survey.

Kappel & Mazur, Westbury, N. Y.
Not approved.

National Beryllia Corp., Haskell, N. J.
Approved as Apollo supplier.

Weckesser Co., Inc., Chicago, Ill.
Conditional approval as source for nylon cables, straps, etc.

Vernon Plating, Woodside, N. Y.
Approved for plating comments n/a for black anodize of beryllium.

Mepco, Morristown, N. J.
Approved for transistors, capacitors.

Summit Finishing, Thomaston, Conn.
Approved for all plating
Conditional approval for black anodize of beryllium.

Design review activity increased significantly as the flow of detailed drawings accelerated. During the year Quality Assurance participated in several design review sessions, each covering at least twenty drawings ranging in status from pre-Class B through Class A. During these reviews extensive Q.A. effort was devoted to the reduction of design inadequacies which may cause problems to arise during the inspection, procurement, fabrication, storage, assembly and test phases. The preventive accomplishments of the design review activity was definitely reflected during latter phases of the program.

Specifications called out on blueprints submitted for design review were in turn reviewed to determine their applicability and adequacy. Particular attention was devoted to the quality and inspection portions of these specifications. In addition to reviewing and commenting upon the specifications already appearing on the blueprints, Q. A. recommended additions and revisions and monitored compliance with such recommendations.

The Quality Assurance Group recommended clarifications, revisions and refinements to its section of the NASA Statement of Work for the Apollo contract. The intent of these recommendations was to provide a quality level commensurate with specific hardware requirements at a reasonable cost with the least delay. These recommendations were generally acceptable to NASA, MSC.

Based upon the limited design information which was available on the Bendix precision resolver, Q. A. developed a method of inspection which simulates the end use of that critical component. In conjunction with this, Q. A. proposed special test equipment which accomplished the desired inspections. The Kollsman test equipment group obtained more information on the resolver prior to detailing the inspection equipment design. Subsequently, Quality Assurance provisions for the procurement of the sixty-four Speed Resolver were successfully negotiated during a meeting attended by representatives of NASA, KI and Eclipse-Pioneer Division of Bendix Corp. During this meeting the NASA representative assisted in the development of mutually acceptable interpretations of applicable NASA quality specifications. These interpretations served as a guide in similar negotiations, such as those conducted with Clifton Precision Products Corporation.

Kollsman inspection personnel completed source inspection tests on three sixteen speed resolvers supplied by Bendix, Eclipse Pioneer Div., and Clifton Precision Products. Excellent correlation with initially recorded values was observed for the electrical accuracy measurements.

One sixty-four speed resolver was received from Bendix and accepted against a Material Review Report. Previous difficulties encountered with repeatability were traced to the test equipment and were corrected. While the accuracy of the unit was outside the tolerance limits (hence the MRR) repeatability was good. The resolver was forwarded to MIT/IL, at their request and with the concurrent of NASA/RASPO, for further testing and analysis. Upon return it was used in AGE 3.

Final acceptance testing of sixty-four speed resolvers Serial Nos. 2 and 3 neared completion. Electrical error spread exhibited by these two units improved considerably in comparison to the spread obtained from the first unit delivered. Although the maximum error approached six (6) arc seconds, the ultimate goal of three (3) arc seconds was expected to be achieved based on the improvements demonstrated to date.

Several releases of Factory Test Equipment (FTE) assemblies were issued to the shop and to suppliers. Quality Assurance established the quality requirements for these components and monitored their implementation. Included in this effort was a Q. A. surveillance of the calibration and acceptance procedure employed by the Moore Special Tool Co, of Bridgeport, Connecticut, on a high-accuracy indexing table which is part of the Precision Test Fixture.

Conferences were held with individual prospective suppliers in an effort to familiarize them with Kollsman Apollo Quality Assurance requirements and goals. Such conferences were generally held with potential suppliers of critical items, i.e., the Barden Corporation, Moore Special Tool Company, etc., so that these companies had an opportunity to implement all of these requirements prior to pre-award survey.

Procurement Document Review began. Quality Assurance reviewed all purchase requisitions, adding to them all special instructions and information. A work statement spelling out most of the special Kollsman Apollo quality requirements was prepared for attachment to each Request for Quotation and each Purchase Order. In addition, all Purchase Orders received a final Q. A. review prior to their release.

A member of the Apollo Quality Assurance Group attended an optical tooling seminar sponsored by the American Society of Tool and Manufacturing Engineers. Several discussions were directly related to aspects of the Optical Subsystem, and a presentation covering significant information obtained from this seminar was made to the other Kollsman Apollo Engineering personnel. Training such as this kept Kollsman Apollo personnel abreast of the advances and limitations of industry, and thus helped to provide an advanced realistic approach to the solution of problems.

A Navy Department quality motivational film, "Integrity Plus" was shown to an audience representing Inspection, Manufacturing, Engineering and Management. The showing of this excellent film was part of a continuing training program attempting to motivate personnel at all levels toward a clear recognition of the importance of quality and reliability.

In order to implement adequate control of Kollsman changes to Apollo documents, in keeping with the plan established by MIT (Technical Data Release Procedures, E-1186; change Control Board; and SIDL releases), a preliminary draft of a Change Control procedure for Kollsman generated support documents (Route and Tool Books) was released for review and comment from all department supervisors. Upon completion of review and draft revisions, the proposal was incorporated in the Apollo Quality Control Manual as a QCI.

Special attention was also given to problems involved in the manufacture and measurement of the Scanning Telescope Spur Gear (P/N 1011178) which has a highly precise tooth spacing requirement. Meetings were held with representatives of Melland Gear Company, Benson Marine, the Reilly Gear Company and Moore Special Tool Company. All aspects of the complex fabrication and inspection techniques were given due consideration.

Detailed inspection requirements and procedures for the Map and Data Viewer Projection Lens (P/N 1011374) were discussed and resolved in a series of meetings between Kollsman Quality Assurance Engineers and representatives of Eastman Kodak.

As a result of extensive inspection test data required on optical components, it was possible to optimize the selection of these parts depending upon ultimate use of the assembly. For example, each MDV Projection Lens, (P/N 1011374) was provided with its resolution test results and a film slip depicting the resolution performance, thus permitting resolution-wise grading of the lenses.

The special development and test study in measurement of lead error on Worm Shaft, Part No. 1011198 was completed. The approved measurement technique established employs the Pratt and Whitney Gage Co. "Helical Path Analyzer" equipment to determine the composite lead error and drunkeness from a theoretical helical angle reference. The repeatability and accuracy of the measuring system, within the limits of three complete threads is 0.000015-0.00002 inch. The accuracy of the system is directly dependent upon, and capable of being checked out by means of gage block standards.

Two prime hardware components (worm shafts) were supplied by Greenfield Tap and Die Company and the lead error measurements obtained were within 0.000035 and 0.000050 inch respectively. These values complied with the required lead error tolerance.

The Polarizer Division of the Polaroid Corporation experienced difficulties in maintaining the required five (5) seconds resolution and thirty (30) seconds deviation for the Beamsplitter Filter, (P/N 1011663). This matter was assigned a critical priority in order that an early satisfactory solution would be achieved.

A special evaluation test of the precision worm shaft (P/N 1011198) and Spur Gear (P/N 1011177) was performed at MIT on parts supplied by KI. Although the parts were not of the required accuracy, the twenty (20) arc seconds obtained over a large range of gear translation was gratifying. Considering the magnitude of the worm shaft lead error (.0001 inch) and the spur gear accuracy (12 arc seconds) of the parts supplied, the error cancelling effect of the gear mesh appeared satisfactory.

A major and continuing quality assurance effort was extended for the final inspection and acceptance of the initial Precision Test Fixture NASA assembly drawing number 1016910. Various improvements both of major and minor consequences were incorporated during this "check-out" phase. A primary result of the aforementioned improvements was in increased stability of the overall structure thus yielding the required repeatability of readings when utilizing the various autocollimators.

6.2.1.3 Control of In-Plant Part and Assembly Manufacturing

Manufacturing operation and route sheets for in-house fabricated parts and assemblies were reviewed by Quality Assurance Engineers and detailed Inspection Procedures were prepared for selected in-process and final inspection characteristics. These were then integrated to provide a complete set of manufacturing, assembly and inspection instructions.

In the preparation of these inspection procedures, the function and criticality of the parts and assemblies, the design characteristics, and the sequence and methods of part fabrication and assembly build-up were considered.

During this period, approximately one hundred and ninety new procedures were written for purchased parts, KI fabricated parts and assemblies. Approximately seventy inspection procedures were revised to reflect the current configuration level.

Difficulties were encountered in the heat treatment and passivation of parts made from 440C stainless steel. A qualtiy Assurance investigation of this problem resulted in changes to both the governing specifications and the actual processes. The speedy resolution of this problem kept the loss of time and material to a negligible minimum.

Manufacturing and inspection personnel completed the prescribed technical training and practical exercises in electrical conductor soldering procedures. Qualified personnel were issued NASA certification cards.

Manufacturing and Inspection personnel underwent training in process control and fabrication procedures of resistance-welded electronic circuit modules. Upon satisfactory completion of the prescribed training program, qualified operators and inspectors were issued NASA certification cards.

To ensure that physical impairments of manufacturing and inspection personnel involved with the fabrication of optical elements and assemblies do not adversely affect the quality of Apollo parts, eye examinations were conducted, and where necessary, corrective lenses were prescribed.

Audits were conducted to determine the effectiveness of the current methods of documentation, implementation and retention of inspection records, Material Review Board actions, waiver authorizations, and change orders. Any required revisions to those procedures were undertaken upon complete evaluation of the results of the audit.

Quality Assurance participated in the Field Operation Training Program by presenting sessions to field service personnel covering general quality requirements of NASA Publications NPC 200-2 and NPC 200-3, and interpretation of True Position Dimensioning and Tolerancing requirements shown on engineering drawings as defined in MIL-STD-8B.

As the need arose, additional Quality Inspection and Manufacturing personnel were instructed in True Position Dimensioning and Tolerancing as related to the recording and interpretation of T. P. requirements.

6.2.1.4 Problem Areas

The "Disposition" called out on some TDRR's was not always feasible or even possible. More attention was given to the effects of the disposition on parts in-process or already complete.

The numerical list of Apollo drawings in SIDL did not indicate all usage code numbers for Specification Control Drawings, nor did TDRR's for SCD's indicate all participating contractors affected. This made it difficult for KI to process revised SCD's on a timely basis to amend outstanding purchase orders to reflect proper revision levels.

6.3 SUMMARY OF YEAR ENDING 31DECEMBER 1964

6.3.1 Program Effort

6.3.1.1 Assignment

Quality Assurance was responsible for preparing and implementing the detailed procedures, methods and directives of a Quality Assurance program which was in accordance with the requirements of NASA Quality Publications NPC 200-2 and 200-3. Coordinating and integration of this effort with the Apollo Reliability Program was also the responsibility of Quality Assurance.

As a member of the Failure Action Committee of the Failure Reporting System, Quality Assurance was jointly responsible for implementing the corrective measures initiated as a result of the failure analysis. A detailed description of the actions undertaken by the Failure Action Committee was included in the Reliability Section of this report.

6.3.2 Accomplishment

A meeting was held at Kollsman during which various questions regarding the Apollo requirements for process control and fabrication of resistance-welded, electronic circuit modules were clarified. A presentation of the basic theory of precision resistance welding and the necessity for stringent quality and performance requirements were discussed. Specific questions, raised by concerned Kollsman personnel regarding interpretation of the requirements, were answered. Near the conclusion of the meeting, microphotograph slides were shown of various levels of both acceptable and unsatisfactory weld cross sections.

The first two Optical Units (AGE 1 & 3) and three Map and Data Viewers (AGE 1, 2, & 4) were subjected to final acceptance tests specified in FTM 1011000 and 1011559, respectively, and found acceptable.

A direct result of the learning experience gained, during the fabrication, assembly and testing of the initial assemblies, was the careful and thorough manner of updating all concerned documentation, i.e., quality assurance, inspection procedures, assembly test methods and manufacturing operation sheets. Inputs were obtained from all responsible personnel (Manufacturing, Test, Inspection, Engineering) and transmitted to those charged with the task of documentation revision. Thus, there was a continuous and deliberate movement towards optimizing the quality and performance of all deliverable units.

During the year, a total of one-thousand three-hundred and forty-six (1346) Material Review actions were processed. Eight hundred and seven (807) of these involved minor variations from drawing requirements and were dispositioned through preliminary review. Five-hundred and thirty-nine (539) actions against nonconforming supplies were referred to the formal Material Review Board for disposition with corrective actions indicated to preclude recurrence. Kollsman suppliers accounted for approximately sixty-one percent of the total number of Material Review Actions.

Quality Assurance, as a participating member of the Change Control Board, reviewed and approved approximately six hundred engineering drawing changes, with primary concern on change effectivity, feasibility of production, inspection and tests and inclusion of applicable quality requirements.

A procedure was instituted for optimizing the assembly of the SXT Head Optical System by mating the two fixed beryllium mirrors, index mirror, beam splitter and polaroid filters by selective assembly as to spherical power and astigmatism.

Quality Assurance investigated all nonconformances to determine the basic cause and the corrective action necessary to preclude recurrence.

A Documentation Review Board was established to control effectively the documentation released from the engineering section. The board included representatives of Documentation, Quality Control, Reliability Engineering, Project Engineering and Field Operations. Review objectives were to ensure accuracy and clarity in specifications, Quality Control provisions and in the following requirements: material and construction, functional characteristics, special conditioning, and qualifications.

Quality Control maintained a joint responsibility with Reliability for corrective action required as a result of failure analysis.

A major effort was devoted to generating the necessary procedures and controls of the Block II Optics which required application of a special high-efficiency reflection reducing film (ND 1002224) on a majority of the Apollo optical elements. The change to the special coating in lieu of the standard magnesium fluoride film created the need for new handling and packaging procedures for the Kollsman optical fabrication facility.

A complete listing of test equipment with equipment evaluation, certification procedures, instrument location and calibration cycles, as specified in the Final Test Method of the Optical Unit, was submitted to Quality Control by Test Equipment Engineering. This listing and others compiled in the area of test equipment designated for Assembly Test Procedures (Job Description Cards) provided a more complete background for equipment control as required by the applicable NASA Quality Publications. Quality Control assisted in this review and provided guidance in the interpretation of the appropriate section of NASA NPC 200-2, so that policies and procedures, after reqrite, presented a method of operation reflecting the requirements of the NASA document. As noted above, a review of all Apollo test equipment was made to determine that the evaluation procedures and data was available as required by NPC 200-2. All areas of nonconformance were rectified. In addition, procedural revisions were generated to preclude recurrence of nonconformance.

Quality Assurance, in conjunction with Engineering and Production Control, was instrumental in developing the configuration and log control procedures. Records were generated and maintained to control the assignment of parts to system assemblies by part number, part serial or lot control number, and as may effect the part the Material Review report and/or waiver number.

As an effort to provide for improved test and inspection instrumentation, Quality Assurance arranged for in-plant demonstrations of a steroscope made by Vision Engineering Inc., and a Kollmorgan autocollimator. This steroscope proved to be vastly superior to the more commonly used steroscopic microscopes and screen projectors. The new line of Kollmorgan autocollimator equipment reflected a fresh approach to collimator design with many interesting features.

Quality Assurance personnel actively participated in the manufacturing assembly phases of deliverable prime equipment. Continuous surveillance during assembly was maintained to ensure adherence to drawing and specification requirements through the use of production method sheets and inspection procedures. Production and inspection methods and procedure sheets were revised whenever the proper function of parts and assemblies were jeopardized by incomplete or inadequate assembly and inspection instructions. Engineering changes were initiated, when required, during fabrication to improve the quality and reliability aspects of the assemblies. All rework dispositions were subjected to the formal documentary requirements of Material Review Board actions for rework and inspection operations.

6.3.2.1 Listed below are the Optical Units and Map and Data Viewers subjected to final acceptance tests, and found acceptable.

OPTICAL UNIT ASSEMBLY (OUA)	MAP & DATA VIEWER (MDV)
AGE 1	AGE 1
AGE 3	AGE 2
AGE 5	AGE 4
AGE 6	AGE 7
AGE 7	AGE 8
AGE 8	
AGE 20	
AGE 17	

6.3.3 Problem Areas

1. Bendix was experiencing difficulties with the 64-speed SXT Trunnion Axis Resolver in the areas of accuracy, insulation resistance and dimensional tolerance requirements. A close liaison between the Bendix and Kollsman engineering and quality control groups was continued in order that the problem areas may be satisfactorily resolved. Procurement Specification requirements were relaxed to provide more realistic performance goals.

6.4 SUMMARY OF THE YEAR ENDING 31 DECEMBER 1965

6.4.1 Management

GENERAL - The Space Division Product Assurance Department was reorganized during the reporting period as shown in Figure 6-1. Of significant importance is the further project orientation of several major Product Assurance functions. These include planning and design control, fabrication control, final test and in-process inspection, all of which are now performed by an Apollo/LM Program Product Assurance Section within the Product Assurance Department. The organization structure of the new group is illustrated in Figure 6-2. The Quality Control Services Section of the Department will continue to provide the Apollo/LM Program with such additional support services as systems and procedures, supplier evaluation and control, audits and special process control.

Other support services such as metrology and receiving inspection, test equipment service, and environmental testing will continue to be performed by the Inspection, Test and Environmental Test Sections of the Product Assurance Department, respectively.

MANPOWER STATUS - Figure 6-3 lists the number of personnel in Apollo/LM Product Assurance at the end of the reporting period.

6.4.2 Motivation

Space Division Product Assurance, as part of a continuing motivation program, presented a series of individual symposia related to the Apollo/LM Programs during the reporting period. The sessions were attended by personnel from all areas concerned with Kollsman's participation in the Apollo/LM Program. The lecturer for the "Apollo Quality Control and Reliability Symposium" was Mr. R. Crimmel, Reliability Research and Education Senior Staff Engineer at AC Electronics Division of General Motors. Mr. Crimmel had been conducting similar symposia at major Apollo/LM subcontractor facilities. His presentation of the subject was highly informative and stimulating.

The motivational film "Walk in Space" was shown during October for professional and engineering personnel.

QUALIFICATION TRAINING - A summary of total Apollo Certifications in the various skills as of the end of the reporting period, 1965, is categorized as follows: welding, 34; wiring and crimping, 48; potting, 13; plating, 15; and heat treatment, 2.

Quality Control held a training lecture that covered the polariscope operation and the inspection requirement for optical surface quality.

ORGANIZATION CHART
SPACE DIVISION
PRODUCT ASSURANCE DEPARTMENT

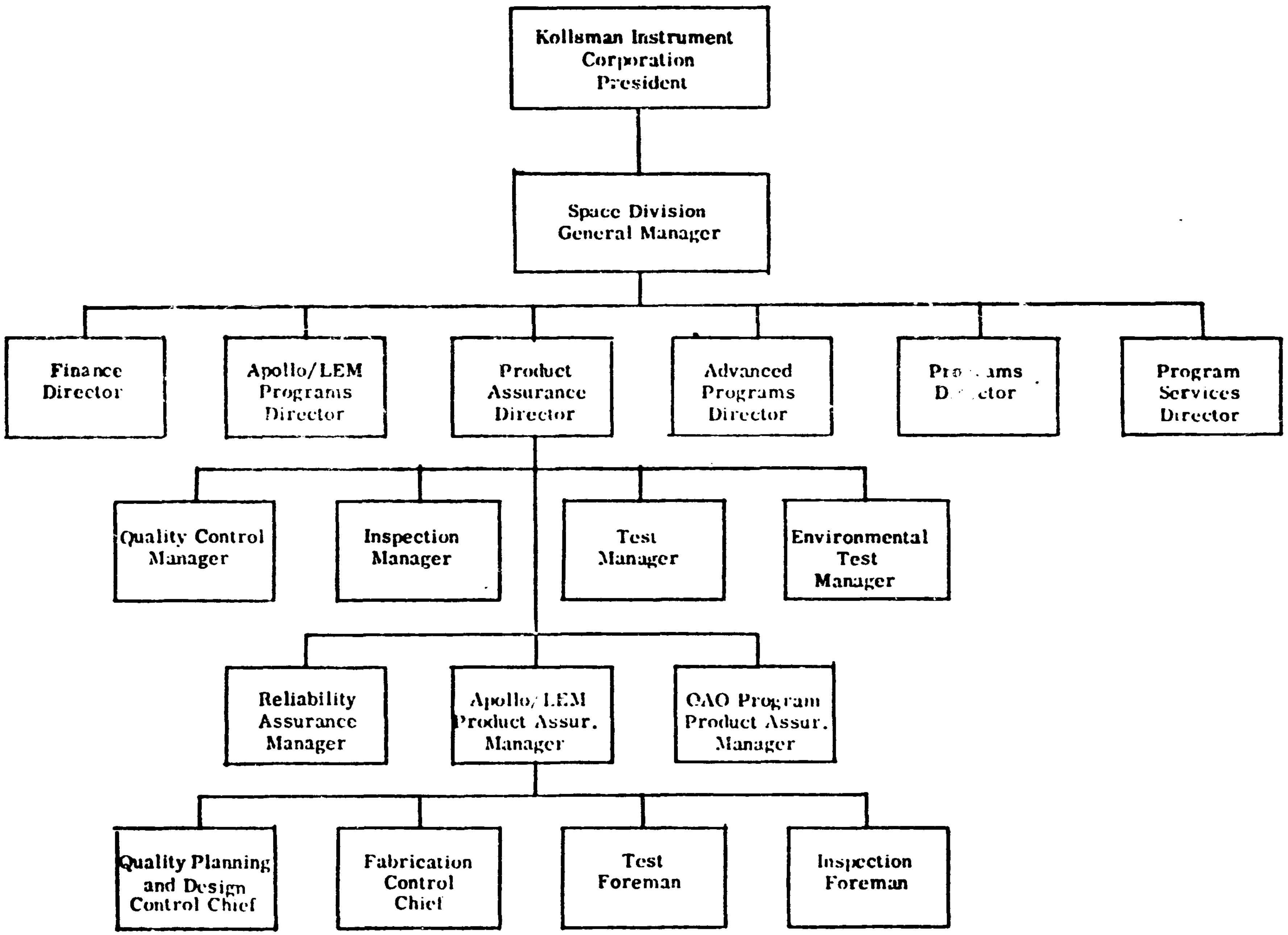


Figure 6-1

PRODUCT ASSURANCE FUNCTIONAL ORGANIZATION FOR APOLLO/LEM PROGRAMS

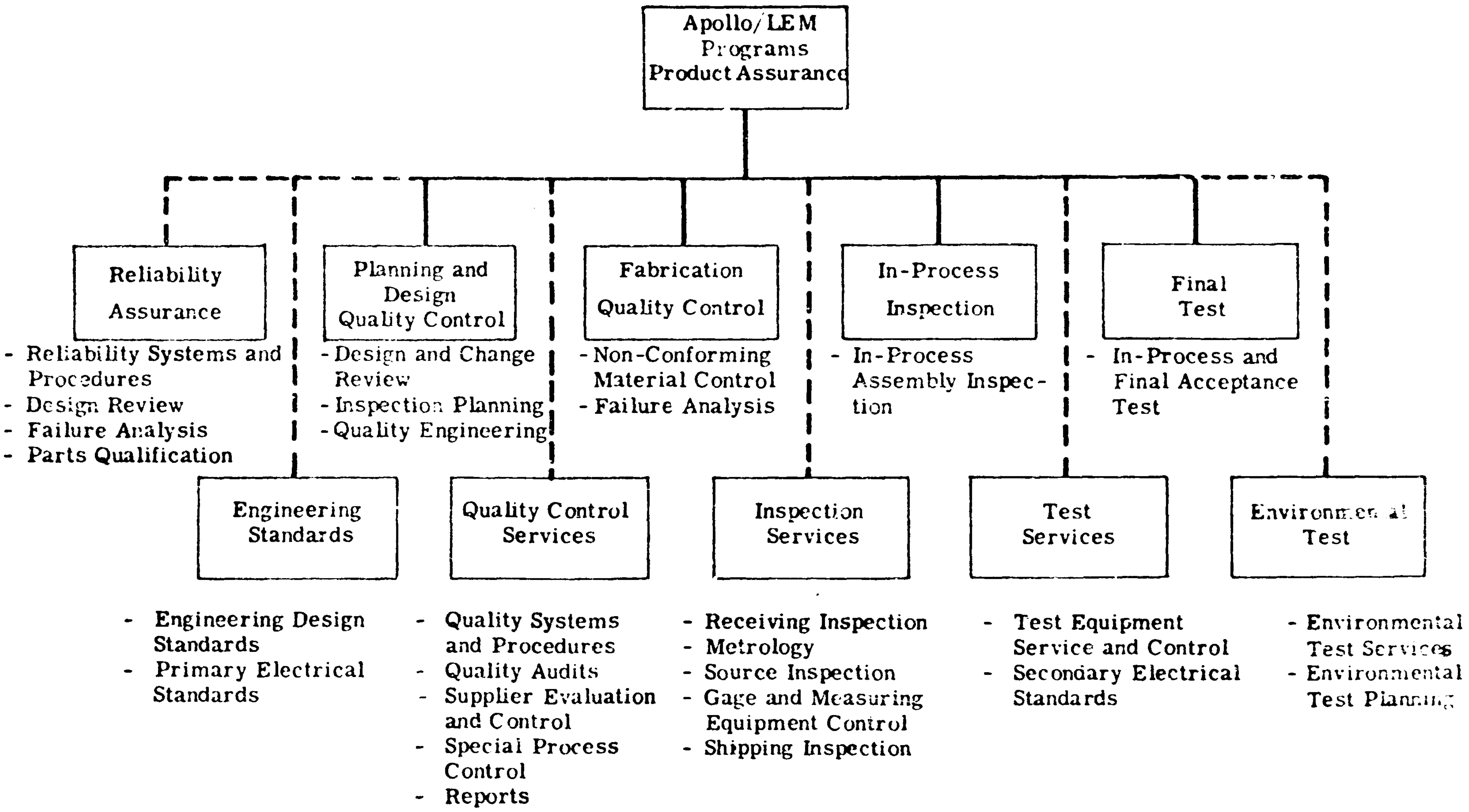


Figure 6-2

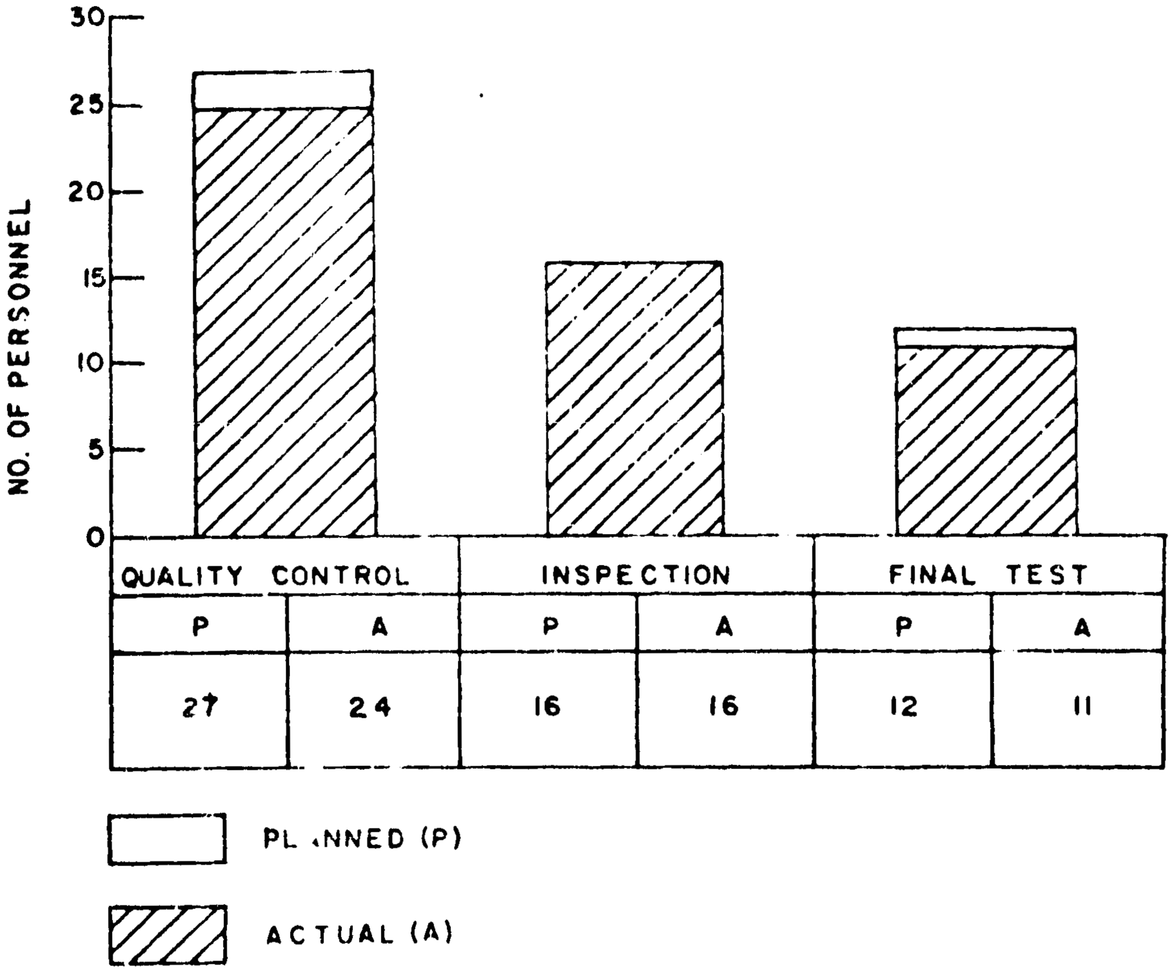


Figure 6-3. Manpower Status

A Quality Control engineering representative attended a series of engineering courses conducted by Apollo Project Engineering personnel. This course was designed to acquaint all cognizant engineering personnel with the engineering design concepts of the Optical Unit Assembly (OUA) and other support equipment.

At the direction of Quality Control, an Optics Training Program was developed to familiarize new supervisory personnel to function efficiently in the direction of the product effort. Instruction was specifically oriented to improving the performance of each trainee in his company-assigned duties by training him in the factory assembly, test, and checkout of all Optics G and N equipment.

6.4.3 Problem Areas and Corrective Action

PROBLEM RESOLVED AND CORRECTIVE ACTION - Table 6-1 lists the problems and corrective action taken.

6.4.4 Procurement

MATERIAL RECEIVED - Of the 11,836 parts inspected by the Receiving Inspection Department during the reporting period, 23 percent were found nonconforming and dispositioned by 224 Material Review Board actions. Fourteen percent, of the total inspected, were discrepant due to improper paperwork, identification marking, or interpretation of procurement requirements and were process in the normal manner by inspection after correction of the deficiency. See Table 6-2 for a breakdown of material received.

A comparison percentage curve of shipments evaluated and units inspected is shown in Figures 6-4 and 6-5. For breakdown of discrepant categories relative to the nonconforming shipments, see Table 6-3. The nonconforming shipments form the basis of the material review action listed in Table 6-4.

MATERIAL REVIEW ACTIVITY - Quality Control during the reporting period processed 224 Formal Board Actions for the Procurement section of the Material Review Board. One hundred ninety-nine FBA's were for the Command Module and 24 for the LM procurement activity. See Table 6-4 for additional breakdown. See Figure 6-6 for linear trend indication.

6.4.4.1 Supplier Activities

SUPPLIER SURVEY STATUS - The status of ND 1015404 Supplier Surveys is listed in Table 6-5.

ACTIVE CONDITIONALLY APPROVED SOURCES - Table 6-6 delineates in detail the status of active conditionally approved sources.

TABLE 6-1 (Page 1 of 5)

MANAGEMENT PROBLEMS RESOLVED

PROBLEM	CORRECTIVE ACTION
Kollsman Process Specification (KPS) removal from drawings was one of NASA's recommendations during the survey of Kollsman's facility on 11 through 14 May 1965.	1. Kollsman TDRR proposal K532 was disapproved by MIT/IL on 23 August 1965. MIT/IL was contacted by Kollsman regarding the disapproval. MIT/IL in turn contacted AC Electronics on 17 September 1965 at the scheduled Configuration meeting. MIT/IL indicated to Kollsman after the subject meeting that TDRR K532 would be approved and all Kollsman Process Specification (KPS) references would be removed from the drawing in approximately four weeks. 2. Subsequently NASA (Mr. Dell) via letter to AC (Mr. Brady) modified the decision mentioned in paragraph one above. The modification was as follows: a. KPS's were removed as drawings were submitted for other changes. b. KPS's on NASA drawings were considered as reference only. 3. In agreement with AC, the following ground rule was applicable to KPS removal from drawings. During the normal processing of TDRR's to MIT/IL, Kollsman reviewed the specified drawing for KPS reference note. When a KPS reference note was indicated, a notation was added to the TDRR requesting KPS removal. 4. Number of drawings with KPS reference. KPS References 198 KPS Removed 0

TABLE 6-1 (Page 2 of 5)

MANAGEMENT PROBLEMS RESOLVED

PROBLEM	CORRECTIVE ACTION
Kollsman forwarded the final status report of the NASA-MSC audit of 11-14 May to AC Electronics during this reporting period. Specifically, this report covers action items completed by Kollsman in regard to the recommendation made in the NASA-MSC Quality Control Report of 1 June 1965.	Paragraph V. A. of NASA Audit Report: 1. The Quality Control Manual Procedure QCI-2SQ-001A, "Drawing and Specification Change Control" has been approved by the KIC resident AFQAR, released, and implemented. ACTION: COMPLETE. 2. Reference drawings have been prohibited for use by Manufacturing and Inspection personnel and have been removed from their respective areas. ACTION: COMPLETE. 3. A new format now requires approval signatures on first page and revision letter on all pages of Quality Control Instructions. ACTION: COMPLETED. 4. A TDRR, initiated by Kollsman, requesting that all KPS references on drawings be removed as one effort, was rejected. Approach now is that as drawings are submitted for other changes, request to remove KPS reference is added to change. KPS's on NASA drawings are to be considered for REFERENCE ONLY per letter from Dell (NASA) to AC Electronics. ACTION: CONTINUOUS. 5. A KPS index has been issued to the Route/Tool Planners with instructions for using the index to reflect the latest KPS revision on the Route/Tool Sheets. Revision to, or a revised KPS Index is issued monthly. ACTION: COMPLETE.

TABLE 6-1 (Page 3 of 5)

MANAGEMENT PROBLEMS RESOLVED

	CORRECTIVE ACTION
	Paragraph V. B. of NASA Audit Report: 1. A new format for the Vendor Approval Summary is now used and includes both approval signatures and dates. ACTION: COMPLETE 2. Less than Class A parts are now identified as such prior to release from Receiving Inspection for stocking in the segregated stores area of the production stock room. Identification is per AOP-1 (Apollo Operating Procedure). ACTION: COMPLETE 3. A receipt and follow-up system is now in use in Receiving Inspection when parts are released prior to final acceptance. ACTION: COMPLETE. Paragraph V.C. of NASA Audit Report: 1. Procedure ARP-4 (Apollo Reliability Procedure) "Age Control for Limited Life Shelf Items" has been initiated and implemented. Remaining useful life of limited life items appears in the Acceptance Data Package shipped with each unit. ACTION: COMPLETE. 2. Present system allows traceability of all items fabricated from a particular lot or piece of raw material but the method is manual and slow. A Procedure for Electronic Data Processing of Configuration and Traceability (CAT) has been written, is being subjected to a trial run, and will be effected on AGE 109 Optical Unit Assembly. ACTION: COMPLETE.

TABLE 6-1 (Page 4 of 5)

MANAGEMENT PROBLEMS RESOLVED

CORRECTIVE ACTION

Paragraph V.D. of NASA Audit Report:

1. All forms and sketches relating to Material Review Reports are now cross referenced by the use of numbers or serial numbers. Black ball-point pens are now used.
   ACTION: COMPLETE.

Paragraph V. E. of NASA Audit Report:

1. All plug gages are now dipped in a protective coating and/or stored in a separate compartment.
   ACTION: COMPLETE.
2. Audits for conformance have been increased in the areas indicated by the NASA Report. The specific items referenced in the report have been corrected.
   ACTION: COMPLETE.
3. At the present time relocation to a more completely environmentally controlled area is planned for the Standards Laboratory as part of a major rearrangement and consolidation of facilities at our Elmhurst Plant. In the meantime, an air-conditioned location in Building F-3 has been provided for performing critical electrical measurements.

   In the air-conditioned Standards Laboratory area in Elmhurst, the filtered air supply is believed to supply satisfactory results for working standards calibration. This aspect of Standards Laboratory control will be further evaluated for the new Standards Laboratory. The Metrology Laboratory at Syosset is in a controlled access area and has a filtered air supply. Temperature and humidity readings are recorded daily. The Syosset Metrology Laboratory is awaiting completion of the relocation of facilities which is also taking place at our Syosset Plant.

TABLE 6-1 (Page 5 of 5)

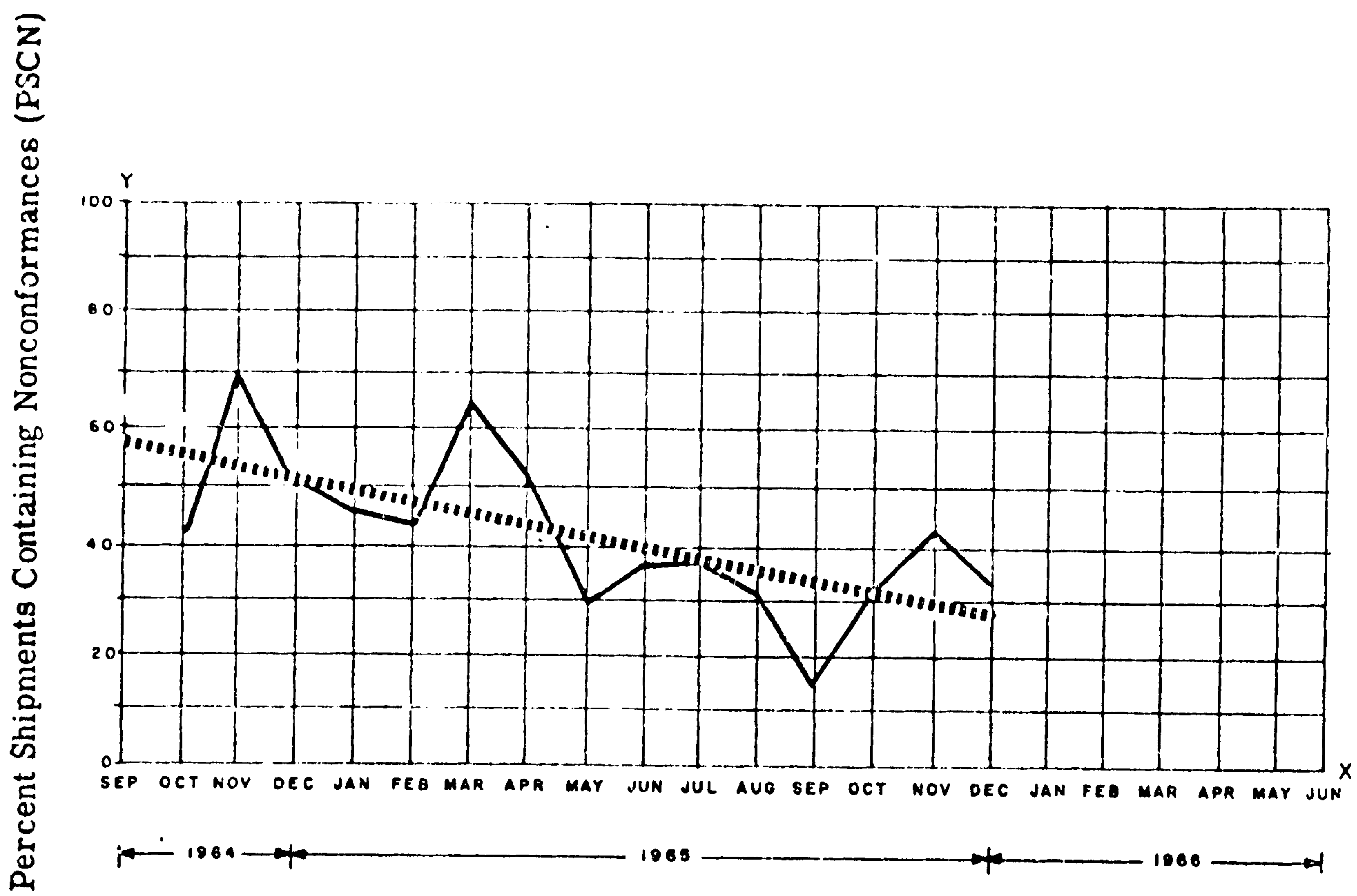
MANAGEMENT PROBLEMS RESOLVED

	CORRECTIVE ACTION
	Paragraph V. E. of NASA Audit Report (cont'd): It should be noted that in cases of critical measurements, such as surface flatness or concentricity measurements on optical and mechanical components, that such measurements are made only after temperature stabilization; that is, the components are allowed to temperature soak over a relatively long period of time so that the item being measured and the measuring equipment are at the same temperature, before the measurements are performed. ACTION: COMPLETE EXCEPT FOR RELOCATION OF FACILITIES. 4. Quality Control Instruction 9SQ001 "Test Equipment Control" and Quality Assurance Procedure 98550 "Gage Control" have been revised to include ratio requirement for equipment specified in JDQ's. ACTION: COMPLETE. 5. Kollsman system of Test Equipment calibration data and analysis has been modified and now meets both the intent and letter of NPC 200-2. ACTION: COMPLETE. 6. Practice of listing test equipment and serial number is now defined in change to Quality Assurance Procedure 98409.

TABLE 6-2

COMMAND MODULE/LUNAR EXCURSION MODULE

Year	Shipments		Units	
	Evaluated	Nonconforming	Inspected	Nonconforming
1965	2326	1523	54322	15005



—— MONTHLY PLOT

▮▮▮▮▮▮▮▮ LINEAR TREND

Percent Shipments Containing Nonconformances = PSCN

$$PSCN = \frac{\text{Shipments Nonconforming}}{\text{Shipments Received}} \times 100\%$$

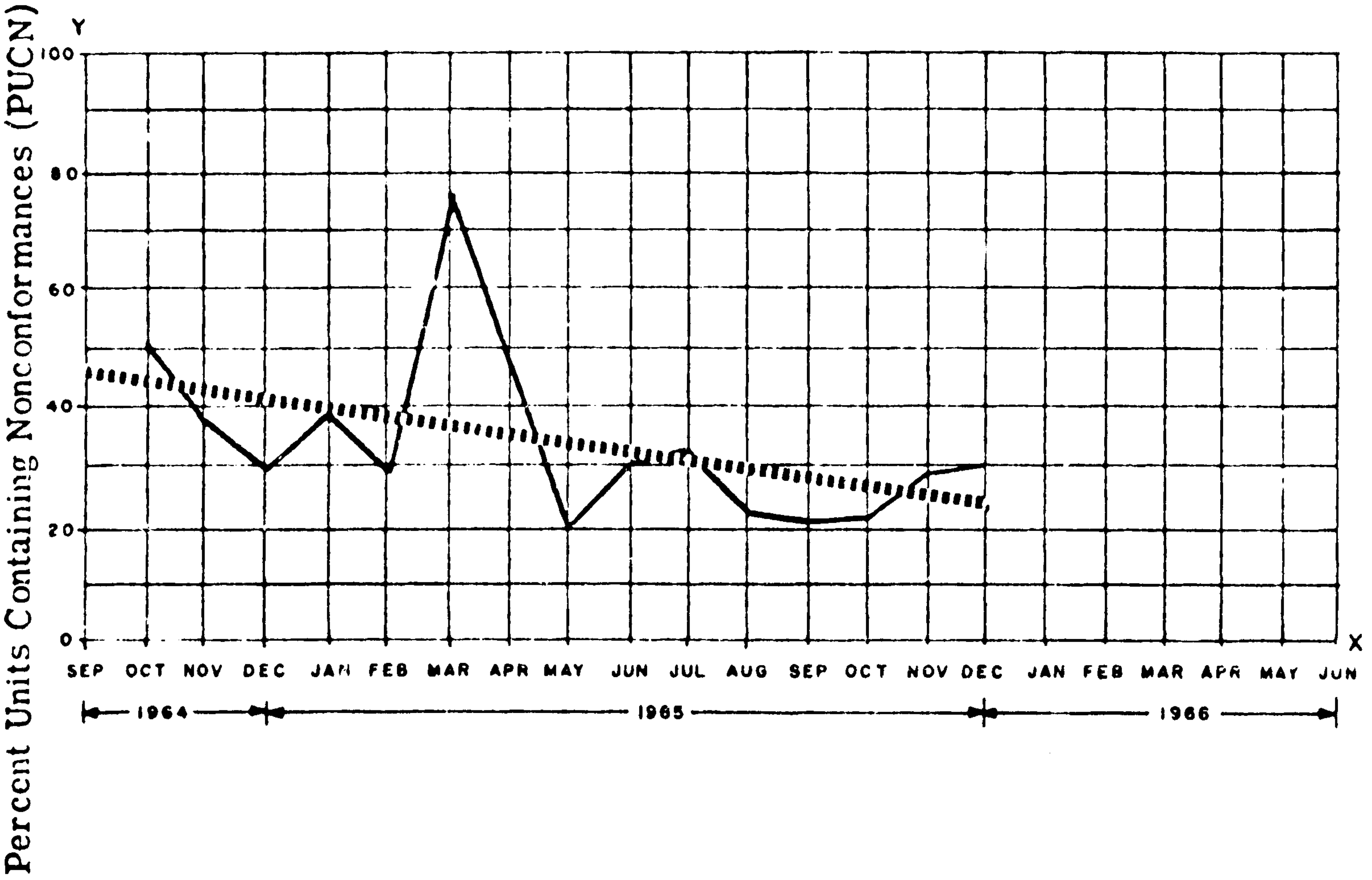
Linear Relationship Y = a - b x

a = Y Intercept

b = Regression Coefficient

Year	End of Quarter	
1965	1st	Y = 48.6 + 1.35x
	2nd	Y = 58.8 - 2.0x
	3rd	Y = 62.7 - 3.0x
	4th	Y = 57.5 - 1.9x

Figure 6-4. Procured Material (Shipment) Nonconformance Trend



MONTHLY PLOT   LINEAR TREND

Percent Units Containing Nonconformances = PUCN

$$\text{PUCN} = \frac{\text{Units Nonconforming}}{\text{Units Inspected}} \times 100\%$$

Linear Relationship Y = a - b x

a = Y Intercept

b = Regression Coefficient

Year	End of Quarter
1965	1st Y = 33.5 + 2.64x
	2nd Y = 44.4 - 1.08x
	3rd Y = 46.9 - 1.74x
	4th Y = 45.5 - 1.50x

Figure 6-5. Procured Material (Unit) Nonconformance Trend

Table 6-3

Nonconforming Material Evaluation for 1965, Reporting Periods

Most Critical Type of Material Nonconformance in Each Shipment	First Period 1965	Second Period 1965	Third Period 1965
Dimensional and/or Functional	192	147	149
Workmanship	82	95	134
Identification Marking	91	48	71
Incorrect and/or Incomplete Paperwork	56	36	36
Total Noncomforming Shipments	421	326	390

Table 6-

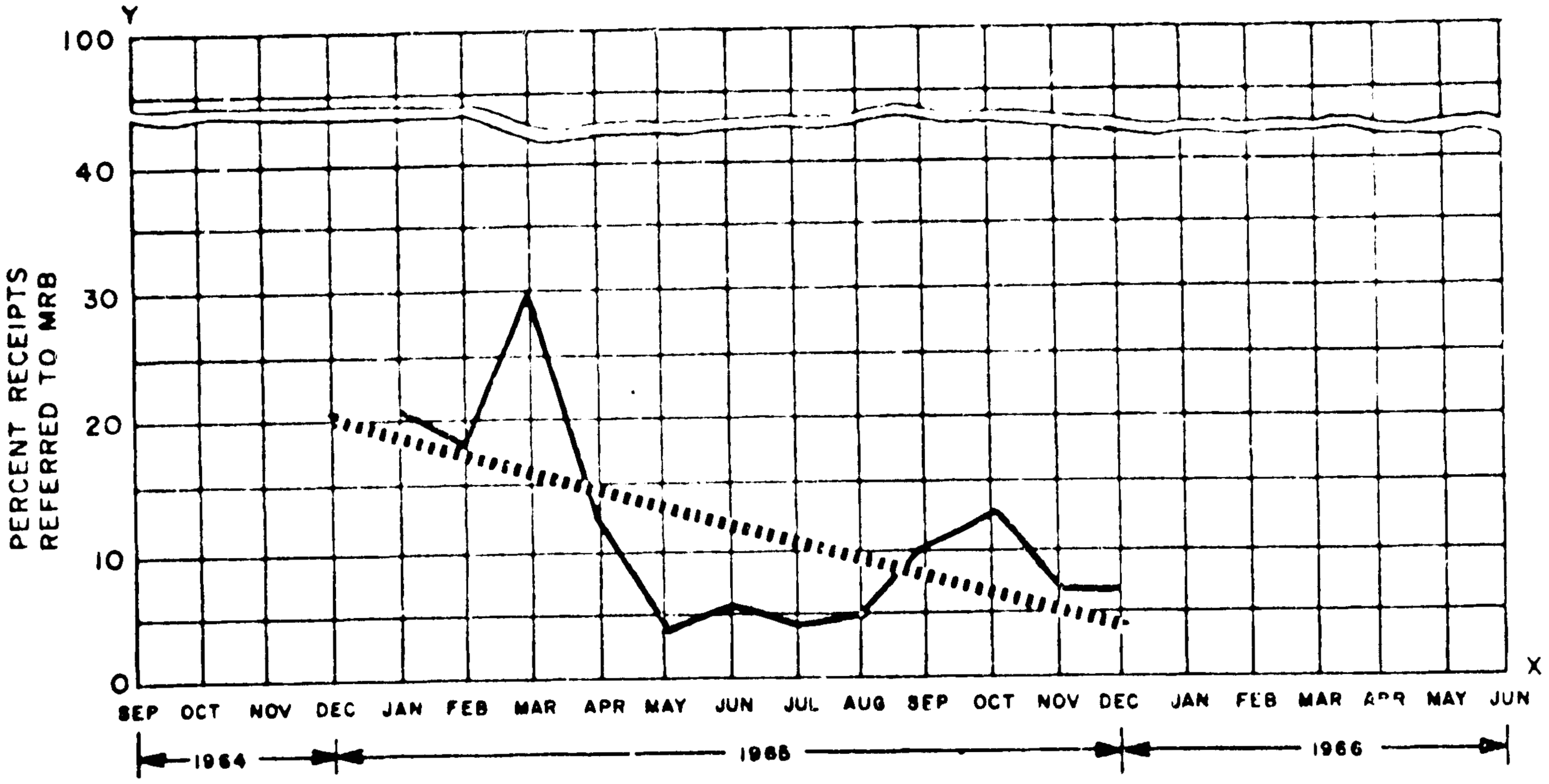
Procurement Material Review Action for 1965 Reporting Periods

COMMAND MODULE/LUNAR EXCURSION MODULE

Month	Formal Board Actions		Total FBA	Total Pieces	Shipments Received	FBA Percentage
	CM	LM				
Third Period 1965	70	12	82	1407	1051	7.8 (Avg.)
Second Period 1965	47	9	56		993	5.6 (Avg.)
Third Period 1965	82	4	86		1282	7.0 (Avg.)

FBA Percentage = $\frac{\text{Total FBA's}}{\text{Shipments Received}}$ x 100%

FBA = Formal Board Action



	1st	2nd	3rd
Formal Board Actions	82	56	86
Receipts (Shipments) Inspected	1282	993	1051

——— MONTHLY PLOT ------LINEAR TREND

Percent Receipts Referred to MRB = %

Linear Relationship Y = a - bx

a = Y Intercept

$$\% = \frac{\text{Formal Board Actions}}{\text{Receipts (Shipments) Inspected}}$$

b = Regression Coefficient

Figure 6-6. Material Review Activity Trend CM/LM (Procured Material)

Table 6-5

Status of ND 1015404 Supplier Surveys

COMMAND MODULE/LUNAR EXCURSION MODULE

Survey Activity	STATUS		
	First Period	Second Period	Third Period
Total Suppliers Surveyed	301	515	607
Approved	205	341	397
Conditional or Limited Approval	39	76	75
Disapproved	55	61	135
Sole Source Supplier	-	-	2
Total Resurveys and Surveillances	111	261	395

TABLE 6-6

DETAILED STATUS OF ACTIVE CONDITIONALLY APPROVED SOURCES

Supplier	Part Type	Date of Conditional Approval	Problem	Status of Corrective Action	Final Disposition
Photronics Flushing, N. Y.	Mirror Lenses	9-3-65	Inadequate inspection records	In process parts re-inspection 100% and recorded. Written procedures to be implemented.	9-30-65
Hudson Tool and Die Newark, N. J.	Sheet metal fabrication cans, shields stampings	7-20-65	Inadequate material control. Unacceptable QC plan.	Submission of QC manual and plan. Supplement Material Control Specification.	10-30-65
Golding Mfg. N. Arlington, N. J.	Sheet metal fabrication	6-15-65	Unacceptable QC plan.	Submission of manual and plan.	9-30-65
Metrigraphic	Reticles	6-3-65	Unacceptable QC plan.	Submission of manual and plan.	9-30-65
Diaphragm Industries Inc. Denvers, Mass.	Rubber seal	3-24-65	Unacceptable QC plan.	Submission of manual	9-30-65

TABLE 6-7

DETAILED STATUS OF INACTIVE CONDITIONALLY APPROVED SOURCES

Supplier	Part Type	Date of Conditional Approval	Problem	Status of Corrective Action	Final Disposition
Scheidl Freeport, New York	Fiberglass Fabrication	8-13-65	Inspection records and control of nonconforming material needs improvement.	No procurement.	None required.
Woodbine Prod. Deer Park, New York	Sheet metal	7-27-65	Inadequate QC plan.	No procurement.	None required.
H. Roessle Hicksville, New York	Metal spinning	6-28-65	Unacceptable QC plan.	No procurement.	None required.
Boxton Beel Brooklyn, New York	Optics	2-9-65	Unacceptable QC plan.	No procurement.	None required.

TABLE 6-8
DETAILED STATUS OF
LIMITED APPROVAL SOURCES (Page 1 of 3)

Supplier	Part Type	Date of Limited Approval	Limitation	Status of Corrective Action
Tangent Tools Farmingdale, N. Y.	Machining General	8-19-65	Class III only	Procurement to any other ND or product classification will require prior resurvey and QC approval.
Solarex Mfg. Farmingdale, N. Y.	Machining General	8-17-65	Class III only	Procurement to any other ND or product classification will require prior resurvey and QC approval.
Skyline Deer Park, N. Y.	Sheet metal fabrication	7-16-65	Class III only	Procurement to any other ND or product classification will require prior resurvey and QC approval.
Gear Components Valley Stream, N. Y.	Gears	6-30-65	Gears only	Procurement to any other ND or product classification will require prior resurvey and QC approval.
Narda Microwave Plainview, N. Y.	Test equipment	6-7-65	GSE only	Procurement to any other ND or product classification will require prior resurvey and QC approval.
Pratt and Whitney W. Hartford, Conn.	Worm gear	10-29-64	Worm Gear only	Procurement to any other ND or product classification will require prior resurvey and QC approval.

TABLE 6-8
DETAILED STATUS OF
LIMITED APPROVAL SOURCES (Page 2 of 3)

Supplier	Part Type	Date of Limited Approval	Limitation	Status of Corrective Action
Creskill-Stillman Englewood, N. J.	Rubber Products	7-27-65	Class III only	Procurement to any other ND or product classification will require prior re-survey and QC approval.
Gen. Astro Metals Yonkers, N. Y.	Processor of Be and machining	10-27-64	Raw Material only	Procurement to any other ND or product classification will require prior re-survey and QC approval.
K and E Hoboken, N. J.	Collimator Fabrication	4-22-64	GSE only	Procurement to any other ND or product classification will require prior re-survey and QC approval.
Greenfield Tap and Die Greenfield, Mass.	Worm Gear	9-26-63	Worm Gear only	Procurement to any other ND or product classification will require prior re-survey and QC approval.
Metavac Inc. Bayside, N. Y.	Optical Coating	6-10-65	Class III only	Procurement to any other ND or product classification will require prior re-survey and QC approval.
Bronner Tool Hanover, N. J.	Machining General	1-17-64	Precision machining except beryllium.	Procurement to any other ND or product classification will require prior re-survey and QC approval.

TABLE 6-8

DETAILED STATUS OF LIMITED APPROVAL SOURCES (Page 3 of 3)

Supplier	Part Type	Date of Limited Approval	Limitation	Status of Corrective Action
Vernon Plating Woodside, N.Y.	Plating	12-2-63	Approved for plating except black anodize.	Procurement to any other ND or product classification will require prior resurvey and QC approval.
C. L. Berger Boston, Mass.	Etching of reticles	7-23-65	Approval limited to etching of reticles (2nd tier supplier)	Procurement to any other ND or product classification will require prior resurvey and QC approval.
Messinger B. B. Philadelphia, Penna.	Ball Bearings	5-23-63	GSE Bearings only.	Procurement to any other ND or product classification will require prior resurvey and QC approval.
Customatic Stamford, Conn.	Machining general	5-7-63	Class III only	Procurement to any other ND or product classification will require prior resurvey and QC approval.
Braun Tool Hawthorne, N.J.	Flat Springs	4-17-63	Class III only	Procurement to any other ND or product classification will require prior resurvey and QC approval.
Electronic Sheet Metal Stoughton, Mass.	Sheet Metal Fabrication	11-17-65	FTE, GSE only MIL-Q-9858	Procurement to any other ND or product classification will require prior resurvey and QC approval.

INACTIVE CONDITIONALLY APPROVED SOURCES - Table 6-7 delineates in detail the status of inactive conditionally approved sources.

LIMITED APPROVAL SOURCES - Table 6-8 delineates in detail the status of limited approval sources.

QUALITY CONTROL SUPPLIER SURVEY VISITS - Table 6-9 delineates in detail the status of Quality Control supplier survey visits.

QUALITY CONTROL SUPPLIER RESURVEY VISITS - Table 6-10 delineates in detail the status of Quality Control supplier visits.

QUALITY CONTROL SUPPLIER SURVEILLANCE VISITS - Table 6-11 delineates in detail the status of Quality Control supplier surveillance visits.

QUALITY CONTROL SUPPLIER SURVEILLANCE AND NEGOTIATION - Table 6-12 delineates in detail the status of Quality Control supplier surveillance and negotiation visits.

IN-HOUSE CONFERENCES WITH SUPPLIERS - Table 6-13 delineates in detail the status of in-house conferences with suppliers at Kollsman.

ND 1015404 IMPLEMENTATION STATUS - Tables 6-14 and 6-15 indicate implementation status of ND 1015404.

PURCHASE REQUISITIONS AND ORDERS - The purchase requisitions processed by Quality Control during the reporting period totaled 2933. Purchase orders reviewed and released by QC totaled 2397 during the reporting period.

SUPPLIER PERFORMANCE RATING - Each supplier of Apollo material to Kollsman receives a quality rating based on the total past performance input. The rating is based on the formula:

$$1.00 - \frac{\text{No. of parts defective}}{\text{No. of parts inspected}} \times 100 \text{ percent} = \begin{array}{l}\text{Quality Performance} \\ \text{Rating expressed} \\ \text{as percent of parts} \\ \text{acceptable.}\end{array}$$

Categories B and C of the Quality Rating of each low-rated supplier are made available on a monthly basis to the Supplier Control Group of Quality Control for analysis and corrective action. This effort is coordinated with the Purchasing Department.

TABLE 6-9

QUALITY CONTROL SUPPLIER SURVEY VISITS (Page 1 of 4)

SUPPLIER	ADDRESS
Excello Tool and Die	Hicksville, New York
Accu-Rite Metal Products	Farmingdale, New York
Pioneer Instrument Co.	Hanover, Massachusetts
American Dura Film	Lower Newton Falls, Mass.
Parker Stearns	Brooklyn, New York
Westfield Gauge Co.	Westfield, Massachusetts
Cole Rubber and Plastics	Sunnyvale, California
Toyad Corporation	Latrobe, Pennsylvania
Cryotherm, Inc.	Fogelsville, Pennsylvania
Dale Electronics	Columbus, Nebraska
Metals and Controls, Inc. (Div. of T.I.)	Attleboro, Massachusetts
Thermal Circuits	Beverly, Massachusetts
Comco Plastics	Richmond Hill, New York
Chemoptics	New York, N. Y.
Central Gasket and Supply	Bellmore, New York
Mercury Plastics	Chicopee Falls, Massachusetts
Fountain Plating	Chicopee Falls, Massachusetts
Springfield Bronze and Aluminum	Springfield, Massachusetts
Lowry Engineering	Danbury, Connecticut
Inland Motors	Radford, New York
Ball Brothers	Denver, Colorado
United Transformer Company	New York, N. Y.
American Electroplating Co.	Cambridge, Massachusetts
General Electric	Syracuse, New York
Electronic Sheet Metal	Stoughton, Massachusetts
General Electric	Auburn New York
Cox and Company	New York, N. Y.

TABLE 6-9

QUALITY CONTROL SUPPLIER SURVEY VISITS (Page 2 of 4)

SUPPLIER	ADDRESS
Logus Manufacturing Company	Farmingdale, New York
Chris-Lin	Farmingdale, New York
General Aviation and Electronics	Wood Ridge, New Jersey
Delta Microwave Survey: Approved	Hackensack, New Jersey
Mercer Rubber Survey: Disapproved	Hamilton Square, New Jersey
Industrial Tectronics Inc. Survey: Approved	Ann Arbor, Michigan
Elgin Machine Corporation Survey: Approved	Valley Stream, New York
Kemet Company Surveillance: Soldering & Lot Control Procedure	Cleveland, Ohio
Metallurgical Heat Treating Survey: Approved	Syosset, New York
RCA Negotiations & Surveillance	Lancaster, Pennsylvania
Skyline Corporation Survey: Conditional Approval	Deer Park, N. Y.
Sprague Electric Surveillance	Concord, New Hampshire
Hudson Tool and Die Resurvey: Conditional Approval	Newark, New Jersey
Kinney Vacuum Resurvey	Pennsauken, New Jersey
Technical Machine Company Survey	Peekskill, New York
Scheidl Manufacturing Co. Resurvey	Copiague, New York
RCA Surveillance	Lancaster, Pennsylvania

TABLE 6-9

QUALITY CONTROL SUPPLIER SURVEY VISITS (Page 3 of 4)

SUPPLIER	ADDRESS
Speedring Corporation Surveillance	Warren, Michigan
Solarex Manufacturing Company Survey:	Farmingdale, New York
Island Precision Resurvey	Farmingdale, New York
Control Alloys Survey	Farmingdale, New York
Thomas Spring Company Survey	Farmingdale, New York
Gearcraft Inc. Survey	Hazel Park, Michigan
Tangent Tools Survey	Farmingdale, New York
Plastic Associates Inc. Survey	Jamaica, New York
R and D Tool Inc. Survey	Farmingdale, New York
L. I. Metal Spinning Co. Resurvey	Freeport, New York
Bayswater Craftsman Survey	Brooklyn, New York
W. L. Gore Surveillance	Newark, Delaware
American Time Products Resurvey	Woodside, New York
Photronics Inc. Resurvey	Flushing, New York
Metavac Inc. Surveillance	Bayside, New York
Thin Film Products Surveillance	Cambridge, Massachusetts

TABLE 6-9

QUALITY CONTROL SUPPLIER SURVEY VISITS (Page 4 of 4)

SUPPLIER	ADDRESS
American Time Products Critical Processes and Bonded File Established	Woodside, New York
C. L. Berger and Sons Survey: Conditional Approval	Boston, Massachusetts
G. E. Capacitor Division Negotiations: Critical Process Agreement	Irmo, South Carolina
W. L. Gore Surveillance and Critical Process List	Newark, Deleware
Astro-Gear and Instrument Co. Inc Surveillance	Stoughton, Massachusetts
Consolidated Testing Laboratory Surveillance	New Hyde Park, N. Y.
Dodge Fibers Corporation Survey	Hoosick Falls, N. Y.
Pioneer Astro Surveillance	Chicago, Illinois
Siliconix Corporation Surveillance	Mountain View, California
Solvere, Inc. Surveillance	Santa Ana, California

TABLE 6-10

QUALITY CONTROL SUPPLIER RESURVEY VISITS

SUPPLIER	ADDRESS	DATE OF VISITATION
	RESURVEY	
R and D Tool Company	Farmingdale, New York	1 October 1965
L and R Stamping Company	Farmingdale, New York	4 October 1965
Customatic, Inc.	Stamford, Connecticut	1 November 1965
Clifton Precision Products	Clifton Heights, Pennsylvania	17 November 1965
Texas Instrument	Dallas, Texas	7-8 December 1965
Scheidl Mfg. Company	Copiague, New York	14 December 1965
	SURVEY AND NEGOTIATION	
Fairchild Semiconductors	Mountainview, California	5 October 1965

TABLE 6-11 (Page 1 of 2)

QUALITY CONTROL SUPPLIER SURVEILLANCE VISITS

SUPPLIER	ADDRESS
American Time Products	Woodside, New York
Consolidated Testing Labs	New Hyde Park, New York
Astro Gear	Stoughton, Massachusetts
Bush Transformer Company	Westwood, Massachusetts
Qualitron	Danbury, Connecticut
Moore Special Tool	Bridgeport, Connecticut
Photronics	Flushing, New York
Metavac	Bayside, New York
American Beryllium	Sarasota, Florida
RCA	Lancaster, Pennsylvania
Photronics Inc.	Woodside, New York
Sanders Flexprint Division	Nashua, New Hampshire
American Time Products	Woodside, New York
Consolidated Test Labs	New Hyde Park, New York
Solvere Inc.	Santa Ana, California
Metavac Inc.	Flushing, New York
General Electric Company	Irma, South Carolina
Clifton Precision Products	Colorado Springs, Colorado
American Time Products	Woodside, New York

TABLE 6-11 (Page 2 of 2)

QUALITY CONTROL SUPPLIER SURVEILLANCE VISITS

SUPPLIER	ADDRESS
H. Roessle	Hicksville, New York
Pyrofilm Inc.	Cedar Knolls, New Jersey
Beryllium Mfg. Company	Valley Stream, New York
Pioneer Astro	Chicago, Illinois
Brush Beryllium	Cleveland, Ohio
W. L. Gore	Newark, Delaware
Astro Gear	Stoughton, Massachusetts
Clifton Precision Products	Clifton Heights, Pennsylvania
Pioneer Astro	Chicago, Illinois
Motorola	Phoenix, Arizona
Hudson Tool and Die	Newark, New Jersey
Austin Tool	Syosset, New York

TABLE 6-12

QUALITY CONTROL SUPPLIER SURVEILLANCE AND NEGOTIATION VISITS

SUPPLIER	ADDRESS
Continental Connector	Woodside, New York
Thin Film Products	Cambridge, Massachusetts
Metrigraphic	Stoneham, Massachusetts
Continental Connector Corp.	Woodside, New York
B. G. Instrument Company	Corona, New York
Diaphragm Industries Inc.	Danvers, Massachusetts
Radio Corp. of America	Lancaster, Pennsylvania
Speedring	Warren, Michigan

TABLE 6-13

IN-HOUSE CONFERENCES WITH SUPPLIERS AT KOLLSMAN

SUPPLIER	ADDRESS
Solvere, Inc.	Santa Ana, California
Moore Special Tool	Bridgeport, Connecticut
Pioneer Astro	Chicago, Illinois
Siliconix	Sunnyvale, California
Photronics	Flushing, New York
Metalcraft	Garden City, New York
Island Precision	Farmingdale, New York
Metals, Inc. (Div. of T. I.)	Attleboro, Massachusetts
Astro-Gear	Stoughton, Massachusetts
Wil-Nic	Corona, New York
Customatic	Stamford, Connecticut
Speedring	Warren, Michigan
Bush Transformer	Westwood, Massachusetts
New Hampshire Ball Bearings	Peterborough, New Hampshire

TABLE 6-13

IN-HOUSE CONFERENCES WITH SUPPLIERS AT KOLLSMAN

SUPPLIER	ADDRESS
New Hampshire Ball Bearing	Peterborough, New Hampshire
Photronics	Bayside, New York
Island Precision	Farmingdale, New York
Kearfott	Little Falls, New Jersey
New Hampshire Ball Bearing	Peterborough, New Hampshire
Bush Transformer Co.	Westwood, Massachusetts
Long-Lok Corp.	
Radio Corp. of America	Lancaster, Pa
Island Precision	Farmingdale, New York
All Metal Screw	Garden City, New York Clarification of Requirements
Kearfott	Little Falls, New Jersey SCD Requirements
Dr. Heidenhaim	8225 Travenreut Uber Traunstein Nannen Strasse, Germany ND 1015404 Negotiations

TABLE 6-14

ND 1015404 Class I and II Suppliers

COMMAND MODULE/LUNAR EXCURSION MODULE

Requirements	STATUS		
	First Period 1965	Second Period 1965	Third Period 1965
Inspection Plans Required	152	223	246
Approved	99	167	199
In Process	53	66	47
Traceability Plans Required	152	232	240
Approved	112	186	212
In Process	40	46	28
Critical Process Agreements Required	298	461	482
Approved	259	426	455
In Process	39	35	27

TABLE 6-15

ND 1015404 Process and Documentation

COMMAND MODULE/LUNAR EXCURSION MODULE

STATUS

Change Status	First Period 1965	Second Period 1965	Third Period 1965
Change Required Received	64	195	266
Accepted	23	136	208
Not Accepted	8	31	45
In Process	33	28	13

The breakdown of the purchase requisitions and purchase orders for the quarterly period is shown in Table 6-16 for the Command Module and Table 6-17 for the Lunar Excursion Module.

Quality Control reviewed 38 Job Parts List releases destined for Block II configuration. This review is part of the Fabrication Documents Control procedure, ensuring adequate control over procurement of machine shop parts. See Table 6-18 for breakdown of the Job Parts List reviewed and released for the reporting period.

TABLE 6-16

COMMAND MODULE

Purchase Requisitions and Orders Processed

Month	Purchase Orders Processed	Purchase Requisitions Processed	Total Processed
First Period	1027	1050	2077
Second Period	614	840	1454
Third Period	501	727	1228

Table 6-17

LUNAR EXCURSION MODULE
Purchase Requisitions and Orders Processed

Month	Purchased Orders Processed	Purchase Requisitions Processed	Total Processed
First Period	140	173	313
Second Period	79	87	166
Third Period	36	56	92

TABLE 6-18

Job Parts List Releases
COMMAND MODULE/LUNAR EXCURSION MODULE

Month	Quality Control Review
First Period	146
Second Period	97
Third Period	38

SUPPLIER QUALITY RATING STATUS- Table 6-19 "Quality Rating Status Chart" lists the number of Suppliers for the third quarter of 1965 and the fourth quarter of 1965 in their respective Quality Rating categories. Three (3) categories have been developed as follows:

Category A = Number of Suppliers with Monthly Quality Rating of 100 - 84 percent

Category B = Number of Suppliers with Monthly Quality Rating of 84 - 40 percent

Category C = Number of Suppliers with Monthly Quality Rating of 40 - 0 percent

Quality Control developed the graphs shown in Figures 6-7, 6-8, and 6-9 to illustrate the results during the reporting period.

PROCUREMENT PROBLEM AREAS - Table 6-20 lists procurement problem areas, their cause and status during the fourth quarter of 1965.

PROCUREMENT PROBLEMS RESOLVED - Table 6-21 lists procurement problems resolved, their cause and corrective action taken during the fourth quarter of 1965.

6.4.5 Quality Engineering

Quality Control (QC), as a member of the Manufacturing Release Committee, reviewed and approved 64 Class "A" drawings for the Block II Optical Unit Assembly (OUA) during the reporting period. Fourteen Class "A" drawings for the LM program were processed during this period.

Five hundred eighty-six engineering changes for the OUA were processed by QC as a representative on the Change Control Board (CCB).

Quality Control maintains a joint responsibility with Reliability for corrective action required as a result of failure analysis. A detailed description of actions instituted by the Failure Committee is included in the Quarterly Reliability Status Report.

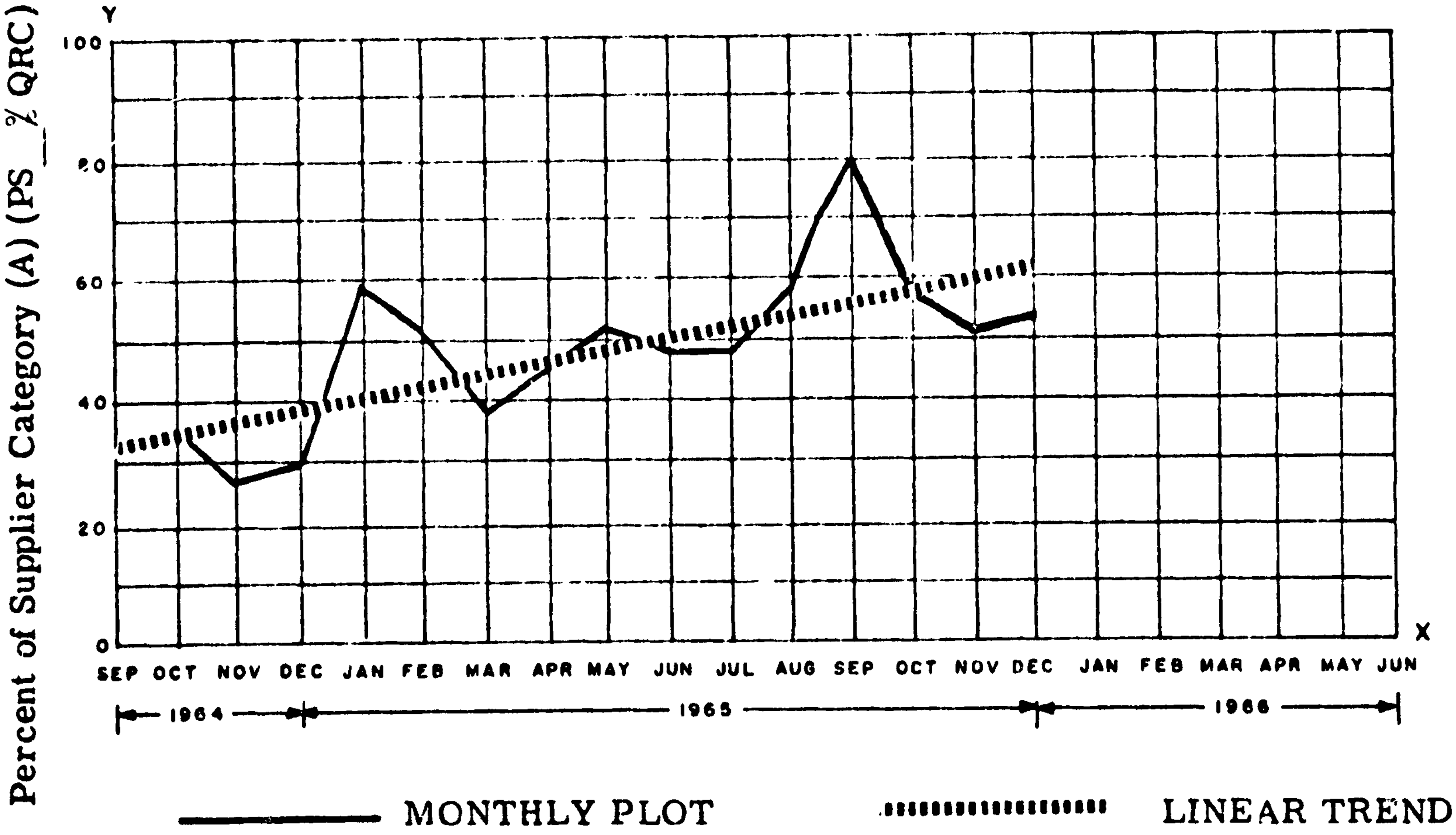
6.4.6 Fabrication Control

INSPECTION PROCEDURES - A total of 3668 inspection procedures received the attention of the Quality Control procedures group during this period. Of this total, 236 covered purchased items and 3432 supplied rework, engineering changes and manufacturing origin in-

TABLE 6-19

QUALITY RATING STATUS CHART

	CATEGORY A 100-84%		CATEGORY B 84-40%		CATEGORY C 40-0%		
Month	Number of Suppliers	Percentage	Number of Suppliers	Percentage	Number of Suppliers	Percentage	Total
First Period	166	50%	53	16%	114	34%	333
Second Period	171	56%	41	14%	91	30%	303
Third Period	196	53%	52	14%	123	33%	371



Percent of Suppliers in 100-84% Q. R. Category A = PS _% QRC

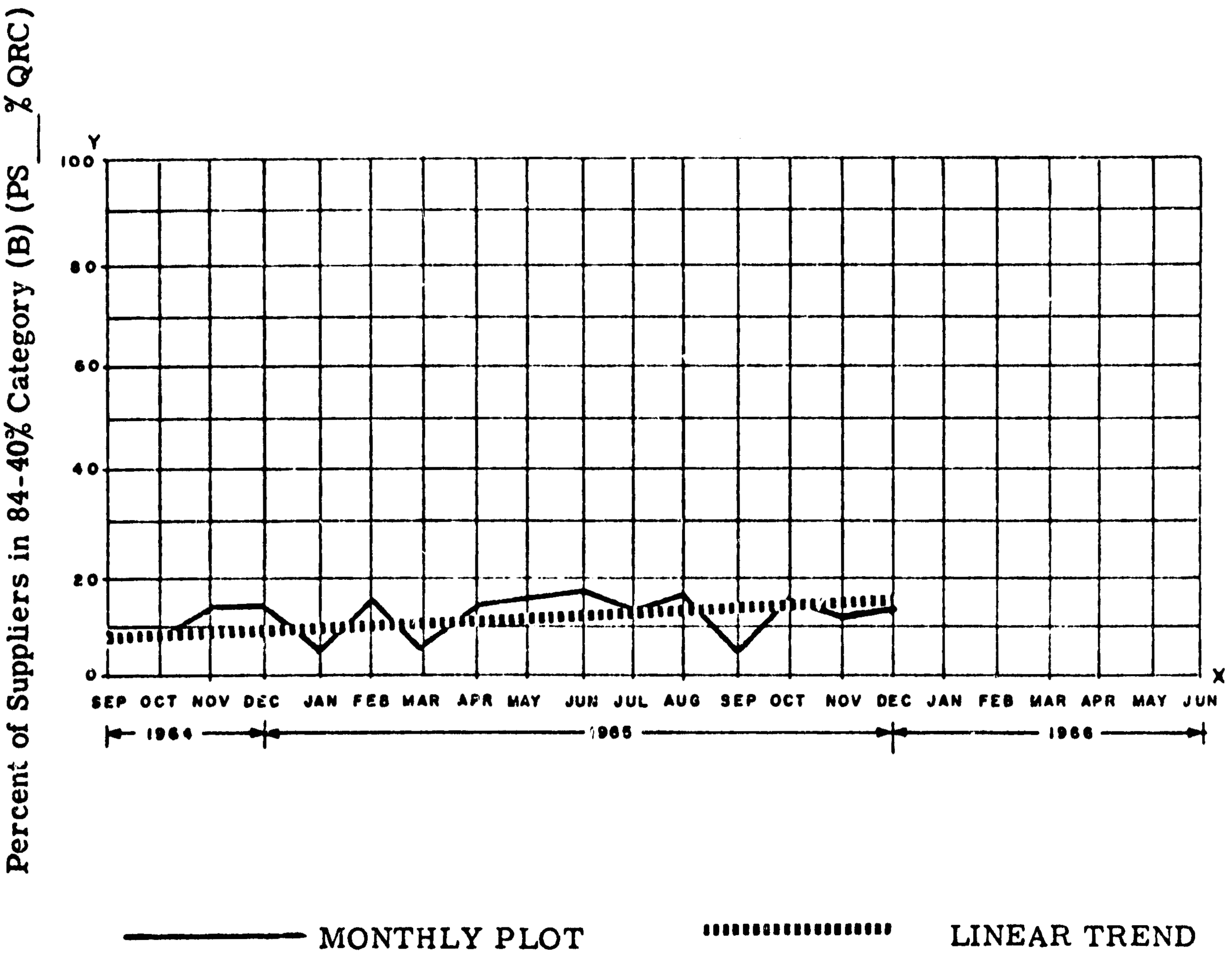
Linear Relationship Y = a + b x

a = Y Intercept

b = Regression Coefficient

$$\text{PS-\% QRC} = \frac{\text{No. of Suppliers in Category A}}{\text{No. of Suppliers Shipping Monthly}}$$

Figure 6-7. Trend of Suppliers in 100-84% Quality Rating Category



Percent of Suppliers in 84-40% Q. R. Category B = PS__% QRC

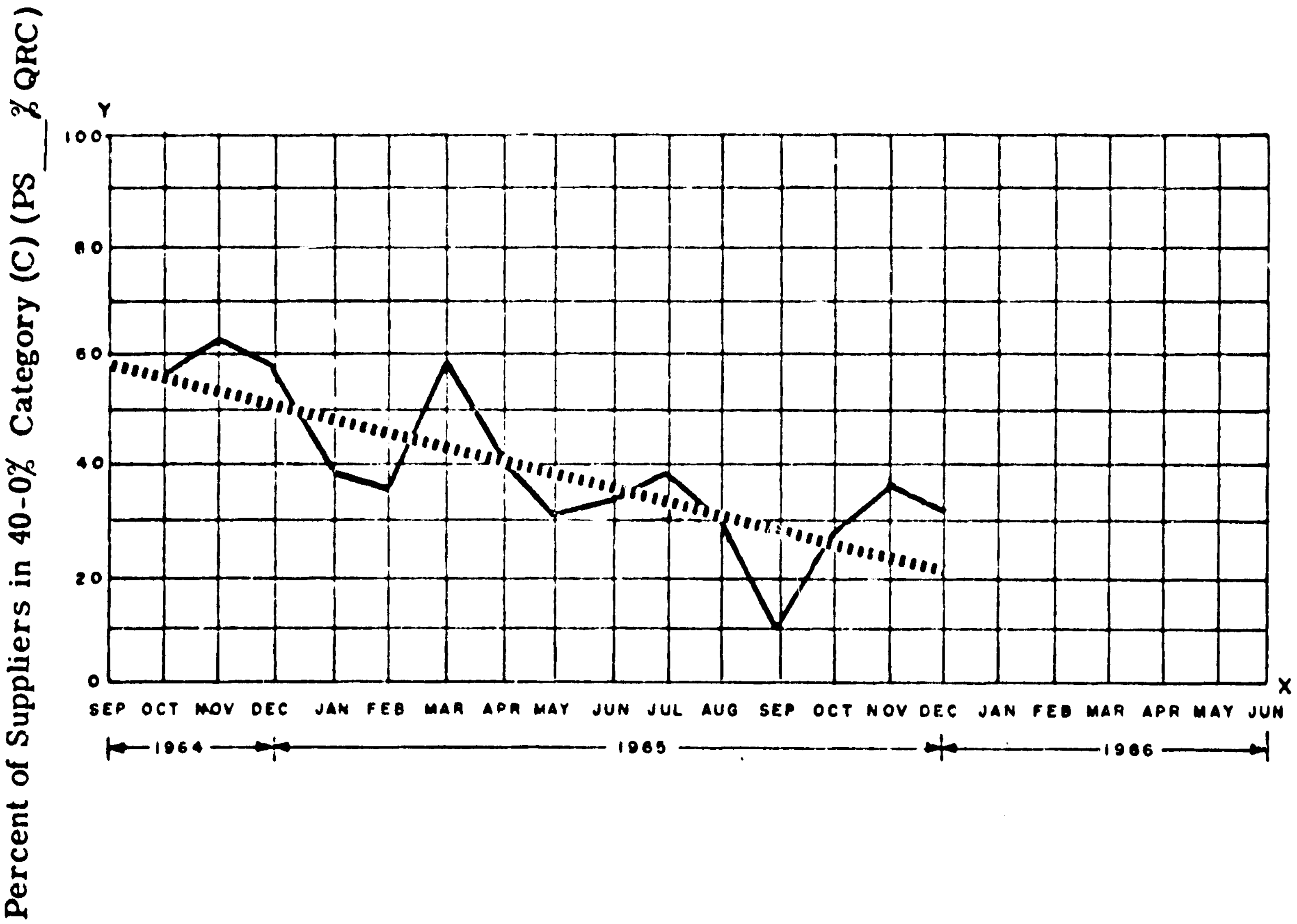
Linear Relationship Y = a + b x

a = Y Intercept

b = Regression Coefficient

$$PS\_\_\%\ QRC = \frac{\text{No. of Suppliers in Category B}}{\text{No. of Suppliers Shipping Monthly}} \times 100\%$$

Figure 6-8. Trend of Suppliers in 84-40% Quality Rating Category



— MONTHLY PLOT ⁞⁞⁞⁞⁞⁞⁞⁞ LINEAR TREND

Percent of Suppliers in 40-0% Q. R. Category C = PS ___% QRC

Linear Relationship Y = a - b x

a = Y Intercept

b = Regression Coefficient

$$PS\_\%\ QRC = \frac{\text{No. of Suppliers in Category C}}{\text{No. of Suppliers Shipping Monthly}} \times 100\%$$

Figure 6-9. Trend of Suppliers 40-0% Quality Rating Category

TABLE 6-20 (Page 1 of 4)

PROCUREMENT PROBLEM AREAS

PROBLEM	CAUSE	STATUS
Fairchild Semiconductor (Transistors) PN 1010342, PN 1010352, PN 1010431		
1. Traceability requirements of ND 1015404, para. 3.3.8, nonconformance. 2. Waivers presently required for all usage.	Disagreement between supplier and AC/KIC on adequacy of present Fairchild controls and expense of ND 1015404 requirements.	1. Coordination with AC for SCD change to relieve supplier of traceability requirements. 2. Contractual relief, other than waivers, required by AC and KIC.
OCLI and Photronics (Beamsplitter) PN 2012222		
1. Suppliers could not maintain flatness requirements as per drawing. 2. Parts and drifting out of specification.	Glass used had inherent unstable working characteristics and could not be stabilized.	KIC evaluation resulted in drawing change to more stable glass.
Chicago Miniature Lamp Works (Lamp) PN 1010493		
100 percent rejection rate for failure to meet SCD visual criteria and workmanship standards.	Supplier unable to manufacture lamps to SCD requirements due to state of the art.	1. KIC and AC Electronics joint drawing review resulted in extensive drawing changes. 2. Supplier and contractors drawing under negotiation prior to CCB approval.

TABLE 6-20 (Page 2 of 4)

PROCUREMENT PROBLEM AREAS

PROBLEM	CAUSE	STATUS
Erie Technological Products (Capacitor) PN 1012041		
1. Low yield (15%) by supplier in manufacture of capacitors. 2. Supplier refusal to continue manufacture of capacitors.	Electrical performance incompatibility with physical size of capacitors.	Drawing change derating electrical requirement is under discussion by KIC and supplier.

TABLE 6-20 (Page 3 of 4)

PROCUREMENT PROBLEM AREAS

PROBLEM	CAUSE	STATUS
High rejection rate on RCA Photomultiplier tubes, PN 1012043, due to defective leads	Leads inherently susceptible to damage due to processing and inspection at RCA (kinks, nicks, solder, etc.)	1. RCA to institute a lead Quality Program. Plan to be submitted to KIC for acceptance by 1 Oct. 1965. 2. KIC and RCA to establish acceptance criteria not later than 15 Oct. 1965.
Supplier (RCA) of Photomultiplier tubes, PN 1012043, experiencing extremely low yield, causing concern for possible schedule impact.	Design of units still in advanced state-of-the-art stage.	Two meetings held at supplier's facility to review design and manufacturing problems. 1. Proposed engineering personnel changes. 2. Proposed operator training program. 3. Supplier continuing investigation of design problems and manufacturing processes. 4. Supplier anticipates problem solution by 30 Sept. 1965. 5. Supplier will submit progress information to KIC via a monthly presentation. 6. KIC processing SCD change. 7. Metal glass seals will be supplied with each lot for lead verification.

TABLE 6-20 (Page 4 of 4)

PROCUREMENT PROBLEM AREAS

PROBLEM	CAUSE	STATUS
Fairchild AFQAR report to NASA-MSC that Taylor Electronics (distributor) has not been passing KIC Purchase Order QC requirements to Fairchild.	Fairchild will not accept direct procurement for quantities less than 1000.	1. KIC requested copies of Purchase Order from Taylor Electronics. 2. KIC AFQAR requested specific details from Fairchild AFQAR. 3. KIC scheduled trip to Fairchild for 28 Sept. 1965.

TABLE 6-21 (Page 1 of 6)

PROCUREMENT PROBLEMS RESOLVED

PROBLEM	CAUSE	CORRECTIVE ACTION
Thermal Circuits Inc. (Heater Pad) PN 1012531		
1. Sole source supplier per QSL.	1. Drawing change from ND 1015404 Class III to Class II.	1. KIC requested thermal circuits removal from QSL.
2. Will not comply with ND 1015404 Class II requirements.	2. No parts procured.	2. KIC requested that Cox and Company, Inc. be placed on QSL.
Bush Transformer Co. (Transformer) PN 1012148		
1. Transformers were rejected for failure to pass self oscillating frequency requests.	1. Excessive distributed capacitance in windings.	1. Implementation of a more precise winding lay procedure.
2. Additional testing revealed continuing degradation of induced voltage characteristics.	2. Faulty dielectric material or overstressing of electrical testing.	2. Failure analysis (including sectioning) of components.
Electra Mfg. Co. (Resistor) PN 1010364		
Supplier would not ship without' waiver of SCD qualification test requirements.	1. Qualification test not performed by supplier.	1. AC presently qualifying parts.

TABLE 6-21 (Page 2 of 6)

PROCUREMENT PROBLEMS RESOLVED

PROBLEM	CAUSE	CORRECTIVE ACTION
	2. AC letter 12-64 relieved Electra of Qualification Test requirements.	2. Supplier to certify design intent to meet Qualification Test.
Clifton Precision Products (Resolver) PN 1012157 and PN 1010341		
Broken lead wires - one unit had broken leads during qualification tests and several units examined at CPPC, Colorado exhibited broken strands.	Wires were bent at a right angle adjacent to the weld and flexing of wires during handling resulted in broken strands.	1. CPPC will change the weld configuration to eliminate right angle bend. 2. CPPC will investigate anchoring wires with epoxy. 3. KIC and CPPC will inspect available units for broken strands and effect repair where required.

TABLE 6-21 (Page 3 of 6)

PROCUREMENT PROBLEMS RESOLVED

PROBLEM	CAUSE	CORRECTIVE ACTION
Following documents require changes: ND 1002224- General specification for extremely low reflection coatings. ND 1002242- General specification for thin film coatings to enhance reflectance of front-surfaced aluminized mirrors	1. Did not cover ultraviolet range as required by tracker and photometer optics. 2. Lot sampling requirements not clearly defined. 3. Test requirements not clearly defined. 4. Spectrophotometer angle of incidence measurement was incorrect.	ND 1002242 - Quality Control initiated preliminary TDRR, K478 to MIT/IL. ND 1002224 - Quality Control initiated changes for submission to MIT/IL.
DODQAR at New Hampshire Ball Bearing Co. would not approve shipment of parts to KIC pending: 1. Monitoring of clean room to Class 100 relative to particle count. 2. Marking of bearings in lieu of tagging. 3. Inadequate supplier certification of lubricant.	NHBB Class 100 clean room not monitored as per Fed. Std. 209. DODQAR, W. Knight, felt that marking specification was ambiguous. NHBB was buying lubricant to Rev. "O" of ND 1002077.	KIC-QC meeting with NHBB and DODQAR resulted in: 1. Clean room recertified by independent laboratory. 2. NHBB decision to purchase Rayco particle counter by 23 August 1965. 3. Marking of bearing inner container was in compliance with ND 1002019. 4. Certification by GE was deemed satisfactory. 5. NHBB to purchase Rayco particle counter for delivery in October 1965, and will monitor the clean room to Fed. Standard 209.

TABLE 6-21 (Page 4 of 6)

PROCUREMENT PROBLEMS RESOLVED

PROBLEM	CAUSE	CORRECTIVE ACTION
Supplier American Time Products; product nonconformance 1. Foreign matter discovered in resonators. 2. An apparent frequency drift between supplier final inspection and assembly at KIC. 3. Black oxide coating removed around aperture.	1. Suppliers assembly area not sufficiently clean; method of installing inertia weight produces chips. 2. Burrs on inertia weight break free causing imbalance. 3. Mechanical gauging of aperture dimensions removing coating.	1. Steri-hood assembly has been installed by supplier and method of installing weights revised and documented. 2. Balancing procedure revised to provide instructions for removal of loose burrs from weights and to the cleaning of the unit after balancing. 3. An optical comparator will be used in the future to measure aperture dimensions.
Use of unqualified and uncertified soldering operators on flex cables by W. L. Gore Co.	1. W. L. Gore preferred to use a NASA-trained job shop facility for soldering. 2. Job shop had certification but was not qualified for miniature precision work.	1. Quality Control coordinated the temporary certification (30 days) of W. L. Gore personnel by a category II KIC instructor. 2. Job shop facility, Mohawk Electric, to certify W. L. Gore personnel. 3. KIC conducted a survey of W. L. Gore to verify use of qualified personnel.

TABLE 6-21 (Page 5 of 6)
PROCUREMENT PROBLEMS RESOLVED

PROBLEM	CAUSE	CORRECTIVE ACTION
Speedring Corp. optical elements nonconformances: 1. Inadequate packing of optical elements. 2. Disputed rejects on flatness and scratches. 3. No clearly defined areas of government inspection responsibility.	1. Packaging material contacting mirror surfaces. 2. Inspection equipment differences among KIC, Speedring and Speedring lower tier supplier (OCLI). 3. Speedring did not impose GSI requirements on lower tier suppliers.	1. Speedring to review entire cleaning and packing proceduré by 30 Sept. 1965. KIC supplied information on superior "anti-tarnish" lens tissue. 2. Speedring procured Davidson D-309 interferometer for flatness check. Tentatively agreed to procure B and L microscope for measuring scratches. This will now provide a related inspection to that of KIC and OCLI. 3. KIC to coordinate GSI request with resident AFQAR. Speedring will impose GSI on OCLI as directed.
High reject rate on All Metal Products Longlok screws, burrs, poor threads, etc.	**1. Insufficient designation of screw requirements.** **2. Poor quality of All Metal Products workmanship.**	1. Longlok agrees to supply instrument type screws from another source. 2. Each PO from KIC to Longlok will state "KIC requires Hi-Q Instrument type screw. Basic screw must be completely free of burrs."

TABLE 6-21 (Page 6 of 6)
PROCUREMENT PROBLEMS RESOLVED

PROBLEM	CAUSE	CORRECTIVE ACTION
Supplier of Pressure Seal, PN 6011096, (Diaphragm Industries, Inc.) has not been able to meet dimensional requirements of the drawing.	Supplier apparently not sufficiently knowledgeable of properties of material used and its reaction to molding process.	Supplier visited and procedures and controls reviewed. 1. Supplier obtained additional information on silicon rubber material properties from Dow Corning, mfr. of the material. 2. Supplier is confident that investigations and experimentation has provided sufficient data to permit production of acceptable parts.
1. Supplier of mirrors, PN 2012368, PN 2012369 and PN 2012451, (Photronics) reported sub-supplier experienced 20 penetrant inspection failures after part marking by electro etch. 2. Sub-supplier claimed parts are too small to mark per drawing and PO requirement.	1. Poor electro etch process control. 2. Inadequate marking equipment.	Checked for similar problems at KIC and other beryllium fabricators. Only likely cause determined to be improper neutralizing and cleaning after etching. Supplier QC checked process of subs facility. Contacted supplier to determine equipment available for marking. Also checked KIC marking procedures and equipment. 1. Supplier QC exercising closer control of sub-suppliers processing. 2. Supplier agreement to purchase recommended marking tools.

formation to the shop and assembly area. See Tables 6-22 and 6-23 for the breakdown of these figures for the Command Module and the LM on a monthly basis.

PROCESS CONTROL - Figure 6-10 illustrates five of the process control charts maintained by QC for trend analysis and corrective action implementation.

PROCESS CONTROL CORRECTIVE ACTION - Problem/Corrective Action (CA) Status of Chart No. 2, Welding Process and Chart No. 3, Hand Soldering Process (Figure 6-10) is listed in Table 6-24.

FABRICATION INSPECTION AND TEST - During the reporting period, 42,556 parts were inspected. Two thousand seven hundred forty-three parts were rejected for a average rejection rate of 7 percent. Table 6-25 represents a final summary for trend analysis and corrective action implementation. See Figure 6-11 for trend in percentage of parts defective (PP/OD).

ASSEMBLY INSPECTION AND TEST - During the quarterly reporting period 17783 assemblies were inspected. Eleven hundred seventy-seven assemblies were rejected for a average rejection rate of 6 percent. Table 6-26 represents a final summary for trend analysis and corrective action implementation. See Figure 6-12 for trend in percentage of assemblies defective (PAD).

6.4.7 Material Review Board

MATERIAL REVIEW ACTIVITY - Quality Control processed 196 Formal Board Actions (FBA) for the in-house section of the Material Review Board (MRB) during the reporting period. One hundred seventy-five FBA's were for the Command Module and twenty-one were for the LM fabrication activity. See Table 6-27 for additional analysis. Figure 6-13 illustrates the in-house assembly activity versus the Material Review Activity.

MATERIAL REVIEW CORRECTIVE ACTION- QC has investigated the cause of the nonconformances contributing to the FBA's processed during the reporting period, referenced in Figure 6-13. Corrective Action, as detailed in Figure 6-14, was initiated by QC to preclude recurrence of the nonconformances.

6.4.8 Problem Areas and Corrective Action

PROBLEMS RESOLVED - In-house fabrication problems resolved are listed in Table 6-28.

TABLE 6-22
Inspection Procedures Processed
COMMAND MODULE

Month	Purchased Items	Rework Eng. Changes Mfg. Origin	Total Inspection Procedures Processed
First Period	117	1001	1118
Second Period	49	934	983
Third Period	41	1107	1148

TABLE 6-23
Inspection Procedures Processed
LUNAR EXCURSION MODULE

Month	Purchased Items	Rework Eng. Chages Mfg. Origin	Total Inspection Procedures Processed
First Period	11	201	212
Second Period	10	105	115
Third Period	8	84	92

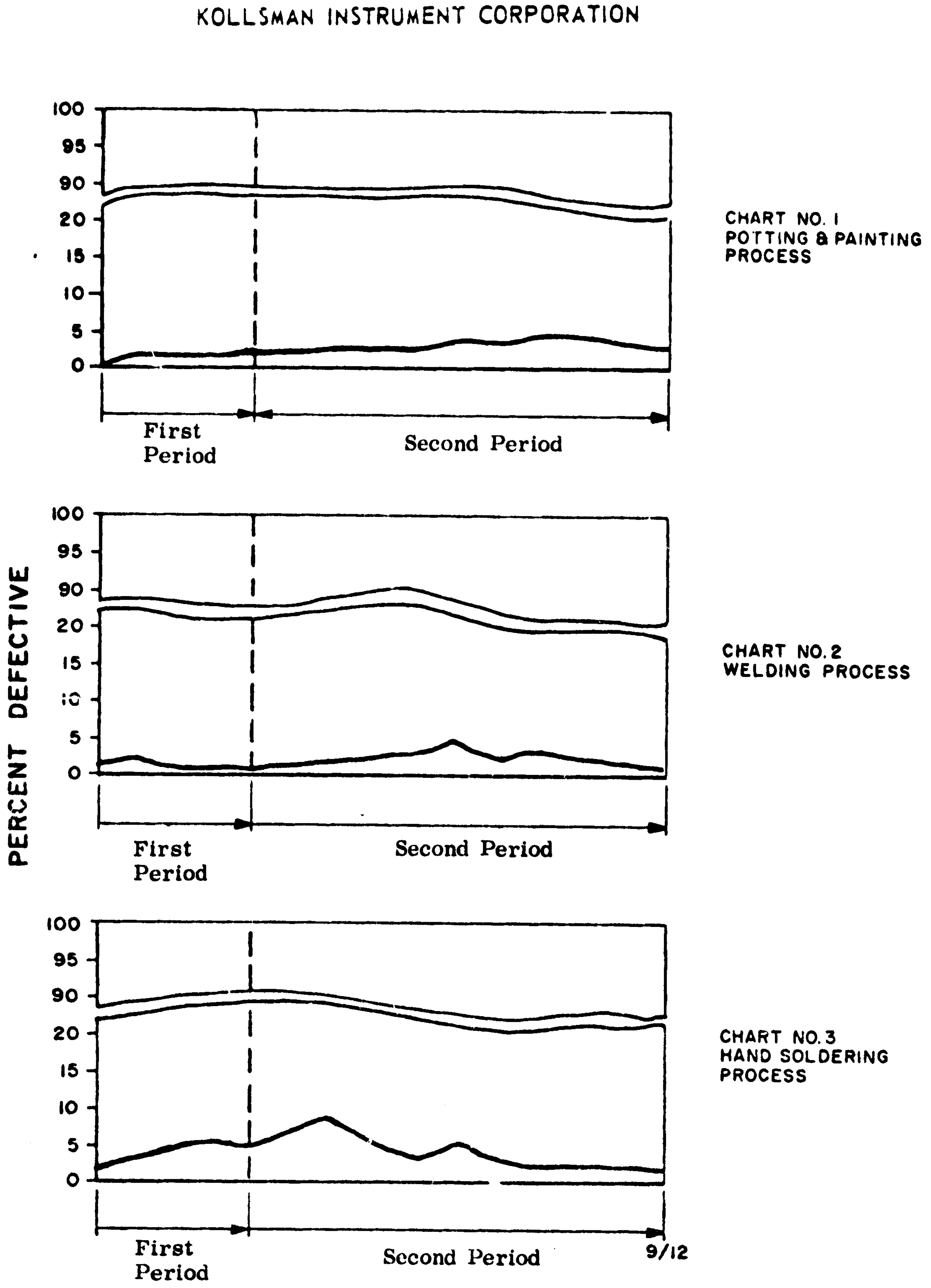


Figure 6-10. (Page 1 of 4) Process Control
(Computed on 3-week moving average)

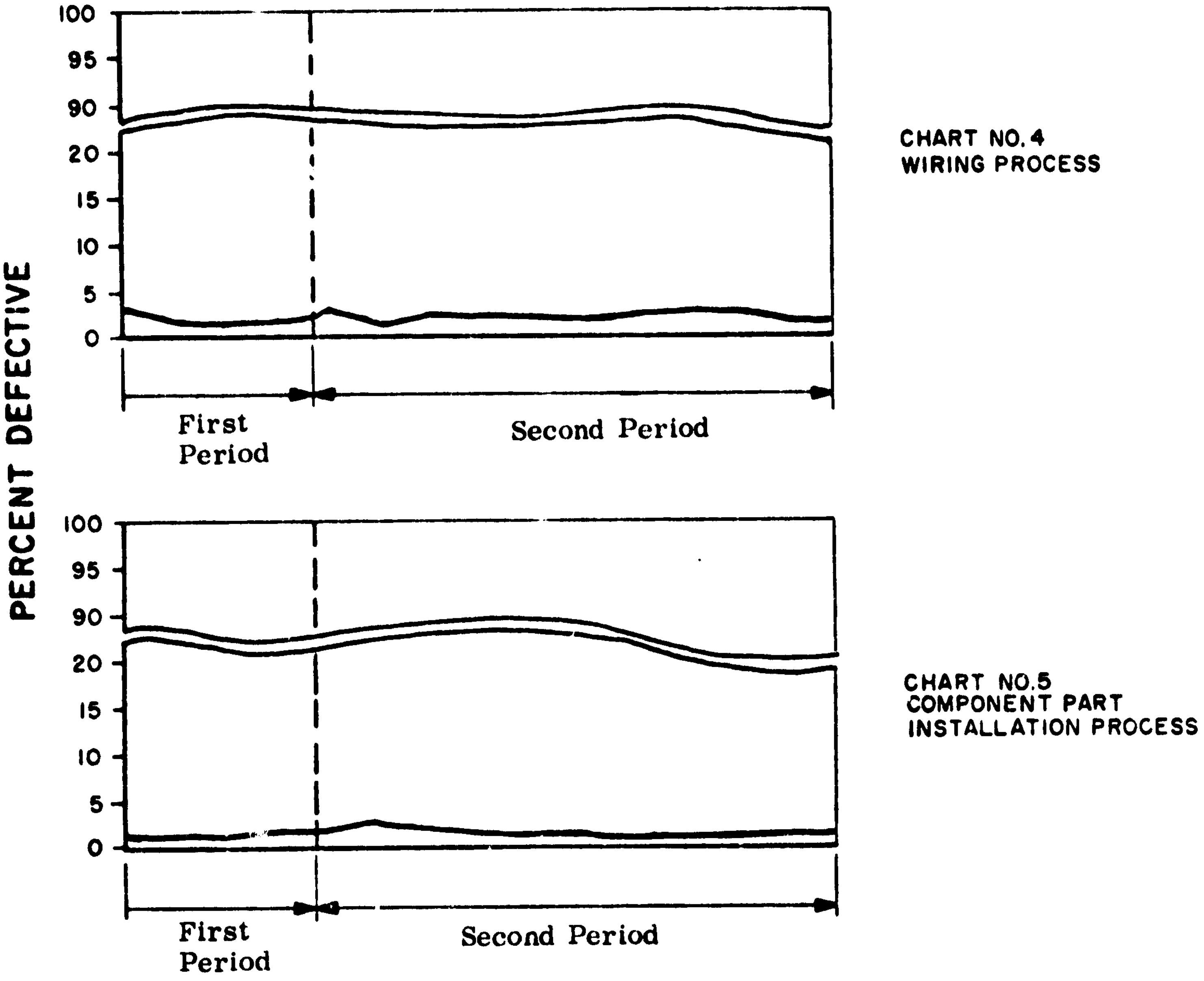


Figure 6-10. (Page 2 of 4) Process Control
(Computed on 3-week moving average)

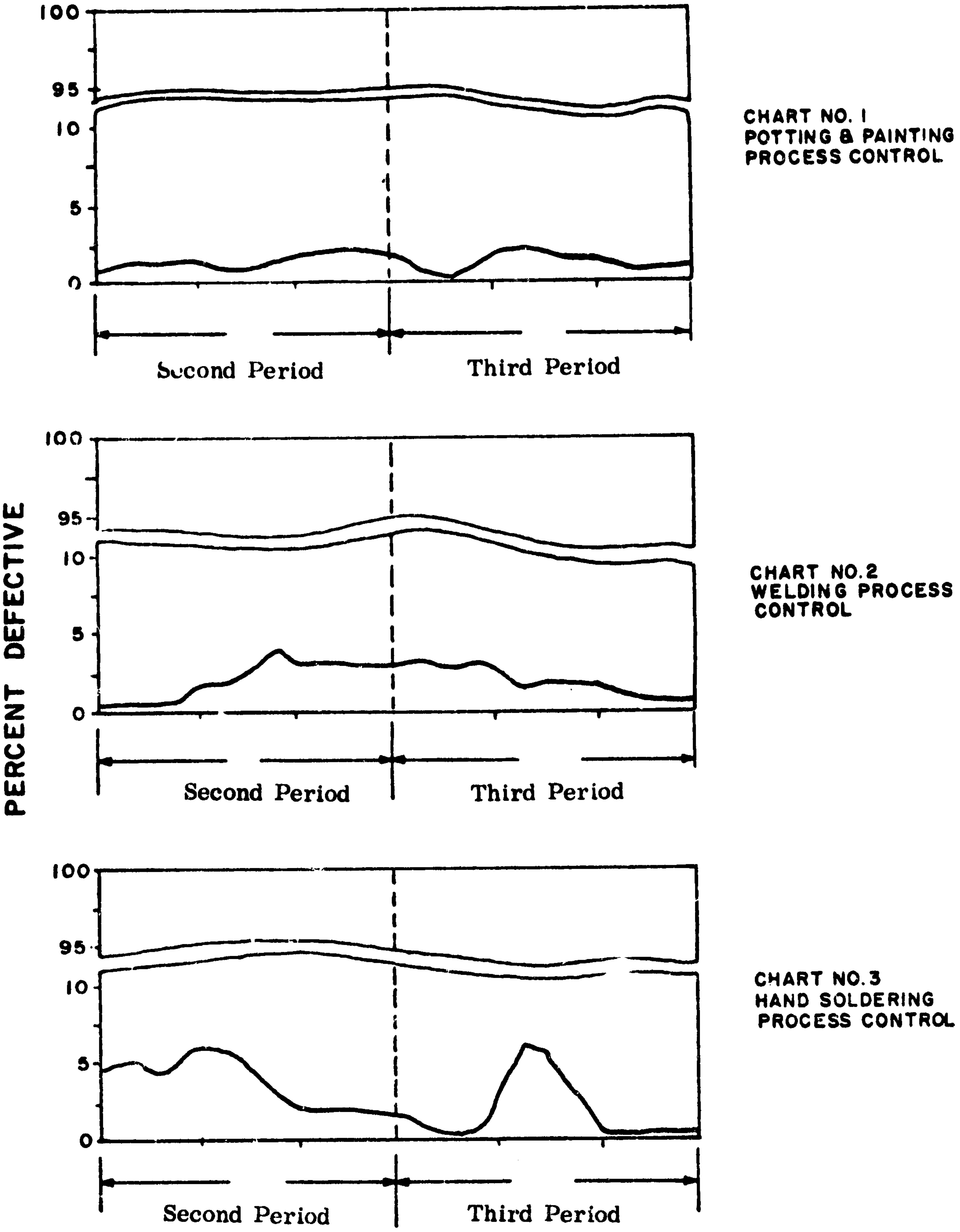


CHART NO. 1
POTTING & PAINTING
PROCESS CONTROL

CHART NO. 2
WELDING PROCESS
CONTROL

CHART NO. 3
HAND SOLDERING
PROCESS CONTROL

Figure 6-10 (Page 3 of 4) Process Control
(Computed on 3-week moving average)

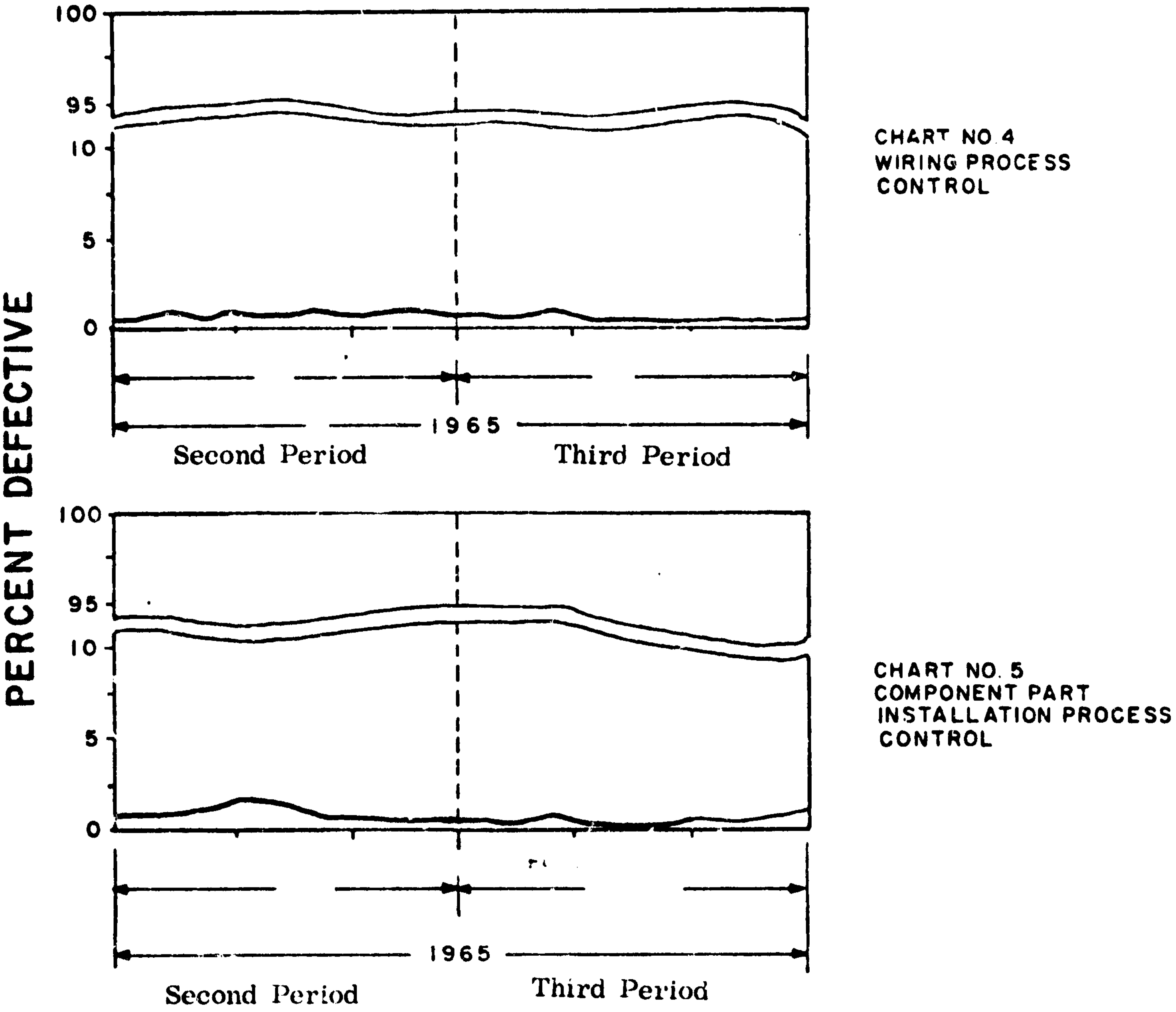


Figure 6-10 (Page 4 of 4) Process Control
(Computed on 3-week moving average)

TABLE 6-24 (Page 1 of 2)

Problem/Corrective Action Status (Figure 6-10)

Chart No.	○ ▼	Problem	Corrective Action
2	1	Rejected module assembly was attributed to a new operator employing poor practice techniques. All the welds on this module were misaligned and the leads were not trimmed, due to a missed operation.	1. Nonconforming operator was retrained by the Program Services Department Training Center.
	2	Subsequent workmanship problems influencing the three weeks average line attributed to four new operators, not including the operator referred to in Problem 1. above.	2. Four nonconforming operators rein approved welding practices by the Program Services Department Training Center.
	3	Trend analysis disclosed random influence of defective modules caused percent defective average to remain approximately constant at a 3 percent level. This was attributed to two nonconforming operators. Percent defective level dropped to 1.6 percent during November after two operators were removed from this process.	3. Two nonconforming operators were released permanently from the welding function.

TABLE 6-24 (Page 2 of 2)

Problem/Corrective Action Status (Figure 6-10)

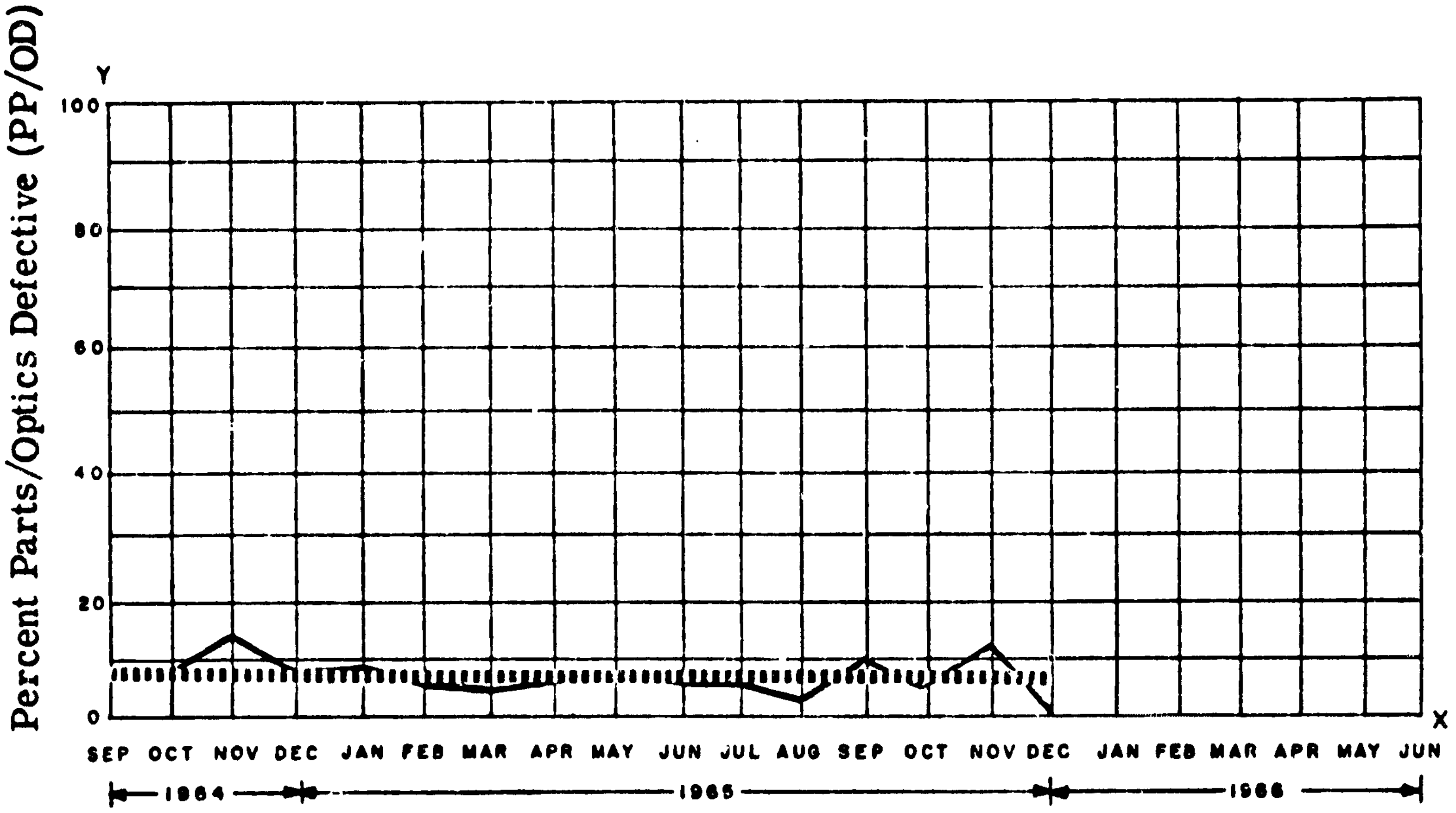
Chart No.	○ ▼	Problem	Corrective Action
3	1	Major causes are "insufficient solder" and "excessive solder." Approximately 75 percent of rejects are of these types. A variation from insufficient-to-excessive-to-insufficient was apparent. Over-correction seemed to be a fault.	1. Visual aids were procured in form of sample solder connections as prepared by NASA for indoctrination purposes. Quality Control conducted an investigation and evaluation of inspection and operations personnel performance relative to the "Hand Soldering Process." Deficient personnel were referred to the Program Services Department Training Center for retraining in the soldering skill.
	2	One lot of lead wires with incorrect strip gap was detected prior to use by assembly. Inspection control was alerted and instituted a tighter control check for this characteristic. Tooling was evaluated and modified by rework to correct this condition.	2. Instituted improved tooling and tighter inspection control procedure.

TABLE 6-25
COMMAND MODULE/LUNAR EXCURSION MODULE PARTS/OPTICS FABRICATION-INSPECTED/REJECTED

Month	Inspected	Rejected	Trend Indicator
First Period	28295	1871	7%
Second Period	8000	562	7%
Third Period	5261	310	7%

TABLE 6-26
COMMAND MODULE/LUNAR EXCURSION MODULE ASSEMBLY FABRICATION-INSPECTED/REJECTED

Month	Assembly Units Inspected	Assembly Units Rejected	Trend Indicator (Relationship ± to Previous Month)
First Period	6297	446	7%
Second Period	5880	369	6%
Third Period	5606	362	6%



▬▬▬ MONTHLY PLOT ┇┇┇┇┇┇ LINEAR TREND

% Parts/Optics Defective = PP/OD

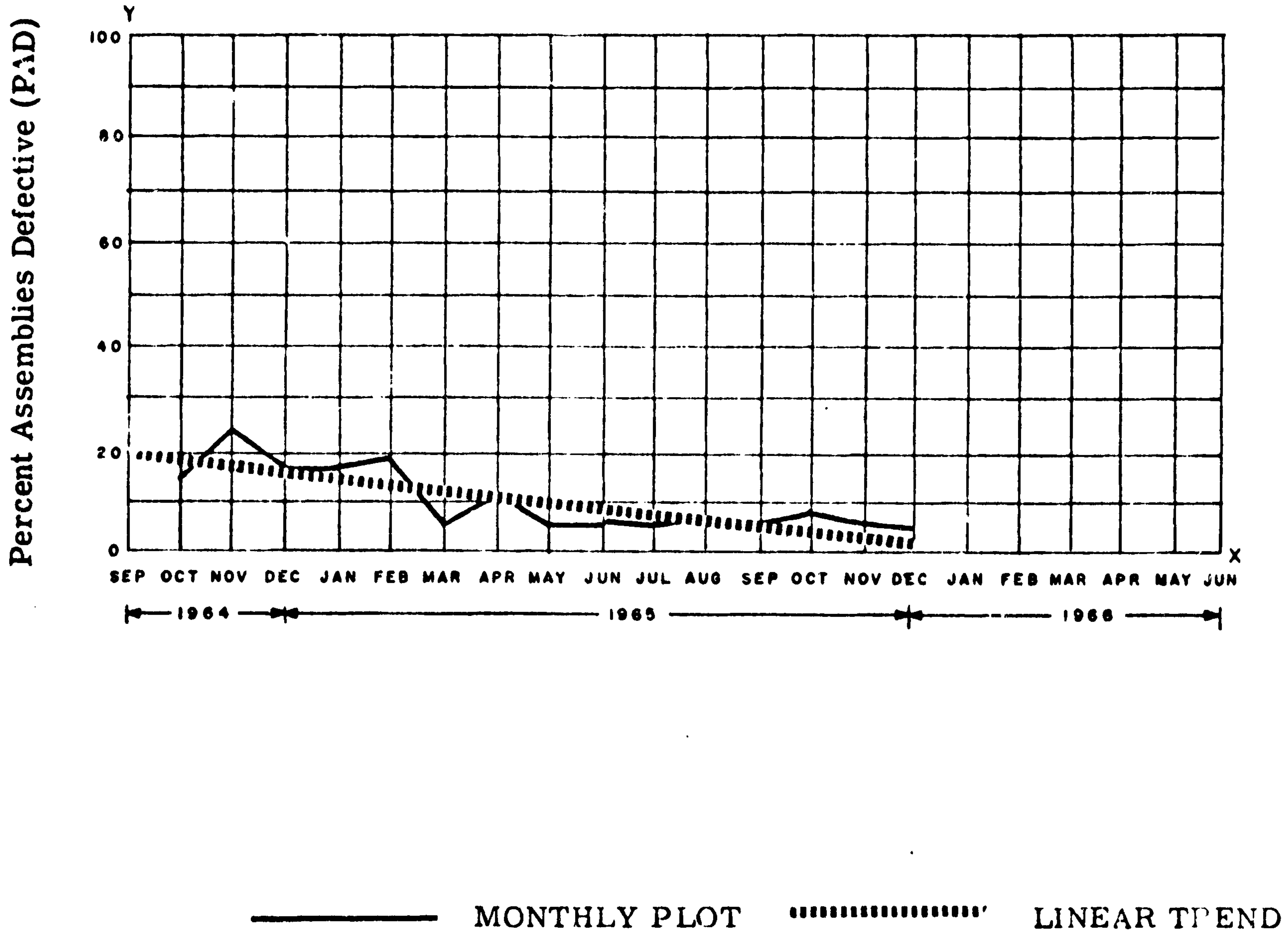
Linear Relationship Y = a - b x

a = Y Intercept

b = Regression Coefficient

$$PP/OD = \frac{\text{Parts/Optics Rejected}}{\text{Parts/Optics Inspected}} \text{ X } 100\%$$

Figure 6-11 Percentage of Parts/Optics Defective



Percent Assemblies Defective = PAD

$$\text{PAD} = \frac{\text{Assemblies Rejected}}{\text{Assemblies Inspected}} \times 100\%$$

Linear Relationship $Y = a - bx$

a = Y Intercept

b = Regression Coefficient

Figure 6-12 Percentage of Assemblies Defective

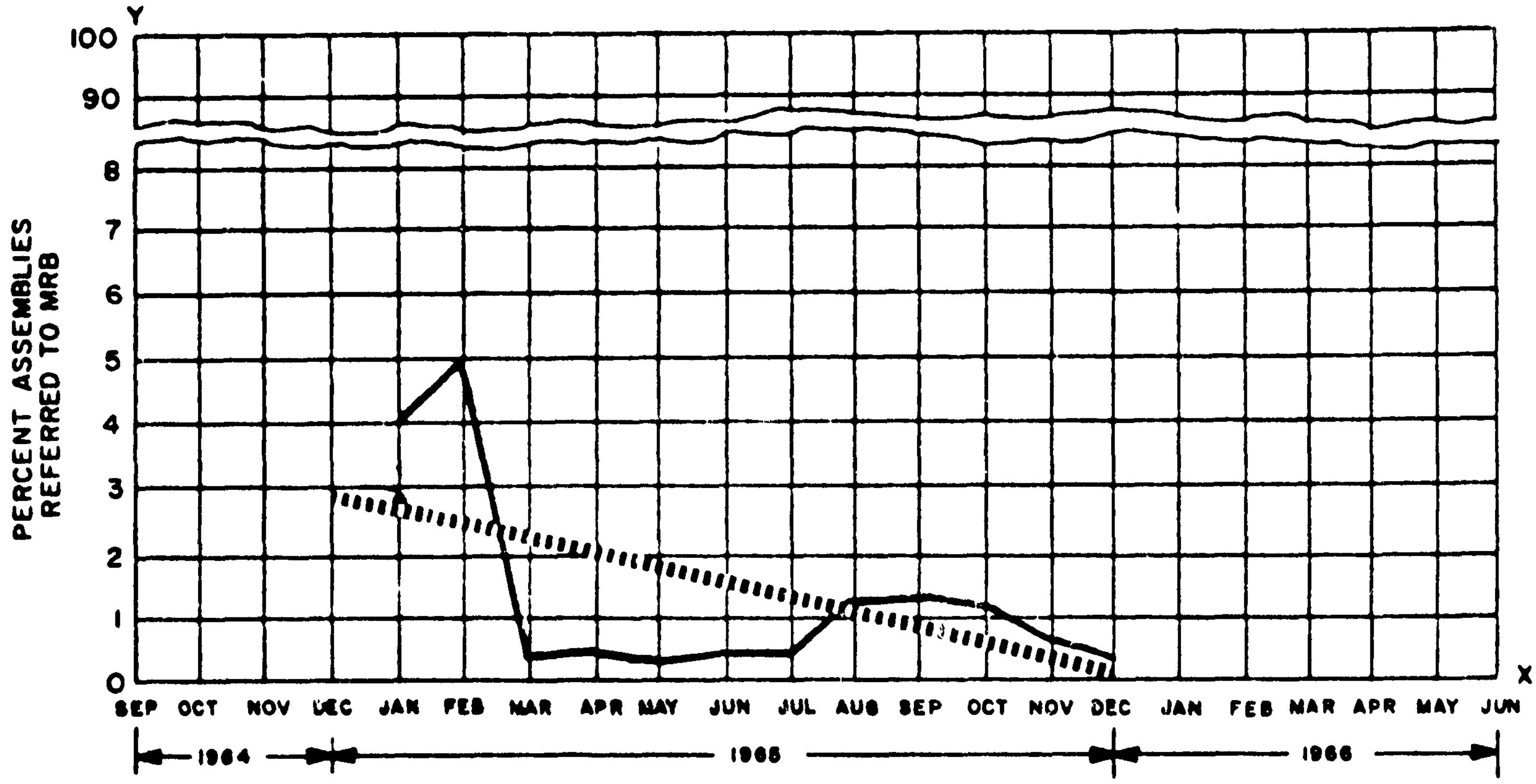
TABLE 6-27

In House Material Review Action

COMMAND MODULE/LM

Month	Formal Board Actions			Inspections			FBA Percentage
	C/M	LM	Total	Assembly	Shop	Total	
First Period	46	5	51	6297	28295	34592	.14
Second Period	75	8	83	5880	8000	13880	.60
Third Period	54	8	62	5606	5261	10867	.6%

$$\text{FBA Percentage} = \frac{\text{Total FBA's}}{\text{Total Inspections}} \times 100\%$$



	First	Second	Third
Formal Board Actions	46	75	54
Total FBA Pieces	34592	13880	10867
Assemblies Inspected	6297	5880	5606
Percent MRB	.14	.60	.60

________MONTHLY PLOT ----------LINEAR TREND

Percent Assemblies Referred to MRB = %

$$\% = \frac{\text{Formal Board Actions}}{\text{Assemblies Inspected}} \times 100\%$$

Linear Relationship $Y = a - b\,x$

a = Y Intercept

b = Regression Coefficient

Figure 6-13 CM/LM Material Review Activity Trend (In-House Assemblies)

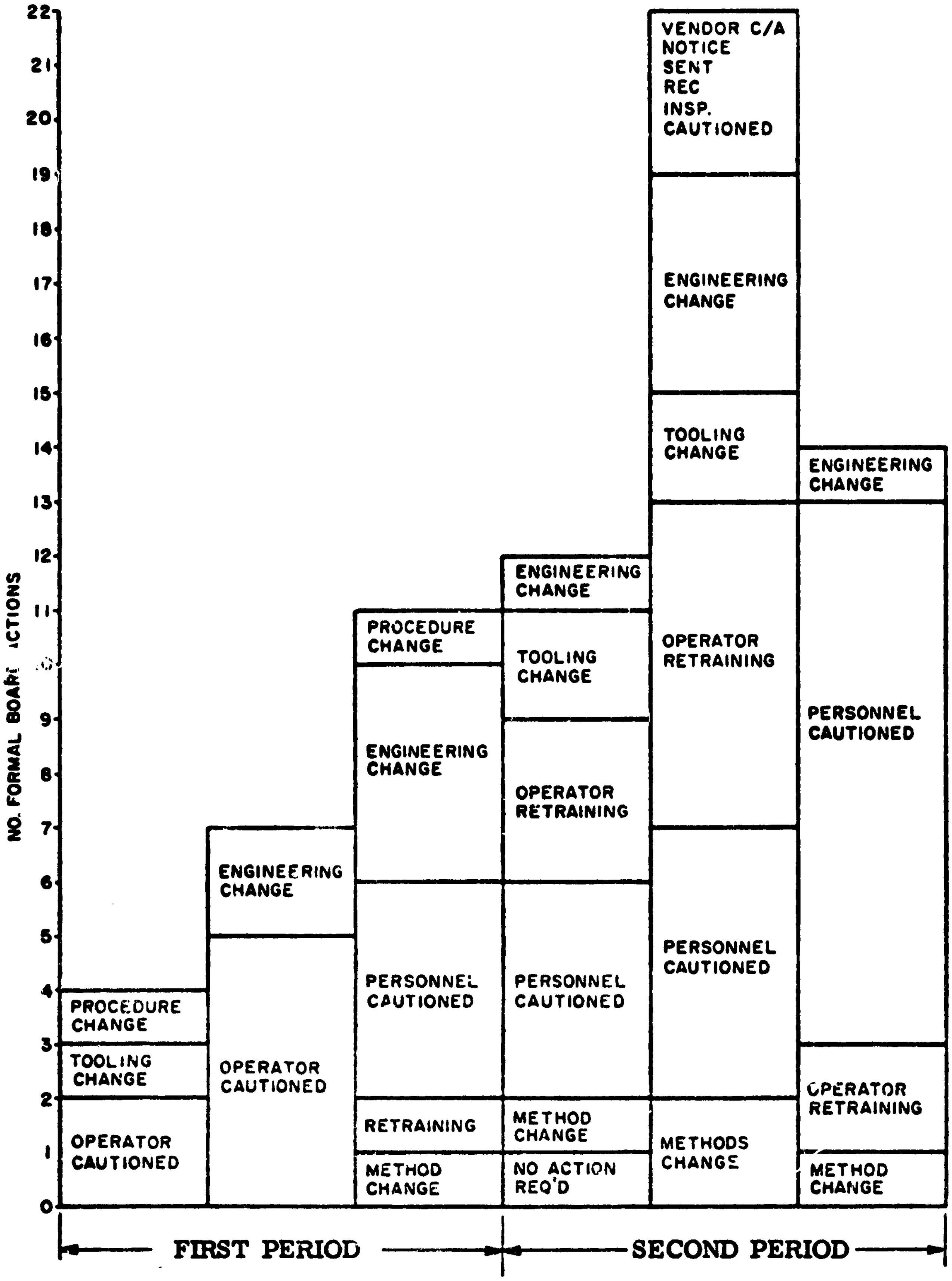


Figure 6-14. CM/LEM Material Review Corrective Action (In-House Assemblies)

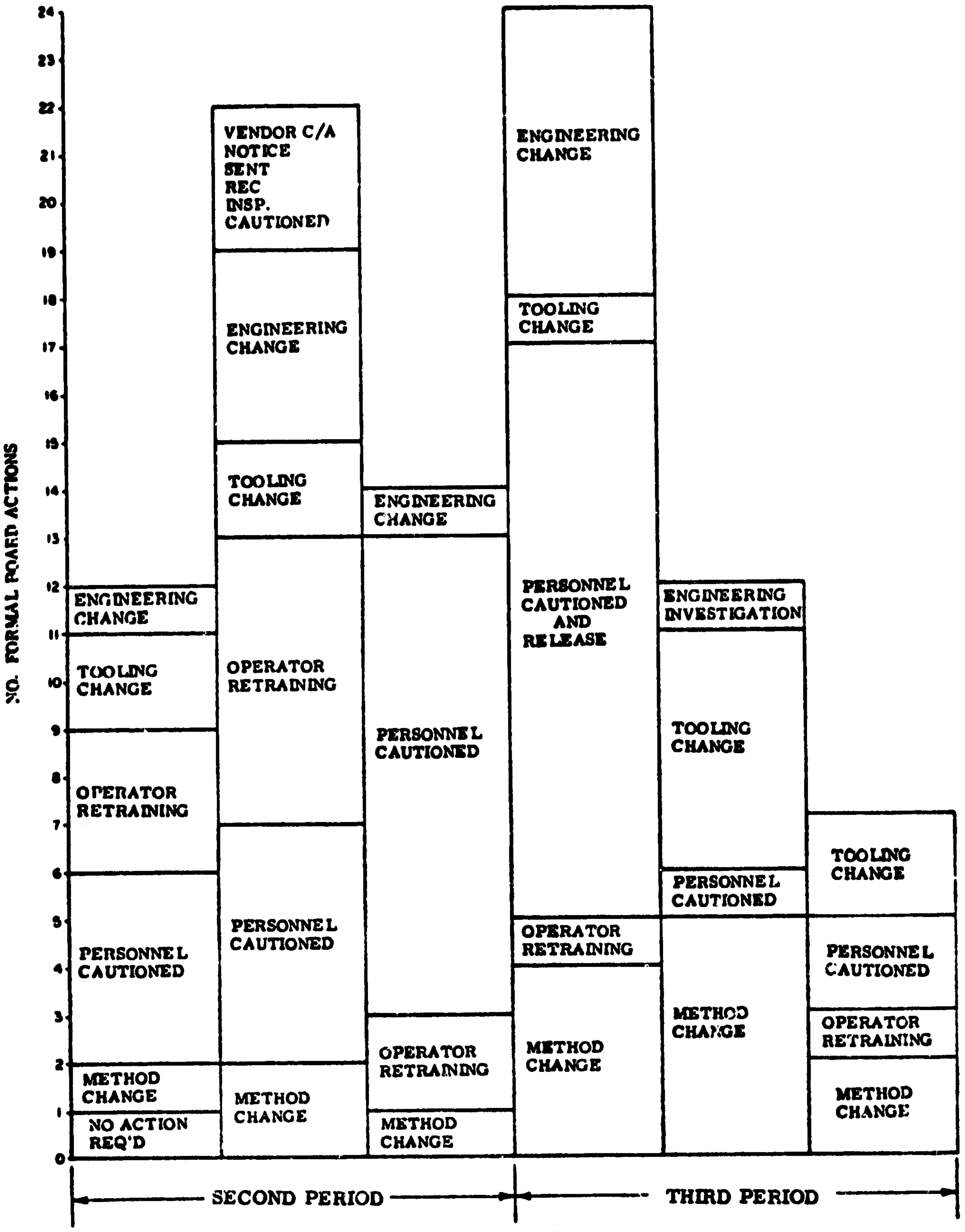


Figure 6-14. Material Review Corrective Action CM/LEM (In-House Assemblies

TABLE 6-28 (Page 1 of 5)

In-House Fabrication Problems Resolved

COMMAND MODULE/LUNAR EXCURSION MODULE

PROBLEM	CAUSE	CORRECTIVE ACTION
Excessive strain on the photomultiplier tube assembly.	Strain resulted from an out-of-perpendicularity condition between the photometer head electronics module and the photomultiplier housing. MIT/IL had removed the perpendicularity requirements from the module drawing.	Perpendicularity requirements have been imposed by KIC in the internal method sheets and inspection procedures.
Signal gradient for a +1.0 magnitude star exceeds specified limits due to incompatibility between test and procurement specifications.	1. Star tracker design requirements allow 5 to 1 change in tracker sensitivity. 2. Procurement specification allows for only 3 to 1 change in sensitivity. 3. Design requirements do not allow for KIC adjustment of Star Tracker sensitivity.	KIC prepared proposal to MIT/IL for design change to allow KIC adjustment of star tracker sensitivity by an external select resistor.
Sextant head shift observed after vibration testing of AGE 121.	Unbalanced condition of sextant head due to tracker electronic module packaging configuration. Analysis revealed unbalance of 10 oz. at 4 in. from SXT head center (40 oz. in.), which could cause oscillation during random vibration.	KIC has submitted a counterweight design proposal to MIT/IL as an efficient economical, permanent fix. As of 20 Sept. 1965, a verbal approval had been granted and a TDRR is being initiated by MIT/IL.

TABLE 6-28 (Page 2 of 5)

In-House Fabrication Problems Resolved

COMMAND MODULE/LUNAR EXCURSION MODULE

PROBLEM	CAUSE	CORRECTIVE ACTION
Random out-of-control points in daily welding machine qualification tests.	Poor repeatability between the three Raytheon calibrators and within the same calibrator using three probes.	1. One calibrator that could not be calibrated by Raytheon, was replaced during KIC visit to Raytheon facility. 2. Purchase order issued to Raytheon for retrofitting our oldest calibrator for compatibility with other two. 3. Coordinated effort with engineering to investigate increase of frequency of calibration. 4. Quality Control and Test Engineering personnel visited AC Electronics 7 and 8 Sept. 1965 to discuss the problem. 5. Control points now within specification.
Scanning telescope TDA and SDA counter shades damaged during test.	Counter shades bent due to the impact force at the slewing stop. The force transmitted affected annealed stainless steel shade.	Stress analysis of shade revealed incapability of material to withstand high velocity shock. "Pipe-line" change of material to half-hard beryllium copper has been approved.

TABLE 6-28 (Page 3 of 5)
In-House Fabrication Problems Resolved
COMMAND MODULE/LUNAR EXCURSION MODULE

PROBLEM	CAUSE	CORRECTIVE ACTION
Test of AGE 121 disclosed that JDQ's 03125 and 03023 could not be run without deviating from the procedure.	This was the first use of these JDQ's on a prime system and test equipment. Major problems were: 1. Photometer and tracker APTF mirror reflectivity coefficients require redefinition. 2. More specific method required to describe star magnitudes.	1. Quality Control engineers directed testing on "round-the-clock" basis for evaluation purpose. 2. Procedures debugged, resulting in significant reduction in test time. 3. JDQ's being revised.
Spring washer (PN 2011944) punctured in two places. Discrepancy found when reticle of AGE 121 was removed to correct focus problem.	Work screws used for removal of reticle were turned down too far. Through the reticle and into washer.	Quality Control directed the use of screws made with a specific number of threads and identified for use with the reticle removal tool.
Failure of LEM-AOT Assembly to meet required diopter range +2 to -2 diopters during Learner Model acceptance test.	Design inadequacy in lever focusing groove.	MIT/IL has been requested to institute a reduction from the presently required (+2 to -2) diopter specification to (+1.7 to -1.7) diopters. (Ref. TDRR No. K5049).
SXT and Kollmorgen reticles were superimposed during OUA alignment test.	Kollmorgen reticle is centered at 5 ft. 0 in. H and 5 ft. 0 in. V. Procedure called for SXT reticle measurements to be taken about the 5 ft. H and V Kollmorgen coordinates.	1. The SXT reticle readings are now taken using H and V Kollmorgen correction factors. 2. Applicable JDQ's revised.

TABLE 6-28 (Page 4 of 5)

In-House Fabrication Problems Resolved

COMMAND MODULE/LUNAR EXCURSION MODULE

PROBLEM	CAUSE	CORRECTIVE ACTION
Increase in rejection of soldered joints	Major causes are "insufficient solder" and "excessive solder." Approximately 75 percent of rejects are of these types. A variation from insufficient-to-excessive-to-insufficient was apparent. Over correction seemed to be a fault.	Visual aids procured in form of sample solder connections as prepared by NASA follow-up investigation of inspection and operations personnel as to performance and retraining necessity.

TABLE 6-28 (Page 5 of 5)

In-House Fabrication Problems Resolved

COMMAND MODULE/LUNAR EXCURSION MODULE

PROBLEM	CAUSE	CORRECTIVE ACTION
Optical Base inserts, PN 2011631 damaged during assembly causing interference with mating screws.	Inadequate depth of thread and excessive wear on tooling permitted mushrooming of locking tangs causing interference with mating screws.	1. Advanced ECO No. 113757 was processed to increase the counter drill depth. 2. New installation tool with improved wear characteristic now in use by assembly.
Damaged bulkhead connector pins (Plug J1 2011799 and 2011798) necessitating disassembly and rework.	Many installations and removals of test harness connectors are made during the course of Manufacturing and Test. Misalignment or operator error can result in damage to the unit connectors.	Intermediate working connectors will be used throughout Manufacturing and Test and will be removed after completion of system operations test.
Present design does not ensure secure seating of the objective lens.	Combination air cushion effect aggravated by resiliency of the "O" ring.	1. Interim action includes revised assembly techniques and additional tests to preclude recurrence. 2. Recommended design change is in preparation by KIC for submittal to MIT/IL.

6.4.9 Audits

QUALITY CONTROL AUDITS - This section provides a detailed breakdown of the auditing activities conducted during the reporting period.

ANALYSES - Table 6-29 -Future indocutrination and applicable reorientation outlines have been revised to include greater emphasis on the precautions required by personnel working in restricted areas.

Table 6-30 - Misinterpretation of the procedure resulted in the application of the "Maintenance Only" labels to equipments which are not used to their full capabilities. Procedures referencing such equipments reflect use limitations. The equipment records shall be revised as necessary.

Table 6-31 - A review of the applicable records indicates that the discrepancy was of an isolated nature requiring no additional measures at this time.

Table 6-32 - A procedure change was immediately effected.

Table 6-33 - Due to a temporary shortage of personnel, the "In-Slip" file was maintained by inexperienced personnel who have since become thoroughly familiar with the system.

Table 6-34 - Since the institution of Inspection Department review of MRR's there have been no recurrences of discrepancies of this nature.

Table 6-35 - A check of outstanding prints indicated that all had been issued with the applicable ECO's. No further action is considered necessary at this time.

QUALITY CONTROL AUDITS PREVENTIVE ACTION PROGRESS REPORTS

In many instances a Quality Control Audit results in immediate correction of the observed discrepancy, and an investigation to determine preventive measures.

In the event Preventive Action requests are generated, interim measures are immediately effected. Interim measures consist of the following:

a. Immediate correction of the observed discrepancy.

b. Institution of temporary measures which will immediately detect and correct all recurrences.

c. Investigation of measures which, when instituted, will preclude recurrence of the type of discrepancy observed.

d. Implementation of preventive measures resulting from "c" above.

The status of all investigations initiated prior to the period covered by this report is now complete.

TABLE 6-29

CONTROL OF AREAS LIMITED TO AUTHORIZED PERSONNEL
(Authority: NPC 200-2)

Discrepancy

The special white coats for exclusive use in areas limited to authorized personnel are being worn elsewhere in the plant.

Preventive Action Taken to Preclude Recurrence

Personnel have been reinstructed to hang the subject coats on the rack provided for that purpose before leaving the area.

STATUS: COMPLETE

TABLE 6-30

ELECTRICAL STANDARDS LABORATORY AUDIT
(Authority: NPC 200-2, MIL-Q-9858A, KIC SPI 8801)

Discrepancy

Records for test equipments which are not required to be used to their full capabilities do not indicate the reason for such exemption and the period of time and type of usage for which such exemption is applicable.

Preventive Action Taken to Preclude Recurrence

A study of all limited-use equipment has been undertaken. As considered necessary by the study, the records of the subject equipments shall be revised

STATUS: COMPLETE

TABLE 6-31

PLATING AND FINISHING FACILITY AUDIT
(Authority: NPC 200-2, MIL-Q-9858A, KIC SPI 8801)

Discrepancy

The ammeter on the anodizing solution control panel requires a maintenance check only; however, the required adhesive label (indicating "Maintenance Check Only") was not in evidence.

Immediate Action Taken

An examination of the ammeter's records indicated that the maintenance check had, in fact, been performed. The applicable label was then affixed to the meter.

Preventive Action Taken to Preclude Recurrence

Personnel were admonished to adhere to all operating procedures. Adherence to these procedures is, mandatory according to KIC policy.

STATUS: COMPLETE

TABLE 6-32

RAW MATERIALS STOCKROOM AUDIT
(Authority: NPC 200-2, KIC QCI No.'s 5SQ-004, 5SQ-006, KIC SPI 7369A)

Discrepancy

Some raw material was identified with an adhesive label containing pertinent information. The material itself was not marked.

Preventive Action Taken to Preclude Recurrence

ACI No. 5SQ-006 was amended by Change Notice No. 1 to allow identification of raw material with adhesive labels containing pertinent information.

STATUS: COMPLETE

TABLE 6-33

FAILURE DATA FEEDBACK SYSTEM AUDIT
(Authority: NPC 200-2, KIC ARP-3, KIC QCI 8SQ-001)

Discrepancy

"In-Slip" No. 23449, for module PN 2007024, SN 2 was misfiled.

Immediate Action Taken

The files were completely reexamined for misfiled "In-Slips"; however, none were found.

Preventive Action Taken to Preclude Recurrence

Personnel were cautioned to exercise additional care in the performance of their duties. The discrepancy was an isolated instance requiring no additional measures at this time.

STATUS: COMPLETE

TABLE 6-34

MATERIAL REVIEW BOARD AUDIT
(Authority: NPC 200-2, KIC QCI 8SQ-002)

Discrepancy

Two Requests for Material Review contained the quantity of previous Requests rather than the Request serial numbers.

Immediate Action Taken

The serial numbers of the previous Material Review Requests were entered.

Preventive Action Taken to Preclude Recurrence

The discrepancy occurred prior to the institution of MRR review by the Inspection Department (re: Table 5-III-6, Quarterly Summary Report of Audit Activities for the third quarter 1965). No further action is required at this time.

STATUS: COMPLETE

TABLE 6-35

DRAWING CHANGE CONTROL AUDIT
(Authority: NPC 200-2, KIC QCI 2SQ-001)

Discrepancy

A copy of the outstanding Engineering Change Order was not delivered with the copy of the print when the latter was requested.

Preventive Action Taken to Preclude Recurrence

Personnel were cautioned to examine the Engineering Change Order file for outstanding ECO's prior to issuing any print.

STATUS: COMPLETE

6.5 SUMMARY OF YEAR ENDING 31 DECEMBER 1966

6.5.1 Management

The organization structure of the Apollo/LM Program Quality Assurance Section within the Product Assurance Department is shown in Figure 6-15. This is a further refinement of the functions that were set up in 1965.

Figure 6-16 lists the number of personnel in Apollo/LM Product Assurance during this reporting period.

6.5.2 Accomplishments

The Quality Control Plan (Volume I) and the Quality Control Procedure (Volume II), were reviewed, jointly by AC Electronics and Kollsman, revised and released as per TDK-2230.

Product Assurance initiated a defect analysis committee to review on a weekly schedule all defects attributed to workmanship. These defects were referred by the Material Review Board (MRB) and from the Process Control function.

The Defect Analysis committee consisted of the following members:

a. Permanent Assignment

Chairman, Quality Control
  Manufacturing Management
  Manufacturing Engineering
  Inspection

b. Consultant Basis

  Reliability Engineering
  Project Engineering.

Corrective action would be initiated by the committee in the following classified "cause for reject" category:

Deficient Procedure
Inadequate Tooling
Faulty Inspection
Critical Design
Operator Workmanship

Figure 6-17 and 6-18 illustrates four of the process control charts maintained by QC for trend analysis and corrective action implementation.

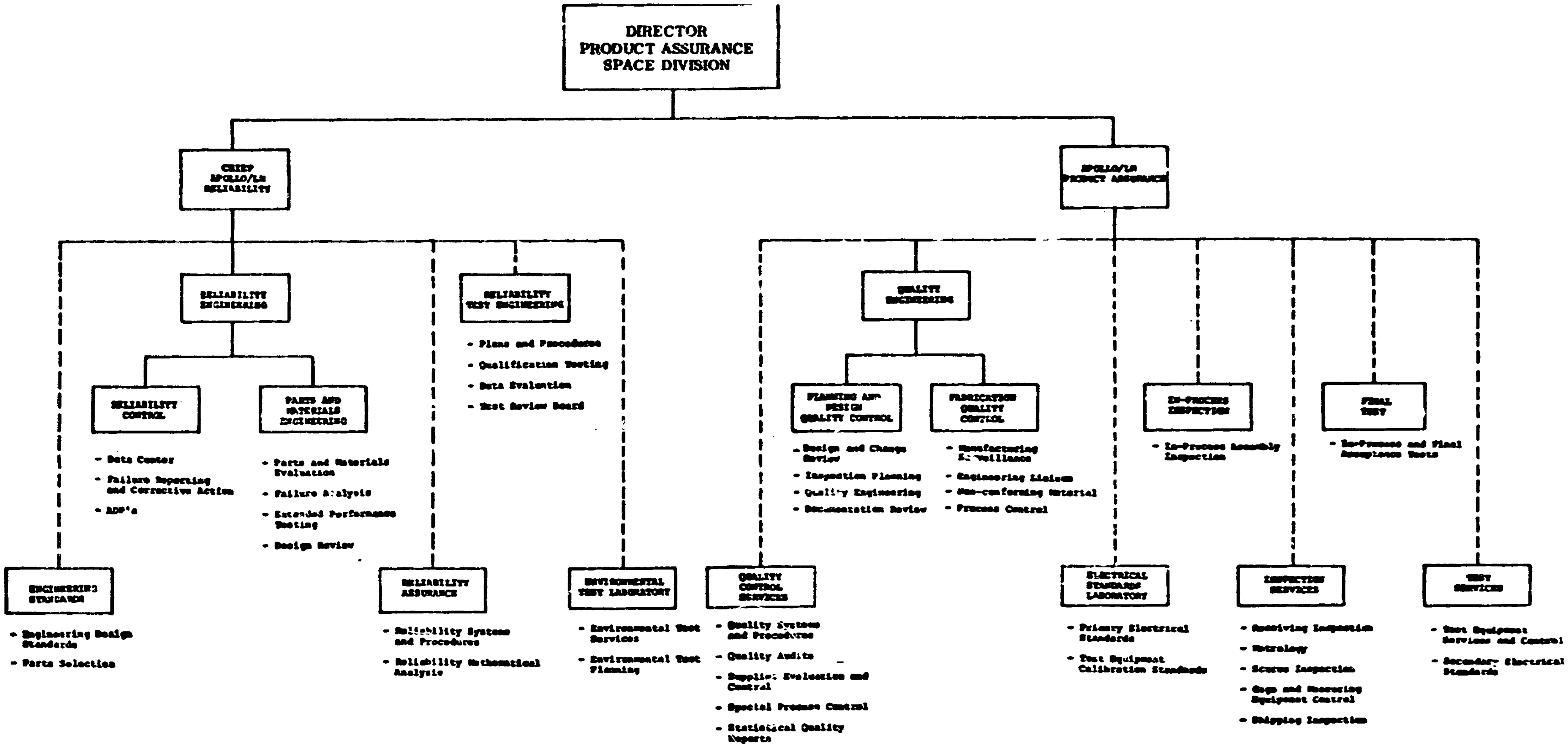


Figure 6-15. Product Assurance Functional Organization for Apollo/LEM Programs

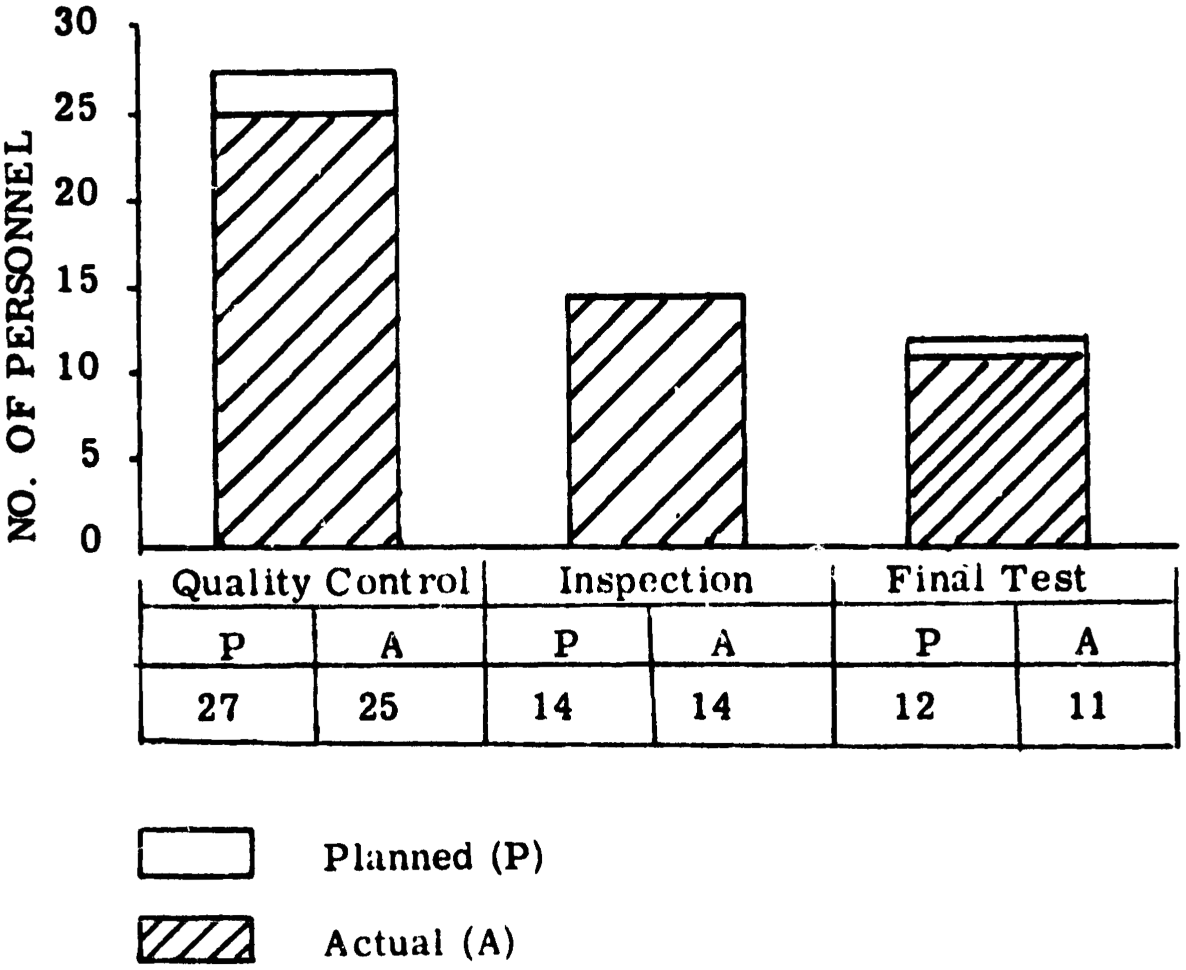


Figure 6-16. Manpower Status

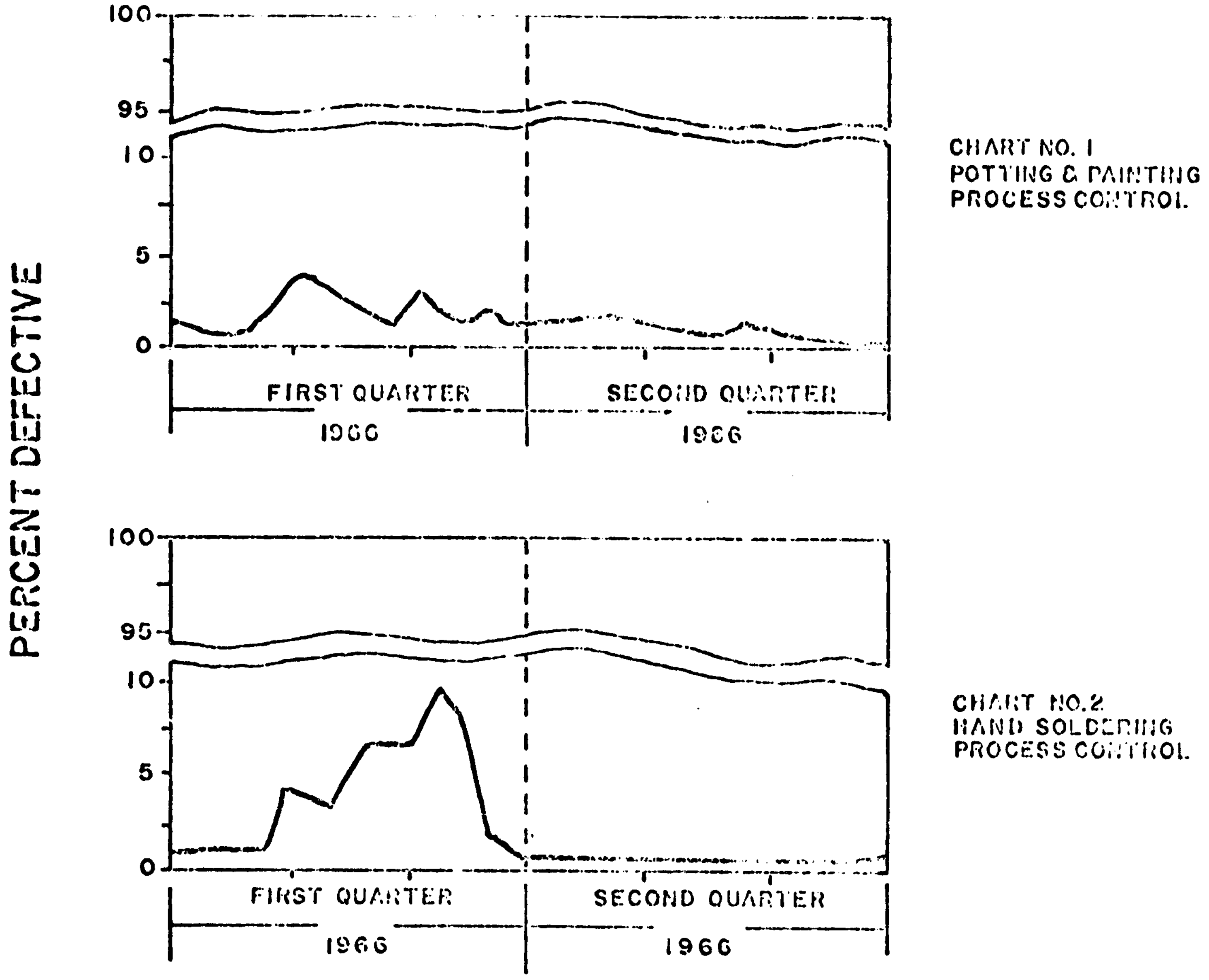


Figure 6-17. (Page 1 of 2) Process Control (Computed on 3-week moving average)

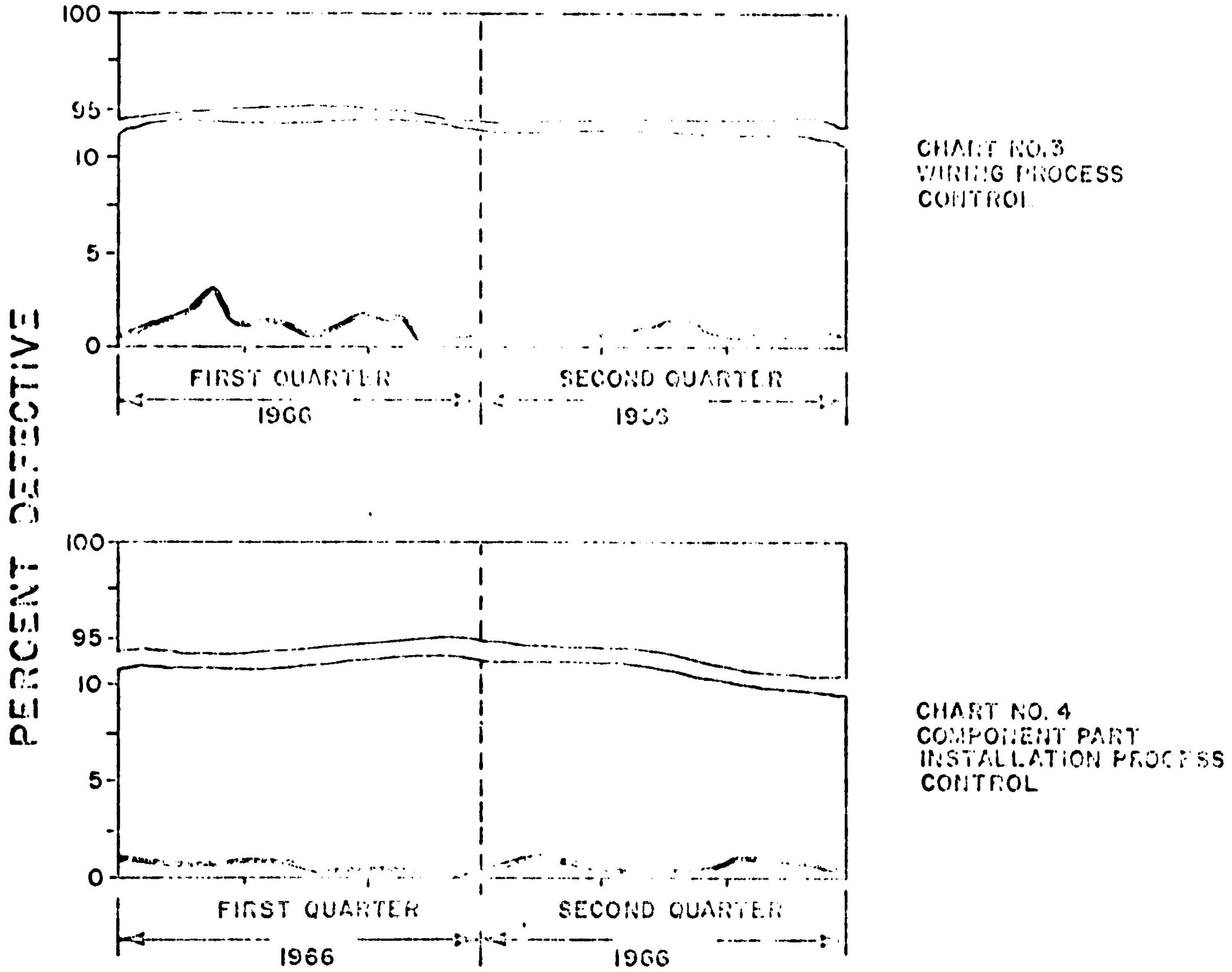


Figure 6-17. (Page 2 of 2) Process Control
(Computed on 3-week moving average)

KOLLSMAN INSTRUMENT CORPORATION

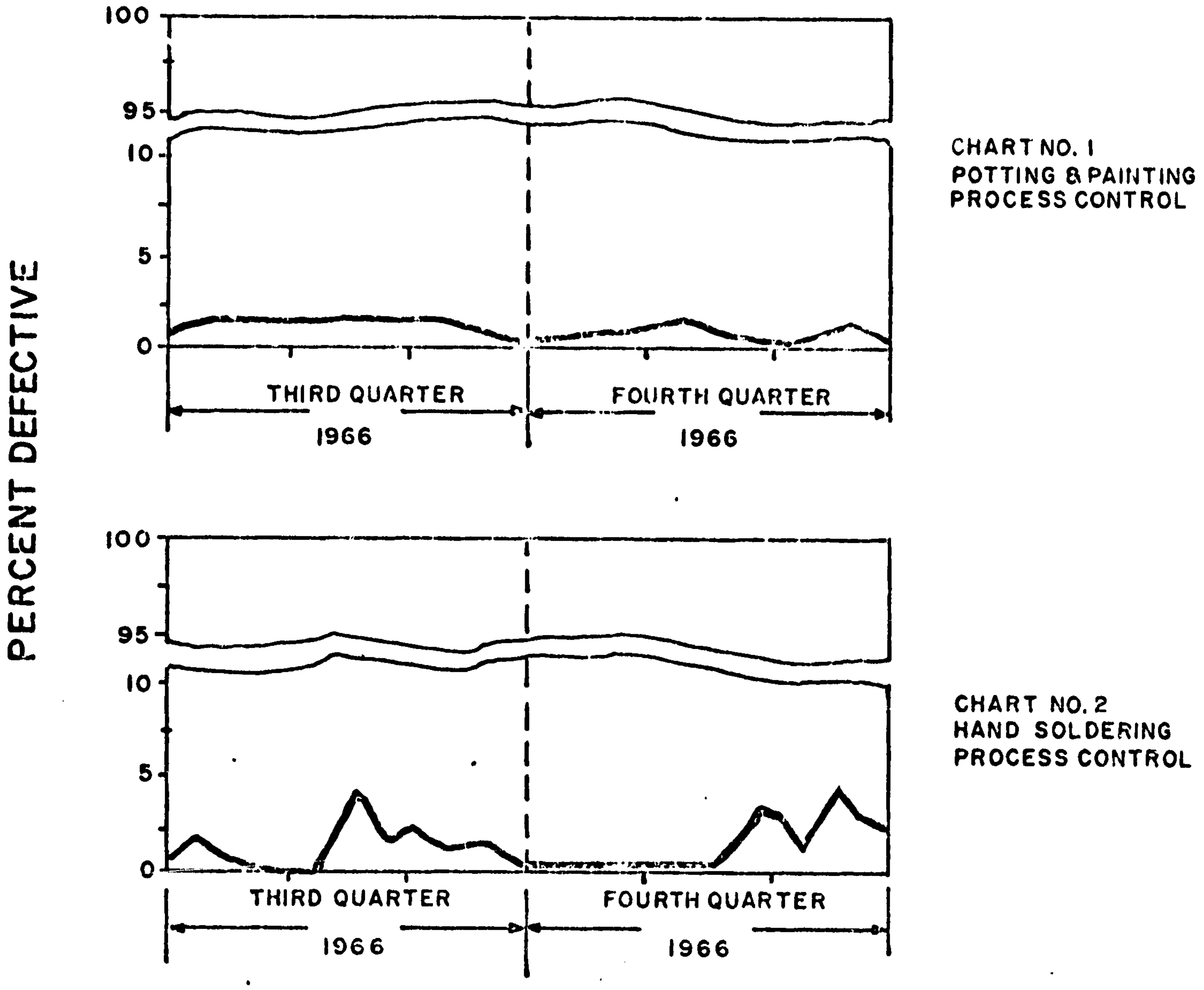


Figure 6-18. Process Control Chart (Sheet 1 of 2)

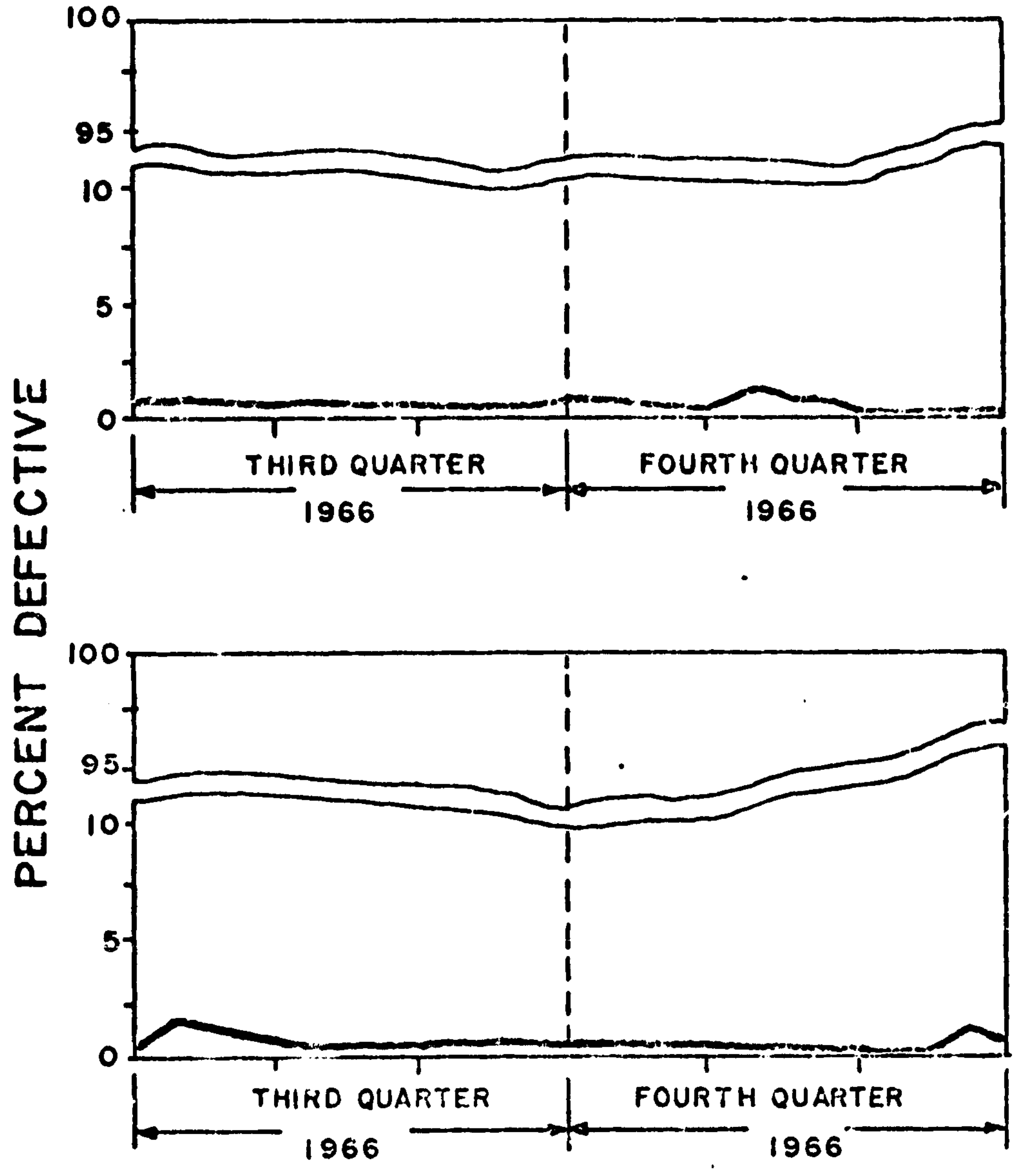


CHART NO.3
WIRING PROCESS
CONTROL

CHART NO.4
COMPONENT PART
INSTALLATION PROCESS
CONTROL

Figure 6-18. Process Control Chart (Sheet 2 of 2)

6.5.3 Motivation

The Product Assurance Department initiated a Quality Control Instruction (QCI) reorientation program to acquaint all line and supervisory personnel with the overall requirements of the Apollo/ LEM Quality Control Manual. The program sessions were held on a weekly basis for a period of 13 weeks.

QCI subjects treated during this program included:

Change Control
Drawing and Specification Review.

Product Assurance also conducted lectures and practical demonstrations pertaining to surface quality of optical elements. The lectures entitled "Surface Quality of Optical Elements", and "Handling and Care of Optical Elements", were attended by all line and supervisory personnel associated with the handling of Apollo/ LEM optical components.

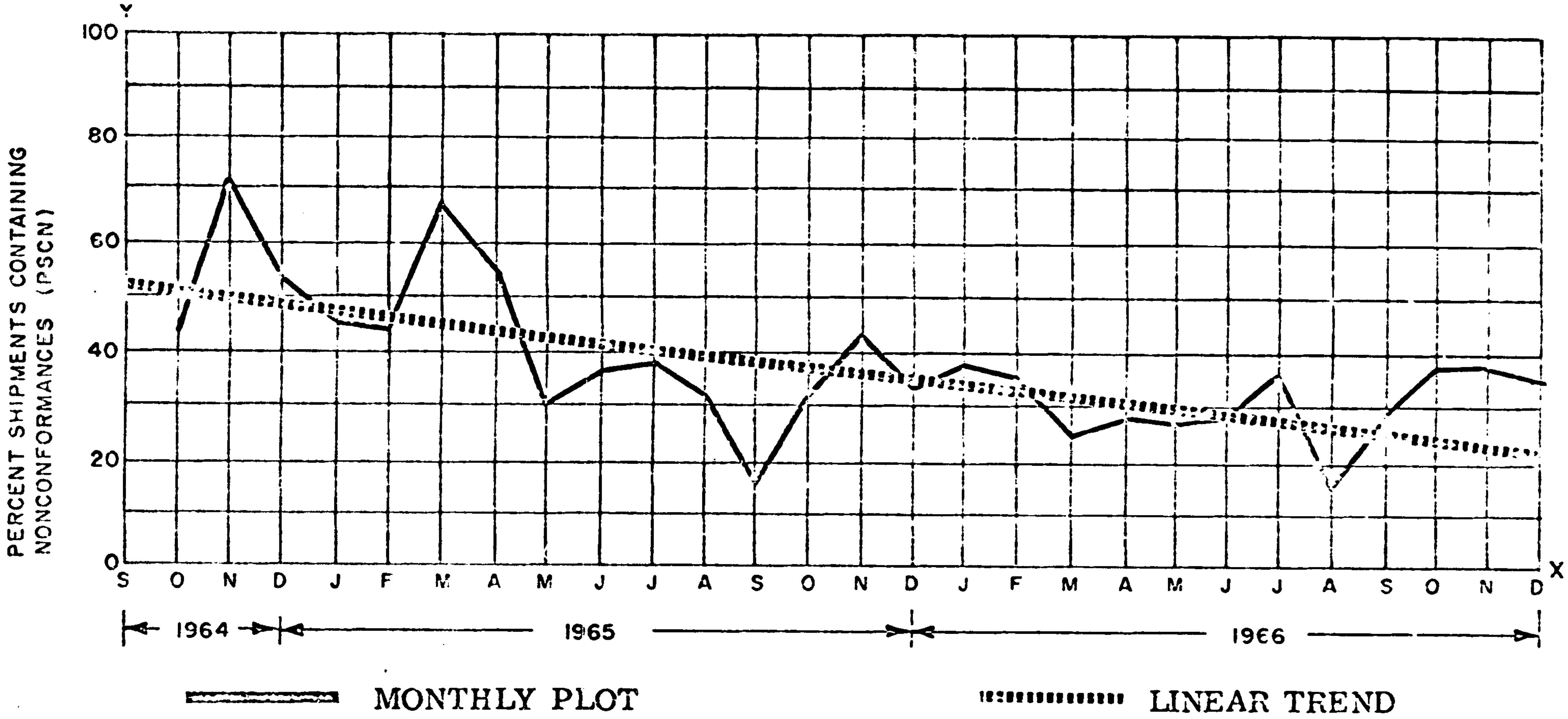
Product Assurance continued the certification of Apollo/LEM personnel in the various skills listed below:

Welding
Soldering & Crimping
Potting
Plating
Heat Treatment
Xyglo
Loctite Application
Clean Room Procedures

6.5.4 Procurement

Figure 6-19 shows a favorable decrease in the linear trend line relative to percent procured material shipments containing nonconforming material. Of the 18601 parts comprising the 782 shipments received during the reporting period, only 291 parts were required to be processed by the Material Review Board as 48 Formal Board Actions.

A total of 11 areas were audited, including 52 individual audits for an overall audit conformance rate of 88 percent during the quarter. An increase in the overall percent conformance rate was noted over a 12-month period ending in the first quarter of 1966. The status of all investigations relative to nonconformances initiated prior to the period covered by this report was completed.



KOLLSMAN INSTRUMENT CORPORATION

% Shipments Containing Nonconformances = PSCN

$$PSCN = \frac{\text{Shipments Nonconformance}}{\text{Shipments Received}} \times 100\%$$

Linear Relationship Y = a - b x

a = Y Intercept

b = Regression Coefficient

Year	Quarter	% Trend
1965	1st	X6 = 56.7
	2nd	X9 = 40.8
	3rd	X12 = 26.7
	4th	X15 = 29.0

Year	End of Quarter		% Trend
1966	1st	Y = 55.7 - 1.6X	X18 = 26.9
	2nd	Y = 55.0 - 1.5X	X21 = 23.5
	3rd	Y = 53.6 - 1.3X	X24 = 22.4
	4th	Y = 50.4 - 1.0X	X 27 = 23.4

Figure 6-19. Procured Material (Shipment) Nonconformance Trend

Supplier activities showed a continuing increase in the number of suppliers in the 100-84 percent Quality Rating, category A, and a marked decrease in the number of suppliers in the 40-0 percent Quality Rating, category C. A gradual increase in the number of suppliers in the 84-40 percent Quality Rating, category B, was also apparent.

PROCUREMENT PROBLEM AREAS

Table 6-36 lists procurement problem areas, their cause and status during the reporting period.

Table 6-37 lists procurement problems resolved, their cause and corrective action taken during the reporting period.

PURCHASE REQUISITIONS AND ORDERS. The purchase requisitions processed by Quality Control during the reporting period totaled 552. Purchase orders reviewed and released by QC totaled 416 during the reporting period. Two major discrepancies were detected in processing the Command Module procurement documentation. A summary of the problem/cause/corrective action is outlined in Table 6-38.

SUPPLIER PERFORMANCE RATING. Each supplier of Apollo material to Kollsman received a quality rating based on the total past performance input. The rating is based on the formula:

$$1.00 - \frac{\text{No. of parts defective}}{\text{No. of parts inspected}} \times 100 \text{ percent} = \begin{array}{l}\text{Quality Performance}\\ \text{Rating expressed as}\\ \text{percent of parts}\\ \text{acceptable.}\end{array}$$

Categories B and C of the Quality Rating of each low-rated supplier are made available on a monthly basis to the Supplier Control Group of Quality Control for analysis and corrective action. This effort is coordinated with the Purchasing Department.

SUPPLIER ACTIVITIES

Active Conditionally Approved Sources. Table 6-39 delineates in detail the status of active conditionally approved sources.

Inactive Conditionally Approved Sources. Table 6-40 delineates in detail the status of inactive conditionally approved sources.

Quality Control Supplier Survey Visits. Table 6-41 delineates in detail the status of Quality Control supplier survey visits.

TABLE 6-36

PROCUREMENT PROBLEM AREAS

Corrective Action Status for First Quarter, 1966

PROBLEM	CAUSE	STATUS
Chicago Miniature Lamp Works (Lamp) PN 1010493 100 percent rejection rate for failure to meet SCD visual criteria and workmanship standards.	Supplier unable to manufacture lamps to SCD requirements due to state of the art.	1. KIC and AC joint drawing review resulted in extensive proposed drawing changes. 2. Duplicate set of drawings, requested by AC, were forwarded by KI contracts department on 19 February 1966.

TABLE 6-37 (Page 1 of 5)
PROCUREMENT PROBLEMS RESOLVED

PROBLEM	CAUSE	CORRECTIVE ACTION
RCA (Photomultiplier) PN 1012043 High rejection rate on Photomultiplier Tubes, due to defective leads.	Leads susceptible to damage due to processing and inspection at RCA (kinks, nicks, solder, etc.)	1. Lead quality program was submitted on September 22, 1965, per RCA report of September 16, 1965, Exhibit No. 5, and was accepted by KIC. 2. Acceptance criteria was established jointly by RCA and KIC.
RCA (Photomultiplier) PN 1012043 Supplier is experiencing extremely low yield, causing concern for possible schedule impact.	Design of units still in advanced stage-of-the-art stage.	1. RCA instituted proposed changes at engineering personnel level. 2. Recommended operator training program to be a serious consideration for future procurement. 3. RCA constantly reviews design problems and manufacturing processes with attendant corrective action initiation. 4. Schedule was completed on October 1, 1965, problem area resolved. 5. Monthly presentations were held on September 14, October 14, November 18, 1965, and January 6, 1966, with RCA. Cancellation of electronic package terminated future presentations.

TABLE 6-37 (Page 2 of 5)

PROCUREMENT PROBLEMS RESOLVED

PROBLEM	CAUSE	CORRECTIVE ACTION
		6. Metal to glass seals were specified for a brief period and then the requirement was rescinded with KIC concurrence.
Erie Technological Products (Capacitor) PN 1012041		
1. Low yield (15%) by supplier in manufacture of capacitors. 2. Supplier refusal to continue manufacture of capacitors.	Electrical performance incompatibility with physical size of capacitors.	Component part of the cancelled electronic package. Drawing change request M689 derating electrical requirements suspended upon the cancellation order.
Austin Instruments, Inc. PN 1022393002		
Procured parts identification omitted and various dimensional deviations.	Supplier in-house problem.	1. Supplier visited by Kollsman on 14 December 1965, refused to discuss and/or initiate corrective action. 2. Supplier subsequently disqualified by Kollsman.

TABLE 6-37 (Page 3 of 5)
PROCUREMENT PROBLEMS RESOLVED

PROBLEM	CAUSE	CORRECTIVE ACTION
American Time Products PN's 1012154, 1012155		
Excessive rejects for solder chips and foreign matter.	Air blast cleaning procedure not adequate to remove flux residue and minute particles.	Supplier has instituted ultrasonic cleaning of parts.
Summit Finishing Co. (Mirror) PN 03386910537		
Rejected for deposit thickness below drawing minimum although Supplier certified thickness as to drawing requirement.	Supplier determined thickness empirically, whereas Kollsman measured thickness utilizing "Dermitron" thickness checker.	Supplier to obtain calibrated standard for "Beta Scope" to permit actual reading of thickness measurement.
Athbro Precision Eng. Corp.		
Machined parts received from the Supplier necessitated continuous material review board action. Upon receipt at Kollsman material was either damaged, dimensionally incorrect or had omitted operation.	Supplier in-house coordination ineffective in maintaining acceptable quality level.	Supplier disqualified as an approved source for machined parts effective 11 March 1966. Present contract was terminated.

TABLE 6-37 (Page 4 of 5)

PROCUREMENT PROBLEMS RESOLVED

PROBLEM	CAUSE	CORRECTIVE ACTION
Clifton Precision Product Co. **(Resolver) PN 1012065**		
Repetitive rejections by Kollsman source inspection due to resolver housing mounting diameter out of tolerance.	Torquing of mounting screw by Supplier during assembly of stator ring affects distribution of material resulting in undersize dimension. Diameter $4.4374 \begin{array}{l} + .0000 \\ - .0003 \end{array}$ on resolver component undersize and tapered from back edge of chamfer. Taper was introduced by CPPC sub-tier supplier's effort to remove sharp corner after chamfer was machined.	1. CPPC will check diameter for torque displacement at subassembly stage and will reset screw to eliminate condition. 100% inspection at this stage of assembly. 2. CPPC to contact sub-tier supplier on taper condition and initiate action to preclude recurrence.
Fairchild AFQAR		
Fairchild AFQAR report to NASA/MSC stated that Taylor Electronics (distributor) has not been forwarding KIC Purchase Order Quality Control requirements to Fairchild.	Fairchild would not accept direct procurement for quantities less than 1000.	1. Copies of Purchase Orders submitted by Taylor Electronics adequately defined Quality Control requirements and were forwarded to Fairchild. 2. KIC and AC Electronics jointly visited Fairchild as scheduled and initiated corrective action as outlined in paragraph 1 above.

TABLE 6-37 (Page 5 of 5)

PROCUREMENT PROBLEMS RESOLVED

PROBLEM	CAUSE	CORRECTIVE ACTION
Fairchild Semiconductor (Transistors) PN 1010342, PN 1010352, PN 1010431		
1. Traceability requirements of ND 1015404, paragraph 3.3.8, nonconformance. 2. Waivers presently required for all usage.	Disagreement between supplier and AC/KIC on adequacy of present Fairchild controls and expense of ND 1015404 requirements.	Components were part of the cancelled electronic package. Prior to the cancellation order in the early part of January 1966, AC and KIC were trying to obtain contractual relief other than waivers for the traceability requirements imposed on this supplier.
OCLI and Photronics (Beamsplitter) PN 2012222		
1. Suppliers could not maintain flatness requirements as per drawing. 2. Drifting out of optical specification.	Glass used had inherent unstable working characteristics and could not be stabilized.	KIC Engineering evaluation resulted in a drawing change to a more stable glass material.

TABLE 6-38 (Page 1 of 2)

Problem/Corrective Action Status

MAJOR DISCREPANCY	PROBLEM	CORRECTIVE ACTION
1	During the procurement document review and verification of the latest ND documents revision letters, it was disclosed that ND 1002251 was nonexistent. This document is referenced as follows: PN 1010838 "Adhesive pressure sensitive silicon." Requirements 3C Spacecraft Crew Compartments 1. Material compatibility. Only these materials/compositions/composites found to be nontoxic and nonflammable when tested as specified in ND 1002251 and ND 1002252 shall be approved for use in spacecraft crew compartments.	MIT/IL (R. Seversen) was notified of this discrepancy through Kollsman's Documentation Department. Kollsman is awaiting MIT/IL reply. In the interim period procurement is continuing as per Requirements 3C to ND 1002252 only.
2	Apollo Production Control used an obsolete Purchase Order (PO) with similar PN identification to determine current configuration requirements instead of the approved procedure of referring to the latest applicable drawing. As it later developed, the subject PO had amendments changing the glass requirements. Procurement	Apollo Production Control Supervisors reemphasized to their ordering personnel that the drawing is the only authorized document to be used in ordering raw materials.

TABLE 6-38 (Page 2 of 2)

Problem/Corrective Action Status

MAJOR DISCREPANCY	PROBLEM	CORRECTIVE ACTION
	documents in error are listed below: Purchase Requisition No. 47453 PN 2011862 - type glass SF-8 869-312 and SF-8 Purchase Requisition No. 24079 PN 2011664 and 201174 - type glass LAK-9, F-5 and 603-380.	

TABLE 6-39

DETAILED STATUS OF ACTIVE CONDITIONALLY APPROVED SOURCES

Supplier	Part Type	Date of Conditional Approval	Problem	Status of Corrective Action	Final Disposition
Hudson Tool and Die Newark, N.J.	Sheet metal fabrication cans, shields stampings	7-20-65	Unacceptable QC Plan.	Submission of QC manual and plan. Supplement Material Control Specification.	Supplier on suspension 3-1-66. Reference memo QC-6-91
Fairchild Semiconductor Mountain View, Calif.	Semi-cond.	10-5-65	Inadequate Traceability Proc.		Semi-conductor is part of discontinued electronic package. No further requirements.

TABLE 6-40

DETAILED STATUS OF INACTIVE CONDITIONALLY APPROVED SOURCES

Supplier	Part Type	Date of Conditional Approval	Problem	Status of Corrective Action	Final Disposition
Woodbine Prod. Deer Park, New York	Sheet metal	7-27-65	Inadequate QC Plan.	No procurement.	None required.
H. Roessle Hicksville, New York	Metal spinning	6-28-65	Inadequate QC Plan.	No procurement	None required.
Boxton Beel Brooklyn, New York	Optics	2-9-65	Inadequate QC Plan.	No procurement.	None required.

TABLE 6-41 (Page 1 of 2)

QUALITY CONTROL SUPPLIER SURVEY VISITS

SUPPLIER	ADDRESS	DATE OF VISIT
Liebros Casting Co.	Long Island City, New York	16 December 1965
Ultronix	Grand Junction, California	10 January 1966
Warnow Ink Products	Los Angeles, California	12 January 1966
Furane Plastics, Inc.	Los Angeles, California	13 January 1966
Long Lok (Eastern)	Carlstadt, New Jersey	19 January 1966
Metalcraft	Garden City, New York	25 January 1966
Triangle Instrument Co.	Syosset, New York	26 January 1966
D. W. Mann Co.	Burlington, Massachusetts	27 January 1966
Lorben Mfg., Co.	Oceanside, New York	27 January 1966
IMC Magnetics	Maywood, California	8 February 1966
Qutronics	Union City, New Jersey	16 February 1966
Howard Castings	Chicago, Illinois	23 February 1966
Wallace Truebore	Patterson, New Jersey	7 March 1966
Mu[illegible]on Corp.	Brockton, Massachusetts	8 March 1966
Astronautic Ind.	Marlboro, Massachusetts	8 March 1966
Techcraft	Nashua, New Hampshire	9 March 1966
Riverside Plastics	Hicksville, New York	10 March 1966

TABLE 6-41 (Page 2 of 2)

QUALITY CONTROL SUPPLIER SURVEY VISITS

SUPPLIER	ADDRESS	DATE OF VISIT
	RESURVEY	
Atlas Pattern and Model	Brooklyn, New York	13 January 1966
Eastern Heat Treat	Glen Cove, New York	17 January 1966
Summit Finishing	Thomaston, Connecticut	21 January 1966
Island Precision	Farmingdale, New York	21 January 1966

Quality Control Supplier Surveillance Visits. Table 6-42 delineates in detail the status of Quality Control supplier surveillance visits.

Quality Control Supplier Surveillance and Negotiation. Table 6-43 delineates in detail the status of Quality Control supplier surveillance and negotiation visits.

In-house Conferences with Suppliers. Table 6-44 delineates in detail the status of in-house conferences with suppliers at Kollsman.

ND 1015404 IMPLEMENTATION STATUS. Tables 6-45, 6-46 indicate implementation status of ND 1015404.

TABLE 6-42
QUALITY CONTROL SUPPLIER SURVEILLANCE VISITS

SUPPLIER	ADDRESS	DATE OF VISIT
Sanders Associates	Nashua, New Hampshire	20 December 1965
RCA	Lancaster, Pennsylvania	6 January 1966
Flex Circuits	Hatboro, Pennsylvania	13 January 1966
Sanders Associates	Nashua, New Hampshire	14 January 1966
Speedring Corporation	Warren, Michigan	24 January 1966
Pioneer Astro	Chicago, Illinois	25 January 1966
Clifton Precision Products	Clifton Heights, Pennsylvania	25 January 1966
Hydro Electronics	Baldwin, New York	3 February 1966
Standard Plastics	Fogelsville, Pennsylvania	4 February 1966
B. G. Instruments	Corona, New York	7 February 1966
Flexible Circuits	Hatboro, Pennsylvania	10 February 1966
American Beryllium	Sarasota, Florida	24 February 1966
Braun Tool and Instrument	Hawthorne, New Jersey	1 March 1966
Solvere	Santa Ana, California	1 March 1966
Clifton Precision Products	Clifton Heights, Pennsylvania	1 March 1966
Parker Seal (Western Div.)	Culver City, California	3 March 1966
Solvere	Santa Ana, California	15 March 1966

TABLE 6-43

QUALITY CONTROL SUPPLIER SURVEILLANCE AND NEGOTIATION VISITS

SUPPLIER	ADDRESS	DATE OF VISIT
Industrial Tectonics	Compton, California	11 January 1966
B. G. Instrument	Corona, New York	12 January 1966
Beryllium Mfg. Co.	Valley Stream, New York	14 January 1966
Creskill Stillman	Englewood, New Jersey	24 January 1966
Metals and Controls Co.	Attleboro, Massachusetts	2 February 1966
Solvere	Santa Ana, California	9 February 1966
Astro Gear	Stoughton, Massachusetts	2 March 1966

TABLE 6-44

IN-HOUSE CONFERENCES WITH SUPPLIERS AT KOLLSMAN

SUPPLIER	ADDRESS	DATE OF CONFERENCE
L and R Stamping	Farmingdale, New York	16 December 1965
Athbro Precision	Sturbridge, Massachusetts	3 January 1966
Clifton Precision Products	Clifton Heights, Pennsylvania	12 January 1966
Athbro Precision	Sturbridge, Massachusetts	7 February 1966
Atlas Pattern	Brooklyn, New York	11 February 1966
Athbro Precision	Sturbridge, Massachusetts	15 February 1966
Sanders Associates	Nashua, New Hampshire	15 February 1966
Kinney Vacuum	Pennsauken, New Jersey	15 February 1966
Customatic	Stamford, Connecticut	15 February 1966

TABLE 6-45

ND 1015404 Class I and II Suppliers

Requirements	STATUS Fourth Quarter 1965 15 Oct.	15 Nov.	15 Dec.	First Quarter 1966 15 Jan.	15 Feb.	15 Mar.
Inspection Plans Required	81	81	84	84	84	84
Approved	63	66	70	74	79	79
In Process	18	15	14	10	5	5
Traceability Plans Required	79	79	82	82	82	82
Approved	69	70	73	76	78	78
In Process	10	9	9	6	4	4
Critical Process Agreements Required	158	162	162	162	162	162
Approved	149	152	154	156	159	160
In Process	9	10	8	6	3	2

TABLE 6-46

ND 1015404 CRITICAL PROCESS LISTS REQUIRED

Supplier	Part Number	Nomenclature	Status End of First Quarter 1966
Astro Gear	1011281 *2011654 *2011655	Differential Gear, Trunnion Drive Gear, Shaft Drive	Critical process list being drafted by supplier and KI
Brush Beryllium	*2011228	Optical Base, Rough Mach.	Completed 2-26-66.
Dickson	1012529	Diode	Not required by AC Electronics and KI - will be removed from QSL ND 1002034 within 30 days.

***Not a requirement of drawing (ND 1015404 Class II imposed by Kollsman Quality Control)**

6.5.5 Audits

6.5.5.1 Hardware Audits Summary

In addition to the procedural audits outlined in this report, a random audit was conducted on machine shop parts manufactured by the Avionics Division, prior to Finished Part Stockroom acceptance within the Space Division. This control operation permits effective monitoring of the Avionic Division Inspection function for trend analysis and subsequent corrective action implementation. See Table 6-47.

TABLE 6-47

HARDWARE AUDIT CONFORMANCE

	1966		
	1/3	2/3	3/3
Audit Samples	28	82	184
Quantity Defective	1	1	0
Total Characteristics	1225	1910	1776
Defective Characteristics	8	8	0
% Defective Characteristics	0.65	0.42	0.0

6.5.5.2 Quality Control Audits

This section provides a detailed breakdown of the auditing activities conducted during the reporting period.

All audits were performed in accordance with the Quality Control Instruction No. QCI 15SQ-001, "Quality Control Audit Procedure."

Each individual audit was presented in detailed tabular form.

TYPE OF AUDITS - Two types of Audits are presented: a standard, or regular type audit, and a general type audit.

a. A regular type audit is one which is subject to grading in the form of a numerical conformance score, which indicates the percentage of conformance of the audited area to the governing requirements.

b. A general type audit is one to which a numerical performance rating cannot be applied or the application of which would be impractical because of the nature of the area under audit. A study to determine the feasibility of converting general type audits to regular type audits has been completed. As a result, the number of general type audits has been minimized. Weighted checklists will be prepared as required in order to determine quantitative evaluations of conformance.

The following tables (6-48 through 6-58) are the result of an in-house, Product Assurance Audit, conducted at Kollsman.

TABLE 6-48

RECEIVING INSPECTION
(Authority: NPC 200-2, QAP 98119, QAP 98550, SPI 8550D)

Discrepancy

1. Receiving Inspection had an adequate area for handling rejected material but the subject area was not properly identified as per procedural requirements, QAP 981119 paragraph 5.5.4.

2. One Detronic plug gage had no visible gage control number plate as per SPI 8550D paragraph III A-1.

Immediate Action Taken

1. Material identification sign was installed in the assigned location.

2. Control number and plate were assigned. Record available in Gage Control area for periodic monitoring.

Preventive Action Taken to Preclude Recurrence

1. Personnel were admonished to adhere to all operating procedures. Adherence to these procedures is mandatory as per KI policy.

2. Same as (1).

STATUS: COMPLETE

TABLE 6-49

PLATING AND FINISHING/PARTS INSPECTION
(Authority: NPC 200-2, SPI 8801 and 8650C)

Discrepancy

1. Specification document, ND 1002083, was not signed by MIT/IL or NASA representatives.

2. Specification document, ND 1002099, had not date or approval signature by MIT/IL or NASA representatives.

3. List of Material Coding could not be cross-referenced for current status as the applicable specification document was not available.

Immediate Action Taken

1. A complete set of current documents as applicable were issued to the department supervisor. Obsolete documents were destroyed.

2. Same as (1).

3. Same as (1).

Preventive Action Taken to Preclude Recurrence

Configuration and Production Control department initiated the necessary procedures to ensure that all specification documents maintained in this subject area are current to the master file status.

STATUS: COMPLETE

TABLE 6-50

OPTICAL FABRICATION
(Authority: NPC 200-2, 5SQ-006, SPI 8801 and 8550D)

Discrepancy:

1. Specification documents ND 1002096, 1002091, 1002215, 1002019 were not signed by MIT/IL or NASA representatives.

2. Several bottles containing chemical solution were unidentified.

3. Standard pitch pots were not covered or identified.

4. Calibration label indicating schedules for periodic monitoring was missing from the following equipment:

    a. Federal Dial Indicator

    b. Optical Measuring Instrument

    c. Periscope Alignment Mirror

    d. Micrometer

Immediate Action Taken

1. A complete set of current documents as applicable were issued to the department supervisor. Obsolete documents were destroyed.

2. Subject bottles were identified with necessary labels.

3. Covers with identification provided.

4. Equipment referenced recertified and assigned to the scheduled calibration interval procedure. Identification labels provided. Personally-owned micrometers were checked and assigned to Tool Control surveillance for periodic calibration check.

Preventive Action Taken to Preclude Recurrence

1. Configuration and Production Control department initiated the necessary procedures to ensure that all specifications documents maintained in this subject area were current to the master file status.

2. Departmental supervisor was instructed to review all applicable procedures for handling chemical solutions and to initiate the necessary action to ensure compliance.

3. Same as Item 2.

4. Personnel were admonished to adhere to operating procedure specifically oriented to the maintenance requirements of personally-owned tools and measuring instruments.

STATUS: COMPLETE

6-51

ELECTRICAL STANDARDS LABORATORY
(Authority: NPC 200-2, SPI 8801)

Discrepancy

There were no humidity readings recorded on a periodic or scheduled basis.

Immediate Action Taken

To comply with a previous action request, the primary standards were maintained on a temporary basis in a controlled area with all the environmental requirements enforced. The remaining secondary standards were transferred to the same controlled area.

Preventive Action Taken to Preclude Recurrence

The laboratory was moved from the present inadequate location to a newly designated area featuring a completely controlled environment with all the necessary controls to ensure compliance with the applicable specifications.

STATUS: COMPLETE

TABLE 6-52

OPTICAL INSPECTION
(Authority: NPC 200-2, SPIU8130E, QAP 98119)

Discrepancy

1. Inspection Procedures and supporting documentation records pertaining to six audit samples contained omissions of inspection data necessary to establish concurrence to quality requirements.
2. Articles were not physically segregated and identified as to status (materials awaiting inspection, conforming materials for stockroom, or rejected material).

Immediate Action Taken

1. Inspection Procedures and supporting documentation records were reviewed by supervisor and brought up-to-date as required.

2. Supervisor segregated material and had additional shelves installed to facilitate storage of subject material. Shelves are now identified with category of material and present status.

Preventive Action Taken to Preclude Recurrence

1. Personnel were cautioned to adhere to all operating procedures.

2. Same as (1).

STATUS: COMPLETE

TABLE 6-53

FINISHED PARTS STOCKROOM
(Authority: NPC 200-2, AOP No. 1)

Observation

The Finished Parts Stockroom was satisfactorily complying with applicable controlling documents as they pertain to the articles subjected to this audit. The area of concern was the limited space provided for this facility. The audit team had recommended that a larger area be considered in future planning to improve handling and storage capabilities.

STATUS: COMPLETE

TABLE 6-54

LIMITED SHELF LIFE ARTICLES
(Authority: NPC 200-2, ARP-4C)

Discrepancy

Production Control records did not indicate requirements of all limited shelf life items. Specifically, PN 1006268 Epoxy Resin and PN 1010303 Adhesive.

Immediate Action Taken

Shelf life requirements were immediately entered into Production Control Records.

Preventive Action Taken to Preclude Recurrence

Production Control was directed to conform with Apollo Reliability Procedure No. 4C which requires these records to be maintained as part of AGE control.

Comments

This was a discrepancy of record keeping and not the AGE controlled material.

Limited shelf life material was always inspected for an acceptable expiration date, prior to issuance from the stockroom to the production floor.

STATUS: COMPLETE

TABLE 6-55

TEST EQUIPMENT LABORATORY
(Authority: NPC 200-2, QCI-9SQ-004)

Discrepancy

1. Temperature indicator No. 2222-1028-1 was not registered for periodic calibration frequency. No procedure was available for this indicator relative to calibration and maintenance requirements.

2. Variable data not recorded for the following equipment:
   a. Vacuum Tube Voltmeter No. 8909-0018 SN 13
   b. Temperature Indicator No. 2222-1028-1

3. "Equipment Service Record" file card for No. 0005-0075 did not indicate type of service for which the equipment was designated.

Immediate Action Taken

1. Indicator was calibrated, registered and returned to laboratory. Procedure was generated for calibration and maintenance requirements.
2. Variable data record cards were instituted for test equipment referenced.
3. File card data was completed by supervisor.

Preventive Action Taken to Preclude Recurrence

Personnel were cautioned to adhere to all operating procedures.

STATUS: COMPLETE

TABLE 6-56

MODEL PART SHOP
(Authority: NPC 200-2, QCI 9SQ-002, 2SQ-001A,
7SQ-003 and 7SQ-002)

Discrepancy

1. Personal micrometer not submitted to gage control for scheduled recheck.
2. Gage block sticker indicated a one-month interval for scheduled calibration, departmental records indicated a 6-month interval.
3. Gage block set was not identified by sticker for scheduled calibration interval.
4. Drawings No. 6011088B and No. 2012676B were marked "For Reference Only".

Immediate Action Taken

1. Micrometer referenced was rechecked, and assigned to the tool control scheduled calibration interval system.
2. New sticker listing 6-month calibration interval affixed to measuring instrument.

3. Gage blocks referenced were used and were identified only for preliminary set-up, then master calibrated gage blocks were used for final alignment.

4. Drawings referenced were removed from area and replaced by authorized manufacturing release drawings.

Preventive Action Taken to Preclude Recurrence

Operating personnel reinstructed in the procedural requirements of QCI 9SQ-002, 2SQ-001A, 7SQ-003 and 7SQ-002.

STATUS: COMPLETE

TABLE 6-57

IN-PROCESS INSPECTION MODEL PARTS SHOP
(Authority: NPC 200-2, QCI 2SQ-001A, 7SQ-003, 7SQ-002)

Discrepancy

1. Drawings which accompanied the audit samples were identified as "For Reference Only" not "Released for Manufacturing".

   a. 6011088B Lens Housing

   b. 2012070B Cover

2. Five audit sample route and tool packages did not have the Operation Sheets or Summary Sheets attached as required for implementation by operating personnel.

3. Incomplete documentation data recorded on completed route and tool sheets.

Immediate Action Taken

1. Reference drawings were removed from area and replaced by authorized manufacturing release drawings.

2. Inspection procedures contained in the subject route and tool package were revised by Quality Control to include the establishment of Operation History and Summary Sheets as per QCI 7SQ-002 and QCI 7SQ-003.

3. Route and tool sheets were reviewed and corrected where support documentation was omitted.

Preventive Action Taken to Preclude Recurrence

Model Shop operating personnel and Quality Control procedure writers were reinstructed in procedural requirements of QCI 2SQ-001A, 7SQ-003 and 7SQ-002. In-process inspection personnel were instructed to intensify their surveillance activity to preclude recurrence of discrepancies.

STATUS: COMPLETE

TABLE 6-58

FINAL INSPECTION
(Authority: NPC 200-2, 10SQ-001)

Discrepancy

1. Inspection rejection stamps were not cancelled by superimposing authorized cancellation stamps.

2. Inspection stamps were not clearly legible or were replaced by a check mark indicating acceptance.

Immediate Action Taken

1. All documents were reviewed and stamped as specified by procedural requirements.

2. Same as (1).

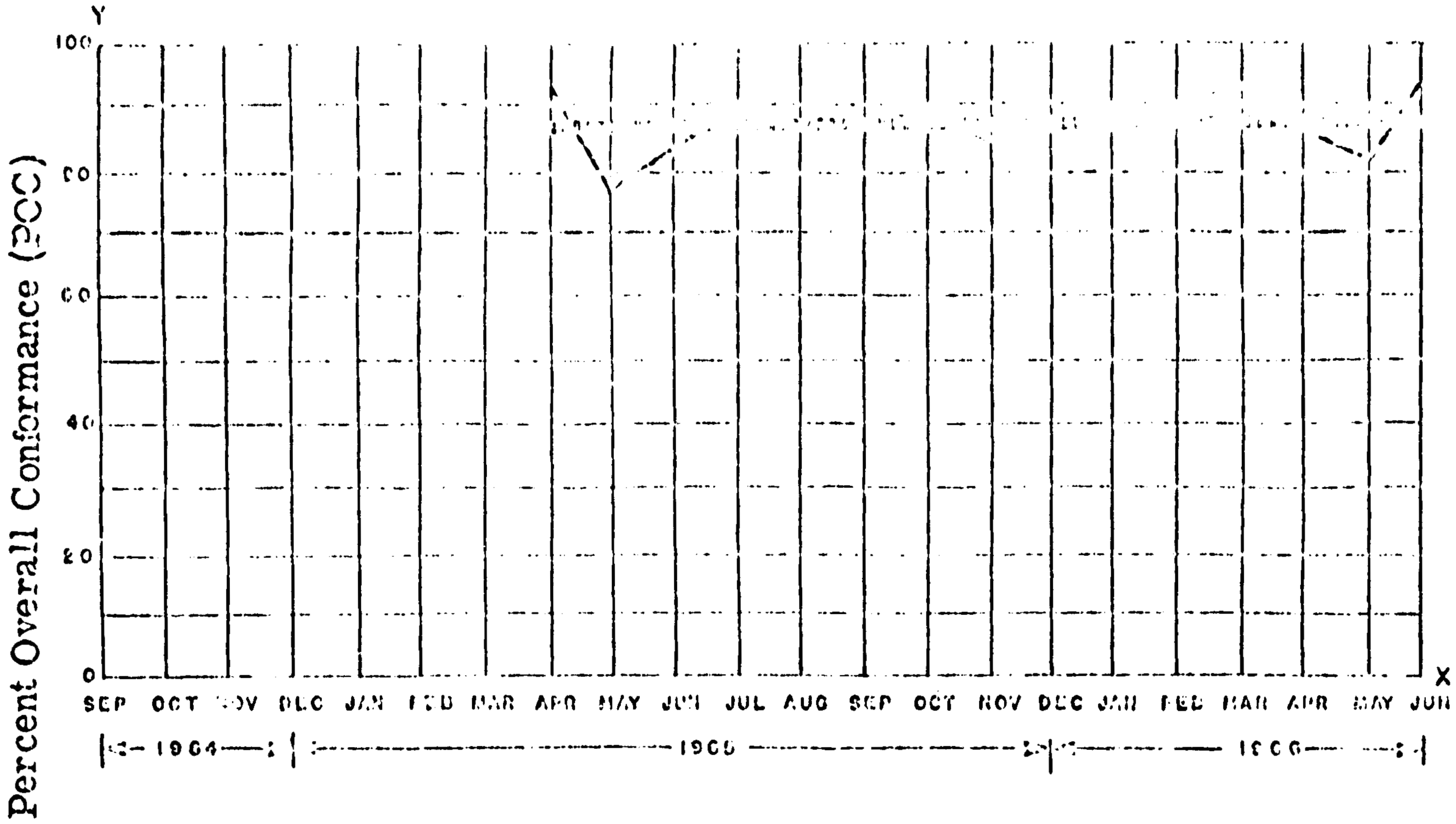
Preventive Action Taken to Preclude Recurrence

Personnel were cautioned to exercise additional care in the performance of their duties and to adhere to all requirements of Quality Control Instruction 10SQ-001.

STATUS: COMPLETE

OVERALL AUDIT CONFORMANCE. Figure 6-20 "Percent Overall Audit Conformance", illustrates the progress of the audit operation in achieving optimum conformance of 100 percent. A monthly summary conformance plot and linear relationship (best line) for the 15-

KOLLSMAN INSTRUMENT CORPORATION



MONTHLY PLOT

LINEAR TREND

% Overall Conformance = POC

$$POC = \frac{\text{Actual Conf. Points}}{\text{Possible Conf. Points}} \times 100\%$$

Linear Relationship $Y = a + b x$

a = Y Intercept

b = Regression Coefficient

Year		End of Quarter	% Trend
1965	3rd	$Y = 85.5 + 0.38x$	x6 = 87.8
	4th	$Y = 85.4 + 0.25x$	x9 = 87.6
1966	1st	$Y = 85.9 + 0.20x$	x12 = 88.3
	2nd	$Y = 86.6 + 0.05x$	x15 = 87.3

Figure 6-20. Percent Overall Audit Conformance

month period are displayed. At the end of the third quarter 1965, the Y intercept of the best line (plot X0) was 85.5 percent out of a possible 100 percent. The end of the second quarter 1966 (plot X15) showed a quarterly Y calculation of 87.3 percent. An increase of 1.8 percent over the past 15 months, with the final monthly plot, June 1966, attained 92 percent conformance. Table 6-59 delineates the supporting statistics used to obtain the overall audit conformance rating.

DETERMINATION OF "PERCENT OF CONFORMANCE" RATING. The degree which each audited area conformed to procedural requirements and contractual obligations, is indicated by the "Area Percent Conformance" figure. The "Area Percent Conformance" figure was determined in the following manner. See Figure 6-21 and Table 6-60.

a. Random selection of at least one part being processed.

b. Determination of compliance with control requirements by examing the part, records and all areas pertinent to the part. The examinations are then quantitatively rated in accordance with a preestablished weighted check list.

c. The part's degree of conformity was then determined by totaling all the quantitative points (Actual No. of Conformance Points) credited to it on the check list. A part which conforms to all requirements will receive a maximum score of 100.

   In most instances more than one part is available for audit scrutiny. In these instances several audits are performed concurrently; however, each part is scored independently.

d. Upon completion of all audits, the individual scores were totaled ("Total Conformance Points"), the total multiplied by 100 and the result divided by the "Total Possible Points". (100 x No. of Parts Audited). The final figure was the Area Percent Conformance. See Example.

Example:

Audited Area: Receiving Inspection

1. Degree of conformity per part:

Part No.	Actual No. of Conformance Points
03386916176	94
1022008	94
1010651	94
1010652	94

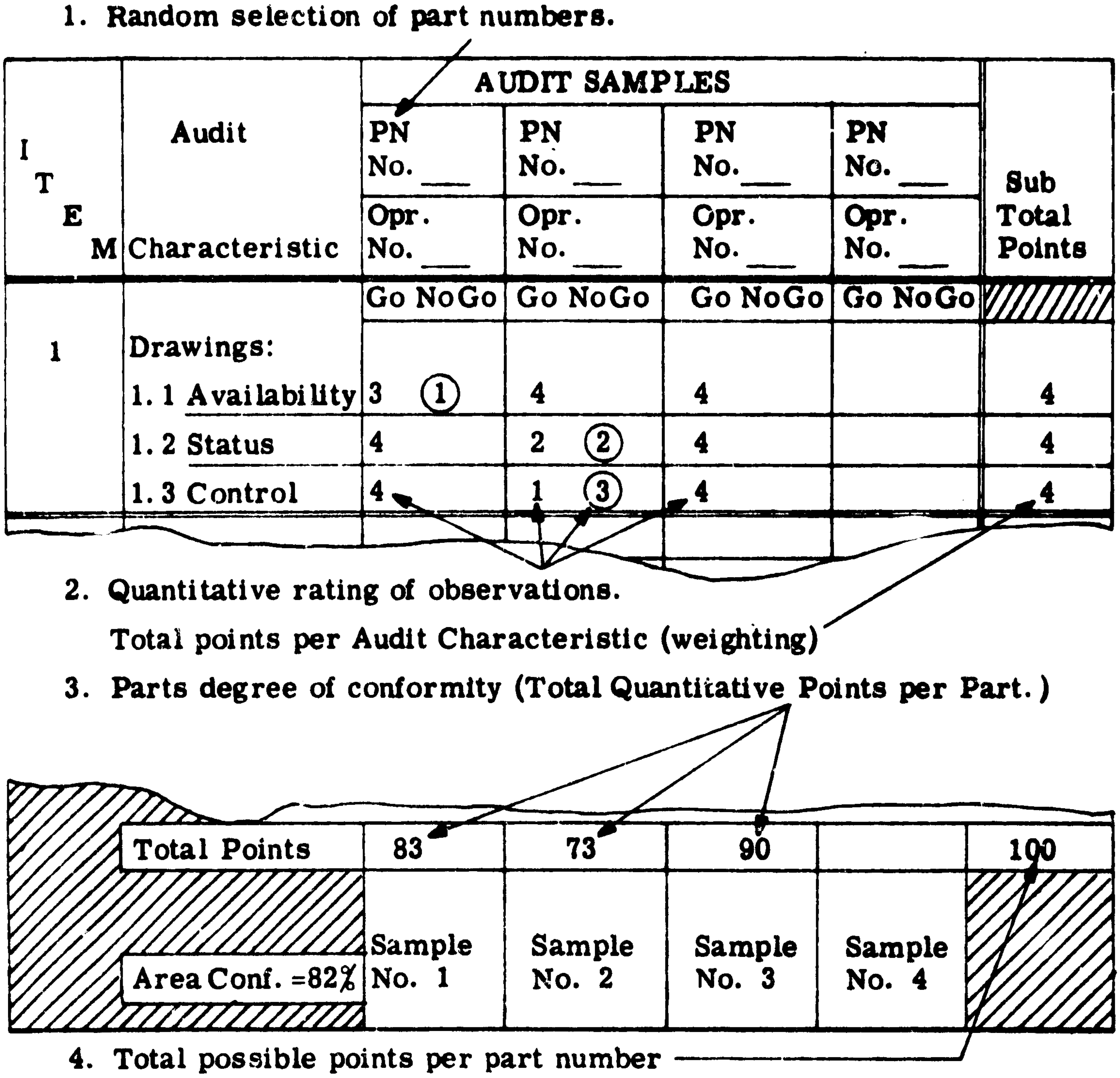
TABLE 6-59

PROCEDURAL AUDITS SUMMARY

					1965							1966	
Monthly Status	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Total Areas	3	6	3	4	4	3	3	3	3	4	4	3	2
Total PN Used	12	21	7	8	9	9	9	9	11	9	16	16	12
Total Audit Samples	12	21	7	9	9	9	9	9	12	14	22	16	12
Total Characteristics	288	396	138	137	165	140	267	135	282	362	440	353	234
Possible Conformance Points	1200	2100	700	485	900	700	900	726	1038	1400	2200	1520	1200

1966

Monthly Status	July	Aug.	Sept.	Oct.	Nov.	Dec.
Total Areas	5	5	4	2	3	3
Total PN Used	14	24	29	6	11	15
Total Audit Samples	14	24	20	6	11	12
Total Characteristics	264	750	750	150	224	374
Possible Conformance Points	4600	2400	2000	600	1100	1250



1. Random selection of part numbers.

ITEM	Audit Characteristic	AUDIT SAMPLES				Sub Total Points
		PN No. ___ Opr. No. ___	PN No. ___ Opr. No. ___	PN No. ___ Opr. No. ___	PN No. ___ Opr. No. ___	
		Go NoGo	Go NoGo	Go NoGo	Go NoGo	▨
1	Drawings:					
	1.1 Availability	3 ①	4	4		4
	1.2 Status	4	2 ②	4		4
	1.3 Control	4	1 ③	4		4

2. Quantitative rating of observations.

Total points per Audit Characteristic (weighting)

3. Parts degree of conformity (Total Quantitative Points per Part.)

Total Points	83	73	90		100
Area Conf. =82%	Sample No. 1	Sample No. 2	Sample No. 3	Sample No. 4	

4. Total possible points per part number

Figure 6-21. Quality Control Audit Sheet

TABLE 6-60 (Page 1 of 5)

PERCENT OF CONFORMANCE

AUDITED AREA: Receiving Inspection **Total Possible Points:** 600

Audited Part Numbers	Max. No. of Points Per PN	Actual No. of Conformance Points	Percent Conformance Per PN	Total Conformance Points	Area Percent Conformance
03386916176	100	94	94		
1022008	100	94	94		
1010651	100	94	94		
1010652	100	94	94		
1012065	100	94	94		
2011176	100	94	94	564	94%
AUDITED AREA: Parts Inspection			**Total Possible Points:** 200		
2011304 (SN 14)	100	88	88		
2011304 (SN 15)	100	88	88	176	88%

TABLE 6-60 (Page 2 of 5)

PERCENT OF CONFORMANCE

AUDITED AREA: Optical Fabrication			Total Possible Points: 200		
Audited Part Numbers	Max. No. of Points Per PN	Actual No. of Conformance Points	Percent Conformance Per PN	Total Conformance Points	Area Percent Conformance
6011405	100	84	84		
6011417	100	84	84	168	84%
AUDITED AREA: Electrical Standards Laboratory			Total Possible Points: 400		
6715-0136-1	100	80	80		
6309-0011-1	100	80	80		
6309-0008-4	100	80	80		
6309-0014-1	100	80	80	320	80%
AUDITED AREA: Optical Inspection			Total Possible Points: 600		
2011169	100	76	76		
2011270	100	76	76		
2011636	100	76	76		
2011651	100	76	76		
2011664	100	76	76		
2011710	100	76	76	456	76%

TABLE 6-60 (Page 3 of 5)

PERCENT OF CONFORMANCE

AUDITED AREA: Finished Parts Stockroom Total Possible Points: 600

Audited Parts Numbers	Max. No. of Points per PN	Actual No. of Conformance Points	Percent Conformance Per PN	Total Conformance Points	Area Percent Conformance
1006750-43	100	91	91		
1006750-53D	100	91	91		
1006750-43	100	91	91		
1012218	100	91	91		
2011702	100	91	91		
1006750-47	100	91	91	546	91%
AUDITED AREA: Limited Shelf Life Articles			Total Possible Points: 400		
1011541	100	80	80		
1006286	100	80	80		
1006835	100	80	80		
1010303	100	80	80	320	80%

TABLE 6-60 (Page 4 of 5)

PERCENT OF CONFORMANCE

AUDITED AREA: Test Equipment Laboratory Total Possible Points: 600

Audited Parts Numbers	Max. No. of Points per PN	Actual No. of Conformance Points	Percent Conformance Per PN	Total Conformance Points	Area Percent Conformance
8909-0034	100	100	100		
8909-0018	100	95	95		
5006-0038	100	100	100		
0506-0008	100	100	100		
5409-0023	100	100	100		
2222-1028	100	64	64	559	93%

AUDITED AREA: Model Parts Shop Total Possible Points: 600

6011088B	100	83	83		
2012726	100	91	91		
2012725	100	91	91		
6011107	100	95	95		
6011140	100	95	95		
2012676	100	87	87	542	90%

TABLE 6-60 (Page 5 of 5)

PERCENT OF CONFORMANCE

AUDITED AREA: In-House Inspection (Model Parts Shop) Total Possible Points: 600

Audited Parts Numbers	Max. No. of Points per PN	Actual No. of Conformance Points	Percent Conformance Per PN	Total Conformance Points	Area Percent Conformance
6011088B	100	82	82		
2012726	100	97	97		
2012725	100	97	97		
6011107	100	97	97		
6011140	100	81	81		
2012676	100	89	89	553	92%

AUDITED AREA: Final Inspection Total Possible Points: 320

Audited Parts Numbers	Max. No. of Points per PN	Actual No. of Conformance Points	Percent Conformance Per PN	Total Conformance Points	Area Percent Conformance
2011722A	80	73	91		
2007176	80	73	91		
2012568	80	73	91		
2012730	80	73	91	292	91%

Part No.	Actual No. of Conformance Points
1012065	94
2011176	94
Total Conformance Points =	564

2. $$\text{Area \% Conformance} = \frac{\text{Total Conformance Points x 100}}{\text{Total Possible Pts.}} = \frac{564 \times 100}{100 \times 6} = 94\%$$

The difference between the actual number of conformance points per part number is not always indicative of a nonconforming part. However, it may indicate nonadherence to a given procedure applicable to the audit area.

QUALITY CONTROL AUDITS PREVENTIVE ACTION PROGRESS REPORTS

In many instances a Quality Control Audit resulted in immediate correction of the observed discrepancy, and an investigation to determine preventive measures.

In the event Preventive Action requests were generated, interim measures were immediately effected. Interim measures consisted of the following:

a. Immediate correction of the observed discrepancy.

b. Institution of temporary measures which would immediately detect and correct all recurrences.

c. Investigation of measures which, wh n instituted, would preclude recurrence of the type of discrepancy observed.

d. Implementation of preventive measures which resulted from "c" above.

The corrective action status of all investigations initiated prior to the period covered by this report were complete.

GLOSSARY OF PROCEDURES REFERENCED

NASA

NPC 200-2	Quality Program Provisions for Space System Contractors

Kollsman

SPI-0000	Standard Practice Instruction
QCI-SQ-000	Quality Control Instruction - Space Division
QAP-0000	Quality Assurance Procedure
AOP-0	Apollo Operating Procedure

6.6 SUMMARY OF YEAR ENDING 1967

6.6.1 Management

6.6.1.1 Personnel and Organization

The organization structure of the Apollo/LM Program Product Assurance Section within the Product Assurance Department is shown in Figure 6-22. The Quality Assurance Section consisted of 18 personnel.

6.6.2 Milestones

The Quality Assurance quarterly presentations were made to AC. The qualification of the design changes to LM-AOT 604 (per KI-AR-TP 2000) was completed early in November.

6.6.3 Major Problems

NASA discontinued MSC-AD-66-3 testing on C-328 viton adhesive due to excessive total organic content during outgassing. A post-cure procedure was required prior to further testing to minimize the rate of outgassing.

The viton sponge used as eyepiece thermal insulation proved unstable at elevated temperatures and/or reduced pressure. Subsequent investigation revealed that the material as received from the vendor, was not post-cured. The probability was high that this material would also fail the NASA outgassing requirements.

6.6.4 Documentation

6.6.4.1 Quality Control Plan (Volume I)

The Quality Plan was finalized and approved. Forty copies of the subject document updated to September 1966 was delivered to A. C. Electronics.

6.6.4.2 Quality Control Procedure (Volume II)

The Quality Plan had been determined acceptable and forty copies of the subject document updated to September 1966 was forwarded to A. C. Electronics.

6.6.4.3 Documentation Review

Engineering changes and documents reviewed during the reporting period are listed in Table 6-61

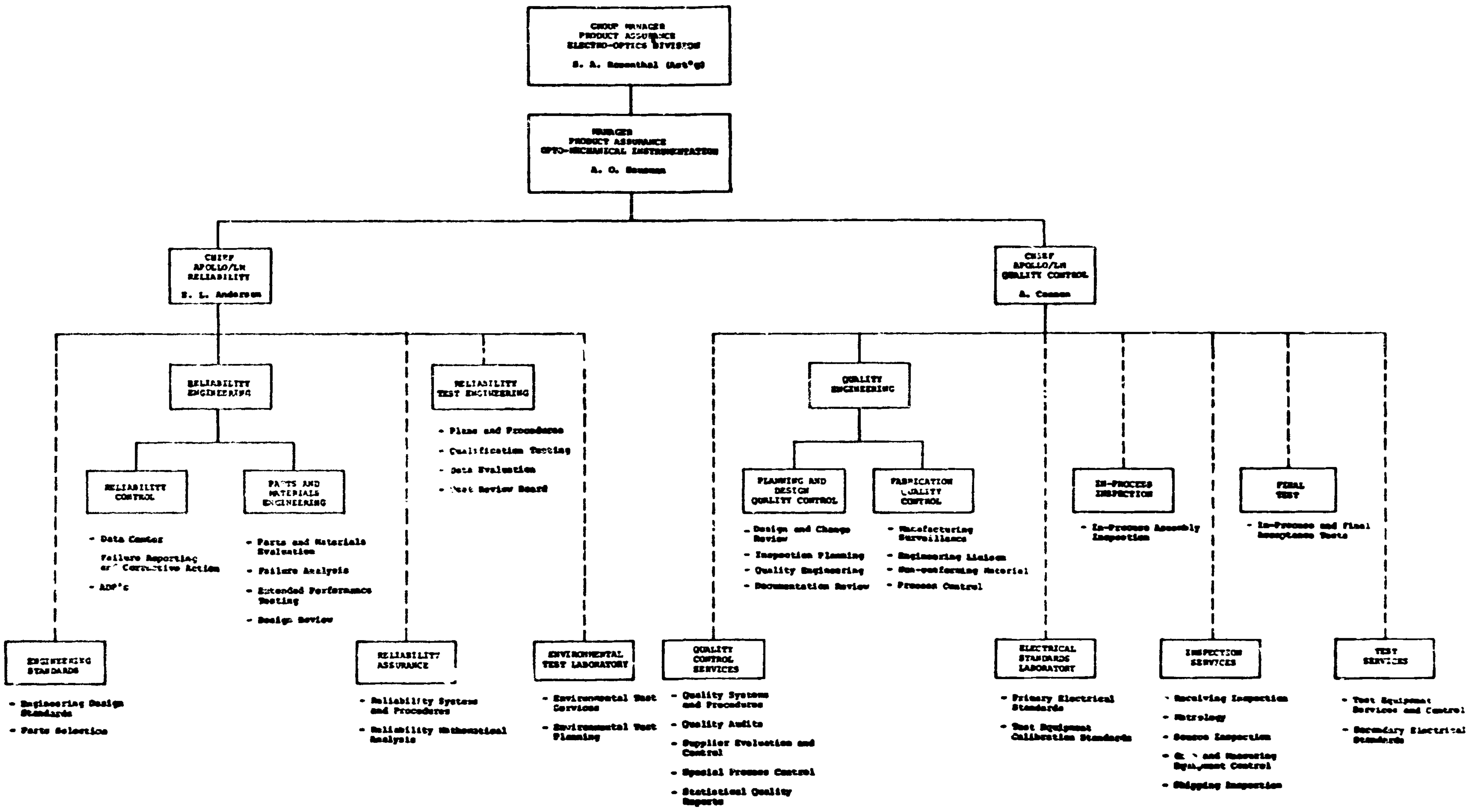


Figure 6-22. Product Assurance Functional Organization for Apollo/LM Programs

TABLE 6-61

SUMMARY DOCUMENT REVIEW	
RTM/ECP/ECO	627
TDRR	87
P.R./P.O.	724
Test Evaluation (JDQ)	470
ADP	38
Specifications	90
Route & Tool Book	
- New	290
- Rework	215
- Revision	383

6.6.5 Procurement

6.6.5.1 Receiving Inspection

Material Received - Of the 17,128 parts inspected by the Receiving Inspection Department during the reporting period, 11.1 percent of 1,607 parts were found to be nonconforming and were subsequently dispositioned by 41 formal Material Review Board (MRB) actions. (See Table 6-62 for additional breakdown of material received for the report period and Figure 6-23 for linear trend indication.)

6.6.5.2 Material Review Board

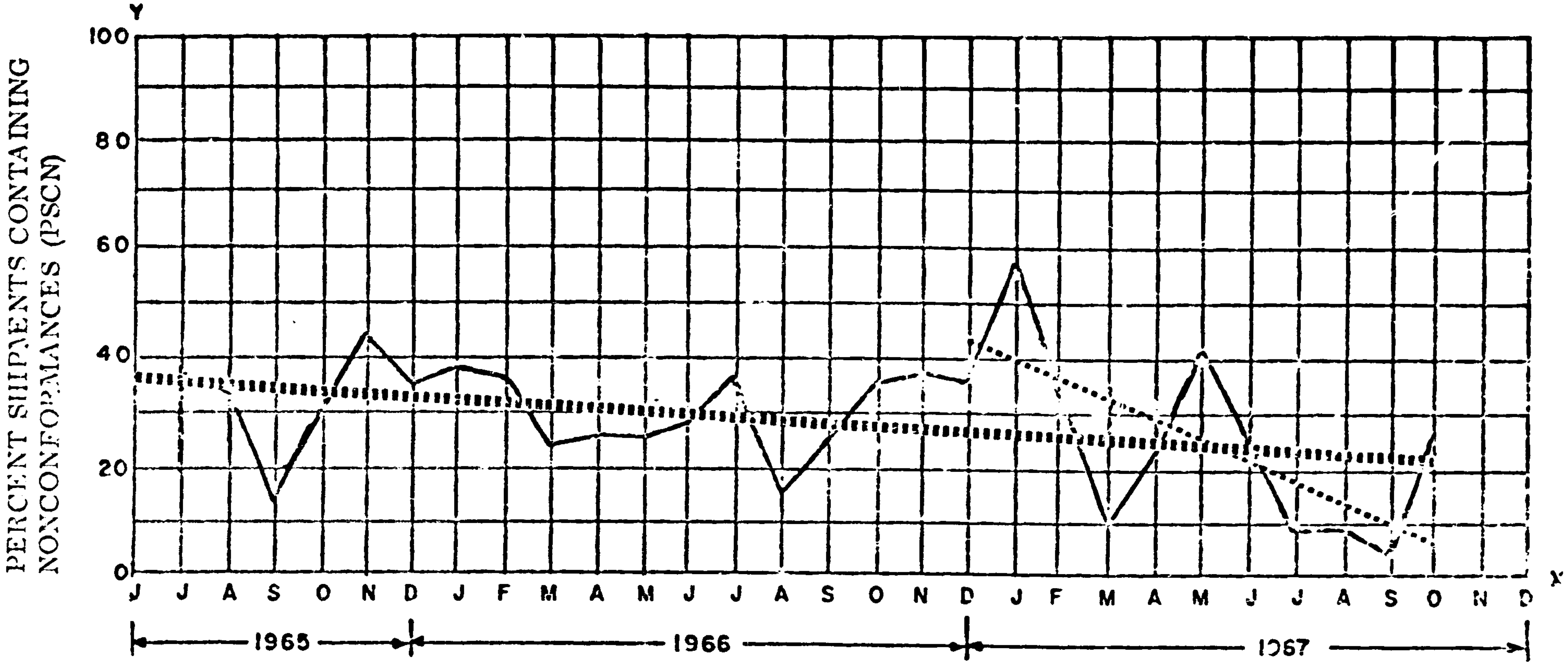
Material Review Activity - Quality Control during the first reporting period processed 41 Formal Board Actions for the Procurement section of the Material Review Board. Thirty-one FBA's were for the Command Module and ten for the LEM procurement activity. (See Table 6-63 for additional breakdown, and Figure 6-24 for linear trend indication.)

Material Review Corrective Action - Table 6-64 delineates the Material REview Corrective Action Status for the CM and LM.

TABLE 6-62

MATERIAL RECEIVED FOR COMMAND MODULE/LUNAR EXCURSION MODULE

Period	Shipments		% Shipments Nonconforming	Parts		% Units Nonconforming
	Evaluated	Nonconforming		Inspected	Nonconforming	
First	260	106	41%	5516	864	16%
Second	180	51	28.3%	1872	221	11.8%
Third	413	49	12%	9740	522	5.4%



——— MONTHLY PLOT

VDB * ▮▮▮▮▮▮

10 months 1967 ·········· LINEAR TREND

% Shipments Containing Nonconformances = PSCN

$$PSCN = \frac{\text{Shipments Nonconformance}}{\text{Shipments Received}} \times 100\%$$

Vertical Deviation Base
(Oct. 1964 thru Dec. 1966)

Linear Relationship $Y = a - b\,x$

a = Y Intercept

b = Regression Coefficient

* Vertical Deviation Base
(July 1965 thru October 1967)

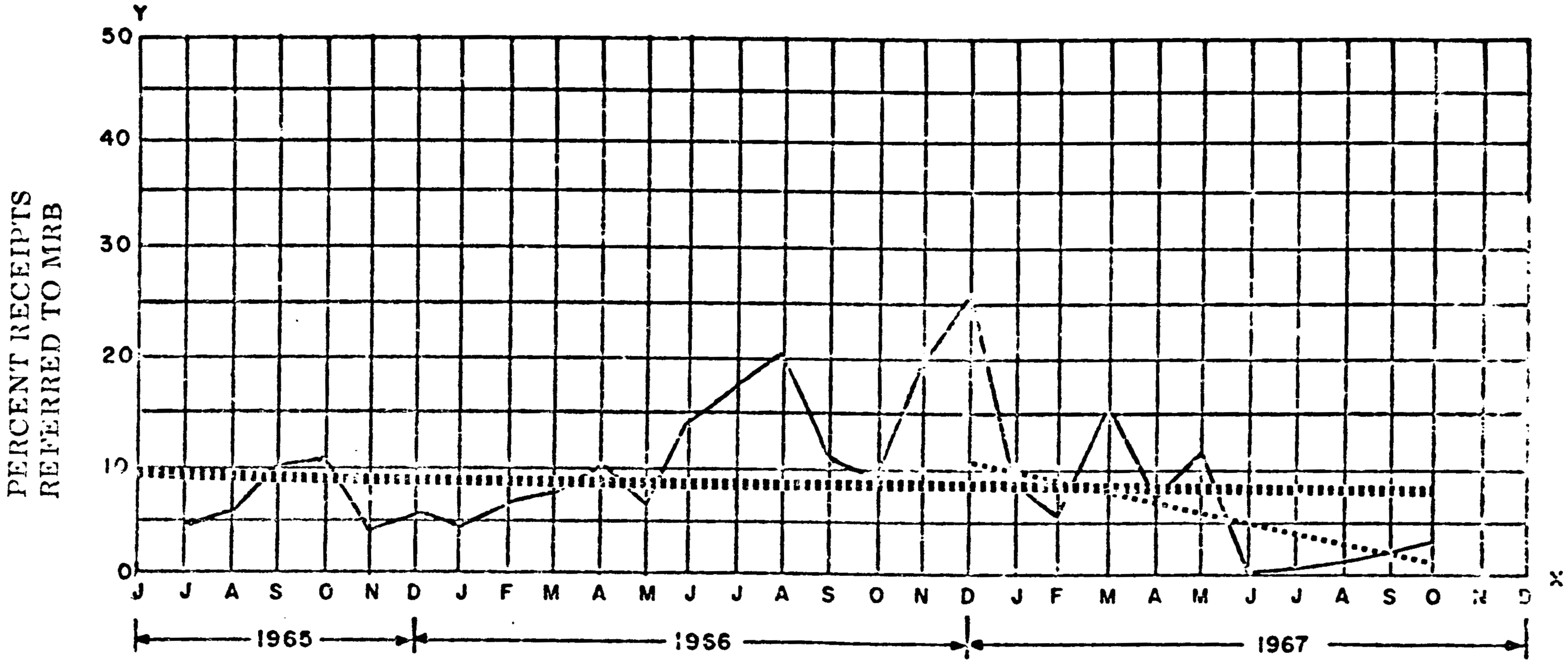
Figure 6-23. Procured Material (Shipment) Nonconformance Trend

TABLE 6-63

PROCUREMENT MATERIAL REVIEW ACTION COMMAND MODULE/LUNAR EXCURSION MODULE

Formal Board Actions						
Period	CM	LEM	Total FBA	Total Pieces	Shipments Received	FBA Percentage
First	16	6	22	171	260	8.5% (Avg)
Second	11	2	13	37	180	7.2% (Avg)
Third	4	2	6	18	413	1.5% (Avg)

$$\text{FBA Percentage} = \frac{\text{Total FBA's}}{\text{Shipments Received}} \times 100\%$$



——— MONTHLY PLOT

VDB* ▮▮▮▮▮▮▮▮ LINEAR TREND

10 months 1967 ············

Percent Receipts Referred to MRB = %

$\% = \frac{\text{FBA}}{\text{Receipts Inspected}}$

Vertical Deviation Base
(Jan. 1965 thru Dec. 1966)

Linear Relationship $Y = a - b x$

a = Y Intercept

b = Regression Coefficient

* Vertical Deviation Base
(July 1965 through October 1967)

Figure 6-24. Material Review ACtivity Trend CM/LM (Procured Material)

TABLE 6-64

MATERIAL REVIEW CORRECTIVE ACTION STATUS
(PROCURED MATERIAL)
COMMAND MODULE/LUNAR MODULE

	First Period 1967	Second Period 1967	Third Period 1967
Shipments Received	260	180	413
Formal Board Actions	22	13	4
FBA Percentage	9.8	6.2	1.2
Supplier Problem Conferences			
At Kollsman	4	2	0
At Supplier Facilities	12	9	3
Telecon	45	58	58
Written Request for Corrective Action			
Requested	6	10	6
Received Reply	4	10	3
Accepted Reply	4	10	3

Material Review Dispositions - Figure 6-25 delineates the Formal Board Action activity, segregated into two disposition categories. Return-to-supplier and scrap material disposition are not shown in this presentation.

6.6.5.3 Supplier Activities

ND1015404 Status - The status of ND 1015404 requirements is listed in Table 6-65.

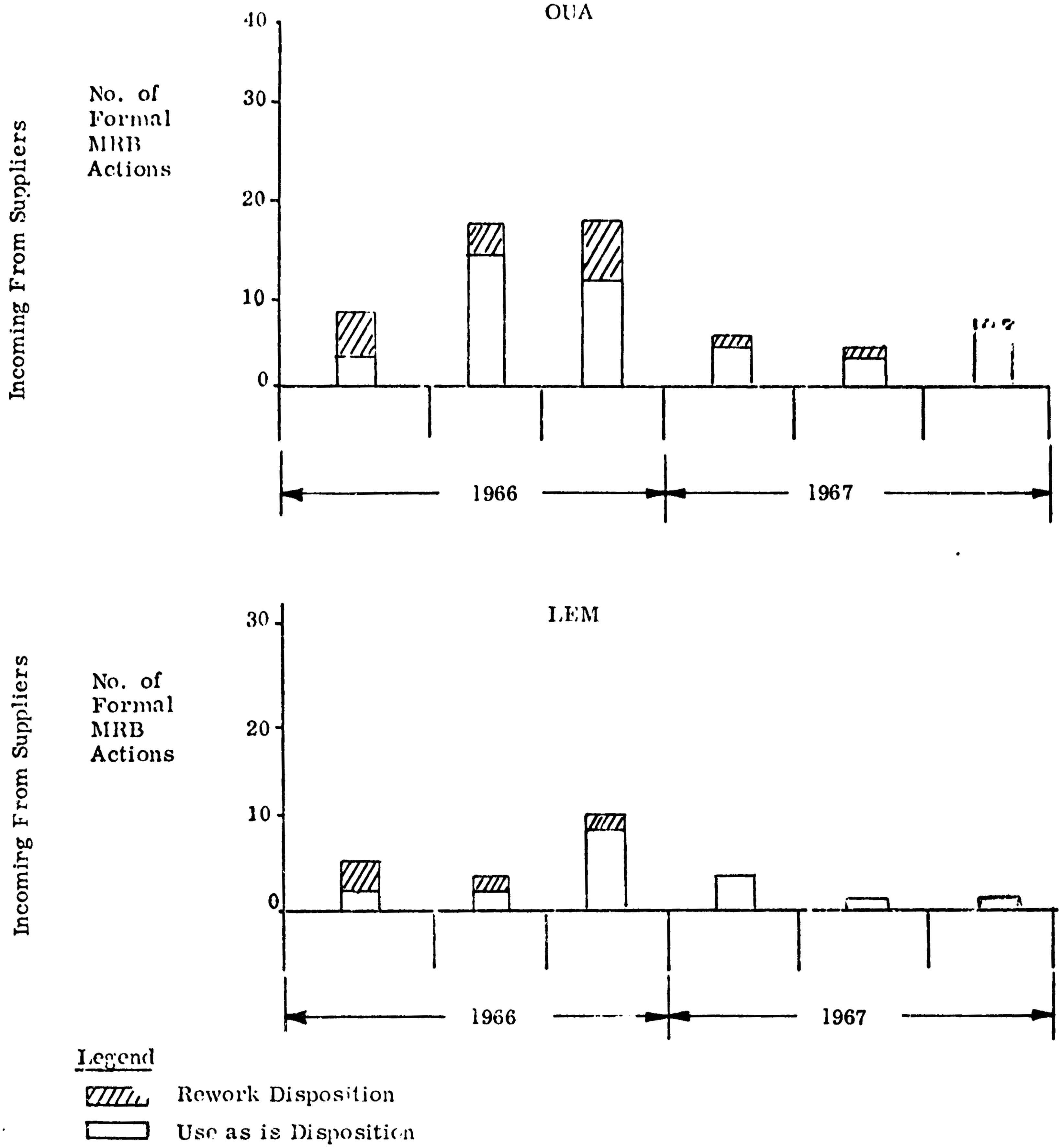


Figure 6-25. CM/LEM Procured Material Review Dispositions

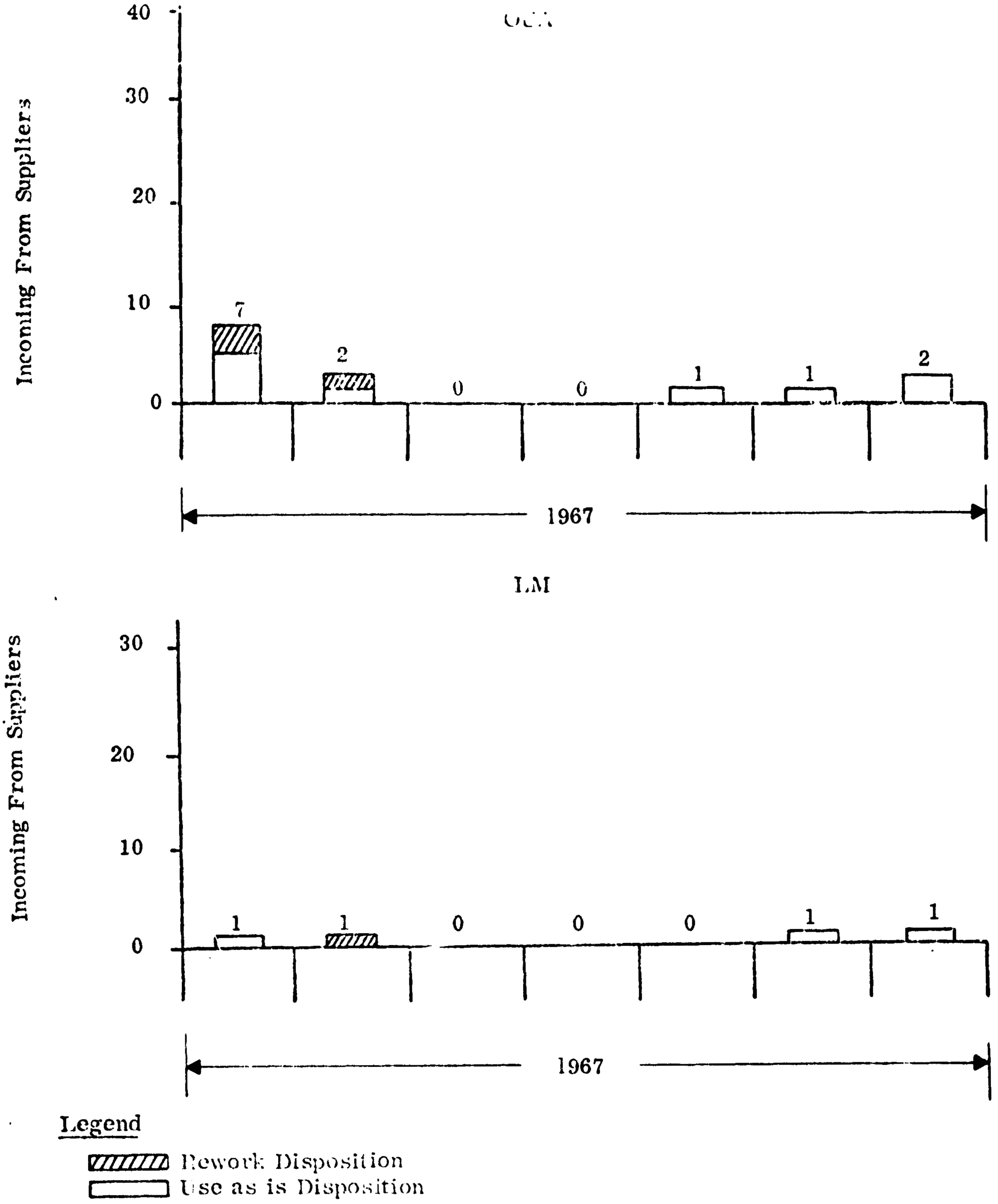


Figure 6-25. CM/LM Procured Material Review Dispostions

TABLE 6-65

ND 1015404 STATUS
COMMAND MODULE/LUNAR MODULE

	First Period 1967	Second Period 1967	Third Period 1967
Suppliers Surveyed			
Approved	603	614	835
Disapproved	186	187	252
Inspection Plans			
Approved	252	252	336
Disapproved	0	0	1
Traceability Plans			
Approved	246	246	328
In-Process	0	0	1
Critical Process Agreement			
Approved	486	486	652
In-Process	0	0	3
Change Requests			
Accepted	424	457	646
Not Accepted	66	66	102
In-Process	7	8	0

6.6.6 In-House Activities

6.6.6.1 Fabrication Control

Parts/Optics Inspection and Test - During the reporting period, 3,148 parts were inspected. One hundred and five were rejected for an average rejection rate of 4.1 percent. Table 6-66 represents a final summary for trend analysis and corrective action implementation. (See Figure 6-26 for trend percentage of parts/optics defective (PP/OD.)

Assembly Inspection and Test - During the reporting period, 5,722 assemblies were inspected. One hundred twenty-eight assemblies were rejected for an average rejection rate of 2.1 percent. (Table 6-67 represents a final summary for trend analysis and corrective action implementation, and Figure 6-27 for trend in percentage of assemblies defective (PAD).)

6.6.6.2 Material Review Board

Material Review Activity - Quality Control processed 74 Formal Board Actions (FBA) for the in-house section of the Material Review Board (MRB) during the reporting period. Forty-four FBA's were for the Command Module and 30 were for the LEM fabrication activity. (See Table 6-68 for additional analysis, and Figure 6-28 illustrates the in-house assembly activity versus the Material Review Activity.)

Material Review Corrective Action - QC investigated the cause of the nonconformances contributing to the FBA's processed during the reporting period, referenced in Figure 6-28. Corrective Action as detailed in Figure 6-29 was initiated by QC to preclude recurrence of the nonconformances.

Material Review Disposition - QC processed the nonconforming material into two categories of disposition, referenced in Figure 6-29, as illustrated in Figure 6-30. Return-to-supplier and scrap material dispositions are not shown.

6.6.6.3 MRB Assignment to OUA

Figure 6-31 illustrates the number of MRB's assigned to the optical unit assembly by AGE designation. The total MRB's per AGE is further classified into prime and carried-over categories. For example; an individual MRB originally initiated for AGE-LM (learner Model) would be considered prime, while all subsequent usage of the MRB material on other AGE-OUA's would be classified as carried-over. The origin of the MRB initiation was also presented at Kollsman (in-house activity) or Supplier (nonconforming procured material).

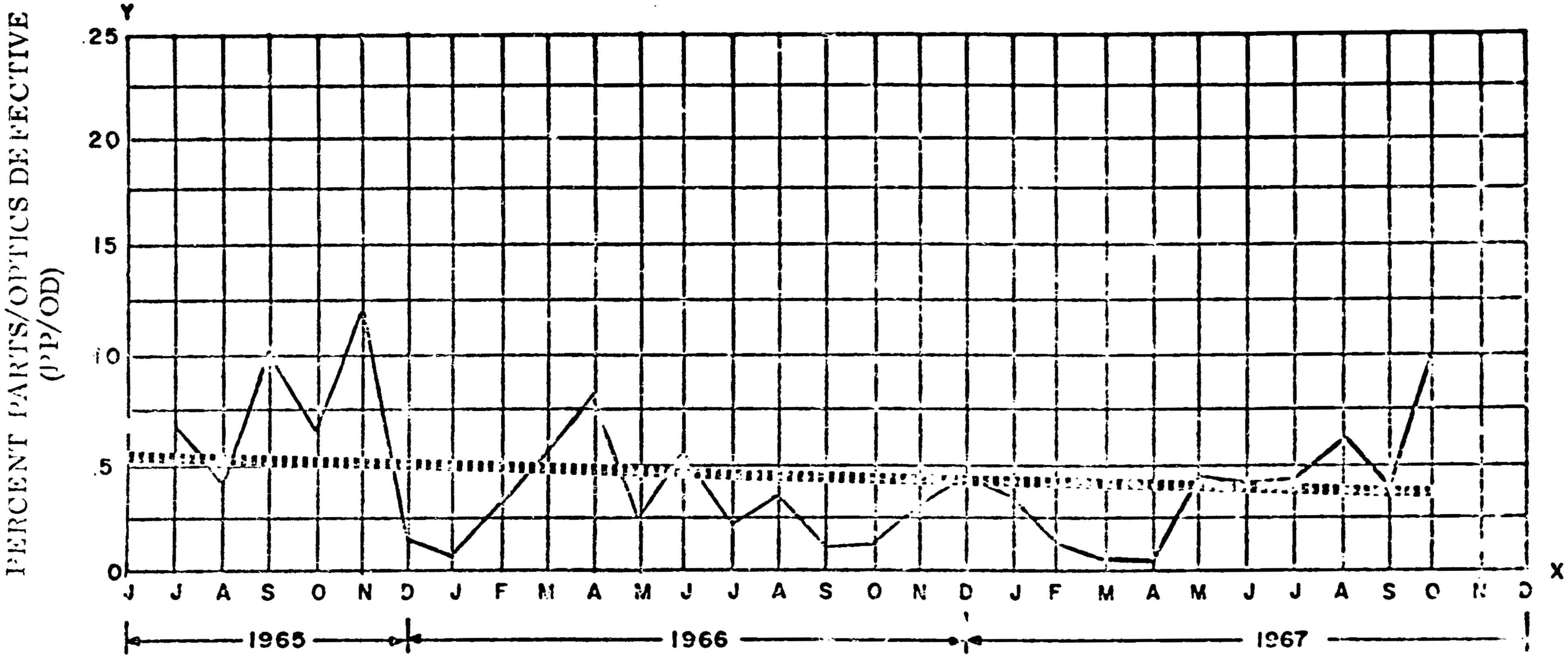
TABLE 6-66

COMMAND MODULE/LUNAR EXCURSION MODULE PARTS/OPTICS FABRICATION - INSPECTED/REJECTED

1967 Period	Inspected		Rejected		PP/OD % Parts/Optics Defective	Trend Indicator
	Parts	Optics	Parts	Optics		
First	1355	581	36	0	-	1.8% (Avg)
Second	372	100	18	0	-	3.8% (Avg)
Third	740	0	50	0	-	6.8% (Avg)

Parts = Machine Shop Input

Optics = Optical Facility Input



—— MONTHLY PLOT

▮▮▮▮▮▮▮▮▮ LINEAR TREND

% Parts/Optics Defective = PP/OD

$$PP/OD = \frac{\text{Parts/Optics Rejected}}{\text{Parts/Optics Inspected}} \times 100\%$$

Vertical Deviation Base
(Oct. 1964 thru Dec. 1966)

Linear Relationship Y = a - b x

a = Y Intercept
b = Regression Coefficient

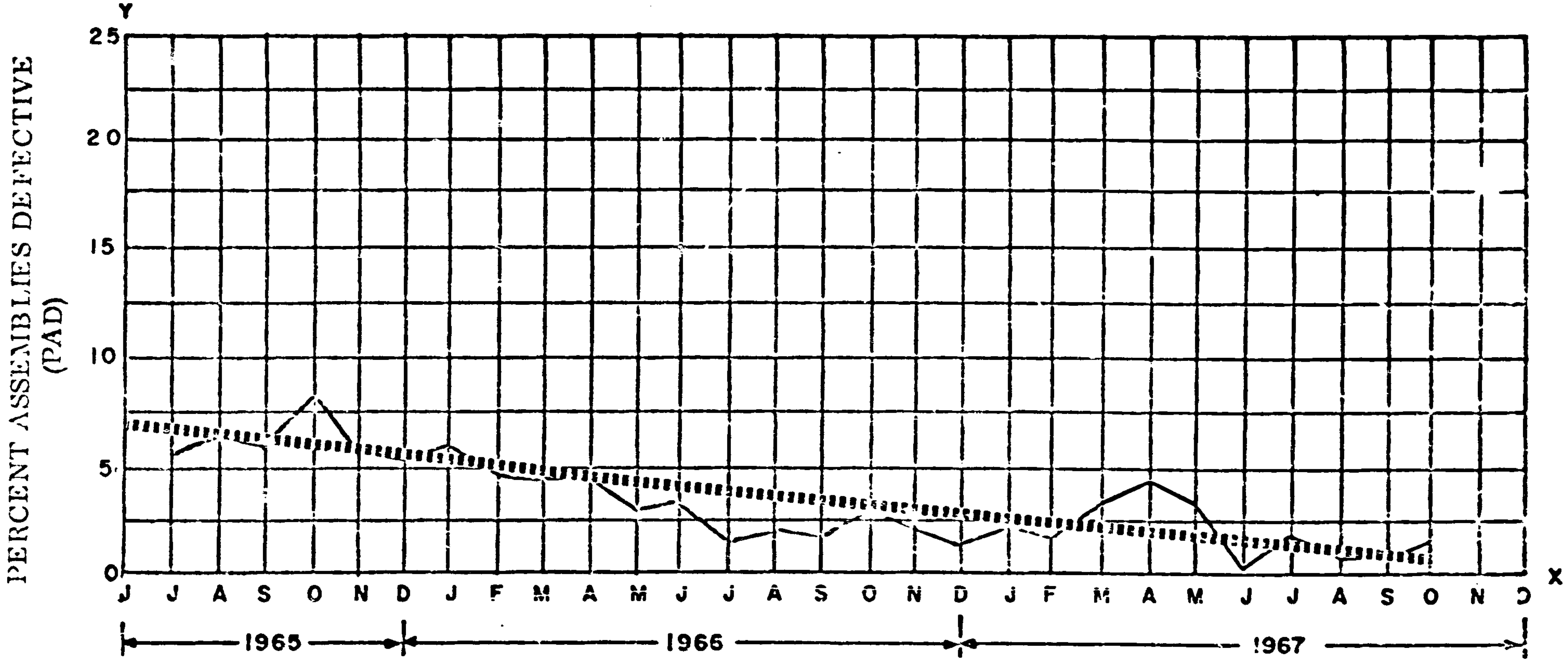
Vertical Deviation Base
(July 1965 thru October 1967)

Figure 6-26. Percentage of Parts/Optics Defective

TABLE 6-67

COMMAND MODULE/LUNAR EXCURSION MODULE ASSEMBLY FABRICATION - INSPECTED/REJECTED

Period 1967	Assembly Units Inspected	Assembly Units Rejected	(PAD) Percent Assemblies Defective	Trend Indicator
First	3027	74	-	2.4% (Avg)
Second	1391	40	-	2.9% (Avg)
Third	1304	14	-	1.1% (Avg)



—— MONTHLY PLOT

% Assemblies Defective = PAD

$$PAD = \frac{\text{Assemblies Rej.}}{\text{Assemblies Insp.}} x\ 100\%$$

Vertical Deviation Base
(Oct. 1964 thru Dec. 1966)

▮▮▮▮▮▮▮▮▮ LINEAR TREND

Linear Relationship Y = a - bx

a = Y Intercept

b = Regression Coefficient

Vertical Deviation Base
(July 1965 thru October 1967)

Figure 6-27. Percentage of Assemblies Defective

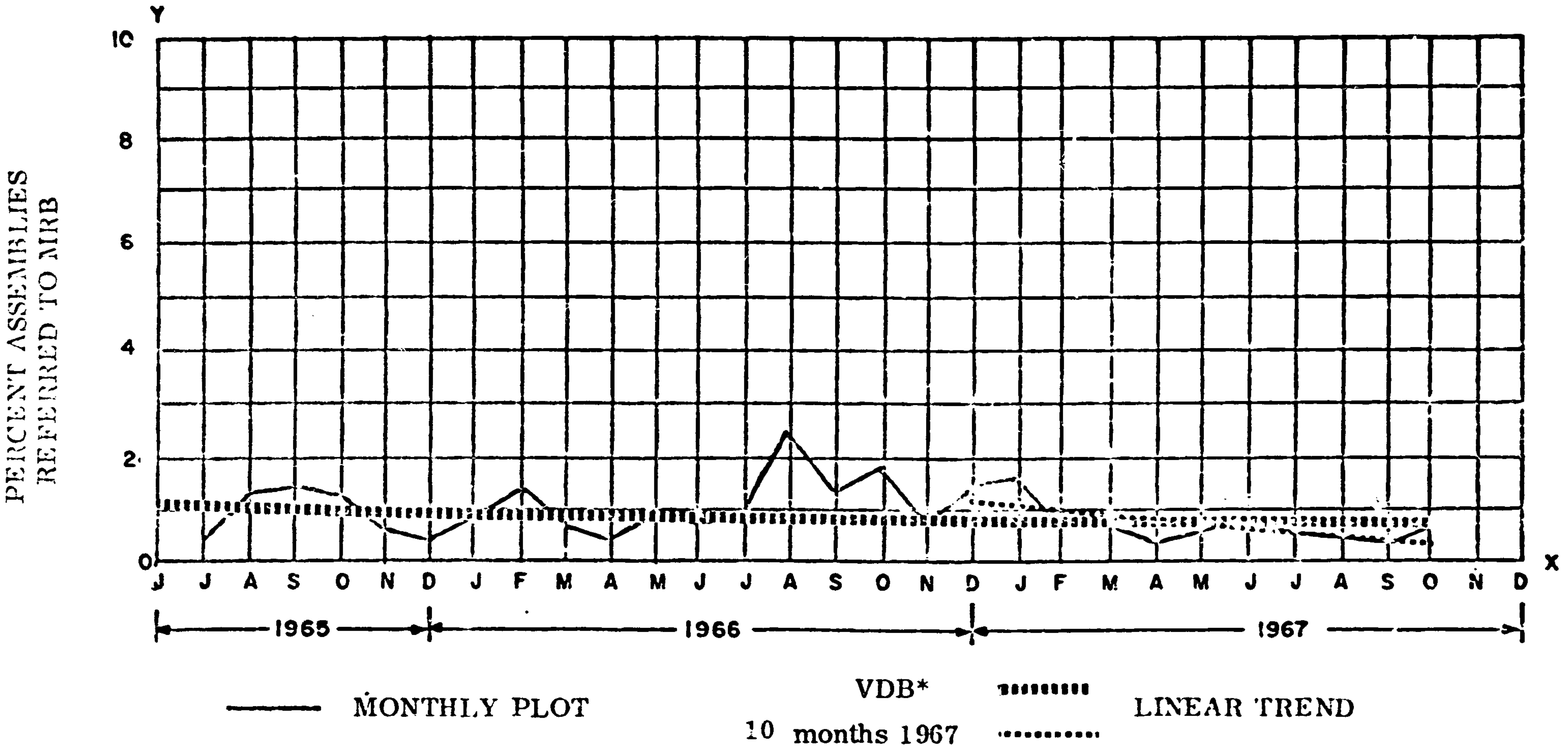
TABLE 6-68

IN-HOUSE MATERIAL REVIEW ACTION
COMMAND MODULE/LEM

Period	Formal Board Actions			Inspections		FBA Percentage
	CM	LEM	Total	Assembly	Total	
First	15	13	28	3027	3027	0.9%
Second	5	4	9	1491	1491	0.6%
Third	24	13	37	2780	2780	1.30%

$$\text{FBA Percentage} = \frac{\text{Total FBA's}}{\text{Total Inspections}} \times 100\%$$

FBA = Formal Board Action



% Assemblies Referred to MRB = %

$$\% = \frac{\text{Formal Board Actions}}{\text{Assemblies Inspected}} \times 100\ \%$$

Vertical Deviation Base
(Jan. 1965 thru Dec. 1966)

Linear Relationship Y = a - b x

a = Y Intercept

b = Regression Coefficient

* Vertical Deviation Base
(July 1965 thru October 1967)

Figure 6-28. CM/LM Material Review Activity Trend (In-House Assemblies)

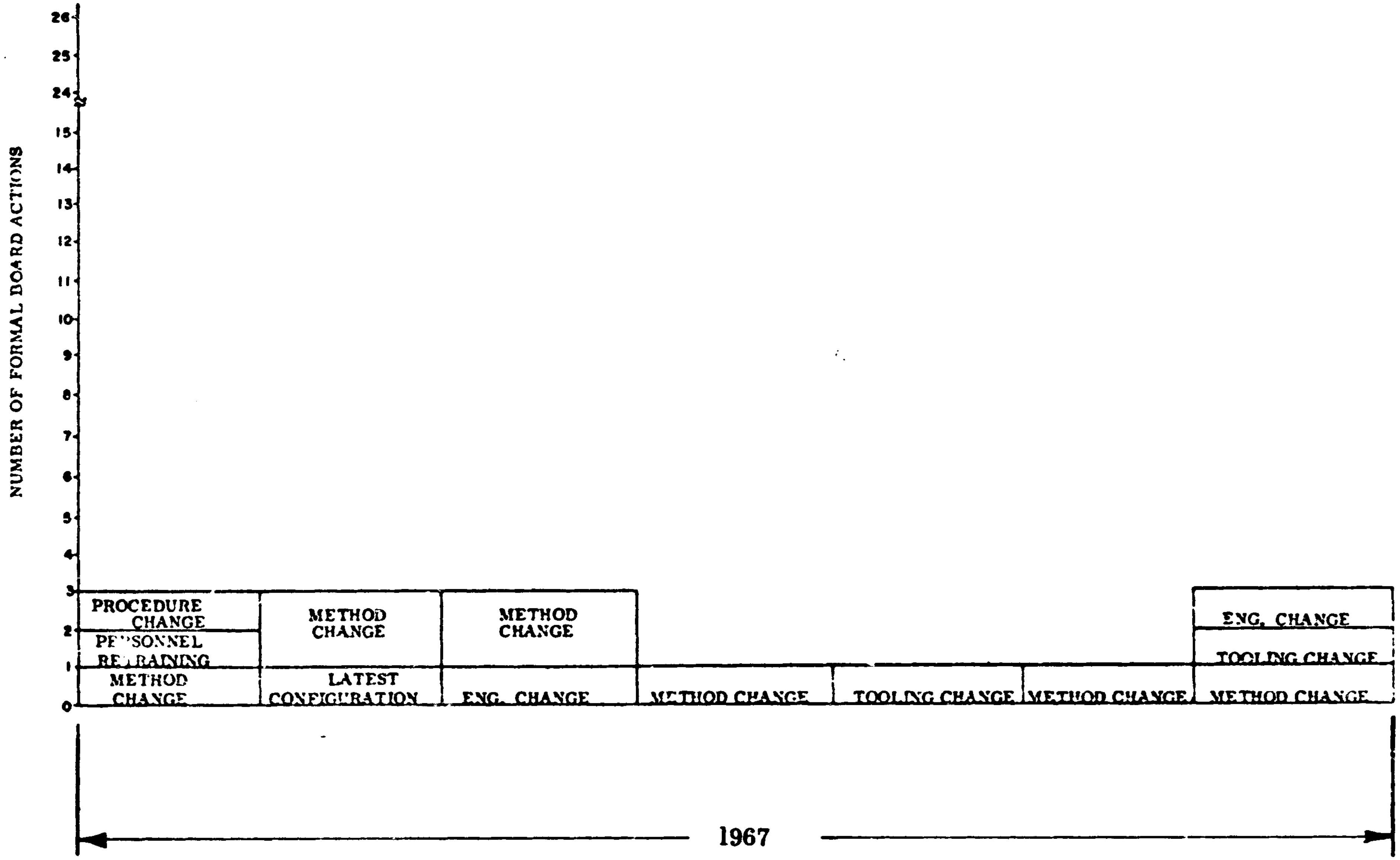


Figure 6-29. MRB Corrective ACtion (In-House Assembly)

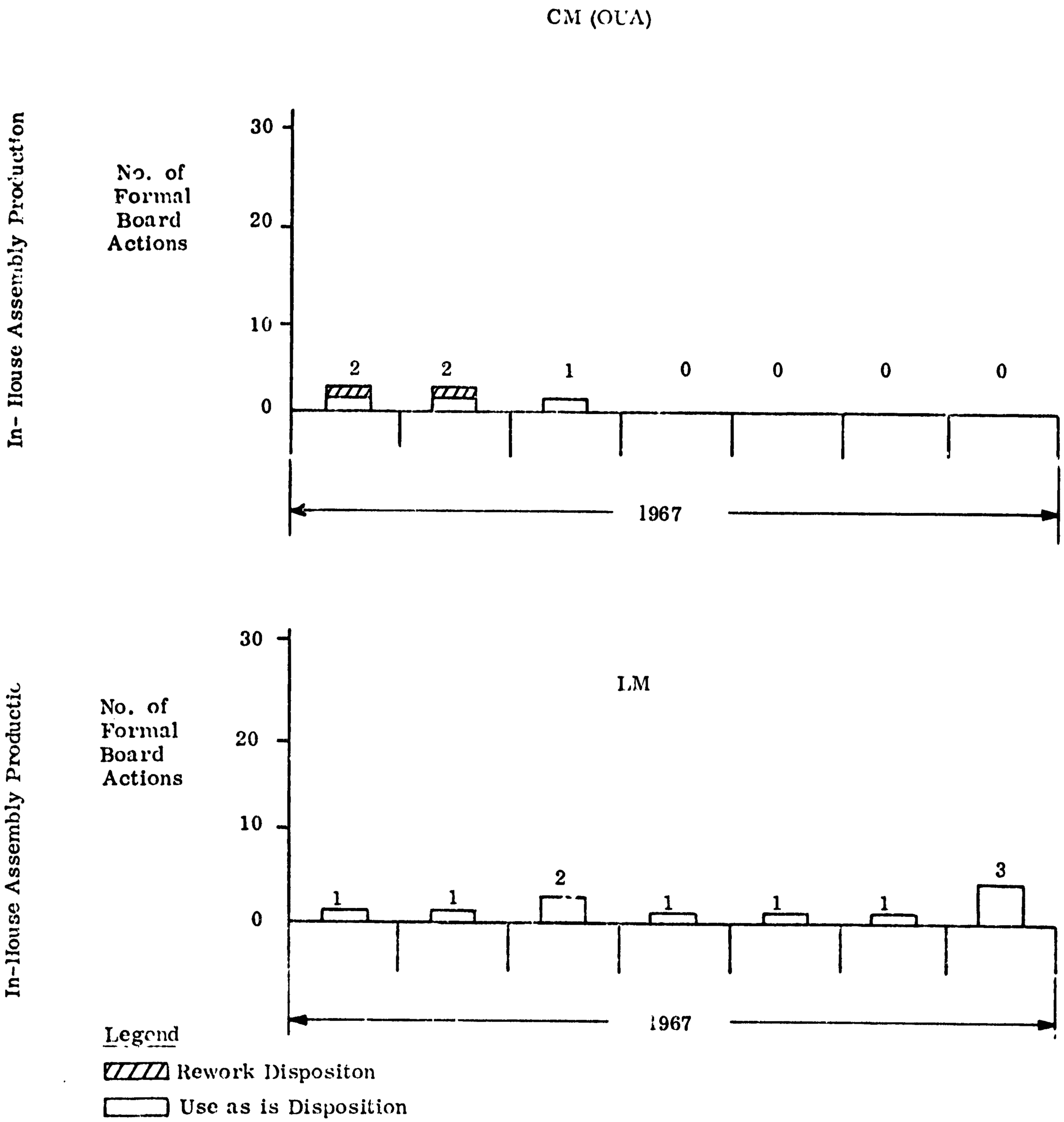


Figure 6-30. Disposition of Nonconforming Material (CM and LM)

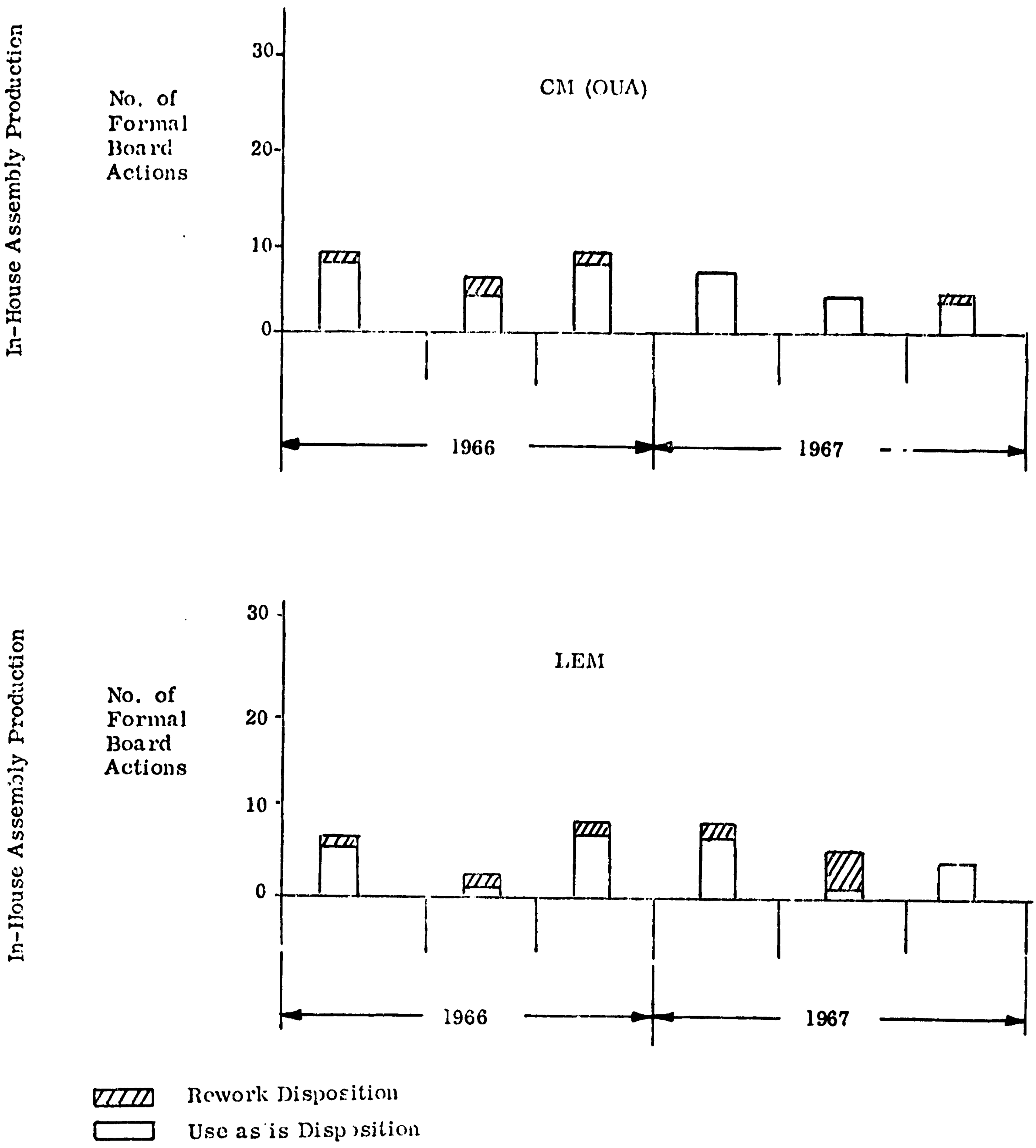


Figure 6-30. Disposition of Nonconforming Material (CM and LEM)

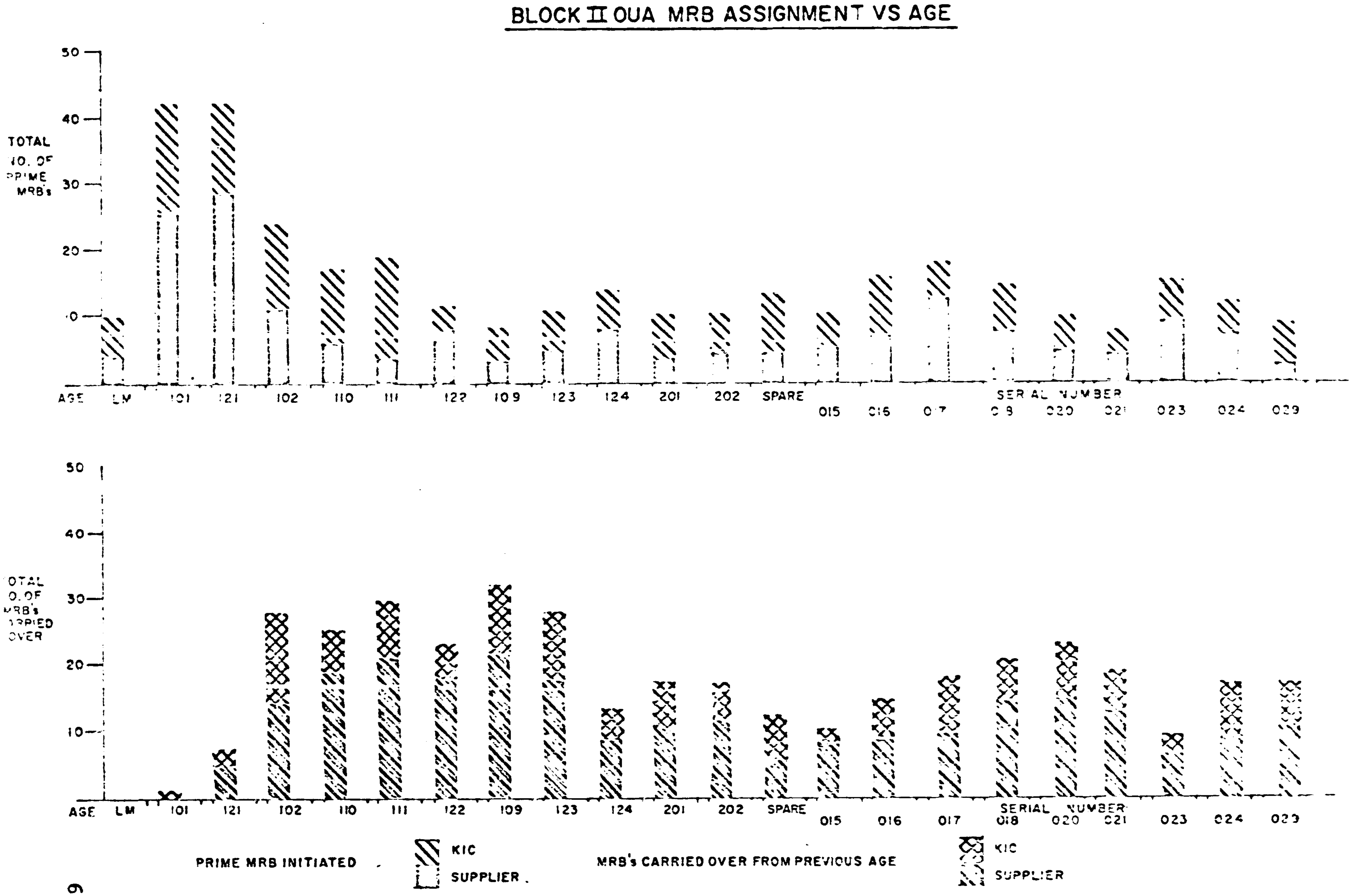


Figure 6-31. MRB Assignment to OUA (CM)

KOLLSMAN INSTRUMENT CORPORATION

6.6.6.4 MRB Assignment to AOT

Figures 6-32 and 6-33 illustrate the number of MRB's assigned to the Alignment Optical Telescope (AOT) individual AOT designation. The total MRB's per AOT is further classified into prime and carried-over categories. For example: an individual MRB originally initiated for AOT-LM (Learner Model) would be considered prime, while all subsequent usage of the MRB material on other AOT's would be classified as carried-over.

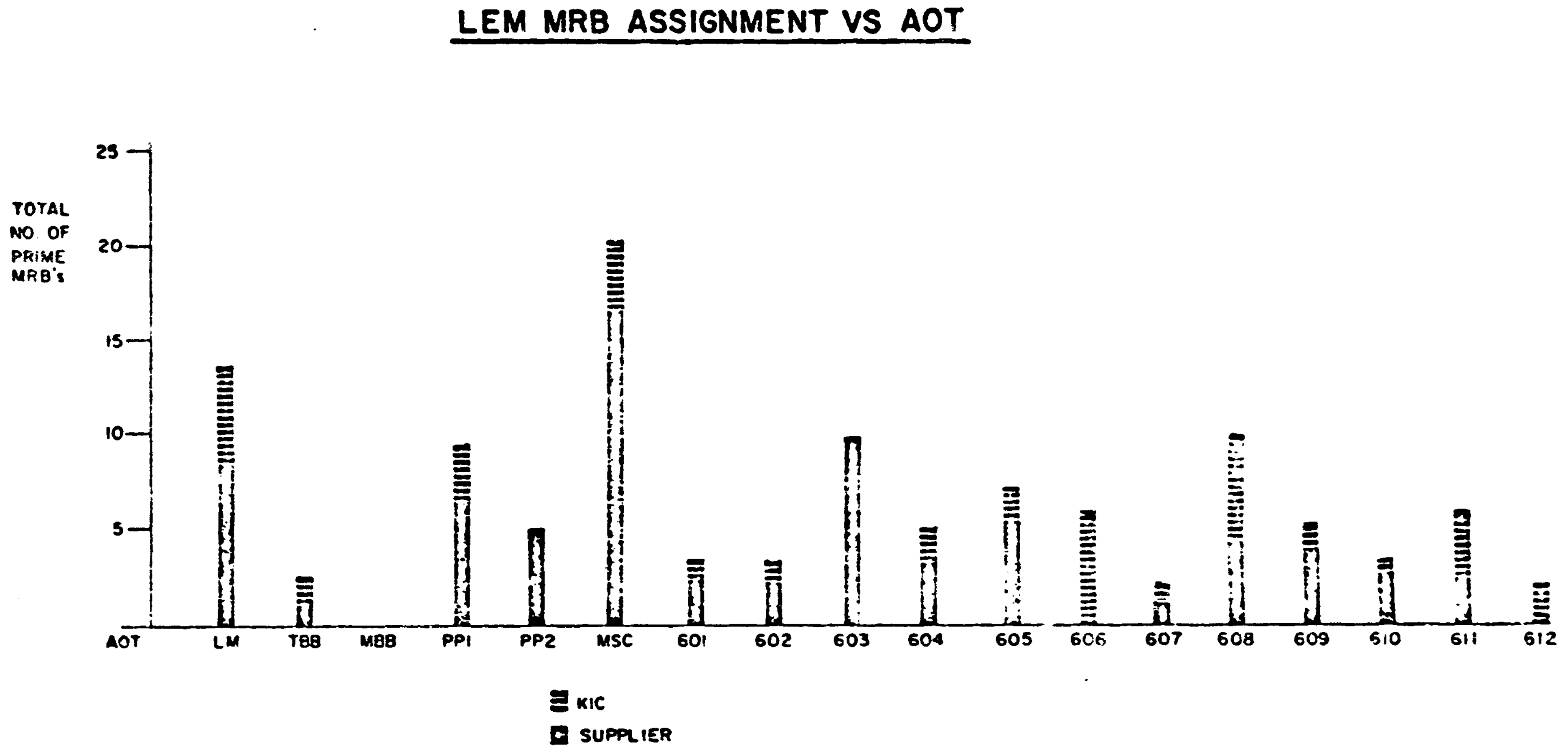


Figure 6-32. Prime MRB Assignment to AOT (LEM)

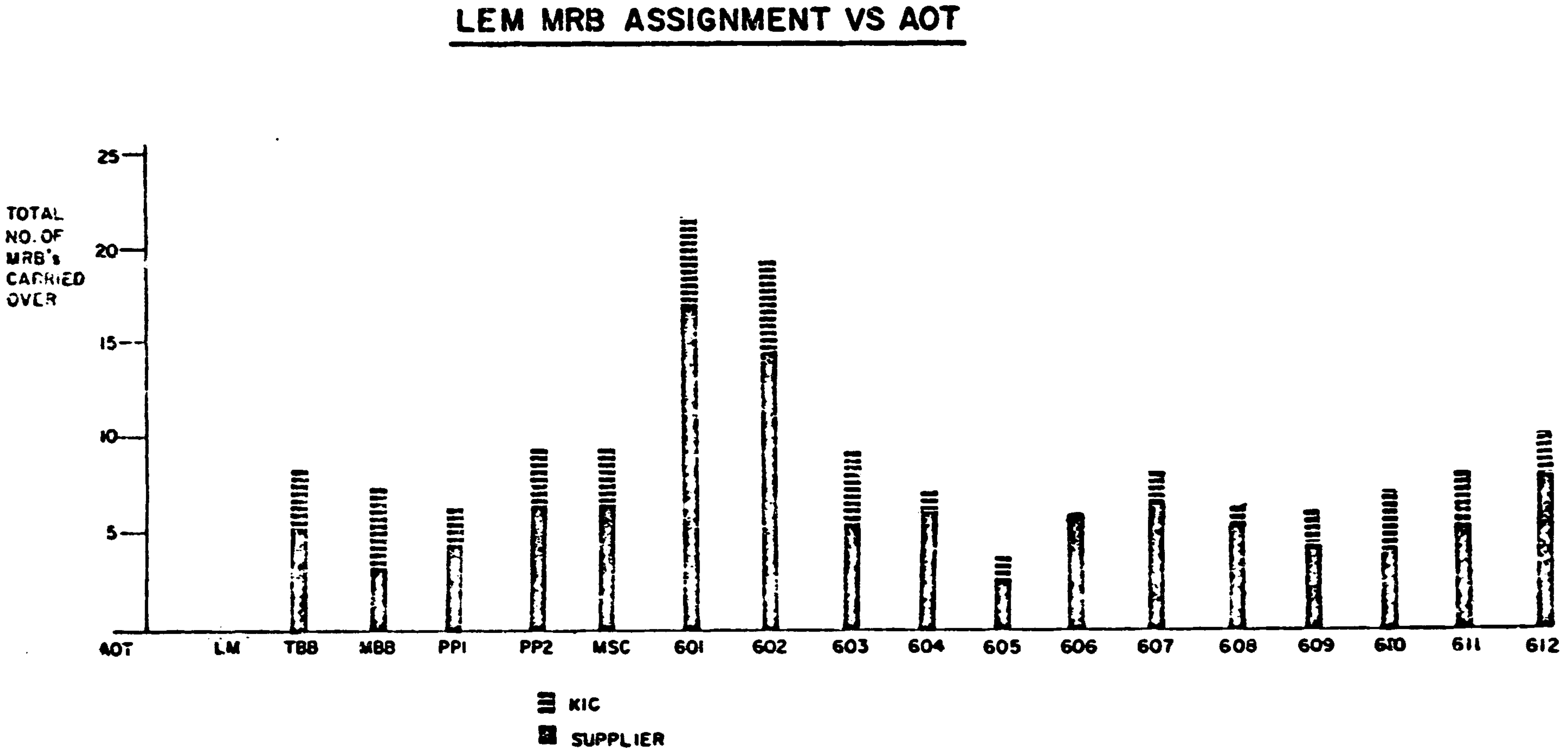


Figure 6-33. Carried-over MRB Assignment to AOT (LEM)

6.7 SUMMARY OF PERIOD 1968 - 1969

6.7.1 Management

6.7.1.1 Personnel and Organization

The organization structure of the Apollo/LM Program Quality Assurance Group within the Product Assurance Department is shown in Figure 6-34.

The total number of personnel employed in the Quality Assurance Section for this reporting period was 14.

6.7.2 Milestones

The Product Assurance quarterly presentation was made to AC as part of the Apollo Programs presentations on 7 May 1968. Product Assurance reported an open Apollo/LM Failure Report status requiring Kollsman action. Immediate preventative action was taken in regard to the OUA SN 021 dog limit stop failure. A qualified AOT sunshade was completed on AOT 604, SN 10. The Non-Metallic Material study was completed during the period. Qualified AOT design changes were completed on AOT 604, SN 10.

6.7.3 Major Problems

The safe shelf life of PN 1012156-4 motor tachometers became a major area of concern to NASA. AC Electronics and Kollsman representatives developed a proposal which was presented to NASA relative to the aforementioned problem. Of primary concern was the justification of the presently assigned two-year storage life in OUA's. The proposed plan was to utilize available assets (parts which do not completely conform to Block II requirements) to demonstrate the ability of motor tachometers with documented histories to perform the Apollo Mission, and to relate the developed data to storage life in terms of the age of the particular units used.

An OUA SXT Trunnion gear train failure occurred at AC on AGE 209, S/N 021. Inspection of AGE 209 at Kollsman disclosed disengagement of the SXT Index Mirror shaft from the Trunnion gear. Failure analysis revealed extensive damage to the gear train. The cause of failure was attributed to repeated impact of the Index Mirror against the ablative cover and/or limit stop failure. In subsequent testing on the Learner Module with three sets of limit stops simulating AGE 209 conditions, Kollsman was unable to duplicate the failure after 9000 cycles. The location of the ablative cover, as assembled by AC, seemed a probable cause of the failure. However, the investigation continued.

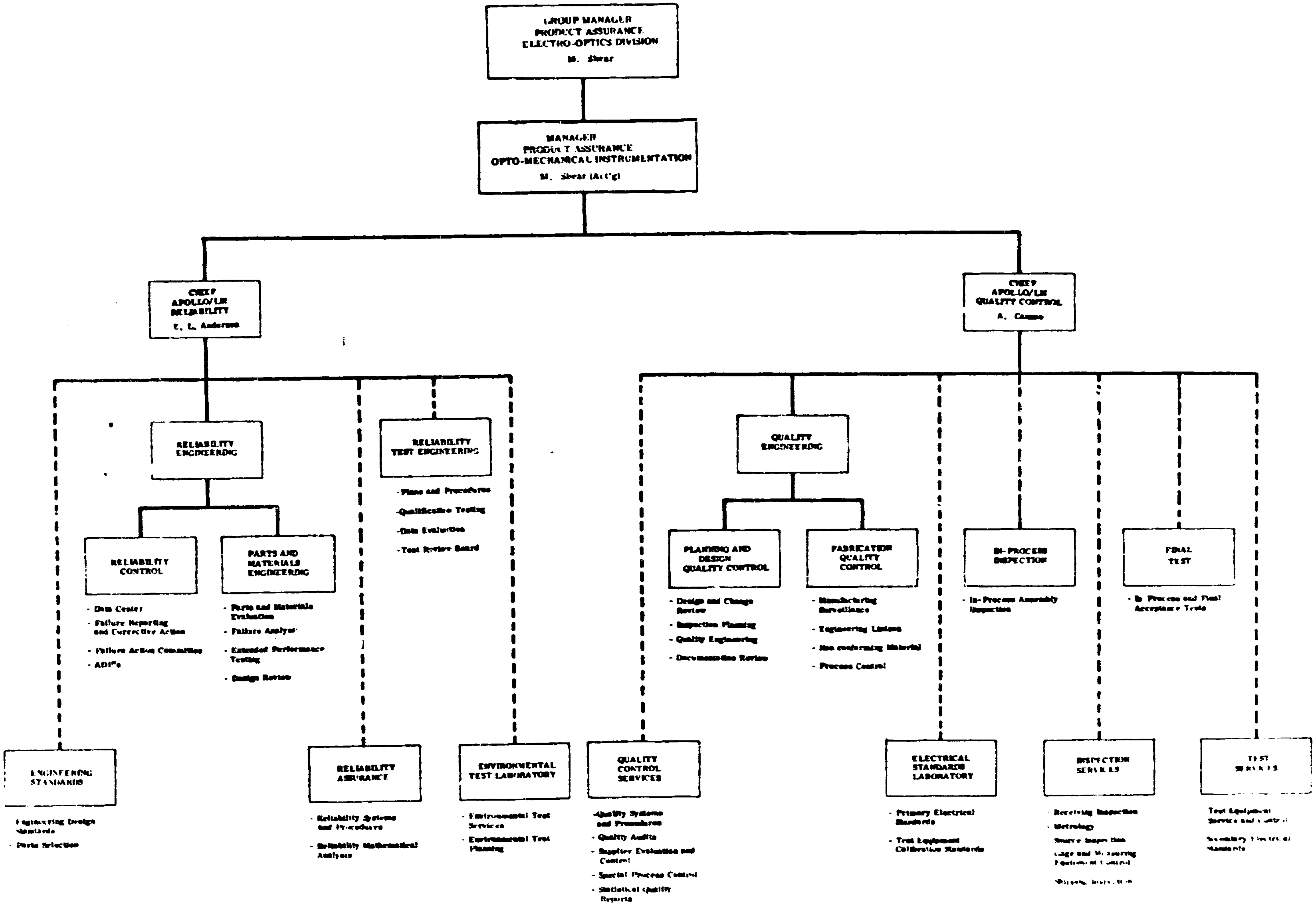


Figure 6-34. Product Assurance Functional Organization for Apollo/LM Programs

During Kollsman source inspection, two Solvere motors failed the dielectric resistance test. Failure analysis performed at Solvere revealed that the motor leads were being pinched by the rear bearing block located near the lead exit hole in the housing. Further investigation revealed that two other motors experienced similar failures at Solvere during prior in-line production without informing Kollsman. Corrective action was instituted by Solvere. However, the reliability of the lot produced prior to the corrective action was currently being investigated.

6.7.4 Procurement

6.7.4.1 Receiving Inspection

MATERIAL RECEIVED. Of the 24,670 parts inspected by the Receiving Inspection Department during the reporting period, 6.9 percent of the parts were found to be nonconforming and were subsequently dispositioned by 29 formal Material Review Board (MRB) actions. (See Table 6-69 for additional breakdown of material received.)

6.7.4.2 Material Review Board

MATERIAL REVIEW ACTIVITY. During the reporting period Quality Control processed sixteen formal Board actions for the Command Module and thirteen for the LM procurement activity. See Table 6-70 for additional breakdown.

MATERIAL REVIEW CORRECTIVE ACTION. Table 6-71 delineates the Material Review Corrective Action Status for the CM and LM.

MATERIAL REVIEW DISPOSITIONS. Figure 6-35 delineates the Formal Board Action activity, segregated into two disposition categories for the reporting period. Return-to-supplier and scrap material dispositions are not shown in this presentation.

6.7.4.3 Supplier Activities

ND 1015404 STATUS. The status of ND 1015404 requirements is listed in Table 6-72.

SUPPLIER SURVEILLANCE VISITS. Surveillance visits were made to the following suppliers:

Solvere (2) March and April

New Hampshire Ball Bearing (2) April and May

TABLE 6-69

MATERIAL RECEIVED
COMMAND MODULE/LUNAR MODULE

	SHIPMENTS			PARTS		
PERIOD	EVALUATED	NONCONFORMING	% SHIPMENTS NONCONFORMING	INSPECTED	NONCONFORMING	% PARTS NONCONFORMING
First Period 1968	271	56	20.6%	5588	411	7.4%
Second Period 1968	165	40	24.2%	9342	641	7.8%
Third Period 1968	413	49	12.0%	9740	522	5.4%

TABLE 6-70

PROCUREMENT MATERIAL REVIEW ACTION
COMMAND MODULE/LUNAR MODULE

FORMAL BOARD ACTIONS						
PERIOD	CM	LM	TOTAL FBA	TOTAL PIECES	SHIPMENTS RECEIVED	FBA PERCENTAGE
First Period	3	9	12	86	271	4.4% (Avg)
Second Period	2	2	4	58	165	2.4% (Avg)
Third Period	11	2	13	18	413	1.5% (Avg)

$$\text{FBA Percentage} = \frac{\text{Total FBA's}}{\text{Shipments Received}} \times 100\%$$

TABLE 6-71

Material Review Corrective Action Status (Procured Material)

COMMAND MODULE/LUNAR MODULE

	FIRST PERIOD	SECOND PERIOD	THIRD PERIOD
Shipments Received	271	165	413
Formal Board Actions	12	13	4
FBA Percentage	4.4%	2.8%	1.5%
Supplier Problem Conferences			
At Kollsman	1	1	0
At Supplier Facilities	2	4	3
Telecon	49	61	58
Written Request for Corrective Action			
Requested	4	3	6
Received Reply	0	2	3
Accepted Reply	0	2	3

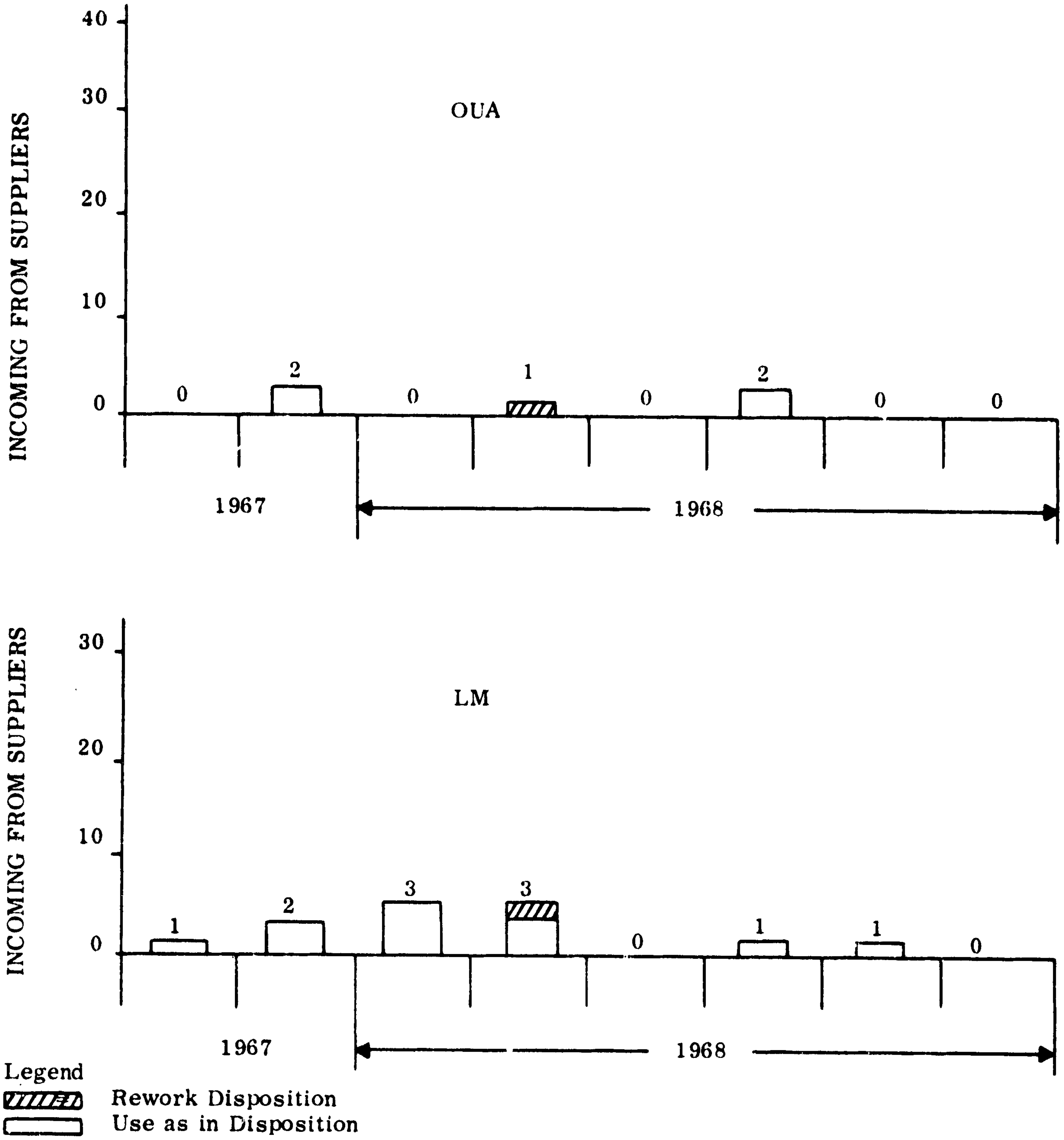


Figure 6-35. CM/LM Procured Material Review Dispositions

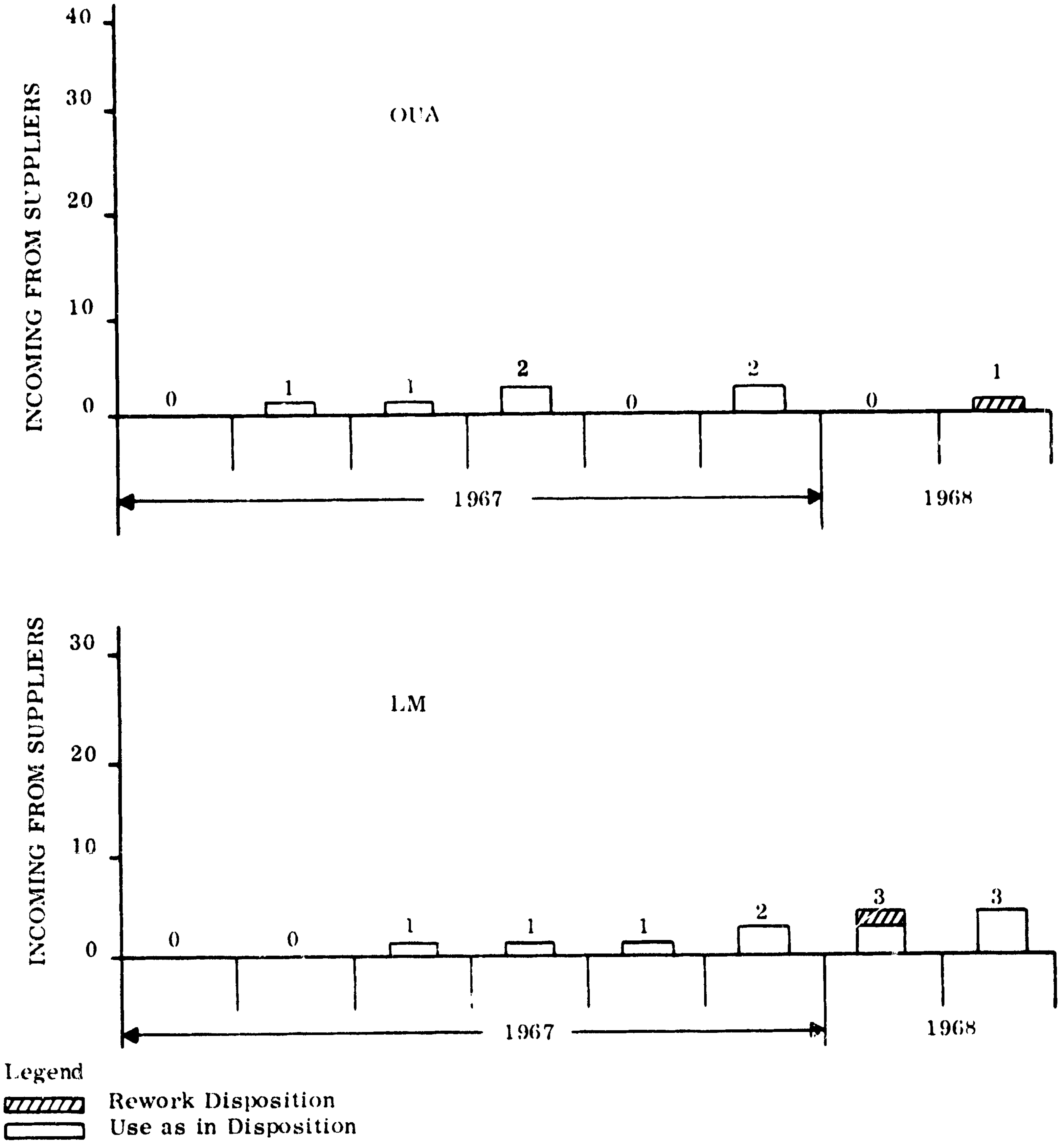


Figure 6-35. CM/LM Procured Material Review Dispositions

TABLE 6-72

ND 1015404 Status
COMMAND MODULE/LUNAR MODULE

	STATUS TO DATE
Suppliers Surveyed	
Approved	215
Disapproved	63
Inspection Plans	
Approved	85
Disapproved	0
Traceability Plans	
Approved	83
In-Process	0
Critical Process Agreement	
Approved	165
In-Process	0
Change Requests	
Accepted	181
Not Accepted	29
In-Process	0

6.7.5 Fabrication

6.7.5.1 Fabrication Control

PARTS/OPTICS INSPECTION AND TEST. During the reporting period, 2206 parts were inspected. One hundred forty-seven were rejected for the average rejection rate of 4.7 percent. (Table 6-73 represents a final summary for Parts/Optics Fabrication - Inspected/Rejected.)

ASSEMBLY INSPECTION AND TEST. During the reporting period, 2898 assemblies were inspected. Fifty-seven assemblies were rejected for an average rejection rate of 1.9 percent.

During the second reporting period, 801 assemblies were inspected. Twenty-three assemblies were rejected for a four-month average rejection rate of 2.8 percent. (Table 6-74 represents a final summary for Assembly Fabrication - Inspected/Rejected.)

6.7.5.2 Material Review Board

MATERIAL REVIEW ACTIVITY. Quality Control processed 46 Formal Board Actions (FBA) for the in-house section of the Material Review Board (MRB) during the period. See Table 6-75 for breakdown of MRB's for CM and LM.

MATERIAL REVIEW CORRECTIVE ACTION. QC investigated the cause of the nonconformance contributing to the FBA's processed during the report period. Corrective action was initiated by QC to preclude recurrence of the nonconformances.

MATERIAL REVIEW DISPOSITION. QC processed the nonconforming material into two categories of disposition, as illustrated in Figure 6-36. Return-to-supplier and scrap material dispositions are not shown in this presentation.

6.7.5.3 MRB Assignment to OUA

Figure 6-37 illustrates the number of MRB's assigned to the optical unit assembly by AGE designation. The total MRB's per AGE is further classified into prime and carried-over categories. For example; an individual MRB originally initiated for AGE-LM (Learner Model) would be considered prime, while all subsequent usage of the MRB material on other AGE-OUA's would be classified as carried-over. The origin of the MRB initiation is also presented as Kollsman (in-house activity) or Supplier (nonconforming procured material).

TABLE 6-73

COMMAND MODULE/LUNAR MODULE
PARTS/OPTICS FABRICATION - INSPECTED/REJECTED

PERIOD	INSPECTED		REJECTED		TREND INDICATOR (RELATIONSHIP ± TO PREVIOUS MONTH)
	PARTS	OPTICS	PARTS	OPTICS	
First Period	1148	-	47	-	4.1% (Avg)
Second Period	1318	-	50	-	3.7% (Avg)
Third Period	740	-	50	-	6.8% (Avg)

TABLE 6-74

COMMAND MODULE/LUNAR MODULE
ASSEMBLY FABRICATION - INSPECTED/REJECTED

PERIOD	ASSEMBLY UNITS INSPECTED	ASSEMBLY UNITS REJECTED	TREND INDICATOR (RELATIONSHIP ± TO PREVIOUS MONTH)
First Period	1063	20	1.9% (Avg)
Second Period	801	23	2.8% (Avg)
Third Period	1034	14	1.1% (Avg)

TABLE 6-75

In-House Material Review Action

COMMAND MODULE/LUNAR MODULE

FORMAL BOARD ACTIONS				INSPECTIONS		FBA PERCENTAGE
PERIOD	CM	LM	TOTAL	ASSEMBLY	TOTAL	
First Period	3	15	18	350	1350	1.3%
Second Period	14	8	22	823	823	2.6%
Third Period	0	6	6	1205	1205	0.5%

$$\text{FBA Percentage} = \frac{\text{Total FBA's}}{\text{Total Inspections}} \times 100\%$$

FBA = Formal Board Action

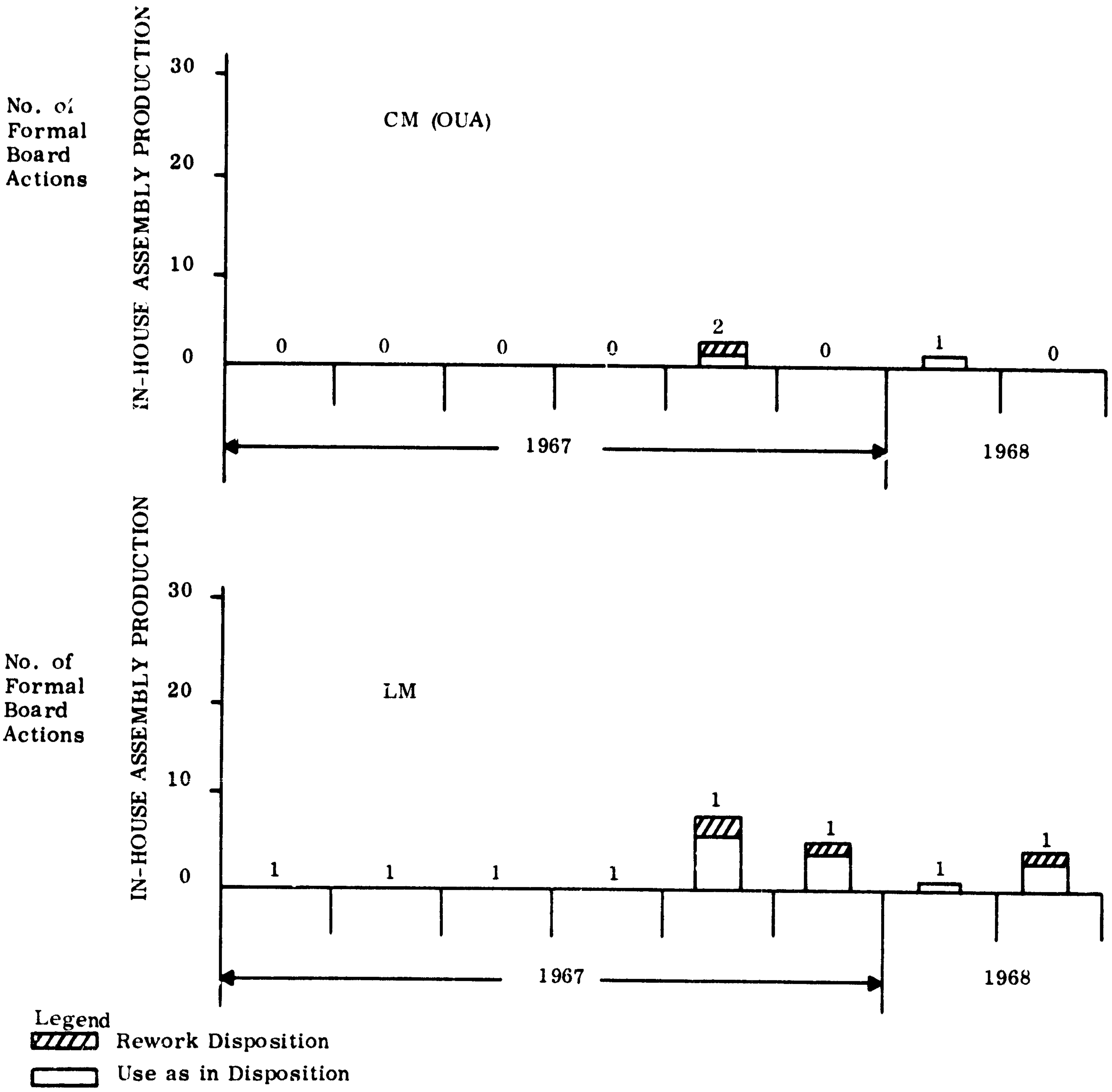


Figure 6-36. Disposition of Nonconforming Material (CM and LM) (Page 1 of 2)

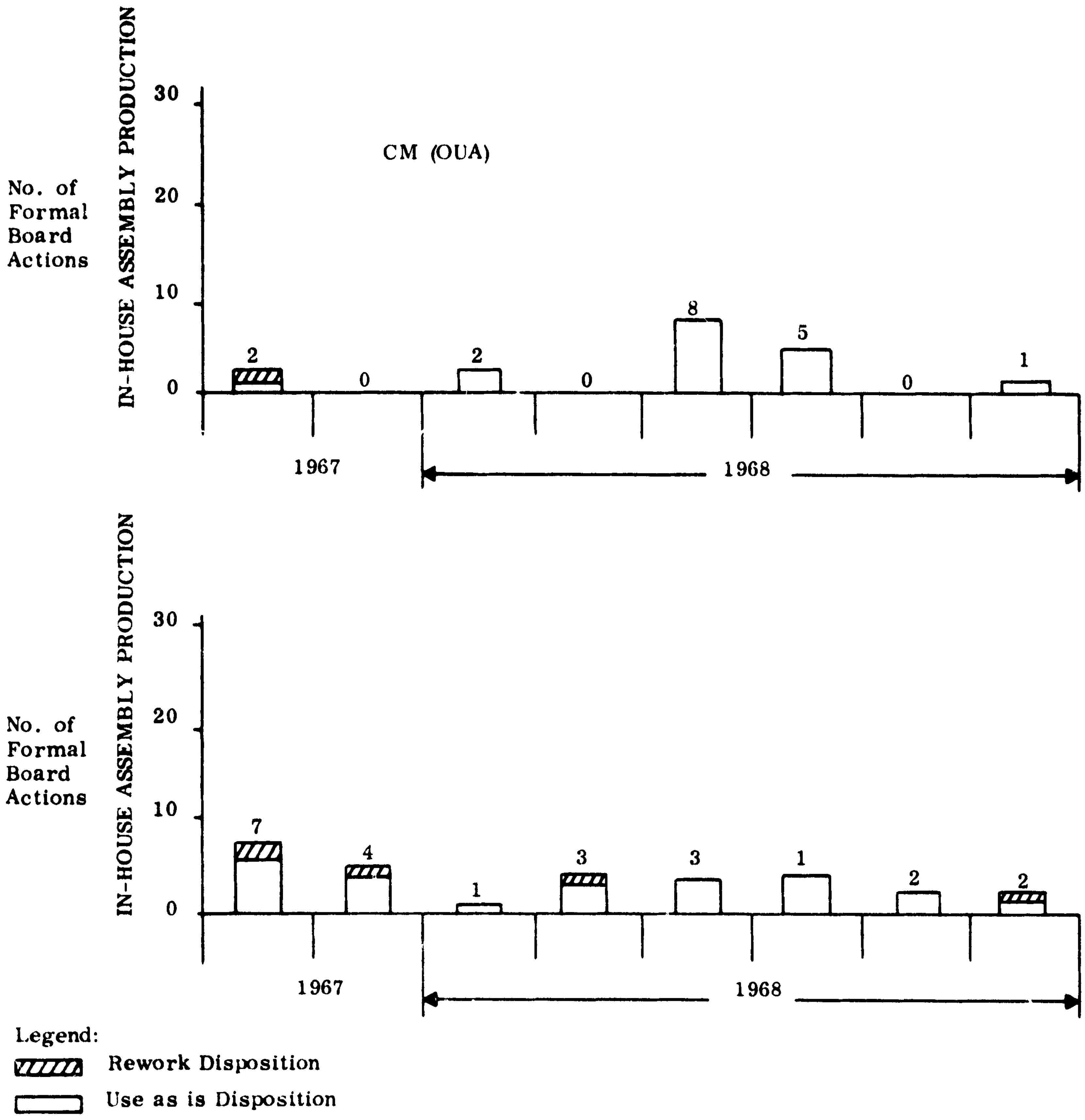


Figure 6-36. Disposition of Nonconforming Material (CM and LM) (Page 2 of 2)

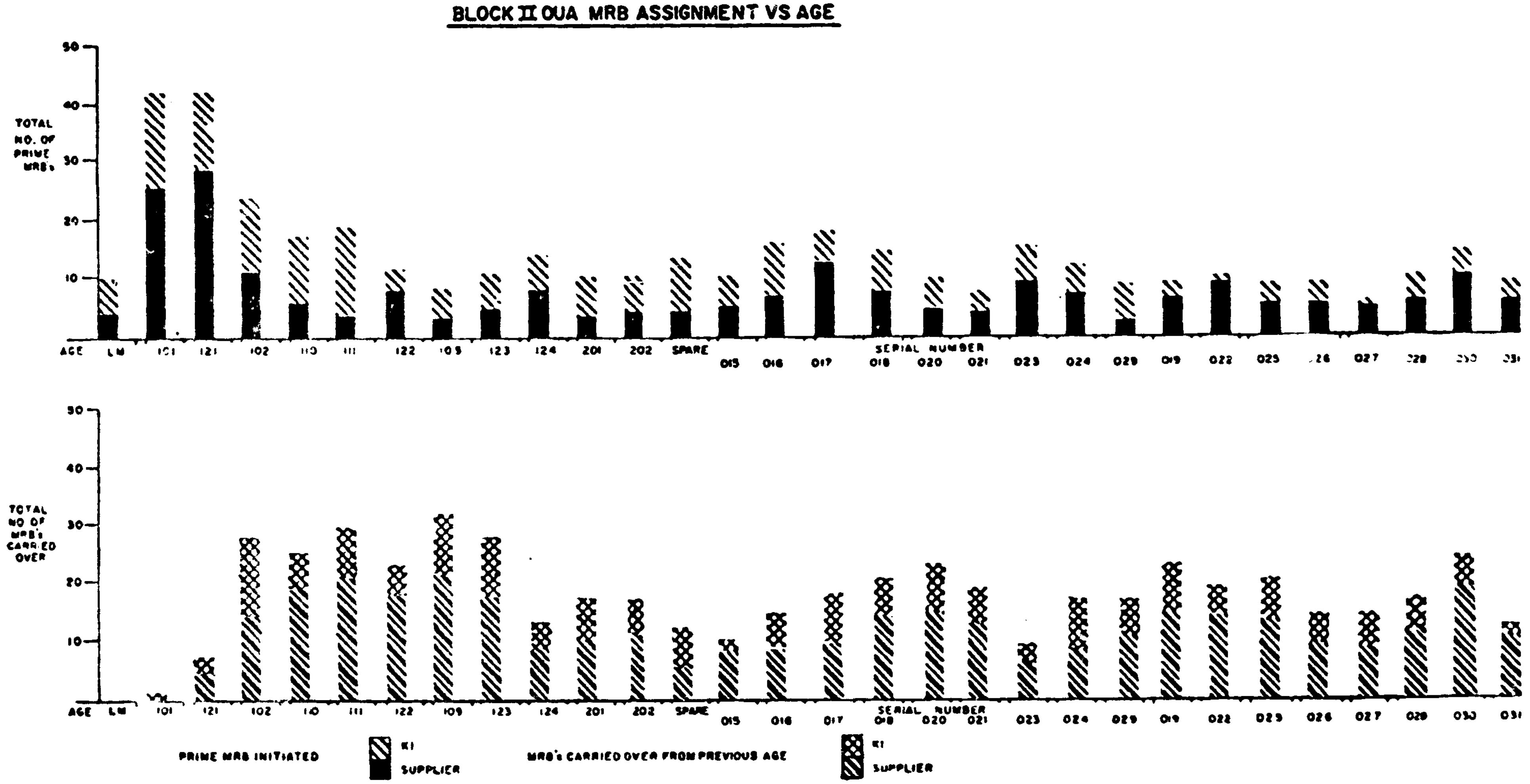


Figure 6-37. MRB Assignment to OUA (CM)

6.7.5.4 MRB Assignment to AOT

Figures 6-38 and 6-39 illustrate the number of MRB's assigned to the Alignment Optical Telescope (AOT) individual AOT designation. The total MRB's per AOT is further classified into prime and carried-over categories. For example: an individual MRB originally initiated for AOT-LM (Learner Model) would be considered prime, while all subsequent usage of the MRB material on other AOT's would be classified as carried-over. The origin of the MRB initiation is also presented as Kollsman (in-house activity) or supplier (nonconforming procured material).

6.7.5.5 Rangefinder

A significant milestone of performance in the early part of 1969 was Quality Assurance's participation in the Apollo Rangefinder Program. Late in November 1968, after the Apollo 7 flight, NASA determined that a flight-qualified Optical Rangefinder was required for the rendezvous of the Apollo 9 Command Module and LM. Kollsman immediately initiated work on this program prior to the receipt of formal direction. Starting work during the last week of November, 1968, a prototype was delivered 17 January 1969, the qualification unit on 24 January, the flight unit on 30 January, the flight backup unit on 7 February. Qualifications tests were completed on 13 February 1969, all ahead of schedule.

Much of the sucess of this program can be attributed to the around-the-clock support that was provided by Quality Assurance. Special handling, surveillance and control were the keys that ensured the maintance of Apollo Class A integrity on the expedite program.

The special "Astroneat" award, presented by AC Electronics to a member of the group for its efforts on the project, highlighted the group's achievement.

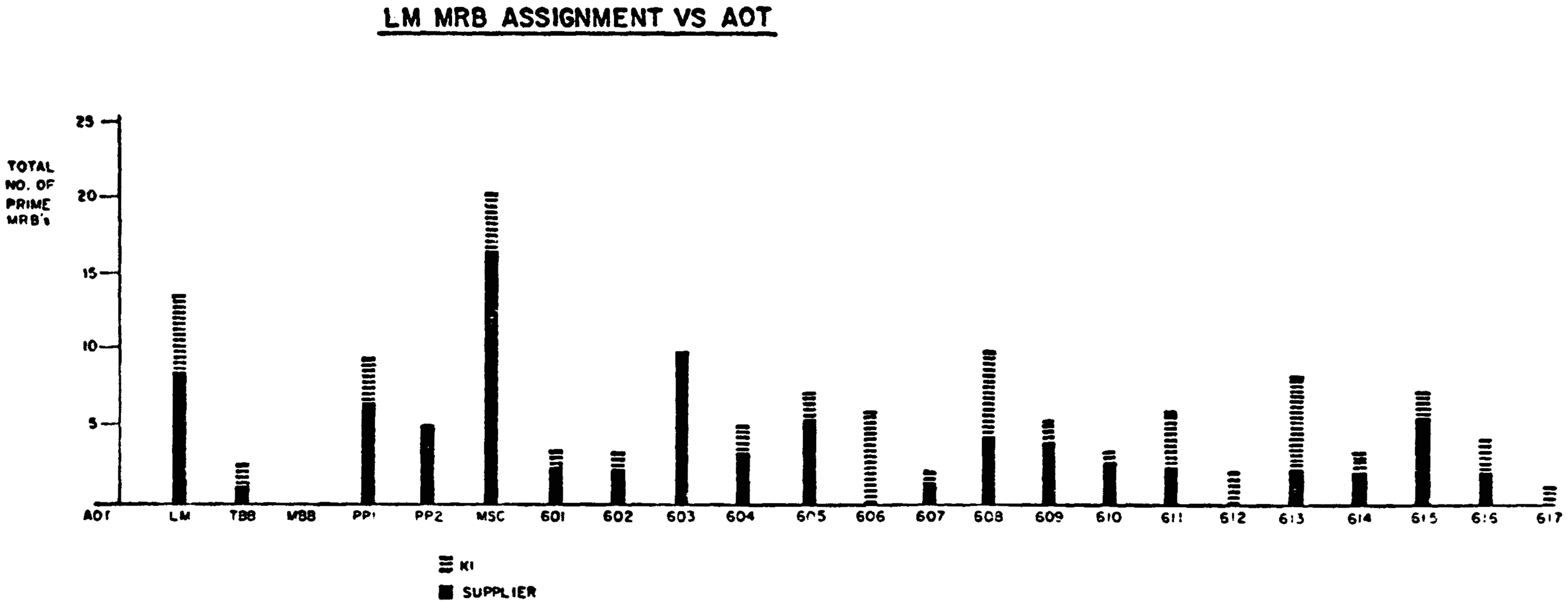


Figure 6-38. Prime MRB Assignment to AOT (LM)

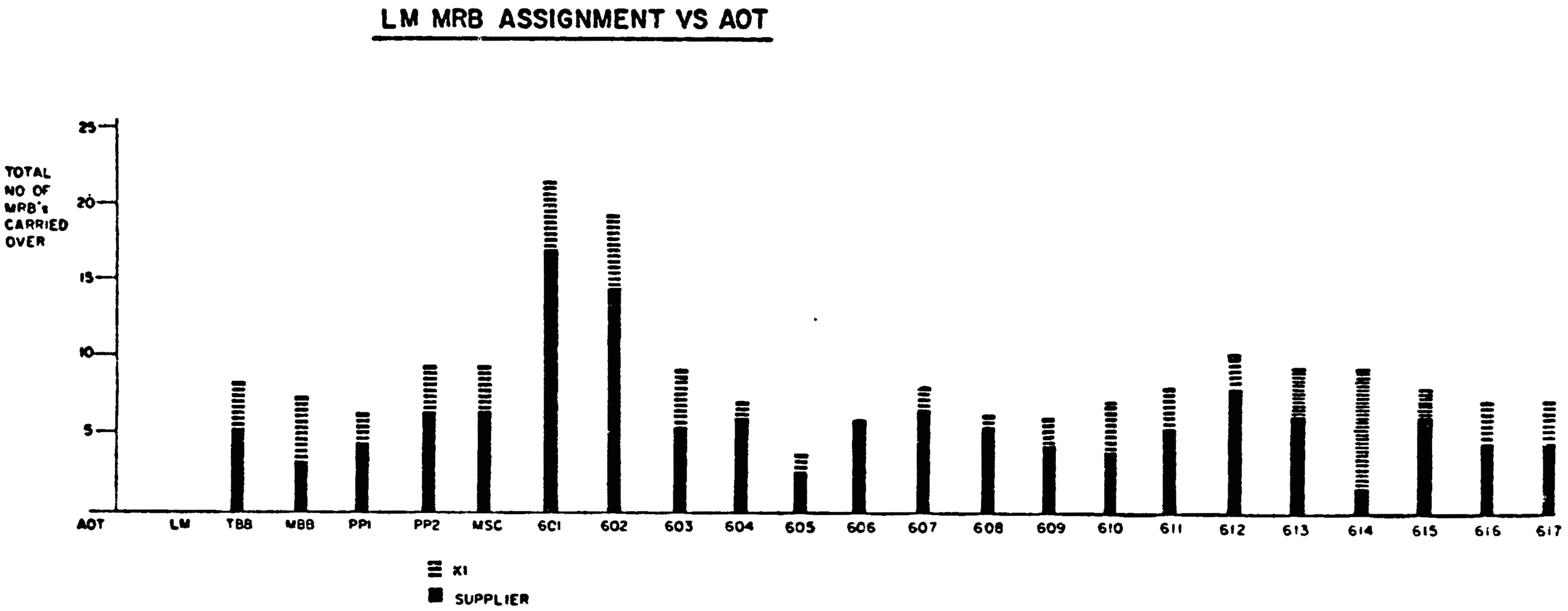


Figure 6-39. Carried-over MRB Assignment to AOT (LM)

Section 7

DOCUMENTATION

7.1 SUMMARY OF YEAR ENDING DECEMBER 31, 1962

7.1.1 Program Effort

Documentation requirements in general consisted of the generation, distribution and preservation of all project information for the life of the Apollo Project.

7.1.2 Assignments

During the period of this report one TD was completed: one was partially completed and four new TD's were assigned. Briefly, documentation areas of effort encompassed by the above TD's were Documentation Plan (Complete); Coordination of Documentation Schedules (partially complete); Implementation of Documentation Organization; Initiation of Progress and Status Reports; Preparation of a Familiarization Manual; and preparation of Procurement Documents. Detailed comments in each of these areas appears below:

7.1.3 Accomplishments

Documentation Plan (TD-K-6) - Formulation of the overall plan was completed. Formulation of detailed responsibilities and procedures within this broad outline continued under TD-K-23.

Documentation Coordination (TD-K-17) - The family tree drawing for the initial design concept of the Optical Subsystem was prepared and submitted, and scheduling of documents along these lines was completed. Revision of these documents to reflect current Optical Subsystem design concepts was deferred pending receipt of more complete information.

Documentation Organization (TD-K-23) - Definition of detailed responsibilities for documentation personnel was commenced, manpower requirements to effect necessary coordination; controls; and preparation of required documents were established.

Technical Data engineering duties were established, and a documentation engineer was added to documentation staff. The Technical Data Engineer is responsible to the Chief of Documents in all technical matters. Primary areas of responsibility include Produceability, Reliability, Quality Control Review Board activities; internal change Control Board; drawing control; and technical records.

Equipment requirements to operate with 35mm aperture cards were established and procurement of this equipment initiated.

Program Progress and Status Reports (TD-K-26)

This TD was received during this report period. Technical progress reports, both monthly and quarterly were implemented.

Separate Reliability and Quality Control reporting was implemented. Initial reports in each of these areas were commenced.

Photographic coverage, both still and motion pictures was planned.

Exploratory talks with motion picture producers indicated the particularly wide latitude of interpretations possible with the requirements contained in this TD. Kollsman therefore conditioned its acceptance of this effort under TD K-26. These conditions were appended to the TD in the form of a work statement; and this work statement was the basis on which Kollsman subcontracted the work.

Familiarization Manual (TD-K-29) - Work under this TD commenced. The first draft of the text was approximately 50% complete at the end of this period.

Process and Control Specifications - (Purchase and Inspection Documents) (TD-K-31). This TD was received and preparation of specifications authorized by this TD was deferred pending receipt of information concerning the design change in Optical Subsystem. Necessary design data was received near the end of the year, and preparation of these documents began during the following year.

7.2 SUMMARY OF YEAR ENDING DECEMBER 31, 1963

7.2.1 Assignments

T.D. K-17	Documentation
T.D. K-23	Documentation Administration
T.D. K-25	Process Specification
T.D. K-26	Program Progress & Status Reporting

T.D. K-27	Familiarization Manual
T.D. K-31	Preparation of Documents
T.D. K-46	Familiarization Manual
T.D. K-50	Maintenance & Repair Manuals
T.D. K-58	Factory Test Plans
T.D. K-95	Maintenance & Repair Manuals
T.D. K-112	Motion Picture Progress Report

7.2.2 Accomplishments

7.2.2.1 Command Module Documentation

T.D. K-17 Specification Family Trees were updated. Task was completed by June 1963.

T.D. K-23 Documentation Administration daily effort to comply to this T.D.K. was on a continual basis especially the administration monitoring and controlling of all MIT and internal documents.

The Documentation Manual which included Spec & Drawing control procedures was finalized.

The manual defined procedures by which all publications both incoming and outgoing were routed.

Manufacturing releases to Production Control were included therein.

A government drawing and specification file for the Apollo program; including NASA, AN, MS drawings, ND and MIL specifications was instituted.

T.D. K-25 Effort completed & TD closed first period of 1963.

T.D. K-26 Documentations progress and status reporting was prepared as scheduled. The motion picture and still picture portion of this direction was revised to agree with the new work statements.

T.D. K-27 Effort completed and TD closed.

T.D. K-31 Preparation of Process and Material Specifications proceded on schedule.

Specs in preparation at this time included:

Weight, Center of Gravity and Moments of Inertia
Performance and Interface
Purchase Specs.

T.D. K-46 Familiarization Manual revision was started and completed this year.

T.D. K-50 Maintenance and Repair manuals were begun in mid 1963. One writer was assigned at that time.

Three Check Out, Maintenance and Repair Manuals were started, covering the Optical Unit MDV and GSE. The GSE manual included coverage of the Precision Test Fixture, MDV Tester and composite GSE equipment, Job Description Cards which were incorporated in these manuals were prepared.

The following analytical reports were submitted during this year.

Report Number	
650182-04-3	Cross Product Velocity Steering Loop - "Limit Cycle Analysis"
550182-04-4	"C.D.U. Analysis"
650192-4	Rendezvous Visibility Problem - "Pyrotechnic Flash Cartridge Characteristics"
650192-5	Rendezvous Visibility Problem - "Narrow Band Optical Transmission Filters"
650192-6	Rendezvous Visibility Problem - "The Steady Light Equivalent of Flashing Lights"
Preliminary Report	"LM Telescope Design"

The following is a listing of documents generated and released by documentation during the year 1963.

a)	ND1002098	"Finish of FT and GSE used in Clean Room"	Release Class B TDRR 05002
b)	ND1002078	"Machining Standards"	Class A release under TDRR 04657 calling for use of in house standards (KES 1002A.2) and NPC 200-2.
c)	ND1002079	"Burrs"	Class A release under TDRR 04658 calling for use of in house standards (KES 1002B.3) and NPC 200-2.
d)	ND1002083	"Solvent Cleaning"	Cancelled
e)	ND1002128	"Indium Foil"	Changed to SCD 1011777
f)	ND1002091	"Application of Luxorb"	Released Class A TDRR 05501 with SCD 1011778 and 1011779.
g)	ND1002099	"Cleaning of Copper and Copper Alloys"	Released Class A TDRR 05500.
h)	ND1002125	"Beryllium Shapes"	Released Class A TDRR 05003.
i)	ND1002215	"Packaging Spec"	Was returned to MIT/IL for acceptance on 29 November. No release to date.
j)	ND1002127	"Black Anodizing of Beryllium:	Released Class A TDRR 05004.
k)	ND1002096	"Cleaning of Optical Elements"	Cancelled

Major efforts were continuing on preparation of the series of other specifications required on the program. The status of these documents, at the conclusion of this reporting period is furnished in Table 7-1.

TABLE 7-1 APOLLO SPECIFICATION STATUS

Optical Unit No.	Title	Status
FTP 1011000	Optical Subsystem	
FTM 1011000	Optical Subsystem	To MIT - 11/19/63 Resubmitted 1/2/64
ATP 1011704	Shaft, Axis Assy.SXT	To MIT - 10/17/63
ATP 1011889	Optical Unit Subassy Stage I	To MIT - 12/7/63
ATP 1011890	Optical Unit Subassy. Stage II	In Final Review
ATP 1011891	Optical Unit Subassy. Stage III	In Final Review
ATP 1011153	Prism Assy. of Dove	To MIT - 11/20/63
ATP 1011197	Dove Prism and Mount Assy.	To MIT - 10/11/63
ATP 1011712	Indexing Mirror and Mount Assy.	To MIT - 10/24/63
ATP 1011724	Inner Tel. Tube Assy.	To MIT - 1st week in January
ATP 1011722	Outer Tel. Tube Assy.	To MIT - 11/20/63
ATP 1011701	Index Head Assy., SXT	To MIT - 11/20/63
ATP 1011792	Relay Lens Assy., SCT	To MIT - 1st week in January
ATP 1011000	Optical Unit (Final Assy.)	To MIT - 1st week in January
FTP 1011559	Map and Data Viewer	In preparation
FTM 1011559	Map and Data Viewer	To MIT - 11/1/63
PS 1011559	Map and Data Viewer	In Final Review
PS 1011483	Amp. and Sw. Unit, Assy. of	In preparation
ATP 1011486	Amp. and Sw. Module (Before Encapsulation)	In preparation
PS 1011420	Cartridge Assy.	In preparation
ATP 1011430	Gear Box Assy.	In preparation
PS 1011430	Gear Box Assy.	In preparation
PS 1011420	Cartlidge Assy.	In preparation
ATP 1011559	Map and Data Viewer	In Final Review

TABLE 7-1 APOLLO SPECIFICATION STATUS (Cont.)

Ground Support Equipment No.		Title	Status
PS	1016911	Short Periscope	Released Class B
PS	1016910	Precision Test Fixture	Released Class B
PS	1016948	MDV Tester	Released Class B
PS	1016949	Functional Tester	Released Class B
PS	1016951	Align. Mirror Assy.	Released Class B
FTM	1016911	Short Periscope	To MIT - 11/2/63
FTM	1016910	Precision Test Fixture	In Final Review
FTM	1016948	MDV Tester	In Final Review
FTM	1016949	Functional Tester	In Final Review
FTM	1016951	Alignment Mirror Assembly	In Final Review
FTM	1016952	Short Periscope Assembly Fixture	To MIT - 11/2/63
PS	1017378	Shaft Accuracy Tester	In Final Review

Shipping Specifications	Title	Status
1016911	Short Periscope	Final Review
1016910	Precision Test Fixt.	Final Review
1016948	MDV Tester	Final Review
1019741	MDV Tester Stand	Final Review
1016949	Functional Tester	Final Review
1016951	Alignment Mirror Assembly	In preparation
1016952	Short Periscope Alignment Fixture	Final Review

7.2.2.2 LM Documentation

Assignment

TD K-4L Documentation

Accomplishments

The requirements of Documentation for the Apollo LM program were reviewed with a view toward establishing similar controls for this effort as for Command Module. Preliminary outlines were formulated for preparation of the Documentation Plan, Reliability Plan, Progress Reports and other documents required early in this program.

7.3 SUMMARY OF YEAR ENDING DECEMBER 31, 1964

7.3.1 Assignments

TD K-2L Internal Engineering
TD K-3L Project Management
TD K-4L Documentation
TD K-23 Documentation Administration
TD K-26 Program Progress Reports
TD K-31 Interface, Purchasing, Process and Material Specs
TD K-58 Factory Test Plans
TD K-95 Maintenance & Repair Manuals
TD K-112 Motion Picture Program Report
TD K-131 G.S.E. Documentation

7.3.2 Accomplishments

The preparation and submittal of the LM Design Concept Report was accomplished in January. No further effort was expended on TD's K-2L, K-3L, and K-4L beyond 31 January 1964.

TD K-23 - Documentation Administration - Continuing liaison was maintained with AC ED on the documentation requirements for Block II and LM.

TD K-26 - Program Progress Reports - The progress reports were per schedule on the program. Separate reports were prepared for C/M, LM, C/M Reliability and C/M Quality Assurance.

TD K-131 - Checkout Maintenance and Repair Manuals - The Checkout, Maintenance and Repair Manual for the Optical Unit (ND 1021067) was published as a Type I document and distributed per NASA instructions.

The Checkout, Maintenance and Repair Manual for the Map and Data Viewer (ND 1021069) was submitted to MIT/IL for final review and CCB release during August.

The Checkout, Maintenance and Repair Manuals for the Functional Tester (ND 1021068) and the Precision Test Fixture (ND 1021070) were approved, published as Type I documents and distributed in accordance with NASA instructions.

The Checkout Maintenance and Repair Manual for the Map and Data Viewer Tester (ND 1021071) was published as a Type I document and distributed in accordance with NASA instructions.

The preliminary Checkout, Maintenance and Repair Manual for Miscellaneous GSE for the Optical Unit (ND 1021066) was rewritten by KI.

The effort on TD-K 131 was completed in December 1964.

TD K-31 - Specifications - Efforts on the preparation of test specifications for the Block I equipment continued, based upon need for revisions as they occurred. The status of these documents is furnished in Table 7-2.

A meeting was held on 3 December 1964 at MIT/IL to discuss a new procurement specification policy and determine the level of documentation. It was requested by NASA/RASPO that a review be conducted by each participating contractor of all Spares and that a documentation procurement level be established for each item. Accordingly, KI submitted the required information on 18 December 1964.

TABLE 7-2. APOLLO SPECIFICATIONS PREPARED AND SUBMITTED TO NASA

Optical Unit No.	Title
FTP 1011000	Optical Subsystem
FTM 1011000	Optical Subsystem
ATP 1011704	Shaft, Axis Assembly SXT
ATP 1011889	Optical Unit Subassembly Stage I
ATP 1011890	Optical Unit Subassembly Stage II
ATP 1011891	Optical Unit Subassembly Stage III
ATP 1011153	Dover Prism, Assy. of
ATP 1011197	Dove Prism and Mount Assembly
ATP 1011712	Indexing Mirror and Mount Assy.
ATP 1011724	Inner Tel. Tube Assembly
ATP 1011722	Outer Tel. Tube Assembly
ATP 1011701	Index Head Assembly, SCT
ATP 1011792	Relay Lens Assembly, SCT
ATP 1011000	Optical Unit (Final Assembly)

Map and Data Viewer No.	
FTP 1011559	Map and Data Viewer
FTM 1011559	Map and Data Viewer
FTM 1012136	Map and Data Viewer
ATP 1012136	Map and Data Viewer
ATP 1014630	Amp. & Sw. Module, Inseparable, Assy. of
ATP 1011559	Map and Data Viewer
ATP 1011483	Amp. and Sw. Assy. of
ATP 1011420	Magazine Assembly
ATP 1011430	Gearbox Assembly
ATP 1012200	Gearbox Assembly

TABLE 7-2 APOLLO SPECIFICATIONS PREPARED AND SUBMITTED TO NASA (Cont.)

Map and Data Viewer No.	Title
ATP 1011486	Wafer and Component, Assy. of (Before encapsulation)
ATP 1011478	Amp. & Sw. Module, Assy. of
ATP 1011479	Amp. & Sw. Unit, Assy. (Before encapsulation)
Ground Support Equipment No.	
PS 1016911	Short Periscope
PS 1016910	Precision Test Fixture
PS 1016948	MDV Tester
PS 1016949	Functional Tester
PS 1016951	Alignment Mirror Assembly
FTM 1016911	Short Periscope
FTM 1016910	Precision Test Fixture
FTM 1016948	MDV Tester
FTM 1016949	Functional Tester
FTM 1016951	Alignment Mirror Assy.
PS 1019769 & FTM	Final Shaft Accuracy Tester
PS 1017383	G & N Install. Qual. Fixture
FTM 1017383	G & N Install. Qual. Fixture
PS 1017382	Azimuth Reference Fixture
FTM 1017382	Azimuth Reference Fixture
PS 1017380 & FTM	Autocollimator Plate Assembly (0°)
PS 1017381 & FTM	Autocollimator Plate Assembly (45°)
PS 1017447 & FTM	Theodolite and Support Assembly

TABLE 7-2. APOLLO SPECIFICATIONS PREPARED AND SUBMITTED TO NASA (Cont.)

Ground Support Equipment No.	Title
PS 1019758 & FTM	Tooling Bar Assembly
PS 1017376 & FTM	Variable Deviation Wedge
PS 1017377 & FTM	Adjustable Mirror Assembly
PS 1019837 & FTM	Portable Light Assembly
PS 1019840	Retroreflecting Prism
FTM 1019840	Retroreflecting Prism
Procurement Specs For Spares	
PS 1011712	Indexing Mirror and Mount Assembly SXT Head
PS 1011197	Dove Prism and Mount, Assy. of
Shipping Containers Number	
FTM 1019720	Optical Unit, Nav Base Shipping Container
PS 1019720	Optical Unit, Nav Base Shipping Container
FTM 1019721	MDV Shipping Container
PS 1019721	MDV Shipping Container

TD K-58 Factory Test Plans - Approval of the Factory Test Plan covering the Optical Unit and the Map an Data Viewer was received from MIT/IL in July. Final publication was completed and distribution was made in August.

7.4 SUMMARY OF YEAR ENDING DECEMBER 31, 1965

7.4.1 Assignments

TD K-23 Documentation Administration

TD K-26 Program Progress Reports

TD K-31 Interface, Purchasing, Process & Material

Specs.

TD K-58 Factory Test Plans

TD K-95 Maintenance & Repair Manuals

TD K-112 Motion Picture Progress Report

7.4.2 Accomplishments

Contractually required schedules for, specifications, reports and manuals were maintained with on-time delivery as shown in the attached milestone charts.

7.4.2.1 Block I (OUA)

The major documentation requirements were completed. All equipment specifications, manuals and reports were released per contract.

7.4.2.2 Block II (OUA)

All specifications, manuals, reports, etc. required during the year 1965 were submitted, and where required, approved.

Milestone charts (Figures 7-1 through 7-5) list all reportable data items, each item is identified by its S.O.W. paragraph reference number.

PARAGRAPH REF NO	CONTRACT END ITEM	TYPE DOCUMENT	1965										1966
			MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY
I	ONE TIME REPORTS												
3.1	TEST PLAN (INPUTS TO ACSP)	I			▲								
3.2	F/O AND SUPPORT PLAN	I	▲										
5.1	QUA PS 201000	I			↑								
	GSE PTF PS 2010606	I				↑							
	FT PS 201060	I			↑								
	STAR HOR. SIM PS 1019977	I			↑								
	JDC'S FOR SHSCF	I				↑							
	STAR HOR. SIM CERT FIX PS 1019970	I				↑						↑	
	SXT/SCT COVERS PS ________	I											
	CONN COVERS PS 1022970	I											
	S-H SIMUL MOUNT STAND PS 1019926	I			↑								
	AZ. REF FIX PS 1016951	I	○	● ▲		△							
	YOKE POS FIXT PS 1019969	I			↑								
	PRIME INT PROCED KPS	III				↑							
	TKR COVER PS1022963											↑	
	AUXILIARY PTF PS 1019962	I			↑								
5.2	MTL, PTS AND PROC SPEC	I											
5.3	MICROFILM SPECS												
6.1	TECH. REPORT AND DATA	II											
6.2	TEST REPORTS AND DATA	II AND III											
6.6	FINAL REPORT	II											
7.1	QC PLAN	I	▲	△					▲				
7.2.1	QUAL TEST REPTS	II											
7.2.2	QUAL TEST DATA	III											
7.4	ACCEPT. DATA PKGS GSE W/DATA SHEETS PRIME	II			▲2	▲1	▲8	▲	▲7	▲	▲	▲4	
7.5	SPEC SAMPL PLANS	II											
7.6	MEAS AND TEST EQPT EVALUATIONS	III											
7.9 7.10	INSP. AND PROCESS CONTROL PROCED	III											
7.11	STORAGE PROCED	II											
8.1	RELIABILITY PROG PLAN	I	●	△ ▲									

△ DOCUMENT DUE DATE
○ INITIATION OF DOCUMENT
● PRELIMINARY INPUT
▲ DOCUMENT SUBMITTED
★ ESTIMATED RELEASE DATE
↑ DOC. RELEASED BY CCB

Figure 7-1. C/M Documentation Requirements-1

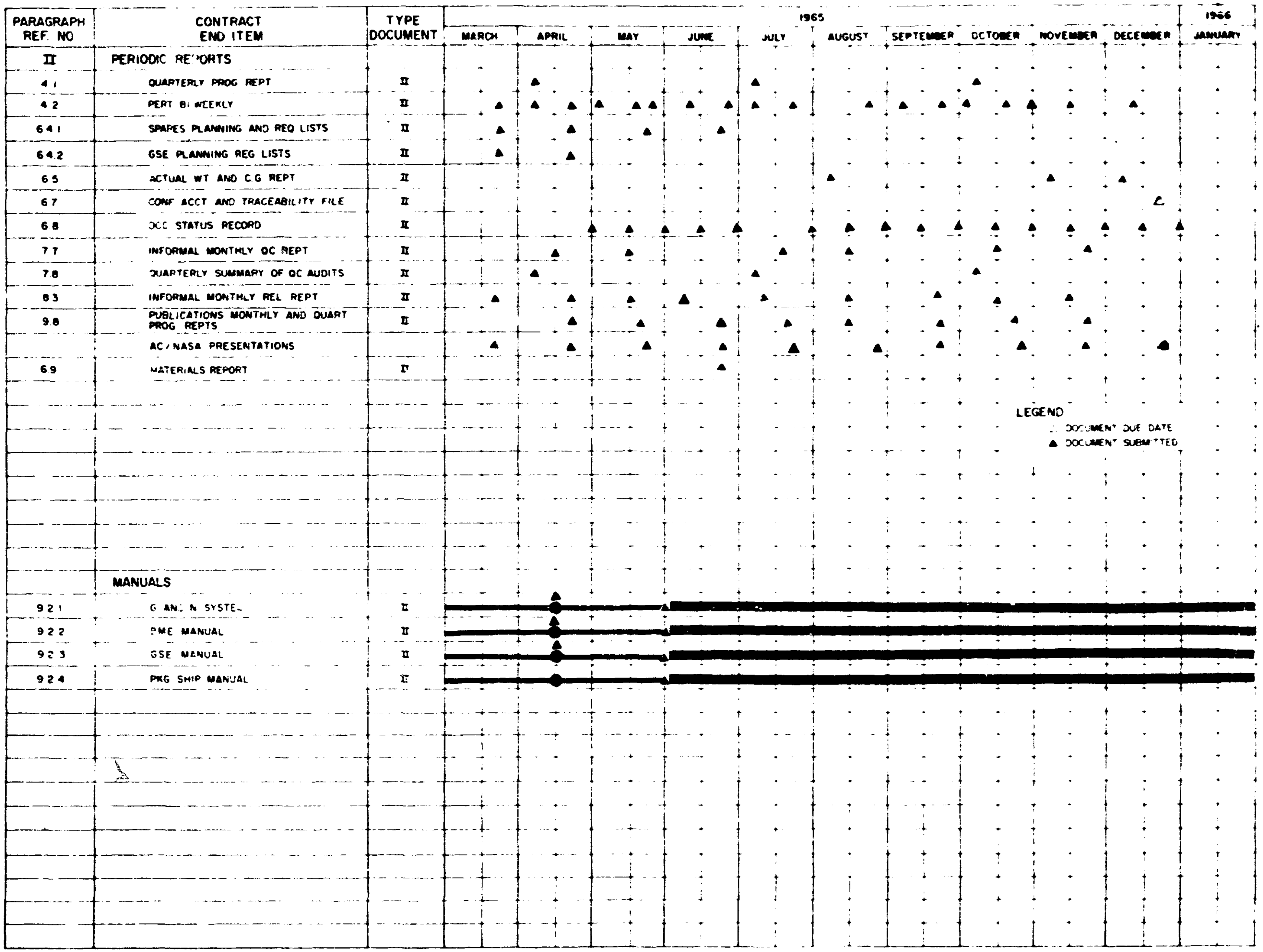


Figure 7-2. C/M Documentation Requirements-2

PARAGRAPH REF NO	CONTRACT END ITEM	TYPE DOCUMENT	1965										1966
			MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY
III	**FIELD OPS REPORTS**												
A 4513A	MAIN "D" FORMS										▲	▲	
A 4513I	FME LIST			▲	▲	▲	▲		▲	▲			
AA 7281	EQUIP STATUS AND LOCATION RPT			▲	▲	▲	▲	▲	▲	▲	▲	▲	
A 4513D	CALIB REQUIR SUMMARY						▲	▲	▲	▲	▲	▲	
A 4513E	GSE DESCRIP LIST						▲	▲	▲	▲	▲	▲	
A 4513F	TOOL LIST						▲	▲	▲	▲	▲	▲	
A 4513G	SOFT CONSUMABLE ITEMS LIST						▲	▲	▲	▲	▲	▲	
A 4513H	BULK ITEMS LIST						▲	▲	▲	▲	▲	▲	
A 4514A	DESIGN REVIEW		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	
A 4514C	MAINT DOWNTIME PREDICTION										▲	▲	
A 451581	RSPL		▲	▲ ▲	▲	▲	▲	▲	▲	▲	▲	▲ ▲	
AA 451584	SPARES DELINQUENCY REPORT		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	
AA 45158[illegible]	GFP INVENTORY						▲						
AA 7251	REPAIR AUTHORIZATION REQUEST						▲ ▲ ▲						
AA 7271	"IN-REPAIR" STATUS REPORT		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	
AA 451584	WEEKLY SPARES CONSUMPTION REPORT		▲ ▲ ▲ ▲	▲ ▲ ▲ ▲	▲ ▲ ▲ ▲	▲ ▲ ▲ ▲	▲ ▲ ▲	▲ ▲ ▲ ▲	▲ ▲ ▲ ▲	▲ ▲ ▲ ▲	▲ ▲ ▲ ▲	▲ ▲ ▲ ▲	
A 4512C2	PERSONNEL ASSIGNMENTS							▲	▲ ▲	▲			
A 45173A	HANDLING AND INSTALLATION PROCEDURES FOR GSE					▲							
DBA 4516181	TRAINING PLAN		▲										
A 45173B	CHECKOUT AND ALIGNMENT PROCEDURES FOR GSE					▲							
A 45161D1	TRAINING FACILITY REPORT		▲										
A 45161D3	TRAINING CHANGE REPORT												
A 45161D.2	MONTHLY TRAINING REPORT		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	
AA 53	MANAGEMENT REPORT											▲	
KD-2188	PREVENTATIVE MAINT REQ LIST												

LEGEND
△ DOCUMENT DUE DATE
▲ DOCUMENT SUBMITTED

Figure 7-3. C/M Documentation Requirements-3

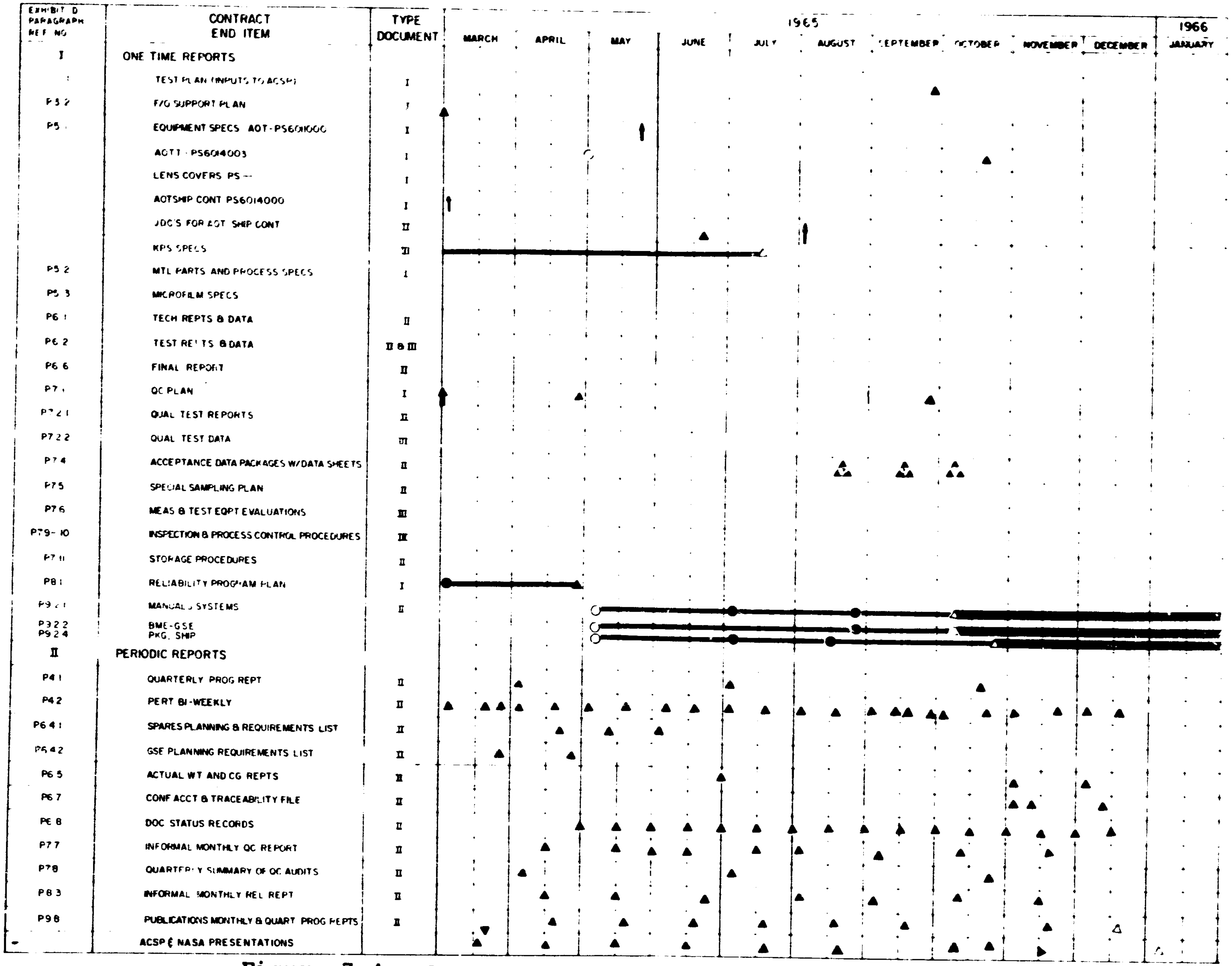


Figure 7-4. LM Documentation Requirements-1

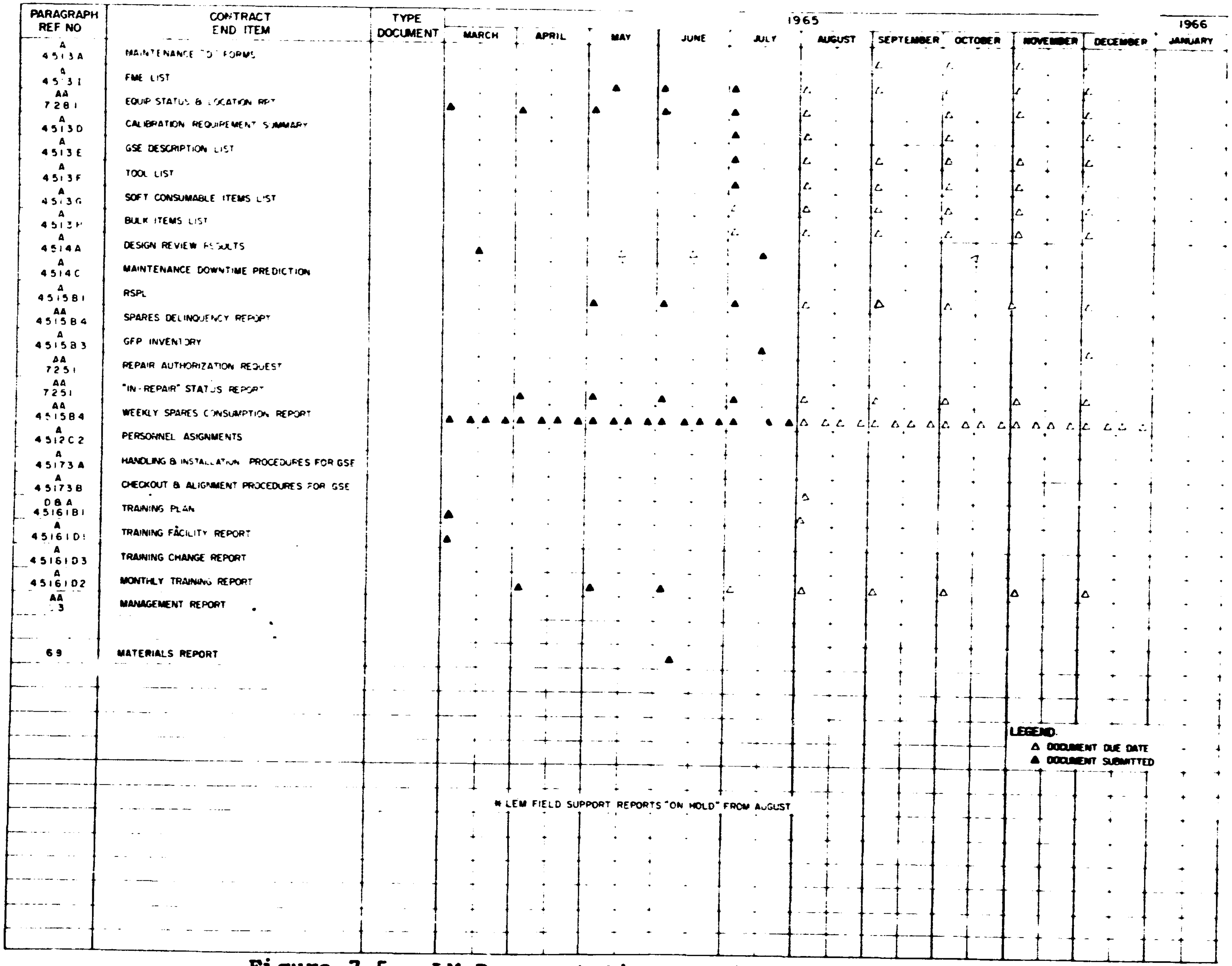


Figure 7-5. LM Documentation Requirements-2

Also included (Figure 7-6) is the Specification Family Tree for the Optical Unit Assembly 2011000-031 configuration.

Individual specification and procedure accomplishments for the year are depicted in graph form in Figures 7-8 through 7-11.

7.4.2.3 LM Documentation

1. Specifications Specifications for the LM effort were completed and accepted. LM spec. family tree is shown in Figure 7-7

2. Manuals LM manual efforts were approximately 80 percent complete and on an "on hold" status by contractual directive.

3. Reports Reports were completed and submitted as required during the year.

7.4.2.4 BLOCK II OUA & LEM Acceptance Data Package (ADP) and Retrofit Instruction Bulletin (RIB) Status.

ADP's in accordance with para. 7.4 and RIB's in accordance with para. 4.6 of Block II SOW are shown in graph form in Figure 7-1.

7.5 SUMMARY OF YEAR ENDING DECEMBER 31, 1966

7.5.1 Assignments

TD K-23	Documentation Administration
TD K-26	Program Progress Reports
TD K-31	Interface, Purchasing, Process & Material Specs
TD K-58	Factory Test Plans
TD K-95	Maintenance & Repair Manuals

7.5.2 Accomplishments

7.5.2.1 Documentation Administration: Documentation schedules were maintained in support of the CM effort. Acceptance Data Packages were provided with each unit delivered during this period.

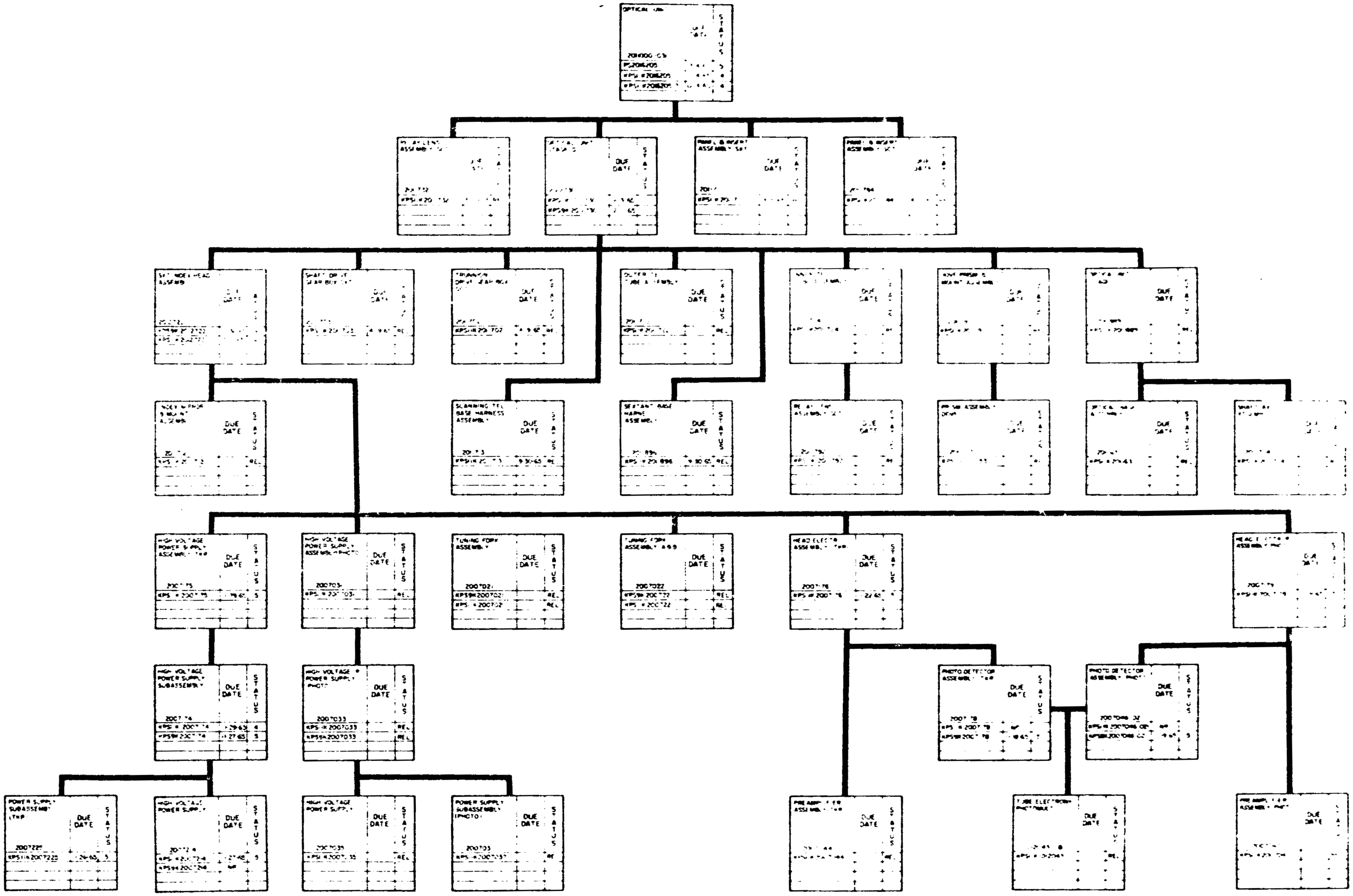


Figure 7-6. Block II Specification, Family Tree

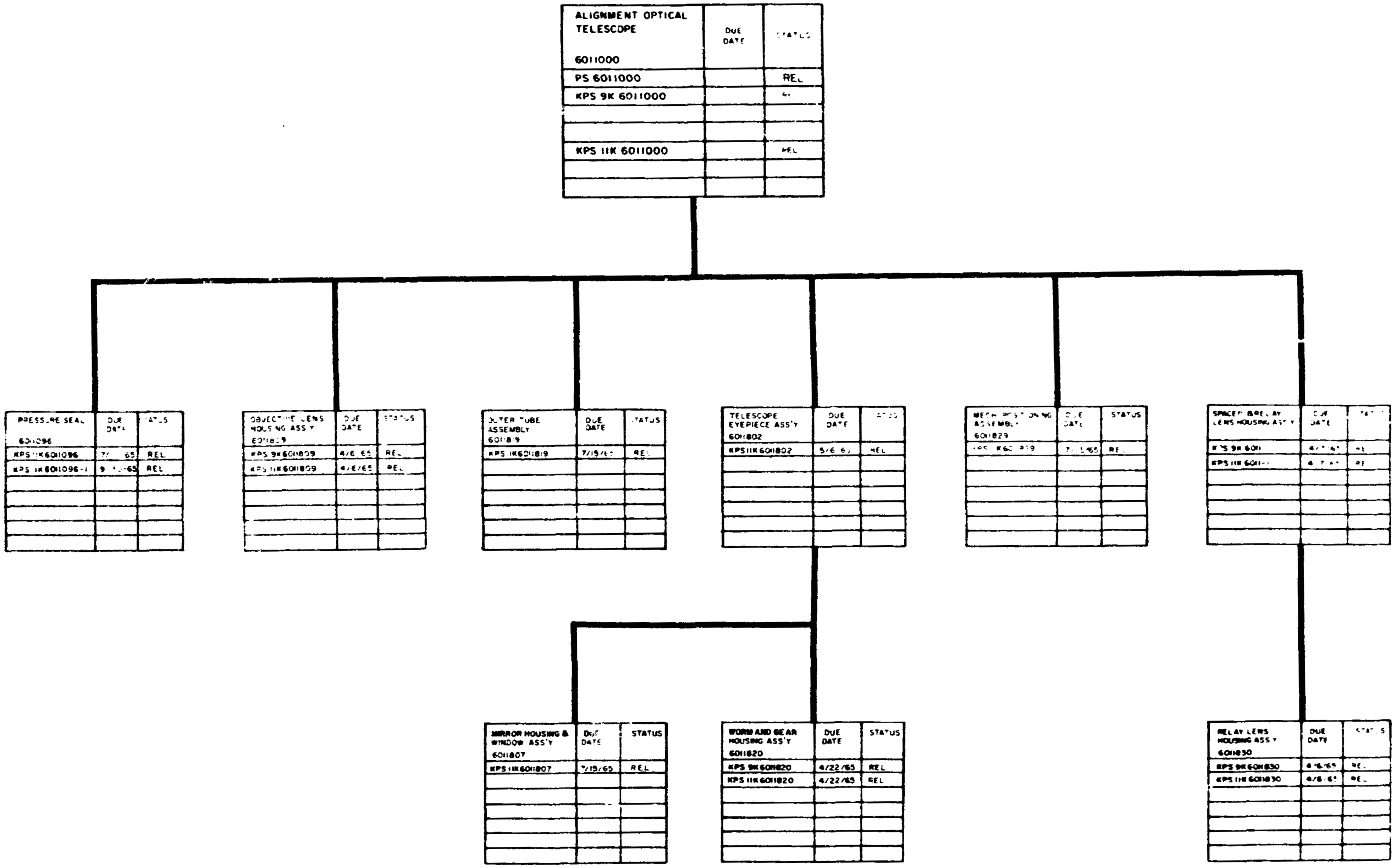


Figure 7-7. LM Specification Family Tree

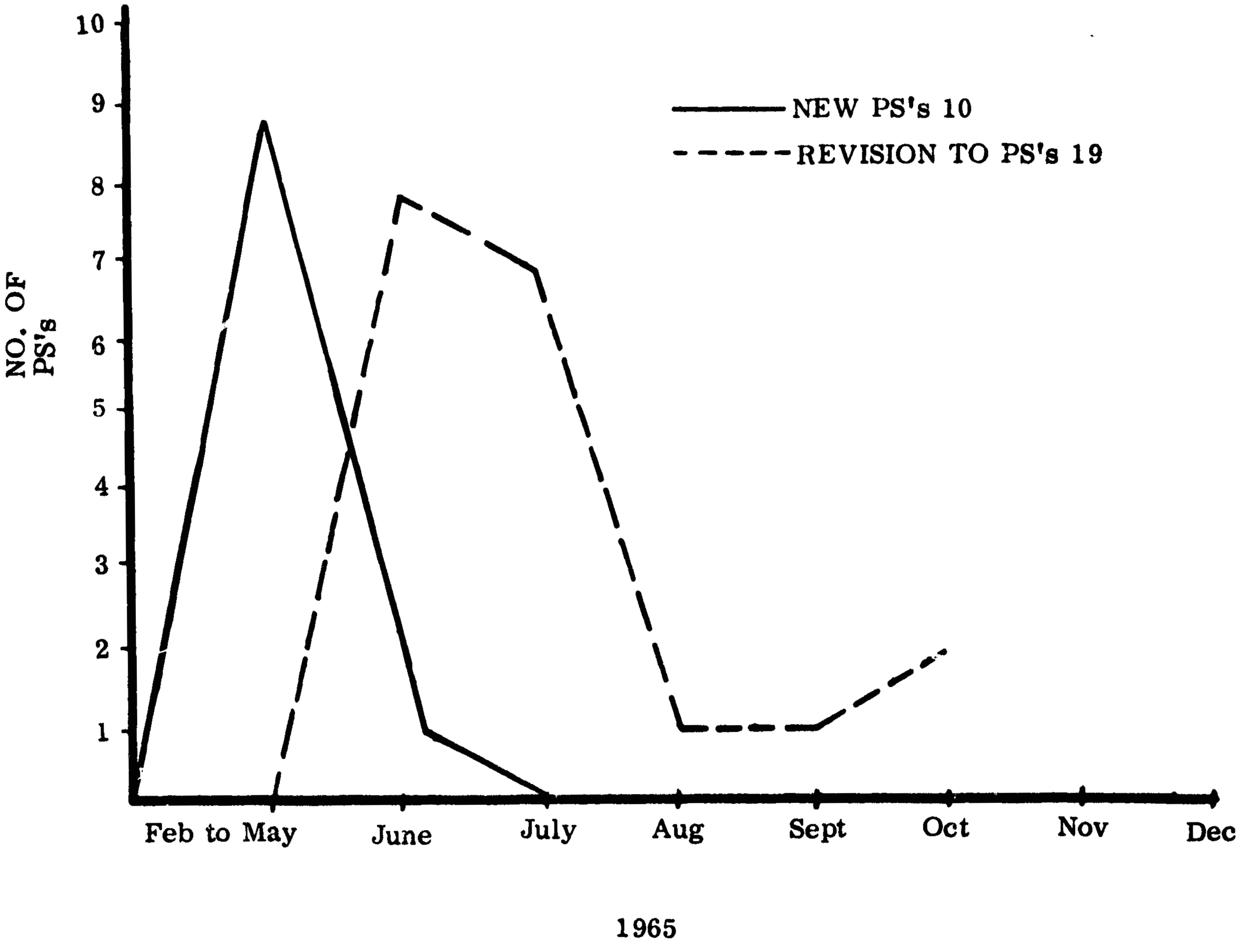


Figure 7-8. Procurement Specification Workload

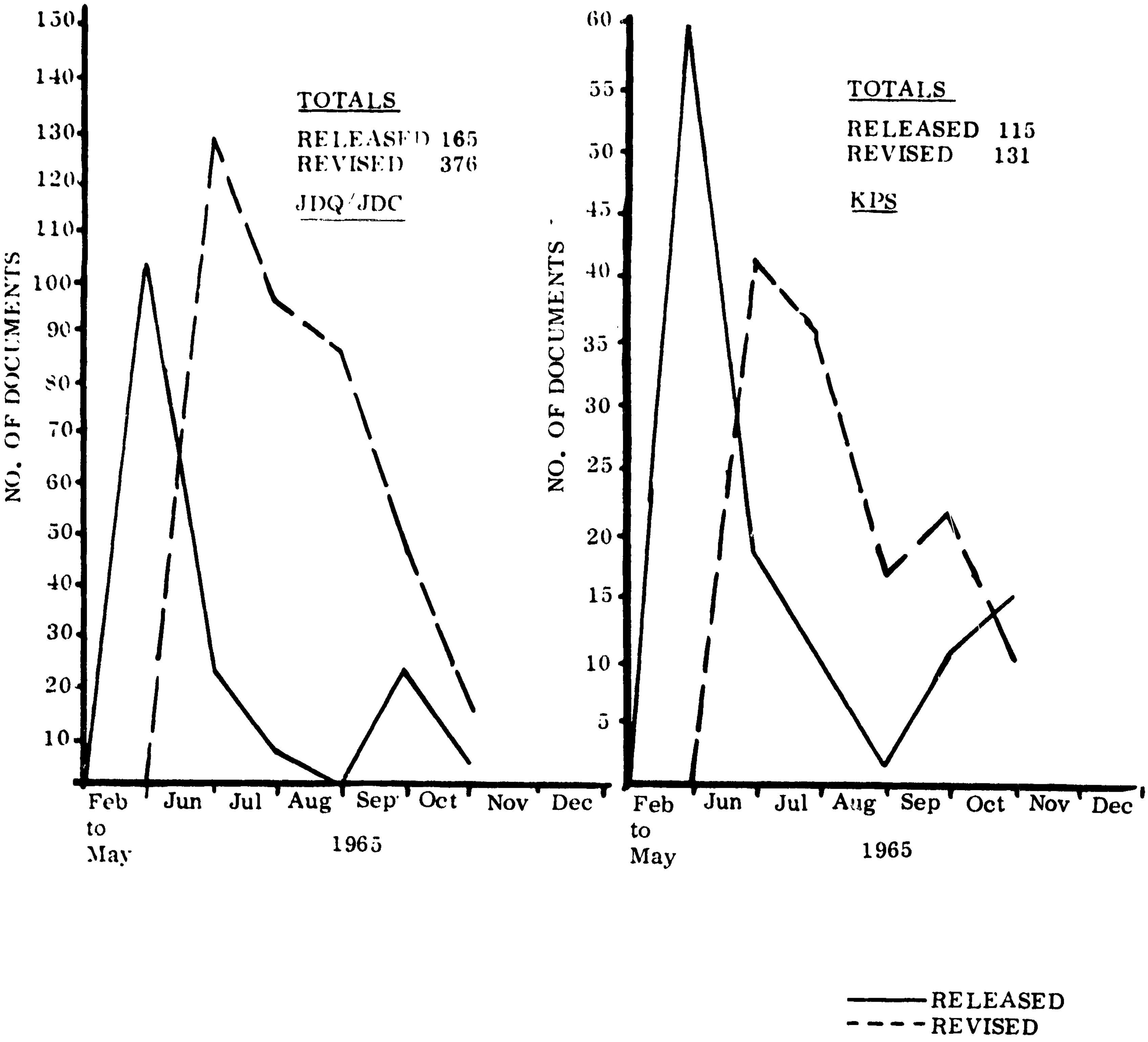


Figure 7-9. Block II/LM, Internal Specification Status

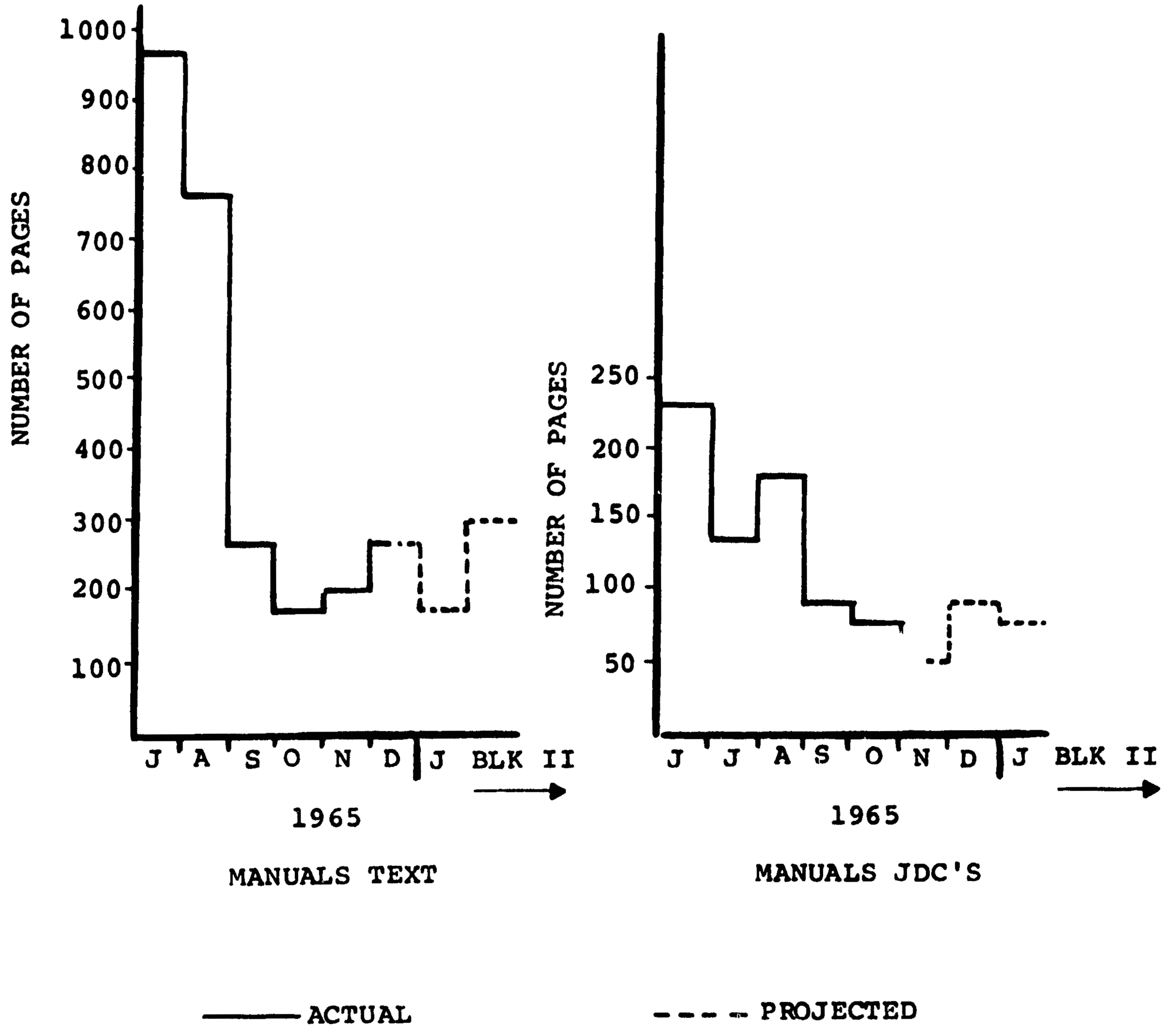


Figure 7-10. Block II, Manual Revision Status

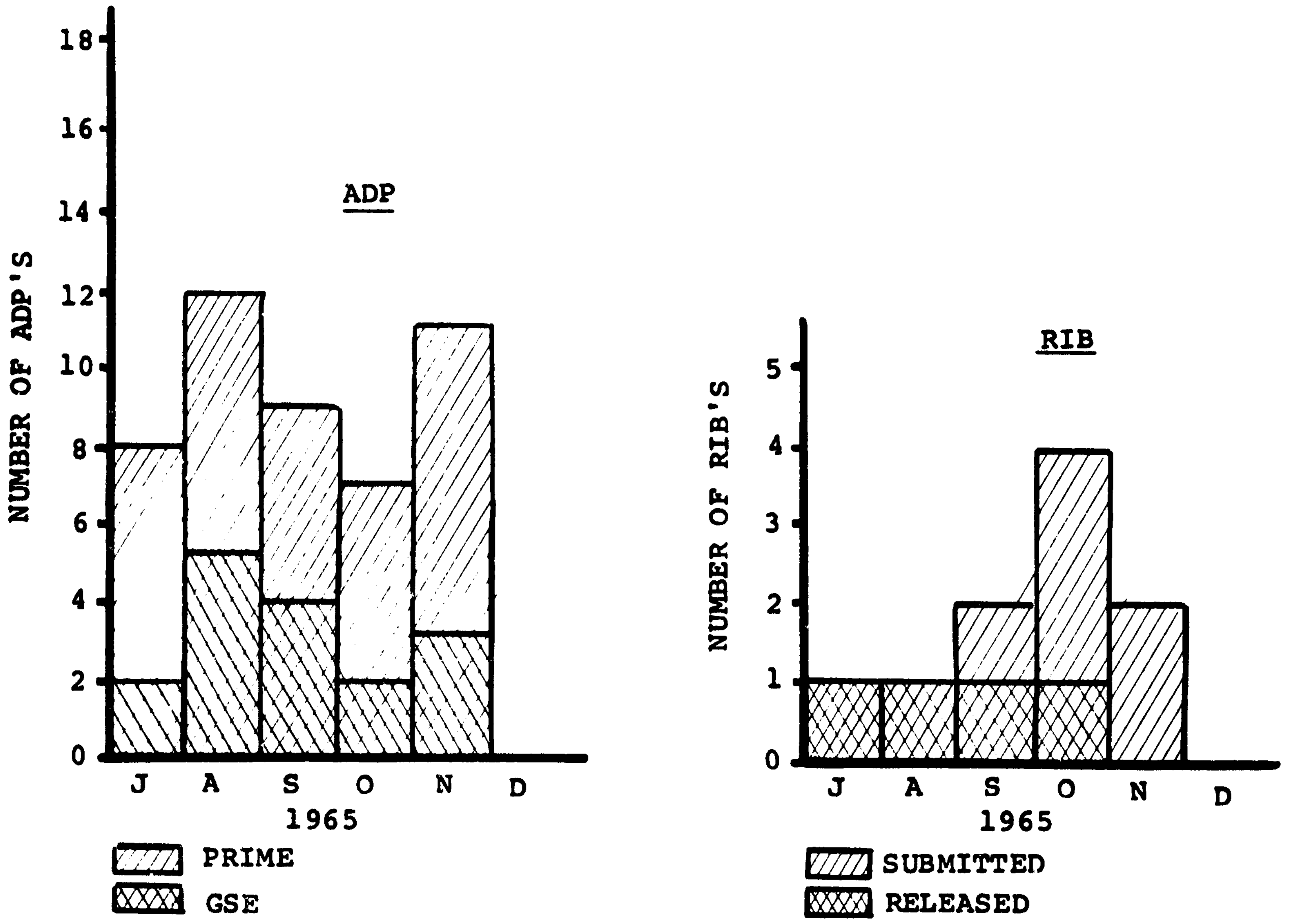


Figure 7-11. ADP and RIB Status

7.5.2.2 Block II

SPECIFICATIONS: All specifications were completed and accepted. These documents were then revised and/or modified in accordance with specific ECP's and TDRR's. Specifications and related procedures were prepared for all Block II Configurations of the OUA.

MANUALS: All manuals inputs to AC were approved during the reporting year. All text, artwork and reference to tracker/photometer and associated GSE was removed from Block I-100 & Block II manuals in accordance with AC KD-2210. All manuals and JDC's at that point in time were relegated to a periodic revision status.

7.5.2.3 LM Documentation

SPECIFICATIONS Specifications for the LM effort were completed. In accordance with ERP-122, which retrofitted the LM eyepieces for installation of eyepiece heaters and insulation.

LM MANUALS The KI inputs to the LM manuals were completed and shipped to AC on 4 March 1966. JDC's in support of the test and alignment efforts were also shipped concurrently.

REPORTS Reports were completed and submitted as required during the quarter.

7.6 SUMMARY OF THE YEARS 1967, 1968, and 1969

7.6.1 Assignments

a. Documentation Administration

b. Maintenance of Specs & Procedures

c. Maintenance of Manuals

d. Preparation of RIB's & RWS's

e. Preparation of Reports

7.6.2 Accomplishments

DOCUMENTATION ADMINISTRATION. Documentation schedules were maintained in support of CM/LM effort RIB's, RWS's and contractually required reports were completed and submitted as required during this period. Acceptance Data Packages were provided with each unit delivered during this period.

7.6.2.1 Block II

SPECIFICATIONS. All specifications were completed and accepted. Revisions on these documents were maintained on a regular basis.

OUA procedures for Block II configurations being maintained numbered 162, JDC's contained in these procedures numbered 266. Revisions to the aforementioned documents totaled 168.

MANUALS. Manual and JDC revision effort continued during this period.

7.6.2.2 LM Documentation

SPECIFICATIONS. Specifications for the LM were completed during this period. Maintenance procedure was instituted, a total of 44 documents were involved; JDC's contained therein totaled 39.

MANUALS. Manual and JDC revision effort continued during this period.

Section 8

FIELD OPERATIONS

8.1 SUMMARY OF PERIOD 1964 - 1965

8.1.1 Organization

The field operations, Block I, support was initiated in 1964. The Block II field operations support began prior to the delivery of the Block II hardware in 1965.

The organizational structure of the group at this time is indicated in Figure 8-1.

Manpower deployment and assignment of Field Operations Engineering personnel is depicted in Figure 8-2.

8.1.2 Accomplishments

TRAINING - A Block II training plan was completed and submitted to AC Electronics. This training plan was accomplished in accordance with the provisions of the existing contractual obligations of Kollsman relating to the training of its field operations personnel, including field engineers and associate engineers. Detail planning of each course was included to indicate the content of the course, method of instruction, and instructors utilized.

INDUSTRIAL CONTRACTOR TRAINING - Field personnel of the Industrial Contractor received intensive training at their home site on Block II and LM prime and support optical equipment. This training strengthened the systems training they received from the parent company and enabled all field personnel to function as a single support team at the field sites. Proper crosstraining contributed to the satisfactory completion of the Apollo Field Operations function.

SPECIAL TRAINING - From time to time it became necessary to provide brief reviews and orientations to official visitors and inspection parties.

UPGRADE TRAINING - The upgraded training consisted of training KI personnel currently assigned to field sites on Block II and LM equipment. Upgrade training at NAA was scheduled and completed

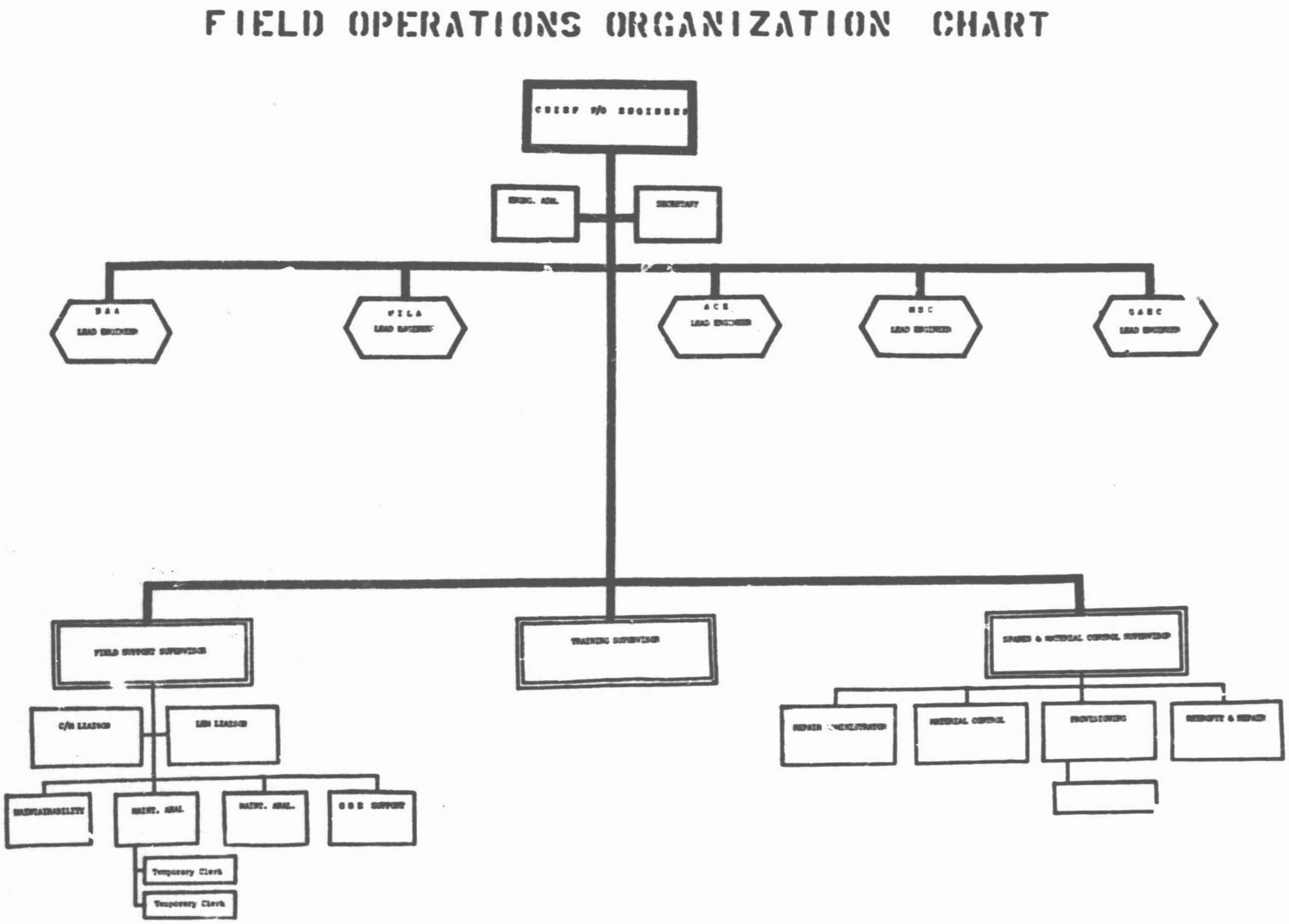


Figure 8-1. Field Operations Organization Chart

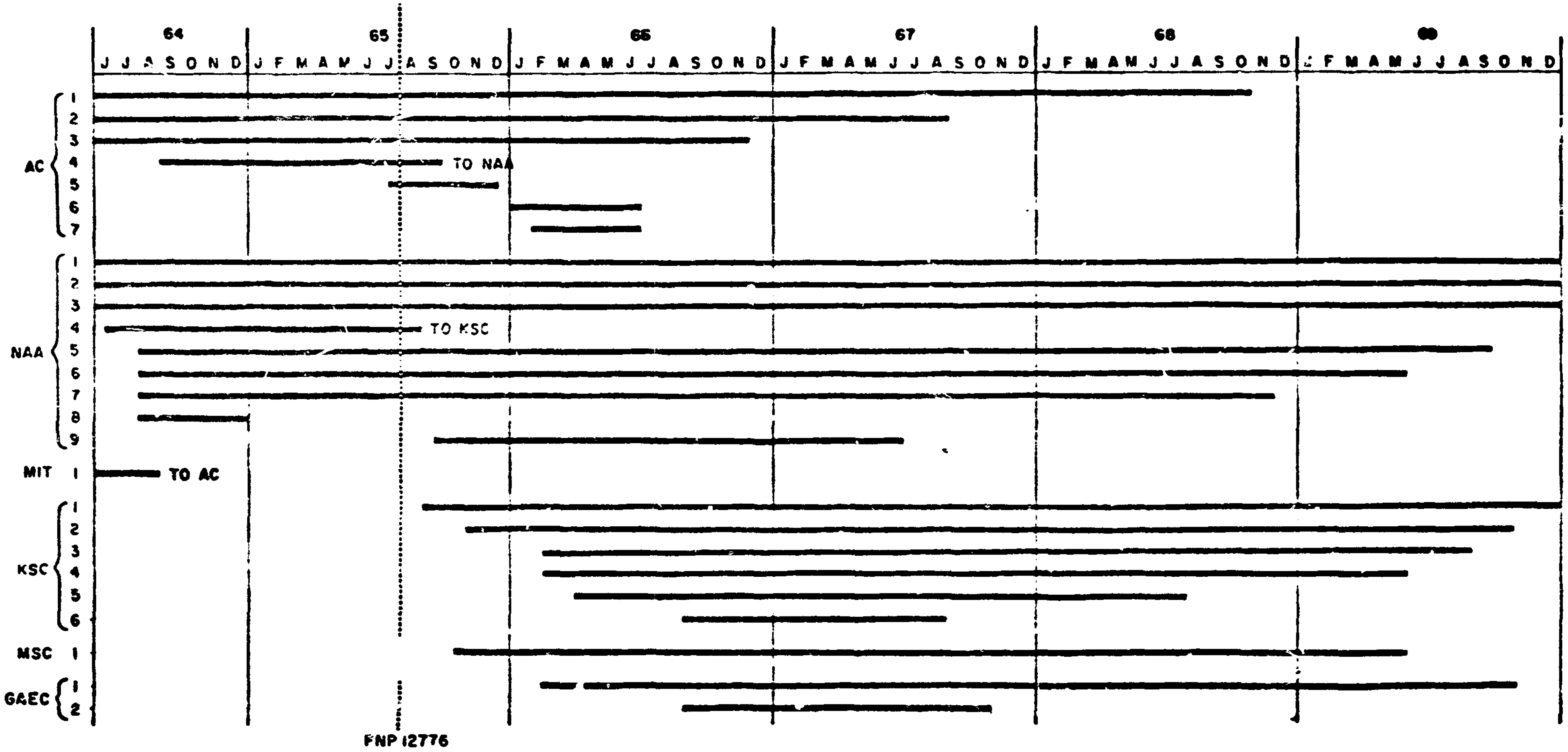


Figure 8-2. Field Operations Site Tenure

April 19-23, 1965 for Block II and LM. Duplicate sessions were held each day for 5 days consisting of 4 hours in the morning and then repeated in the afternoon.

The training schedule, for training of additional field engineers on Block II Equipment is depicted in Table 8-1.

8.1.3 Support Reporting

During this period the major part of field support effort was expended on the checking out and integrating of Block II GSE test equipment.

Concurrent with above, Block I-100 hardware started to become available. Utilization and testing of this equipment enabled the field engineers to lay the groundwork for the advent of the Block II hardware which arrived in 1966.

As problems arose, special field reports were issued, outlining the difficulty and suggested corrective action. Two significant reports during this period are listed below.

a. A new procedure was recommended for azimuth determination. There was a possibility that MIT might relax the overall accuracy. The new procedure was offered as an interim measure for effective utilization of manpower.

b. An alignment and certification procedure was developed for the porro prism for use as a G & N Lab azimuth reference device. The procedure covered mounting the porro prism to the pedestal assembly and aligning it to north/south bench marks.

8.1.4 Test Stations

Figures 8-3 through 8-5 show typical layouts of Test Stations.

8.2 SUMMARY OF YEAR ENDING 31 DECEMBER 1966

8.2.1 Assignments

Training continued for additional field engineers, spares provisioning, procurement, maintenance and analysis support.

Table 8-1

KOLLSMAN F/O TRAINING SCHEDULE

	1965												1966	
	J	F	M	A	M	J	J	A	S	O	N	D	J	F
Field Op.								Opt.Engr. Course #2.1 3			Opt. Engr. Course #2.1 2			
Upgrade Training On Site				KI AT NAA			KI AT AC							
System Training by AC at KI's facility										AC AT KI				
Subsystem Training by KI at AC	WAS SCHEDULED UPON REQUEST OF AC													

NOTE 1. Upgrade training was scheduled as required by Block II Modifications.

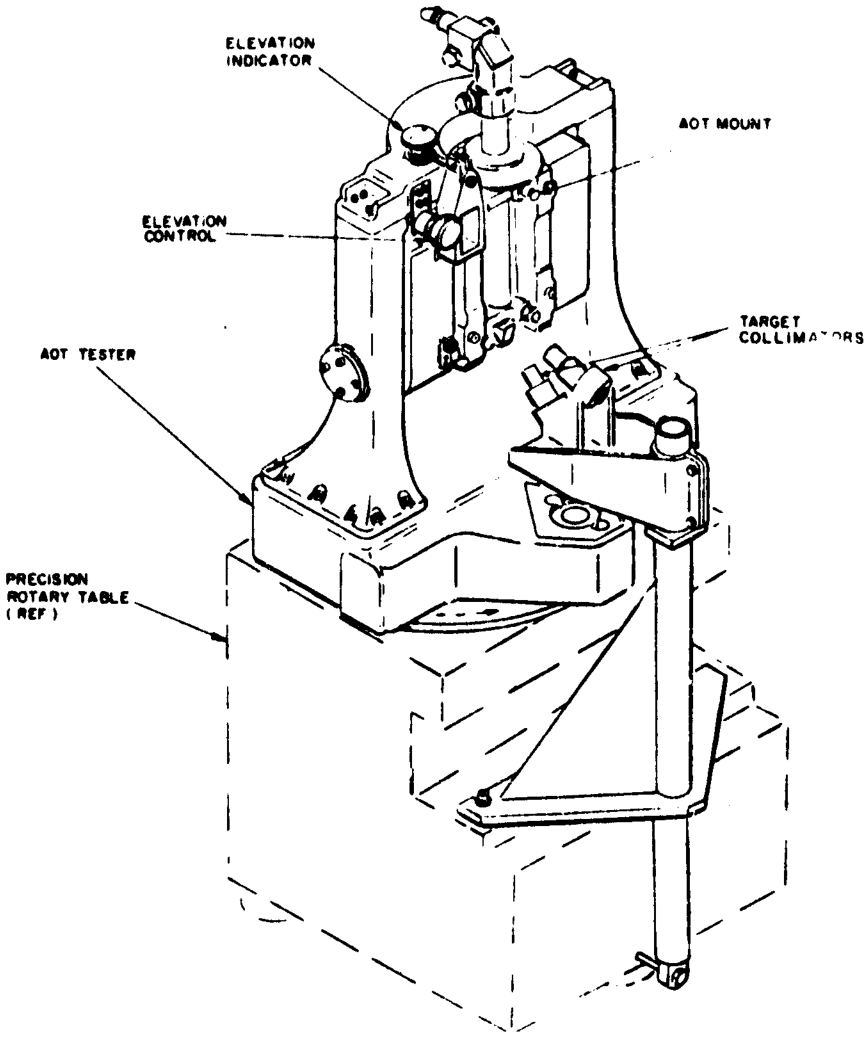


Figure 8-3. AOT/LM Test Station

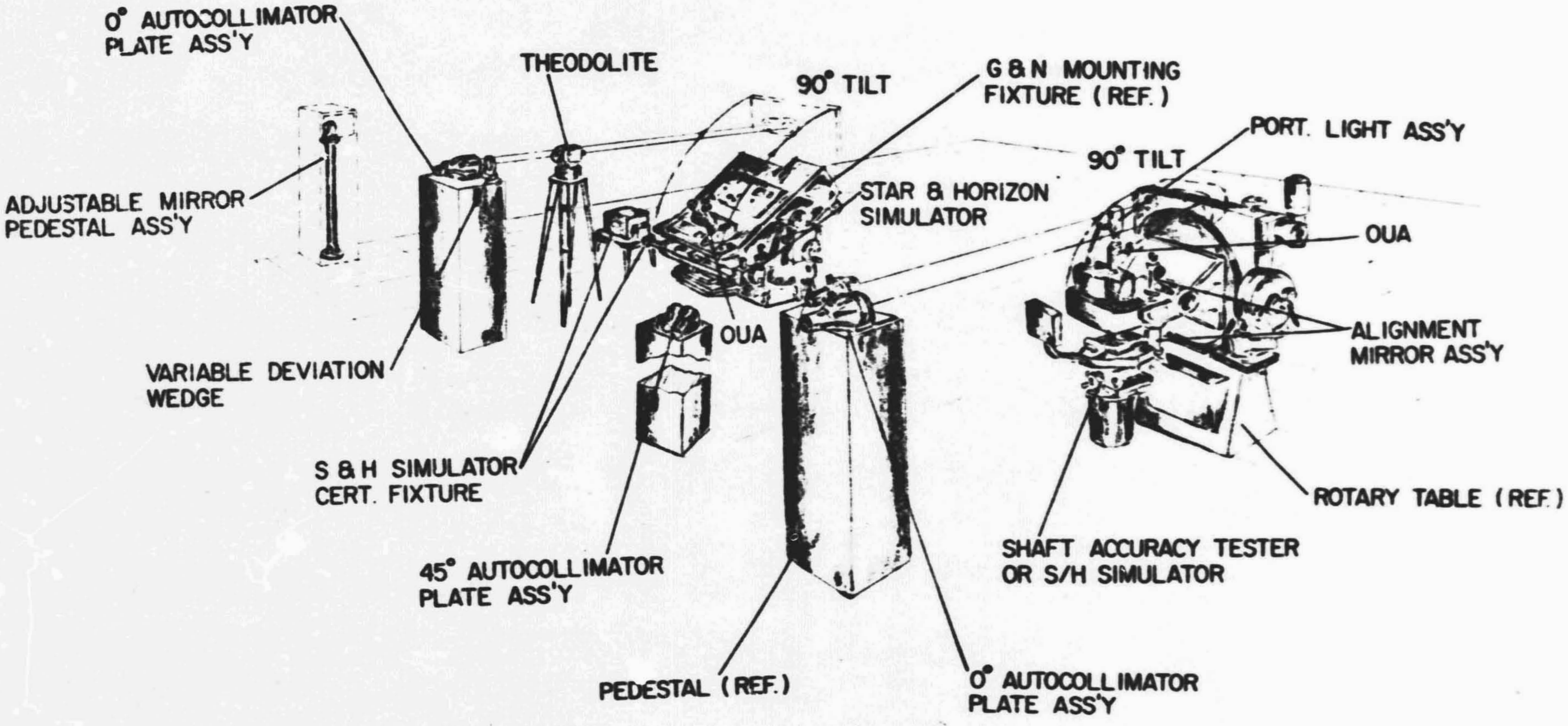


Figure 8-4. Universal Test Station (TYP.) G and N Lab Area

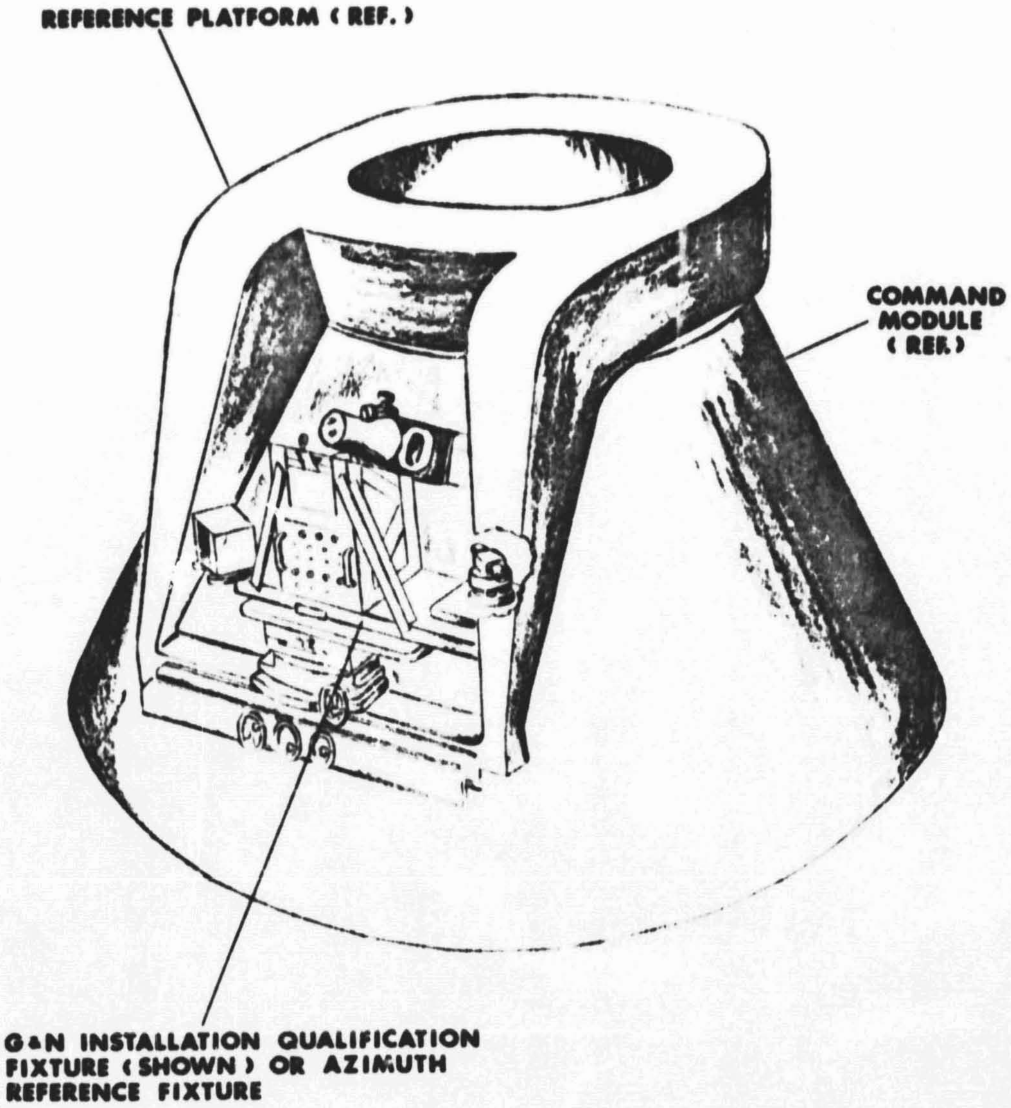


Figure 8-5. S/C-C/O Area

8.2.2 Accomplishments

TRAINING - A Field Operations Engineer class was completed and the graduates assigned to a G and N Systems training course at KSC conducted by AC instructors. Upon completion of the course, 25 February 1966, the trainees reported to the KI unit at KSC for duty.

In-service training for Documentation Engineers was started during the second quarter of 1966. The update training of field-assigned personnel was completed during this quarter. Field engineers were returned to Syosset and underwent training that included a stay at Grumman to inspect and work with the LM/AOT.

A training program was administered at Cape Kennedy to 20 of the G & N staff, including NASA, NAA, and AC Electronics personnel. The course dealt solely with the LM/AOT.

8.2.3 Maintenance Analysis Support

Maintenance Analysis inputs for the Command Module (CM) and the Lunar Excursion Module (LEM) were submitted in accordance with the contractual requirements. These inputs included the following reports:

Bulk Items List
Equipment Status and Location Report
Calibration Requirement Summary
Maintenance Engineering Analysis Form "D"
Maintainability Design Evaluation Report
Preventive Maintenance Requirement List
Recommended Apollo Ground Equipment List
Soft Consumables List
Tool List
Handling and Installation Procedures
Checkout and Alignment Procedures
Facility Requirements.

All basic maintenance analysis efforts were completed for both CM and LEM.

The Maintainability Design Evaluation Reports for CM and LEM were also completed.

8.2.4 Field Operations Personnel Deployment

During 1966 the following additional assignments were made:

No. of Eng. Assigned	Title	Site	Effective Date
1	Opt. Eng.	KSC	2/14/66
1	Opt. Eng.	KSC	2/14/66
1	Opt. Eng.	GAEC	2/21/66
1	Opt. Eng.	KSC	7/25/66
1	Opt. Eng.	GAEC	9/ 1/66

8.2.5 Support Reporting

During this period, activity at the North American Aviation site was accelerated with the arrival of the first Block II hardware (AGE 201). Concurrent with this field support, effort was concentrated on resolving interface and test procedure problems. Significant problems in this area are listed below.

a. A problem was encountered on CUA 201 concerning the limit cycle in the SCT shaft. A limit cycle of .04° peak to peak with a period of approximately three seconds was noted during OSS testing of the first Block II Unit. ACED felt that this might result in a manufacturing problem. Adjusting and torquing the anti-backlash gear did not solve the problem. Further investigation continued in this area.

b. An analysis was made on the result of sealing the optical unit eyepiece window with Locktite. The sealed unit was tested by applying a torque of 25 inch/pounds. Those units which did not pass the torque test were resealed, using Kollsman instructions.

c. During this period a severe design problem was disclosed concerning the operation of the astrosextant door. Subsequent meetings finally recommended the installation of ablative covers, and the elimination of the astrosextant doors. As MSC had experience in using ablative material, it was decided that the modifications for S/C 008, 011, 012, and 014 would be fabricated in MSC's shops. The installation of the first ablative covers on S/C 008 presented many fit and interface problems. Field Support personnel during this time spent much effort and actually made this first installation. To accomplish this, it was necessary to sand various areas of the covers to gain proper fit, and the epoxied areas were difficult to slip into place without smearing epoxy over adjacent parts. When the ablative plugs were installed with epoxy, they were sanded flush to the ablative filler.

d. A recommendation was made to relocate the autoset targets on the G&N Qualification Fixture baseplate. By reducing the SXT trunnion angle and the nominal angle between the target LOS, the autosets were placed in a better protected position with the same target symmetry and LOS intersection point maintained.

e. A new procedure was recommended for installing the optical target stability qualification fixture. It had become apparent that the autoset level lateral alignment was particularly vulnerable to displacement when the equipment was handled or operated.

f. Changes were recommended in the installation and alignment of the optical target GSE on the spacecraft. It was suggested that the alignment procedure should be divided: a preliminary, with power off, and a final when power is available to position the sextant STLOS for sighting.

g. Field personnel recommended a new procedure for certifying the G&N Installation Qualification Fixture in order to maintain a valid certification. Prior to this time it was necessary to use the altitude chamber at the Kennedy Space Center which was time consuming and costly. A removable fixture and support bracket with precision tapered dowel pins was suggested.

8.3 SUMMARY OF THE YEAR ENDING 31 DECEMBER 1967

8.3.1 Assignments

Training continued for additional field engineers, spares provisioning and procurement, maintenance and analysis support.

8.3.2 Accomplishments

TRAINING - Training materials and course control documents were revised to conform with the most recent configuration of equipment.

Conferences with Kollsman field personnel and inspection of laboratory and assembly areas provided an opportunity for exchange of the latest information. In addition to the periodic return to Kollsman by lead engineers, Kollsman representatives at NAA worked with Engineering at the Syosset facility on problems which developed.

8.3.3 Field Operations Deployment

There were no new field assignments made during this reporting period. Field operations deployment was maintained at its 1966 level.

During this period, the field effort concentrated on ensuring the meeting of schedule commitments in preparation for the Apollo flights in early 1968.

8.3.4 Support Reporting

During this period support emphasis was shifted to Kennedy Space Center in anticipation of the first Apollo flight in 1968. Field support continued at an accelerated rate at North American Aviation as Block II units continued to be cycled through. Significant reports during this period are listed below.

a. A report was prepared defining the requirements for the optical GSE in the VAB. The optical targets were presented (with alternate solutions for the installation of the targets) and other optical considerations for OUA testing were also discussed.

b. An analysis was prepared, describing a proposed installation of optical targets in the "A" Bay of the vertical assembly building for use in gyro compassing verification. An adjacent building roof was found to be suitable for mounting the targets.

c. A short optics test was prepared to meet spacecraft retest requirements. The proposed test was a quick operational check of optics, exercising those functions and modes which do not require LOS measurements and optical target GSE.

d. An analysis describing the problems of SXT target image motion non-linearity in respect to hand controller displacement was completed. It was found that the problem was due to gear train backlash, a situation which would be corrected by the incorporation of ECP 590.

e. An analysis was performed to investigate SCT shaft tach monitor load disturbance, associated with SCT head mass imbalance. It was found that the SCT shaft tach pulses are a function of head mass umbalance, bearing and gear train friction and backlash. The head imbalance had no effect on potential accuracy of the SCT. It contributes only slight fluxuation in slow rate, which is limited by the magnitude of gear train backlash.

f. An evaluation and recommendation of the eyepiece heater tests was completed. The bench test performed was the same as that performed for acceptance with the exception of the heat soak test, for which equipment was not available. Further test would involve a breakout box and the disconnection of connector in the spacecraft, which would not verify circuit integrity. A simple temperature test was recommended.

AOT

Concurrent with the Block II OUA effort, field support personnel began to expand in the AOT area. Some significant problems follow.

a. Light scatter reflected to the AOT was investigated. Tests were performed to determine the effect of light reflected from the rendezvous radar antenna. It was decided, however, that as the antenna simulator used was unpainted, it should duplicate the actual unit.

b. Dust particles and imperfections were found in all AOT reticles S/N 605 through 610. An evaluation of the imperfections was completed and a report was prepared.

c. Evaluation of the data obtained at Kitt Peak was prepared. Data was collected on AOT reticle imperfections and light scatter effects.

8.4 SUMMARY PERIOD 1968 AND 1969

8.4.1 Accomplishments

This year marked the beginning of the first flights for the Optical Unit Assembly (OUA). Apollo 7 and Apollo 8, flown in October and December, respectively, both carried the OUA.

During this year, field support effort became focused on supporting not only these two flights, but the scheduled moon flights for 1969.

TRAINING - During the period covered by this report, the Training Section maintained current training materials, and provided updated training to field personnel returning to the Syosset facility from NAR, Downey, California and from Kennedy Space Center, Florida. Representatives of the Training Section visited AC Electronics Division at Milwaukee to discuss future training schedules and courses.

8.4.2 Material and Spares Integration

a. LM Airborne, CM Airborne and GSE Spares, which were authorized during this period, were released for manufacturing and/or procurement.

b. Provisioning of spares in support of ERP's continued.

c. Reprovisioning of consumed spares continued.

d. Preparation of Cost and Delivery Schedule, for those spares approved at the Apollo Spares Provisioning Conference was accomplished.

MAINTENANCE ANALYSIS - Maintenance Analysis inputs were reviewed for information pertinent to support, and when applicable, submitted.

8.4.3 Support Reporting

With the advent of the Apollo flights, investigations began to take place relative to post-flight conditions. Some of these findings are listed below:

a. The post recovery removal and evaluation of the NAV Base Optics Assembly from Spacecraft 17 was completed. The degree of burn was inspected and evaluated. Except for heat effect, the exposed optics outside the C/M showed no significant damage.

b. The post recovery removal and evaluation of the optical unit from spacecraft 101 was completed. The amount of burn was moderate. The trunnion mirrors and the SCT double dove prism were discolored and covered with salt-water deposits. The SXT and SCT shaft axes were frozen, probably due to salt water immersion.

c. The post flight removal of the optical unit from spacecraft 020 was completed. Visual inspection indicated a greater degree of burn than was observed on spacecrafts 011 and 017. The SXT trunnion mirror and the SCT double dove prism were discolored and covered with burn residue and salt water deposits. Both the shaft and trunnion axes were frozen and would not respond to power drive signals.

In addition to the post-flight analyses, field personnel were active in the support of OUA and AOT procedures and problems.

a. A proposed evaluation of the LC-34 optical target stability test, performed at the Kennedy Space Center was completed. The test was proposed to determine the accuracy of optical sightings from level F 224 of the mobile service simulator to the LC-34 optical targets. It was concluded that accurate optical sightings can be made. The stability of the targets however, was questionable.

b. An evaluation describing the SXT shaft limit cycles in OPTICS CMC mode was prepared. It was concluded that the discrepancy was due to normal CMC coarse align operation. As the OPTICS CMC Mode is used to position the optics to a desired target and not to make precise measurements, it was felt that the cycling in coarse align would not affect operational use.

c. An analysis was performed on the Optical Target alignment procedure. Careful review and pertinent alignment data reaffirmed that the procedure used with JDC 12223 for target no. 1 positioning to true North had been correct. The 18 minute misalignment appeared to be due to the equipment configuration, which does not precisely represent that at NR G/N Lab.

d. A revised assembly procedure was recommended, for installing the AOT pressure seal, clamping ring, and flange. As it was difficult to align the mounting screw holes, it was suggested that indexing mark should be added to the parts.

e. An investigation and evaluation into the cause for the AOT binding problem in LM-4 was completed. The problem was caused by improper installation of the entire cover assembly. Procedures for preventing a similar problem was proposed.

Much of the Field Operations effort during the busy launch schedule was utilized in surveillence prior to the flight and ready stand-by support during the actual flight. In summary, the field support effort pursued and insured a smooth intergration of Kollsman Apollo hardware to the G & N System and subsequent launch missions.