T73-12413
N73-20491
CR-128889

SDO/CMO—455
FEBRUARY 1973

Prepared for
NASA Manned Spacecraft Center
under Contract NAS9—11528
DRL 9, DRD MA—129T

FINAL REPORT FOR TASK II OF THE ULTRAVIOLET SPECTROMETER EXPERIMENT S169

SPACE DEVELOPMENT DEPARTMENT

THE JOHNS HOPKINS UNIVERSITY • APPLIED PHYSICS LABORATORY

THE JOHNS HOPKINS UNIVERSITY
APPLIED PHYSICS LABORATORY
SILVER SPRING, MARYLAND

Prepared for
NASA Manned Spacecraft Center
Under Contract NAS9-11528
MSC Number DRL 9, DRD MA-129T
APL Number SDO/CMO-455

FINAL REPORT FOR TASK II OF THE ULTRAVIOLET SPECTROMETER EXPERIMENT S169

FEBRUARY 1973

Prepared by: M E Goss
M. E. Goss
S169 Project Office

Approved by: TWyatt
T. Wyatt
Project Engineer

The Johns Hopkins University
Applied Physics Laboratory
8621 Georgia Avenue
Silver Spring, Maryland

INITIAL DISTRIBUTION EXTERNAL TO THE APPLIED PHYSICS LABORATORY

Organization/Location	Attention	Copies
NASA Manned Spacecraft Center Lunar Experiments Procurement Section Houston, Texas 77058	T. C. Cone/BC34(88)	1
NASA Manned Spacecraft Center Technical Information Dissemination Branch Houston, Texas 77058	Retha Shirkey/BM6	4
NASA Manned Spacecraft Center Management Services Division Houston, Texas 77058	John T. Wheeler/BM7	1
NASA Manned Spacecraft Center Lunar Orbit Experiments Development Project Office Houston, Texas 77058	Code ED2	2
NASA Manned Spacecraft Center Reliability Branch Houston, Texas 77058	Earl Smith/NB5	2
NASA Manned Spacecraft Center Quality Branch Houston, Texas 77058	Harold Harvey/ND6	1
NASA Manned Spacecraft Center Houston, Texas 77059	Nat Hardee/TD4	5
NASA Manned Spacecraft Center Data Systems Application Section Houston, Texas 77058	L. W. McFadin/EB8	5
NASA Manned Spacecraft Center S/C Experiments & Support Systems Contract Engineering Branch Houston, Texas 77058	Code BT4	1

INITIAL DISTRIBUTION EXTERNAL TO THE APPLIED PHYSICS LABORATORY (continued)

Organization/Location	Attention	Copies
NASA Manned Spacecraft Center Flight Safety Analysis Office Houston, Texas 77058	Otho Lindsey/SN	1
NASA Manned Spacecraft Center Houston, Texas 77058	J. Gorge/PG	1
NASA Goddard Space Flight Center Building 7 - Rm. 103 Greenbelt, Maryland 20771	J. L. Diggins/ Code 325	1
John F. Kennedy Space Center Florida 32899	W. M. Baulig/ AD-PRO-24	1
John F. Kennedy Space Center Florida 32899	W. D. Moody/ LS-TMP-1	1
The Boeing Company P.O. Box 58747 Houston, Texas 77058	Code HS-01	1
North American Rockwell 12214 Lakewood Boulevard Downey, California 90241	M. M. Vucelie/ FB84 Dept. 601 for V. L. Dobbs	1
ONR Resident Representative The Johns Hopkins University 34th & Charles Streets Baltimore, Maryland 21218	W. B. Girkin	1
The Johns Hopkins University Office of Sponsored Research Administration 34th & Charles Streets Baltimore, Maryland 21218	A. P. Ashton, Director	1
The Johns Hopkins University Department of Physics 34th & Charles Streets Baltimore, Maryland 21218	W. G. Fastie	3

INITIAL DISTRIBUTION EXTERNAL TO THE APPLIED PHYSICS LABORATORY (continued)

Organization/Location	Attention	Copies
Naval Plant Representative Office 8621 Georgia Avenue Silver Spring, Maryland 20910	Commanding Officer	2

INITIAL DISTRIBUTION INTERNAL TO THE APPLIED PHYSICS LABORATORY

R. W. Cole
L. D. Eckard
M. E. Goss (5 copies)
C. T. Holliday
I. B. Irving
B. D. Kellam
R. W. Larson
E. L. Marshall
L. C. Miller

R. J. Ossie
A. C. Reymann
M. M. Schaefer
I. H. Schroader
C. J. Smith
G. D. Wagner
T. Wyatt
CMO Files
SDO Central Files
Archives (2)

ABSTRACT

The Far Ultraviolet Spectrometer for the Apollo 17 lunar scientific mission was constructed to meet the specific requirements and technical specifications as directed by the Manned Spacecraft Center, National Aeronautics and Space Administration. The Ebert Scanning Monochromator (UVS) was derived from the extensive experience of the Principal Investigator in the development of a variety of Ebert scanning monochromators for experiments aboard rockets and satellites.

This final report delineates the effort expended by the Applied Physics Laboratory, The Johns Hopkins University to design and develop instrument hardware and associated test equipment having the capability to perform quantitative measurements of the composition of the atmosphere of the moon as seen from the Apollo 17 CSM in lunar orbit and to study the spectra of a number of astronomical sources during trans-earth coast.

CONTENTS

---

*Parenthetical numbers refer to the contract SOW paragraphs.

CONTENTS (continued)

CONTENTS (continued)

CONTENTS (continued)

CONTENTS (continued)

CONTENTS (concluded)

ILLUSTRATIONS

TABLES

DEFINITIONS

Flight Hardware. That hardware required for accomplishment of the UVS Experiment S169 which was installed in the Apollo 17 spacecraft for flight.

Backup Hardware. That hardware which is identical to the flight hardware in configuration, production processing and testing, and maintained in a state of readiness as replacement for the flight hardware.

Qualification Test Hardware. That hardware which was used for environmental testing and is identical in configuration and production processing to the flight hardware.

High Fidelity Mockup. That hardware which was used by the astronauts for training purposes. The mockup meets the flight hardware specifications relating to dimensions, tolerance, form, fit, and function in all areas affecting flight crew member interfaces or performance.

Prototype Hardware. That hardware which is identical to the flight hardware in configuration and production processing, but not qualified for flight.

Cross Calibration Unit. That hardware which was reconfigured from the UVS prototype unit and used for cross calibration trials at Goddard Space Flight Center and The Johns Hopkins University Physics Department. This UVS unit was electrically certified for possible future flight.

ATEE Unit. That hardware which was reconfigured from various UVS components to produce a simulated UVS unit with identical electrical characteristics as the flight hardware. This unit was used during the Apollo Telecommunications Engineering Evaluation.

Thermal Model. That hardware which was fabricated to simulate the thermal aspects of the UVS instrument including heat conduction flow paths, radiation paths, and sources of heat dissipation. This model was used as an aid to the UVS instrument design.

Thermal Analytical Model. A detailed thermal analysis of the UVS instrument such that the outer surface nodes and contact point nodes respond thermally to instrument operation and the environment when integrated into the overall SIM thermal analytical model.

Ground Support Equipment. That equipment which is required for servicing, testing, handling, maintaining, and transporting the UVS experiment hardware. This equipment is that hardware which is applicable to the requirements of the experiment and is not already available as government furnished equipment. All GSE referred to herein is classified as Mission Support Class II as defined in MSC-GSE-MEIS-2A Section 3.2.

ABBREVIATIONS AND ACRONYMS

ADP	Acceptance Data Package
AIP	Acceptance Inspection Package
ALEM	Apollo Lunar Exploration Missions
APL	Applied Physics Laboratory The Johns Hopkins University
AR	Acceptance Review
ATEE	Apollo Telecommunications Engineering Evaluation
ATP	Acceptance Test Procedures
BTE	Bench Test Equipment
CCA	Contract Change Authorization
CCB	Change Control Board
CDR	Critical Design Review
CEI	Contract End Item
CMR	Configuration Management Requirements
COFW	Certificate of Flight Worthiness
CSM	Command and Service Module
DC	Direct Current
DRD	Data Requirement Description
DRL	Date Requirement List
DTR	Detail Technical Review
ECP	Engineering Change Proposal
EEE	Electronic, Electrical, and Electromechanical
EIP	Experiment Implementation Plan
EMI	Electromagnetic Interference
EMR	Electromechanical Research Division of Weston Instruments, Inc.
ER	Established Reliability
FIAR	Failure Investigation Analysis Report
FMEA	Failure Mode and Effects Analysis
GFE	Government Furnished Equipment
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center, Greenbelt, Maryland
ICD	Interface Control Document
IDL	Indentured Drawing List
IRN	Interface Revision Notice
JHU	The Johns Hopkins University
KSC	Kennedy Space Center
LM	Lunar Module
MRB	Material Review Board

ABBREVIATIONS AND ACRONYMS

(concluded)

MS	Military Standards
MSC	Manned Spacecraft Center, Houston, Texas
NASA	National Aeronautics and Space Administration
NR	North American Rockwell Corporation
OTE	Optical Test Equipment
PI	Principal Investigator
P&I	Performance and Interface
PIRN	Preliminary Interface Revision Notice
PIT	Pre-installation Test
PMT	Photomultiplier Tube
PSCN	Preliminary Specification Change Notice
RCS	Reaction Control System
RF	Radio Frequency
SCL	Specification Change Log
SCN	Specification Change Notice
SDS	Scientific Data System
SIM	Scientific Instrument Module
SLA	Spacecraft Launch Adapter
SM	Service Module
SMIC	Service Module Integrating Contractor
SOW	Statement of Work
TAM	Thermal Analytical Model
UVS	Ultraviolet Spectrometer
WBS	Work Breakdown Structure

SUMMARY

The Ultraviolet Spectrometer Program, under contract from the NASA Manned Spacecraft Center, was implemented to perform measurements in the far ultraviolet spectrum as part of the Apollo 17 lunar mission. Task I of the contract provided for the services of the Principal Investigator at the Physics Department of The Johns Hopkins University. This final report concerns Task II of the contract which was assigned to the Applied Physics Laboratory. Task II included the design and fabrication of two Fastie-Ebert spectrometers for flight use, a mockup for astronaut training, a prototype unit, a qualification unit, and test equipment. During the course of the program, the contract was amended to include a thermal test model and two additional end items, i.e., a unit reconfigured for use during ATEE tests at NR, and a reconfigured unit for cross calibration trials at Goddard Space Flight Center.

Program management controls were developed initially and maintained throughout the program. Program management provided an organization of technically competent APL personnel well experienced in other space related endeavors. The program management system, constrained only by DRL 4, DRD MA-124T, established a timely work breakdown structure, provided for program reporting, and specifically, formulated the necessary program controls to assure program accomplishment.

A configuration management system was developed to define the experiment hardware at any point in time. A Configuration Management Office, constrained only by the Configuration Management Plan, was established to be responsible for implementing the plan. Configuration identification was maintained after a baseline was established, and a system of review and analysis was developed to identify all contract end items in order to determine the specifications required. CEI specifications were prepared to establish the design, development, and qualification requirements of all end items.

Subsequent configuration management efforts provided for timely acceptance reviews, interface management, and configuration accounting based on a clearly defined and approved configuration baseline.

Data management was established to maintain project files of all administrative, management, and technical information by using existing APL data storage and retrieval systems. All contractual documentation required to support the UVS program was prepared and submitted as required by the DRLs and DRDs of the Statement of Work. Other supporting documentation such as internal memoranda, design studies, analyses, and test data was also available upon request, especially all data required for design and acceptance reviews.

A logistics plan was prepared in accordance with contract requirements to identify the personnel, facilities, planning, and procedures necessary to support the logistics needs for the program. The UVS instrument and bench test equipment were modularized for ease of maintenance and repair. Whenever rework was required, the scope of rework, realignment, or recalibration was constrained in accordance with Section 8.3 of the Qualification Program Plan. Because the UVS instruments were especially sensitive to shock, vibration,and contamination, particular care was extended in the areas of transportability, transportation, packaging,and maintenance. Although the experiment hardware was constantly transported and handled at NR, MSC, KSC, JHU, GSFC, and was subjected to numerous periods of test, calibration,and maintenance, not a single mishap occurred.

Program cost and schedule performance was closely monitored and periodically reported throughout the program. The UVS Program Administrator compared monthly cost data with cost allocations. He also maintained detailed schedules which established the planned and scheduled progress of the various tasks to help assure the program effort would meet contractual requirements. Program progress schedules were submitted periodically to MSC in accordance with DRL 29, DRD SC-015T.

Internal performance control was maintained through constant program status reviews which provided for the implementation of corrective action for possible problems which could affect schedules, performance, reliability, or cost. External performance control was similarly contained through the APL Contracts Administrator and technical Problem Sponsors. All subcontractors and vendors were required to comply with the standards set forth in the Quality Program Plan.

A system safety program provided for organized activity in which management efforts and technical disciplines were coordinated to provide timely identification and the required corrective action to eliminate or control those conditions or events which would have contributed to injury or loss of crew, operating personnel, system failure, or damage to equipment and hardware throughout all phases of the program. All aspects of the program were established and maintained within the constraints and scope of the Apollo mission safety requirements. Evaluation studies and system analyses were performed to identify and categorize possible hazards and failure modes, particularly those spanning interfacing systems. The UVS Hazard Analysis Report was submitted for approval in accordance with DRL 32, DRD SA-021T.

Design safety requirements, as constrained by the contract, were included in all appropriate documentation and presented at the Critical Design and Acceptance Reviews. All hardware was reviewed for operational safety, including incoming vendor items. A system of internal safety reporting was established and monthly safety progress reports were submitted to MSC.

Design and development effort required to produce a UV spectrometer was outlined in accordance with DRL 37, DRD SE-174T. Exhibit B of the contract, SD 69-315, and the preliminary interface control documents were reviewed for constraints in establishing a performance/design verification matrix. During the system design phase, the optical, electrical, mechanical, and thermal subsystems were defined and documented. A Design and Development Plan was prepared to provide for the design, development, fabrication, and testing of one hi-fi mockup, one prototype unit, one qualification unit, two flight units, and two sets of ground support equipment. In conjunction with this plan, detailed functional flow diagrams were prepared to identify what must be accomplished to satisfy contract performance requirements and objectives. The physical and functional engineering requirements for each end item hardware were documented in a format engineering drawing system. Critical design parameters were identified and closely monitored during the UVS design and development phases. Emphasis encompassed protection of the optical and electronic systems in the flight environment and across interfaces. Tradeoff analyses were conducted to present optimum solutions to various design problems, and working breadboards of circuit designs were built for evaluation.

A system functional analysis was performed on the electronic circuits to assure optimum performance, and a thermal analytical model was formulated using input data from NR. Upon completion of the prototype unit, it was used to analyze the UVS design through a complete qualification program.

End Item Specifications were prepared for each deliverable end item in accordance with contractual requirements. During the Critical Design Review (CDR) it was demonstrated that the UVS detail design satisfied the technical requirements of the contract and that the CEI specification reflected the proper design configuration of the contract end item. The CDR also identified the engineering documentation which defined the UVS and GSE design and established the product configuration baseline. Subsequent to the CDR, documentation control of the UVS design was maintained and data update was accomplished through interface coordination with the integrating contractor and through media such as ECNs, MRBs, and ECPs and IRNs.

An End Item Test Plan was developed to establish a Performance/Design Verification Program. The plan also delineated test objectives, identified test items and emphasized test ground rules and constraints. UVS qualification was performed in accordance with constraints of the Qualification Test Plan and the detailed test procedures. The qualification test demonstrated that the UVS would meet the applicable CEI specification. Tests were conducted during those exposure periods where flight hardware would be expected to operate. A test report was submitted in accordance with DRL 49, DRD TM-097T.

Acceptance Testing was performed with the UVS prototype unit, qualification unit, two flight units, and two BTEs using approved test procedures. These tests demonstrated that the experiment hardware would meet the applicable CEI specification. After successful completion of the Acceptance Test, each appropriate end item was ready for formal Acceptance Review.

Pre-installation Test Procedures were prepared in cooperation with NR and KSC to demonstrate whether or not delivered equipment had been degraded or damaged upon delivery. The PIT was conducted on both flight units at KSC. Also in cooperation with NR, the development and performance of Integrated Systems Test at KSC was accomplished. The tests were conducted to verify that the UVS flight units were functionally and operationally compatible when integrated with other systems hardware. Although KSC was responsible for Prelaunch Tests, APL reviewed and concurred with the procedures. A Certificate of Flight Worthiness was prepared for both UVS flight units.

EMI tests were conducted on the UVS prototype unit to measure conducted susceptibility, radiated susceptibility, and radiated interference. During these tests two major anomalies were evident: detected spurious frequencies caused increased PMT dark count, and high field intensity would trip the UVS circuit breaker. Subsequent diagnostic testing with the prototype and cross calibration units provided the opportunity to develop and implement specific fixes which were accomplished in accordance with ECP-023. An EMI test report and summary were submitted to MSC. At the request of MSC, UVS EMI qualification testing was conducted at MSC in Houston, Texas. Resultant test data indicated that limits established by MC 999-0002C were exceeded by conducted and radiated interference. The amplitude was very low; however, and further action was not recommended.

ATEE tests were conducted at NR on the newly configured ATEE unit and BTE No. 3. Preliminary tests were satisfactory; however, some minor discrepancies were uncovered. Although UVS housekeeping functions were appearing normally on the vehicle SDS, the BTE digital printer did not function properly in the open loop mode. The problem was attributed to a wiring error within the BTE. The error was corrected and testing resumed. All major facets of the ATEE tests were satisfactory except during integrated experiment interference tests when the ITEK pan camera and the UVS BTE digital recorder produced bucking ground currents, which caused erroneous UVS analog data readings. This anomaly was persistent only when the BTE digital recorder and the pan camera were operating at the same time. Since this condition is nonflight and since the data variations were small enough to be within specification, no further action was recommended. APL did; however, subsequently repeat this test at KSC to successfull verify that the voltage variations were within tolerance under flight conditions.

The UVS Thermal Model was the test unit fabricated and instrumented to verify the analytical model (TAM). Tests were also conducted with the unit to simulate mission environmental conditions. Although several test setup deficiencies were uncovered during the test program, the analytical model was validated by this effort. A complete and detailed report was submitted to MSC.

UVS Shipping Container qualification tests were performed. Tests included rough handling, such as shock and vibration, and pressure leak tests. All tests were satisfactory.

Quality assurance programming was promoted with considerable emphasis. A Quality Program Plan was promulgated, and quality program status was reported monthly. Various efforts included periodic inspection and calibration of test equipment, maintenance of component historical records, instigation of procedures to protect experiment items from detrimental environments during handling, shipping and storage, and fabrication control of critical items. All tests, inspections, and quality documentation adequacy were verified by a government inspection agency in residence.

Reliability programming provided for specific tasks vital to reliability assurance such as management, control, reviews, training, engineering, failure reporting and correction, evaluation, documentation, and the like. Approved Failure Mode and Effects Analysis and a Single Failure Point Summary were developed to minimize hazards to personnel and the experiment by identifying and eliminating failure points which could cause the experiment to fail. During formal reviews, all reliability data were made available including EEE parts list, nonmetallic materials list, the FMEA and all in-house data pertinent to reliability. Topics of reliability were also subject of periodic in-house reviews and those involving subcontractors.

The Reliability Engineer was active throughout the program. He participated in experiment hardware inspection and testing, and approved all necessary reliability documentation. Other areas of reliability included a limited life program, parts and materials program, parts traceability, and documentation reporting.

The UV Spectrometer was developed to measure the ultraviolet spectrum between 1180 and 1680 Angstroms. Scientific data were transmitted to the ground station by the Scientific Data System (SDS) of the CSM. The spectrometer was located in the aft bay of the Scientific Instrument Module (SIM) of the CSM. It was electrically stimulated from the CSM by an on-off switch located on the instrument panel. Operation of the NR RCS plume cover was also remotely controlled at the CSM instrument panel.

The instrument was contained within a modular mechanical arrangement consisting of the baffle, or sunshade, electronics module, front plate for component mounting, a light-tight machined aluminum main housing, and a rear mounting for the Ebert mirror. The optical subsystem, in addition to the external baffle, consisted of the entrance slit, inner baffle, Ebert mirror, scanning diffraction grating, exit slit mirrors, exit slit, and photoelectric sensor. The heart of the electronics subsystem was the photomultiplier tube. The tube was followed by a pulse amplifier/discriminator, the output of which was counted by an accumulator and transmitted to an output register via a multiplexer. Supporting electronics included power supplies, timing circuits, motor drive electronics, fiducial detector, and a system of housekeeping telemetry measurements.

UVS hardware development was paced in accordance with a baseline master schedule. The first end item produced was the High Fidelity Mockup, delivered to MSC for mission training purposes. Ray Lee Machine Company was subcontracted to fabricate the major UVS mechanical hardware to APL specifications. The hi-fi unit was accepted by MSC during the CDR on 13-15 October 1971.

Ground support equipment, i.e., equipment required for servicing, testing, field calibration, handling, and maintaining and transporting experiment hardware were produced in various quantities greater than originally required by the baseline contract. Three sets of bench test equipment (BTE) were provided for use in the program. Other ground support equipment developed included handling fixtures, a full scale simulated SIM bay section for thermal vacuum testing, optical test and alignment fixtures, a front plate simulator, and shipping containers.

Each BTE Unit consisted of two electronic units housed in fiberglass, airtight, shock-mounted suitcases. One suitcase consisted of a digital recorder and the other suitcase housed the control unit and power supply. The BTE units interfaced mechanically and electrically as specified in the ICD. All three BTEs were constantly in use testing the UVS instruments and subassemblies. MSC officially accepted the BTEs during the UVS flight unit No. 1 acceptance review on 6-8 June 1972.

The UVS Prototype Unit was developed to be identical to the flight hardware as regards configuration, mechanical and electrical design; however, some select parts were not required to be of flight quality. Modifications to the prototype electronics were a direct result of the DTR which was held on 12-15 July 1971. The range of the housekeeping temperature circuits was extended and the fiducial circuits were modified for improved reliability. Also resulting from the DTR, specifications for the photomultiplier tube were updated, and acceptance test procedures submitted by EMR were approved.

The RCS contamination problem required engineering studies in coordination with NR. As a result, technical support was rendered the vehicle contractor for the design of a protective, remote controlled door to cover the UVS baffle entrance during periods of RCS burning. The addition of the NR RCS protective door prompted the decision to delete the electromechanical solar operated shutter and solar detector mechanism from the UVS design. The solar shutter was considered a serious single point failure mode.

During electrical testing of the Prototype Unit several minor problems were encountered; however, all were relatively minor and fixes were readily implemented. During the week of 28 February 1972, MSC formally accepted the UVS prototype unit. The unit was used to support extensive EMI tests which revealed some radiation susceptibility problems. The problems were identified and subsequent fixes were implemented. At the direction of MSC, the prototype unit was refurbished to be of flight quality and reconfigured to a cross calibration unit to be used during subsequent cross calibration trials at GSFC and JHU.

The UVS Qualification Unit was fabricated as a flight type instrument to be subjected to qualification tests as specified in the CEI specification. During fabrication, APL was directed to modify the design to provide for nitrogen purging of the instrument for protection against contamination in unfavorable environments. A second directive resulted in modification to the UVS mounting feet to preclude possible torque loading of the NR mounting bracket. By March 1972, the standard TV acceptance test was completed successfully, and the qualification unit was formally accepted by MSC at the review held on 29-30 March 1972.

Qualification testing performed with the Qualification Unit proceeded without serious problems. The unit was disassembled to incorporate EMI fixes resulting from the prototype unit EMI tests. As directed, qualification EMI testing was conducted successfully at MSC. After the unit was returned to APL it was subjected to a 600-hour life test. No problems were apparent; however, when attempting post life-test optical calibration, the UVS drive motor failed to start. Subsequent investigation revealed a failure of the motor bearings. The discrepant hardware was sent to MSC for analysis; however, preparation for mission operations at KSC precluded further work on the qualification unit at that time. Unlike the flight unit motors, the motor in the qualification unit accumulated a total operating time of 940 hours.

UVS Flight Unit No. 1 electronic parts assembly and test began in December 1971 and fabrication of mechanical components was completed by March 1972. Acceptance testing of the completed unit was not begun until after the Qualification Unit Acceptance Review. Meanwhile, suspected tantalum capacitors were replaced in the electronics module and the unit was retested. During optical calibration a wavelength discrepancy sparked an investigation that revealed a defective wavelength cam. After an unsuccessful attempt to procure additional cams of good quality, APL repaired the cams of both flight units. The cam inspection procedure was improved, and a waiver was prepared to relax specified wavelength tolerances which did not jeopardize mission requirements. The wavier was approved and subsequently extended to cover all UVS instruments. The EMI fixes were incorporated, and after successful completion of the acceptance test, UVS flight unit No. 1 was formally accepted at the AR on 6-8 June 1972. The unit was shipped to KSC on 9 June.

UVS Flight Unit No. 2 parts fabrication was completed by February 1972; however, electrical testing was suspended until an Alert regarding Mallory capacitors was investigated. All Mallory capacitors in house were tested for suspected leakage. None proved to be faulty; nevertheless, all Mallory tantalum capacitors in APL-built UVS hardware were replaced with a comparable Sprague component. When electronic testing was resumed, a degraded PMT assembly was discovered which may have been damaged during exposure to an Oriel mercury vapor lamp. The tube assembly was replaced with a spare and returned to the vendor for failure analysis.

Final assembly and inspection of Flight Unit No. 2 proceeded thereafter without difficulty until, during optical calibration, the Lyman-alpha response became erratic. The problem was traced to the cam and its associated components. Excessive cam coating and material erosion appeared to be the cause, and after appropriate rework of the cam and cam follower-pin, good results were obtained. Subsequent testing revealed another cause for concern when a slight variation in the fiducial period was evident in the data output stream. The problem was traced to inherent jitter of the hysteresis drive motor, but not until after considerable effort was expended in reworking the motor and cam shaft assembly. Acceptance testing and subsequent optical calibration were completed successfully after disposition of FIAR No. 019. This apparent failure occurred as a Lyman-alpha shift in the data output; however, appropriate compensation during optical alignment assured compliance with the CEI specification. Flight unit No. 2 was formally accepted during the AR on 14-18 August 1972 and shipped to KSC on 19 September. Flight unit No. 2 was designated the experiment primary flight unit by the Principal Investigator.

The Cross Calibration Unit was reconfigured, as directed by MSC, from major mechanical parts from the prototype unit , the spare electronics module, some prototype optics, and a few new components. The new end item was constructed and tested to the standards and formality applicable to flight equipment. Following current modifications, operational verification and optical calibration, the unit was subjected to a cam endurance test. Vacuum optical calibration at NASA/GSFC and cross calibration at the JHU Physics Department was then performed.

The ATEE Unit was configured by using the electronics module that was removed from the UVS prototype unit and UVS components that were currently on hand. The unit was completed, tested, and shipped to NR on 19 May as scheduled. The ATEE tests were conducted at NR from 30 May through 2 June and repeated in August. The tests were completed satisfactorily after BTE rework, and the unit was returned to APL.

A Thermal Test Model was designed and fabricated for use in performing thermal testing to obtain thermal design data and to verify the Thermal Analytical Model (TAM). In December 1971, fabrication of the model was completed, assembled, and instrumented for test. The model was constructed from basic flight parts except where impractical or unnecessary; thermal resistance simulation was used when possible. Thermal vacuum testing began in January 1972. The model was a complete success in that useful UVS thermal design data were obtained and good correlation with the TAM was demonstrated.

KSC field operations, under Exhibit D of the contract, required an APL staff averaging 2.5 people for the duration of the mission. An APL support manager was in residence at KSC from May 1972 through the duration of the mission. Typical and routine prelaunch operations and testing were performed such as, inspection, test equipment calibration and acceptance testing. The UVS Preinstallation Test (PIT) was completed successfully with both flight units. During the UVS K-0070 Solo Test with the BTE, the same anomalies occurred as those found during the ATEE tests at NR. The BTE buffer amplifier and printed circuit card were returned to APL for modification to relieve the problem. The K-8241 High Gain Antenna Test was completed successfully.

Flight Unit No. 2 was received at KSC on 26 September 1972, inspected and tested successfully prior to installation of the TM temperature sensor on the electronics module. After flight unit No. 2 was installed in the spacecraft, mechanical interference between the UVS baffle cover and the door assembly was discovered. A modified cover was hand-carried from APL and substituted for the cover causing interference. Meanwhile, flight unit No. 1 was returned to APL for recalibration. No change was observed. This unit was subsequently returned to KSC, inspected, and subjected to the PIT test. The Apollo K-0028 Flight Readiness Test was completed satisfactorily with flight unit No. 2 installed. The K-0007 CDDT UVS test was also successfully completed.

Mission Launch Operations commenced with the Apollo 17 launch countdown (K-0007) on 30 November 1972 and continued until lift-off on 6 December. The UVS performed properly during the final test when data were monitored via the spacecraft SDS. On 5 December the nitrogen purge was disconnected and the SIM door was installed. Lift-off of Apollo 17 occurred at 11:33 p.m. C.S.T. on 6 December. Earth orbit was achieved 11 minutes and 47 seconds later, and translunar injection took place at 3:12:36.

The large and highly sensitive ultraviolet spectrometer was included in the Apollo 17 SIM to cyclically scan the spectral region 1180 to 1680 Angstroms every 12 seconds. A number of lunar, solar system, and galactic observations were made, the prime objective being to measure the lunar atmospheric emissions in an attempt to determine the density, composition, and temperature of the lunar atmosphere.

On the fourth day of mission operations the spacecraft entered lunar orbit. Also on the fourth day, the SIM bay was jettisoned and the UVS was activated. The UVS obtained numerous useful data during the entire mission, and all practical objectives were achieved. The UVS sensitivity to cosmic radiation was considerably higher than expected, which appeared in the output data as high PMT dark count. On the last day of the mission, two telemetry housekeeping data functions failed due to the loss of the reference voltage for these measurements. This condition did not impair nor degrade the functional performance of the spectrometer.

RESULTS

The UVS Experiment S169 program, under NASA Contract NAS9-11528, produced the required end item hardware on a schedule commensurate with need dates. This effort culminated with the UV spectrometer being successfully operated with other scientific instruments during the Apollo 17 lunar mission. During the mission, the spectrometer collected data continuously when activated. Following turn-on and initial door opening on 10 December, two immediate observations were made by the UVS. As in Mode II, when the lunar terminator was viewed from the dark side to the light side, the UVS measured an intensity of 6 Rayleighs of Lyman-alpha 1216 Angstroms radiation from the dark side, and about 50 kilorayleighs from the lighted side near the subsolar point. The transition from the dark side to the light is abrupt, indicative of a low atomic hydrogen density. When the limb was viewed tangentially by the spectrometer during the descending portion of the orbit, as in Mode III, the geometry provided a very sensitive test for xenon. This first observation indicates a low upper limit on the amount of xenon in the lunar atmosphere.

These results are indicative of the entire mission. A detailed report of the scientific findings will be forthcoming from the Principal Investigator.

CONCLUSIONS

The UV Spectrometer obtained numerous useful data throughout the entire mission. All major experiment objectives were achieved. Although the UVS dark count remained higher than preflight levels throughout the mission, it did not impair the ability to measure the lunar albedo on the sunlit side or the Lyman-alpha at 1216 Angstroms on the dark side, nor did it impair the ability to measure the hydrogen density in the lunar atmosphere. The successful completion of Apollo 17 mission operations closes Task II contractual requirements. No further effort is required unless specifically requested by MSC.

In addition to this section on conclusions, each section of the main body of this report contains recommendations and conclusions within the scope of the section.

RECOMMENDATIONS

APL has complied with the MSC instructions to transfer UVS and BTE hardware and documentation to the JHU Physics Department. Of the residual deliverable end items, the hi-fi unit and the thermal test model are at MSC; the cross calibration unit and BTE No. 1 are at the JHU Physics Department; flight unit No. 2 was the Apollo 17 Mission Flight Unit, flight unit No. 1 was the mission back-up unit, and BTE No. 2 supported the launch operations. The ATEE Unit, BTE No. 3, and the qualification unit are currently at APL. The qualification unit was reassembled with a reworked drive motor and electrically verified at no expense to MSC. This unit is currently stored in its shipping container under dry nitrogen pressure at APL. All Experiment S169 items at KSC will be returned to APL for further disposition.

APL recommends that JHU be authorized to retain all residual items and equipment for use on research and government sponsored programs by the Principal Investigator and by APL. In particular, the items of general purpose laboratory equipment can be used by APL on other programs performed for NASA and DoD.

Although the instrument performed well and satisfied mission requirements, it is recommended that, in the event UV spectrometers are again required for use in an outer space environment, a device be included in the design to filter cosmic radiation in order to lower the PMT dark count. Also, the motor drive system, especially the cam mechanism, could be redesigned to eliminate some of the pitfalls that were experienced during manufacturing, calibration, and test operations at APL.

ULTRAVIOLET SPECTROMETER PROGRAM

INTRODUCTION

The Ultraviolet Spectrometer Program, under contract from the NASA Manned Spacecraft Center, was implemented to perform measurements in the far ultraviolet spectrum as part of the Apollo 17 lunar mission. The objective of the experiment was to perform quantitative measurements of the composition of the atmosphere of the moon during various degrees of solar illumination as part of the continuing analysis of the interaction of the solar wind with the lunar surface.

Task I of the contract provided for the services of Mr. William G. Fastie of the JHU Physics Department as the Principal Investigator. The final report for Task I is prepared under separate cover by JHU.

Task II was assigned to the Applied Physics Laboratory and included the design and fabrication of two Fastie-Ebert spectrometers for flight use, a mockup for astronaut training, a prototype unit, a qualification unit, and test equipment. This report deals only with Task II.

In May 1972, two new contract end items were added to Task II, an Apollo Telecommunications Engineering Evaluation Unit for use in testing at North American Rockwell, and a cross calibration unit for cross calibration tests at Goddard Space Flight Center and the JHU Physics Department.

Exhibit D, by modification number 9S dated 1 April 1972, was added to the contract to provide for APL field support and sustaining engineering in two parts:

Part I – Lunar Orbit Science Missions Test and Operations at Kennedy Space Center

Part II – Factory Based Support of KSC and MSC Activities

PROGRAM MANAGEMENT (Par. 2.1.1)

Program Organization. The structural makeup of the APL organization that performed and supervised the contract tasks is shown in Fig. 1 and is discussed in DRL 1, DRD-121T. The UVS project organization was established within the Space Development Department. The chart designates and identifies the functional relationship between organization elements, the flow of authority, and key personnel assignments.

Program Plan. A program plan was devised which contained a description of the design and development effort and management controls which APL employed to satisfy the requirements for the Ultraviolet Spectrometer Experiment Program (S169) as specified in DRL 3, DRD MA-123T. The objective of this plan was to specify the significant elements of the management, design, test, reliability, quality, and fabrication functions for this program. It contained a description of the methods and controls that were implemented by APL to assure compliance with the intent of the performance of these functions.

This plan was not only specifically applicable to the APL effort, but was imposed upon all APL suppliers as well.

Program Management. A program management system was established in accordance with the latest revision of the Management Plan, DRL 4, DRD MA-124T, to formulate the necessary program controls to assure program accomplishment. The scope of this system was broad enough to provide the means for monitoring implementation of program requirements and to assure that task performance was in accordance with the technical constraints of the contract. Further, the management system also provided for overall integrated system compatibility and interface requirements.

Program Reporting. All contract correspondence was issued through the Contract Office of The Johns Hopkins University Applied Physics Laboratory. Contractual

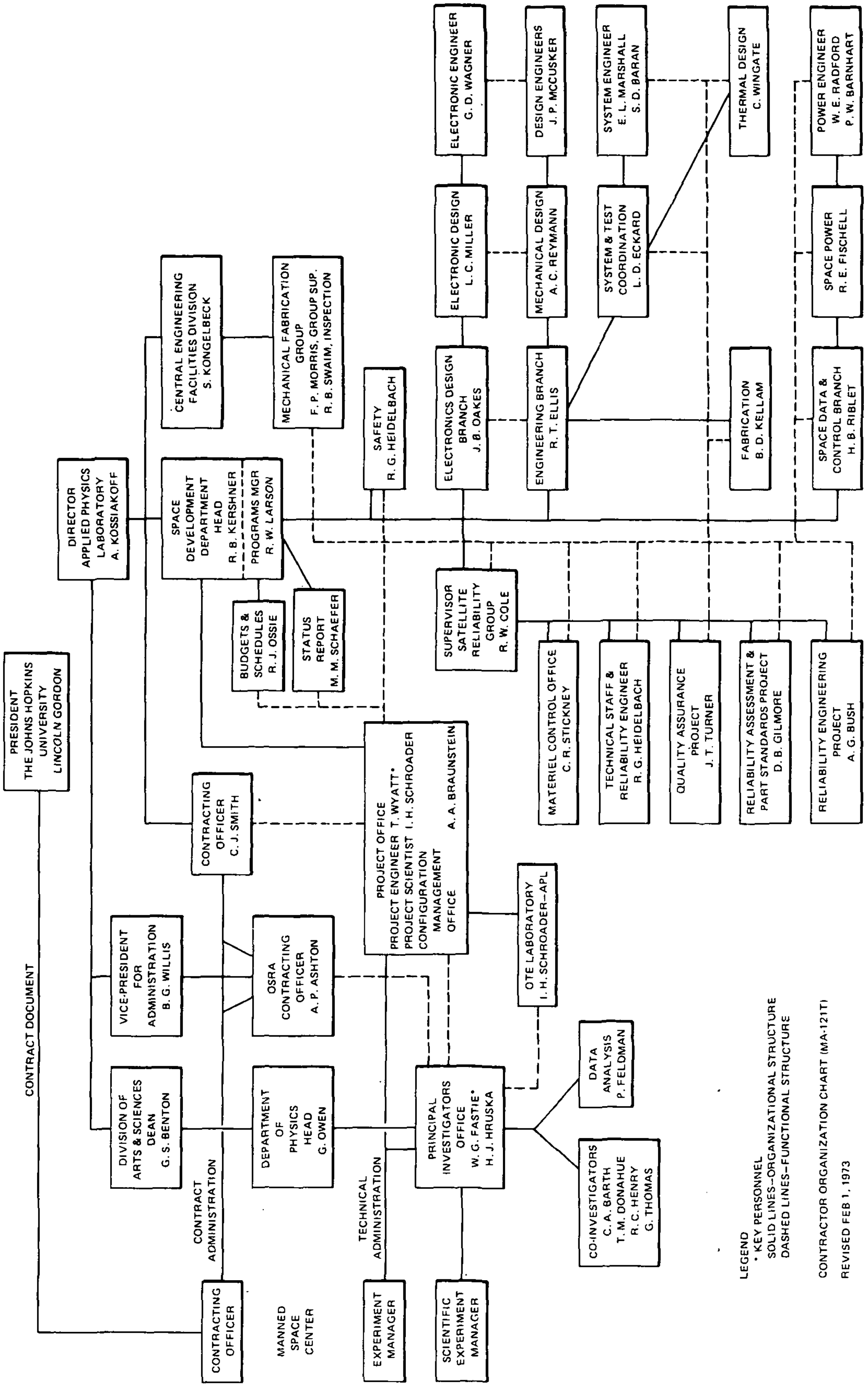


Fig. 1 CONTRACTOR ORGANIZATION CHART

reports were identified as to the proper DRL and DRD numbers whenever applicable. Table 1 is a schedule of delivered contractual documentation reports.

Monthly Program Progress Reports were prepared by the Reports Office for each 30-day period during the active portion of the contract. A total of 20 monthly progress reports was submitted.

Monthly Financial Management Reports were prepared by the Programs Administration Office for each 30 calendar day period during the active portion of the contract.

Periodic Program Schedule Assessment Reports were presented to identify, describe, and analyze trends which were considered significant or had some bearing on completion of the tasks in accordance with the established schedule and milestone dates. These reports were rendered in great detail informally at frequent intervals, and formally in accordance with DRL 6, DRD MA-126T, and during design and acceptance reviews.

At the completion of the Critical Design Review, minutes of the meeting were prepared and submitted to MSC in accordance with the requirements of DRL 43, DRD SE-189T. All action items and RIDs generated during the review were satisfactorily settled.

Acceptance review reports were prepared for each deliverable end item in order to identify and qualify the status of the end items. These reports were prepared in accordance with DRL 23, DRD CM-049T; all action items and RIDs generated during the acceptance reviews were satisfactorily settled. Tables 2 and 3 are summaries of MSC and APL action items, respectively.

Work Breakdown Structure. A WBS was prepared and the integration of all technical and management activities was contained within the framework established by the WBS. The WBS was a family tree subdivision of work to be

Table 1

UVS Documentation Schedule

DATA CODE	DRD No.	DRL No.	DOCUMENT	1971	1972							
				DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG
II	MA-121T	1	Organization Chart	RESUBMITTED 10/18/71								
II	MA-122T	2	List, Key Personnel	SUBMITTED WITH PROPOSAL								
IA	MA-123T	3	Program Plan	SUBMITTED JUNE, 71								
I	MA-127T	7	Structure Work Breakdown	SUBMITTED SEPTEMBER, 71								
IA	LS-064T	25	Logistics Plan	RESUBMITTED SEPTEMBER, 71. MSC–APPROVED NOVEMBER, 71								
I	SC-015T	29	Schedule Program Detail	▼	▼	▼	▼	▼	▼	▼	▼	
I	SA-019T	30	System Safety Plan	RESUBMITTED JUNE, 71. MSC–APPROVED AUGUST, 71								
IA	SE-171T	34	Diagrams, Function Flow	SUBMITTED WITH PROPOSAL								
I	RA-083T	56	Quality Program Plan	RESUBMITTED OCTOBER, 71. MSC–APPROVED NOVEMBER, 71								
I	RA-085T	58	Contamination Control Plan	RESUBMITTED APRIL,72 MSC–APPROVED APRIL,72								
I	RA-092T	65	Reliability Program Plan	RESUBMITTED MAY, 71. MSC–APPROVED JUNE, 71								
I	MA-124T	4	Management Plan	RESUBMITTED JUNE, 71								
II	MA-125T	5	Progress Reports	▼	▼	▼	▼	▼	▼	▼	▼	
II	MA-126T	6	Program Schedule Reports	▼	▼	▼	▼	▼	▼	▼	▼	
II	CM-045T	18	ECP Status Report	▼	▼	▼	▼	▼	▼	▼	▼	
II	CM-051T	24	Index, Configuration Identification and Accounting	▼	▼	▼	▼	▼	▼	▼	▼	
IA	LS-065T	26	Spares and Repair Parts Support Plan	RESUBMITTED OCTOBER, 71. MSC–APPROVED DECEMBER, 71								
II	MF-015T	27	Financial Management Report	▼	▼	▼	▼	▼	▼	▼	▼	
II	MF-016T	28	Overtime Report	▼	▼	▼	▼	▼	▼	▼	▼	
II	SA-022T	33	Safety Review Report	▼	▼	▼	▼	▼	▼	▼	▼	
II	SE-184T	45	Monthly Weight Status Report	▼	▼	▼	▼	▼	▼	▼	▼	
II	RA-084T	57	Monthly Quality Status Report	▼	▼	▼	▼	▼	▼	▼	▼	
I	RA-097T	70	Open Failure Status Rpt.	▼	▼	▼	▼	▼	▼	▼	▼	

Table 1

UVS Documentation Schedule (continued)

DATA CODE	DRD No.	DRL No.	DOCUMENT	1971	1972							
				DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG
II	RA-108T	81	Reliability Progress Report	▼	▼	▼	▼	▼	▼	▼	▼	
II	MA-140T	82	Agenda, Technical Management Review	SUBMITTED AUGUST, 71								
II	MA-128T	8	Minutes, Technical Management Review	SUBMITTED AUGUST, 71								
I	CM-038T	10	Configuration Management Plan	RESUBMITTED JULY, 71. MSC–APPROVED SEPTEMBER 71								
III	CM-040T	12	Index, Documentation	PREPARED DECEMBER, 71; AVAILABLE IN FILES								
II	RA-099T	72	List, Time/Cycle Sensitive Components	RESUBMITTED JUNE, 71								
II	RA-105T	78	List, EEE Parts Usage	RESUBMITTED MARCH, 72								
IA	CM-039T	11	Configuration Identification Procedures	RESUBMITTED SEPTEMBER, 71. MSC–APPROVED OCTOBER, 71								
I	CM-043T	15	Configuration-Control Procedures	RESUBMITTED SEPTEMBER, 71. MSC–APPROVED OCTOBER, 71								
IA	RA-093T	66	Failure Mode Effects Analysis Report	SUBMITTED SEPTEMBER, 71. MSC–APPROVED NOVEMBER, 71								
IA	RA-094T	67	Single Failure Point Summary	SUBMITTED SEPTEMBER, 71. MSC–APPROVED NOVEMBER, 71								
IA	RA-103T	76	List of Non-Metallic Materials	RESUBMITTED DECEMBER, 71; SUPP. NO. 1 MSC-APPROVED MARCH, 72;LIST MSC–APPROVED JUNE '72 RESUBMITTED FINAL FORM AUGUST, 72								
II	SA-021T	32	Report, Hazard Analysis	SUBMITTED SEPTEMBER, 71								
IA	SE-173T	36	Specification, Design/ Performance	CANCELLED								
I	SE-176T	39	Specification, Contract End Item	ALL SUBMITTED BY DECEMBER, 71 GSE, REV A RESUBMITTED JANUARY, 72 ALL MSC–APPROVED								
II	SE-177T	40	Reports, System Function Analysis	AS REQUIRED								
II	SE-167T	41	Agenda, Critical Design Review	SUBMITTED SEPTEMBER, 71								
I	SE-168T	42	Package, CDR Baseline Documentation	SUBMITTED SEPTEMBER, 71. MSC–APPROVED NOVEMBER,71								
I	TM-094T	46	Plan, End Item Test,	RESUBMITTED APRIL, 72, MSC–APPROVED MAY,72								
I	TM-098T	50	Plan, Acceptance Test,	SUBMITTED DECEMBER, 71. MSC--APPROVED DECEMBER,71								

Table 1

UVS Documentation Schedule (continued)

DATA CODE	DRD No.	DRL No.	DOCUMENT	1971	1972							
				DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG
IA	RA-086T	59	Plan, Soldering	SUBMITTED SEPTEMBER, 71. MSC–APPROVED SEPTEMBER 71								
IA	RA-087T	60	Soldering Procedures	SUBMITTED SEPTEMBER, 71. MSC–APPROVED SEPTEMBER 71								
II	RA-089T	62	Special Parts Mounting Standards	SUBMITTED JULY, 71								
II	RA-090T	63	Cordwood Module Standards	SUBMITTED JULY, 71								
II	RA-091T	64	Integrated Circuit Mounting and Connection Stds.	SUBMITTED DECEMBER, 71								
II	RA-100T	73	Time/Cycle Control Procedures	SUBMITTED NOVEMBER, 71								
I	SE-169T	43	Minutes, Critical Design Review	SUBMITTED PART A NOVEMBER, 71 MSC–APPROVED NOVEMBER, 71; SUBMITTED PART B JULY 72								
II	SE-170T	44	List, Engineering Baseline Drawings and Specifications	SUBMITTED SEPTEMBER, 71; RESUBMITTED WITH EACH AR DATA PACKAGE								
I	TM-095T	47	Plan, Qualification	RESUBMITTED APRIL,72 MSC–APPROVED MAY,72								
IA	TM-100T	52	Acceptance Test Report	PROTO SUBMITTED MAY,72; QUAL. SUBMITTED MAY,72 FLT 1 SUBMITTED JULY 72;								
II	TM-102T	54	Procedures, Pre-Installation Test	60 DAYS PRIOR TO DELIVERY OF FIRST FLIGHT UNIT					▼			
I	TM-103TA	55	Certificate of Flight Worthiness	SUBMITTED FOR HI–FI OCT, 71; FOR QUAL. MAR, 72; FOR FLIGHT NO. 1 JUNE 72; FOR FLT 2–AUG 72								
I	CM-052T	22	Package, Acceptance Data	PROTO, QUAL, FLT 1, GSE, BTE, ATEE, FLT 2–ALL SUBMITTED. PROTO, QUAL, FLT 1, GSE, BTE,ATEE–APP'D								
II	CM-049T	23	Report, Acceptance Review	PROTO, QUAL, FLT 1, – ALL MSC APPROVED								
I	TM-097T	49	Report, Qualification								▼	
IA	MA-129T	9	Report, Final	60 DAYS AFTER LAUNCH OF FINAL FLIGHT								
II	CM-041T	13	Log, Specification Change	ISSUED WITH SCN'S								
III	CM-042T	14	Log, Specification Identification No. Assignment	AVAILABLE IN FILES								
I	CM-044T	16	Engineering Change Proposals	▼ ▼ ▼	▼▼▼▼	▼▼▼▼	▼▼▼▼	▼▼▼▼	▼▼▼▼	▼▼▼▼	▼ ▼ ▼	
I	CM-046T	17	Notice, Specification Change	LAST SUBMITTAL APPROVED MAY 72								
II	SA-020T	31	Report, Accident	PER EVENT								
III	SE-172T	35	Diagrams, Schematic	SUBMITTED WITH AR DATA PACKAGES								
I	SE-174T	37	Plan, Design and Development	INCLUDED IN PROGRAM PLAN								
II	SE-175T	38	Report, Trade-off Analysis	SUBMITTED CDR AND TELEPHONE CONFERENCES								
II	TM-096T	48	Procedures, Qualification Test			▼	RESUBMITTED	▼ RESUB.	▼			

Table 1

UVS Documentation Schedule (continued)

DATA CODE	DRD No.	DRL No.	DOCUMENT	1971	1972						
				DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG
II	TM-099T	51	Procedures, Acceptance Test	BTE SUBMITTED DECEMBER, 71 MSC–APPROVED FEB, 72. UVS SUBMITTED FEB, 72 MSC–APPROVED FEB, 72 UVS, REV C, RESUBMITTED APRIL, 72; MSC–APPROVED APRIL, 72 REV D SUBMITTED APRIL, 72								
II	RA-088T	61	Provisions, Special Storage and Handling, Electrical/Electronic Assemblies	SUBMITTED SEPTEMBER, 71								
II	RA-095T	68	Report, Failure				▼▼	▼▼▼	▼▼▼	▼▼	▼	
II	RA-096T	69	Plan, Failure Report Closure	10 DAYS AFTER NOTIFICATION OF FAILURE				▼▼▼	▼▼▼	▼▼	▼	
III	RA-098T	71	Logs, Time/Cycle Equipment	SUBMITTED NOVEMBER, 71								
II	RA-101T	74	Report, Alert Response	▼▼	▼	▼▼	▼▼	▼▼	▼▼	▼▼	▼	
II	RA-102T	75	Report, Parts and Materials Problem Identification	SUBMITTED CDR AND TELEPHONE CONFERENCES								
III	RA-104T	77	Specifications, EEE Parts	SUBMITTED AS RELEASED: AVAILABLE IN FILES								
III	RA-106T	79	Report, Parts Application Review	RESUBMITTED JANUARY, 72 STUDIES OF PARTS APPLICATION IN OUR FILES MSC–APPROVED MARCH, 72								
II	RA-107T	80	Report, EEE Parts Derating	SUBMITTED APRIL, 71 STUDIES OF PARTS APPLICATION IN OUR FILES								

LEGEND:

▼ = Contract End Item Delivered

Table 2

MSC Action Item Summary

TWX/Letter No. & Date	From	Action Requested	Answering TWX/ Ltr. & Date	Action Taken
AC-9446 6/4/71	CJSmith	Request review and approval of Rev. A of Management Plan		
AC-9447 6/8/71	CJSmith	Request review and approval of Design and Development Plan (Appendix to Program Plan)		
AC-9920 3/10/72	CJSmith	Request review and approval of EMI Test Plan for BTE		
AC-10054 5/17/72	CJSmith	Request review and approval of Waiver No. 7, Change of Transportation Shock Test Pulse Deviation	MSC Letter BC341/L410-72/L90 7/27/72	Approved
AC-10064 6/1/72	CJSmith	Request review and approval of Configuration Management Plan, Rev. A, Change No. 2	MSC Letter BC341/L418-72/L90 8/3/72	Approved
AC-10069 6/9/72	CJSmith	Request review and approval of Waiver No. 8, Wavelength Range and Tolerance		
AC-10071 6/13/72	CJSmith	Request review and approval of Flight Unit No. 1 AR Report	Signed-off title page hand-delivered to APL	Approved
AC-10206 7/28/72	CJSmith	Request review and approval of Qualification Test Report		
AC-10208 8/10/72	CJSmith	Request review and approval of Final Submission of Nonmetallic Materials List		

Table 3

APL Action Item Summary

TWX/Letter No. & Date	From	Action Requested	Answering TWX/ Ltr. & Date	Action Taken
AR 3/1/72	RGFenner	35 RIDs written; 2 closed at Preboard; 1 withdrawn; 32 to be answered by APL		All answered
Flight Unit No. 1 AR 6/8/72	RGFenner	6 RIDs written; 3 closed; 3 to be answered by APL		All answered

accomplished in order to achieve the contract objectives. A preliminary Work Breakdown Structure was submitted with the contract proposal; a final WBS was submitted on 18 March 1971.

Periodic technical and management progress reviews were conducted, mostly by telecon. APL submitted a proposed agenda for each review and documented the proceedings and action assignments in accordance with DRL 8, DRD MA-128T.

APL participated in periodic working group meetings on the Interface Control Documents controlling the interfaces between flight hardware and the SIM. The purpose of the ICD meetings was to resolve and reach mutual agreement on experiment/SIM interface problems and provisions. The NR prepared minutes of the proceedings were processed into the UVS data control system.

Conclusions. The program management effort described above served well in the achievement of the contract goals without serious constraint. All contract items as regards program management have been completed and no unresolved problems remain. No further action is recommended.

CONFIGURATION MANAGEMENT (Par. 2.1.2)

Configuration Management Plan. A Configuration Management Plan was prepared to establish and define how APL would comply with MSC-02436, Configuration Management Requirements for Apollo Lunar Orbit Experiments. The plan described the methods to be used to establish contract requirements in terms of policies, procedures, and instructions; to implement these procedures and instructions, and to audit program actions.

Configuration Management System. A configuration management system was developed to define accurately the experiment hardware at any point in time. This system provided for the definition of a configuration baseline and control of subsequent changes to this baseline. A Configuration

Management Office, headed by the Configuration Manager, was established to be responsible for implementing the plan. A Change Control Board, headed by the UVS Project Engineer and staffed by the Systems Engineer, the Project Scientist, the Configuration Manager, and the Reliability Engineer, was established for the evaluation of proposed changes.

Configuration Identification. Configuration identification was maintained, e.g., the technical documentation of the approved configuration of the experiment hardware after the baseline configuration was established, extending through manufacturing, testing, delivery, and flight. The baseline configuration was established at the Critical Design Review. Hardware configuration at any later date was identified by the original baseline configuration plus all subsequent approved changes. Acceptance reviews were conducted prior to the acceptance and delivery of each CEI.

Contract End Item Specifications. A system of review and analysis was developed and maintained to identify all contract end items and determine the specifications required. The design, development, and qualification requirements of all end items were controlled by the associated CEI specification. Upon approval of MSC, the specifications defined the configuration baseline. The CEI specifications were prepared to the requirements and format of Fig. 3-1 of Attachment 2 to the contract, and were numbered and titled in accordance with MIL-STD-100A.

A system was established whereby the interrelationship between the hardware and software at any point in time would be known. The assignment of identifying numbers and titles to the specifications, in addition to drawings, lists, release records, and hardware was implemented and controlled as per the requirements of MIL-STD-100A.

CEI specifications were prepared for the following end items:

CEI No. 7232-0000-01	Prototype Unit
CEI No. 7232-0000-02	Qualification and Flight Units
CEI No. 7232-0080-HF-1	High Fidelity Mockup Training Unit
CEI No. 7232-3000-01	Bench Test Equipment
CEI No. 7232-3004-01	Ground Support Equipment

Baseline Review. A Critical Design Review was conducted to assure that detailed designs satisfied the technical requirements of the contract and that the CEI specifications accurately reflect the "as designed" configuration of the CEI. The results of this CDR were used to establish configuration baselines from which change control was maintained.

APL participation in the CDR is reported in a later paragraph.

Configuration Control. Configuration control procedures were prepared in accordance with DRL 15, DRD CM-043T as part of a system to implement and maintain control of technical changes which deviated from the established configuration baselines. Specifically, the procedures that were prepared are as follows:

SDO/CMO-096. 01	Preparation of Engineering Change Proposals (ECPs)
SDO/CMO-096. 02	Preparation of Preliminary Specification Change Notices (PSCNs)
SDO/CMO-096. 03	Preparation of Preliminary Interface Revision Notices (PIRNs)
SDO/CMO-096. 04	Class I Change Control
SDO/CMO-096. 05	Interchangeability
SDO/CMO-096. 06	Class II Change Control
SDO/CMO-096. 07	Preparation of Waivers and Deviations
SDO/CMO-096. 08	Change Control Board
SDO/CMO-095. 01	Preparation of Specification Change Notices (SCNs) and Log SCNs

Changes. A Change Control Board was established and constituted as described in an earlier paragraph. The CCB processed all internal requests for engineering changes and reviewed them for technical adequacy and the effects on specification requirements, contract requirements, and configuration control. When changes were approved, the CCB established the change priority, classification, and serial number effectively, and released the request for incorporation into the UVS drawing system.

Internal ECNs were prepared in accordance with the APL Space Division Drafting and Design Procedures Manual for preparation and processing ECNs. They included, as a minimum, a listing of all drawings affected, effectively, current issue letters, and a description of the changes. After the baseline was established, APL prepared and submitted to MSC an Engineering Change Proposal for each proposed Class I change to the CEI specification, engineering drawings, or documentation referenced in the specification. Specifically, ECPs were generated and submitted to MSC for approval whenever a proposed change affected any of the following:

a. Delivered CEIs
b. CEI production, cost, schedule, or delivery
c. Baseline configuration specifications
d. Approved documentation referenced in the baseline specifications.

Approximately 1000 Class I and Class II ECNs were written against the UVS documents during the course of the program. Twenty-five ECPs were prepared and submitted to MSC for approval.

Contract Change Proposals were prepared whenever an engineering change necessitated a contractual modification. Some were initiated by APL, but most were in response to Contract Change Authorizations issued by MSC. Sixteen CCPs were submitted to MSC during the course of the UVS program.

Whenever a specification change was justified, a preliminary specification change notice was prepared and submitted with an ECP to MSC for approval. Each PSCN reflected the exact change in terms of finite numbers, values, and parameters, page for each affected page. After approval by MSC, the PSCNs became final SCNs for eventual incorporation into the specification. Only nine PSCNs were formally submitted during the course of this program.

Deviation requests were submitted for MSC approval of temporary departures from the mandatory requirements of the documentation prior to manufacture of an item. Waivers were requested when written MSC authorization was needed for the acceptance of manufactured articles that did not conform precisely to the documentation. A total of seven Deviations/Waivers were formally submitted during the course of the UVS program.

Acceptance Reviews. Each CEI unit was the subject of an Acceptance Review whereby MSC determined the acceptance readiness of the CEI and that all required documentation was proper. APL scheduled each AR to support delivery requirements of the related CEI, and submitted a proposed agenda and a preliminary Acceptance Data Package at least two weeks in advance of the AR. After satisfying all apparent discrepancies, MSC formally accepted all CEI hardware as certified against the audited and approved CEI specifications.

APL provided technical representation and a co-chairman for each AR. The APL co-chairman was responsible for the presentation of the data and documentation and the preparation of the final AR report and ADP. An Acceptance Review Report was prepared for each AR and submitted to MSC within ten days after each AR. The reports provided a record of the review results including any action items with their disposition, any deviations authorized, any shortages authorized, and a copy of the completed Material, Inspection, and Receiving report, Form DD250.

Interface Management. A system of interface management was established and maintained to identify, document, implement, and control interfaces between the UVS experiment and other equipments. During the UVS design phase, APL reviewed, coordinated and approved Interface Control Documents and Preliminary Interface Revision Notices from NR or MSC. APL prepared and submitted final design and detailed documentation of the APL side of the interfaces which became part of the baseline at the CDR. After the CDR, changes to the ICDs were proposed by APL via an appropriate ECP. Whenever ICDs were received from MSC or NR for review, APL responded with comments and/or recommended corrections within 14 working days.

APL participated in periodic working group meetings on the ICDs controlling the interfaces between the UVS flight hardware and the SIM. The meetings were conducted at NR on a periodic basis to help the attendees reach mutual agreement on experiment/SIM interface problems and provisions. All resultant ICDs were countersigned by MSC, APL, and NR prior to release.

APL incorporated all applicable ICDs and related IRNs into the CEI specifications. All contractually approved ICDs and revisions to ICDs are listed in Section 2 of the CEIs pecification. APL formally submitted seven PIRNs for approval.

The ALEM Performance and Interface Specification SD 69-315 defined the lunar orbit experiment CEI performance and interface requirements. Also defined were the natural and induced environmental levels imposed on the CEI by the CSM. APL used this P and I specification in conjunction with the technical specification and Exhibit B to the contract as a design guide in the preparation of the UVS experiment. A combined ECP/CCP/IRN/SCN tabulation is shown in Table 4.

Table 4

Combined ECP/CCP/IRN/SCN Tabulation

TITLE	ECP	CCP	CCA	SCN	SCN	SCN	IRN	IRN	IRN	IRN	IRN	ACTION
				Ex. B	SD 69-315	Qual & Flt CEI	63-434	62-234	64-434	60-134	12909-234	
Schedule Revision and Cost Overrun	001 Not Issued	002 8/19/71	-									Rejected by BC341/L828-71/L88 11/26/71
Cost Increase Proposal		002A 7/6/72	1/24/72									Not formally negotiated
Thermal Test Model	002 6/1/71	JHU ltr. 7/15/71	3 6/27/71									Approved
Optical Components Shock Test	003 6/1/71	-	-									Disapproved
Change Calib. Facil. from Task II to I	004 6/10/71											Disapproved
	1/17/72 004-R1	006	5									Negotiated 6/8/72
QA - Metallurgical Traceability	005	-	-									Cancelled by APL
Deletion of Solar Shutter	006 7/23/71	-	-									Contract Mod. 11S
	11/30/71 006-R1	004	4	001				9226				IRN-9226 withdrawn
RCS Aggravated Thermal and Contamination Environment	007 9/3/71											Contract Mod. 11S
	12/23/71 007-R1	005	2									
Special Items and Spares	008	-	-									Cancelled by APL
Revised Shock Environment	009 9/8/71	003	6	002	001		003		001			In-scope determination by MSC
Electrical Power Increase	010 8/30/71	-	-	003				9227				Approved BC341/L828-71/L88
Power Connector Interface Wiring	011 9/20/71	-	-					9230				Approved 10/28/71 BC341/L763-71/L88 (1J043)
TM Data Values and Boundary Conditions	012 9/30/71	-	-					9228				Considered resolved by BC341/L833-71/L88

Table 4

Combined ECP/CCP/IRN/SCN Tabulation (Cont'd)

TITLE	ECP	CCP	CCA	SCN	SCN	SCN	IRN	IRN	IRN	IRN	IRN	ACTION
				Ex. B	SD 69-315	Qual & Flt CEI	63-434	62-234	64-434	60-134	12909-234	
Grounding Straps	013 12/3/71	-	-							9231		BC 341/L117-72/L88 2/15/72
	1/26/72 013A									9233		Approved
Input Voltage Monitor	014 12/20/71	-	-									Disapproved 3/8/72 BC341/L175-72/L88
NR Temperature Sensor Relocation	015 2/14/72	008	9			002	Final SCN 002 submitted by AC-10077 - 6/21/72					Contract Mod. 11S
Nitrogen Purge Provision	016 2/14/72	009	8								9234 With-drawn	Negotiated
	016-R1 4/28/72	009-R1 4/24/72				001					9235 Not Used	Contract Mod. 11S
Top Assembly Drawing	017 1/26/72											Withdrawn
	2/22/72 017A											
Torque Free Mounting Provision	018 2/16/72	011	10									Contract Mod. 11S Negotiated
Change to Proto CEI Spec.	019 2/29/72	-	-			Proto CEI Spec						Approved
	019-R1 3/16/72					001 002						
Top Assembly Drawing	020 3/21/72	-	-									Withdrawn
GSE ICD	021 4/11/72	-	-								9236	Requested by AR RID
Mechanical ICD	022 4/11/72	-	-								9237	Requested by AR RID
EMI Test	023 5/19/72	012 4/24/72	11									Approved
	023-R1 5/24/72						ECP 023C-1 submitted by AC-10056C - 6/29/72					Contract Mod. 11S
Fuse Protection	024 4/12/72	-	-									Not to be implemented. BC341/L291-72/L88

Table 4

Combined ECP/CCP/IRN/SCN Tabulation (Cont'd)

TITLE	ECP	CCP	CCA	SCN	SCN	SCN	IRN	IRN	IRN	IRN	IRN	ACTION
				Ex. B	SD 69-315	Qual & Flt CEI	63-434	62-234	64-434	60-134	12909-234	
Field Operations Support	-	007 2/7/72	-									Additional info requested by BC341/L200-72/L88.
	-	007-R1 4/19/72	-									Contract Mod. 9F
ATEE Test Support	-	010 Not Issued	-									Not submitted
Reconfiguration ATEE and Cross Calibration Units	025	013 5/23/72	12									ECP not submitted Contract Mod. 155
Wavelength Cam	028	015 5/5/72	-			004						In scope determination by BC341/L512-72/L90(2J0084)
Proto Refurbishment	026	014 5/11/72	13									ECP not submitted Contract Mod. 155
New Time-Temperature Profile	027 5/24/72	016 5/24/72	14									Contract Mod. 155
Clinch Nut Change	029 6/13/72											Approved BC341/L414-72/L90(2J0067)
PMT Assembly Replacement	030 6/14/72											Disapproved BC341/L435-72/L90(2J0069)
BTE Problem Analysis and Fix	031 6/16/72			Revision sent by TWX R282117Z Jun 72								Approved BC341/L395-72/L90
Change to Qual & Flt CEI Spec 7232-0009	032 7/5/72					003						Approved BC341/L441-72/L90(2J0068)
Baffle Test Cover Mod.	033 10/9/72											Approved by CCA 18 (2J0087)

Configuration Accounting. Configuration accounting was accomplished by preparing a Configuration Identification and Accounting Index for each CEI on a monthly basis. This index provided the basic CEI description as defined at the completion of the AR for that end item, and the accounting and current status of all authorized ECPs from the point of contractual authorization through the physical incorporation of the change into the end item.

The Configuration Identification and Accounting Index was a four-section management report which defined the following:

a. End Items Report — All acceptance reviewed end items
b. ECP Report — All authorized ECPs to acceptance reviewed end items
c. Allocation Report — The allocation plan by serial number of all acceptance reviewed end items
d. Spares Report — The hardware incorporation status of all authorized ECPs for hardware spares.

An aggregate Configuration Identification and Accounting Index is shown in Table 5.

Conclusions. All aspects of Configuration Management as detailed in the contract have been thoroughly exercised during the execution of the UVS program. The effort described above served well in the achievement of the contract goals without serious constraint. All items as regards configuration management have been completed and no unresolved problems remain. No further action is recommended.

DATA MANAGEMENT (Par. 2.1.3)

Data Management Organization and Function. The task of Data Management was assigned to the Configuration Management Office. This task required the maintenance of Authoritative project files of all administrative, management, and

Table 5

Configuration Identification and Accounting Index
End Item Approved Configuration Index

Section I
Nomenclature: UVS Experiment S169 (Prototype), S/N 01, 7232-0000-9D, CEI Spec. 7232-0010

ECP Number	ECP Title	Effectivity Product.		CCA/To No.	Inter. Dir.	Spare	New Part Number
		First	Last				
None							

Table 5

Configuration Identification and Accounting Index
End Item Approved Configuration Index (Cont'd)

Section I
Nomenclature: UVS Experiment S169 (Qual. Unit) S/N 02, 7232-0000D, CEI Spec. 7232-0009 Rev. A

ECP Number	ECP Title	Effectivity Product.		CCA/To No.	Inter. Dir.	Spare	New Part Number
		First	Last				
007-R1	RCS Aggravated Thermal and Contamination Environment	N/A	N/A				N/A
016-R1	Provide a right angle quick-disconnect nitrogen fitting	N/A	N/A				N/A
023-R1	EMI Fix Implementation	N/A	N/A				N/A
029	Clinch Nut Change	N/A	N/A				N/A

Table 5

Configuration Identification and Accounting Index
End Item Approved Configuration Index (Cont'd)

Section 1
Nomenclature: UVS Experiment S169 (Flight 1) S/N 03, 7232-0000D, CEI Spec. 7232-0009, Rev. A

ECP Number	ECP Title	Effectivity Product.		CCA TO No.	Inter. Dir.	Spare	New Part Number
		First	Last				
007-R1	RCS Aggravated Thermal and Contamination Environment	N/A	N/A				N/A
015	Relocation of SIM Bay Temperature Sensor SL1218T (included in CCP-008)	N/A	N/A				N/A
016-R1	Provide a right angle quick-disconnect nitrogen fitting	N/A	N/A				N/A
023-R1	EMI Fix Implementation	N/A	N/A				N/A
029	Clinch Nut Change	N/A	N/A				N/A

Table 5

Configuration Identification and Accounting Index
End Item Approved Configuration Index (Cont'd)

Section I
Nomenclature: GSE, Experiment S169, Four Sets, CEI Spec. 7232-0013, Rev. A

ECP Number	ECP Title	Effectivity Product.		CCA/To No.	Inter. Dir.	Spare	New Part Number
		First	Last				
None							

Table 5

Configuration Identification and Accounting Index
End Item Approved Configuration Index (Conc'd)

Section I
Nomenclature: BTE, Experiment S169, S/N 01, S/N 02 and S/N 03, CEI Spec. 7232-0012, Rev. A

ECP Number	ECP Title	Effectivity Product.		CCA/TO No.	Inter. Dir.	Spare	New Part Number
		First	Last				
031	BTE Problem Analysis and Fix	N/A	N/A				N/A

Table 5

Configuration Identification and Accounting Index
Approved ECP (Change) End Item Index

Section II
Contractor: APL/JHU

ECP Number	Affected End Items						
007-R1	UVS S/N 02	UVS S/N 03					
015	UVS S/N 03						
016-R1	UVS S/N 02	UVS S/N 03					
023-R1	UVS S/N 02	UVS S/N 03					
029	UVS S/N 02	UVS S/N 03					
031	BTE S/N 01	BTE S/N 02	BTE S/N 03				

Table 5

Configuration Identification and Accounting Index
End Item Quantitative Requirements Schedule

Section III
Contractor: APL/JHU

Equipment Identification	Part Number	Serial Number	1 KSC	2 Mich.	3 MTF	4 MSC	5 MSFC	6 Factory APL/JHU
Prototype UVS	7232-0000-9D	01						X
Qual. Unit UVS	7232-0000D	02						X
GSE (Prototype)	Set No. 1							X
Shipping Container	7232-0008	01						X
Handling Fixt.	7232-0408	02						X
Bagging Fixt.	7232-0263	01	X					
Rhomb Assy.	7232-0569	N/A						
N_2 Purge System Hose Assy.	7232-0560	N/A						
Test Cover Assy.	7232-0267	N/A						
GSE (Qual. Unit)	Set No. 2							X
Shipping Cont.	7232-0008	02						X
Handling Fixt.	7232-0408	03						X
Bagging Fixt.	7232-0263	02						X
Rhomb Assy.	7232-0569	01						X

Table 5

Configuration Identification and Accounting Index
End Item Quantitative Requirements Schedule (Cont'd)

Section III
Contractor: APL/JHU

Equipment Identification	Part Number	Serial Number	1 KSC	2 Mich.	3 MTF	4 MSC	5 MSFC	6 Factory APL/JHU
N_2 Purge System Hose Assy.	7232-0560	None						X
Test Cover Assy.	7232-0267	01	X					
GSE (Flt. 1)	Set No. 3		X					
Shipping Container	7232-0008	03	X					
Handling Fixt.	7232-0409	04	X					
Bagging Fixt.	7232-0263	03						X
Rhomb Assy.	7232-0569	02						X
N_2 Purge System Hose Assy.	7232-0560	None	X					
Test Cover Assy.	7232-0267	02						X
GSE (Flt. 2)	Set No. 4							X
Shipping Container	7232-0007	04						X
Handling Fixt.	7232-0409	05						X
Bagging Fixt.	7232-0263	04						X

Table 5

Configuration Identification and Accounting Index End Item Quantitative Requirements Schedule (Conc'd)

Section III
Contractor: APL/JHU

Equipment Identification	Part Number	Serial Number	1 KSC	2 Mich.	3 MTF	4 MSC	5 MSFC	6 Factory APL/JHU
Rhomb Assy.	7232-0569	03	X					
N_2 Purge System Hose Assy.	7232-0560	None						X
Test Cover Assy.	7232-0267	03						X
Flight # 1 UVS	7232-0000D	03	X					
BTE	7232-3000	01						X
BTE	7232-3000	02	X					
BTE	7232-3000	03						X

Table 5

Configuration Identification and Accounting Index
Configuration Status Accounting Spares Status

Section IV
Contractor: APL/JHU

End Item Ident. No.	ECP Number	Sp. or Comp. Serial No.	Seq.	Old Part Number	New Part Number	Typ.	Inc. Dates		Loc	Trn.
							SCD	Act.		
None										

technical information. Use was made of existing data storage and management retrieval systems already in use for other APL programs.

Data Requirements. All contractual documentation required to support the UVS program was prepared and submitted as required by the DRLs and the DRDs of the Statement of Work. Engineering drawings and electrical diagrams, whether originating within APL or subcontracted, were computer listed and readily accessible whenever required. All other supporting documentation such as internal memoranda, design studies, analyses, test data and the like, was also readily available to MSC or NR upon request.

A data package consisting of released drawings and related supporting documentation was submitted at least two weeks prior to design and acceptance reviews.

Classification of Data. All data that required written approval by MSC prior to implementation were classified and maintained as Type I. Data clearly marked Type IA were submitted to MSC for approval, but incorporation proceeded unless disapproval was received within 25 days. Type II data were submitted to MSC for information, and Type III data were made available upon request only.

Data Identification. All deliverable data were organized into a series of numbered documents and referenced in accordance with the contract number (see Table 1). All data prepared during the course of this program including subcontracted effort, vendor material, internal memoranda, analyses, and the like, are completely categorized and available to MSC upon request.

Preparation of Data. All data were prepared in accordance with the DRDs specified by the DRL of the contract. Data reproduction, binding, and handling were in accordance with the contract.

Maintenance of Data. All documentation has been maintained complete and with the latest revision. Implementation and marking of revisions were in accordance with the appropriate DRD. Control of the change content was maintained by use of ECPs, SCNs, and logs as provided in the DRDs.

Conclusions. Data management as specified in the contract has been followed. The effort described above was executed in the intent to satisfy specific requirements without serious constraint. No problems as regards data management were experienced and no action is recommended.

LOGISTICS (Par. 2.1.4)

Logistics Plan. The Logistics Plan was prepared in response to MSC requirement number DRL 25, DRD LS-064T, for the UVS experiment. The plan identified the cognizant personnel, facilities, planning, and procedures necessary to support the logistics needs for the UVS program. The preliminary plan was submitted with the original program proposal, and the final plan (S4S-0-673) was submitted on 28 April 1971.

Maintainability. The UVS instrument used modularized packaging for ease of maintenance and repair. Whenever realignment of the instrument was required, a minor disassembly operation exposed the necessary optical and/or electronics subsystems that may have required adjustment or replacement.

Whenever electronic subassemblies required replacement they were removed as a complete housing assembly and replaced with a completely qualified spare. Determination of the scope of rework, realignment, or recalibration was in accordance with Section 8.3 of the Qualification Program Plan, DRL 3, DRD-083T.

The BTE was also modularized wherever possible for ease of maintenance and repair. Since three identical BTE sets were fabricated, complete subassembly interchangeability was established and used to expedite repair.

Transportability. In spite of design considerations, the UVS instruments were particularly susceptible to extreme shock, vibration, and contaminating environments. For this reason, the UVS shipping containers were designed to provide sufficient immunity to these environments. Instruments within the shipping and storage containers were shock mounted, and pressurized dry nitrogen was provided to retard contamination within the containers.

The BTE units were designed to be portable and were not particularly susceptible to normal indoor environments. The control unit and recorder were mounted in special suitcases that provided shock isolation and moisture prevention when closed.

Transportation. Transportation methods and environmental controls were developed and used to assure safe and timely delivery of the experiment system. Actual transportation was arranged for and monitored by the Materiel Control Office of the Reliability and Quality Assurance Group. The UVS system engineer provided the necessary liaison between APL and the remote test sites. The APL station wagon and driver were used for short-distance transportation and commercial airlines for long distance. Whenever commercial airlines were necessary, the UVS instrument was hand-carried by an APL employee, but the GSE was moved via standard air freight.

Packaging. APL has maintained a packaging and shipping facility and personnel technically capable of providing suitable protection from damage and/or deterioration for the UVS experiment, BTE, and associated GSE.

At the appropriate times, the UVS instruments were packaged in a Type I closure per MSC-SPEC-C-12A. The instruments were over wrapped with a sufficient amount of Nylon 6 film which formed a cushion. The cushioned items were placed into inner barrier bags of Nylon 6. The interior of the barrier bags and cushioned items were purged with dry nitrogen gas prior to sealing the inner barrier bags; then the sealed items were placed into a shipping container. The shipping container protected the items from shock, vibration, temperature, humidity, dirt, and fungus from storage and/or transit environment. The shipping containers were always purged, sealed, and positive pressurized with nitrogen to maintain a controlled environment.

The GSE was separately packaged for shipping distances in excess of 100 miles. Typically, custom cartons and shock absorbent materials were used to package lightweight GSE for transport. Large GSE items were packaged in custom-made wooden crates fabricated by the APL wood shop. The UVS mechanical and reliability engineers approved the container design and construction prior to shipment. Unusual requirements were identified by the cognizant mechanical and/or reliability engineer who determined whether the proposed packaging would assure equipment integrity.

Maintenance. For the duration of the contract, APL provided the facilities, personnel, and documentation for any planned or unplanned requirement for rework, retest, or realignment of the UVS, BTE, or GSE.

During the hardware development phase, whenever the UVS, BTE, or its associated GSE failed to comply with respective end item specifications, or failed to perform within the tolerances delineated in the test procedures, appropriate maintenance, modification, recalibration, or refurbishment measures were exercised. All maintenance tasks were accomplished under the direction of the UVS Systems Engineer or his designated alternate.

Failed components or subsystems were recycled through the Reliability and Quality Assurance Group for a determination of the failure mode. APL used a system for reporting, analysis, correction, and data feedback of all failures and malfunctions that occurred throughout the fabrication, handling, test, checkout, and operation of the UVS, BTE, and supporting GSE as part of the Reliability Plan in accordance with Exhibit A of the contract. Failure Investigation Analysis Reports (FIAR) were the vehicle by which such failures were reported. Twenty-one FIARs were formally submitted to MSC during the course of the program.

The UVS program provided a fully flight qualified spectrometer to serve as a backup unit to replace the delivered unit in the event of a failure at the field site.

Spares and Repair Parts. Spares and repair parts were provided for and maintained for quick replacement for anticipated failures on the minimum level possible. The selection of spare parts and determination of quantities were made with the object of avoiding high replacement costs and preventing schedule delays. APL established the need and supplied and maintained all spare parts that were required to fulfill the obligations of the contract. All spare flight parts were subjected to the same acceptance and screening criteria as flight hardware. Spares were purchased and maintained in accordance with DRL 26, DRD LS-065T, the Spares and Repair Parts Support Plan.

Long-lead items were identified and ordered early in the program to reduce the risk of a parts shortage causing costly schedule delays. The long lead items were:

a. Grating and mirrors
b. Integrated photomultiplier tubes, including high voltage, power supplies and pulse amplifier/discriminators
c. Grating drive motors
d. Integrated circuits
e. Semiconductors.

The APL Satellite Reliability Control Group maintained a controlled materials area and provided the procedures to assure protection for all articles that required storage at the part and component level.

Conclusions. All parameters of logistics as detailed in the contract have been thoroughly exercised during the execution of the UVS program. The effort described above enhanced the achievement of contract goals without serious constraint. All items as regards logistics have been completed and no unresolved problems remain. No further action is recommended.

FINANCIAL AND COST/SCHEDULES PERFORMANCE MEASUREMENT (Par. 2.1.5)

WBS Cross Reference. In correlation with the WBS, each functional group within the APL Space Development Department was assigned a charge number corresponding to one of the functional tasks on the WBS. Associated with the charge number were budget allocations which specified direct manpower and other authorized cost items.

Cost Reporting. The APL monthly IBM cost and accounting program collected all costs by charge number and tabulated them for review. The UVS Program Administrator compared the monthly cost data with cost allocations. A monthly report was issued in the form of a graph indicating actual versus projected costs by the month. MSC was notifed whenever prevailing conditions of cost overrun or underrun existed.

In addition, a running account was maintained of all manpower loading, purchases, subcontracts, computer chargeback, and service work orders. Any major deviations from the budget allocations were reviewed by the Project Engineer and the Program Administrator for justification and availability of funding.

Direct manpower charges were reported monthly in a separate printout which identified all direct labor charges to each charge number by the person's name, his group, and the percentage of his time charged for the month. Overtime was not scheduled on a regular basis but was authorized from time to time as required. Overtime was strictly controlled by a requirement for prior written authorization and written confirmation of actual use.

The Program Administrator prepared a monthly program cost report in the format negotiated and approved in the contract. Data for this report were extracted from the IBM accounting print-out and reflected costs for the reporting period by functional group, cost-to-date for the APL fiscal year, and an estimate of costs for the next reporting period. Reported costs covered only those for which funding was actually committed. As for purchases and subcontracts, funding for the total contract or purchase price was committed as of the contract or purchase order date.

Major monthly/periodic reports as regards cost and schedule performance prepared and submitted to MSC for the duration of the contract were as follows:

DRL 27, DRD MF-015TA	Financial Management Report
DRL 28, DRD MF-016T	Overtime Report
Contract Labor Summary	

Plans/Schedules. The Program Administrator prepared and maintained detailed bubble schedule charts which established the planned and scheduled progress of the various tasks to aid in assuring that the program effort would meet contractual requirements of performance and delivery. With this yardstick, the Project Engineer applied personal and visual follow-up wherever corrective action was warranted.

Detail, Summary, and Master Schedules were periodically submitted to MSC in accordance with DRL 29, DRD SC-015T.

Internal Performance Control. In addition to the controls described above, a separate accounting report each month identified all personnel charges to the UVS program and the aggregate man months charged. The Project Engineer and Program Administrator would monitor the charges regularly to discourage variance with the established plan.

A separate monthly accounting report identified all materials charged to the program. All purchase requisitions were subject to Program Management review and approved prior to release for purchase.

The Configuration Management Office assumed responsibility for the follow-up of all contractual documentation. This effort was performed by personal contact with the various responsible engineers, rendering assistance whenever necessary.

Through personal contact, the Payload Engineer exercised his responsibility for overall system performance by constantly monitoring the program from the start of the design effort through the completion and delivery of the contract end items.

The Project Engineer was continuously abreast of every facet of the program. He conducted weekly program staff meetings to review the current program status and implemented corrective action for conceivable problems which could affect schedules, performance, reliability or cost.

External Performance Control. Performance control of the various subcontractors was maintained by an APL Contracts Administrator assigned to the UVS program with the assistance of an appropriate Problem Sponsor. The Problem Sponsors, who were technical specialists, worked with the Contracts Administrator to monitor the performance of each subcontractor. Continuous follow-up effort commensurate with the nature and quantity of work performed was exercised through personal contact and visits to the subcontractor's facility. The Problem Sponsors were supplied aid from other pertinent APL groups in areas such as reliability, quality assurance, and configuration management.

When purchasing, the buyer, with the assistance of the Reliability and Quality Control Engineers, exercised control of vendors of purchased parts in a manner similar to that described above for subcontractors.

All subcontractors and vendors were required to comply with the applicable sections of the latest revisions to the Quality Program Plan (SOR-70-031) and the Reliability Program Plan (SOR-71-030).

Conclusions. The task of performance measurement was diligently pursued throughout the UVS program in all aspects as prescribed in the contract and outlined above. This effort provided considerable usefulness as regards program achievement. All items have been completed and no unresolved problems remain. No further action is recommended.

SYSTEM SAFETY (Par. 2.1.6)

System Safety Plan. A system safety plan was prepared to define comprehensive safety program requirements and present a methodology for implementing the defined safety tasks in support of the design, development, manufacturing, testing, and flight phases of the UVS experiment. The preliminary plan was submitted with the original program proposal in accordance with DRL 30, DRD SA-019T. The final plan (SOR-71-002) was submitted to MSC in March 1971.

Safety Management and Control. The UVS System Safety Program at APL provided for organized activity in which management efforts and technical disciplines were coordinated to provide timely identification and the required corrective action to eliminate or control those conditions or events which would have contributed to injury or loss of crew, operating personnel, system failure, or damage to equipment and hardware throughout all phases of the program.

Management and control of the safety program provided for and insured implementation of:

a. Specialized safety engineering and technical competency for system safety and crew safety tasks.
b. Functional participation by all disciplines in the safety program effort.
c. Management awareness of risks and requirements for risk management
d. Establishment and compliance with safety requirements and criteria which are commensurate with the scope of the Apollo program.

Specific Requirements. The Safety Plan applied to all elements of the APL role as contractor for the UVS experiment. As such, the plan covered all safety aspects relating to hardware, software, ground equipment (GSE), Government Furnished Equipment (GFE), and to all associated activities pertaining to design, manufacture, checkout, test training, handling, transportation, and storage of the UVS equipment. All specific details of system safety as delineated in the contract were incorporated during the course of the program.

Hazard Analysis and Categories. APL performed evaluations and studies to identify all systems and experiment interface problems. Overall experiment analysis was conducted early during initial design stages on equipment and operating procedures to identify and categorize problems affecting crew safety. Identified hazards were classed in accordance with those specified in the contract.

Detailed system analyses using Failure Mode and Effects Analysis (FMEA) activity for each failure mode were conducted. The analyses were used to determine the effects on interfacing systems to insure that problems would not propagate across the interface. Such effects were classified in accordance with the Hazard Categories of the MSC directive System Safety Requirements for Manned Space Flight.

Operational hazard analyses were conducted to identify operational problems relative to the experiment and its support equipment. Analysis methodology identified the function and corresponding tasks. Hazards associated with the task were identified to establish their effect on personnel, equipment, facilities, and airborne hardware. All hazards were categorized to identify cause, criticality, and recommended controls. Status was maintained until all identified hazards were resolved.

The Hazard Analysis Report, DRL 32, DRD SA-021T, was submitted to MSC in final form in August 1971.

Hazard Reduction Precedence Sequence. All identified hazards, for the duration of the contract, were assessed for the proper order of risk reduction precedence in accordance with the contract.

Design Safety. All design safety requirements as specified by the contract were included in the applicable design drawings, specifications, and engineering requirement documents. All changes to these documents were reviewed for compliance with system safety requirements. APL supported and participated in the Critical Design Review and Acceptance Reviews to establish that system safety requirements were satisfied. In addition, the Safety Engineer participated in internal design reviews for the assessment and resolution of safety problems to insure response to MSC identified hazards.

Design drawings were reviewed for safety consideration of mechanical design, i.e., sharp edges and protuberances, burrs, improper arrangement, pinch points, and shear points. Electrical designs were reviewed for possible electric shock hazards and necessary current limiting devices where required. All hardware was reviewed for safety of operation in specified environments involved in flight. Special item purchase requisitions were reviewed for safety requirements. Incoming parts inspections of vendor items were also monitored for safety compliance, as were vendor item specifications and vendor sites, when necessary.

In-house fabrication processes were monitored to insure safety compliance with Alerts and other governing documents. All top assembly drawings, test and operational procedures and formal specifications and/or drawing changes were reviewed and approved by the Safety Engineer.

Safety Reporting. Monthly safety progress reports were submitted to MSC as a part of the Monthly Program Progress Report and contained: the status of safety reviews conducted and those procedures or items identified as "Safety Critical"; hazards identified as critical or catastrophic with disposition of the action requirements and status of corrective action; design changes affecting safety and their status; safety discrepancies, their disposition and status; summaries of accident/incident, and failure reports, as necessary.

Formal safety assessments were submitted two weeks prior to the Critical Design Review. Significant system safety activities or critical safety problems were reported as soon as possible upon identification.

APL established and maintained a safety file as a central control point for all documentation relating to the safety program. This file included, as a minimum:

a. Correspondence
b. Safety Plans
c. Directives
d. Engieering System Safety Analyses
e. Operations System Safety Analyses
f. Safety Manuals
g. Hazardous Materials Controls
h. Waivers/Deviations
i. Reports to MSC
j. Audit Reports

k. Accident/Incident File
l. Safety Corrective Action File
m. Safety Alerts

All identified hazards were reported to the Project Engineer and MSC for resolution as outlined in the System Safety Organization Flow Chart of Fig. 2.

Conclusions. Program safety observation and pursuit in accordance with the effort described above has provided a considerable asset for the UVS program. There were no outstanding hazards nor any significant design changes affecting safety or safety discrepancies of magnitude during the course of the program. All contract items as regards safety have been complied with and no unresolved problems remain. No further action is recommended.

TECHNICAL DESCRIPTION/SYSTEM ENGINEERING (Par. 2.2)

Technical Evaluation. The conceptual design and development phase of the UVS program was initiated with a system definition phase. This phase included a review of all available technical specifications applicable to the UVS program. In particular, Exhibit B to the contract was studied along with its referenced documents including SD 69-315. Conflicts between these documents and the preliminary interface control documents were identified. Section 3.0 of Exhibit B was reviewed in order to establish the performance/design verification matrix.

During the system definition phase, the optical design was reviewed to assure optimum system sensitivity. In addition, an optical system was chosen and all detailed optical design tasks were identified. At the same time, mechanical design requirements and tasks were identified with regard to the UVS packaging and mounting considerations. Preliminary engineering layouts were made.

The electrical design effort during the system definition phase consisted of establishing system signal flow, power

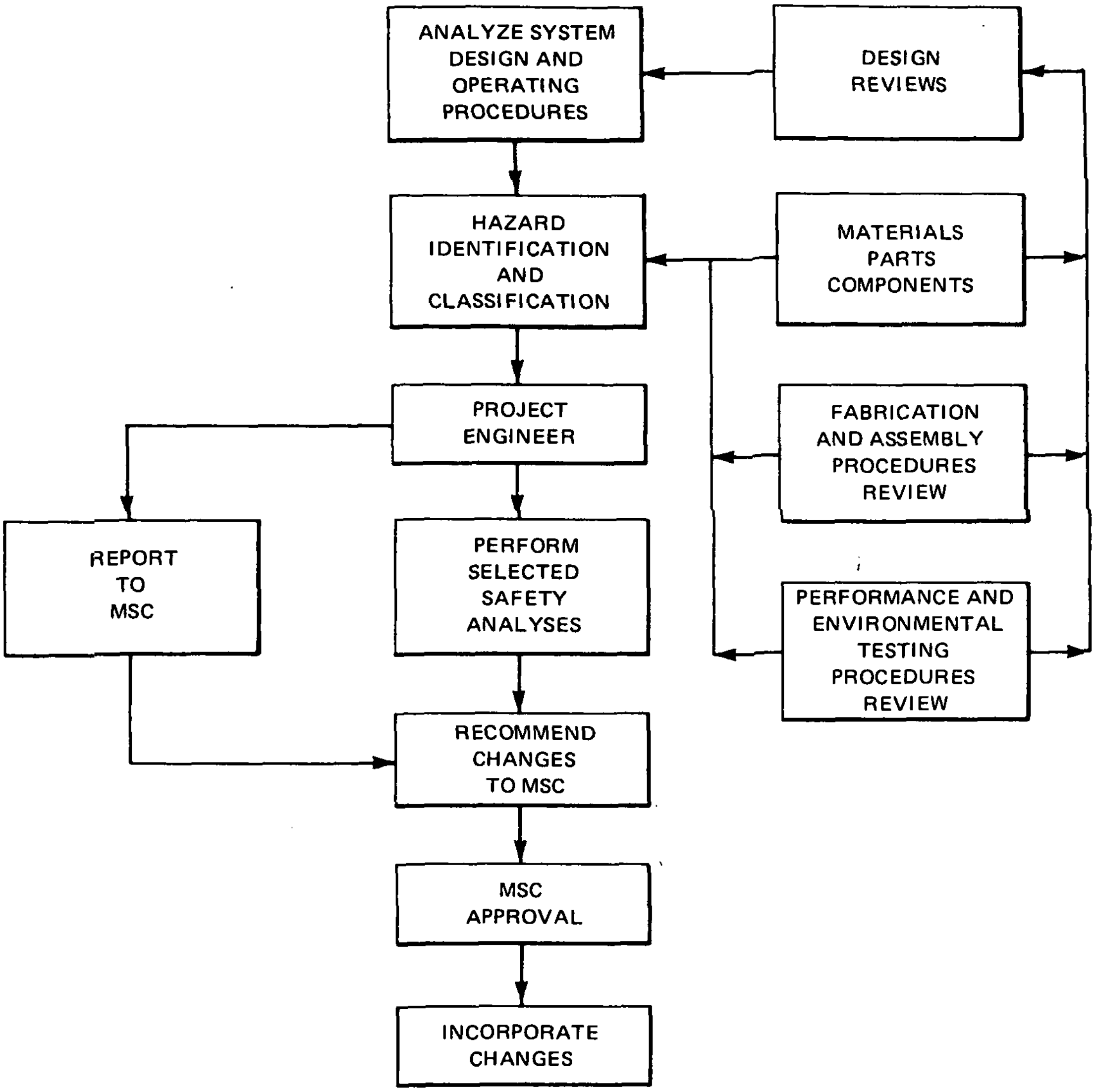


Fig. 2 SYSTEM SAFETY ORGANIZATION FLOW CHART

flow, and block diagrams. All major electronic subsystems were identified and the design approach established. Major electrical interface system parameters were discussed with MSC to obtain the best possible scientific data from the UVS.

Concurrently, preliminary thermal studies were conducted to estimate the temperature excursions of the UVS structure during the mission. This analysis was based on:

a. The preliminary layout of the UVS package
b. The environmental thermal inputs due to earth and moon albedo and direct solar radiation
c. Temperature excursions of the SIM bay
d. RCS jet heating.

Design and Development Plan. A Design and Development Plan was prepared to outline the planned portions of the design and development effort required to produce an Ultraviolet Spectrometer as specified in DRL 37, DRD SE-174T.

The plan includes the development program for the design, development, fabrication, and testing including the delivery of one hi-fi mockup, one prototype unit, one qualification unit, two flight units, and two sets of ground support equipment.

Functional Flow Diagrams. APL prepared detailed functional flow diagrams in accordance with DRL 34, DRD SE-171T to identify and portray the functions which must be accomplished in order to satisfy total contract performance requirements and/or objectives. These diagrams were updated at weekly intervals, and expected completion dates were added to each function, therby providing a complete program status document.

Engineering Drawings. Engineering drawings were prepared to define and control the physical and functional engineering requirements for each part of the end item hardware. The drawings were prepared in a tree that progressed from the top assembly drawing to detailed component and part drawings, and provided a complete definition of all end items. The drawings also depicted relationships of subsystems, components,and the physical and functional interfaces with the end items and other pertinent systems.

A complete set of engineering drawings was sent to MSC after all end items were accepted.

Critical Design Parameters. Critical design parameters were constantly monitored and reported during the UVS design and development phases. Particular attention was given to such design parameters as mounting-system configuration of the UVS unit, adequate spacing of the internal optical system and its associated mechanism to avoid interference during vibratory resonance, and the strength of various components exposed to the acceleration responses.

The optical grating was supported within a machined aluminum mount with an integral shaft which served as the axis about which the grating rotates. The grating was accurately located within the mount by three Kel-F locator pads which required adjustment so that the grating rulings were positioned parallel with the grating shaft. It was further required that the grating rulings be parallel to the slits which was achieved by tolerances on the mechanical parts.

The temperature distribution and transient thermal response of the UVS was computed for the orbital operating range. These consisted of time dependent environmental heat inputs, internal power dissipation and duty cycles, conductive and radiative exchange between the UVS and the interfacing SIM bay, and the exchange between the UVS and space.

Trade-off Analysis. Selected trade-off studies were conducted to provide recommended solutions to design problems. For the shock spectrum analysis, two mathematical models were formulated from the UVS design configuration. These models consisted of a 25-degree-of-freedom system in the direction of the optical axis and a 16-degree-of-freedom system in the other two mutually perpendicular directions. Separate computer programs were specifically generated to facilitate cumbersome calculations of these two models. Trade-off analysis has shown that the acceleration responses of the internal components are excessive for a hard mount configuration, whereas a more flexible UVS support system can reduce the response to a tolerable level.

Table 6 shows the comparison of the acceleration responses of the internal UVS components as a result of the two studies.

Design Breadboards. The first major milestone as regards the UVS electronic design was the completion of a working electronic breadboard. Before this was accomplished, however, certain preliminary system definitions were made, e. g., the required dynamic range of the counters, the electrical interface requirements, and the operational temperature limits of the UVS. Preliminary circuit designs were breadboarded with the more critical circuits evaluated first; circuits of functions directly associated with the scientific data were followed by the ancillary functions. To aid design evaluation, the breadboard was used to conduct preliminary EMI tests, thermal tests, and pertinent tests to assure compatibility with operating and interface specifications.

Following the determination of electronic loads and requirements for voltage regulation ascertained from the breadboard design, a working breadboard of the converter and regulators was produced to verify and evaluate the design. The breadboard provided the means to evaluate the electronic design over a wide range of input voltages and temperature variations.

Table 6

Comparison of Acceleration Response of the Internal Components by Support Systems with Various Flexibilities

Support System	Hard-Mount with Bath-Tub Fittings (f = 700 Hz)			More Flexible System (f = 90 ± 10 Hz)		
Results Internal Components	Mode	Frequency (Hz)	*Acceleration Response (g peak)	Mode	Frequency (Hz)	*Acceleration Response g Peak
Ebert Mirror	3	418	402	1	93	27
P/M Tube	4	440	653	5	730	35
Converter	6	1229	2399	5	730	43
Sun Sensor	4	440	589	1	93	25
Motor (100 Hz)	7	1332	765	5	730	29

*Along the optical axis

CEI Specifications. End Item Specifications were prepared for each end item after MSC design approval in accordance with requirements specified in the contract. The delivered end items for which CEI specifications were promulgated are described as follows:

CEI No. 7232-0080-HF-1. This specification, submitted on 31 August 1971, established the requirements for complete identification and acceptance of the High Fidelity Mockup Training Unit for the UVS Experiment S169 for the formal acceptance by MSC. The hi-fi Mockup was the nonfunctional model of the UVS that was intended for astronaut training and familiarization. The unit was identical to the UVS flight units in external configuration and mounting provisions.

CEI No. 7232-0000-01. This specification, approved on 17 November 1971, established the requirements for complete identification and acceptance of the prototype UVS Experiment S169 for the formal acceptance by MSC. The prototype unit was the first completely integrated functional unit to represent the final hardware design. Originally this unit did not have all the aspects of a flight unit; however, later in the program the prototype unit was refurbished and reconfigured as a flight quality cross calibration unit at the request of MSC.

CEI No. 7232-0000-02. This specification, approved on 17 November 1971, established the requirements for complete identification and acceptance of the qualification unit for the UVS Experiment S169 for the formal acceptance by MSC. After the configuration baseline was established by the formal acceptance review for the qualification unit, all subsequent flight units were manufactured and accepted on the basis of this specification.

CEI No. 7232-3000-01. This specification, approved on 17 November 1971 established the requirements for complete identification and acceptance of the bench test equipment (BTE) for the UVS Experiment S169 and formal acceptance by MSC.

CEI No. 7232-3004-01. This specification, approved on 7 February 1972, established the requirements for complete identification and acceptance of the ground support equipment (GSE) for the UVS Experiment S169 and formal acceptance by MSC. The GSE consists of shipping containers, handling fixtures, test rhombs, dust covers,and pertinent ancillary equipment.

Design Documentation. In parallel with the breadboard development, specification control drawings were prepared. Package design documentation also began during breadboard testing. Detailed schematics and diagrams, interface control, assembly, and installation drawings were developed and entered into the UVS documentation system in accordance with accepted engineering practice.

System Functional Analysis. Analyses of the electronic circuits were performed to assure that optimum dynamic range and accurate counting rates could be obtained for the minimum and maximum UVS environments. Power supply variations, temperature effects, component tolerances, corona considerations, and cross talk effects were also analyzed during the early part of the design phase.

A thermal analytical model consisting of a maximum of 40 isothermal nodes and 150 conduction and radiation resistors was formulated. The model included variations in surface optical properties where applicable and variable thermal conductance couplings. Input data from NR was used and the inclusion of nodal capacity allowed both steady state and transient boundary conditions to be used. A copy of the computer model was prepared to be compatible with the NR instrument-integrated thermal model of the SIM bay.

Later the prototype unit was operated both on the bench and at the JHU Physics Department to demonstrate the following parameters for system functional analysis:

a. Alignment
b. Optical field-of-view

c. Scan stability
d. Sensitivity
e. Electrical signal linearity
f. Calibration
g. Dynamic range
h. Operation temperature range
i. Power consumption
j. RFI generation
k. Electrical, mechanical,and optical interface.

The prototype was used to analyze operability and/or survivability through a complete qualification program.

CDR Participation. A Critical Design Review (CDR) was conducted to demonstrate that the detailed design satisfied the technical requirements of the contract and that the CEI specification accurately reflected the proper design configuration of the CEI.

APL provided representation and a co-chairman for the CDR. The co-chairman was responsible for the APL participation, prepared the schedule and agenda for MSC approval, and was responsible for the APL presentations. In addition, the co-chairman provided minutes of the CDR. This formal technical review of the UVS Experiment established the design as the basis for supporting subsequent APL, MSC, and NR activities. The CDR identified the engineering documentation which defined the UVS and GSE design and established the product configuration baseline.

Specific applicable subjects prepared for review included the following:

a. Compliance of the CEI to specific design criteria and requirements and other technical direction included in the contract including general technical system criteria, program requirements, applicable NASA/military standards, and recognized engineering standards

b. Compatibility with technical requirements

c. Anticipated development cycle with specific attention to determination of testing incident to the qualification of the CEI

d. Handling restrictions with emphasis on specific planning to broaden unusual handling criteria.

e. General environmental restrictions

f. Human factors, with particular emphasis on safety and hazardous conditions

g. Manufacturing considerations

h. CEI specification with emphasis on the compatibility between design, quality control methods, production test procedures, acceptance test procedures, reliability assurance methods, and shipment requirements

i. Status of all documentation requirements with attention to technical adequacy and test procedures

j. Reliability analyses including a Failure Mode and Effects Analysis (FMEA) identification of single-point failure conditions, identification of anticipated failure modes and the means used to prevent them

k. Design and process specification adequacy

l. Detail design of the CEI

m. Electrical aspects including power input and tolerances, functional interfaces, relative environmental characteristics, test support equipment, external measuring point provisions, and parts selection standards

n. Mechanical aspects of shock, vibration and acoustics effects, installation/interface considerations, and weight and center of gravity analysis

o. Interface Control Documents.

Following the CDR, APL submitted to MSC a report which was a record of the review that included all action items with their disposition, deviations, and shortages, and a copy of the completed Material, Inspection, and Receiving Report, Form DD250.

Documentation Control. A list of engineering baseline drawings and specifications was prepared to provide a complete itemization of all drawings and specifications that defined the baseline configuration of the CEIs as approved at the CDR. This list included all the drawings and specifications contained in the CDR Baseline Documentation Package which reflected the approved design together with all design changes approved at the CDR and listed in the CDR minutes.

Interface Coordination. Continuous liaison was provided with the integrating contractor and suppliers to assure proper interfacing throughout the UVS program. Early in the program the overall instrument maximum envelope, the location of the instrument in the SIM bay, the location of the interface electrical connectors, and the location and dimensions of the four shock mounts which interface with the SIM mounting bracket were described in the mechanical ICD. Early contributions of UVS interface parameters as regards electrical, environmental, and functional interfaces were also coordinated continuously during the program.

Close coordination and liaison related to thermal interfaces were provided by holding interface meetings as necessary. Thermal computer models were revised to account for action items and follow-up required as a result of interface meetings and to account for new information included in the ICDs.

Data Update. All documentation, particularly engineering design data, was maintained in an orderly up-to-date status throughout the program. Specification change notices updated CEI specifications, preliminary interface revision notices updated interface control documents, and ECNs, MRBs, and ECPs updated engineering drawings. Of particular emphasis, was the update status as regards UVS design, performance, and interfaces.

Weight Status Report. A UVS weight status report was included in the Monthly Program Progress Report in accordance with DRL 45, DRD SE-184T to assure that the spacecraft and launch vehicle design capabilities had not been exceeded by the UVS Experiment. The weight of all UVS subassemblies and the total flight hardware was reported. Also included were specification weight, previous and current weight, and an explanation for any weight change.

Conclusions. All parameters of the UVS Experiment S169 technical description and system engineering have been complied with in accordance with the contract. The effort described above enhanced the achievement of contract goals without serious constraint. All items as regards system engineering and technical description have been completed and no unresolved problems remain. No further action is recommended.

END ITEM TESTS (Par. 2.3)

End Item Test Plan. End item testing was performed in accordance with the End Item Test Plan (S4S-0-679B) and DRL 46, DRD TM-094T which was submitted on 20 April 1972. The plan listed all applicable documents, established test equipment objectives, test conditions and measurements, and described the test equipment and facilities required. The plan also established quality assurance provisions and general requirements such as test documentation, satisfactory operation and failure criteria, and safety aspects to be observed.

As regards tests, the plan delineated test objectives, identified the test items and emphasized test ground rules and constraints. Specific test types required were described, which were:

a. Prototype development tests
b. Acceptance testing
c. Qualification tests
d. Vibration testing
e. Thermal vacuum test
f. Preinstallation tests
g. Integrated system tests
h. Prelaunch tests.

Finally, the End Item Test Plan established a Performance/ Design Verification Program.

Qualification Test Plan. UVS qualification was performed in accordance with the Qualification Test Plan (S4S-0-68DA) and DRL 47, DRD TM-095T which was submitted on 28 April 1972. The plan listed all applicable documents, established test equipment objectives, test conditions and measurements, and described the test equipment and facilities required. The plan also established quality assurance provisions and general requirements such as test documentation, satisfactory operation and failure criteria, and safety aspects to be observed.

Qualification methods to verify that the UVS hardware could meet the technical requirements of the CEI specification were defined in a Qualification Matrix and included with the plan. The end item data package resulting from the qualification plan was defined.

As regards tests, the plan delineated test objectives, emphasized test ground rules and constraints, and established the test program and qualification requirements. Specific tests required were described which were:

a. Operational Verification
b. Optical Verification
c. Optical Calibration
d. Vibration
e. Shock
f. Thermal Vacuum
g. Electromagnetic Interference.

Qualification Test. A document was prepared in accordance with the approved Qualification Test Plan to define the detailed qualification test procedures and operations to be performed on the UVS qualification unit (S4S-0-750 and DRL 48, DRD TM-096T). These procedures were so designed to demonstrate that the UVS would meet the applicable specifications delineated in the CEI Specification 7232-0009. Prior to subjecting the UVS to the Qualification Test, the qualification unit was formally accepted by MSC during the Acceptance Review held at APL on 28-30 March 1972.

Tests to determine whether the qualification test hardware was performing within specification tolerances were required before and after each environmental exposure. These same tests were conducted during those exposure periods where flight hardware would be required to operate. Test environments and conditions were based on those defined in Exhibit B of the contract so as to establish a realistic simulation of the effects of exposure to the actual operational conditions. An NR mounting bracket was used to simulate flight vehicle mounting where required. The UVS Qualification Test Flow Diagram, with test completion dates, is shown in Fig. 3. Strict controls were exercised to assure that the qualification test was conducted in accordance with the approved test procedures. Adjustment or tuning of the test hardware was not permitted except where normal to in-service operation and within allowable limits as indicated in the procedures.

A qualification test report was prepared in accordance with DRL 49, DRD TM-097T and submitted to MSC for approval.

Acceptance Test Plan. Acceptance testing of the UVS instrument was performed in accordance with the Acceptance Test Plan (S4S-0-681C) and DRL 50, DRD TM-098T which was submitted to MSC on 3 December 1971. The plan defined the acceptance tests to be conducted, the test items and number of items to be tested, test objectives, and performance criteria of all tests required to verify that each end item is acceptable. The plan also established quality assurance provisions and general requirements such as test documentation, satisfactory operation and failure criteria, and safety aspects to be observed.

Additionally, environmental conditions, testing time or cycles, allowable maintenance, logging requirements, manner of analysis, and utilization of test results, disposition of test specimens, retest requirements, location of tests, facilities and support requirements, and time phasing of the tests were established.

Acceptance testing of the Bench Test Equipment (BTE) was performed in accordance with the Acceptance Test Plan for the Bench Test Equipment (S4S-3-781A) and DRL 50, DRD TM-098T which was submitted to MSC in November 1971. The plan outlined the acceptance tests to be conducted, the sequence of testing, responsibilities, and scope of tests for the Experiment S169 BTE. All tests were applicable to all three contracted BTE units unless otherwise specified.

Acceptance Test. A document was prepared in accordance with the approved Acceptance Test Plan to define the detailed acceptance test procedures and operations to be

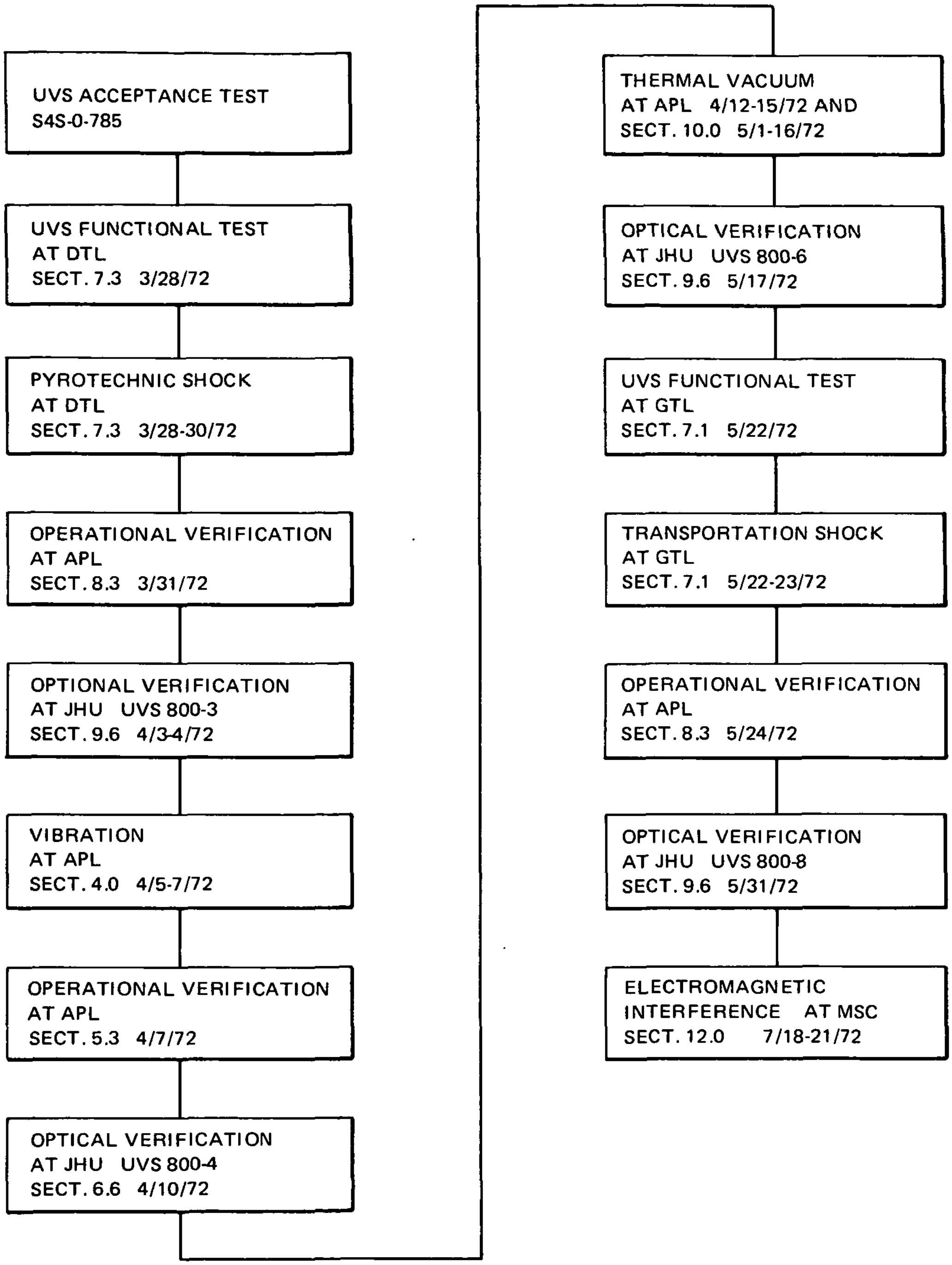


Fig. 3 ACTUAL QUALIFICATION TEST SEQUENCE FOR UVS S/N 2

performed on the UVS prototype unit, qualification unit, and two flight units (S4S-0-785E and DRL 51, DRD TM-099T). These procedures were so designed to demonstrate that these instruments would meet the applicable specifications delineated in CEI Specifications 7232-0009 and 7232-0010. Prior to subjecting the instruments to acceptance testing, the Acceptance Test Plan and Acceptance Test Procedures were reviewed and approved by MSC.

Functional tests were conducted on all test articles before, during, and after application of vibration and thermal environments. The following operations, in the sequence shown, constitute acceptance testing that was conducted at APL and the JHU Physics Department:

a. Inspection of assembled UVS in the APL clean room
b. Operational Verification with BTE in the APL clean room (See Fig. 4 for test configuration.)
c. Optical Verification with BTE in the JHU Calibration Test Equipment (CTE). (See Fig. 5 for test configuration.)
d. Optical Calibration (Proto only) with BTE in the JHU CTE
e. Vibration Exposure at APL Environmental Test Laboratory (See Fig. 6 for test configuration.)
f. Operational Verification with BTE in the APL clean room
g. Optical Verification with BTE in the JHU CTE
h. Thermal Vacuum Test in APL Environmental Test Laboratory (See Fig. 7 for test configuration.)
i. Optical Calibration with BTE in the JHU CTE
j. Mass Properties in the APL clean room.

Test data were duly recorded by the Systems Test Engineer with the concurrence of the Reliability Engineer and the MSC Representative. These data always remained with the particular end item and copies were maintained for MSC review. After successful completion of the acceptance test, each appropriate end item was ready for formal Acceptance Review.

A separate document was prepared in accordance with the BTE Acceptance Test Plan to define the detailed acceptance test procedures and operations to be performed on the Bench Test Equipment (S4S-3-784B and DRL 51, DRD TM-099T). These procedures were so designed to demonstrate that the BTE hardware would meet the applicable specifications delineated in the CEI Specification 7232-0012A.

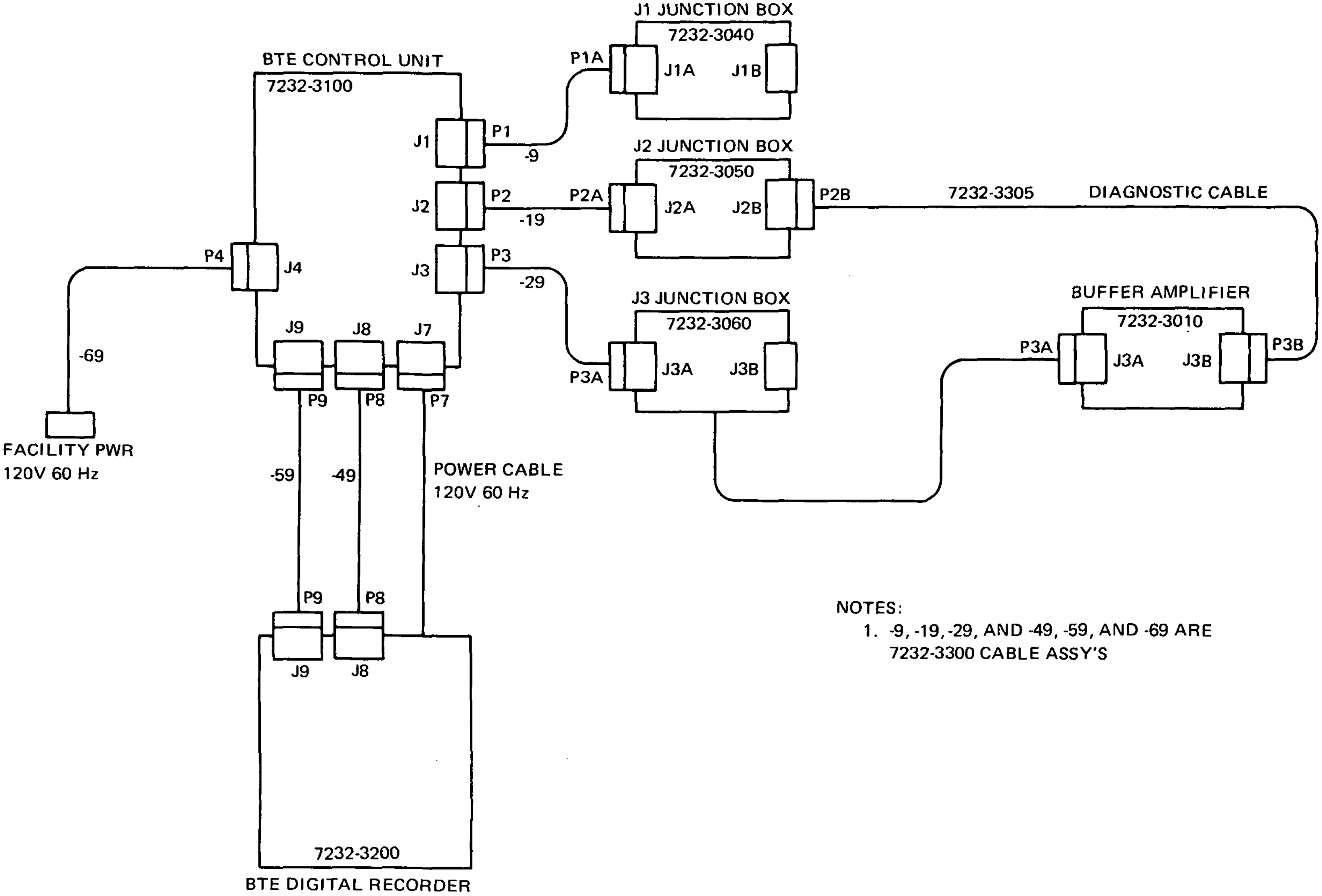
In addition to specification compliance verification, the test was used to confirm satisfactory operation of all three equipments after fabrication and subsequent to transportation/handling between major facilities and prior to being used to control and monitor flight type UVS instruments.

The BTE units were tested as follows:

a. Wiring harness inspection and continuity test
b. Subsystem preintegration test
c. Full Systems Functional Acceptance Test. (See Fig. 8 for test configuration.)
d. Electromagnetic Interference Test (one unit only).

Test data were duly recorded by the System Test Engineer with the concurrence of the Reliability Engineer and the MSC Representative and were included in the BTE Acceptance Data Package.

Preinstallation Test. A document was prepared in accordance with DRL 54, DRD TM-102T (S4S-0-814 Issue C) to establish inspection and test procedures which would assure prevention of the installation of nonconforming UVS hardware in the Apollo spacecraft. Cooperating fully with NR and KSC, the procedures were so designed to give assurance that the delivered equipment had not been degraded or damaged because of mishandling or excessive storage life. The test consisted primarily of a UVS Operational Verification.



NOTES:
1. -9, -19, -29, AND -49, -59, AND -69 ARE 7232-3300 CABLE ASSY'S

Fig. 8 BTE TEST CONFIGURATION

Details of the PIT conducted on UVS flight units Nos. 1 and 2 are reported later in this document under "Launch Site Operations."

Integrated Systems Tests. APL cooperated with the Integrating Contractor in the development and performance of Integrated Systems Test at KSC. The tests were conducted to verify that the UVS flight units Nos. 1 and 2 were functionally and operationally compatible when integrated with mating systems hardware. APL monitored the UVS Experiment S169 hardware performance during all systems testing. Details of specific Integrated Systems Tests are reported later in this document under "Launch Site Operations."

Prelaunch Tests. KSC was responsible for developing and conducting prelaunch tests; however, APL reviewed and concurred with these Prelaunch Test Specifications and procedures as regards Experiment S169 adequacy and compatibility. APL monitored the UVS experiment hardware performance throughout prelaunch testing.

A Certificate of Flight Worthiness was prepared for both flight units in accordance with DRL 55, DRD TM-103A and included with the respective Acceptance Data Package. The COFW signifies to NASA that all requirements have been fulfilled and that the hardware is ready for flight.

EMI Tests. The UVS prototype units was exposed to limited radiated and conducted signal emissions during March 14 through March 17 at the EMC/RFI Branch of the Melpar Division of LTV Electrosystems, Inc. in Falls Church, Virginia. The tests were conducted in accordance with applicable portions of MC999-0002C Electromagnetic Interference Control for Apollo Space System. The UVS and associated BTE were operated by APL personnel. The EMI generation and measuring equipment was operated by Melpar personnel.

Tests performed were: conducted susceptibility, radiated susceptibility, and radiated interference. The tests proved to be inconclusive; however, several problems were observed during the radiated susceptibility testing. Of primary concern, spurious frequencies were detected that would cause highly erratic readings on the PMT dark current monitor and, on numerous occasions, high field intensity of the radiated signals would trip the UVS circuit breaker.

Further EMI testing was performed with the UVS prototype unit and the BTE during April 5 through April 18 at Melpar. During this test period, it was determined that the UVS was susceptible to radiated signals in the region of 50 to 300 MHz, that the UVS produced both conducted and radiated interference above specified limits, and that the radiated and conducted ambient produced by the BTE signals on the UVS cables was above specified limits.

After analyzing the test results, it was determined that by adding a capacitor across the electronic circuit breaker terminals, the unit would readily pass susceptibility requirements. Subsequently, all effort was concentrated on solving the conducted and radiated interference.

A screen room set-up was established at APL for EMI diagnostic testing. Specific fixes were developed and implemented in all units in accordance with ECP-023. No further EMI tests were performed with the prototype unit pending its reconfiguration as the cross calibration unit. However, the prototype electronics module was used in configuring the ATEE Test Unit, therefore a complete set of radiated and conducted interference tests were conducted on this unit at APL between 5 May and 17 May 1972. The final results of these tests were within specifications.

The EMI tests were conducted in accordance with the Electromagnetic Interference Test Plan for the UVS Experiment S169, DRL 47, DRD TM-095T and S3E-72-001, and the Electromagnetic Interference Test Procedure for the BTE, SDO/CMO-412. Typical test set-ups are shown in Figs. 9 through 18. An EMI test report, S3E-72-156 and a test report summary, S3E-72-157, were submitted to MSC.

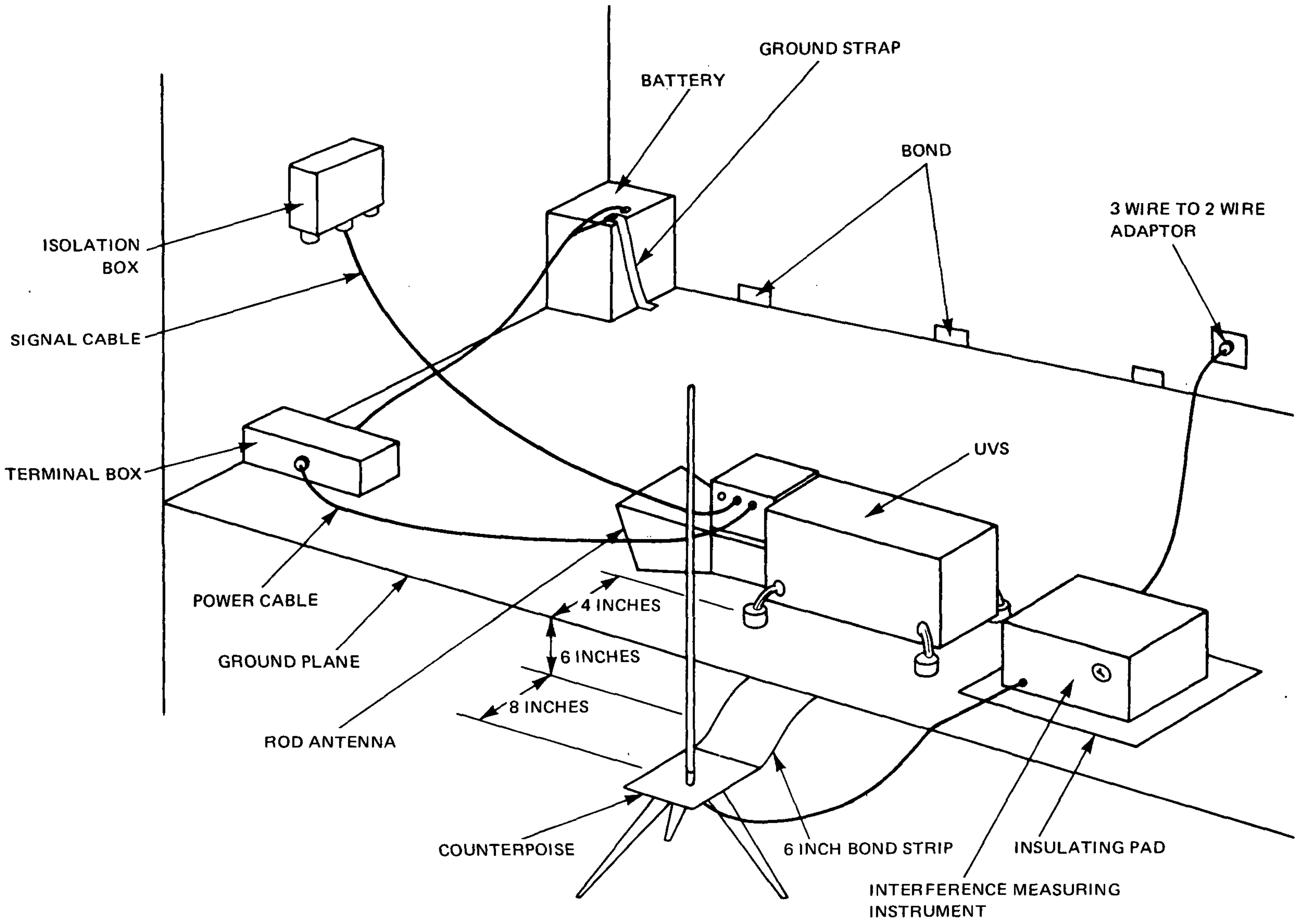


Fig. 9 TEST SETUP FOR RADIATED INTERFERENCE MEASUREMENT (ROD ANTENNA)

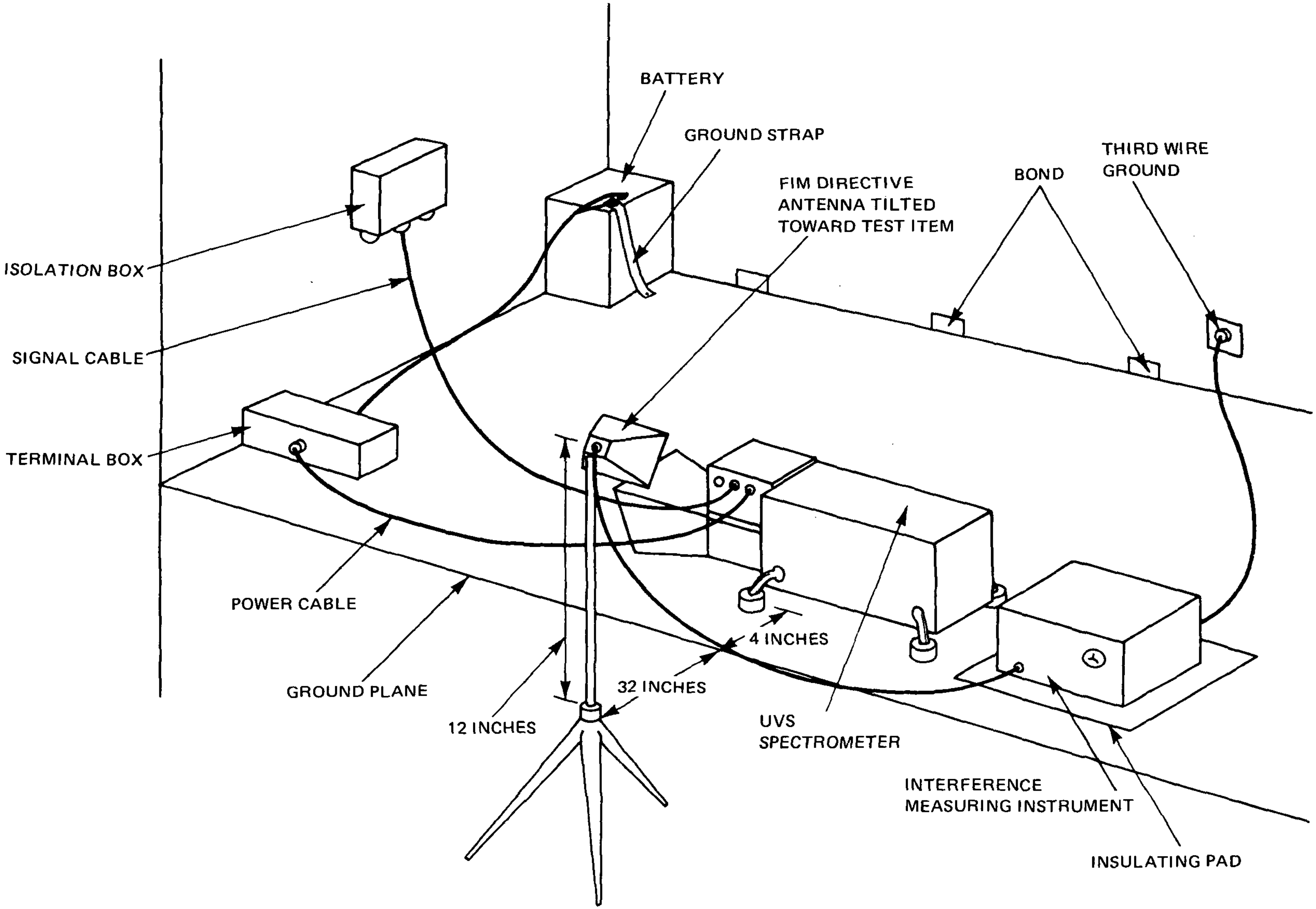


Fig. 10 TEST SETUP FOR RADIATED INTERFERENCE MEASUREMENT
(MICROWAVE–DIRECTIVE ANTENNA)

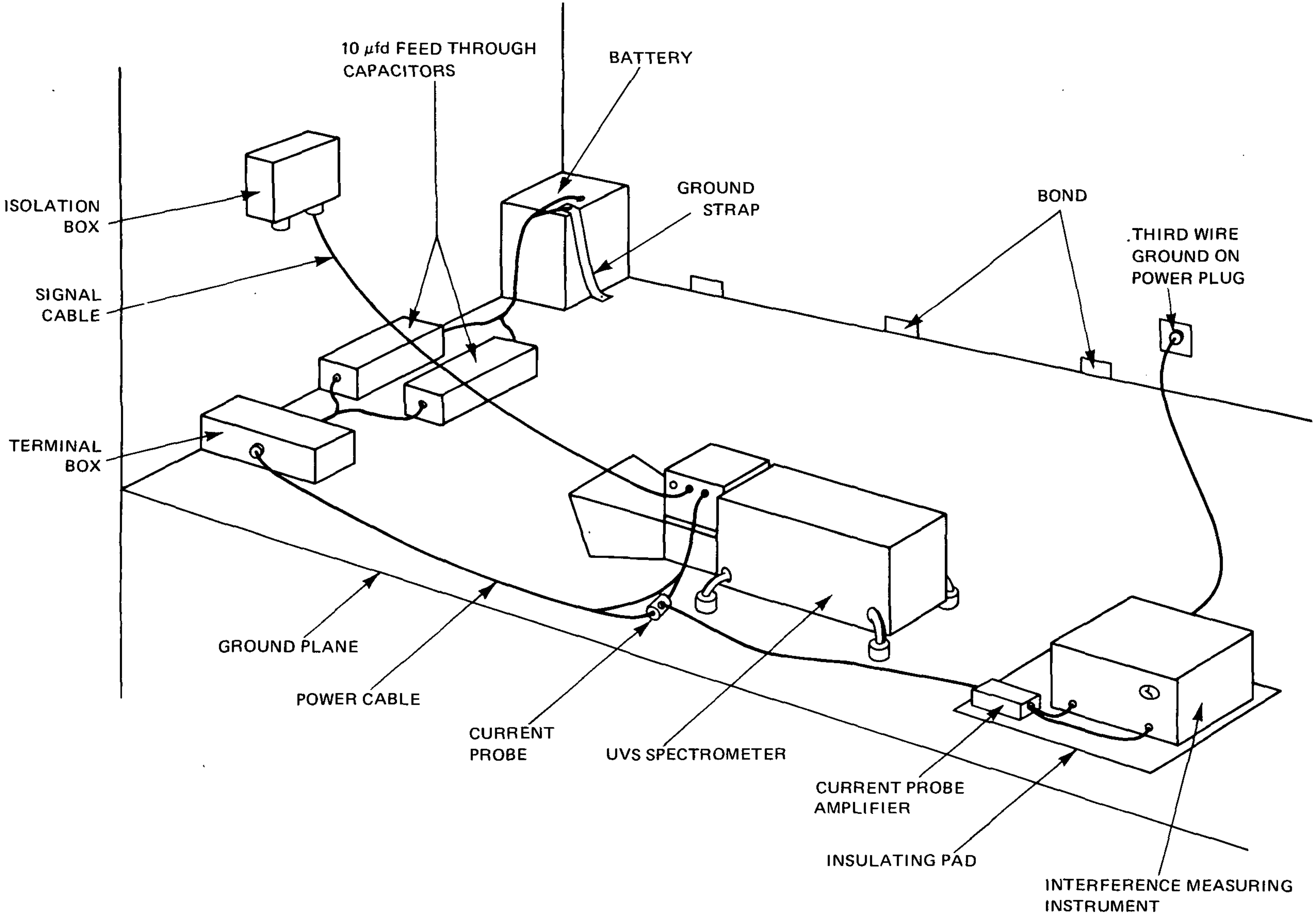
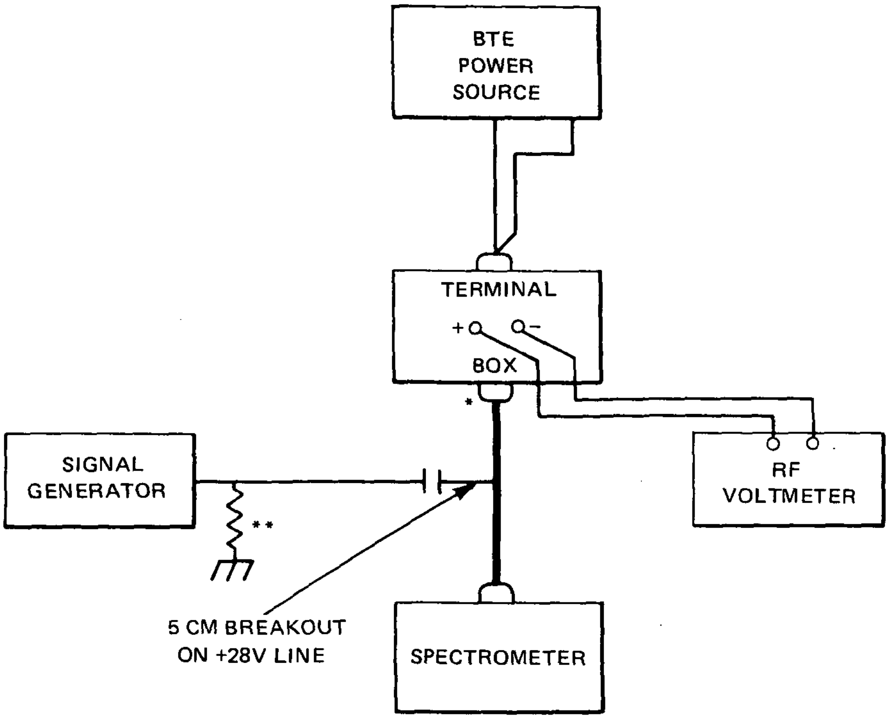


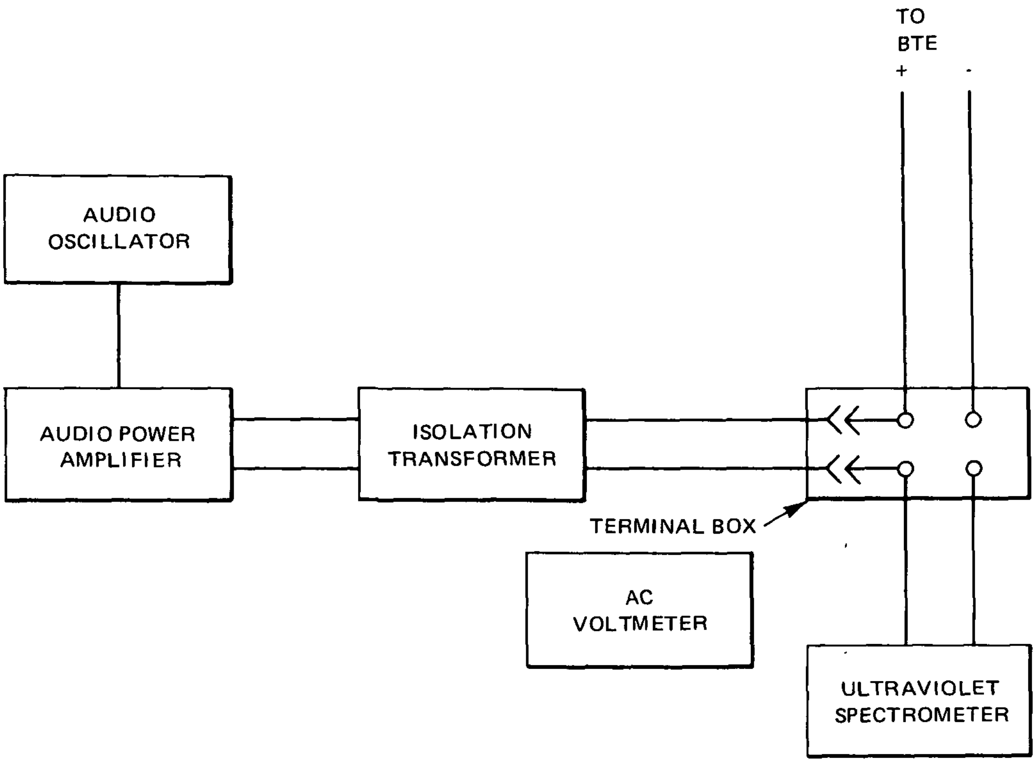
Fig. 11 TEST SETUP FOR CONDUCTED INTERFERENCE MEASUREMENTS
(30 Hz to 20 kHz)



* CAPACITOR, 5 OHMS IMPEDANCE OVER FREQUENCY RANGE MAY BE CHANGED DURING TEST TO MAINTAIN IMPEDANCE.

**RESISTOR, PROPER TERMINATING RESISTANCE FOR SIGNAL GENERATOR.

Fig. 12 RF SUSCEPTIBILITY (CONDUCTED) TEST SETUP



TRANSFORMER WILL CARRY ALL CURRENTS
WITHOUT SATURATION.

SERIES CONDENSER ON AC VOLTMETER WILL HAVE
REACTANCE NOT GREATER THAN 1/10 METER IMPEDANCE.

Fig. 13 AC SUSCEPTIBILITY TEST SETUP

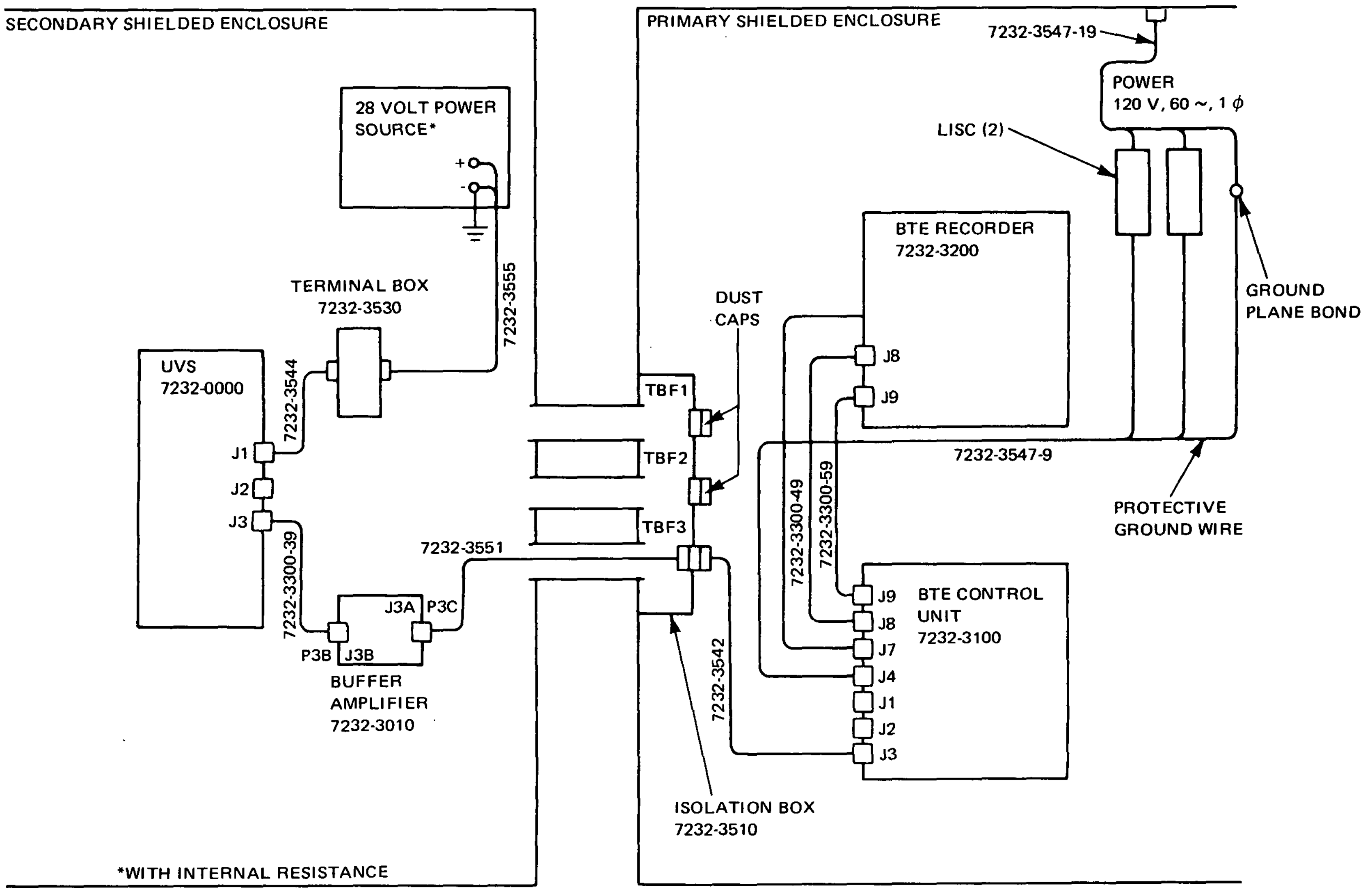
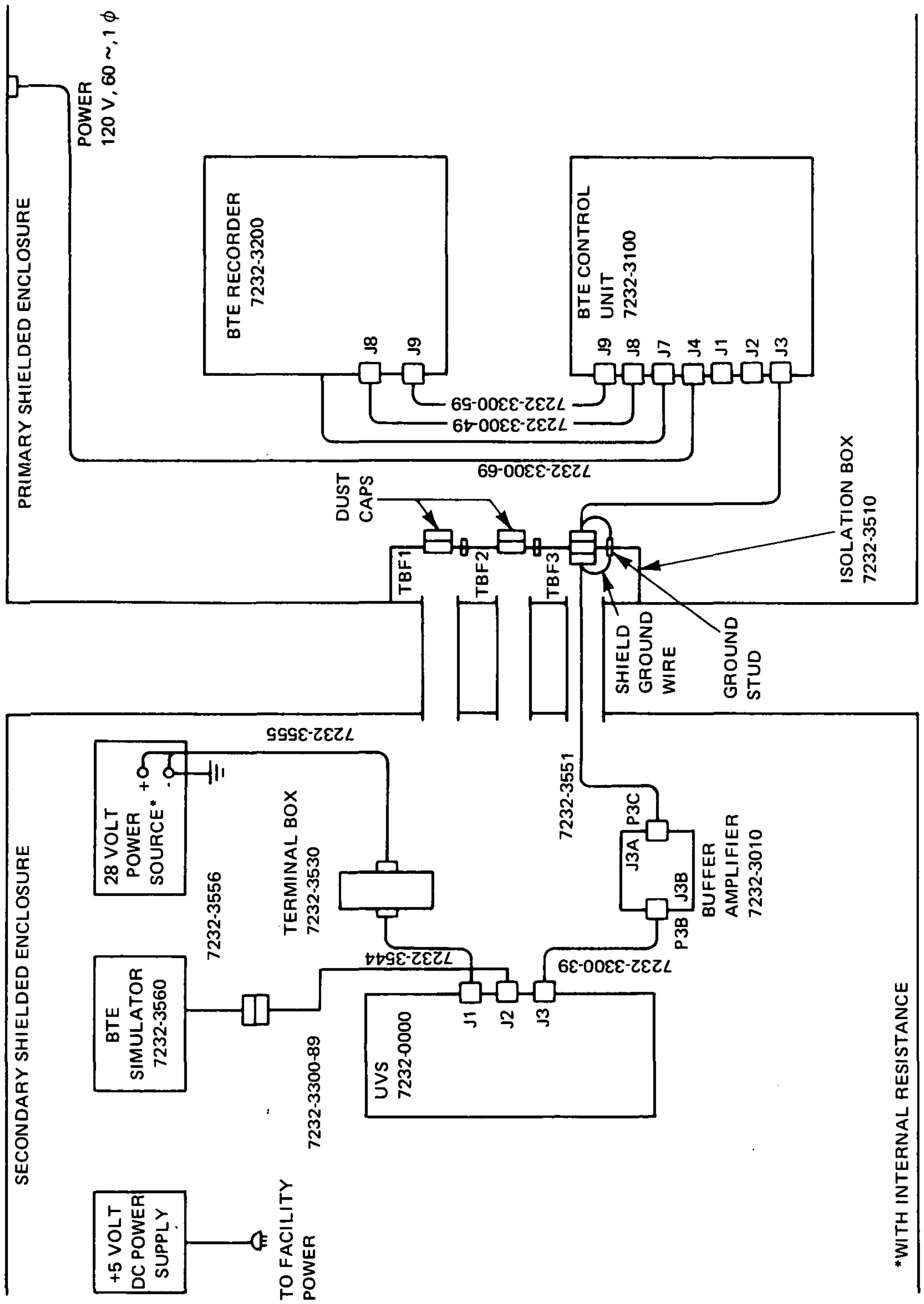


Fig. 14 BTE/UVS/DC POWER SOURCE INTERCONNECTIONS FOR CONDUCTED INTERFERENCE TESTS



*WITH INTERNAL RESISTANCE

Fig. 15 SETUP FOR BTE OPERATIONAL VERIFICATION AND RADIATED INTERFERENCE TEST

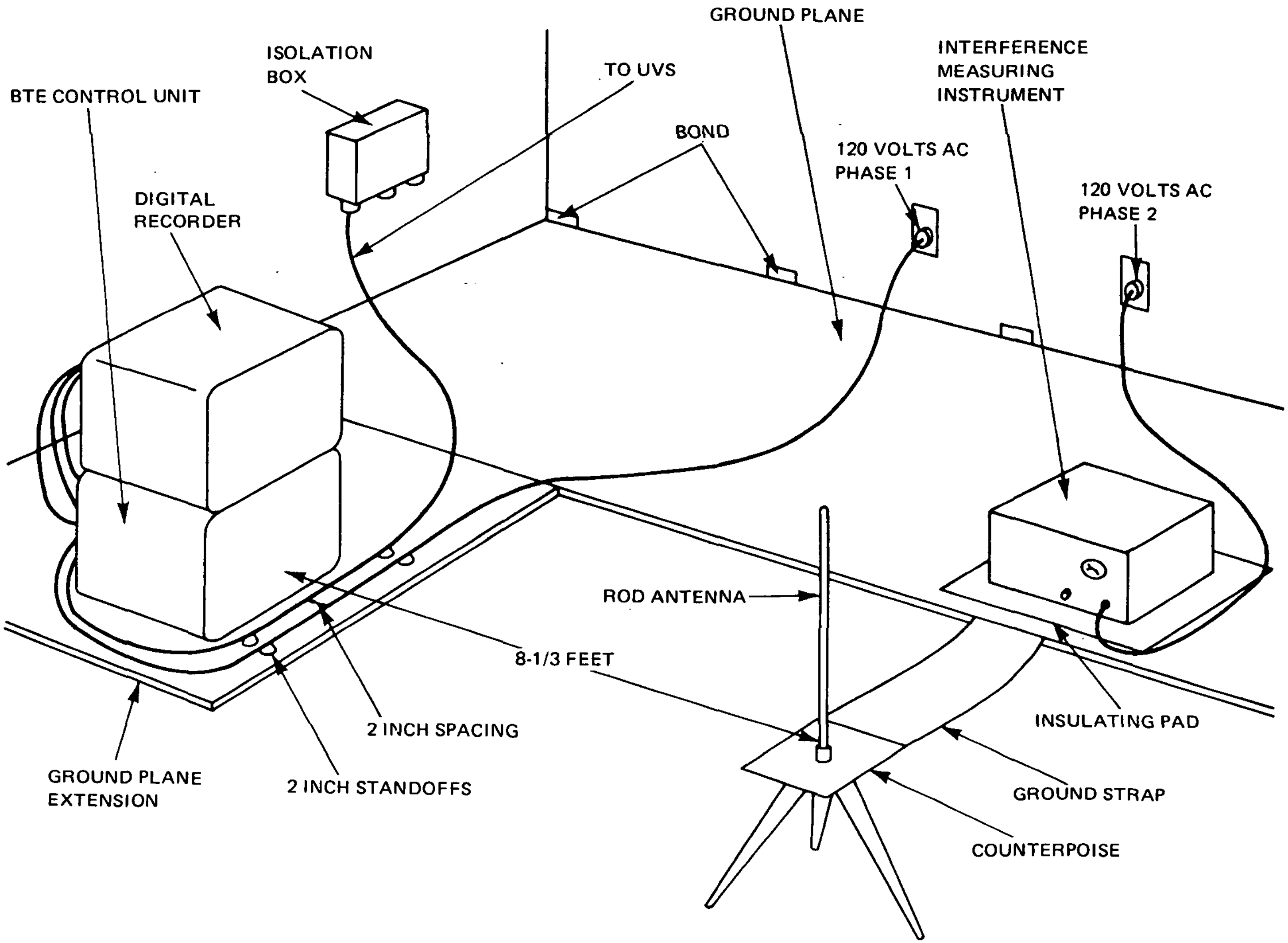


Fig. 16 TEST SETUP FOR BTE RADIATED INTERFERENCE MEASUREMENT (ROD ANTENNA)

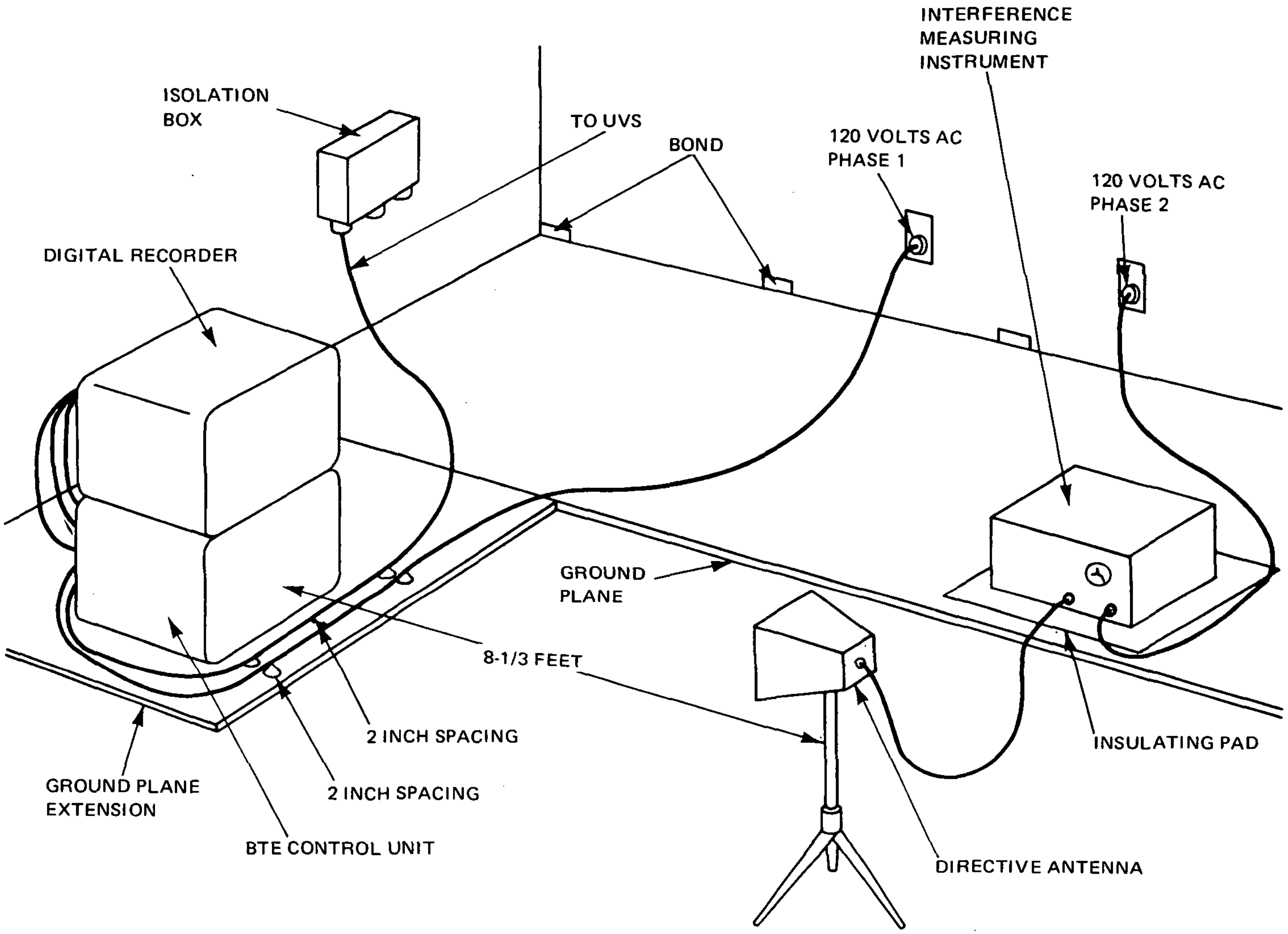


Fig. 17 TEST SETUP FOR BTE RADIATED INTERFERENCE MEASUREMENT (MICROWAVE DIRECTIVE ANTENNA)

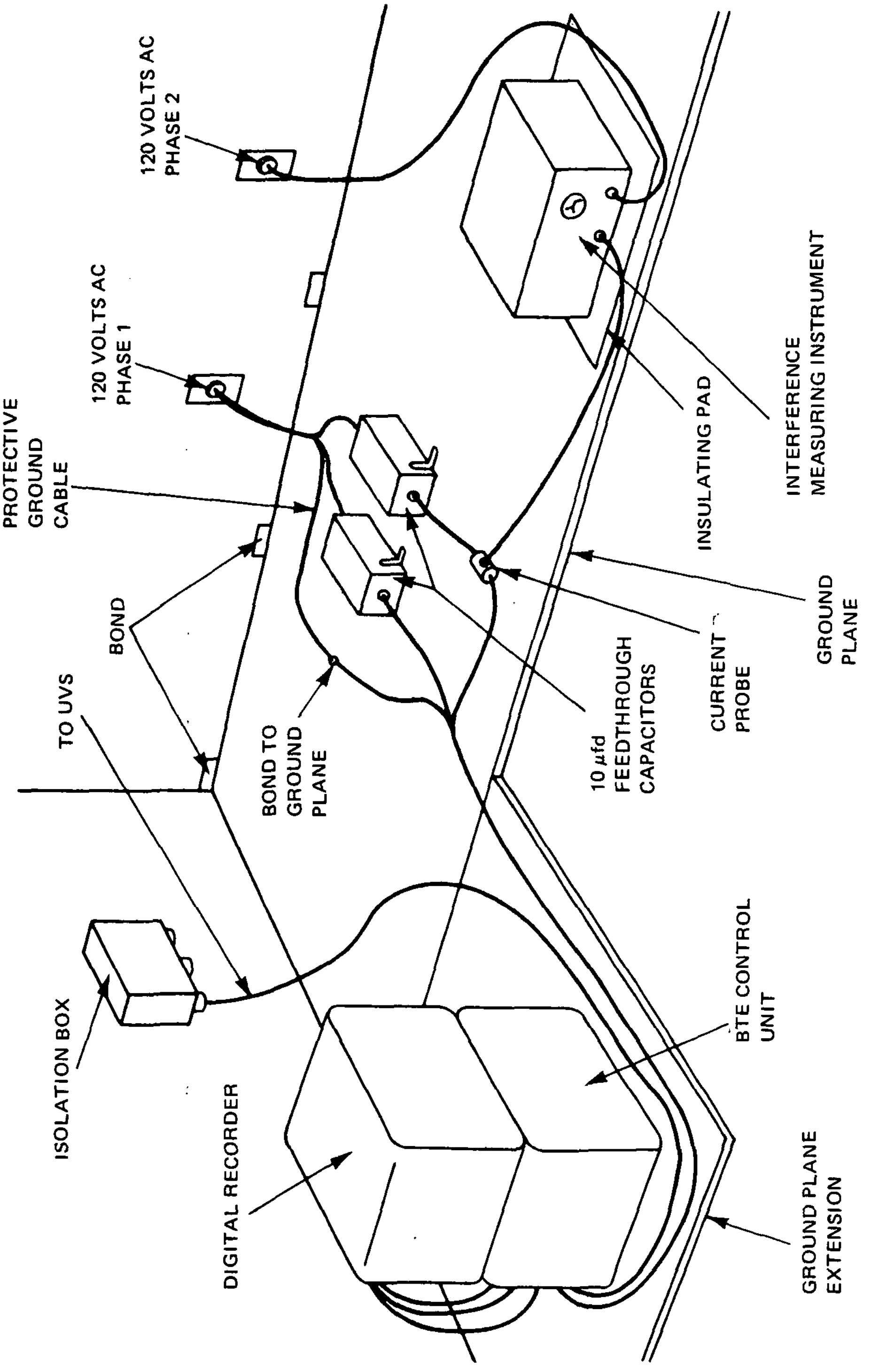


Fig. 18 TEST SETUP FOR BTE CONDUCTED INTERFERENCE MEASUREMENTS

Pursuant to an MSC directive (CCA-015), APL provided the required technical personnel and equipment to support qualification unit EMI testing at MSC, Houston, Texas. An APL systems engineer operated the UVS experiment, and Lockheed personnel operated the EMI test equipment. Under these conditions, APL was relieved of the requirement to procure EMI testing facilities and the necessity to contract for an EMI specialist. APL documentation responsibility was also reduced to the review of test documentation provided by MSC and the integration of it into the qualification unit data package.

The UVS EMI Qualification Testing at MSC began on 18 July 1972 and was completed on 20 July 1972. The tests were performed in accordance with MC999-0002C (NR) and S4S-0-750, July revision (APL). Resultant test data indicated that broadband conducted and radiated interference emanating from the UVS exceeded the limits established by MC999-0002C. No attempt was made to determine if the source of the radiated interference was the spectrometer chassis or the interconnecting cables. The amplitude of the out-of-specification interference was, however, very low and no corrective hardware modifications were recommended.

The BTE EMI testing on BTE No. 3 was begun and completed at MSC on 21 July 1972. The tests were performed in accordance with MC999-0002C (NR) and SDO/CMO-412, July revision (APL). Resultant test data indicated that narrowband and broadband conducted and radiated interference emanating from the BTE exceeded the limits established in MC999-0002C for equipment of this type. However, there was never a requirement for the BTE to meet the limits of MC999-0002C. The test data were collected and documented for engineering information only; no recommendations for corrective action were made.

MSC documentation of these two EMI tests, Ultraviolet Spectrometer Experiment S169 Electromagnetic Interference and Susceptibility Qualification Test Report MSC / TCSD Document EMC-R-EB8-004, and Ultraviolet

Spectrometer Bench Test Equipment Electromagnetic Interference Evaluation Test Report MSC/TCSD Document EMC-R-EB8-005, was submitted to APL for review and comment. The APL response was favorable concurrence with the MSC results and recommendations.

ATEE Tests. After the newly configured ATEE unit was completed and satisfactorily checked out, it was shipped to NR on 19 May 1972 as scheduled, and BTE No. 3 was shipped on 26 May. NR conducted the BTE and UVS Apollo Telecommunications Engineering Evaluation from 30 May through 2 June 1972. APL personnel were present to operate the S169 Experiment equipment. Operational testing of the ATEE unit with the BTE was performed and satisfactorily completed on 31 May, and there were no mechanical fit problems when the unit was installed in the SIM bay. Checkout of the ATEE unit with the NR Scientific Data System (SDS) was also satisfactory.

All housekeeping functions were normal when the unit was powered by the vehicle power bus and monitored with the BTE; however, the BTE digital printer did not function properly when operating in an open-loop mode. This problem, caused by a wiring error on BTE Card A1, was corrected, and testing was resumed. Thereafter digital data were recorded with the BTE printer, but under some simulated pulse count conditions the digital readout became erratic. Investigation revealed that the BTE shift register was receiving an extra shift pulse, probably caused by ground noise at the BTE/ATEE unit interface. Although throughout the testing all digital data and housekeeping telemetry data were consistently received and correctly recorded at the NR ground station, the BTE was disconnected and testing suspended on 2 June 1972.

Following modification and evaluation of the BTE at APL, ATEE testing was resumed at NR on 26-27 June.

The ATEE unit was mounted in the SIM bay and powered by the vehicle power bus. Housekeeping functions monitored with the BTE were normal. Digital data were recorded by the BTE printer with simulated pulse count conditions in accordance with the UVS Acceptance Test Procedure. When the test was completed, all digital data and housekeeping functions were recorded at the NR ground station and compared with the BTE recorded data. No discrepancies were found.

Additional tests conducted were: (a) monitoring of the SDS generated timing signals, (b) motor inhibits in accordance with the UVS Acceptance Test Procedure, and (c) monitoring of the dark count for ten consecutive scans. All tests performed normally and were within specifications. The BTE was disconnected from the ATEE unit on 27 June and returned to APL.

BTE No. 3 again arrived at NR/ATEE Test Laboratory on 3 August 1972. After successfully completing a UVS/BTE operational test, the NR "J" Mission Experiments ATEE Test Procedure for Apollo 17 CSM 14, Section 11, 08-000, was followed on 3 August 1972. On 4 August all tests in this section were completed with no problems.

During partial integrated experiment interference tests, it was noted that the ITEK pan camera, when cycling, was causing the UVS analog TM voltages to vary on both the BTE and the TGS. The problem was noted and the test continued. The combined experiments phase of the test procedure, in which the UVS and BTE were no longer connected together, was run with very little notice of the problem. Analysis indicated that the pan camera ground, either signal or power, was returning through the UVS J2 cable and leaving on the J3 cable to the BTE ground return.

At the time the tests were being conducted, it appeared that the varying TM voltage problem was in the ATEE test SIM bay and associated control panel, and that this condition may be present in the flight hardware at KSC. Continued investigation, however, revealed that the power and signal grounds of the ITEK pan camera were common within the camera, and the UVS BTE digital recorder had common signal and chassis grounds. This produced a closed loop between the UVS and pan camera grounds as shown in the UVS/NR ATEE Test Configuration Diagram, Fig. 19. Bucking ground currents in this circuit arrangement caused the UVS analog TM channels to read in error, which would vary depending on the pan camera return impedance and the cycling currents produced by the camera stereo operating mode.

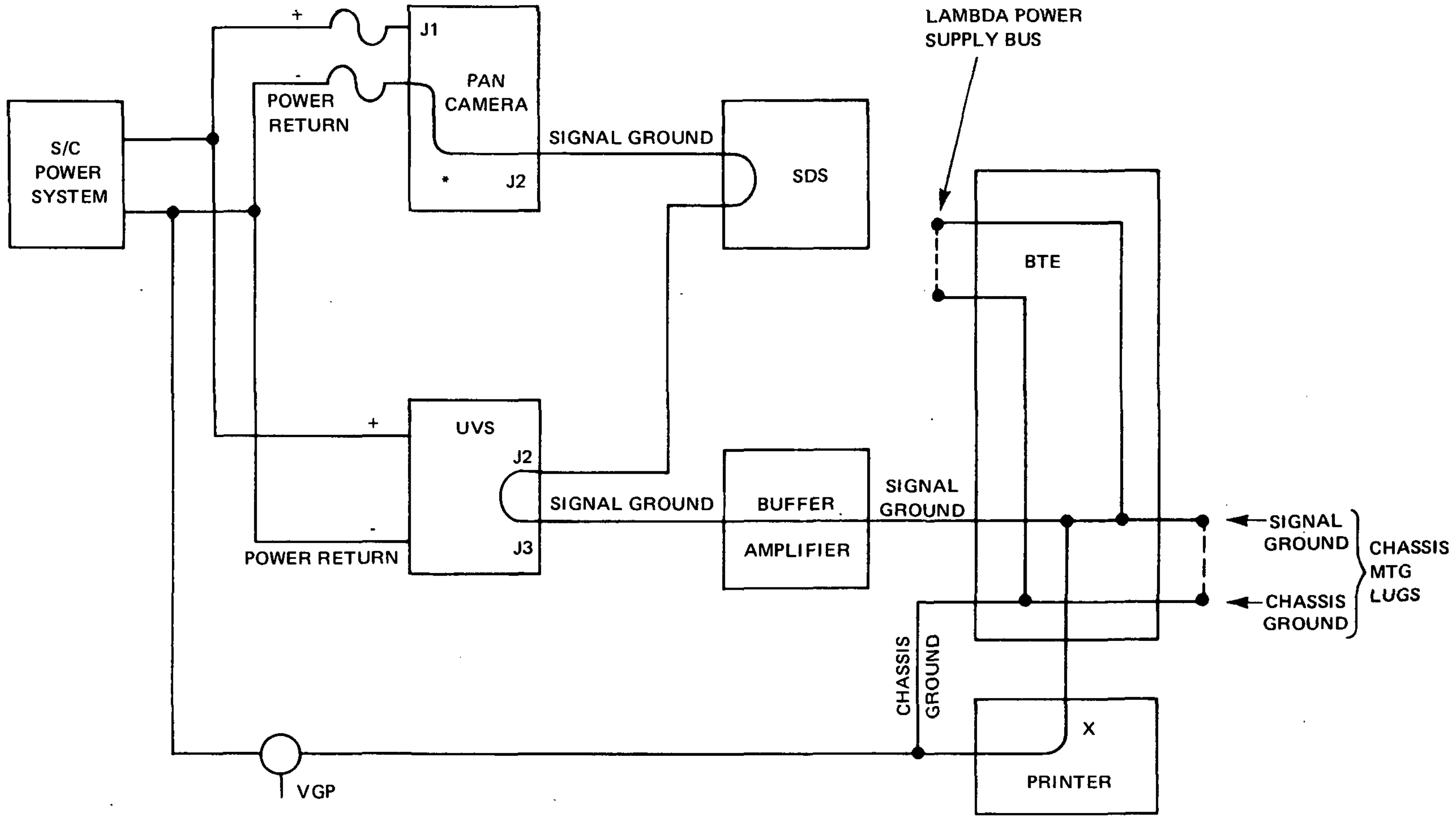
An expedient solution to the problem was recommended by APL, i.e., incorporate a procedural change that would disconnect and not use the BTE digital recorder whenever the UVS with the BTE and the pan camera were required to operate simultaneously. UVS data would be available over the SDS. However, since the voltage variations proved to be trivial and within tolerances contained in the specifications, no further action was taken.

At the request of MSC, APL agreed to participate in a test at KSC duplicating the ATEE test parameters as conducted at NR. In this regard, a separate compatibility test was conducted during the 0028 test in September 1972 at KSC. This test verified that the voltage variations were within tolerance while the UVS was installed in the spacecraft and would disappear completely when the BTE was disconnected.

Other Tests

Thermal Test. A UVS thermal model was fabricated as a test unit to verify the analytical model (TAM). A mockup of the SIM bay lower shelf area was constructed so that the proper view factors of the UVS could be maintained. A simulated SIM bay was established in one of the thermal vacuum chambers at the APL Environmental Test Laboratory.

A total of 101 No. 22 AWG Copper-Constantan Thermocouples were attached at various locations on the instrument. Thermocouple readout was multiplexed through a scanner and read out on a DORIC thermocouple DVM. Continuous calibration of the DVM was maintained by using two channels with stable voltages corresponding to +100° and -100°F.



* = PAN CAMERA WAIVER CONNECTS SIGNAL GROUND TO POWER GROUND.

x = UVS – BTE WAIVER (REF. APL TSSD-3042) FOR HEWLETT PACKARD DIGITAL RECORDER. MANUFACTURER DOES NOT ALLOW FOR SIGNAL GROUND AND CHASSIS GROUND SEPARATION.

PAN CAMERA WAIVER AND BTE WAIVER ALLOW FOR POWER AND SIGNAL GROUND INCONSISTENCY, THUS ALLOWING GROUND LOOP COMPLETION THROUGH PAN CAMERA AND DIGITAL PRINTER.

Fig. 19 UVS – NR ATEE TEST CONFIGURATION

Input power to the heater resistors was measured by using a scanner for multiplexing to a VIDAR DVM. The arithmetical product of the voltage across the heater, the voltage across the current sensing resistor, and a calibration factor provided the desired result.

The test program was divided into two parts: analytical model verification and mission simulation. Three test runs were conducted for analytical model comparison: a hot soak at 100°F, a cold soak at 0°F, and a transient between these two limits. A complete mission simulation was out of the scope of these tests, therefore only the most critical phases were simulated. These were: hot bias SIM door jettison, hot bias lunar orbit, and cold bias trans-earth. In all cases, the SIM simulator was used, and temperatures were manually controlled by varying the voltage, and consequently the power input to the chamber heaters.

The first series of tests was completed successfully and the first mission simulation test, SIM Door Jettison, was attempted. During this test it became immediately apparent that manual control of the power supplies would be inadequate to follow the mission simulation temperature profiles. The remaining simulation tests on the thermal model were discontinued since a complete mission simulation would be performed on the qualification unit. It was also decided to incorporate computer controlled power supplies for use during the Qualification Test Program. Several revisions in the TAM were made to obtain better agreement with the test results. Excluding the circuit boards, the RMS difference between test and analysis was reduced to 3.5°F. Circuit board differences were much larger (about 17°F). Since this is an area difficult to physically model accurately, it was decided to correct this part of the TAM during the qualification tests.

Although several test setup deficiencies were uncovered during the test program, the analytical model was validated by this effort. A complete and detailed report of the Thermal Model Tests, S4S-72-094, was submitted to MSC on 24 August 1972.

Shipping Container Tests. Qualification tests were performed on the UVS Shipping Container to determine compliance with the design and performance requirements of the Shipping Container Specification, 7232-0008. The tests were performed by the container vendor and witnessed by an APL representative. Test work was conducted in two phases. Rough handling tests and pressure tests were conducted at Applied Design Company, North Tonawanda, New York, on 21 December 1971. The vibration test work was conducted at Ogden Technology Laboratory, Deer Park, New York.

The UVS Shipping Container included an elastic suspension system to provide shock protection for the spectrometer from abnormal handling and vibration during any mode of transportation. The container also used a hermetically sealed shell to provide interior protection from harmful effects of the atmosphere.

The container was first subjected to a pressure proof test by filling with air at 25 psig for 30 minutes. No excessive deformation or structural deficiency was noted. A leak test subjected the container to an internal pressure of 2 psig and a soap solution for leaks. No leakage was detected. The container was then subjected to an additional leak test with an internal pressure of 15 psig for a period of 24 hours. The noted pressure drop was 0. 15 psi which was less than the allowed 0. 5 psi.

The container was next subjected to an edgewise drop test. The maximum shock readings observed were as follows:

Direction	Measured Load (Max)	Allowable Load (Max)
X (Vertical	11. 5g	15g
Y (Lateral)	1. 5g	15g
Z (Longitudinal)	3. 2g	16g

The subsequent corner-wise rotational drop test revealed the following:

Direction	Measured Load (Max.)	Allowable Load (Max.)
X (Vertical)	9.0g	15g
Y (Lateral)	1.5g	15g
Z (Longitudinal)	2.5g	15g

Prior to the above tests, the suspended mass was equipped with clay to monitor the deflection and subsequent clearance between the suspended mass and the container. After each of the rough handling tests, the container was opened for inspection which revealed that adequate clearance was maintained during the tests.

The container was loaded with a dummy spectrometer and shock recorder prior to vibration testing. The container was vibrated in each of the three planes with a varied frequency from 5 Hz to 500 Hz at a sweep rate of 1 octave per minute and sinusoidal inputs as follows:

Frequency (Hz)	Vibration Input
5 to 26.5	1.30g
26.5 to 52	0.036 inches double amplitude
52 to 500	5.0g

Results of the vibration tests are summarized in the following tabulation:

Direction of Vibration	Natural Frequency (Hz)	Acceleration (g)		Amplification Factor
		Max. g at Resonance	Allow. Accel.	
X (Vertical)	7.5 - 8.0	4.3	15	3.3
Y (Lateral)	9.0	2.5	15	1.9
Z (Longitudinal)	6.0	3.0	15	2.3

The 2 psig soap solution leak test was repeated at the conclusion of the test work and no leaks were noted.

It was concluded that these tests demonstrated that the UVS Shipping and Storage Container satisfied the requirements of the specification, and that it will provide satisfactory shock and vibration isolation of the UVS in transit.

Conclusions. All test requirements as specified in the contract for each end item have been carefully and liberally applied and documented as described above. All contract items as regards end item testing have been completed and no unresolved problems remain. No further action is recommended.

QUALITY ASSURANCE (Par. 2.4.1)

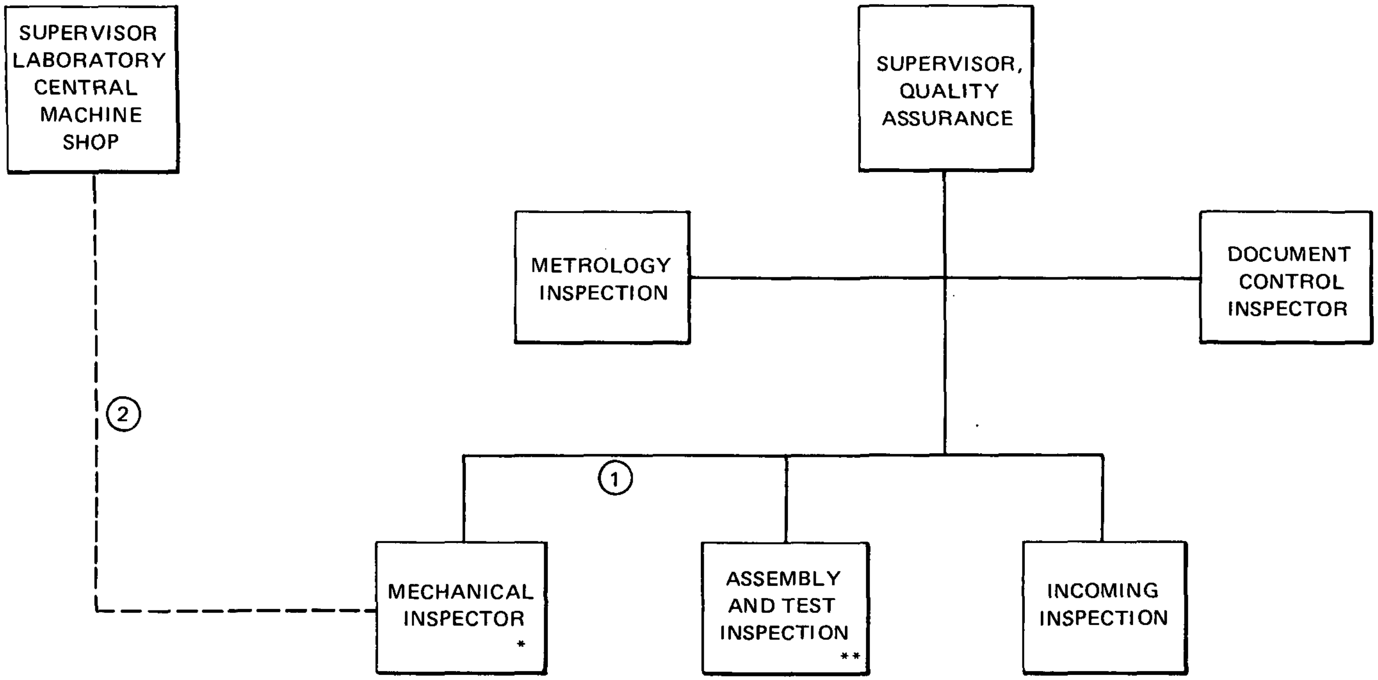
Quality Program Plan. A Quality Program Plan was prepared to establish the requirements for a system of controls to assure compliance with the quality assurance requirements as set forth in NASA Quality Assurance Publication NHB 5300.4 (1B), Quality Program Provisions for Aeronautical and Space Systems Contractors, as applicable to the UVS Experiment S169 Program. The plan provided for the following tasks which are vital to Quality Assurance:

a. Quality Program Management
b. Design and Development Control
c. Identification and Data Retrieval
d. Procurement Controls
e. Fabrication Controls
f. Inspections and Tests
g. Non-Conforming Article and Material Control
h. Metrology Controls
i. Inspection Status Stamp Control
j. Handling, Storage, Preservation, Marking/Labeling, Packaging, Packing and Shipping
k. Sampling Plans, Statistical Planning and Analysis
l. Control of Sub-Contracted Hardware and of the Calibration Test Equipment.

The Quality Program Plan, Revision C, was prepared in accordance with DRL 56, DRD RA-083T and submitted to MSC in February 1971. Figure 20 depicts elements of the APL Quality Assurance organization applicable to the UVS Experiment.

Documentation. Quality Program status was reported as a separate item in the regular monthly program progress report. The Quality Program status report included, as required in DRL 57, DRD RA-084T:

a. Organization and key personnel changes.
b. Significant program and article or material problems, their solutions, and remedial and preventive actions



* FUNCTION: DIMENSIONAL MEASUREMENT OF EACH FABRICATED MECHANICAL PART TO DRAWING REQUIREMENTS.

** FUNCTIONS INCLUDE:

1. ELECTRONIC ASSEMBLY INSPECTION.
2. WORKMANSHIP AND CLEANLINESS INSPECTION OF FABRICATED AND PURCHASED MECHANICAL PARTS. CLEANING AND PACKAGING PER CONTAMINATION CONTROL PLAN PRIOR TO SENDING TO CONTROLLED STOCK.
3. ELECTROMECHANICAL AND MECHANICAL ASSEMBLY INSPECTION.
4. TEST WITNESSING, CALIBRATION WITNESSING, TEST VERIFICATION.

① MECHANICAL INSPECTORS WILL BE UNDER THE SUPERVISION OF THE SUPERVISOR, QUALITY ASSURANCE IN ALL TECHNICAL MATTERS.

② MECHANICAL INSPECTORS WILL REPORT "ADMINISTRATIVELY ONLY" TO THE SUPERVISOR, LABORATORY CENTRAL MACHINE SHOP.

Fig. 20 APL QUALITY ASSURANCE ORGANIZATION

c. Contractor performance, such as inspection and test activities and procurement activities relative to supplier selections, surveys, and procurement document reviews
d. Supplier performance, such as acceptance and rejection rates.

Test equipment was inspected, evaluated, and calibrated prior to initial use and at periodic intervals. Recalibration schedules were determined in accordance with past history and current needs to assure continued accuracy of measuring and test equipment involved in product evaluation or in establishment of product conformance. Special test equipment was evaluated to verify that it met all function and accuracy requirements. Results of these evaluations were maintained available for inspection as required. System and Component Historical Records, MSC Form 772, were duly prepared and maintained for each end item. The Government inspector in residence at APL verified all entries on these forms which were included with the appropriate end item acceptance package.

APL provided adequate procedures designed to protect all items that were subject to deterioration from air, moisture, or other adverse elements during fabrication and storage. Appropriate marking and labeling was also provided for packaging, shipping, and storage of articles and materials as required by specification or contractural requirements.

APL prepared procedures for packaging to assure that articles requiring shipment would be protected from damage or deterioration. These procedures provided for all problems unique to the experiment. Cushioning, blocking, bracing, and bolting as applicable, were used to prevent damage caused by free movement within containers, rupture of flexible barriers, and the like.

A Contamination Control Program Plan, DRL 58, DRD RA-085T (SOR-70-060), was prepared, maintained, and implemented for the UVS Program. Revision E was submitted to MSC for approval on 24 January 1972. The plan delineated the cleanliness requirements to be attained, the methods to be used during fabrication, handling, test, calibration, shipment, pre-installation checkout, and installation for the UVS Experiment S169 for the prototype, qualification, and flight units. The plan was made applicable to the UVS electronic and signal conditioning module, prior to integration with the main housing assembly; the main housing assembly, including all parts and components, prior to integration with the electronic and signal conditioning module; and the completed instrument, after integration.

Specific requirements for cleanliness and contamination control were described, and, where warranted, detailed procedures were outlined to emphasize the importance of these requirements. Hardware packaging was accomplished in accordance with MSC-SPEC-C-12A, and detailed step procedures were prepared accordingly. After packaging and sealing, the logged items were identified with a membrane-type decal containing identification, inspection, and certification of cleanliness information.

A Soldering Program Plan, DRL 59, DRD RA-086T (SOR-71-007), was prepared to establish a program of soldering procedures and techniques to be followed during the development phase of the UVS Experiment S169 Program. The plan also describes the training and certification provisions necessary to achieve the quality and other requirements of NHB 5300.4 (3A). Table 7 outlines the Soldering Training Program. The Soldering Program Plan was submitted to MSC for review on 20 August 1971.

Provisions for Special Storage and Handling of Electrical/Electronic Assemblies, DRL 61, DRD RA-088T (SOR-71-060) was prepared to establish the procedures and facilities used by APL for the protection of electrical and electronic parts and assemblies before, during, and after fabrication. To provide for this, APL maintained a controlled stockroom for the storage of all parts and assemblies to be used in spaceflight. Special and separate areas were provided for the UVS Program which included the following:

a. Perpetual inventory file for all parts used on the program

Table 7

Training Program – Course Outline

The Reliable Electrical Connections (Hand Soldering) Course QUAL-E-1

Subject & Class No.	Hours*	Scope	Refs.
Introduction REC-S-002-1-1	3	To register the student into the course and to familiarize him with the overall breakdown of the course schedule and the contents to be taught	NHB-5300.4(3A) Requirements for Soldered Electrical Connections.
Printed Circuit Boards REC-S-002-1-2	6	To have the student acquire the ability to select and prepare properly the tools, materials, components, and printed circuit board for the application of solder and evaluation of finished product in accordance with existing specifications and standards	NASA SP 5002 Soldering Electrical Connections Handbook
Turret Terminals REC-S-002-1-3	3	To have the student acquire the ability to prepare conductors and turret terminals, apply the proper soldering techniques, and evaluate the finished product	NASA SP 5002 Soldering Electrical Connections Handbook
Hook and/or Eyelet Terminals REC-S-002-1-4	3	To have the student acquire the ability to prepare conductor and hook and/or eyelet terminals, apply the proper soldering techniques and evaluate the finished product	NASA SP 5002 Soldering electrical Connections Handbook
Bifurcated Terminals REC-S-002-1-5	6	To have the student acquire the ability to pre-conductors and bifurcated terminals, apply the proper soldering techniques, and evaluate the finished product	NASA SP 5002 Soldering Electrical Connections Handbook
Connector Pins REC-S-002-1-8	3	To have the student acquire the ability to prepare conductors and terminal cups, apply the proper soldering techniques, and evaluate the finished product	NHB-5300.4(3A)
Specification and (written) Examination REC-S-002-1-9	3	To have the student acquire a thorough understanding of the applicable specifications and a comprehensive written examination on all material covered in the course	NHB-5300.4(3A) NASA SP 5002
Practical Examination REC-S-002-1-10	8	To have the student demonstrate his ability to select properly and prepare tools, components, and materials and to apply the proper soldering techniques to printed circuit boards, turret terminals, bifurcated terminals, connector pins, and hook and/or eyelet terminals	NHB-5300.4(3A) NASA SP 5002

35 hours (instruction time)

b. Perpetual inventory file for all completed subassemblies, modules, and assemblies
c. Storage bins and shelves for all flight parts
d. Limited access, locked cabinets for assembled flight modules and packages, scrap, and withheld parts.

The APL Quality Assurance Project assigned inspection lot numbers; maintained lot control, prepared, followed, and filed inspection flow cards, performed inspections of all incoming parts; and performed electrical tests on all parts other than semiconductor devices.

The Material Control Office, in addition to parts requisition and procurement, operated the controlled stockroom. The flow of received electrical and electronic components and parts through the stockroom is shown in Figs. 21 and 22.

Fabrication of electrical and electronic component assemblies usually began with the assembly and inspection of a module kit. The flow of all parts, module kits, components, and assemblies to and from the controlled stockroom was controlled by the use of serialized four-copy Stock Issue Cards and Perpetual Inventory Cards. The flow of a typical assembly throughout its history is given in the three page Fig. 23.

This document, SOR-71-060, was submitted to MSC for review on 27 September 1971.

The Integrated Circuit Mounting and Connection Standard, DRL 64, DRD RA-091T (SOR-71-056), was prepared to establish standards for the mounting and connection of integrated circuits in printed wiring board assemblies. The Standard outlined the procedures for the procedures for the preparation of flat pack leads and their attachment fittings to printed circuit boards with subsequent welded connections. It specified the method, equipment, and materials to be used in the preparation and attachment procedures.

Acceptance of completed work was based on its comparison with the weld samples made and examined in Section 6 of the

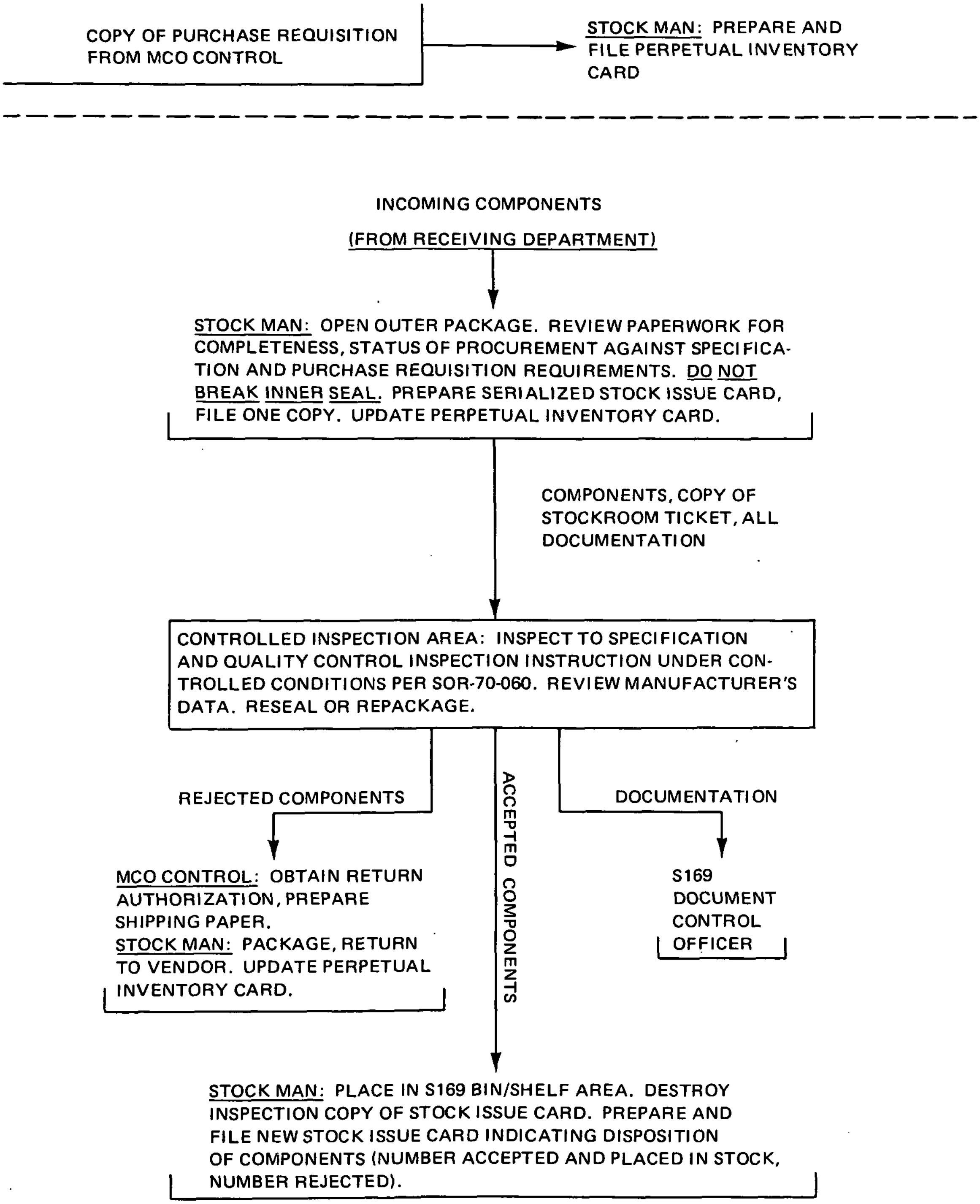
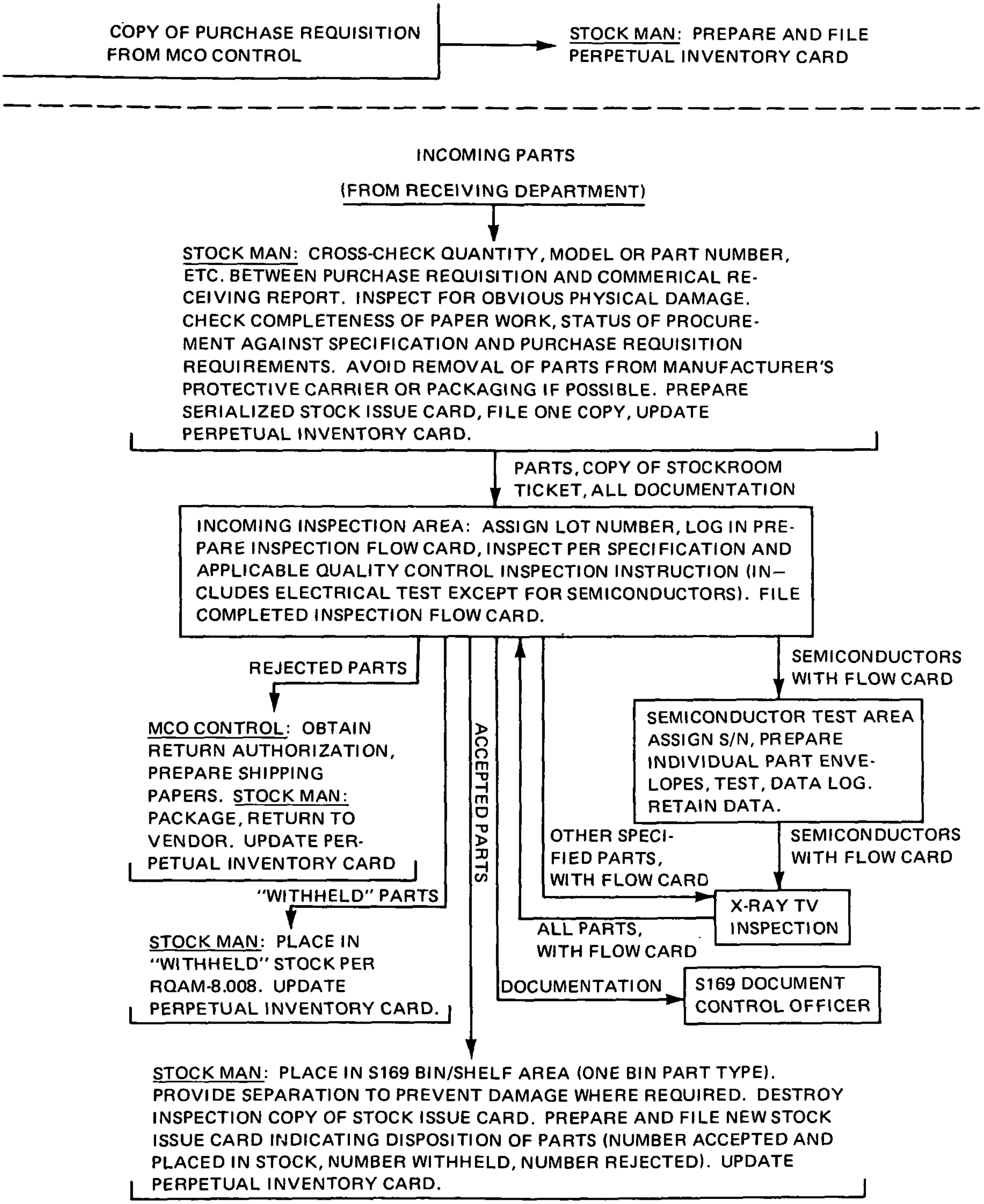


Fig. 21 FLOW OF COMPONENTS UNDER CONTAMINATION CONTROL THROUGH THE CONTROLLED STOCKROOM



COPY OF PURCHASE REQUISITION FROM MCO CONTROL

STOCK MAN: PREPARE AND FILE PERPETUAL INVENTORY CARD

INCOMING PARTS (FROM RECEIVING DEPARTMENT)

STOCK MAN: CROSS-CHECK QUANTITY, MODEL OR PART NUMBER, ETC. BETWEEN PURCHASE REQUISITION AND COMMERICAL RECEIVING REPORT. INSPECT FOR OBVIOUS PHYSICAL DAMAGE. CHECK COMPLETENESS OF PAPER WORK, STATUS OF PROCUREMENT AGAINST SPECIFICATION AND PURCHASE REQUISITION REQUIREMENTS. AVOID REMOVAL OF PARTS FROM MANUFACTURER'S PROTECTIVE CARRIER OR PACKAGING IF POSSIBLE. PREPARE SERIALIZED STOCK ISSUE CARD, FILE ONE COPY, UPDATE PERPETUAL INVENTORY CARD.

INCOMING INSPECTION AREA: ASSIGN LOT NUMBER, LOG IN PREPARE INSPECTION FLOW CARD, INSPECT PER SPECIFICATION AND APPLICABLE QUALITY CONTROL INSPECTION INSTRUCTION (INCLUDES ELECTRICAL TEST EXCEPT FOR SEMICONDUCTORS). FILE COMPLETED INSPECTION FLOW CARD.

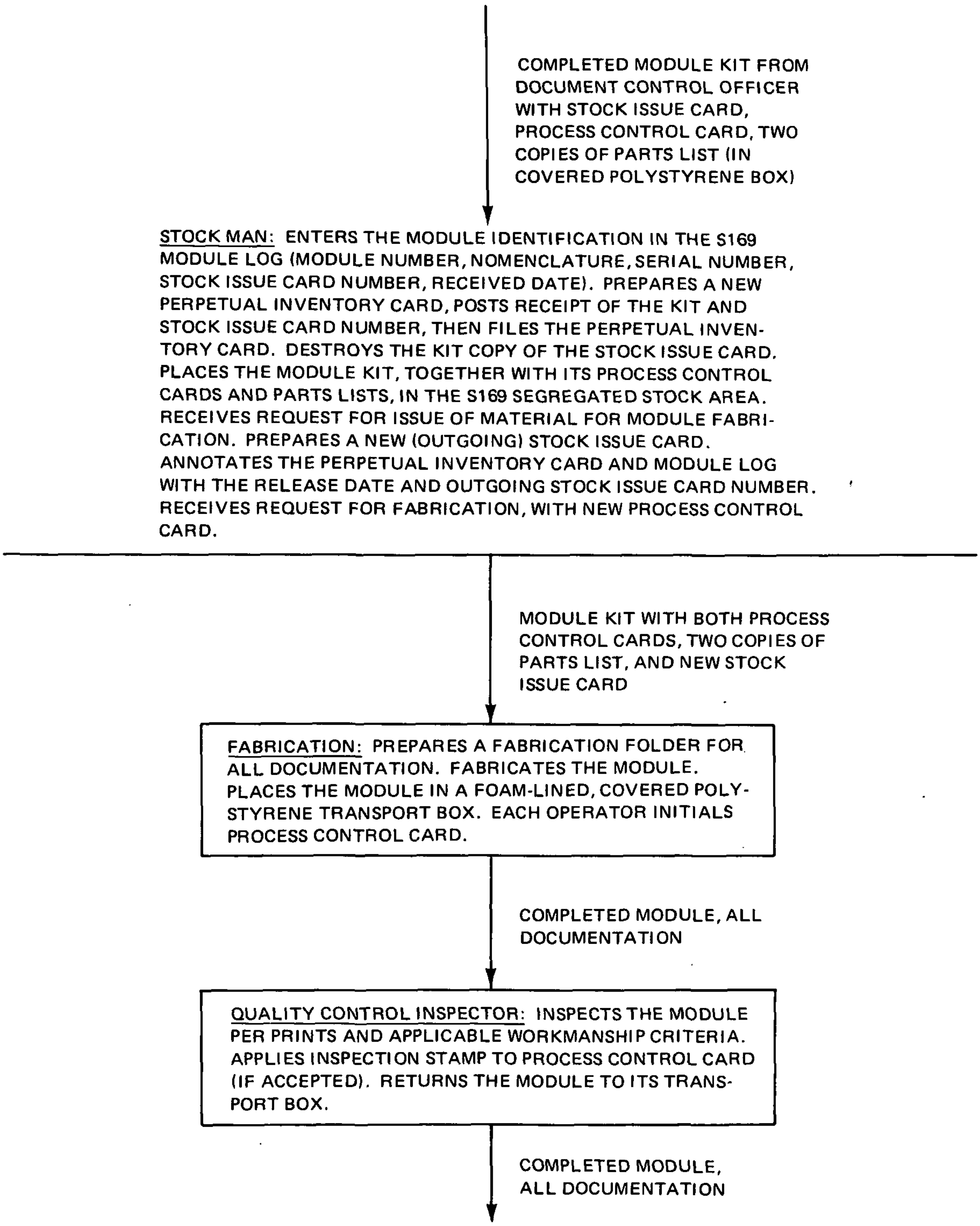
MCO CONTROL: OBTAIN RETURN AUTHORIZATION, PREPARE SHIPPING PAPERS. STOCK MAN: PACKAGE, RETURN TO VENDOR. UPDATE PERPETUAL INVENTORY CARD

SEMICONDUCTOR TEST AREA ASSIGN S/N, PREPARE INDIVIDUAL PART ENVELOPES, TEST, DATA LOG. RETAIN DATA.

STOCK MAN: PLACE IN "WITHHELD" STOCK PER RQAM-8.008. UPDATE PERPETUAL INVENTORY CARD.

STOCK MAN: PLACE IN S169 BIN/SHELF AREA (ONE BIN PART TYPE). PROVIDE SEPARATION TO PREVENT DAMAGE WHERE REQUIRED. DESTROY INSPECTION COPY OF STOCK ISSUE CARD. PREPARE AND FILE NEW STOCK ISSUE CARD INDICATING DISPOSITION OF PARTS (NUMBER ACCEPTED AND PLACED IN STOCK, NUMBER WITHHELD, NUMBER REJECTED). UPDATE PERPETUAL INVENTORY CARD.

Fig. 22 FLOW OF ELECTRICAL/ELECTRONIC PARTS THROUGH THE CONTROLLED STOCKROOM



COMPLETED MODULE KIT FROM DOCUMENT CONTROL OFFICER WITH STOCK ISSUE CARD, PROCESS CONTROL CARD, TWO COPIES OF PARTS LIST (IN COVERED POLYSTYRENE BOX)

STOCK MAN: ENTERS THE MODULE IDENTIFICATION IN THE S169 MODULE LOG (MODULE NUMBER, NOMENCLATURE, SERIAL NUMBER, STOCK ISSUE CARD NUMBER, RECEIVED DATE). PREPARES A NEW PERPETUAL INVENTORY CARD, POSTS RECEIPT OF THE KIT AND STOCK ISSUE CARD NUMBER, THEN FILES THE PERPETUAL INVENTORY CARD. DESTROYS THE KIT COPY OF THE STOCK ISSUE CARD. PLACES THE MODULE KIT, TOGETHER WITH ITS PROCESS CONTROL CARDS AND PARTS LISTS, IN THE S169 SEGREGATED STOCK AREA. RECEIVES REQUEST FOR ISSUE OF MATERIAL FOR MODULE FABRICATION. PREPARES A NEW (OUTGOING) STOCK ISSUE CARD. ANNOTATES THE PERPETUAL INVENTORY CARD AND MODULE LOG WITH THE RELEASE DATE AND OUTGOING STOCK ISSUE CARD NUMBER. RECEIVES REQUEST FOR FABRICATION, WITH NEW PROCESS CONTROL CARD.

MODULE KIT WITH BOTH PROCESS CONTROL CARDS, TWO COPIES OF PARTS LIST, AND NEW STOCK ISSUE CARD

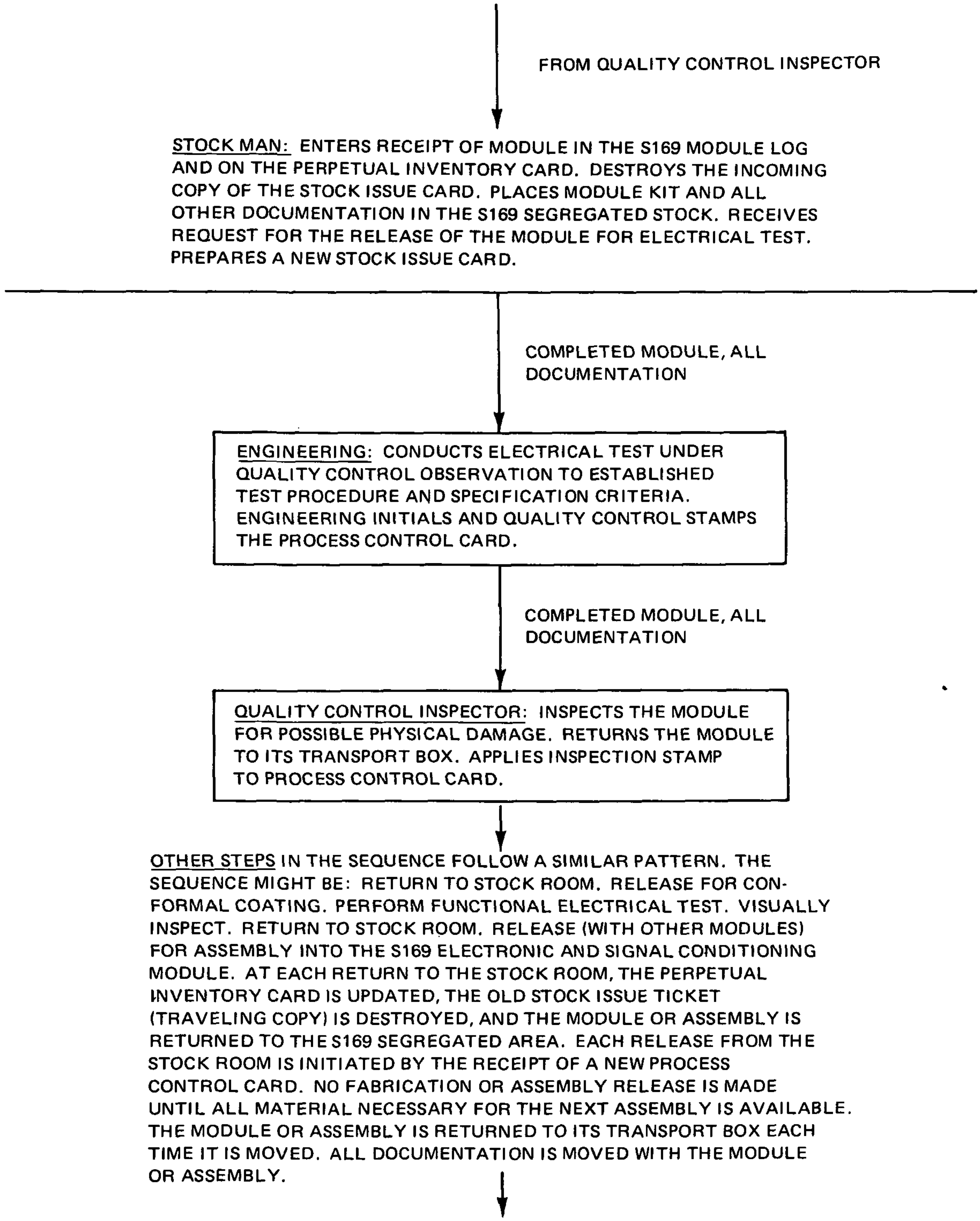
FABRICATION: PREPARES A FABRICATION FOLDER FOR ALL DOCUMENTATION. FABRICATES THE MODULE. PLACES THE MODULE IN A FOAM-LINED, COVERED POLYSTYRENE TRANSPORT BOX. EACH OPERATOR INITIALS PROCESS CONTROL CARD.

COMPLETED MODULE, ALL DOCUMENTATION

QUALITY CONTROL INSPECTOR: INSPECTS THE MODULE PER PRINTS AND APPLICABLE WORKMANSHIP CRITERIA. APPLIES INSPECTION STAMP TO PROCESS CONTROL CARD (IF ACCEPTED). RETURNS THE MODULE TO ITS TRANSPORT BOX.

COMPLETED MODULE, ALL DOCUMENTATION

Fig. 23 FABRICATION FLOW CHART, ELECTRICAL AND ELECTRONIC ASSEMBLIES



STOCK MAN: ENTERS RECEIPT OF MODULE IN THE S169 MODULE LOG AND ON THE PERPETUAL INVENTORY CARD. DESTROYS THE INCOMING COPY OF THE STOCK ISSUE CARD. PLACES MODULE KIT AND ALL OTHER DOCUMENTATION IN THE S169 SEGREGATED STOCK. RECEIVES REQUEST FOR THE RELEASE OF THE MODULE FOR ELECTRICAL TEST. PREPARES A NEW STOCK ISSUE CARD.

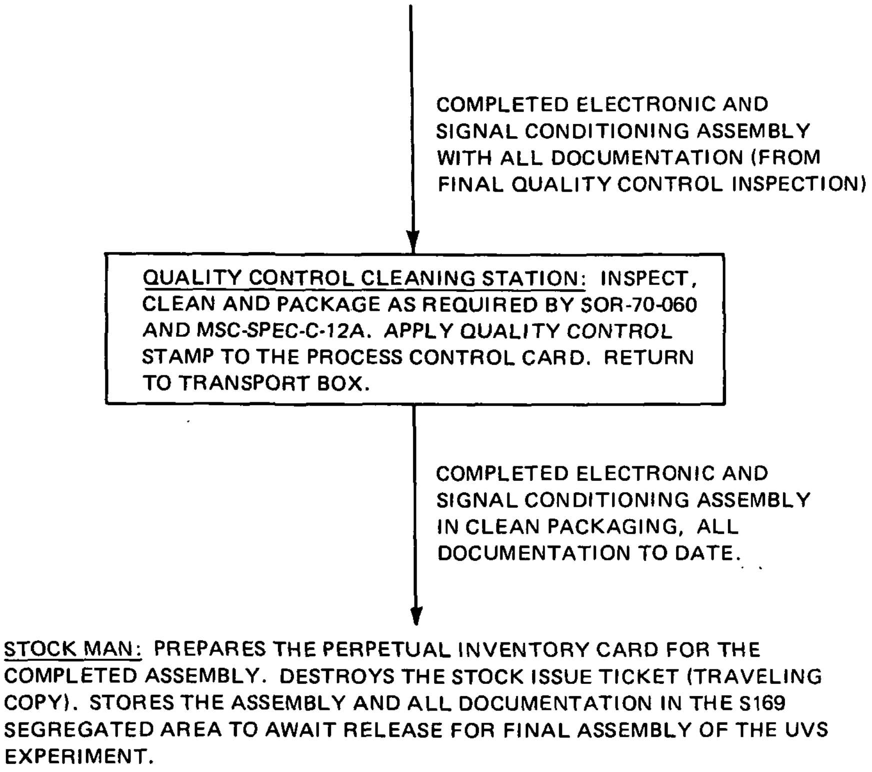
ENGINEERING: CONDUCTS ELECTRICAL TEST UNDER QUALITY CONTROL OBSERVATION TO ESTABLISHED TEST PROCEDURE AND SPECIFICATION CRITERIA. ENGINEERING INITIALS AND QUALITY CONTROL STAMPS THE PROCESS CONTROL CARD.

QUALITY CONTROL INSPECTOR: INSPECTS THE MODULE FOR POSSIBLE PHYSICAL DAMAGE. RETURNS THE MODULE TO ITS TRANSPORT BOX. APPLIES INSPECTION STAMP TO PROCESS CONTROL CARD.

OTHER STEPS IN THE SEQUENCE FOLLOW A SIMILAR PATTERN. THE SEQUENCE MIGHT BE: RETURN TO STOCK ROOM. RELEASE FOR CONFORMAL COATING. PERFORM FUNCTIONAL ELECTRICAL TEST. VISUALLY INSPECT. RETURN TO STOCK ROOM. RELEASE (WITH OTHER MODULES) FOR ASSEMBLY INTO THE S169 ELECTRONIC AND SIGNAL CONDITIONING MODULE. AT EACH RETURN TO THE STOCK ROOM, THE PERPETUAL INVENTORY CARD IS UPDATED, THE OLD STOCK ISSUE TICKET (TRAVELING COPY) IS DESTROYED, AND THE MODULE OR ASSEMBLY IS RETURNED TO THE S169 SEGREGATED AREA. EACH RELEASE FROM THE STOCK ROOM IS INITIATED BY THE RECEIPT OF A NEW PROCESS CONTROL CARD. NO FABRICATION OR ASSEMBLY RELEASE IS MADE UNTIL ALL MATERIAL NECESSARY FOR THE NEXT ASSEMBLY IS AVAILABLE. THE MODULE OR ASSEMBLY IS RETURNED TO ITS TRANSPORT BOX EACH TIME IT IS MOVED. ALL DOCUMENTATION IS MOVED WITH THE MODULE OR ASSEMBLY.

Fig. 23a FABRICATION FLOW CHART, ELECTRICAL AND ELECTRONIC ASSEMBLIES (continued)

]



COMPLETED ELECTRONIC AND SIGNAL CONDITIONING ASSEMBLY WITH ALL DOCUMENTATION (FROM FINAL QUALITY CONTROL INSPECTION)

QUALITY CONTROL CLEANING STATION: INSPECT, CLEAN AND PACKAGE AS REQUIRED BY SOR-70-060 AND MSC-SPEC-C-12A. APPLY QUALITY CONTROL STAMP TO THE PROCESS CONTROL CARD. RETURN TO TRANSPORT BOX.

COMPLETED ELECTRONIC AND SIGNAL CONDITIONING ASSEMBLY IN CLEAN PACKAGING, ALL DOCUMENTATION TO DATE.

STOCK MAN: PREPARES THE PERPETUAL INVENTORY CARD FOR THE COMPLETED ASSEMBLY. DESTROYS THE STOCK ISSUE TICKET (TRAVELING COPY). STORES THE ASSEMBLY AND ALL DOCUMENTATION IN THE S169 SEGREGATED AREA TO AWAIT RELEASE FOR FINAL ASSEMBLY OF THE UVS EXPERIMENT.

Fig. 23b FABRICATION FLOW CHART, ELECTRICAL AND ELECTRONIC ASSEMBLIES (concluded)

Standard, as well as with samples made for obtaining optimum weld setting per Process 7205-9927. Rework, if required, was at the discretion of the Quality Assurance Engineer and the Welding Supervisors.

This document, SOR-71-056, was submitted to MSC for review on 10 September 1971.

The mounting of special parts during the UVS fabrication phase was accomplished in accordance with the requirements published in NASA NHB 5300.4 (3A), and all nondestructive testing of hardware was conducted by using the guidelines established by MIL-STD-271.

Verification of all tests, inspection, and quality documentation adequacy was duly verified by the Government inspection agency; in particular, safety precautions and special handling instructions, test data sheets, and testing summaries and conclusions.

Conclusions. All parameters of reliability assurance as detailed in the contract have been thoroughly exercised during the execution of the UVS Program. The effort described above enhanced the achievement of the contract goals without undue constraint; however, in spite of these elaborate precautionary measures, some failures were experienced. Specifically, the UVS drive motor failed following the 600-hour life test on the qualification unit, although the unit had logged 940 hours of operating time when the failure occurred; and a series of difficulties were encountered with the wavelength cams and associated cam hardware. These events are discussed in later sections describing End Item Development of the qualification and flight units. Another failure, discussed in the section describing mission performance evaluation, occurred on the last mission day before splashdown when two UVS telemetry data functions failed to operate.

All items as regards quality assurance have been completed and no unresolved problems remain. No further action is recommended.

RELIABILITY ASSURANCE (Par. 2.4.2)

Reliability Program Plan. A Reliability Program Plan, incorporating elements of NPC-250-1 applicable to the design and fabrication of the UVS Experiment S169, was prepared to serve as the master planning and control document for the reliability program. The plan provided for specific tasks vital to reliability assurance, some of which were:

a. Reliability program management
b. Reliability program reviews
c. Reliability program control
d. Reliability indoctrination and training
e. Subcontractor and supplier control
f. Reliability engineering
g. Failure mode, effect and criticality analysis
h. Design reviews
i. Failure reporting and correction
j. Standardization of design practices
k. Parts and materials program
l. Testing and reliability evaluation
m. Documentation of reliability program.

The Reliability Program Plan, Revision C, was prepared in accordance with DRL 65, DRD RA-092T and submitted to MSC on 19 May 1971. Figure 24 depicts elements of the APL reliability organization applicable to the UVS Experiment.

Failure Mode, Effect, and Criticality Analyses. A report of the Failure Mode and Effects Analysis (FMEA) and Single Failure Point Summary (SFPS) was prepared in accordance with DRL 66, DRD RA-093T and DRL 67, DRD RA-094T. Issue B of this report (SOR-71-057) was submitted to MSC on 30 September 1971.

The FMEA and SFPS were used to eliminate or minimize hazards to personnel and the UVS instrument, and to enhance the reliability of the instrument through the identification and elimination or reduction of those failure points which, by themselves, could cause the experiment to fail. The FMEA provided the following:

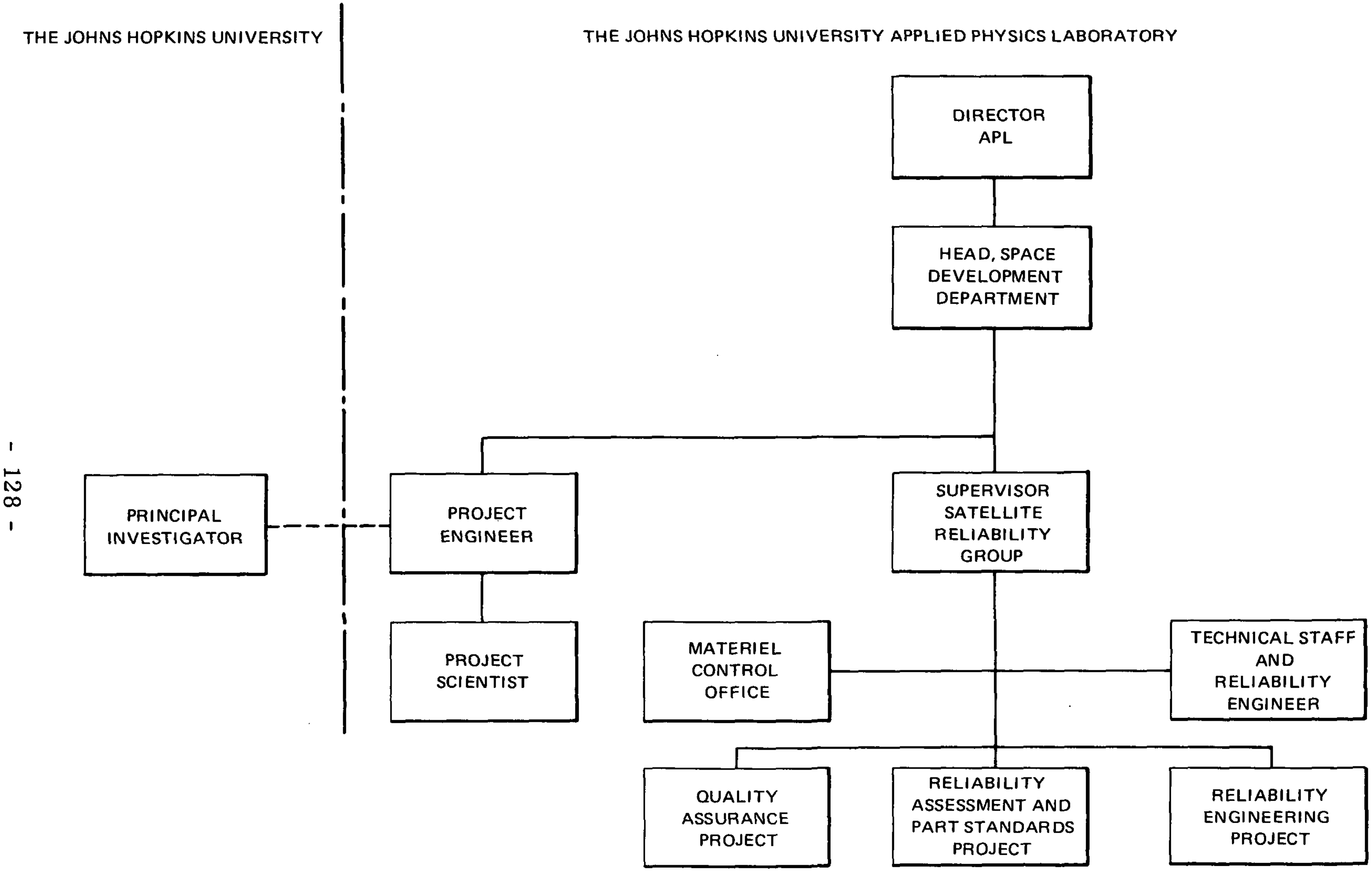


Fig. 24 APL RELIABILITY ASSURANCE ORGANIZATION

a. Assessment of the effects of the failure modes or component, subsystem, systems, and personnel safety

b. Identification of the single failure point modes of the system

c. Identification of the single failure points that directly affect personnel safety

d. A summary of the corrective action to eliminate the single failure points or provide a rationale for their retention

e. A review of the development and qualification test plans and reports for compatibility with the failure modes identified in the FMEA and for detection of possible marginal conditions or unidentified failure modes

f. Updating of the FMEA and SFPS to incorporate design changes and new failure modes.

The following ground rules were used in performing the FMEA:

a. No attempt was made to go below component functional level unless multiple inputs or outputs of a component made it necessary

b. Component failures considered were limited to a single failure occurrence, with one exception, and its single or multiple effects on the system and/or personnel

c. Where redundancy was provided in the system to prevent undesired effects of a particular failure, the redundant element was considered operational and the failure was considered to terminate at this point in the system

d. Where the effects of a failure propagated to a top level of a system to cause the system to fail (or resulted in a personnel hazard) the failure was defined as a single failure point

e. Failure mode criticality categories were determined by the criteria explained in the following pages:

   1. Criticality Category I: A failure which could adversely affect personnel safety
   2. Criticality Category II: A failure which could result in failure of the UVS but could not adversely affect personnel safety
   3. Criticality Category III: A failure which could not adversely affect personnel safety or cause the UVS to fail

f. Reliability logic diagrams were developed for the subsystems to show the functional interdependencies between components of the subsystems so that the effects of potential failures could be readily traced

g. The basic modes of failures considered were: premature operation failure to operate or cease operation at prescribed times, and failure during operation

h. Functional failures, such as blockage of light paths or out of specification operation, were not considered.

Design Review Program. The APL Reliability Engineer assumed an active role in all design reviews, particularly the formal Critical Design Review and the End Item Acceptance Reviews. Reliability data and information were supplied to MSC two weeks prior to the formal CDR including the EEE Parts List, Non-Metallic Materials List, and the FMEA. In-house data available at the review included all other reliability data, e.g., procurement specifications, circuit design trade-off analyses, and the like.

In addition to the formal reviews, APL conducted periodic in-house design reviews. Topics representative of those which were consisered at each review were:

a. Performance requirements for mission success
b. Review of experience, any failures, any degraded performance, and corrective action
c. Changes or improvements
d. Parts drafting
e. Critical parts application
f. Failure modes and effects
g. Noise immunity
h. Power supply effects
i. Environmental effects
j. Failsafe measures
k. Interface interactions
l. Worst case analyses
m. Fault isolation
n. Standardization of design practices
o. Magnetic materials
p. Potting materials

When applicable, and with Laboratory personnel participating, APL invoked the requirement for design reviews on subcontractors. Reporting requirements were implemented as required by the contract.

Failure Reporting and Correction. Whenever a malfunction occurred during the testing of hardware, subsystems, or systems for qualification of flight hardware after the start of formal acceptance testing, APL notified MSC directly within 24 hours and followed with the submittal of MSC Form 2174, Failure Investigation Action Report (FIAR), Copy No. 1, completed through block 27. FIAR s were transmitted to Problem Assessment Engineering at MSC within 48 hours. After isolation of the malfunction and completion of the problem analysis (within two weeks after the failure), Copy No. 2 of the FIAR, completed through block 33 would be forwarded to MSC. Upon completion of corrective action, e.g., design change, procedure change, or the like, Copy No. 3 of the completed FIAR, together with all supporting documentation would be forwarded to MSC Problem Assessment Engineering. Whenever possible, all action was completed, and the final FIAR s were submitted within 30 days of failure occurrence. Twenty-one FIAR's were implemented and submitted to MSC during the development phase of the UVS program.

Testing and Reliability Evaluation. The Reliability Engineer actively participated in the testing of the UVS Experiment. He reviewed and approved the Acceptance and Qualification Test Plans and Procedures and the Acceptance and Qualification Test Reports. In addition, he witnessed all major tests and calibrations, watching for potential failures which may not have been obvious in design reviews or reliability analyses.

In evaluating the UVS Experiment reliability, APL used to the maximum extent possible the experience gained from other space flight hardware programs. Reliability testing of components and critical circuits was conducted where necessary.

Limited Life Program. The UVS Experiment does not contain time/cycle sensitive components, therefore logs and procedures for a limited life program are not required. APL did, however, consider some components as possible candidates for the sensitive list. These are shown in Table 8 in accordance with DRL 72, DRD RA-099T. A historical log, NASA Form 772, was maintained to insure that the synchronous motors remained within the time period specified.

Parts and Materials Program. To assure that each part of the UVS Experiment hardware was of the highest quality, APL maintained a continuing parts control effort. This effort included the selection, evaluation, specification, and application of parts and materials, coupled with receiving inspections as described in the Quality Program Plan. IDEP files were reviewed in the selection of new parts, and NASA Alert were reviewed and implemented throughout the program.

Traceability of all semiconductor devices was maintained from the "as installed" position in the UVS hardware to the original serialized incoming inspection and screening data on the individual part and to the part manufacturer's lot/date code. Traceability of remaining EEE parts was maintained

Table 8

Considered Time/Cycle Sensitive Components List for the Ultraviolet Spectrometer Experiment S169 DRL 72, DRD RA-099T

	Examples of Components Analyzed		
Component and/or Applicable Materials	Time/Cycle (Period/Duration) before Performance Degradation	Handling/Storage Instructions	Remarks
Synchronous Motor and Gearhead Schaeffer Magnetics, Inc. Dwg. No. 100445 Issue A	The unit is to be capable of operating intermittently or continually under the following conditions (cumulative operating time): a. Under essentially a complete vacuum - 1000 hours b. Under room ambinet conditions - 1000 hours	Standard procedures	Since total operating time, with consideration of the environments encountered during testing, has been determined to be considerably less than the time period specified, this component is not considered time/cycle sensitive. Nevertheless, an historical operating log will be maintained to insure that the motors remain within the time period specified.
Photomultiplier Tube EMR Model 542-09-18 Rev	Shelf Life: 10 years min. Continuous operating life: 5 years at room ambient conditions. Start-stop cycles: no limit	Sensitive to He	Actual operating parameters to be greatly less than rated life
Optic Elements	Not affected by time or cycling	Cannot be exposed to hydrocarbon fumes. Cleanliness and humidity precautions very stringent	
Thermal Insulation	Not affected by time or cycling	Qualities impaired if crushed	

to the part manufacturer's lot/date code. The APL Satellite Reliability Group was responsible for the selection, evaluation, and specification of parts and materials used in the UVS Experiment S169 Program. This group provided the designers with technical assistance in the application of parts and materials.

The order of precedence in the selection of parts that was used in APL fabricated experiment hardware was:

a. APL Space Development Department Control Drawings -- The Satellite Reliability Group developed and maintains a preferred parts list for which the control drawings exist. APL accumulated extensive experience with these parts including design evaluation, receiving inspection and test, and operation in orbit. APL vendors are aware of the demand for stringent reliability, quality, and workmanship requirements. The combination of vendor awareness and actual experience created a level of confidence in the procured parts that exceeded that for JAN-TX and at least equaled that for ER parts. The Control Drawings include:

    1. Scope
    2. Intended application
    3. Electrical characteristics
    4. Physical requirements
    5. Marking
    6. 100% screening (NASA General Screening Guidelines for EEE parts was used as a guide)
    7. Notification of changes
    8. Approved source
    9. Data requirements

On the few occasions when delivery of these fully qualified control drawing parts could not be obtained without an unacceptable impact on hardware delivery schedules, the Satellite Reliability Group prepared Procurement Instructions which described in detail the acceptable requirements and waivers. Parts for which Procurement Instructions were issued were reported to MSC by means of EEE Parts List revisions.

b. JAN-TX and MIL-ER Parts -- The Satellite Reliability Group specified the part vendor and identified any additional screening or burn-in necessary to meet the requirements for the NASA General Screening Guidelines for EEE Parts.

c. NASA Preferred Parts Lists (including GSFC and MSFC lists) -- The Satellite Reliability Group generated a Procurement Instruction for the purchase of parts selected from these NASA lists. These documents specified the parts vendor, when possible. Sample parts were disected by the Reliability Group, when necessary, to evaluate the quality of design and workmanship for acceptability for UVS Experiment hardware.

d. Military Specifications -- Prior to the use of MIL-SPEC parts, the Reliability Group would review any test results found in the IDEP files. In addition, sample parts from a particular specified vendor would be disected, when necessary, to evaluate the quality of design and workmanship for acceptability in the UVS Experiment hardware. Further testing to establish part qualification was conducted on a case-by-case basis. To purchase these parts, a Procurement Instruction was prepared to include specification of the manufacturer, requirement for 100% screening (including burn-in by the manufacturer), and reference to the MIL-SPEC.

Parts and materials applications, including derating, were the primary responsiblity of the design engineers. The Satellite Reliability Group reviewed and approved all parts and material lists and provided technical assistance to the design engineers for parts and materials applications and deratings. The NASA General Derating Guidelines for

EEE Parts was used as a guide. All reliability data have been maintained and made available for MSC review upon request. A Parts Application Review Report, DRL 79, DRD RA-106T (SOR-71-077) was submitted to MSC for review two weeks prior to the CDR.

A EEE Parts List was prepared in accordance with DRL 78, DRD RA-105T, submitted to MSC for review on 5 April 1971, and subsequently revised to Revision E on 24 February 1972. A nonmetallic material list, DL 76, DRD RA-103T, was submitted to MSC for approval two weeks prior to the CDR. These documents were updated as design changes dictated.

Reliability Documentation. Appropriate data and records associated with the UVS reliability program were maintained throughout the life of the contract. Documentation was submitted to MSC in accordance with the schedule shown in Table 9.

The progress of the reliability program was included as a separate item in the Monthly Program Progress Report under DL 81, DRD RA-108T.

Conclusions. All parameters of reliability assurance as detailed in the contract have been thoroughly exercised during the execution of the UVS Program. The effort described above enhanced the achievement of contract goals without undue constraint. All items as regards reliability assurance have been completed and no unresolved problems remain. No further action is recommended.

OPERATIONS (Par. 2.5)

Operation Control. The UVS Program Project Office maintained constant surveillance and control of the entire program for the duration of the contract. This included, at the minimum, engineering, design, design reviews, procurement, quality assurance, reliability, liaison, fabrication, test, qualification, documentation, packaging, delivery, etc.

Table 9

Required Reliability Documentation

Item	Document	Documentation Type	Schedule
1	Failure Mode, Effects and Criticality Analysis, and Single Failure Point Summary	IA	Preliminary at 10% design completion. Final 15 days prior to CDR
2	List, EEE Parts Usage and Revisions	II	Submitted 5 April 1971. Revisions to reflect current usage
3	List, Nonmetallic Materials	IA	Two weeks prior to CDR. Revisions to reflect current usage
4	Report, Failure Investigation Action	II	Initial report 48 hours after failure, analysis within 14 days, closeout within 30 days. Telephone notification within 24 hours after occurrence. Failures reportable after start of acceptance testing
5	Report, "Alert" Response	II	Within 30 days after "Alert" notification
6	Report, Reliability Progress	II	With monthly program progress reports
7	Report, EEE Parts Derating	II	Submitted 26 April 1971
8	Report, Part Application Review	III	Two weeks prior to CDR

Tools used to accomplish the above consisted of:

a. Good management practices that had been developed for other APL space programs

b. The Configuration Management Office which used existing data retrieval programs and maintained constant configuration control by continuous monitoring and audits

c. Control of data management through the use of data storage and retrieval systems already established at APL

d. Operational support supplied in a manner indicative of the UVS Program organization, Fig. 1. At the minimum, this consisted of engineering, fabrication, system and test, coordination, electronic and mechanical design, quality and reliability, budgets and schedules, and status reporting

e. Milestone charts, status charts, graphs, and other visual guides were maintained. Existing facilities and equipment were used wherever possible. Make or buy decisions were made by the UVS Project Office. Cost, schedule, and technical capability were elements considered prior to the making of such provisions.

Conclusions. The effort described above provided for adequate conformance with the specific tasks required by the contract. All items have been completed and no unresolved problems remain. No further action is recommended.

MANUFACTURING AND FACILITIES (Par. 2.6)

Design and Development Plan. The Design and Development Plan for the Ultraviolet Spectrometer Experiment S169, DRL 37, DRD SE-174T, (Appendix to SDO/CMO-24) provided for the implementation of the tasks required by this section of the contract. The incorporation of this plan assured such disciplines as manufacturing and process control interfaces, reliability, maintainability, quality control, and configuration management functions leading to the final acceptance testing of the end items.

Conclusions. All parameters of manufacturing and facilities as outlined in the contract have been thoroughly exercised during the execution of the UVS Program. The achievement of contract goals was enhanced by this prescribed effort. All items as regards manufacturing and facilities have been completed, and no unresolved problems remain. No further action is recommended.

CONTRACT END ITEM DEVELOPMENT (Par. 3.0)

General Description. The UVS Experiment S169 design was originally derived from the extensive experience of the Principal Investigator and coexperimenters in the development of a variety of Ebert scanning monochrometers for experiments aboard rockets, satellites, and interplanetary vehicles. Several features of the Apollo UVS represented advances in design and performance with respect to the earlier flight spectrometers. These are:

a. A multiple angled external entrance baffle to reduce scattered light impingement on the photomultiplier tube (PMT)

b. A photoelectron data system that provided a wide dynamic range and a limit of detection dictated by dark current noise pulses emitted by the PMT

c. An image tripling mirror system at the exit slit to increase the sensitivity of the spectrometer.

The net result of these features provided an instrument with a sensitivity of at least one order of magnitude improved over Ebert systems previously used in space experiments, and exhibited greatly improved scattered light characteristics.

The mechanical design of the instrument was modular to provide for simplified assembly and subcomponent interchangeability. These modules, shown in Fig. 25, are described briefly as follows:

a. The baffle, or sunshade, contained rectangular baffle plates that formed a rectangular, pyramid shaped field-of-view to minimize the effects of scattered radiaion.

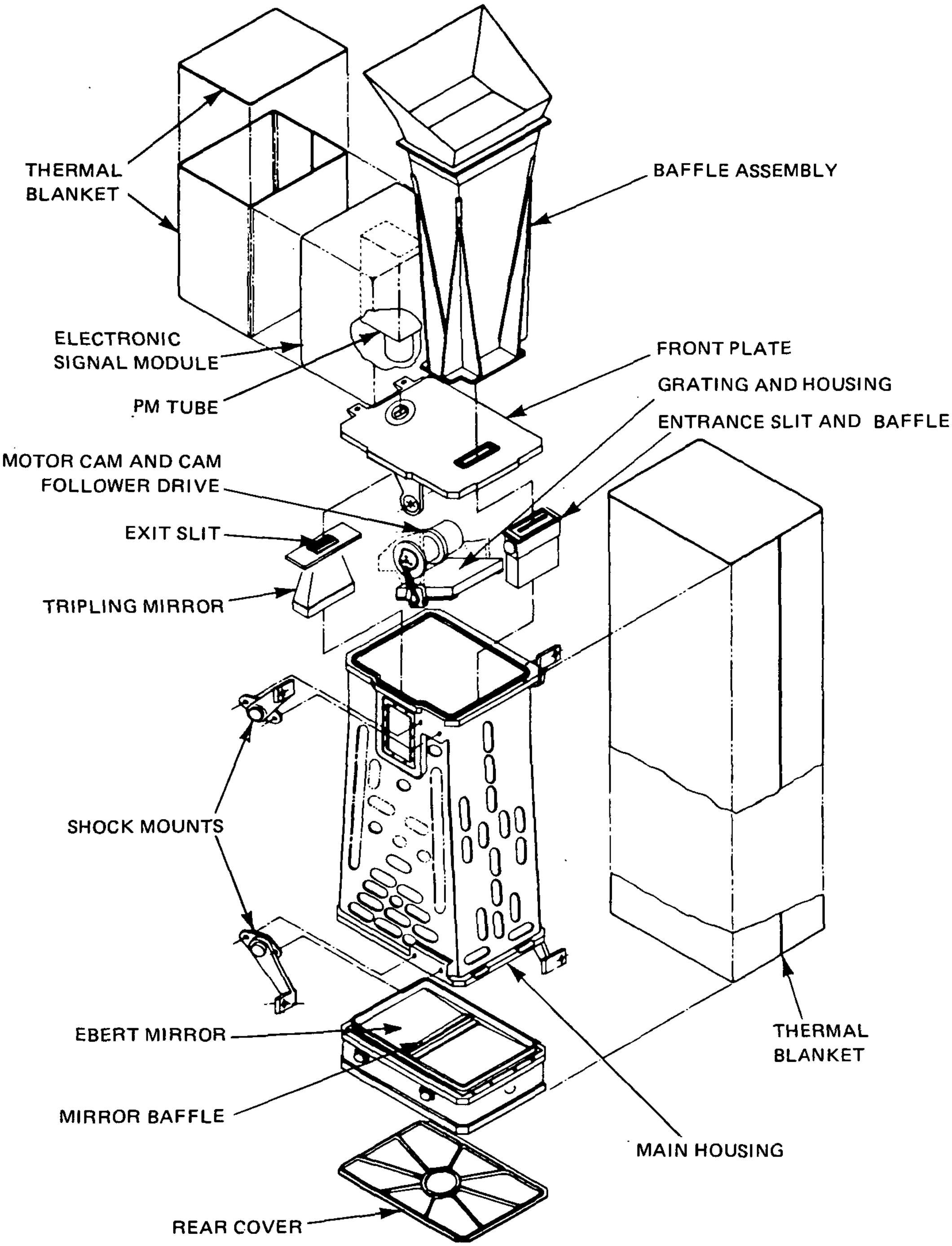


Fig. 25 ULTRAVIOLET SPECTROMETER EXPERIMENT S169

b. The electronics module contained an integrated PMT, a pulse amplifier and discriminator, a high voltage supply for the PMT, a low voltage DC/DC converter, pulse counting circuitry, and telemetry preconditioning circuitry. The electronics module contained the electrical connectors which interfaced with the spacecraft system and with the ground support equipment.

c. The front plate served as a mounting base for the baffle, electronics housing, the entrance and exit slits, inner baffles, image tripling mirrors, and diffraction grating with its associated motor driven scan mechanism.

d. The main housing was a machined aluminum casting that served as a light-tight box for the optical system and supporting structure for the other UVS modules. The main housing provided interfaces with the scientific instrument module (SIM) through four shock isolating mounting brackets on the sides of the casting. The housing was bolted to the NR bracket through a bolt hole located in each mounting bracket.

e. The Ebert mirror was mounted in a separate machined housing that bolts to the aft end of the main housing.

f. The Ebert mirror was divided into input and output halves by a light baffle strip. The input half acted as a collimator to provide parallel light incident on the grating, and the output half focused the diffracted light from the grating onto the exit slit. The mirror housing was made light tight with a thin machined cover.

g. As an assembled single package, the UVS was completely enclosed within super-insulation blankets, except for the baffle, front plate, interface connectors, and mounting points. The blankets were made of layers of aluminized Mylar and and Kapton sheets.

The overall instrument maximum envelope, the location of the interface connectors, and the location and dimensions of the four mounting points which interface with the NR bracket were described in Interface Control Document (ICD) MH01-12460-134.

The baffle was a multiple angled, rectangular shaped assembly approximately 19 inches long. The assembly consisted of four machined aluminum plates riveted together at the corners. The plates were machined with $\frac{1}{2}$-inch-high thin fins spaced $\frac{1}{2}$-inch apart. The plates were riveted together with the fins internal to form a rectangular, pyramid shaped field-of-view for the entrance slit. The field-of-view was approximately 12° x 12°. The second angular section was 17° x 17°, and the third angular section was over 35°. The angle change in the second and third sections was made to prevent reflected light from entering directly into the entrance slit. Scattered light could not reach the entrance slit without reflecting from one side of the baffle to the other many times, thereby reducing the reflected light intensity. The second and third sections did not have fins. The inner and outer surfaces were smooth, and the outer edges were rounded. This was done to protect the astronaut from possible clothing damage during extra vehicular activity (EVA). The baffle was supported by right-angle stiffeners at the four corners which were bolted to a mounting plate at the entrance slit end. The internal portion of the baffle was painted black to reduce light reflection. The entrance baffle was physically connected, both thermally and electrically, to the front plate by six aluminum buttons with through bolts. The external surface was coated with a special white paint having an α/ϵ of 0.21/0.85. Thereby, the baffle was the primary radiator and absorber of heat energy since the remainder of the UVS was insulated from its environment.

The housing consisted of an aluminum casting weighing approximately 10.3 pounds and machined to section thicknesses compatible with reasonable stress levels and thermal considerations. The aluminum alloy was 356-T6, which was selected because of its extreme dimensional stability, ease of machining, high strength, and suitability for optical coating.

Components considered integral to the front plate after mounting were the exit slit mirrors, and the inner baffle over the entrance slit. The entrance and exit slits were slots machined approximately 0.078-inch wide by 2.24 inches long and 0.078-inch wide by 0.090-inch long, respectively.

The inner baffle, a 0.050-inch-thick rectangular aluminum tube, had small fin sections to reduce scattered light and admit only the direct rays in the field-of-view to the input half of the mirror, It also had a black finish. The exit slit mirrors, made of Cervit coated with aluminum, were mounted on aluminum brackets at the ends of the exit slit. The exit mirrors were about 0.2-inch thick, approximately 4.52 inches long, and trapezoidal in shape; the ends being about 1.25 and 0.50-inch wide.

The grating mechanism provided a means for cycling the grating through a wavelength range of 1180 to 1680Å. It consisted of a motor and gear reducer drive, cam, cam follower, grating housing, reflective diffraction grating, and fiducial mark detector. All were supported from the front of the housing by two integrated mounting brackets machined on the front plate.

A synchronous motor and gear reducer unit, which required approximately 2.5 watts at a frequency of 100 Hz, would drive a cam in one direction at a uniform rate to repeat the wavelength scan cycle once every 12 seconds. The radius of the cam groove, as a function of the angle of rotation, controlled the wavelength scan profile as a function of time. The cam was machined with a groove to retain and prevent the cam follower from damaging the cam because of vibration-induced chattering during Apollo launch.

The fiducial mark detector consisted of a small slit in the cam through which infrared light, emitted by a gallium arsenide light source, could pass to a phototransistor detector. The fiducial mark indicated the end of scan and its output synchronized the word format.

The cam follower was fastened to the shaft which rotated the grating through an angle of 5°. The angular relationship between the cam follower and the normal to the grating was adjustable. The adjustment was made with the aid of a theodolite to set the grating angular position to match the precise relative position of the cam follower to 1215.65Å.

The grating was supported within a machined aluminum mount having an integral shaft which served as the axis about which the grating rotated. The grating was positively located within the mount by (a) three Kel-F locator pads (one adjustable) bearing aginst its back, (b) pairs of adjustable Kel-F locator pads bearing against the four sides, and (c) three Kel-F locator pads bearing against the front surface opposite the rear surface locator pads. The locator pads were so adjusted that the grating rulings were positioned parallel with the axis of the grating shaft. It was further required that the grating rulings be parallel to the slits, which was achieved by maintaining close tolerances on the mechanical parts. The finished grating blank was approximately 4 inches wide by 4 inches long by 0.63 inch thick. The material was Cervit.

The Ebert mirror was also made of Cervit and coated on its polished surface with aluminum and magnesium fluoride. The finished blank dimensions were approximately 9.25 inches long by 6.30 inches wide by 1.80 inches thick, with a spherical radius of 39.37 inches. The mirror surface was separated into two halves by a baffle strip approximately 0.9-inch wide. The back of the mirror was of ribbed design to allow weight reduction without compromising structural strength. All edges of the mirror were chamfered. The mirror was mounted in the end of the main structure with the mirror face positioned against three Lexan mounting points, all of which were adjustable in length to provide focus and alignment capability.

The structural design of the UVS involved the determination of the acceleration response of the structure and internal components under dynamic environments of rocket lift-off and sustained space flight. The lift-off environment dictated both sinusoidal and random excitations of shock and vibration. The space flight environment consisted of sustained vibrations and severe levels of pyrotechnic shock resulting from the SIM bay door separation. Particular attention was given to such design parameters as mounting the UVS system configuration and adequate support of the internal optical system and its associated mechanism so as to avoid motion during vibration resonance.

The optical design of the UVS was that of an Ebert spectrometer whose optical components consisted of an external baffle, entrance slit, Ebert mirror, scanning diffraction grating, exit slit mirrors, exit slit, and photoelectric sensor. Figure 26 is a sketch of the UVS optical system.

The external baffle may be described as a multiple angled horn designed so that light originating from sources outside the specified field-of-view was greatly attenuated because of multiple reflection before passing through the entrance slit. Figure 27 is a sketch of the UVS external baffle.

The Ebert mirror collimated the radiation admitted by the entrance slit, redirected the radiation onto the diffraction grating, and refocused the diffracted radiation onto the exit slit. The specified entrance and exit slit dimensions, and the Ebert mirror dimensions were designed to maximize the energy throughput. The inclusion of the exit slit mirrors reduced optical vignetting to virtually

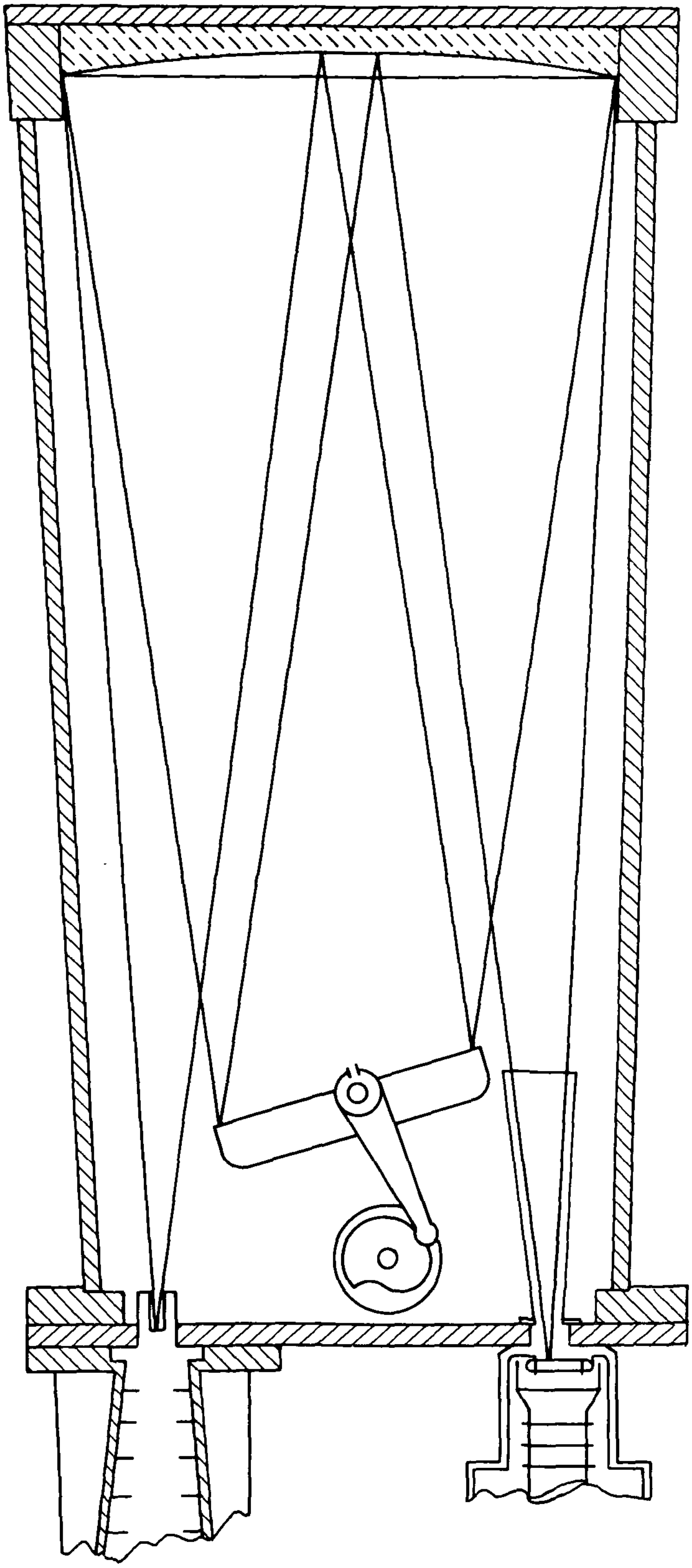


Fig. 26 UVS OPTICAL SYSTEM

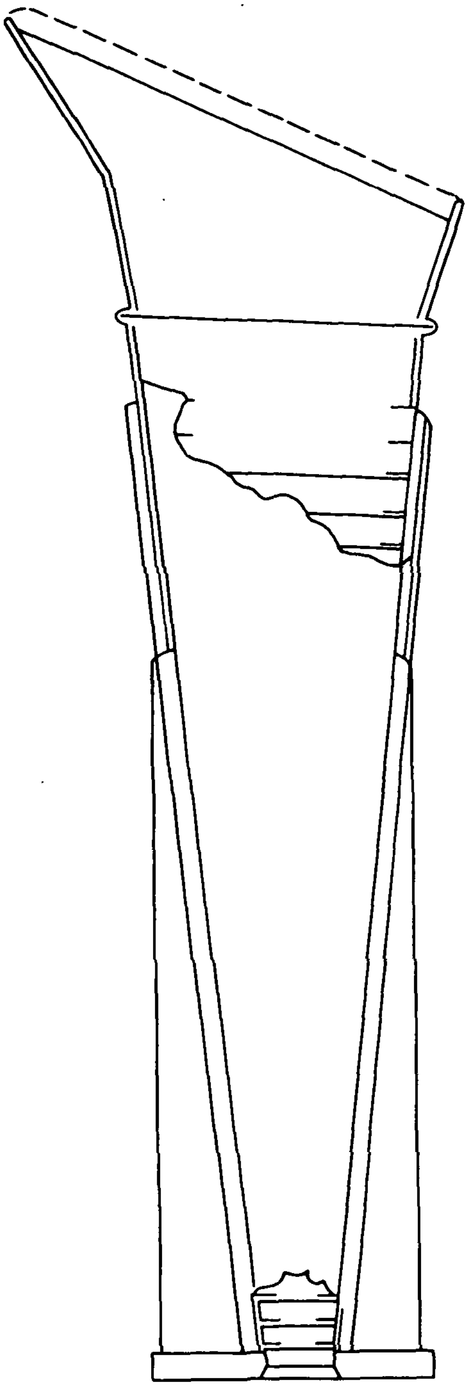


Fig. 27 UVS EXTERNAL BAFFLE

zero. Beyond that, the highest available reflectivity coatings were specified on all reflecting surfaces. The baffles served to reduce scattered light from entering the spectrometer.

Figure 28 is a block diagram of the electronics system for the UVS. It shows those functions directly associated with the scientific data gathering system such as the photomultiplier tube, pulse amplifier and discriminator, counting circuits, timing circuits, and the output register. Also shown are ancillary functions such as power supplies, electronic circuit breaker, housekeeping electronics, motor drive electronics, and buffer amplifiers. The electronics system was designed to meet all interface requirements as described in Interface Control Document (ICD) MH01-12462-234.

Scientific data gathering originated at the PMT. An EMR 542G-09-18 tube was selected for this function because of its large cathode area, low dark current, high gain (nominally 10^6), and proven reliability in aerospace applications.

A digital counting system followed the PMT. Outputs from the photomultiplier, which consisted of approximately 10 ns pulses of 10^5 to 10^7 electrons, were processed by the pulse amplifier and discriminator (PAD). The PAD integrated each pulse, amplified it sufficiently, and provided threshold discrimination. Pulses with energies above the selected threshold generated a standardized pulse for further counting. Pulses below the predetermined threshold of $\approx$ 3 mv were rejected. A threshold discriminator drove a one-shot multivibrator that generated the standard pulse to drive the counter. The one-shot had a pulse width of about 0.8 μs, and a dead time of about 0.8 μs. Thus, for every 10 ns input pulse greater than the selected threshold, a standardized 0.8 μs (approx.) pulse was generated, except for the situation where input pulses would arrive closer than 1.6 μs, at which time the system became overloaded. Thus, the maximum periodic rate at which the system counted was approximately 625,000 pulses/second.

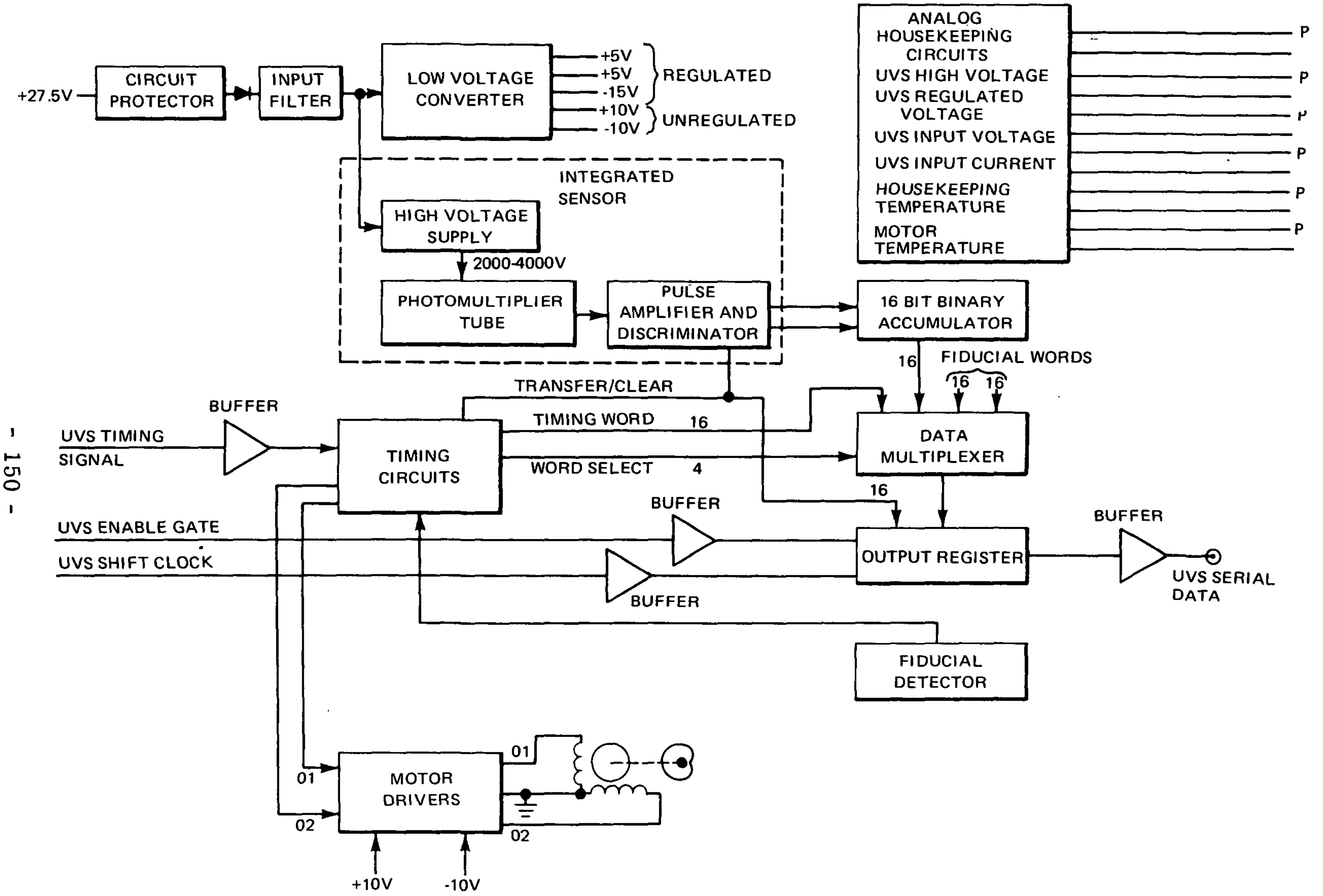


Fig. 28 BLOCK DIAGRAM FOR UV SPECTROMETER

Because the generation of photoelectrons occurred at random times, the system became nonlinear; however, this nonlinearity affected only the result at high count rates. The recorded count differed by the actual number of photoelectrons as given by:

$$n \approx \frac{\bar{n}}{1 - \bar{n}\tau} ,$$

where:

n = the actual count rate,

$\bar{n}$ = the recorded count rate, and

τ = the total rest time (approximately 1.6 μs).

The output from the PAD was counted by the 16-bit accumulator. The accumulator counted the 0.8 μs pulses for a 0.1 second period. At the end of each 0.1-second period (as defined by the timing circuits) the accumulator transferred its data to the output register and was cleared, to prepare it for counting during the next 0.1-second count period. The clear operation and the data transfer would take place in less than 30 μs, therefore causing negligible loss in the accumulator count period. Data transfer to the output register would take place via the data multiplexer. It should be noted that use of a 16-bit accumulator allowed the digital electronics to accumulate 65,536 pulses every 0.1 second, while the PAD could generate only approximately 62,500 pulses/0.1 second. Thus, the system could not overflow to cause ambiguities in the data.

The data multiplexer normally transmitted scientific data in the accumulator to the output register. During the cam flyback time, however, the multiplexer inserted special fiducial words into the output register. The cam flyback time was approximately 0.5 second. This means that five 16-bit words could be transmitted in that time. All five special words were initiated by the detection of a fiducial mark located on the cam. The mark was located on the cam at the end of scan position.

Words 1 and 2 formed a special fixed pattern, selected because such a pattern could not occur naturally in the data pattern. Word 3, called the scan period word, recorded the number of 2.5 ms intervals occurring between fiducial marks. This was nominally 12 seconds; hence, the word would nominally record 4800 counts. Words 4 and 5 were also special sync words. Words 4 and 5 were identical to words 2 and 1 respectively.

The output register was a 16-bit parallel-to-serial register. Data were entered in parallel via the data multiplexer at the end of each 0.1 second accumulation period. Upon arrival of the UVS enable gate and the UVS shift clock, the data were then serially shifted to the UVS data output line via the buffer amplifier as shown in Fig. 28. Specific electrical characteristics of the data system and the data format were described in detail in the Electrical Interface Control Document.

The timing circuits controlled the accumulation period and the transfer of all data to the output register. Proper data word synchronism with the wavelength scan system was accomplished by the fiducial mark detector. Generation of two-phase square wave, required for the motor drive electronics, was also accomplished by the timing circuits.

The system was designed so that all counting of photoelectrons must be synchronized with the grating position to establish the wavelength reference. Thus, the fiducial mark detector signal was used to synchronize a divide-by-40 counter once during each 12-second scan. The divide-by-40 counter was driven from the 400-Hz UVS timing signal, and generated the 0.1-second intervals for the accumulator. Thus, the accumulator counting circuits were maintained in synchronism with the grating drive system.

The sync, word code (words 1, 2, 4, and 5) was also generated by the timing circuits, upon the arrival of the fiducial pulse. The code was generated and injected into the data stream via the data multiplexer. The special timing word (word 3) was also injected into the data stream by the timing circuits. This word was generated by a 16-bit counter that recorded the number of 400-Hz pulses between fiducial marks. This number gave information on any possible variations of motor speed.

Since the hysteresis synchronous motor required a two-phase 100-Hz square wave drive, the timing circuits used the 400-Hz timing reference to generate the motor drives. Flip-flop circuits, appropriately gated, accepted the 400-Hz signal and divided it into two 100-Hz square waves having a phase relationship of 90°.

The fiducial mark detector consisted of a solid-state light-emitting diode and a photo transistor, followed by a comparator and one-shot multivibrator. The diode emitted light to the photo transistor via a 0.01 inch slot in the cam. Output from the photo transistor was amplified and used for triggering a one-shot multivibrator. The fiducial mark detector synchronized the divide-by-40 counter in the timing system. Thus the electronic data system was synchronized with the wavelength scan. The fiducial mark was positioned so that it could be generated at the beginning of the flyback period.

The hysteresis synchronous motor required a 100-Hz, two-phase, square wave drive. The frequency and phasing were derived from the 400-Hz UVS timing signal and generated by the timing circuits. These signals were utilized to synchronize the motor drive circuits. Both motor drive circuits consisted of push-pull transistor drivers, operating from the ±10 volt unregulated supplies. Use of push-pull square wave drive allowed the system to run at high efficiency and kept losses in the drive circuits low.

The housekeeping electronics generated six analog telemetry functions. The circuits consisted of integrated operational amplifiers to serve as buffers between the SDS analog system and the primary sensors. For the bus voltage function, resistor scaling circuits were used to drive the output operational amplifiers. The bus input current was measured by differentially sensing the voltage across a resistor inserted in series with the 28 volt DC return. Two temperature measurements were made by sensing the voltage across a thermistor-resistor bridge network driven by a precision voltage reference. All telemetry function outputs were 0 to 5.0 volts full scale and had source impedances in accordance with the electrical ICD.

A current sensing device was provided to limit the 28-volt bus current delivered to the UVS should an electrical failure occur in the UVS. A solid-state switch would open the 28 volt bus in approximately 5 ms should the current exceed the 1.5 ampere limit. The circuit breaker would reset automatically should bus power be removed and reapplied.

The UVS DC/DC converter converted CSM bus power (28 volt) to +5, +15, -15, +10, -10 volts, which supplied all the electronics except for the photomultiplier tube high voltage. Power delivered to the converter by the CSM during normal UVS operation was 6.8 watts at 27.5 volts. The ±15, -15, and the +5 volt lines were regulated; the ±10 volt line was unregulated. The system was suitably shielded and filtered to satisfy the required EMI specifications.

The high-voltage supply was physically integrated with the PAD and the photomultiplier tube. It consisted of an oscillator and a Cockroft-Walton multiplier network to step up the voltage to 2000 to 4000 volts DC. Voltage adjustment of the supply was provided to allow for gain control of the photomultiplier tube. The integrated high-voltage supply was completely encapsulated to minimize high-voltage corona problems.

The thermal control system for the UVS was basically passive during most of the mission. An exception was the baffle door which was controlled from the CM to protect the instrument during RCS jet firings. Of three design approaches that were investigated, the thermal configuration using the baffle as the main thermal radiator proved to be best. The remainder of the instrument was covered with multilayer insulation.

The Ultraviolet Spectrometer Master Schedule, given in Fig. 29, indicates the base line schedule to which the program was paced.

UVS High-Fidelity Mockup Training (Hi-Fi) Unit. A mockup of the UVS flight hardware, CEI 7232-0080-HF-1, was specified, fabricated, and accepted by MSC for Apollo 17 mission training purposes. The mockup met all of the requirements of the UVS instrument external dimensions, tolerances, form, fit and function in all areas affecting flight crew member interfaces and performance.

A subcontract was let to Ray Lee Machine Co. in January 1971 for the mechanical design and fabrication of the spectrometer mechanical hardware, such as the main housing, baffle, grating mount, mirror mounts, etc. After these component parts became firm, fabrication and assembly of the Hi-Fi unit was begun in conformance with the APL assembly drawing number 7232-0080. The unit was also designed to meet the requirements as specified in ICD MH01-12460-134, CSM/UV Spectrometer Envelope/Installation, to assure proper interface between the systems and equipment adjoining, around, and associated with it.

Ray Lee completed the baffle assembly and the main housing casting in August 1971. APL fabricated a dummy electronic package, a handling fixture, and thermal blankets. Final assembly of the Hi-Fi unit was begun upon completion of the simulated shock mounts. After the unit was completed and inspected, APL subsequently made the following adjustments:

a. The raw edges of the thermal blankets were sealed with aluminized Kapton
b. The restraining chain on the J3 receptacle cover was covered with plastic tubing

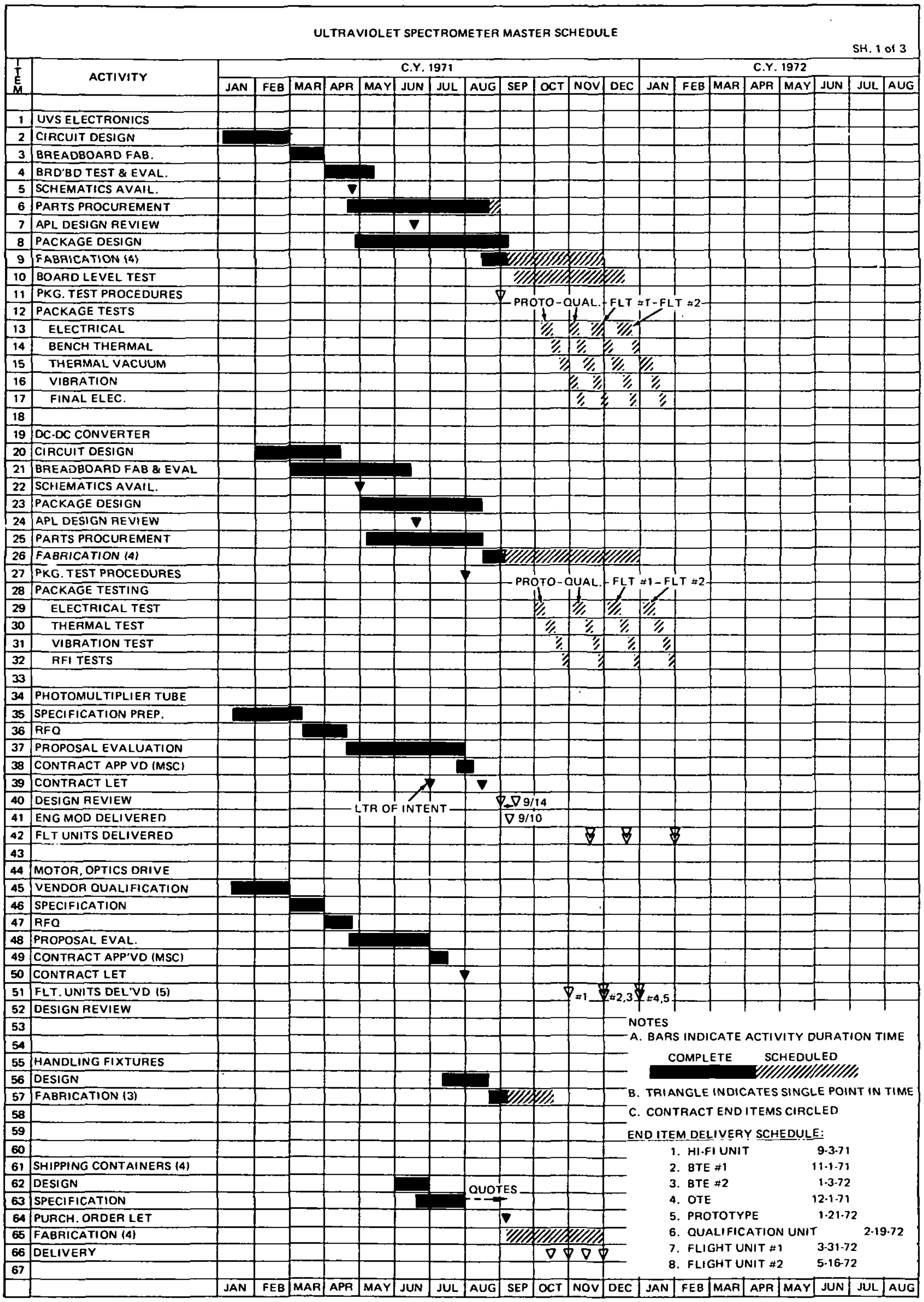


Fig. 29 ULTRAVIOLET SPECTROMETER MASTER SCHEDULE

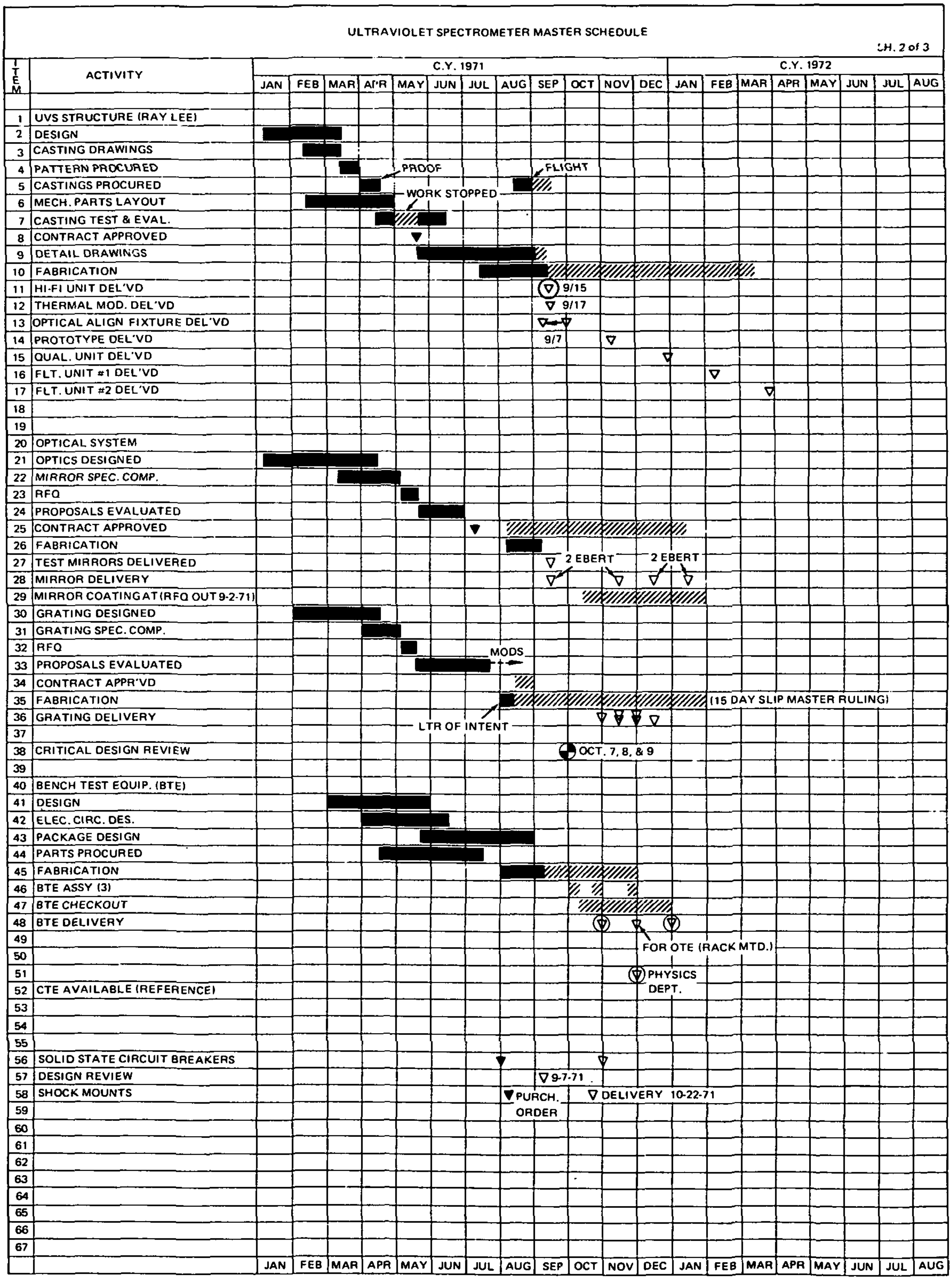


Fig. 29a ULTRAVIOLET SPECTROMETER MASTER SCHEDULE (continued)

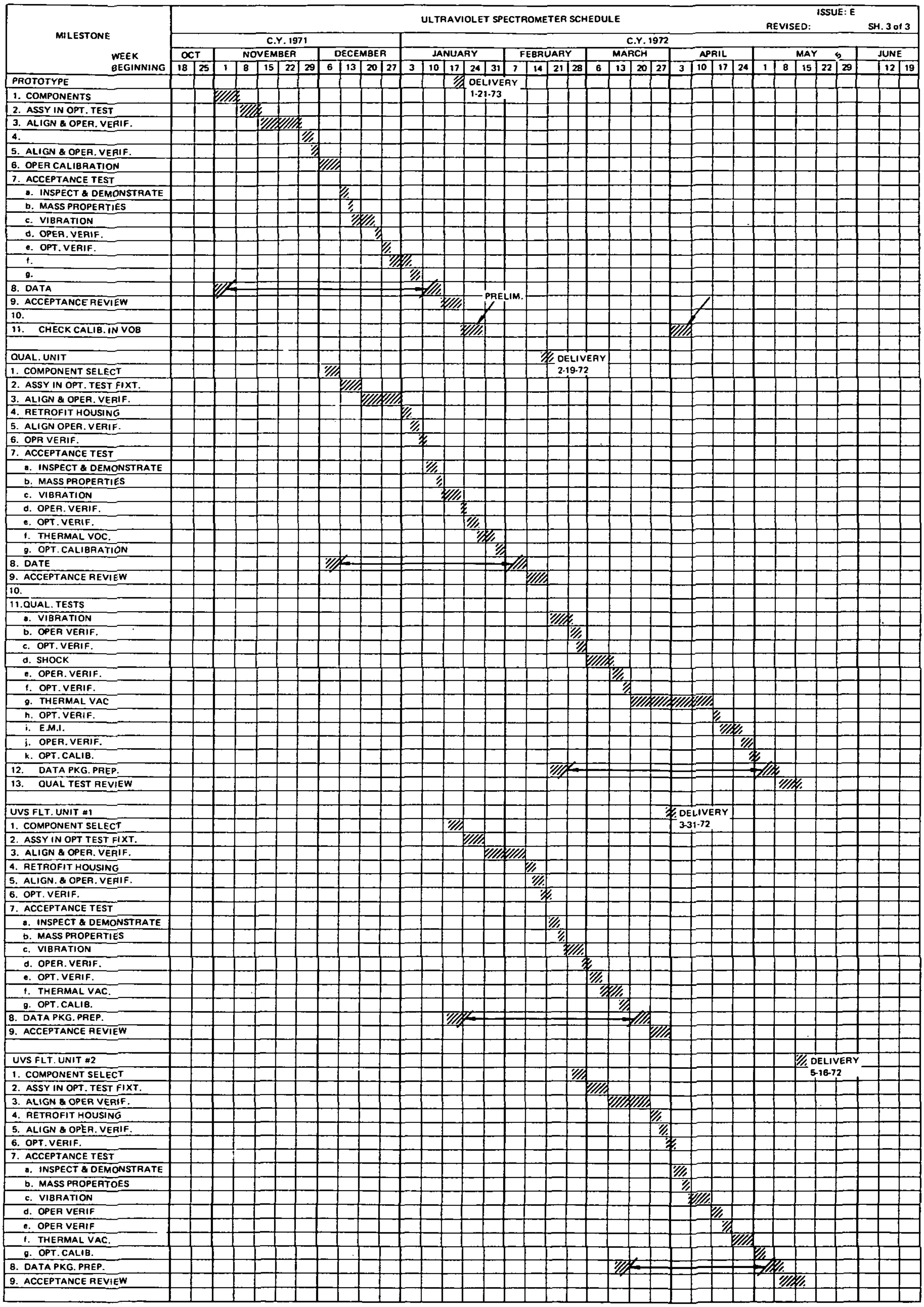


Fig. 29b ULTRAVIOLET SPECTROMETER MASTER SCHEDULE (concluded)

c. The grounding straps were shortened
d. The front plate was painted white with PV100.

Engineering Change Notices (ECNs) to cover these items were duly prepared and processed.

Figure 30 shows the High Fidelity Mockup.

The High-Fidelity Mockup Training Unit was accepted by MSC during the CDR at APL during 13-15 October 1971 and was shipped to MSC on 28 October in a container fabricated by APL.

Ground Support Equipment

The baseline contract originally called for two complete sets of ground support equipment (GSE) for the UVS Experiment S169 which were identified as that equipment required for servicing, testing, field calibration, handling, maintaining, and transporting experiment hardware. However, three major departures were found necessary during the course of the program; specifically, three bench test equipment (BTE) sets, four UVS shipping containers, and five handling fixtures were required and provided. Other lesser items were provided at greater quantities when needed.

Handling Fixture. Drawings for the Handling Fixture, 7232-0409, were completed and released to the shop for fabrication in August 1971. Each of the completed fixtures was subjected to a 120-pound pull test. All passed the test and were suitably marked.

Simulated SIM Bay. A design for a full scale simulated SIM bay section was made, detailed, and released to the shop for fabrication in August 1971. The simulator was used in the thermal vacuum testing of the UVS instruments, including the thermal test model. Fabrication of the simulator was completed in September; however, it was discovered that, in order to reach the low-temperature

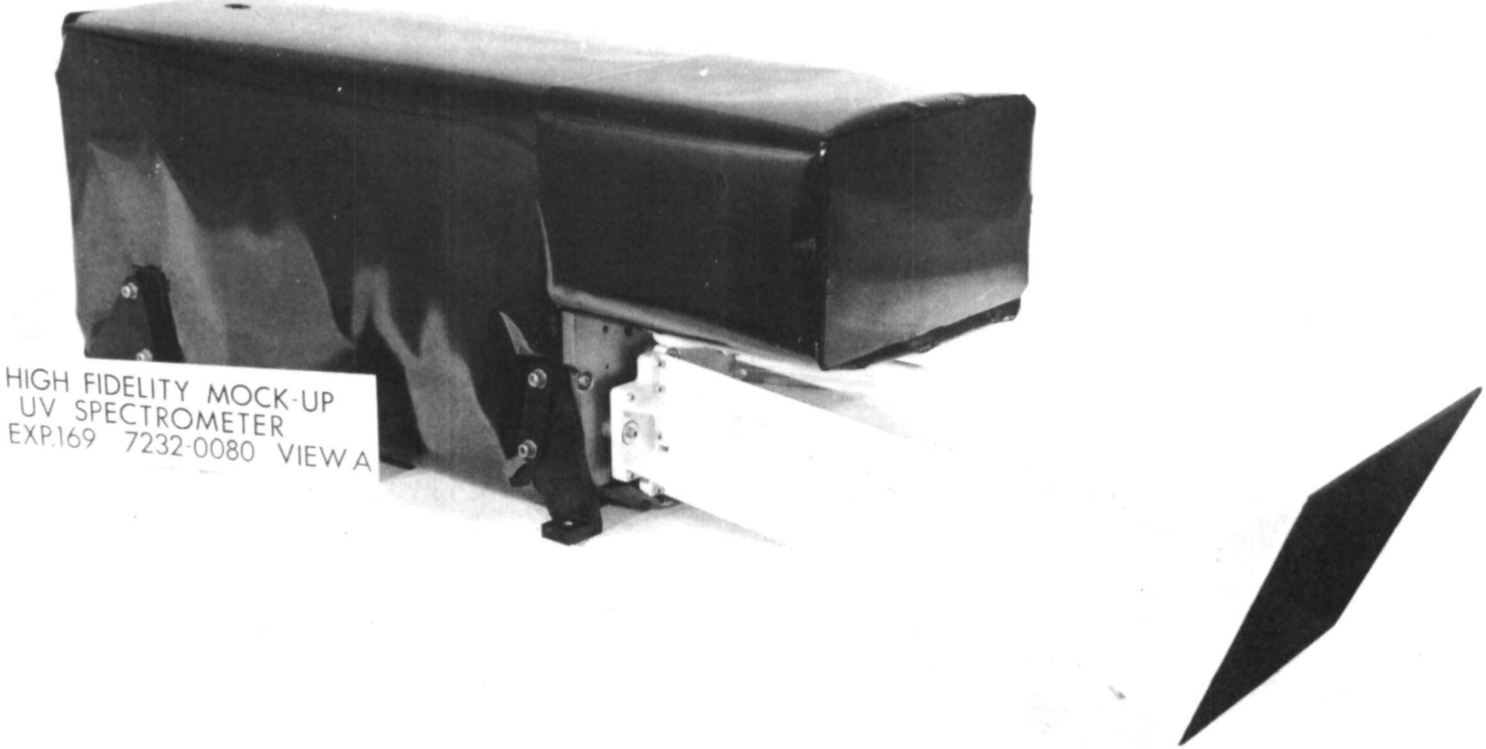


Fig. 30 HIGH FIDELITY MOCKUP, UV SPECTROMETER

environments, a movable door was required. The door and associated control equipment were designed, fabricated, and installed in November 1971. Also included was the installation of heaters and thermocouples.

Optical Alignment Fixture. A test and alignment fixture for the UVS optics (grating and mirror) was started in August 1971. Thirty-three drawings for this fixture were prepared and signed off, to which Ray Lee fabricated and delivered hardware on 15 September. This fixture and all functional test operations on the UVS instruments were conducted in the APL clean room.

Front Plate Electrical Simulator. A front plate electrical simulator was designed and fabricated. This simulator, completed in December 1971, was used to expedite the testing of the prototype electronics. Other special test equipment included a special test rack that was configured and assembled for testing and evaluating the EMR photomultiplier assembly. Also, a shake fixture, a mass properties fixture, an accelerometer mount, and a center of gravity fixture were designed, fabricated, and assembled on a schedule compatible with the prototype unit acceptance testing.

Shipping Container. A specification was prepared (7232-0008) and a subcontract was issued to the Applied Design Company, Inc., for the design, fabrication,and test of the Shipping Container (51053-1-001). Two units were delivered to APL in December 1971 and two more followed in January 1972. These containers were used to protect the assembled UVS instrument from shock and vibration during transportation and handling; temperature, pressure, and humidity variations during transportation and storage; and dirt, salt spray, and fungus in storage areas. The tops of the containers were provided with the means for attaching a two-legged sling for hoisting. At each side there were two handles for carrying the loaded container for short distances and for transportation tie downs and hoisting tag lines.

Bench Test Equipment. A specification was prepared (7232-0012) to define the configuration and acceptance requirements for the Experiment S169 bench test equipment, CEI 7232-3000-1. The bench test equipment (BTE) provided multipurpose capabilities for supporting all aspects of prototype, qualification, and flight hardware checkout and diagnosis during bench tests at APL, at remote sites, and during preflight operations at KSC. The BTE was classified as mission support equipment Class II in accordance with MSC-GSE-MEIS-2A, Appendix B.

Specifically, the major functions of the BTE were to:

a. Provide the 28-volt DC power to the UVS normally provided by the CSM
b. Generate the timing, enable, and clock pulses to the UVS normally provided by the CSM
c. Process the TM signals derived from the experiment normally sent to the CSM, both digital and analog
d. Assure the compatibility of the electrical interface connections.

In addition, the BTE was required to:

a. Check the UVS digital counting system by injecting a known bit pattern into the input of the pulse amplifier and discriminator
b. Test the current limiter circuitry
c. Stop the grating motor at any specific wavelength
d. Provide a nonresettable elapsed time indicator to record the total on time of the UVS.

Preliminary block diagrams and harness diagrams were formulated for the BTE in February 1971. A commercial suitcase manufactured by Hewlett Packard was selected to house the portable BTE because it incorporated a standard 19-inch rack and panel scheme and shock mounting. Similar suitcases were used for the power and control panel and the digital recorder. The portable BTE configuration was described in ICD MH01-12909-234.

Detailed design of the BTE, including circuit board schematics and parts lists, was completed in August 1971. Breadboards were built and tested to support the BTE design effort. A BTE design review was held on 6 August 1971, and the changes recommended by the review board were implemented. Breadboarded BTE circuits and breadboarded parts of the UVS system were interfaced satisfactorily. The logic circuits boards A1 through A7 were tested for continuity and given an operational check by substitution in the breadboard test setup. This breadboard test setup satisfied the electrical test requirement prior to installation of the circuit boards in the BTE. In October the BTE was electrically checked for possible wiring errors that may have occurred during fabrication and then returned to the shop for rework and final inspection.

The operation of the breadboarded UVS was tested with input signal conditions having the rise and fall times of the timing signals to verify that the flight hardware would operate on rise and fall times of 1.5 μs or less, as required. The results were satisfactory. The housekeeping voltage monitor functions were trimmed on the breadboard to meet the ±20 mv requirement, and the breadboard appeared completely operational.

Assembly of the control unit of BTE No. 1 was completed by 1 November, and, after final dressing of the harness, functional tests were started. Buffer amplifiers and all interconnecting cables were completed. The ground studs specified in the Ground Support Equipment ICD were installed. The three suitcases ordered to serve as BTE accessory cases were received and rejected because of poor workmanship; therefore APL built the required cases. The accessory cases were used to carry the BTE ancillary equipment such as the test cables, junction boxes, and the sensor excitation source.

BTE No. 1 was ready for acceptance testing on 10 December 1971. The formal acceptance test was performed, and no problems were encountered. The unit was put to work testing the prototype UVS. BTE No. 2 was completed shortly thereafter, and formal acceptance testing was successfully performed without problems. BTE No. 2 was immediately used for troubleshooting flight hardware electronic boards. BTE No. 3 was also completed and successfully checked out. It completed formal acceptance testing without difficulty in January 1972.

All three BTE units consisted basically of two electronic units, each housed in a fiberglass, airtight, shock-mounted operating suitcase. Each suitcase dimensions was $26\frac{1}{4}$ inches wide, $17\frac{1}{8}$ inches high, and $28\frac{1}{4}$ inches deep and weighted less than 100 pounds. One suitcase, 7232-3200, contained a Hewlett-Packard 5050B digital recorder; the other suitcase, 7232-3100, housed the control unit and power supply. Used in conjunction with the BTE was the buffer amplifier, 7232-3010, and the BTE cable harness, 7232-3300. The BTE interfaced mechanically and electrically with the facility and equipment as specified in the ICD. Static and instrument ground studs were provided as required, and the BTE conformed with MSC Specification GSE-MEIS-2A.

By May 1972 all three BTE units were updated with the latest ECNs and subsequently passed final acceptance tests. Two breakdowns occurred in the Hewlett Packard line printer of BTE No. 3. In both cases, miniature fuses had failed, causing one or more columns of data to be dropped from the output tape. Replacement of the defective fuses corrected the problem.

The three BTE units were in constant use testing the UVS assemblies. During April 1972, they supported the EMI testing of the prototype unit, qualification unit mission simulation, optical verification, cam evaluation, acceptance testing of flight unit No. 1, and preliminary electronic module testing of the flight No. 2 electronics. During May the BTEs supported EMI testing of the ATEE unit, integration testing of the ATEE unit in the SIM bay at NR, and testing of the qualification unit and both flight units.

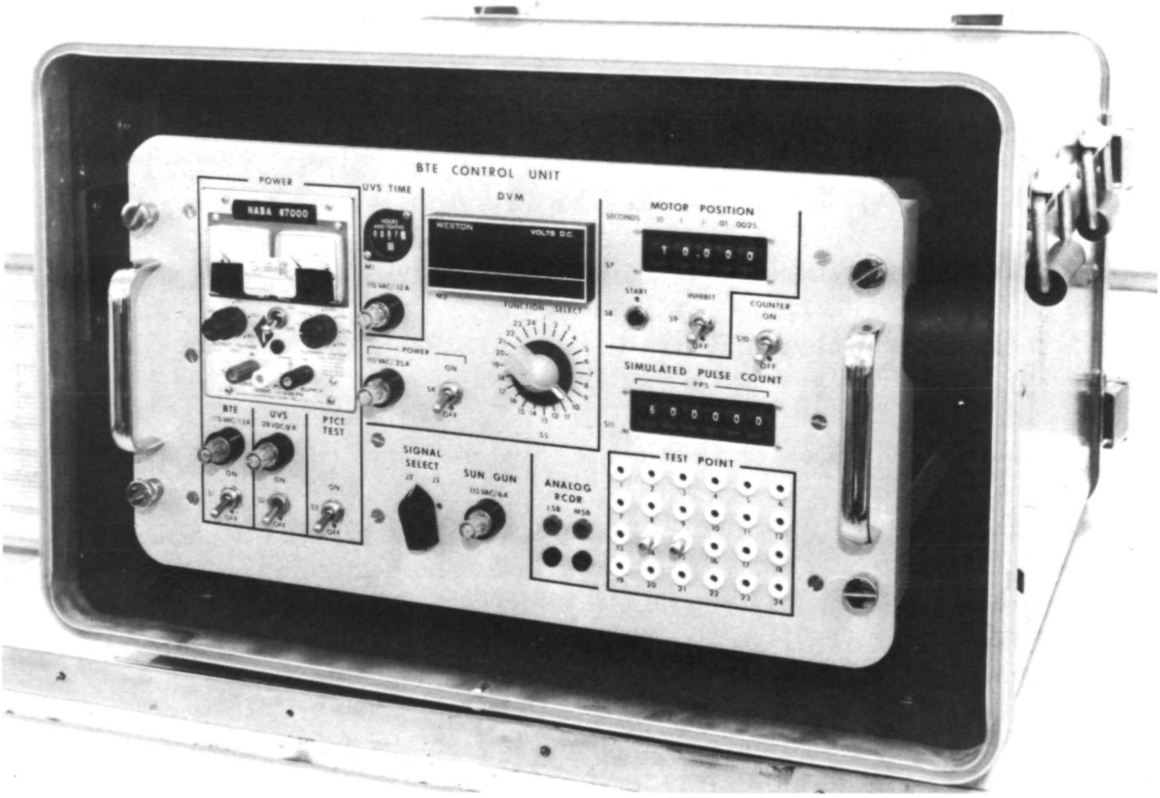


Fig. 31 BTE CONTROL UNIT

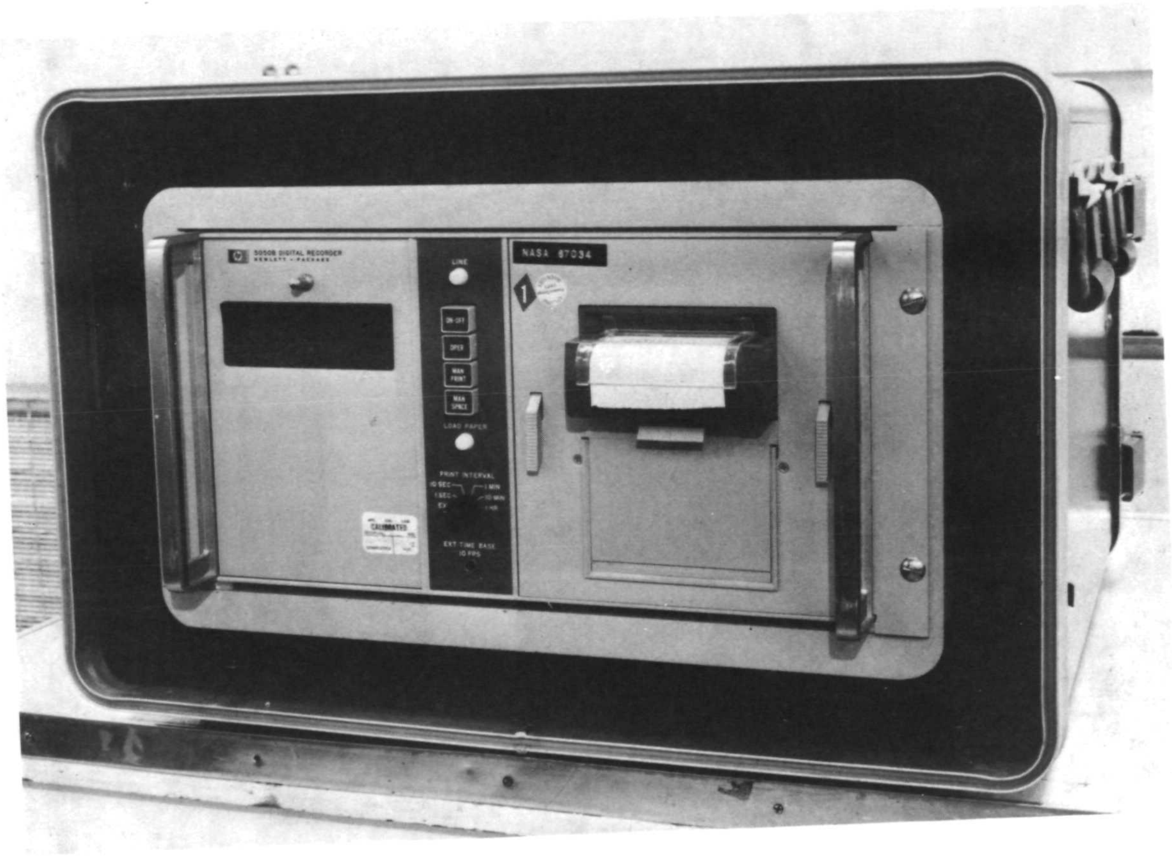


Fig. 32 BTE DIGITAL RECORDER

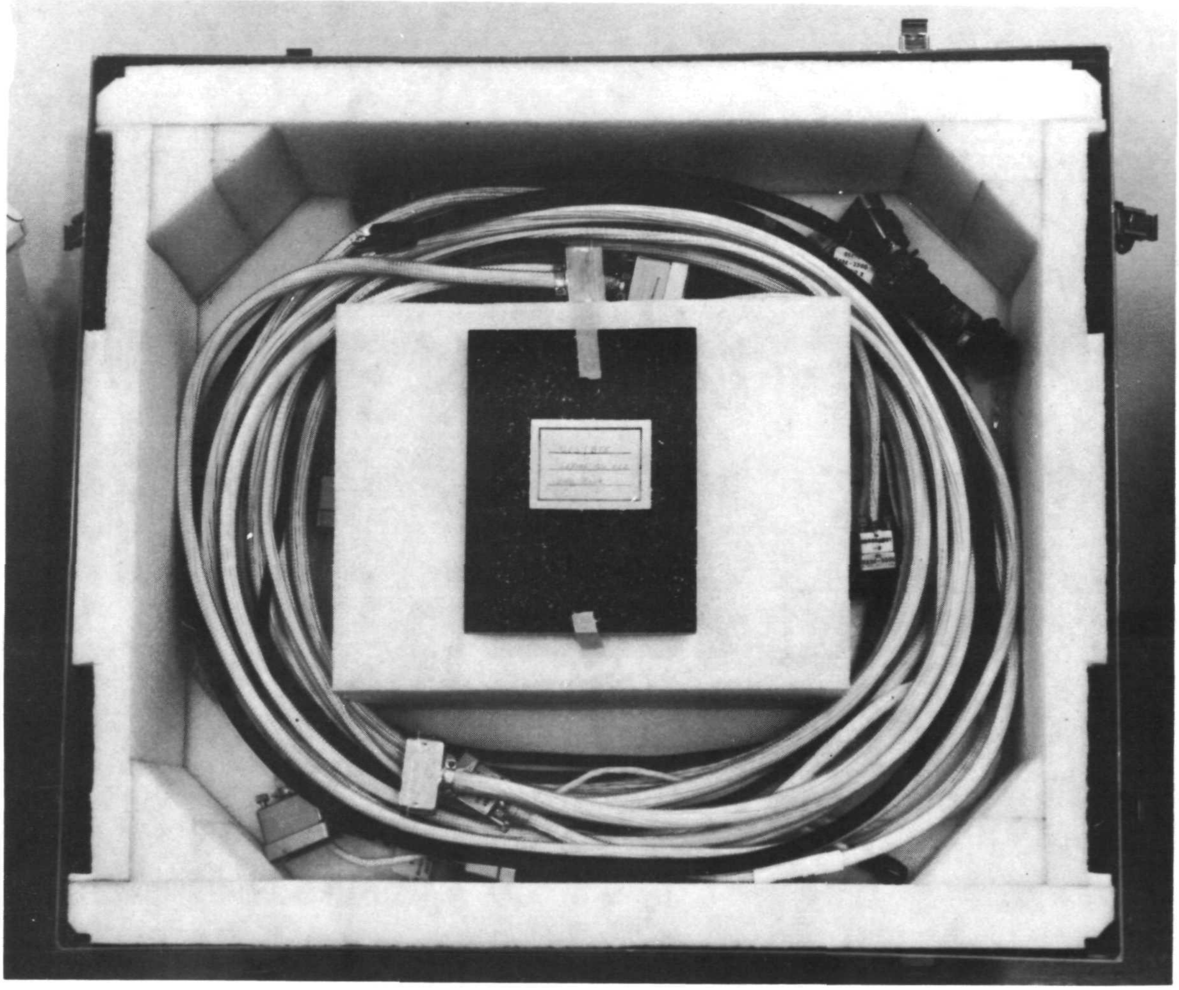


Fig. 33 BTE ACCESSORY CASE

Another miniature fuse in the Hewlett Packard line printer of BTE No. 3 failed, causing one or more columns of data to be dropped from the output tape. Replacement of the defective fuse corrected the problem. Two other problems that occurred with this BTE during testing of the ATEE unit were described earlier in this report under ATEE Tests. A breakdown of the printer of BTE No. 1 also occurred, and the printer was returned to Hewlett Packard for repair. BTE No. 3 was checked out on its return to APL from NR. The noise problem noted during the ATEE tests was corrected by modifying the D/A converter card A1, and the ground returns within the BTE buffer amplifier. The BTE was shipped back to NR, and the earlier ATEE tests were repeated successfully. The same modifications were made to the buffer amplifier and card A1 of BTE No. 1. This BTE unit was retained at APL to support testing of the qualification unit, flight unit No. 2, and the cross calibration unit.

BTE No. 2, which was at KSC at the time the other units were modified, was similarly updated by a field change. The buffer amplifier, D/A converter card, and a cable with an incorrect part number were returned to APL for modification. After the field change was implemented, subsequent BTE acceptance testing revealed a malfunction during the housekeeping word checkout. Troubleshooting revealed that the fiducial mark was not being generated. After a new fiducial mark generator, hand carried from APL, was connected to the test setup, the housekeeping word test was successfully rerun, and the remainder of the BTE acceptance test was completed satisfactorily. Later analysis of the faulty fiducial mark generator at APL revealed a loose integrated circuit.

Photographs of the BTE control unit, digital recorder, and accessory case are shown in Figs. 31, 32, and 33.

BTE No. 3 was returned by NR to APL for use in the EMI testing of the qualification unit at MSC. APL later shipped the BTE back to NR for additional ATEE Unit Tests. BTE

No. 1 supported testing of flight unit No. 2, and was subsequently transferred to the JHU Physics Department for use with the cross calibration unit. BTE No. 2 remained at KSC to support launch operations. A new HP 5050B digital recorder was received by APL, checked out, and placed in spare stock.

The UVS bench test equipment was officially accepted by MSC curing the acceptance review of flight unit No. 1 on 6-8 June 1972.

UVS Prototype Unit

Specification No. 7232-0010 was released on 15 October 1971 to define the UVS prototype unit, CEI No. 7232-0000-1. The prototype unit was required to be identical to the flight hardware with respect to configuration, mechanical, and electrical design, but not necessarily contain high rel parts or the approved manufacturing and production processes ordinarily required for flight hardware.

Electronic Design Update. As a result of action items and discussion at the DTR on 12-15 July 1971, some changes and modifications were incorporated in the electronics slated to be installed in the prototype unit. Those implemented in the electronics data system were:

a. The temperature range of the housekeeping temperature circuits was extended to cover the range of -40° to +82°C. This was accomplished with a slight modification of the circuitry and by using a thermister having a wider range.

b. The fiducial circuits were modified for improved reliability and to allow for wider mechanical tolerances. The redundant fiducial circuit was removed; the fiducial mark at the end of scan served to synchronize the system. All appropriate documentary changes were made.

The effect of these changes made it necessary to redefine the data format for the UVS which was included in SDO/CMO-060.05. In addition, the cam program was defined and specific word/wavelength assignments were made and documented.

The changes allowed the UVS to collect data on the ultraviolet radiation in the range from 1180 to 1680Å. These data were collected in a digital accumulator and transmitted to the Apollo CSM as a serial bit stream. Each word of the UV data was associated with a particular wavelength in the range from 1180 to 1680Å. Specific wavelength assignments for the words were derived directly from the final cam design. The nonlinear cam was designed to dwell heavily on those wavelengths of greatest interest. The 16 data bits of each digital word were serially shifted to the CSM at a 64K bit rate, the most significant bit being shifted out first. The data were sampled at the rate of 10 words per second. Thus, the UVS generated one word every 0.1 second and was required to output that word serially as 16 bits in a 250 μs burst.

The housekeeping functions of the UVS were measured in analog form. Each measurement was suitably scaled to cover the 0 to 5 volt dynamic range required by the CSM telemetry system. The signals appeared continuously at the UVS/CSM interface. The CSM, however, would scan these with a multiplexer and perform analog-to-digital conversions at a rate of approximately one sample per second. Table 10 lists the individual housekeeping functions including the updated temperature ranges and sensitivity, nominal ranges, and red-line limits.

As a result of the DTR, the specifications for the PMT assembly were reviewed and updated. The acceptance test procedures were submitted by EMR and approved. The list of nonmetallic materials used by EMR was submitted to MSC for approval. Problems originally encountered by EMR as regards interaction between the pulse amplifier discriminator (PAD) and the high voltage power

Table 10

Characteristics of UVS Housekeeping Data System

TM Function	Range	Sensitivity	Accuracy (%)	Nominal Range	*Red-Line Limits	
					Low Limit	High Limit
UVS Housing Temperature	-40° to +82°C (-40° to +180°F)	6.6°C/v (44°F/v)	2	-12.2° to +43°C (10° to 110°F)	-24.9°C (-13°F)	+54.5°C (+131°F)
UVS Motor Temperature	-40° to +82°C (-40° to +180°F)	6.6°C/v (44°F/v)	2	-12.2° to +43°C (10° to 120°F)	-40°C (-40°F)	+82°C (+180°F)
UVS Input Voltage	0 to 40 volts DC	8 v/v	4	25 to 30 volts	21 volts	32 volts
UVS Input Current	0 to 1.0 ampere	0.2 A/v	4	300 to 400 mA	200 mA	1.0 ampere
UVS Photo-Multiplier High Voltage	0 to 4000 volts DC	800 v/v	2	3000 to 3800 volts	2000 volts	4000 volts
UVS Regulated Voltage	0 to 10 volts DC	2 v/v	2	4.8 to 5.2 volts	4.0 volts	6.0 volts

*Red-line limits are those limits which if exceeded will result in, or are likely to be the result of, a catastrophic failure to the UVS system. Whenever telemetry is detected to be outside these limits, it is desirable to turn off the UVS system, except when low temperatures are detected. When low temperatures are detected and all other telemetry is nominal, it is desirable to leave the UVS system on.

supply were resolved. The design review at EMR was conducted on 14 September 1971, and the acceptance test of the PMT engineering model was conducted on 16 September.

Mechanical Design Update. Two other events occurred early in the program as regards basic design which influenced the fabrication of the prototype unit. During working group meetings with NR at Downey, California, the RCS contamination problem was reviewed. APL was directed to determine the deleterious effects that the UVS may suffer as a result of the RCS burning and to propose the necessary solutions to MSC. APL responded with CCP 005 and ECP 007-R1 which provided for the APL pursuit of engineering studies and analyses to provide protective measures and resultant design modifications as follows:

a. Additional thermal analysis that produced calculations of the heating due to the RCS plume indicating ΔT s on the UVS baffle of 400° to 800°F. These data were then used to baseline for subsequent re-analyses for the various redesign approaches.

b. Analysis determining the effects of contaminant deposits on the optical and thermal control surfaces that indicated a need to reduce these effects. This was accomplished, in part, by removing the outgassing vents in the UVS main housing design.

c. Thermal re-analysis indicated a need to improve the thermal capacity of the baffle. This was accomplished by redesign of the baffle, i.e., by increasing the wall thickness.

d. Technical support was afforded the vehicle contractor for the design of a protective, remote controlled door to cover the UVS baffle entrance during nonoperating periods, particularly during RCS burning.

e. Requiring additional thermal protection, an inconel shield in the proximity of the UVS electronic housing was installed by NR, and several thermal protective black-paint compounds were tested and analyzed by APL for the final instrument finish.

Subsequent to the DTR and by CCA No. 4, MSC directed APL to delete the requirement for the electromechanical solar operated shutter and solar detector mechanism in the UVS. APL responded with CCP-004 and ECP 006-R1. Justification for this modification was based primarily on these two factors:

a. The rather complex mechanism presented a serious single point failure mode.

b. NR was in the process of providing a manually controlled RCS contamination protective door that could be closed during critical sun angle periods to prevent sunlight from entering the baffle slit.

Logistics of Testing, APL/JHU. A meeting was held on 30 July 1971 at the JHU Physics Department with the Principal Investigator and his staff, MSC, and APL personnel in attendance to solidify the UVS testing concepts and required milestones. Several significant agreements were made, i. e. :

a. The component acceptance process was an APL responsibility; however, a quality or grading selection of, specifically, the optics and PMT would be performed by the PI at the JHU facility.

b. APL would then assemble at APL the optical components in an alignment fixture and adjust the optical system using optical/mechanical measuring techniques.

c. Subsequently, the optical system would be assembled within a UVS instrument and an alignment confirmation would be performed.

d. Next, the electronics housing would be mated to the front plate assembly, and an additional verification test would be conducted on the entire spectrometer using the suitcase BTE.

e. In order to validate the alignment procedure, an optical calibration would be performed on the UVS prototype unit using the CTE at the JHU Physics Department.

f. The JHU Physics Department CTE would be used to conduct the Optical Verification Test on the prototype unit and subsequent UVS units. This test would be a part of the UVS alignment confirmation procedure and also a definitive step in the Acceptance Test Procedure.

Fabrication and Test Operations. All drawings for the prototype unit were released in September 1971 and Ray Lee started the fabrication of parts at that time. By November all prototype parts were completed and delivered enabling APL to perform receiving inspection and surface finishing and begin assembly operations.

After assembly of the prototype electronics data system, some problems were encountered during low voltage and low temperature testing of the timing and data multiplexer board which were caused by the 54L122 multivibrator. Since updated and corrected components could not be obtained on a timely schedule, APL waived the extensive low-voltage board level performance tests at low temperatures on the prototype boards. The UVS +5 volt power supply was suitably regulated to avoid the problem during prototype test operations.

Testing of the completely assembled UVS prototype unit electronics revealed several minor problems which were corrected by ECNs:

a. The output data sync pattern would appear in error under certain variations of motor speed. A simple modification of the timing and data multiplexer board eliminated this problem.

b. Some excess ripple was present on the output of two of the housekeeping data lines. Reducing the bandwidth of an operational amplifier in the housekeeping electronics removed the ripple from one of the data lines, and removal of a feed-through filter eliminated the ripple from the other data line. ECNs were written to correct these problems on future units.

c. The foam potting material for the circuit breaker was not acceptable to MSC; therefore, a hermetic seal was proposed and implemented in its place.

Some problems encountered during mechanical assembly and optical alignment of the prototype unit also required ECNs to reflect the necessary corrections:

a. The front plate and the slit mirrors were reworked to eliminate mechanical interference. The rework consisted of changing the mirror profiles by grinding the glass and by removing metal from the area where the mirrors fit.

b. Attachment points were added to the front plate for the fiducial mark detector.

c. The plastic Kel-F pads on the fixed pins and retaining screws for alignment of the Ebert mirror were replaced with pads of Lexan to assure that mirror alignment would not change during instrument operation.

After the optical components were satisfactorily aligned, and the prototype unit fully assembled, all systems tests with BTE No. 1 were successfully completed. The unit was transported to the JHU Physics Department where the preliminary handling procedures were checked out and modified as required. A fit check of the prototype unit with the calibration test equipment (CTE) was accomplished satisfactorily and the unit was operated with a UV source. A preliminary operational test was performed successfully; however, the wavelength calibration indicated the presence of a small alignment error. Later analysis of this error established a tabulation of wavelength versus word number which applied specifically to the prototype unit.

Acceptance testing of the prototype unit was begun in January 1972. The vibration tests were completed successfully, and the optical alignment verification at the JHU Physics Department was favorable. During thermal vacuum testing a failure occurred so that, under high-voltage conditions, a significant increase in background count was detected. Investigation revealed that the true PMT background (dark) count was satisfactory, but the problem was related to motor interference.

Following completion of the TV tests, during which time no other significant electrical problems occurred, the unit was opened to study the motor interference problem. Detailed investigation revealed that the PMT PAD was detecting the DC/DC converter switching pulses whenever the motor was running with the bus voltage greater than 29 volts. This spurious pickup was via the PAD test input lead and was always greatest when the converter was operating from high bus voltage, with the motor running. Several corrections were applied. A filter capacitor (0.1 mf) was added between the 28-volt bus return and the signal ground. A diode and a 50-ohm resistor were also added to the PAD test input line to specifically isolate the unwanted noise. Suitable ECNs were written and the prototype unit was retested to verify proper performance.

During the period of retesting, it was noted that voltage measurements on the ±15 volt lines were not correlating well with the subsystem test results. It was determined that the regulators were slightly underloaded, and therefore additional 5K ohm loads were added to their outputs. The ±10 volt lines also varied whenever the motor was stopped. These anomalies were corrected by adding a 10K resistor to the +10 volt line, and by adding a 15 volt zener diode to the -10 volt line. The 10K resistor provided for minimum loads on the +10 volt line whenever the motor was off and prevented peak detection whenever the motor was off. The 15 volt zener clamped the -10 volt supply to -15 volt maximum during the motor turn-off transient. It also served to limit any possible peak voltage to -15 volt maximum whenever the motor was off. All appropriate ECNs were written and processed.

The prototype unit was installed on the SIM bay mounting bracket in the thermal vacuum chamber where abbreviated acceptance test procedures were performed. The unit was next taken to the JHU Physics Department for verification of optical calibration, which was satisfactory.

APL tested the prototype unit to determine if it could detect a xenon lamp; however, the UVS was not sensitive to xenon. Therefore, the mercury vapor lamp was used in further tests of the unit,and it was used thereafter when necessary to excite the UVS in ambient atmosphere.

UVS Prototype Unit Acceptance. During the week beginning 28 February 1972, the Prototype Acceptance Review was held at APL. At the Review, it appeared that the fall time of the UVS data signal was out of specification tolerances during TV tests. Subsequent investigation of the problem revealed that under all test conditions using the TV cable configuration, the fall time was out of tolerance because of the excessive cable capacity necessary for TV operation. Since the cables could not be changed readily, and the relationship between cable capacity and fall time was well known, the allowable fall time limit was increased to 1.6 μs during TV testing in order ot obtain a meaningful reading with the excessively long cables.

MSC accepted the UVS prototype unit, after which it was used for systems testing of BTE 1 and BTE 2 to simulate PAD conditions.

Prototype Unit EMI Tests. MSC directed APL, by CCA 11 on 28 March 1972, to conduct engineering EMI tests on the prototype unit. APL responded with CCP-012 and ECP-023. Some radiation susceptibility problems were observed, in particular, anomalous tripping of the electronic circuit breaker and possible increases in the dark current. See the section on End Item Tests, appearing earlier in this report, for a detailed description of the EMI testing conducted with the prototype unit. Included also are subsequent fixes which were implemented as a result of these tests.

Prototype Unit Refurbishment and Reconfiguration. On 29 March, CCA 13 directed APL to update and virtually refurbish the prototype unit so that its configuration would more closely resemble the qualification and flight units. APL responded with CCP-014 and a statement of work that included:

a. Obtain two additional replica gratings from the new Bausch & Lomb master
b. Replace the prototype grating with a new grating; retain the other one as a spare
c. Replace grating buttons with Kel-F and Ebert buttons with Lexan
d. Install a new wavelength cam procured under CCP-015
e. Install new entrance slit
f. Install new fiducial mark detector and cover
g. Install connector cover
h. Install new grating arm and straps
i. Remove back-lash and end-play in grating arm shaft

j. Install new wavelength eccentric
k. Replace all bright metal screws with black oxide screws
l. Modify front plate for new fiducial mark detector
m. Install hard feet; grind anodize coating to obtain electrical grounding
n. Modify bearing retainer
o. Install new vent tubes
p. Check baffle alignment
q. Realign optics
r. Obtain wavelength cam profile data
s. Relocate and machine fiducial detector index (slit)
t. Perform optical calibration
u. Perform operational verification.

Concurrently, MSC directed APL, by CCA 12, to reconfigure the prototype unit to the cross calibration unit which would be a new identifiable contract end item. Details of this effort are described later in this report under cross calibration unit. Upon receipt of CCA 12, the completion of the RFI tests and the refurbishment described above, the prototype unit no longer existed.

UVS Qualification Unit

Specification No. 7232-0009 was released on 15 October 1971 to define the UVS qualification unit, CEI No. 7232-0000-02. The product configuration baseline was established by the Acceptance Review of the qualification unit. This unit and subsequent units, regardless of intended use, were manufactured and accepted to the configuration defined by the specification and formally approved Engineering Change Proposals (ECPs) and Specification Change Notices (SCNs).

Tests simulating the environments to which the UVS will be exposed were required to assure the experiment hardware capability to comply with its performance requirements as outlined in Section 3. 1 of the CEI specification. The qualification unit, UVS Serial No. 02, a flight type instrument, was fabricated specifically to be subjected to the qualification tests as specified in the CEI specification.

Nitrogen Purge Provision. Fabrication of the qualification unit electronics system was started by APL by the first of November 1971, and Ray Lee began mechanical parts fabrication at about the same time. On 22 December MSC, by CCA 8, directed APL to provide for nitrogen purging of the UVS instrument for protection against contamination in unfavorable environments. APL responded with CCP 009-R1 and ECP 016-R1. This change provided a right angle, quick disconnect pneumatic fitting on the grating box access door located on the UVS housing. Through this fitting, pressurized dry nitrogen was provided by KSC during preflight operations until closure of the SIM. The right angle fitting, i.e., a manifold block, and the male portion of the quick disconnect fitting became flight items. APL also furnished, as nonflight hardware, the mate to the fitting, flexible tubing, and all other fittings required to be compatible with the NR nitrogen system. APL analysis and subsequent test confirmed that the NR supplied flow rate of 5 to 10 SCFH should provide adequate purging. ECNs were prepared to implement this change into the qualification unit and both flight units.

Fabrication and Test Operations. In November 1971 only 90% of the qualification unit mechanical parts were complete. To expedite the schedule, APL completed fabrication of the front plate and baffle top assembly, both of which had been delayed at Ray Lee. EMR delivered PMT assemblies Nos. 3 and 4; the covers had been modified to correct a poor fit. PMT No. 2 was returned to EMR for retrofit of the cover changes, and for an electrical change related to the maximum count rate.

All of the qualification unit mechanical parts were assembled by January 1972, and testing of the electronics module was completed. During the tests an interference problem similar to that experienced with the prototype unit was observed. Extraneous counts were observed at high bus voltage (30.0 volts), but only at -28.9°C. PMT No. 4 was replaced with PMT No. 3, and the problem no longer occurred. After mating the electronics with the main housing, an overall systems test was conducted. During the tests, the data word count indicated that the motor, S/N 3, was slipping out of synchronism. Investigation revealed that excessive thrust loading on the shaft caused the slippage. Changes in the assembly procedures removed this excessive thrust load; however, the motor was replaced with motor S/N 4 and returned to Schaeffer Magnetics for a precautionary examination.

On 3 February 1972, MSC directed APL, by CCA 10, to modify the UVS shock mounting system to assure that any possible torque loading, such as that induced by excessive vibration or random side loading of the instrument, would not be transmitted through the NR mounting bracket. APL responded with CCP 011 and ECP 018 which included detailed drawings and ECNs for the redesign. APL fabricated the parts and mated them with the qualification unit and both flight units. Meanwhile, the applicable ECNs to rid the prototype unit of the electronic interference experienced during TV testing were incorporated into the qualification unit.

After operational verification tests of the qualification unit were completed satisfactorily, it was prepared for vibration testing. During a low-level equalization run, the electrical power input to the unit suddenly dropped to zero. It was determined that the power input bus wire had severed at the circuit breaker terminal. The wire was repaired, the unit was inspected, reassembled, and the vibration tests were completed successfully.

In March 1972, the standard thermal-vacuum acceptance test on the qualification unit was completed successfully. Again, as during prototype unit testing, the simulated SIM bay door actuator troubles were encountered. In addition, many heater circuits on the door developed short circuits thereby rendering them useless. Consequently, a new door was fabricated using printed circuit heaters and incorporating roller guides to eliminate binding.

The unit was subjected to vibration and pyrotechnic shock tests. After each of these tests, operational and optical verification tests were conducted. The unit operated within specification during all tests.

The Acceptance Review for the qualification unit was held on 29-30 March 1972 and the unit was formally accepted by MSC.

Qualification Testing. After approval of the qualification test procedures, qualification testing on the unit was begun. The portion of the qualification thermal vacuum test without the thermal blanket and shock-mount feet was successful. The unit was removed from the TV chamber for installation of the thermal blanket, thermocouples in the electronics housing, and the shock-mount feet. Also, measurements of the grating versus function of cam rotation were made, which were satisfactory. On 1 May, the qualification unit was reinstalled in the thermal-vacuum chamber for the mission simulation portion of the TV test. The remaining tests were completed on 16 May 1972. Some computer system malfunctions occurred but were quickly repaired, and all phases of the test were completed successfully. These tests constituted the final proof that the UVS could be expected to perform adequately through all expected thermal environments. A comparison of the mission simulation results with the allowable temperature limits for operating, nonoperating, and turn-on proved adequate margins in all phases of the mission except for the cold-biased lunar orbit with contingencies (cold holds). In this case, the turn-on limit was exceeded; however, should this event occur, a return to normal SBA in lunar orbit would quickly heat the instrument to an acceptable temperature. The remaining qualification tests, including the optical calibration, transportation shock, operational verification, and a second optical calibration were also completed satisfactorily.

The allowable operating and nonoperating temperature margins were derived from procurement specifications with approved derating of solid-state components. In addition, tests of assembled breadboards were used to establish turn-on limits. Although the test results agreed with original TAM predictions, only proven test results were used to determine the capability of the instrument to perform its mission. The tests concluded that the instrument was capable of performing adequately during all required phases of the mission.

EMI Fix Update. The electronics module was removed from the qualification unit main housing, disassembled, and updated with the EMI fixes incorporated on all other units in accordance with ECP 023. These fixes included L-section filters in the DC/DC converter and a by-pass capacitor across the circuit breaker. The electronics module was retested to the 7232-2029 Signal Conditioning Module Test Procedure before it was reassembled to the main housing. Bonding straps were installed from the electronics module to the front plate to the main housing to eliminate the electrical resistance between ground points caused by protective coatings. The operational verification test of the reassembled qualification unit was performed successfully. At this time the wavelength cam was burnished to remove harmful coating buildup of the groove edges.

Qualification Unit EMI Testing. Pursuant to the MSC directive in CCA 15 and the APL responding CCP 017, the qualification EMI testing was conducted at MSC, Houston, Texas, in July 1972. Details of the test are discussed in an earlier section of this report. Upon completion of the EMI testing, the qualification unit was returned to APL.

MSC gave approval for removal of the front plate of the qualification unit, providing this disassembly would not disturb the unit's calibration. Without disturbing the calibration, APL removed the front plate and examined the unit for wear and deterioration. The wavelength setting was measured and found to be within seconds of its original setting. The grating was checked, without disturbing the unit's calibration, for a mode of distortion that could introduce a systematic error in the wavelength setting. No systematic error was detected, a result compatible with the CTE calibration.

At the request of MSC, the Qualification Test Report was rewritten to a large extent, although there were no apparent disagreements with the actual test results.

Drive Motor Failure. The 600-hour life test was conducted with the qualification unit during October 1972 without apparent problems; however, on 17 November, when the unit was installed in the CTE at the JHU Physics Department for post life-test optical calibration, the UVS drive motor failed to start. Initial investigation indicated that the UVS and BTE electrical circuitry were functioning normally, all connections were intact, and the motor was stalled as a result of some type of mechanical disruption. FIAR No. 022 was initiated and the qualification unit was returned to APL for further troubleshooting. The failure occurred after the qualification unit had a total operating time of 940 hours.

Detailed inspection of the qualification unit at APL verified normal electrical response, but upon partial disassembly, it was discovered that the motor could be made to operate, but erratically and with excessive radial wobbling motions of the shaft. The motor was removed from the unit and sent to the manufacturer for disassembly and inspection.

The motor was disassembled at Schaeffer Magnetics, Inc., in the presence of an APL representative. It was discovered that improper assembly of the motor bearings had permitted excessive wear and ultimate failure. In addition, a foreign substance had apparently contaminated the bearings and aggravated the problem. It was postulated that formation of the foreign substance had interfered with the normal lubrication transfer process and abraded the ball separators. Wear on the separators, combined with the improper assembly, allowed the separator to fall out of place and resulted in the complete failure of the motor.

Photographs taken at the time of motor disassembly and contamination samples were sent to MSC for analysis. Subsequently, the entire motor was sent to MSC. Two remaining motors on hand at APL were returned to Schaeffer Magnetics for examination and/or repair. One motor was a spare; the other was removed from the cross calibration unit. Preparation for mission operations at KSC precluded further work on the qualification unit at that time.

After inspecting the spare motors, and considering the excessive operating time logged with the qualification unit, the motors in the flight units were considered satisfactory.

UVS Flight Unit No. 1

Fabrication and Test Operations. Assembly and test of electronic parts began in December 1971 in preparation for final assembly of flight unit No. 1. In January, circuit board level testing was completed, the mirror cell was assembled to the main housing, the Ebert mirror and grating were installed, and a preliminary optical alignment was made through the use of the dummy front plate.

Fabrication and painting of the mechanical components were completed by March 1972. Complete electrical check-out of the electronic and signal conditioning module was accomplished at the subsystem level. The module was mounted to the main housing, and preliminary systems tests were conducted. During assembly operations, two slit mirrors were broken, necessitating the use of spares. The optical components were reassembled and aligned satisfactorily. The unit was completely assembled and ready for acceptance testing; however, this testing did not commence until after completion of the Qualification Unit Acceptance Review.

Tantalum capacitors suspected to be of poor quality were replaced with acceptable components in the DC/DC converter, the motor drive electronics, and the timing and data multiplexer circuits. The data system was reassembled and retested in accordance with the 7232-2029 procedure. Acceptance testing was again delayed pending a decision on whether to incorporate fuses in the circuit breaker. An output of the Qualification Unit Acceptance Review, MSC informed APL that the UVS solid-state circuit breaker was the first such unit ever encountered on an Apollo spacecraft. MSC would, therefore, study the design carefully for possible failure modes. MSC suggested that, since double failures could short out the spacecraft power bus, large series fuses may be required to protect the bus line. To prevent long delays in the event fuses would be required, APL ordered 100 fuses recommended by NR and prepared seven ECNs for their implementation as a precautionary measure. When later informed by MSC that the addition of fuses would not be required, flight unit No. 1 was completely assembled, the baffle aligned, and the operational verification tests were performed successfully.

Wavelength Cam Problem. The unit was taken to the JHU Physics Department for optical calibration. During this procedure, a discrepancy in the wavelength program of 5Å was reported. Investigation revealed that the fiducial mark had not been set and that the cam was defective. The grating alignment and Ebert mirror alignment were satisfactory. Approximately two-thirds of a word error was corrected by resetting the fiducial mark detector and slot.

The cam was returned to APL where profile data were obtained (cam angle versus wavelength). This profile revealed a high spot in the cam groove that was located precisely at the 1215.65Å scribe line, which is the reference index used by APL during optical alignment. It was determined that the high spot was formed by upset metal at the groove edge made by the scribe mark engraving tool. Ray Lee reworked their master cam and fabricated a new cam to correct the problem. However, the groove edges of the new cam were not perpendicular to the plane of the cam which also produced invalid profile data. Ray Lee, on the premise that the cam defect was caused by fabrication machinery, made another cam from the master. This second cam was identical to the first cam; neither was acceptable. While attempting to correct their master, Ray Lee broke it, therefore a new master cam was produced.

Meanwhile, inspection revealed that the cam earmarked for flight unit No. 2 had the same flaw as the flight 1 cam, but less extensive. APL reworked the flight 2 cam to eliminate the flaw and sent it to Medwest Research Institute in Kansas City to be stripped and recoated with molybdenum disulfide (MLRZ). APL then cut a new slit in the recoated cam for the fiducial mark detector index. Profile data taken from the reworked cam were satisfactory, and it was installed in flight unit No. 1.

The cam inspection procedure was changed to provide for combined mechanical and optical measurements which greatly facilitated determination of cam suitability. After realizing that the state-of-the-art of manufacturing cams was not compatible with the accuracies specified in the CEI Specification, Waiver No. 8 was prepared, submitted to MSC and approved. The waiver relaxed specified wavelength tolerances without jeopardizing the mission scientific requirements. It covered flight unit No. 1; subsequently, the waiver was extended to cover all UVS instruments by the submittal of PSCN-004 via ECP 028-R1.

Flight Unit No. 1 Acceptance. The EMI fixes that were incorporated in the earlier UVS units were added to the flight unit No. 1 electronics module. The module was retested to the 7232-2029 test procedure and mated to the main housing. Acceptance testing was resumed and completed successfully. Ferrules were added to the coaxial cables in accordance with an ECN written for this purpose. The unit passed final Government and APL inspection. The UVS flight unit No. 1 was formally accepted at the AR held at APL on 6 through 8 June, and the unit was shipped to KSC on 9 June 1972.

UVS Flight Unit No. 2

Fabrication and Test Operations. Fabrication of the mechanical and electronics parts for flight unit No. 2 was started in December 1971. By February 1972 all parts fabrication was complete. The mounting holes in the mirror cell housing were improperly located. The housing was rejected and another fabricated. Circuit board level testing was completed at this time, allowing the electronics module to be assembled. Further electrical testing of the module was suspended, however, pending investigation of reported leakage in the Mallory tantalum capacitors. These capacitors were used in all UVS instruments. APL conducted tests on all Mallory capacitors held in stock that had the same log date code as given in the MSC Alerts MSFC-71-03A and MSFC-71-03B. The tests concluded that none of the capacitors leaked; nevertheless all Mallory capacitors were replaced in all UVS hardware with comparable Sprague components.

In April 1972, the electronics module was reassembled and started through the test cycle. Some problems were encountered relative to interference effects on the PMT during low temperature and high voltage tests. Investigation revealed that a jumper wire on the PMT bulkhead had been inadvertently omitted from both wiring harnesses. The jumper was installed and the module appeared acceptable; however, further testing was suspended until incorporation of the EMI fixes.

Photomultiplier Tube Problem. Upon implementation of the EMI fixes, the UVS flight unit No. 2 electronics module was retested in accordance with the 7232-2029 test procedure. During test operations, a suspiciously low dark count was observed, and in a preliminary attempt to verify the PMT sensitivity, the tube was exposed briefly to the Oriel mercury vapor lamp. The test result was indeterminant; therefore the electronics module was returned to the JHU Physics Department where a full optical test was attempted. At that time it was determined that the tube had totally lost its sensitivity. This PMT assembly (S/N 2) was replaced with S/N 7, and the optical test was repeated successfully. The electronics module was then installed on the UVS main housing. The S/N 2 PMT assembly was returned to EMR for failure analysis.

A thermal vacuum test was performed on PMT No. 6 at the JHU Physics Department to determine what effects thermal vacuum has on quantum efficiency, tube gain, or the electronic circuitry. Results indicated no significant change. A special optical test was performed on PMT No. 4 and No. 6 to verify "dead time" effects on the high signal level tube output. Analysis of the results indicated good correlation between the dead time measurements. Final testing of the spare PMT (S/N 7) was completed at APL and at the JHU Physics Department. The test results correlated generally well with all previous test results.

Cam Lubricant Problem. A third generation cam (S/N 7) was installed in the unit. A cam profile was plotted, and the wavelength adjusted accordingly. Final assembly and inspection of flight unit No. 2 proceeded without difficulty. Acceptance testing was started on 6 June 1972. Upon successful completion of the operational verification test, the unit was taken to the JHU Physics Department for optical calibration. During this calibration, the Principal Investigator noted that the edges of the Lyman-alpha response were erratic from scan to scan and to a greater degree than had been observed on previous units. FIAR No. 018 was dispatched to MSC and an immediate investigation was begun.

Critical inspection of the cam by APL and Midwest Research Institute disclosed flaking of the coating. This cam, S/N 7, was returned to Midwest Research for stripping and recoating. Subsequent inspection of the remaining cams revealed a coating thickness buildup of uneven proportions at the top edge of the cam grooves. It was determined that this anomaly created an erratic profile. Further, inspection of the cam follower revealed that the uneven cam grooves, caused by the coating buildup, damaged the periphery of the cam follower pin. To correct this problem, the grooves of cams S/N 1, 2, and 4 were burnished and polished to reduce excess coating and material erosion. The cam follower pin was reworked by machining a relief groove locally to preclude interference with the cam groove. The S/N 7 cam was replaced in flight unit No. 2 with cam S/N 4, and a cam profile was plotted. After realignment of the grating and fiducial detector, the unit was reassembled and acceptance testing resumed. Cam hardware integration with the UVS instruments was rescheduled and implemented as outlined in Table 11.

Drive Motor Problem. Subsequent testing of flight unit No. 2 indicated a fiducial mark period error, i.e., a 1 ms variation, such as could be caused by a mechanical drag in the motor and cam assembly. The following steps were taken to recognize the eliminate the error source:

a. Removed the motor mount assembly
b. Checked the alignment dimensions of the motor mount and the cam drive
c. Added a shim under the motor mount foot
d. Replaced motor drive bearings
e. Removed paint from the front plate
f. Reworked the motor mount attach surfaces
g. Machined the feet of the motor mount
h. Reinstalled the motor assembly
i. Replaced the fiducial mark detector
j. Reinstalled the front plate
k. Cleaned the front plate
l. Conducted a critical inspection (APL and NPRO).

Appropriate Material Review Dispositions were prepared to accomplish this rework.

After reassembly and subsequent testing of flight unit No. 2, a ±2.5 ms variation in the fiducial period was still

Table 11

UVS Wavelength Cam Characteristics

Cam S/N	Type	Allocation	Master	Hole Location	Hole Type	Scribe Marks	Comments	Status	Follower Pin
1	-1	Qual Unit	1st	141° 23'	Oval	Random Location	Profile accepted by W. G. Fastie	Burnished Original	Original
2	-4	Cross Cal Unit	1st	143° 00'	Slit	Random Location	Profile accepted by W. G. Fastie	Burnished Original	Reworked
3	-4	Flight 1	1st	143° 00'	Slit	Random Location	Profile accepted by W. G. Fastie	Reworked Original	Original
4	-3	Flight 2	1st	143° 00'	Slit	Aligned to Zero	Profile accepted by W. G. Fastie	Reworked and Burnished Original	Reworked
5 & 6	-3	None	1st Reworked	None	None	Aligned to Zero	Profile rejected by W. G. Fastie	Rejects	NA
7	-3	Spare	3rd	143° 00'	Slit	Aligned to Zero	Profile accepted by W. G. Fastie	Burnished	NA

occurring. Investigation and comparison with other grating motors indicated that the "jitter" that was being experienced was a characteristic inherent to all hysteresis motors. In view of this realization, and since the variation was within specification, no further changes were proposed.

Wavelength Misalignment. After implementation of the changes described above, acceptance testing of the flight unit No. 2 was resumed. During optical calibration, it was observed that Lyman-alpha occurred two words late in the data output stream. FIAR No. 015 was prepared to document this problem. On a test deviation, the xenon lamp was substituted and the xenon line was observed to occur two words beyond its nominal position. This Lyman-alpha shift was interpreted to be due to a wavelength misalignment. Subsequent testing, however, confirmed that the entrance slit image was properly aligned in a direction perpendicular to the spectral dispersion. A detailed analysis of possible alignment errors and of other sources of misalignment was conducted. From this analysis it was determined that sources of misalignment could exist of the sign and magnitude to explain the wavelength error observed. However, it could not be successfully demonstrated that any of these sources in fact existed in flight unit No. 2. Since the precise source of error could not be identified without seriously affecting the schedule, and since the errors were compensated for during optical alignment, no further changes were recommended. The compensation was an arbitrary offset in θ, by the amount $\Delta\theta = + 1' \, 20''$, using standard alignment procedures. This action assured compliance with the CEI specification.

Flight Unit No. 2 Acceptance. The operational verification test was repeated with no problems occurring, followed by another optical calibration at the JHU Physics Department. Results were satisfactory. The unit was returned to APL where the vibration, operational verification, and thermal vacuum tests were accomplished successfully. The cam profile was also plotted. The final optical calibration was then performed satisfactorily at the JHU Physics Department, and the unit was again returned to APL for mass property measurement which was completed without difficulty. The ICS 32 dimension of 21.25 inches was out of tolerance by 0.033 inch. This measurement however, was considered adequate in as much as it allows clearance for the RCS plume door. All other measurements were well within specification.

The UVS flight unit No. 2 was formally accepted by MSC during the AR held on 14-18 August 1972. By the recommendation of the Principal Investigator, and with the concurrence of APL and MSC, flight unit No. 2 was designated the Experiment S169 flight unit and flight unit No. 1 became the backup unit. The flight unit was shipped to KSC on 19 September 1972.

UVS Cross Calibration Unit

On 28 March 1972, CCA 12 directed APL to construct two new identifiable contract end items. One of these was the Apollo Tellecommunications Engineering Evaluation (ATEE) Unit for use principally during compatibility testing at NR. The second was the cross calibration unit for use during calibration trials at Goddard Space Flight Center and the JHU Physics Department. The new units were derived primarily from parts and assemblies already on hand. The cross calibration unit was reconfigured with major mechanical parts from the prototype unit plus new mechanical parts, the spare electronics module, a new diffraction grating, and the slit mirrors and Ebert mirror from the prototype unit. Since the new units were required to be constructed and tested to the standards and formality applicable to flight equipment, a new flight quality fiducial mark generator was built for the cross calibration unit, and an additional motor was purchased for it.

Reconfiguration and Test Operations. The book level testing of the spare electronics module indicated that transistors in the DC/DC converter were mismatched enough to cause high frequency oscillations at high current levels. The transistors were therefore replaced with a matched set, and the electronics module was checked out with satisfactory results. After the spare electronics module was completely assembled in May, it was subjected successfully to the 7232-2029 test procedure. Subsequently, it was determined that the PMT was low in output after short exposure to the mercury vapor lamp. Attempts were made to improve performance of the PMT by increasing the high voltage, thereby increasing the tube gain. These efforts were moderately successful but not sufficiently so for the unit to be considered flightworthy. Therefore PMT assembly S/N 4 was replaced with the spare PMT assembly S/N 6, which was repotted and retested. The fiducial mark generator was completed and installed, the cam profile was plotted, the new grating was installed and aligned, and optical alignment was accomplished.

After all modifications and subsystem tests were completed in June 1972, the electronics package was mated to the main housing for acceptance testing and cross calibration testing. Operational verification of the cross calibration unit was completed successfully and the unit was transported to JHU for optical calibration. When returned to APL, the unit was partially disassembled for cam groove burnishing and cam follower pin modification for reasons reported earlier.

A 30-day cam life test was started at APL on 10 July. The only parameter monitored was the fiducial period. After this test, the cross calibration unit was taken to NASA/GSFC for vacuum optical calibration. The unit was subsequently taken to the JHU Physics Department for cross calibration. This test was performed successfully and the unit remains at the Physics Department for use in simulated missions.

ATEE Test Unit

Configuration and Test Operations. The Apollo Telecommunications Engineering Evaluation (ATEE) Unit was configured by using the electronics module that was removed from the UVS prototype unit and UVS components that were currently on hand. Specifically, the ATEE unit evolved from the following effort:

a. The main housing was fashioned from a partially machined Ray Lee casting and a marked-up drawing

b. The aft cover was fashioned from a dummy aft mirror cell cover and a marked-up drawing

c. A front plate was fabricated from a marked-up drawing

d. The thermal model hard feet were used for mounting feet. The anodized coating was ground down to obtain a good electrical bond

e. New aluminum mounting spacers were fabricated

f. The electronics module from the prototype unit was mounted on the front plate

g. The front plate simulator was mounted on the opposite side of the front plate from the electronics module

h. The last motor in stock and the fiducial mark generator from the prototype unit were used to complete the ATEE unit

i. A wooden shipping container with 4 inch foam padding was designed and fabricated.

The electronics module which had been modified to reduce radiated and conducted interference, as detailed earlier in this report, was subjected to preliminary EMI tests at APL. The earlier modifications effectively suppressed all of the converter noise and reduced the UVS interferences to levels below the specified levels. In order to reduce the radiated and conducted interference generated by the UVS/BTE combination, two fixes were implemented which lowered the interference levels below the specified maximum limits.

ATEE at NR. The ATEE unit was completed and satisfactorily checked out. It was shipped to NR on 19 May as scheduled, and BTE No. 3 was shipped on 26 May 1972. The ATEE tests were conducted at NR from 30 May through 2 June and repeated in August. Details of the ATEE tests are discussed earlier in this report. After completion of the tests, the UVS equipment was returned to APL.

Thermal Test Model

Early design studies showed that the UVS thermal design margins were very small so that an experimental confirmation of the analytical model would be desirable. At that time, the prototype unit was scheduled too far in the future to be of value. Therefore, on 1 June 1971, ECP 002 proposed that a thermal test model be fabricated for use in performing thermal testing in order to obtain thermal design data and to verfy the thermal analytical model (TAM). The ECP was approved by MSC (CCA 3).

Configuration. On September 1971, the thermal test model had been designed and Ray Lee had completed fabrication of mechanical parts. APL fabricated the mounting feet. By December, the model was complete, assembled, and instrumented for test.

The thermal test model was constructed from basic flight parts except where impractical or unnecessary. In these cases, capacity and/or thermal resistance simulations were used. The baffle was identical to a flight baffle including thermal control coatings and all hardware pieces. The instrument housing was identical to flight hardware including weight relieving and thermal control coatings.

The mirror cell assembly consisted of a flight-type cell with a simulated Ebert mirror installed. Using transient conduction scaling rules, the proper thickness of plate glass was used to give the correct thermal lag, and the first surface was aluminized to simulate the correct optical properties. In a like manner, the grating was simulated and installed in a flight grating holder.

Because the front plate was an extremely complicated machining, only thermal capacity and conductance were simulated in the form of a flat plate. A motor mount and a grating mount were included on the front plate. The grating mount was suspended with ball bearings to simulate the actual conductance path, and an aluminum slug of the proper weight was used for the motor.

A complete flight-type electronics housing was used. It was fitted with simulated electronic boards, aluminum slugs and resistors to simulate the electronics. A typical simulated electronics board consisted of an epoglas board on which aluminum slugs were mounted to simulate the capacity of bulk parts, and a resistor to provide a heat source simulating the total board electrical dissipation. The IPS was simulated with an aluminum slug of the proper weight. The actual thermal capacity of the flight parts was not known at the time; however, assuming an average specific heat of 0.23 was applicable, aluminum slugs were sized accordingly. Flight type multilayer blankets were used on the electronics and main housing. To avoid excess thermal leaks, the internal heater lead wires were brought out through an electrical connector. The thermal test model was mounted on the NR mounting bracket.

Final Disposition. The thermal vacuum test of the thermal model was commenced in January 1972 which is described in an earlier section of this report. At the request of MSC on 30 August 1972, the UVS thermal model and the NR mounting bracket were shipped to MSC in Houston, Texas.

Conclusions. All Contract end items were fabricated, tested, accepted, and delivered on a schedule compatible with the Apollo mission needs, although slightly behind the baseline schedule projection. Table 12 is the UVS Experiment Deliverable End Items Schedule Summary. It should be noted that four major hardware items were required to be fabricated and tested after the baseline schedule was established.

APL has complied with the MSC instructions to transfer UVS and BTE hardware and documentation to the JHU Physics Department. APL/JHU letters AC-10218 of 23 August 1972 and AC-10222 of 28 August 1972 identify all items transferred in detail. An inventory and accounting of Experiment S169 residual property was inclosed in APL letter AC-10401 dated 1 December 1972. Of the residual deliverable end items, the Hi-Fi unit and the thermal test model are at MSC; the cross calibration unit and BTE No. 1 are at the JHU Physics Department; flight unit No. 2 was the Apollo 17 mission flight unit, flight unit No. 1 was the mission back-up unit, and BTE No. 2 supported Experiment S169 launch operations. The ATEE unit, BTE No. 3, and the qualification unit are currently at APL. All experiment S169 items at KSC will be returned to APL for further disposition.

APL recommends that JHU be authorized to retain all residual items and equipment for use on research and government sponsored programs by the Principal Investigator and by APL. In particular, the items of general purpose laboratory equipment can be used by APL on other programs performed for NASA and DoD.

Figures 34, 35, and 36 are photographs of the UVS flight unit No. 1. These photographs, however, are indicative of the prototype unit, qualification unit, flight unit No. 2, and the cross calibration unit. Figure 37 is a photograph of the thermal test model.

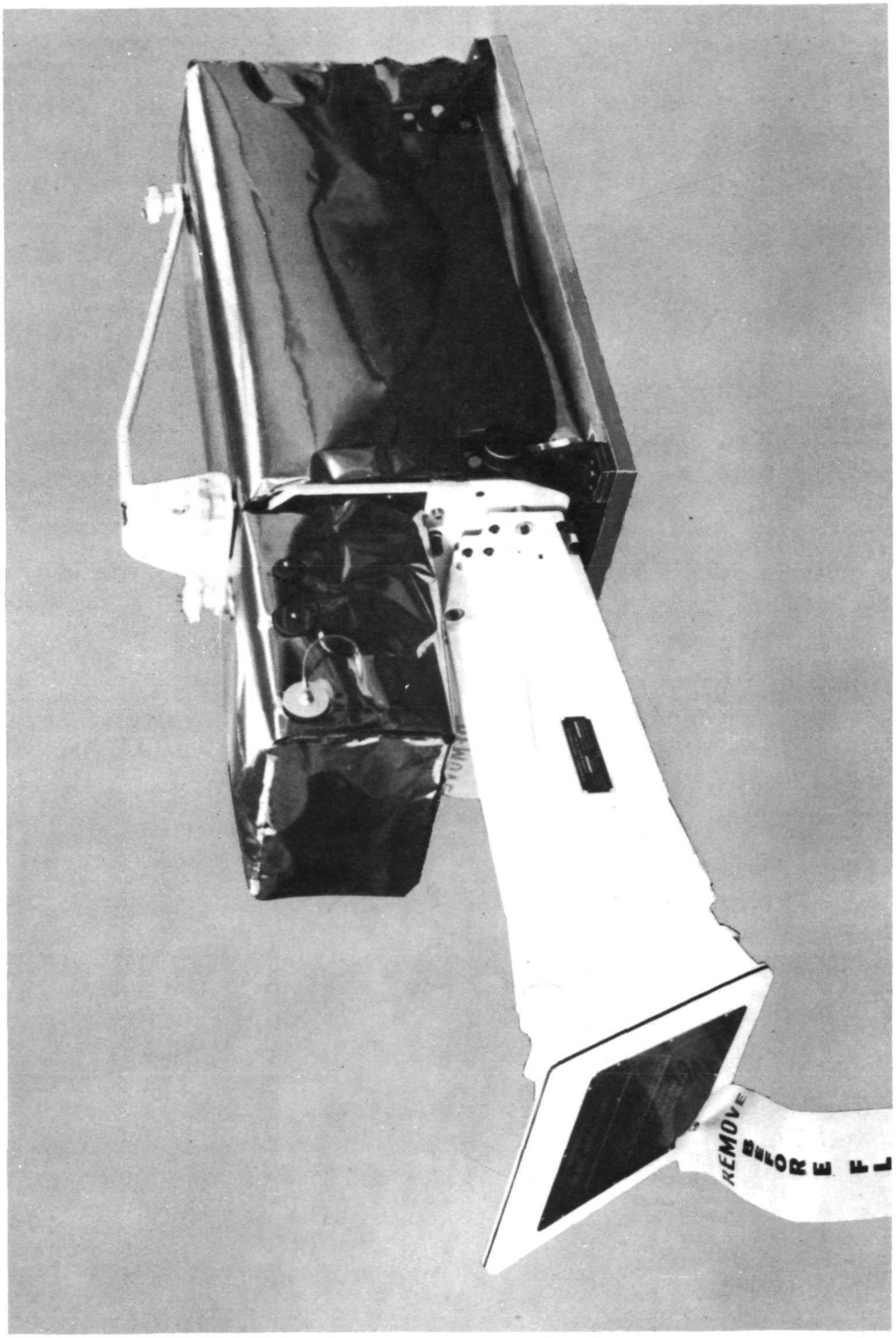


Fig. 34 UVS FLIGHT UNIT 1, VIEW A

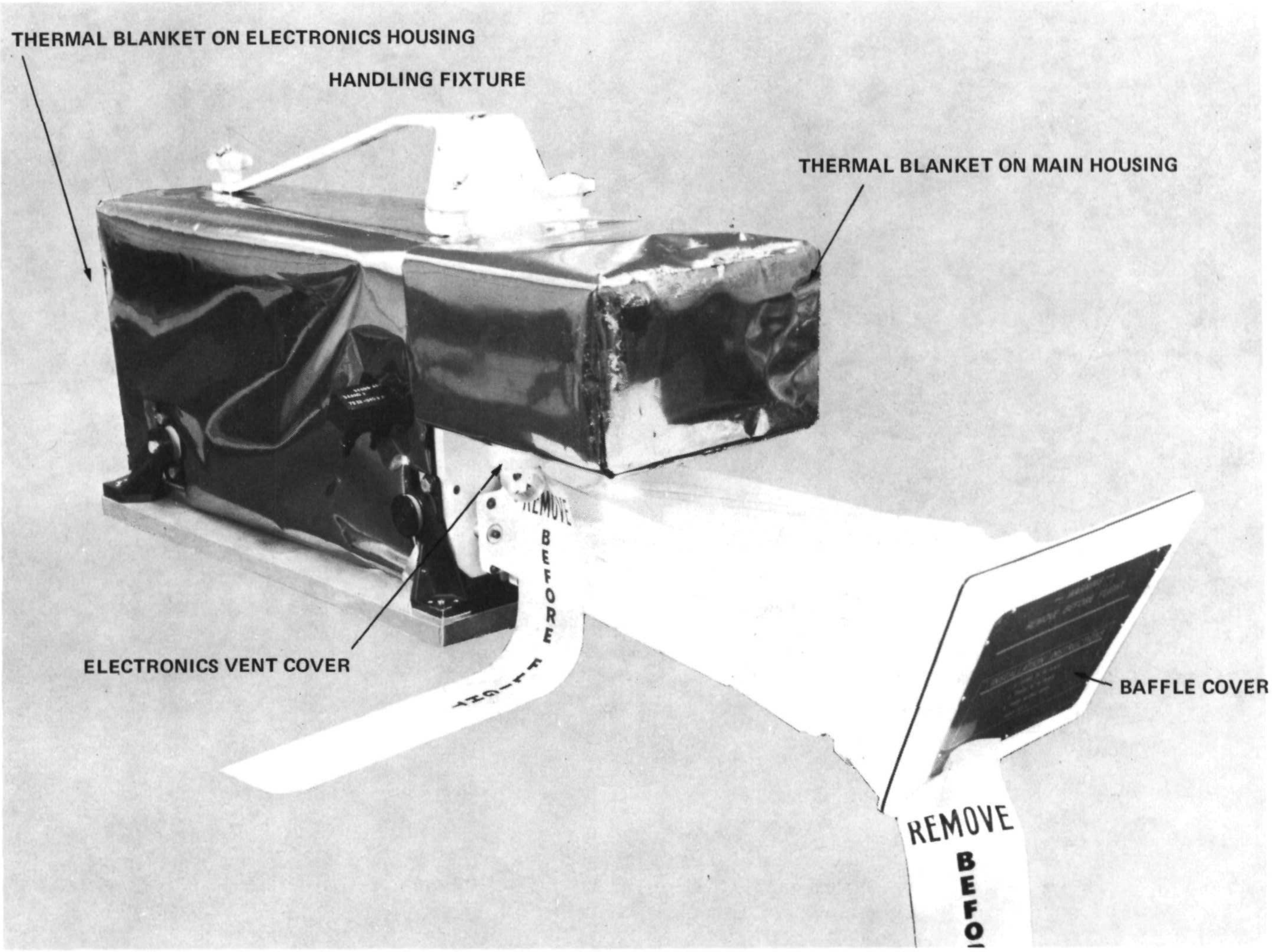


Fig. 35 UVS FLIGHT UNIT 1, VIEW B

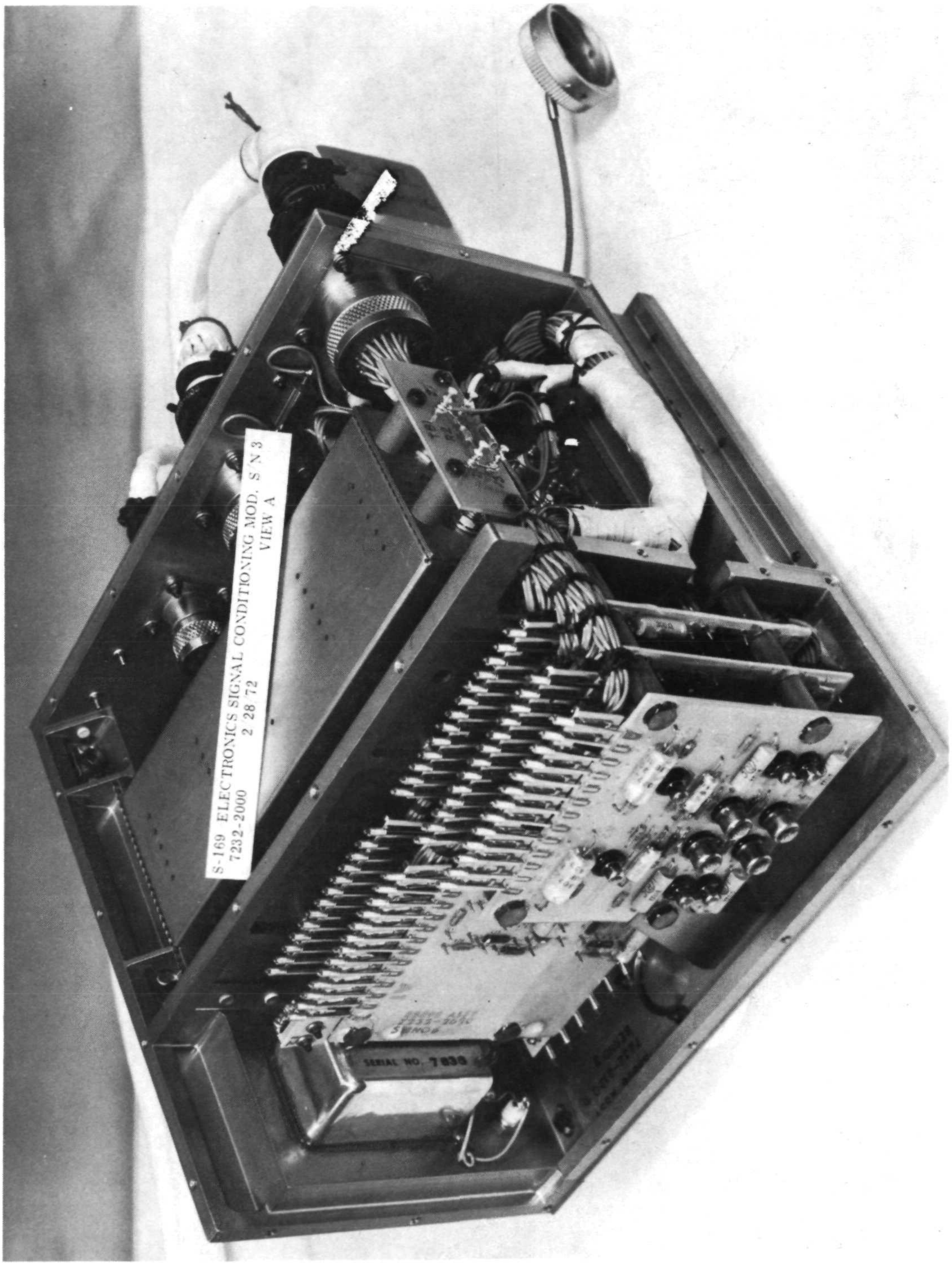


Fig. 36 UVS ELECTRONIC SIGNAL CONDITIONING MODULE

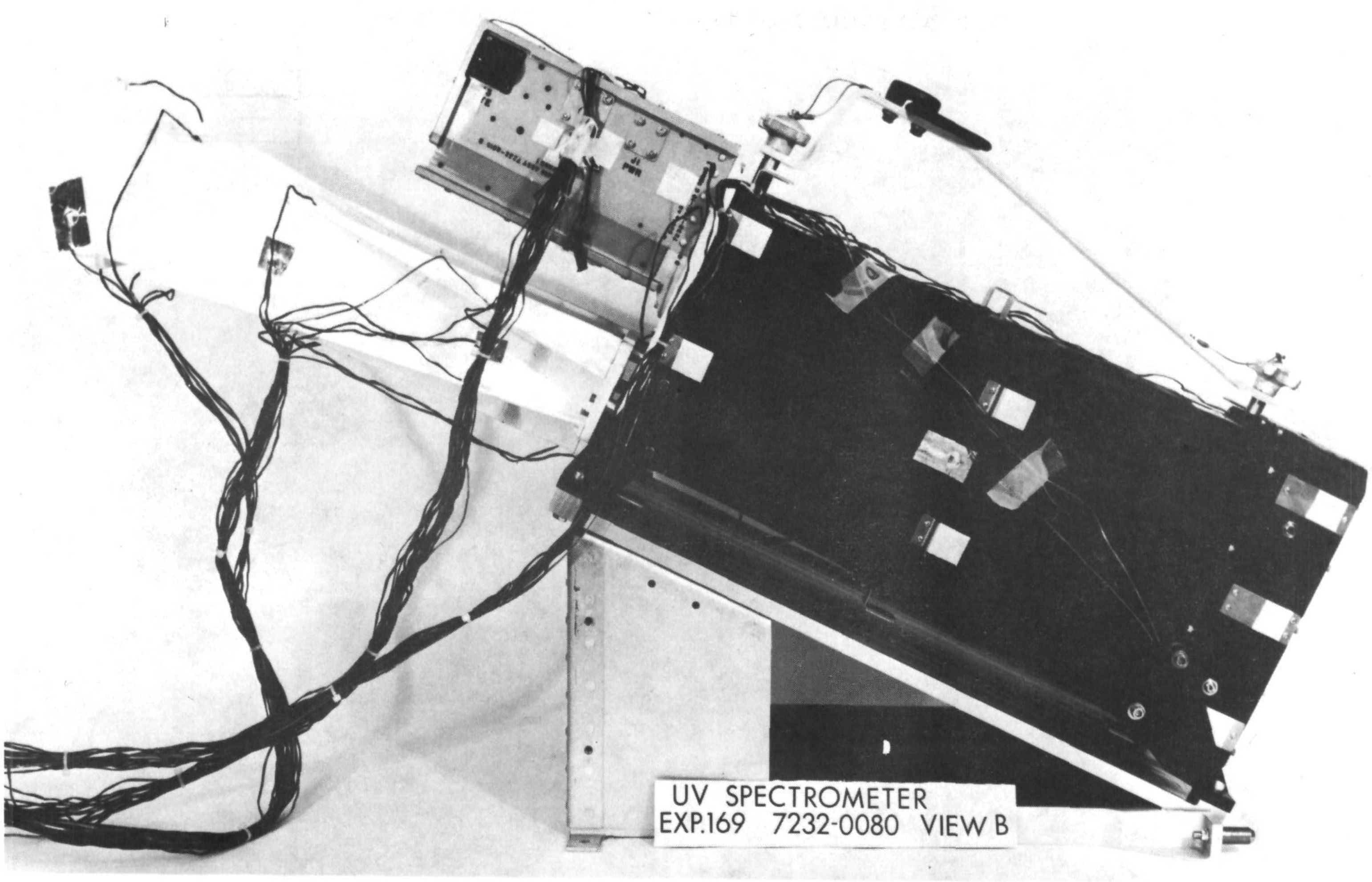
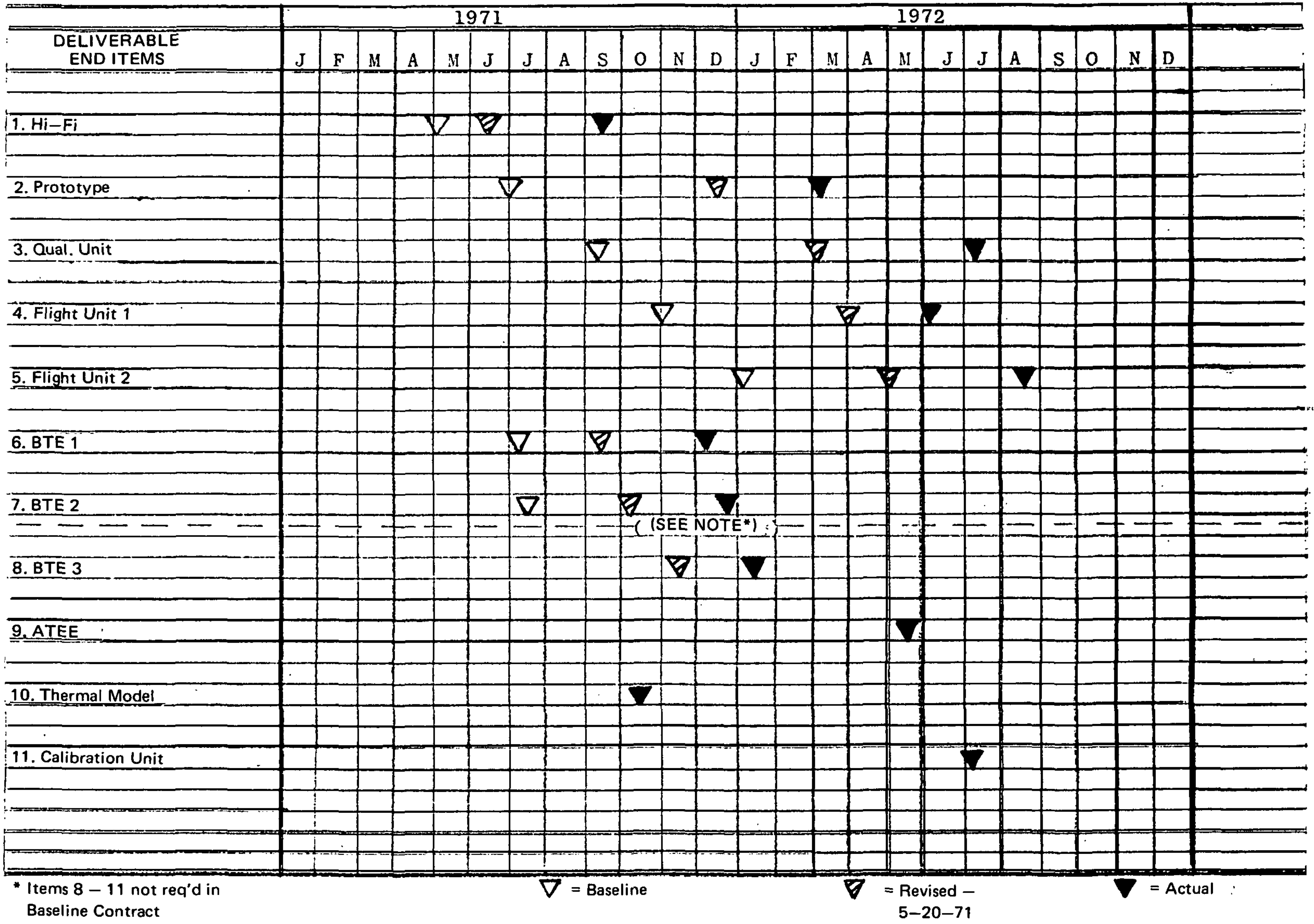


Fig. 37 UVS THERMAL TEST MODEL

Table 12

Ultraviolet Spectrometer Experiment
Deliverable End Item
Schedule Summary



* Items 8 – 11 not req'd in Baseline Contract

LAUNCH SITE OPERATIONS (Exhibit D)

APL participation in the Apollo 17 launch operations was not included in the base line contract, therefore APL was requested to participate in a meeting at KSC on 9-10 November 1971 to define tasks and the scope of effort required to satisfy the spacecraft test and checkout activities at KSC. On 12 April 1972, under Exhibit D of the contract, APL submitted a revised and final proposal for the field support of KSC operations for the UVS Experiment S169. APL provided a staff averaging 2.5 people for the duration of the field operations including one optical specialist, one electromechanical systems engineer, two supporting engineers during peak periods, and one shared secretary. An APL support manager was in residence at KSC from May 1972 through the duration of the mission.

Pre-Launch Testing. UVS flight unit No. 1, BTE No. 2, and GSE arrived at KSC on 12 June 1972 and were processed through receiving and inspection. The KSC Calibration Certification Laboratory conducted the APL calibration procedure on the BTE successfully. APL performed the BTE acceptance test which was temporarily interrupted pending the arrival of a replacement for an incorrect cable, and the 7232-3305 cable which was inadvertently excluded from the original shipment. Several test deviations were written to correct the test procedures. The UVS Acceptance Testand the Preinstallation Test (PIT) were also completed successfully. Test deviations were written to correct several errors in these test procedures.

At the request of MSC, the UVS access plate was removed so that the cam could be inspected for anomalies similar to those found in flight unit No. 2. The unit was removed from the nitrogen purge and bagged for transportation to a clean room in the O & C building where the access plate was carefully removed. It appeared that the cam lubricant had accumulated on the cam follower pin, causing it to make contact only along the edge of the cam groove. Also, small splotches of lubricant were extending from the groove onto the side of the cam. A sample was taken by NASA QC for analysis.

Flight unit No. 1 was installed in the spacecraft successfully on 29 June after NR modified the mounting bracket to eliminate an interference between the bracket and the UVS baffle, and after NR obtained mounting bolts of sufficient length. The electrical bond between the instrument and the spacecraft was measured to be 0.003 ohm. Mating of the spacecraft-to-UVS cables was accomplished, but with extreme difficulty because of the NR shroud location.

The UVS K-0070 Solo Test was conducted with the BTE, and the same anomalies occurred as those found during the ATEE tests at NR. The K-0070 Combined Systems Test and the UVS test were satisfactory. The UVS was removed from the spacecraft for performance of the Spacecraft Altitude Chamber Test. At this time, the BTE buffer amplifier and printed circuit card to be repaired (as reported earlier) were removed from the BTE and returned to APL.

On 14 July 1972, flight unit No. 1, with the NR mounting bracket attached, was installed in the spacecraft by hand, i.e., without using the NR 115 handling fixture. The electrical bond between the UVS and the spacecraft was measured to be 0.003 ohm. The spacecraft cables were then connected.

The modified buffer amplifier and printed circuit board for BTE No. 2 were received from APL, inspected, and installed. The BTE Acceptance Test was begun, but the unit malfunctioned during the housekeeping word checkout. The trouble was traced to the fiducial mark generator. A new generator was received from APL and installed; the acceptance test was then completed satisfactorily.

The BTE was connected to the UVS for SIM bay DR 0047 checkout. A test similar to K-0007 was conducted and good data were recorded by the BTE during the 400 K pulse count test. After completing these tests, the BTE was disconnected and returned to the UVS "J" Mission

Laboratory. The K-8241 High Gain Antenna Test was conducted without difficulty.

A check fit of the UVS with the NR plume shield door, made on 24 July, revealed interference at the upper left hand corner of the baffle cover. The cover was removed, but the plume door frame still rubbed against the baffle. It was later discovered that NR had installed two square washers under the UVS mounting bracket instead of on top of the bracket. With the washers installed correctly, the baffle dust cover could be installed while the plume door frame was closed. Flight unit No. 1 was removed from the spacecraft on 26 July 1972 and stored in the NR bond room.

The mirror rhomb that was replaced on UVS flight unit No. 1 early in August was taken to the JHU Physics Department for a contamination test. The test was negative, which indicated that contamination of the unit at KSC was negligible. APL objected to the extensive use of MEK cleaning agent in the SIM bay. As a result, NR added a step to the K-3550 procedure for purging the SIM bay access panel hardware with dry air or nitrogen to eliminate the MEK residue.

UVS flight unit No. 2 was received at KSC and inspection completed on 26 September 1972. The PIT was completed successfully; however a DR was written because noise was detected from the cam linkage. NR completed installation of the temperature sensor on the flight unit No. 2 electronics module. Relocation of this temperature sensor (measurement No. SL1109T) originated with CCA 9 on 7 January 1972 and ECP 015/SCN002. After the sensor was installed, the thermal blankers were installed and the unit was installed in the spacecraft.

Flight unit No. 1 was returned to APL for calibration. After incoming inspection and an operational verification, a final calibration of flight unit No. 1 was performed at the JHU Physics Department. No change in calibration was observed over previous measurements.

On 3 October, NR removed the baffle test cover from the installed flight unit No. 2 for RCS plume door fit checks. During this process, it was learned that helium was used as a purging agent at the 4A level. Since helium is a UVS contaminant, the K-0005 Solo Test was repeated as a precautionary measure. The test was completed satisfactorily; however, the NR plume door fit check revealed mechanical interference between the baffle cover and the door assembly. The interference was due to excessive material on the lip of the Teflon baffle cover. The baffle test cover is nonflight hardware, but contains the UVS light source which is required for preflight testing. A "make work" change was initiated as the solution to the problem. Specifically, the excess lip material was removed from the top edge of the S/N 3 cover at APL. The S/N 3 cover was hand-carried to KSC on 10 October 1972 and exchanged for the cover causing the interference. Details of this effort was proposed in ECP-033 and approved in CCA 18.

All Discrepancy Reports had been satisfied by 10 October. The FRR preboard meeting was held on 13 October where UVS flight unit No. 1 was cited with a Quality Assurance FARRID because the unit was at APL for calibration at that time. Also, the UVS had not yet been qualified for flight because the life test with the qualification unit had not been completed. A subsequent Delta FRR resolved these problems.

Flight unit No. 1 was again delivered to KSC on 16 October 1972, received and inspected, and successfully subjected to the Pre-installation Test. Three open DRs were closed, and the unit was temporarily stored until NR installed the temperature sensor on the electronics module. After completing this operation, flight unit No. 1, the mission back-up instrument, was packed in its pressurized shipping container for storage. Meanwhile, the Apollo K-0028 SV Flight Readiness Test was completed satisfactorily with the UVS flight unit No. 2 installed. The RCS plume shield door was open during this test.

The Countdown Demonstration Tests (CDDT) began on 13 November. During these K-0007 tests, the S/N 2 rhomb was removed and replaced with S/N 5. The K-0007 CDDT UVS test with complete BTE was conducted satisfactorily, and the rhomb was hand-carried to JHU for contamination evaluation. NR exercised the plume door. It was opened and closed ten times with a 2-minute wait between each cycle. No problems were experienced.

Launch Operations. The Apollo 17 launch countdown (K-0007) began on 30 November 1972 and continued until lift-off on 6 December. During this period the spectrometer performed properly and UVS data were monitored continually via the spacecraft SDS. On 2 December the baffle rhomb dust cover was removed from the spectrometer. At this time the UVS plume cover was installed on the plume door and SIM door 28 was installed. The rhomb was returned to JHU for contamination evaluation. In the afternoon of 5 December, the UVS nitrogen purge was disconnected and SIM door 29 was installed. This completed the final SIM bay operation prior to launch. The Apollo 17 space vehicle was launched at 11:33 p. m. C. S. T. on 6 December from launch complex 39A at KSC, Florida. Lift-off was delayed for 2 hours and 40 minutes because of a failure in the terminal count automatic sequencing. The signal for S-IVB liquid oxygen tank pressurization enable was not received. The function was jumpered and the countdown was recycled. After lift-off, the spacecraft operated nominally achieving earth orbit after 11 minutes and 47 seconds of powered flight. Translunar injection occurred at 3:12:36.

Mission Operations. The UV spectrometer was included with other scientific experiments for the Apollo 17 mission. The purpose of the UVS was to determine the atomic composition, density, and scale height for each constituent in the lunar atmosphere, and to investigate far ultraviolet radiation from the lunar surface and galactic sources. Data were obtained while the CSM was in lunar orbit and during transearth coast under several conditions identified in the following modes:

Mode I — Data were collected when the CSM +X axis was aligned to the velocity vector and the SIM bay centerline aligned to the nadir. Data were collected during one lunar orbit and during crew rest periods, with emphasis on a 15-minute period spanning CSM sunset terminator crossing.

Model I — Data were collected when the CSM +X axis was aligned to the velocity vector and the SIM bay centerline to the nadir. Data were collected during crew rest periods, with emphasis on a 15-minute period spanning CSM sunrise terminator crossing.

Modes I and II permitted observation of the lunar atmosphere during predawn and postsunset periods, whereby the lunar atmosphere is illuminated and the lunar surface is not; a condition allowing resonantly scattered radiation to be observed. The remaining operating time in these modes provided a measure of the lunar albedo and, possibly, lunar phosphorescence.

Mode III — Data were collected during two lunar orbits with the spectrometer optical axis pointing at grazing incidence to the lunar surface. This mode provided a look through a long atmospheric path against a galactic background which maximized the instrument's signal strength.

Mode IV — Considering the moon an occulting disc, the UVS viewed zodiacal light both parallel and perpendicular to the ecliptic plane, and scanned several predetermined bands on the celestial sphere.

Mode V — Data were collected during transearth coast with the spectrometer axis aligned to different celestial coordinate positions.

Mode VI — The spectrometer was operated during transearth coast while the CSM was in passive thermal control (PTC). Modes V and VI permitted the investigation of the presence and distribution of atomic hydrogen between the earth and the moon, and determination of ultraviolet emission of galactic and extragalactic sources. Figure 38 shows the UVS look angle from the CSM.

Controls were furnished in the CSM for the crew to activate and deactivate the instrument and to open and close the RCS plume protective door that covered the baffle entrance. A CSM talkback display was provided to indicate the deployment status of the protective door. A predetermined timeline of periods, such as when the UVS was activated with and without the plume door open, data system on or off, and other vehicle status, was followed throughout the mission.

Apollo 17 entered lunar orbit on the fourth day of mission operations. Also on the fourth day, the SIM bay door was jettisoned, and shortly thereafter the UVS was activated. After lunar orbit injection (LOI), lunar orbital scientific exploration was initiated and completed with the transearth injection maneuver which occurred during the eleventh day of operations. Splashdown occurred on the fourteenth day.

Performance Evaluation. The UV spectrometer obtained numerous useful data throughout the entire mission. All experiment objectives were achieved. Spectrometer operation was normal in every respect with two exceptions:

a. The instrument experienced photomultiplier tube dark current of 25 counts per second, which is considerably higher than 0. 7 counts per second measured during preflight tests. The high dark count was attributed to cosmic radiation, and was about an order of magnitude higher than expected. This anomaly, however, was not an instrument malfunction and did not seriously impact the scientific data collected.

b. During the last mission day before splashdown, two housekeeping telemetry data functions

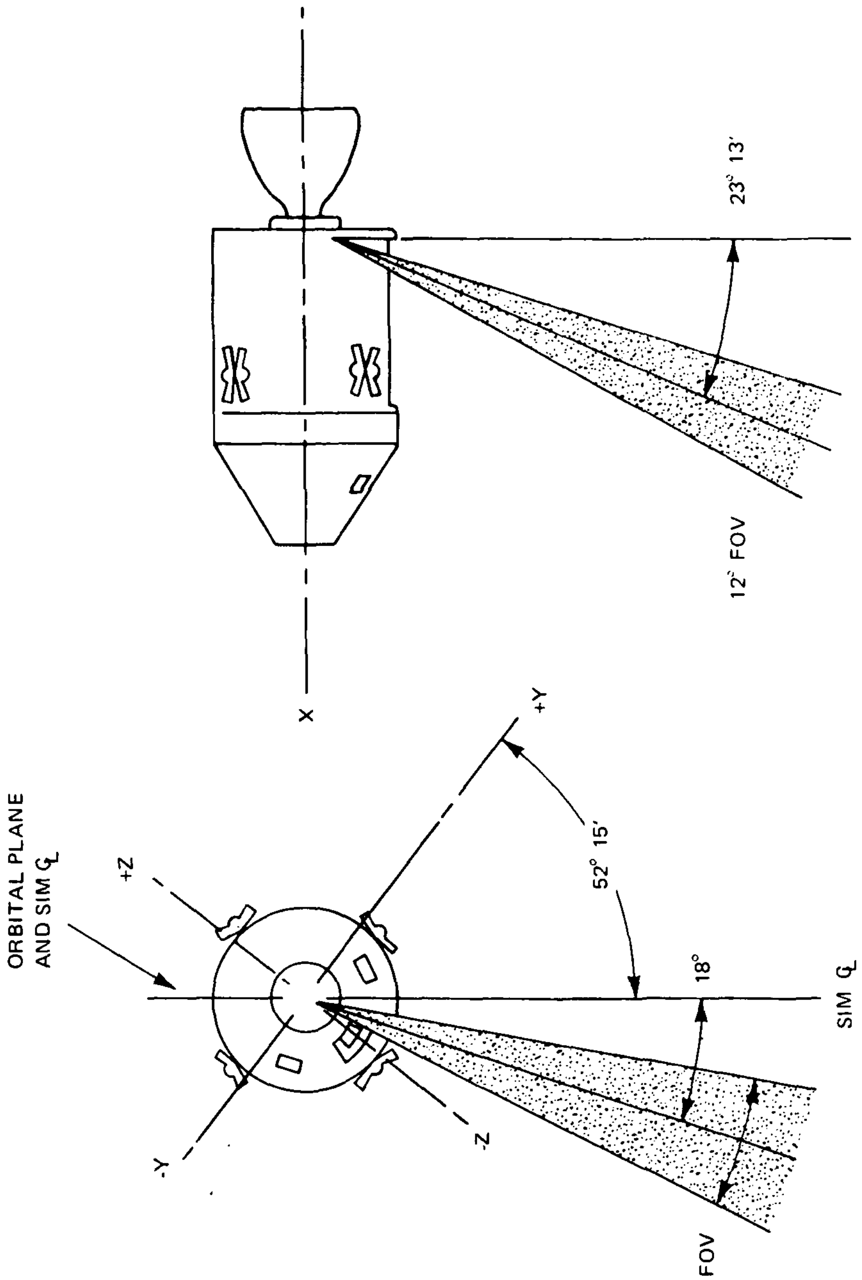


Fig. 38 UV SPECTOMETER ORIENTATION

> ceased to operate. These functions were SL1101T, housing temperature, and SL1102T, motor temperature. At this time SL1101T indicated a false value of less than -40°F and SL1102T indicated a false temperature of approximately -25°F. Simultaneous with the temperature channel failures, SL1104C, input current, varied by 15 mA. These anomalies did not impede the ability of the spectrometer to complete its mission. All other UVS telemetry functions indicated measurements well within nominal operating limits and correlated well with preflight thermal vacuum demonstrations.

Failure of the telemetry temperature measurements was attributed to the loss of the telemetry common voltage reference which was derived from the UVS -15 volt power supply. Under this condition, the jump in the UVS input current, SL1104C, is normal. This postulation was demonstrated by conducting a subsequent test with the ATEE unit.

Conclusions. All launch site operations as regards the UV spectrometer proceeded exceedingly well without problems. Although the UVS dark count remained higher than normal throughout the mission, it did not impair the ability to measure the lunar albedo on the sunlit side or the Lyman-alpha at 1216Å on the dark side, not did it impair the ability to measure the hydrogen density in the lunar atmosphere. The successful completion of Apollo 17 mission operations closes Task II contractual requirements. No further effort is required unless specifically requested by MSC. In the event UV spectrometers are required for use in an outer space environment at some future date, it is recommended that a device be included in the design to filter cosmic rays in order to lower the PMT dark count.

BIBLIOGRAPHY

APL/AC-2624 9 Sep 1971	Detail Program Schedule for the Ultraviolet Spectrometer Experiment S169, Issue B
APL/AC-9439 20 May 1971	Minutes for Technical and Management Review, Ultraviolet Spectrometer Experiment S169, Between MSC/APL, 11-12 May 1971
APL/AC-9340 12 Apr 1971	Minutes for Technical and Management Review, Ultraviolet Spectrometer Experiment S169, Between MSC/APL, April 1971
APL/AC-9450 16 Jun 1971	Time/Cycle Sensitive Components List for the UVS Experiment S169
APL/AC-9451 16 Jun 1971	Minutes for Technical and Management Review, Ultraviolet Spectrometer Experiment S169, Between MSC/APL, 8-9 June 1971
APL/AC-9455 30 Jun 1971	Cordwood Module Standard for the Ultraviolet Spectrometer Experiment S169
APL/AC-9456 30 Jun 1971	Special Parts Mounting Standard for the Ultraviolet Spectrometer Experiment S169
APL/AC-9461 21 Jul 1971	Minutes for Technical and Management Review, Ultraviolet Spectrometer Experiment S169, Between MSC/APL, 16 July 1971
APL/AC-9578 9 Aug 1971	UVS Experiment S169 Agenda for the Technical and Management Review of 18 August 1971
APL/AC-9583 26 Aug 1971	Minutes for Technical and Management Review, Ultraviolet Spectrometer Experiment S169, Between MSC/APL, 20 August 1971
APL/AC-9597 7 Sep 1971	Ultraviolet Spectrometer Experiment S169 Work Breakdown Structure

APL/AC-9598 18 Oct 1971	Contractor Organization Chart for the Ultraviolet Spectrometer Experiment S169
APL/AC-9715 1 Nov 1971	UVS Experiment S169 Data Package for the Hi-Fi Training Unit
APL/AC-9735 3 Dec 1971	UVS Experiment S169, Minutes for Critical Design Review (CDR) Held at APL 13-15 October 1971
APL/AC-9921 10 Mar 1972	UVS Experiment S169 Acceptance Review Data Package for the Prototype Unit
APL/AC-9935 6 Apr 1972	UVS Experiment S169 Acceptance Review Data Package for the Qualification Unit
APL/AC-10045 25 Apr 1972	UVS Experiment S169 Acceptance Review Data Package for the Qualification Unit, Book 3
APL/AC-10047 2 May 1972	UVS Experiment S169 DD-250 and 1149 Forms for the Prototype Unit, Qualification Unit and Four Sets of GSE
APL/AC-10073 13 Jun 1972	UVS Experiment S169 DD-250 and 1149 Forms for Flight Unit Number One and BTE's S/N-01, 02 and 03
APL/AC-10078 21 Jun 1972	UVS Experiment S169 Field Operations Support Progress Report for the Period 1 through 31 May 1972
APL/AC-10083 7 Jul 1972	UVS Experiment S169 Part B Minutes CDR, 13-15 October 1971
APL/AC-10085 10 Jul 1972	UVS Experiment S169 AR Data Packages for BTE (S/N 01), BTE (S/N 03), GSE (Set 1), GSE (Set 2) and GSE (Set 4)
APL/AC-10205 26 Jul 1972	UVS Experiment S169 Field Operations Support Progress Report for the Period 1 through 30 June 1972

APL/AC-10209 9 Aug 1972	UVS Experiment S169 AR Data Package for Flight Unit Number Two
APL/AC-10215 18 Aug 1972	UVS Experiment S169 Field Operations Support Progress Report for the Period 1 through 31 July 1972
APL/AC-10217 22 Aug 1972	UVS Experiment S169 AR Data Package for Flight Unit Number Two, Book 3
APL/AC-10218 23 Aug 1972	UVS Experiment S169 Inventory of Hardware and Documentation Transferred from APL to the Physics Department, The Johns University
APL/AC-10219 24 Aug 1972	UVS Experiment S169 DD-250 Forms for Flight Unit Number Two
APL/AC-10221 25 Aug 1972	UVS Experiment S169 AR Data Packages for the Cross Calibration Unit (S/N CC1)
APL/AC-10229 14 Sep 1972	UVS Experiment S169, Specification Change Log for CEI Specification 7232-0009, Rev. A, Qualification and Flight Units
APL/AC-10232 18 Sep 1972	UVS Field Operations Support Progress Report for the Period 1 through 31 August 1972
APL/AC-10237 25 Sep 1972	UVS Experiment S169, Waiver Number Nine, EMI Qualification Limits Change
APL/AC-10244 7 Nov 1972	UVS EMI and Susceptibility Qualification Test Report and BTE EMI Evaluation Test Report, Comments on
APL/AC-10245 23 Oct 1972	UVS Experiment S169 Qualification Test Report, Rev. A, Supplemental Information
APL/AC-10247 31 Oct 1972	UVS Experiment S169 Field Operations Support Progress Report for the Period 1 through 30 September 1972

APL/AC-10401 1 Dec 1972	UVS Task II Residual Hardware Inventory - Maintenance Required through Launch, Residual Property Inventory, and Residual Hardware Items at KSC
APL/AC-10403 22 Dec 1972	UVS Experiment S169 Field Operations Support and Sustaining Effort for the Months of September and October 1972
APL/AC-10405 15 Jan 1973	UVS Experiment S169 Field Operations Support and Sustaining Effort for the Month of November 1972
APL/CCP-013 23 May 1972	Reconfiguration of the UVS ATEE and Cross Calibration Units
APL/CCP-014 11 May 1972	UVS Prototype Refurbishment
APL/ECP-002 1 Jun 1971	UVS Thermal Test Model
APL/ECP-004R1 17 Jan 1972	Change UVS Calibration Facility from Task II to Task I
APL/ECP-006R1 30 Nov 1971	Deletion of UVS Solar Shutter
APL/ECP-007R1 23 Dec 1971	RCS Aggravated Thermal and Contamination Environment
APL/ECP-009 8 Sep 1971	Revised UVS Shock Environment
APL/ECP-010 30 Aug 1971	UVS Electrical Power Increase
APL/ECP-011 20 Sep 1971	UVS Power Connector Interface Wiring

APL/ECP-012 30 Sep 1971	UVS TM Data Values and Boundary Conditions
APL/ECP-013A 26 Jan 1972	UVS Grounding Straps
APL/ECP-015 14 Feb 1972	NR Temperature Sensor Relocation
APL/ECP-016R1 28 Apr 1972	UVS Nitrogen Purge Provision
APL/ECP-018 16 Feb 1972	UVS Torque Free Mounting Provision
APL/ECP-019R1 16 Mar 1972	Change to UVS Prototype Unit CEI Specification
APL/ECP-021 11 Apr 1972	Change in UVS Ground Support Equipment Interface Control Document
APL/ECP-022 11 Apr 1972	Change in UVS Mechanical Interface Control Document
APL/ECP-023R2 8 Jun 1972	UVS EMI Fix Implementation
APL/ECP-027 24 May 1972	New UVS Time-Temperature Profile
APL/ECP-028 5 May 1972	UVS Wavelength Cam Mechanism Rework and Replacement
APL/ECP-029 13 Jun 1972	UVS Clinch Nut Change
APL/ECP-031 16 Jun 1972	BTE Problem Analysis and Fix
APL/ECP-032 5 Jul 1972	Change to UVS Qualification and Flight CEI Specification

APL/ECP-033 9 Oct 1972	UVS Baffle Test Cover Modification
APL/JHU Technical Proposal 24 Nov 1970	Description of Proposed UVS for Apollo 17
APL/RQAM 8.008 Issue B, May 1971	APL Procedure for Handling of Scrap and "Withheld" Parts S169 (UVS) Program
APL/S3E-72-001 Jun 1972	Electromagnetic Interference Test Plan for the Ultraviolet Spectrometer Experiment S169
APL/S3E-72-011 Mar 1972	UVS Experiment S169 Electromagnetic Interference Test Plan for the Bench Test Equipment
APL/S3E-72-115 24 Apr 1972	Test Report for the Preliminary Electromagnetic Interference Tests on the Ultraviolet Spectrometer and Bench Test Equipment
APL/S3E-72-156 22 May 1972	Test Report for the Preliminary Electromagnetic Interference Tests on the Ultraviolet Spectrometer
APL/S4M-2-250 Dec 1971	Final Stress Analysis Report Ultraviolet Spectrometer S169
APL/S4S-0-750 Change No. 1 Nov 1972	Qualification Test Procedures for the Ultraviolet Spectrometer Experiment S169
APL/S4S-0-673 Apr 1971	Logistics Plan for the Ultraviolet Spectrometer Experiment S169
APL/S4S-0-679B Apr 1972	End Item Test Plan for the Ultraviolet Spectrometer Experiment S169

APL/S4S-0-680A Apr 1972	Qualification Plan for the Ultraviolet Spectrometer Experiment S169
APL/S4S-0-681C Nov 1971	Acceptance Test Plan for the Ultraviolet Spectrometer Experiment S169
APL/S4S-0-878 Apr 1972	Acceptance Test Report for the Ultraviolet Spectrometer Experiment S169 Prototype S/N 01
APL/S4S-2-645 1 Dec 1971	UV Spectrometer Thermal Analytical Model
APL/S4S-3-785 Rev. E, May 1972	Acceptance Test Procedure for the Ultraviolet Spectrometer Experiment S169
APL/S4S-72-007 Change No. 1 Jun 1972	Acceptance Test Report for the Ultraviolet Spectrometer Experiment S169 Qualification Unit S/N 02
APL/S4S-72-008 Rev. A, Sep 1972	Qualification Test Report for the Ultraviolet Spectrometer Experiment S169
APL/S4S-72-019 Jun 1972	Acceptance Test Report for the Ultraviolet Spectrometer Experiment S169 Flight Unit One S/N 03
APL/S4S-72-036 Aug 1972	Acceptance Test Report for the Ultraviolet Spectrometer Experiment S169 Flight Unit Two S/N 04
APL/S4S-72-094 25 July 1972	UVS Experiment S169 TV Test Report for the Thermal Model
APL/SDO-CMO Sep 1971	Agenda for Critical Design Review Ultraviolet Spectrometer Experiment S169, Between MSC/APL 13-15 October 1971

APL/SDO/CMO-060.1 through 060.20 Feb 1971 through Sep 1972	Monthly Progress Report for the Ultraviolet Spectrometer Experiment S169
APL/SDO/CMO-012 Rev. A, Jul 1971	Configuration Management Plan for the Ultraviolet Spectrometer Experiment S169
APL/SDO/CMO-013 Rev. A, May 1971	Management Plan for the Ultraviol-Spectrometer Experiment S169
APL/SDO/CMO-024 May 1971	Program Plan UVS Experiment S169 and Appendix - Design and Development Plan
APL/SDO/CMO-095 Sep 1971	Configuration Identification Procedures for the Ultraviolet Spectrometer Experiment S169
APL/SDO-CMO-096 Issue D, Dec 1971	Configuration Control Procedures for the Ultraviolet Spectrometer Experiment S169
APL/SDO/CMO-334 Rev. A, May 1972	Documentation Index for the Ultraviolet Spectrometer Experiment S169
APL/SDO/CMO-351 Mar 1972	Acceptance Review Report, Prototype Unit and Bench Test Equipment, UVS Experiment S169
APL/SDO/CMO-384 Mar 1972	Acceptance Review Report, Qualification Unit, Bench Test Equipment, and Ground Support Equipment, UVS Experiment S169
APL/SDO/CMO-410 Jun 1972	Acceptance Review Report, Flight Unit Number One and Bench Test Equipment, UVS Experiment S169

APL/SDO/CMO-412 Jun 1972	Electromagnetic Interference Test Procedure for the Bench Test Equipment, UVS Experiment S169
APL/SDO/CMO-436 Aug 1972	Acceptance Review Report, Flight Unit Number Two, UVS Experiment S169
APL/SOR-70-031 Rev. C, Feb 1971	Quality Program Plan for the Ultraviolet Spectrometer Experiment S169
APL/SOR-70-060 Rev. E, Jan 1972	Contamination Control Program Plan for the Ultraviolet Spectrometer Experiment S169
APL/SOR-71-002 Jun 1971	System Safety Plan for the Ultraviolet Spectrometer Experiment S169
APL/SOR-71-007 Rev. A, Aug 1971	Soldering Program Plan for the Ultraviolet Spectrometer Experiment S169
APL/SOR-71-023 Rev. D, Oct 1971	Spares and Repair Parts Support Plan for the Ultraviolet Spectrometer Experiment S169
APL/SOR-70-030 Rev. C, May 1971	Reliability Program Plan for the Ultraviolet Spectrometer Experiment S169
APL/SOR-71-037 Apr 1971	EEE Parts Derating Report for the Ultraviolet Spectrometer Experiment S169
APL/SOR-71-053 Jul 1971	Soldering Procedures for the Ultraviolet Spectrometer Experiment S169
APL/SOR-71-056 Sep 1971	Integrated Circuit Mounting and Connection Standard

APL/SOR-71-057 Issue B, Sep 1971	Failure Mode and Effects Analysis Report and Single Failure Point Summary Report for the Ultraviolet Spectrometer Experiment S169
APL/SOR-71-058 Aug 1971	Hazard Analysis Report for the Ultraviolet Spectrometer Experiment S169
APL/SOR-71-060 Aug 1971	Provisions, Special Storage and Handling, Electrical/Electronic Assemblies for the Ultraviolet Spectrometer Experiment S169
APL/SOR-71-077 Rev. C, Jan 1972	Report, Parts Application Review for the UV Spectrometer Experiment S169
APL/SOR-72-002 5 Jan 1972	NASA Alert MSFC-71-3B Solid Tantalum Capacitor X-ray Rejection Criteria, UVS Experiment S169
APL/SOR-RCEvans Aug 1972	Nonmetallic Materials List
APL/SOR/WWVinson Rev. E, Mar 1972	EEE Parts List
APL/TSSD-2662 1 Oct 1971	CDR Baseline Documentation Package, UVS Experiment S169
APL/7232-0009 Rev. A 15 Oct 1971	Contract End Item Specification, Product Configuration and Acceptance Requirements CEI No. 7232-0000-02 Qualification and Flight Units, Ultraviolet Spectrometer Experiment S169
APL/7232-0010 15 Oct 1971	Contract End Item Specification, Product Configuration and Acceptance Requirements CEI No. 7232-0000-01 Prototype Unit, Ultraviolet Spectrometer Experiment S169

APL/7232-0011 Rev. A 21 Sep 1971	Contract End Item Specification, Product Configuration and Acceptance Requirements CEI No. 7232-0080-HF1 High Fidelity Mockup Training Unit for the Ultraviolet Spectrometer Experiment S169
APL/7232-0012 Rev. A 15 Oct 1971	Contract End Item Specification, Product Configuration and Acceptance Requirements CEI No. 7232-3000-01 The Bench Test Equipment for the Ultraviolet Spectrometer Experiment S169
APL/7232-0013 Rev. A 7 Feb 1972	Contract End Item Specification, Product Configuration and Acceptance Requirements CEI No. 7232-3004-01 The Ground Support Equipment for the Ultraviolet Spectrometer Experiment S169
JHU/APAshton 4 Feb 1972	Proposal for APL Participation in the ATEE Test Program at NAR for the J-Series Mission, Contract NAS9-11528 Ultraviolet Spectrometer Experiment S169
JHU/WGFastie Undated	The Apollo 17 Far Ultraviolet Spectrometer Experiment
JHU/WGFastie 12 Sep 1972	Cross Calibration of JHU Test Equipment with GSFC Vacuum Optical Bench Equipment
KSC/TCP KE-8003 APL/S4S-0-814 Rev C, Oct 1972	Preinstallation Test Procedure for the Ultraviolet Spectrometer 7232-0000
MSC/TCSD EMC-R-EB8-004 Aug 1972	UVS EMI and Susceptibility Qualification Test Report

MSC/TCSD EMC-R-EB8-005 Sep 1972	UVS Experiment S169, BTE EMI Evaluation Test Report