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MSC 04727

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

# SKYLAB OPERATIONS HANDBOOK

## ORBITAL WORKSHOP (OWS)
## AIRLOCK MODULE (AM)
## MULTIPLE DOCKING ADAPTER (MDA)

### VOLUME I

### SYSTEMS DESCRIPTIONS

PREPARED BY
MCDONNELL DOUGLAS ASTRONAUTICS COMPANY
UNDER DIRECTION OF
CREW PROCEDURES DIVISION
SYSTEMS PROCEDURES BRANCH

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

20 JULY 1970
REVISED 24 JANUARY 1972

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OWS/AM/MDA

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SYSTEMS DESCRIPTIONS

PREPARED BY: W. D. West

W. D. West, Senior Engineer
Skylab Mission Operations
McDonnell Douglas Astronautics Company

APPROVED: R. B. Tunnicliff
for
E. A. Thompson, Section Manager
Skylab Mission Operations
McDonnell Douglas Astronautics Company

APPROVED: D. L. Boatman

D. L. Boatman, Program Manager
Skylab Mission Operations
McDonnell Douglas Astronautics Company

NAS 9-11001

Prepared under direction

of

NATIONAL AERONAUTICS and SPACE ADMINISTRATION

MANNED SPACECRAFT CENTER

CREW PROCEDURES DIVISION

SYSTEMS PROCEDURES BRANCH

APPROVED: J. L. Baker

J. L. Baker, Chief
Thermodynamics & Mechanical Procedures Section

APPROVED: Jack Hudson
for
M. E. Dement, Chief
Systems Procedures Branch

24 January 1972

LIST OF EFFECTIVE PAGES

NOTE: This issue is a total revision, contains all pages required for a complete manual, and supersedes all previous issues.

Total number of pages in this publication is 938

TABLE OF CONTENTS

| SECTION | TITLE | PAGE |
|---|---|---|
| FOREWORD | | xv |
| 1.0 | INTRODUCTION | 1.0-1 |
| 1.1 | MISSIONS | 1.1-1 |
| 1.1.2 | MISSION OBJECTIVES | 1.1-1 |
| 1.1.3 | SL-1/2 MISSION | 1.1-1 |
| 1.1.4 | SL-3 MISSION | 1.1-1 |
| 1.1.5 | SL-4 MISSION | 1.1-1 |
| 1.2 | SWS SYSTEMS | 1.2-1 |
| 2.0 | CONFIGURATION AND STRUCTURES | 2.0-1 |
| 2.0.2 | INSTRUMENTATION UNIT | 2.0-1 |
| 2.0.3 | PAYLOAD SHROUD (PS) | 2.0-1 |
| 2.0.3.2 | SYSTEM INTERFACES | 2.0-1 |
| 2.0.3.3 | FUNCTIONAL DESCRIPTION | 2.0-1 |
| 2.0.3.4 | SUBSYSTEM AND MAJOR COMPONENT DESCRIPTION | 2.0-5 |
| 2.0.3.5 | FAILURE MODES | 2.0-13 |
| 2.0.3.6 | PERFORMANCE AND DESIGN DATA | 2.0-17 |
| 2.0.3.7 | OPERATIONAL LIMITATIONS AND RESTRICTIONS | 2.0-17 |
| 2.0.3.8 | INSTRUMENTATION | 2.0-18 |
| 2.0.4 | DISCONE ANTENNA BOOMS | 2.0-18 |
| 2.0.4.2 | SYSTEM INTERFACES | 2.0-18 |
| 2.0.4.3 | FUNCTIONAL DESCRIPTION | 2.0-19 |
| 2.0.4.4 | SUBSYSTEM AND MAJOR COMPONENT DESCRIPTION | 2.0-20 |
| 2.0.4.5 | FAILURE MODES | 2.0-23 |
| 2.0.4.6 | PERFORMANCE AND DESIGN DATA | 2.0-24 |
| 2.0.4.7 | OPERATIONAL LIMITATIONS AND RESTRICTIONS | 2.0-24 |
| 2.0.4.8 | INSTRUMENTATION | 2.0-24 |
| 2.0.5 | APOLLO TELESCOPE MOUNT (ATM) | 2.0-24 |
| 2.0.5.2 | ATM RACK | 2.0-26 |
| 2.0.5.3 | EXPERIMENT CANISTER | 2.0-26 |
| 2.0.5.4 | SOLAR ARRAY | 2.0-26 |
| 2.0.6 | ATM-DEPLOYMENT ASSEMBLY (ATM-DA) | 2.0-26 |
| 2.0.6.2 | SYSTEM INTERFACES | 2.0-26 |
| 2.0.6.3 | FUNCTIONAL DESCRIPTION | 2.0-27 |
| 2.0.6.4 | SUBSYSTEM AND MAJOR COMPONENT DESCRIPTION | 2.0-27 |
| 2.0.6.5 | FAILURE MODES | 2.0-34 |
| 2.0.6.6 | PERFORMANCE AND DESIGN DATA | 2.0-39 |
| 2.0.6.7 | OPERATIONAL LIMITATIONS AND RESTRICTIONS | 2.0-39 |
| 2.0.6.8 | INSTRUMENTATION | 2.0-39 |
| 2.0.7 | MULTIPLE DOCKING ADAPTER (MDA) | 2.0-39 |
| 2.0.7.2 | INTERFACES | 2.0-43 |
| 2.0.7.3 | SUBSYSTEM AND MAJOR COMPONENT DESCRIPTION | 2.0-43 |
| 2.0.7.4 | FAILURE MODES | 2.0-49 |

| SECTION | TITLE | PAGE |
|---|---|---|
| 2.0.8 | AIRLOCK MODULE (AM) | 2.0-50 |
| 2.0.8.2 | SYSTEM INTERFACES | 2.0-55 |
| 2.0.8.3 | SUBSYSTEM AND MAJOR COMPONENT DESCRIPTION | 2.0-55 |
| 2.0.8.4 | FAILURE MODES | 2.0-66 |
| 2.0.9 | FIXED AIRLOCK SHROUD (FAS) | 2.0-72 |
| 2.0.9.2 | INTERFACES | 2.0-72 |
| 2.0.9.3 | SUBSYSTEM AND MAJOR COMPONENT DESCRIPTION | 2.0-72 |
| 2.0.10 | ORBITAL WORKSHOP (OWS) | 2.0-74 |
| 2.0.10.2 | SYSTEM INTERFACES | 2.0-74 |
| 2.0.10.3 | CONFIGURATION | 2.0-74 |
| 2.0.10.4 | SUBSYSTEM AND MAJOR COMPONENT DESCRIPTION | 2.0-85 |
| 2.0.10.5 | FAILURE MODES | 2.0-106 |
| 2.1 | ELECTRICAL POWER SYSTEM | 2.1-1 |
| 2.1.2 | INTERFACES | 2.1-1 |
| 2.1.2.1 | MODULE INTERFACE | 2.1-1 |
| 2.1.2.2 | SYSTEM INTERFACE | 2.1-1 |
| 2.1.3 | FUNCTIONAL DESCRIPTION | 2.1-4 |
| 2.1.3.2 | POWER GENERATION | 2.1-6 |
| 2.1.3.3 | POWER CONDITIONING | 2.1-6 |
| 2.1.3.4 | POWER DISTRIBUTION | 2.1-13 |
| 2.1.4 | SUBSYSTEM AND MAJOR COMPONENT DESCRIPTION | 2.1-24 |
| 2.1.4.1 | POWER GENERATION | 2.1-24 |
| 2.1.4.2 | POWER CONDITIONING | 2.1-31 |
| 2.1.4.3 | POWER DISTRIBUTION | 2.1-39 |
| 2.1.5 | FAILURE MODES | 2.1-44 |
| 2.1.6 | PERFORMANCE AND DESIGN DATA | 2.1-46 |
| 2.1.7 | EPS OPERATIONAL LIMITATIONS AND RESTRICTIONS | 2.1-48 |
| 2.1.8 | INSTRUMENTATION AND GROUND COMMANDS | 2.1-48 |
| 2.2 | COMMUNICATION SYSTEM | 2.2-1 |
| 2.2.2 | SYSTEM INTERFACES | 2.2-1 |
| 2.2.3 | FUNCTIONAL DESCRIPTION | 2.2-1 |
| 2.2.3.1 | AUDIO SUBSYSTEM | 2.2-1 |
| 2.2.3.2 | TELEVISION SUBSYSTEM | 2.2-6 |
| 2.2.3.3 | TELEPRINTING SUBSYSTEM | 2.2-8 |
| 2.2.3.4 | RANGING SUBSYSTEM | 2.2-8 |
| 2.2.3.5 | RF SUBSYSTEM | 2.2-9 |
| 2.2.4 | SUBSYSTEM AND MAJOR COMPONENT DESCRIPTION | 2.2-11 |
| 2.2.4.1 | AUDIO SUBSYSTEM | 2.2-11 |
| 2.2.4.2 | TELEVISION SUBSYSTEM | 2.2-11 |
| 2.2.4.3 | TELEPRINTING SUBSYSTEM | 2.2-11 |
| 2.2.4.4 | RANGING SUBSYSTEM | 2.2-15 |
| 2.2.4.5 | RF SUBSYSTEM | 2.2-15 |
| 2.2.5 | FAILURE MODES | 2.2-15 |
| 2.2.6 | PERFORMANCE AND DESIGN DATA | 2.2-17 |
| 2.2.7 | OPERATIONAL LIMITATIONS AND RESTRICTIONS | 2.2-21 |
| 2.2.8 | INSTRUMENTATION AND GROUND COMMANDS | 2.2-21 |

| SECTION | TITLE | PAGE |
|---|---|---|
| 2.3 | THRUSTER ATTITUDE CONTROL SYSTEM | 2.3-1 |
| 2.3.2 | SYSTEM INTERFACES | 2.3-1 |
| 2.3.2.1 | INSTRUMENT UNIT ATTITUDE CONTROL MODE | 2.3-1 |
| 2.3.2.2 | ATM ATTITUDE CONTROL MODE | 2.3-1 |
| 2.3.3 | FUNCTIONAL DESCRIPTION | 2.3-3 |
| 2.3.3.1 | PROPELLANT SUPPLY/DISTRIBUTION PROPULSION | 2.3-3 |
| 2.3.3.2 | THRUSTER CONTROL | 2.3-6 |
| 2.3.4 | SUBSYSTEM AND MAJOR COMPONENT DESCRIPTION | 2.3-14 |
| 2.3.4.1 | POWER AND CONTROL SWITCHING ASSEMBLY | 2.3-14 |
| 2.3.4.2 | THRUSTER | 2.3-16 |
| 2.3.4.3 | CONTROL VALVES | 2.3-16 |
| 2.3.4.4 | FILL DISCONNECT | 2.3-16 |
| 2.3.4.5 | N2 STORAGE SPHERES | 2.3-16 |
| 2.3.4.6 | STORAGE SPHERE METEOROID SHIELD | 2.3-16 |
| 2.3.4.7 | N2 SUPPLY LINE FILTER | 2.3-16 |
| 2.3.4.8 | PRESSURE SWITCH | 2.3-16 |
| 2.3.4.9 | TIME DELAY MODULE | 2.3-16 |
| 2.3.4.10 | VOLTAGE SENSOR | 2.3-20 |
| 2.3.5 | FAILURE MODES | 2.3-20 |
| 2.3.6 | PERFORMANCE AND DESIGN DATA | 2.3-22 |
| 2.3.7 | OPERATIONAL LIMITATIONS AND RESTRICTIONS | 2.3-27 |
| 2.3.8 | INSTRUMENTATION AND GROUND COMMANDS | 2.3-29 |
| 2.4 | ENVIRONMENTAL CONTROL SYSTEM | 2.4-1 |
| 2.4.2 | SYSTEM INTERFACES | 2.4-3 |
| 2.4.3 | FUNCTIONAL DESCRIPTION | 2.4-4 |
| 2.4.3.1 | PRESSURIZATION AND GAS DISTRIBUTION | 2.4-4 |
| 2.4.3.2 | THERMAL CONTROL | 2.4-4 |
| 2.4.3.3 | ATMOSPHERE CONTROL | 2.4-7 |
| 2.4.3.4 | EVA/IVA SUPPORT | 2.4-7 |
| 2.4.3.5 | REFRIGERATION | 2.4-7 |
| 2.4.4 | SUBSYSTEM AND MAJOR COMPONENT DESCRIPTION | 2.4-11 |
| 2.4.4.1 | PRESSURIZATION AND GAS DISTRIBUTION | 2.4-11 |
| 2.4.4.2 | THERMAL CONTROL | 2.4-37 |
| 2.4.4.3 | ATMOSPHERE CONTROL | 2.4-67 |
| 2.4.4.4 | EVA/IVA SUPPORT | 2.4-95 |
| 2.4.4.5 | REFRIGERATION | 2.4-101 |
| 2.4.5 | FAILURE MODES | 2.4-111 |
| 2.4.5.1 | PRESSURIZATION AND GAS DISTRIBUTION | 2.4-111 |
| 2.4.5.2 | THERMAL CONTROL | 2.4-113 |
| 2.4.5.3 | ATMOSPHERE CONTROL | 2.4-113 |
| 2.4.5.4 | EVA/IVA SUPPORT | 2.4-114 |
| 2.4.5.5 | REFRIGERATION | 2.4-115 |
| 2.4.6 | PERFORMANCE AND DESIGN DATA | 2.4-115 |
| 2.4.7 | OPERATIONAL LIMITATIONS AND RESTRICTIONS | 2.4-120 |
| 2.4.8 | INSTRUMENTATION AND GROUND COMMANDS | 2.4-123 |

| SECTION | TITLE | PAGE |
|---|---|---|
| 2.5 | CREW SYSTEMS | 2.5-1 |
| 2.5.2 | SYSTEM INTERFACES | 2.5-2 |
| 2.5.3 | RESTRAINTS AND MOBILITY AIDS | 2.5-2 |
| 2.5.4 | LIGHTING SYSTEM | 2.5-13 |
| 2.5.5 | STOWAGE | 2.5-33 |
| 2.5.6 | WEARING APPAREL | 2.5-48 |
| 2.5.7 | EVA SUPPORT | 2.5-49 |
| 2.5.8 | OFF-DUTY EQUIPMENT | 2.5-66 |
| 2.5.9 | TRASH DISPOSAL | 2.5-69 |
| 2.5.10 | FOOD MANAGEMENT | 2.5-71 |
| 2.5.11 | WASTE MANAGEMENT | 2.5-83 |
| 2.5.12 | WATER SYSTEM | 2.5-103 |
| 2.5.13 | PERSONAL HYGIENE | 2.5-129 |
| 2.5.14 | VACUUM PROVISIONS | 2.5-134 |
| 2.5.15 | ORBITAL MAINTENANCE | 2.5-138 |
| 2.5.16 | CREW SAFETY PROVISIONS | 2.5-143 |
| 2.5.17 | INSTRUMENTATION AND GROUND COMMANDS | 2.5-153 |
| 2.5.18 | FAILURE MODES | (TBS) |
| 2.5.19 | PERFORMANCE AND DESIGN DATA | (TBS) |
| 2.5.20 | OPERATIONAL LIMITATIONS AND RESTRICTIONS | (TBS) |
| 2.6 | INSTRUMENTATION SYSTEM | 2.6-1 |
| 2.6.2 | SYSTEM INTERFACES | 2.6-1 |
| 2.6.3 | FUNCTIONAL DESCRIPTION | 2.6-2 |
| 2.6.3.1 | POWER SUBSYSTEM | 2.6-2 |
| 2.6.3.2 | PCM SUBSYSTEM | 2.6-5 |
| 2.6.3.3 | RECORDING SUBSYSTEM | 2.6-5 |
| 2.6.3.4 | TRANSMISSION SUBSYSTEM | 2.6-8 |
| 2.6.3.5 | OPERATIONAL FLOW | 2.6-12 |
| 2.6.3.6 | PCM TM FORMATS | 2.6-12 |
| 2.6.3.7 | PROTON SPECTROMETER | 2.6-15 |
| 2.6.4 | SUBSYSTEM AND MAJOR COMPONENT DESCRIPTION | 2.6-15 |
| 2.6.4.1 | POWER SUBSYSTEM | 2.6-15 |
| 2.6.4.2 | PCM SUBSYSTEM | 2.6-20 |
| 2.6.4.3 | TAPE RECORDER | 2.6-34 |
| 2.6.5 | FAILURE MODES | 2.6-36 |
| 2.6.6 | PERFORMANCE AND DESIGN DATA | 2.6-36 |
| 2.6.7 | OPERATIONAL LIMITATIONS AND RESTRICTIONS | 2.6-38 |
| 2.6.8 | INSTRUMENTATION AND GROUND COMMANDS | 2.6-38 |

| SECTION | TITLE | PAGE |
|---|---|---|
| 2.7 | DIGITAL COMMAND SYSTEM/TIME REFERENCE SYSTEM | 2.7-1 |
| 2.7.2 | SYSTEM INTERFACES | 2.7-1 |
| 2.7.3 | FUNCTIONAL DESCRIPTION | 2.7-1 |
| 2.7.3.1 | DIGITAL COMMAND SYSTEM/TIME REFERENCE SYSTEM CONTROL | 2.7-4 |
| 2.7.3.2 | DIGITAL COMMAND SYSTEM/TIME REFERENCE SYSTEM DATA FORMATS | 2.7-6 |
| 2.7.4 | SUBSYSTEM AND MAJOR COMPONENT DESCRIPTION | 2.7-7 |
| 2.7.4.1 | RECEIVER/DECODER | 2.7-7 |
| 2.7.4.2 | DCS RELAY MODULE | 2.7-9 |
| 2.7.4.3 | CRDU | 2.7-9 |
| 2.7.4.4 | ELECTRONIC TIMER | 2.7-9 |
| 2.7.4.5 | TCB | 2.7-9 |
| 2.7.4.6 | GMT CLOCK | 2.7-11 |
| 2.7.4.7 | EVENT TIMER | 2.7-11 |
| 2.7.4.8 | PORTABLE TIMER | 2.7-14 |
| 2.7.5 | FAILURE MODES | 2.7-14 |
| 2.7.6 | PERFORMANCE AND DESIGN DATA | 2.7-15 |
| 2.7.7 | OPERATIONAL LIMITATIONS AND RESTRICTIONS | 2.7-17 |
| 2.7.8 | INSTRUMENTATION AND GROUND COMMANDS | 2.7-18 |
| 2.8 | CAUTION AND WARNING SYSTEM | 2.8-1 |
| 2.8.2 | SYSTEM INTERFACES | 2.8-1 |
| 2.8.3 | FUNCTIONAL DESCRIPTION | 2.8-1 |
| 2.8.3.1 | CAUTION (WARNING) CONDITION DETECTION | 2.8-5 |
| 2.8.3.2 | RAPID $\Delta$P DETECTION | 2.8-9 |
| 2.8.3.3 | FIRE DETECTION | 2.8-9 |
| 2.8.3.4 | C&W SUBSYSTEM POWER | 2.8-13 |
| 2.8.3.5 | EMERGENCY SUBSYSTEM POWER | 2.8-13 |
| 2.8.4 | SUBSYSTEM AND MAJOR COMPONENT DESCRIPTION | 2.8-13 |
| 2.8.4.1 | CONTROLS AND DISPLAYS | 2.8-13 |
| 2.8.4.2 | CAUTION AND WARNING SENSORS AND DETECTORS | 2.8-20 |
| 2.8.4.3 | C&W SIGNAL CONDITIONING DISPLAY CONVERTER PRI (SEC) | 2.8-20 |
| 2.8.4.4 | RAPID $\Delta$P SENSORS | 2.8-20 |
| 2.8.4.5 | ULTRA VIOLET FIRE SENSOR ASSEMBLIES | 2.8-21 |
| 2.8.4.6 | CAUTION AND WARNING UNIT | 2.8-21 |
| 2.8.4.7 | C&W HIGH-LEVEL AUDIO AMPLIFIER | 2.8-26 |
| 2.8.4.8 | C&W RELAY MODULE | 2.8-26 |
| 2.8.4.9 | KLAXON (2 UNITS) | 2.8-26 |
| 2.8.5 | FAILURE MODES | 2.8-27 |
| 2.8.6 | PERFORMANCE AND DESIGN DATA | 2.8-28 |
| 2.8.7 | OPERATIONAL LIMITATIONS AND RESTRICTIONS | 2.8-29 |
| 2.8.8 | INSTRUMENTATION AND GROUND COMMANDS | 2.8-29 |
| 2.8.9 | CAUTION/WARNING AND EMERGENCY PARAMETER SUMMARY | 2.8-31 |
| 2.9 | DOCKING AND CREW TRANSFER | 2.9-1 |
| 2.9.2 | RENDEZVOUS | 2.9-1 |
| 2.9.3 | DOCKING | 2.9-1 |
| 2.9.4 | CREW TRANSFER | 2.9-3 |
| 2.9.5 | DEACTIVATION | 2.9-3 |
| 2.9.6 | SUBSYSTEM AND MAJOR COMPONENT DESCRIPTION | 2.9-3 |

| SECTION | TITLE | PAGE |
|---|---|---|
| 2.10 | EXPERIMENTS | 2.10-1 |
| 2.11 | SEQUENTIAL | 2.11-1 |
| 2.11.2 | INTERFACES | 2.11-1 |
| 2.11.3 | SEQUENTIAL CONTROL | 2.11-1 |
| 2.11.3.1 | IU | 2.11-1 |
| 2.11.3.2 | AM DCS | 2.11-3 |
| 2.11.3.3 | ATM DCS | 2.11-3 |
| 2.11.3.4 | ATM APCS | 2.11-3 |
| 2.11.4 | SEQUENTIAL EVENTS | 2.11-4 |
| 2.11.4.1 | SEQUENCE EVENT CATEGORIES | 2.11-4 |
| 2.11.4.2 | INTERLOCKS | 2.11-4 |
| 2.11.4.3 | SL-2 CSM LAUNCH COMMIT CRITERIA AS A FUNCTION OF SWS STATUS | 2.11-4 |
| 2.11.4.4 | SWS LIFTOFF CONFIGURATION | 2.11-4 |
| 2.11.4.5 | SEQUENTIAL EVENTS FROM LIFTOFF TO SL-2 CSM DOCKING | 2.11-6 |
| 3.0 | CONTROLS AND DISPLAYS | 3.0-1 |
| APPENDIX | | |
| A | ABBREVIATIONS AND ACRONYMS | A-1 |
| B | SYMBOLS | B-1 |
| C | LOCATOR INDEX | C-1 |
| D | ALPHABETICAL INDEX | D-1 |

ILLUSTRATIONS

| FIGURE | TITLE | PAGE |
|---|---|---|
| 1.0-1 | ORBITAL ASSEMBLY CONFIGURATION | xvi |
| 1.1-1 | SKYLAB MISSION PROFILE | 1.1-2 |
| 1.1-2 | SKYLAB LAUNCH CONFIGURATION | 1.1-3 |
| 1.1-3 | OA ORIENTATION | 1.1-4 |
| 2.0.2-1 | INSTRUMENTATION STRUCTURAL ARRANGEMENT | 2.0-2 |
| 2.0.3-1 | PAYLOAD SHROUD | 2.0-3 |
| 2.0.3-2 | PS GENERAL CONFIGURATION | 2.0-4 |
| 2.0.3-3 | PAYLOAD SHROUD ATM SUPPORT STRUCTURE | 2.0-6 |
| 2.0.3-4 | PAYLOAD SHROUD TO FAS INTERFACE | 2.0-7 |
| 2.0.3-5 | PAYLOAD SHROUD LATCH ACTUATOR SYSTEM | 2.0-8 |
| 2.0.3-6 | PAYLOAD SHROUD DEPLOYMENT SCHEMATIC | 2.0-9 |
| 2.0.3-7 | EBW FIRING UNIT | 2.0-11 |
| 2.0.3-8 | EBW DETONATOR | 2.0-11 |
| 2.0.3-9 | PS SEPARATION ORDNANCE SYSTEM | 2.0-12 |
| 2.0.4-1 | DISCONE ANTENNA BOOMS | 2.0-19 |
| 2.0.4-2 | DISCONE ANTENNA BOOMS - CONFIGURATION | 2.0-20 |
| 2.0.4-3 | DISCONE ANTENNA RELEASE MECHANISMS | 2.0-21 |
| 2.0.4-4 | DISCONE ANTENNA ROTATION ASSEMBLY | 2.0-22 |
| 2.0.4-5 | DISCONE ANTENNA DEPLOYMENT | 2.0-22A |
| 2.0.4-6 | RELEASE ACTUATOR | 2.0-22B |
| 2.0.4-7 | ROTARY JOINT | 2.0-22B |
| 2.0.5-1 | APOLLO TELESCOPE MOUNT | 2.0-25 |
| 2.0.6-1 | ATM DEPLOYMENT ASSEMBLY | 2.0-26 |
| 2.0.6-2 | DA TRUSS ASSEMBLY | 2.0-28 |
| 2.0.6-3 | RIGIDIFYING MECHANISM | 2.0-29 |
| 2.0.6-4 | ATM DEPLOYMENT RELEASE MECHANISM | 2.0-30 |
| 2.0.6-5 | PIN RETRACTOR | 2.0-31 |
| 2.0.6-6 | PRESSURE CARTRIDGE | 2.0-31 |
| 2.0.6-7 | ATM DEPLOYMENT LATCH RELEASE SYSTEM BUS 1 | 2.0-32 |
| 2.0.6-8 | DA ROTATION MECHANISM | 2.0-33 |

| FIGURE | TITLE | PAGE |
|---|---|---|
| 2.0.6-9 | TRUNNION | 2.0-33 |
| 2.0.6-10 | DEPLOYMENT REEL | 2.0-34 |
| 2.0.6-11 | ATM DEPLOYMENT DA MOTORS ON CONTROL SYSTEM - BUS 1 | 2.0-36 |
| 2.0.6-12 | ATM DEPLOYMENT DA MOTORS OFF CONTROL SYSTEM - BUS 1 | 2.0-37 |
| 2.0.6-13 | DA LATCHING MECHANISM | 2.0-38 |
| 2.0.7-1 | MDA EXTERNAL CONFIGURATION | 2.0-40 |
| 2.0.7-2 | -Y HALF INTERNAL CONFIGURATION | 2.0-41 |
| 2.0.7-3 | +Y HALF INTERNAL CONFIGURATION | 2.0-42 |
| 2.0.7-4 | STRUCTURAL CONFIGURATION | 2.0-44 |
| 2.0.7-5 | MDA STRUCTURE | 2.0-45 |
| 2.0.7-6 | RADIATOR/METEOROID SHIELD CONFIGURATION | 2.0-46 |
| 2.0.7-7 | S190 WINDOW | 2.0-47 |
| 2.0.7-8 | MDA MOUNTED DOCKING TARGET | 2.0-48 |
| 2.0.7-9 | MDA DROGUE | 2.0-48 |
| 2.0.7-10 | DROGUE ASSEMBLY | 2.0-51 |
| 2.0.7-11 | MDA HATCH | 2.0-52 |
| 2.0.7-12 | MDA HATCH - Details | 2.0-53 |
| 2.0.8-1 | AM CONFIGURATION | 2.0-54 |
| 2.0.8-2 | AM MAJOR STRUCTURE ASSEMBLY | 2.0-56 |
| 2.0.8-3 | AM EXTERNAL CONFIGURATION | 2.0-57 |
| 2.0.8-4 | AM INTERIOR LAYOUT | 2.0-58 |
| 2.0.8-5 | STRUCTURAL TRANSITION SECTION | 2.0-59 |
| 2.0.8-6 | STS WINDOW AND COVER | 2.0-60 |
| 2.0.8-7 | RADIATOR CONFIGURATION | 2.0-61 |
| 2.0.8-8 | TUNNEL ASSEMBLY | 2.0-62 |
| 2.0.8-9 | TUNNEL ASSEMBLY SHEAR WEBS | 2.0-63 |
| 2.0.8-10 | TUNNEL INTERIOR | 2.0-64 |
| 2.0.8-11 | INTERIOR HATCHES | 2.0-65 |
| 2.0.8-12 | EVA HATCH | 2.0-70 |
| 2.0.8-13 | FLEXIBLE TUNNEL EXTENSION ASSEMBLY | 2.0-71 |
| 2.0.8-14 | AM SUPPORT TRUSS ASSEMBLY | 2.0-72 |
| 2.0.9-1 | FIXED AIRLOCK SHROUD | 2.0-73 |
| 2.0.10-1 | ORBITAL WORKSHOP | 2.0-74 |
| 2.0.10-2 | OWS HABITATION PROVISIONS | 2.0-75 |
| 2.0.10-3 | WATER STORAGE TANKS CONFIGURATION | 2.0-76 |
| 2.0.10-4 | CONTAINER FLOOR MOUNTING | 2.0-76 |
| 2.0.10-5 | FORWARD COMPARTMENT FLOOR STRUCTURE | 2.0-77 |
| 2.0.10-6 | SCIENTIFIC AIRLOCK CONFIGURATION | 2.0-78 |
| 2.0.10-7 | CREW QUARTERS LAYOUT | 2.0-79 |
| 2.0.10-8 | CREW QUARTERS WALL ARRANGEMENT | 2.0-79 |
| 2.0.10-9 | CREW QUARTERS COMPARTMENT FLOOR STRUCTURE | 2.0-80 |
| 2.0.10-10 | WARDROOM ARRANGEMENT | 2.0-80 |
| 2.0.10-11 | WARDROOM VIEWING WINDOW | 2.0-81 |
| 2.0.10-12 | WMC ARRANGEMENT | 2.0-82 |
| 2.0.10-13 | SLEEP COMPARTMENT ARRANGEMENT | 2.0-82 |
| 2.0.10-14 | EXPERIMENT COMPARTMENT ARRANGEMENT | 2.0-83 |
| 2.0.10-15 | WASTE TANK | 2.0-84 |
| 2.0.10-16 | MAJOR STRUCTURAL ASSEMBLIES | 2.0-85 |
| 2.0.10-17 | FORWARD SKIRT ASSEMBLY | 2.0-87 |
| 2.0.10-18 | AFT SKIRT ASSEMBLY | 2.0-88 |
| 2.0.10-19 | OWS HABITATION TANK | 2.0-89 |
| 2.0.10-20 | TACS SPHERES AND METEOROID SHIELD | 2.0-90 |
| 2.0.10-21 | RADIATOR PLUME IMPINGEMENT SHIELD | 2.0-91 |
| 2.0.10-22 | REFRIGERATION SYSTEM RADIATOR PROTECTIVE SHIELD JETTISON | 2.0-92 |
| 2.0.10-23 | SOLAR ARRAY BEAM FAIRING | 2.0-92 |
| 2.0.10-24 | SAS WING ASSEMBLY | 2.0-93 |
| 2.0.10-25 | SAS STOWED CONFIGURATION | 2.0-94 |
| 2.0.10-26 | SAS BEAM FAIRING RELEASE SYSTEM | 2.0-95 |
| 2.0.10-27 | SOLAR ARRAY FAIRINGS 1 AND 2 DEPLOYMENT SYSTEMS | 2.0-96 |
| 2.0.10-28 | SAS DEPLOYMENT MECHANISM | 2.0-97 |
| 2.0.10-29 | SAS WING PANEL RELEASE SYSTEM | 2.0-99 |
| 2.0.10-30 | SOLAR ARRAY WING SECTIONS DEPLOYMENT SYSTEM | 2.0-100 |
| 2.0.10-31 | WING SECTIONS PARTIALLY DEPLOYED | 2.0-101 |
| 2.0.10-32 | DEPLOYMENT INSTRUMENTATION | 2.0-102 |
| 2.0.10-33 | METEOROID SHIELD CONFIGURATION | 2.0-103 |
| 2.0.10-34 | METEOROID SHIELD DEPLOYMENT MECHANISM | 2.0-104 |
| 2.0.10-35 | METEOROID SHIELD DEPLOYMENT ORDNANCE SYSTEM | 2.0-105 |
| 2.0.10-36 | METEOROID SHIELD DEPLOYMENT SYSTEM | 2.0-107 |
| 2.0.10-37 | METEOROID SHIELD DEPLOYMENT INSTRUMENTATION | 2.0-108 |
| 2.0.10-38 | OWS HATCH | 2.0-109 |
| 2.0.10-39 | AFT INTERSTAGE | 2.0-110 |

| FIGURE | TITLE | PAGE |
|---|---|---|
| 2.1.2-1 | OA EPS INTERFACES | 2.1-2 |
| 2.1.2-2 | MDA TUNNEL POWER CONNECTION | 2.1-2 |
| 2.1.2-3 | EPS FUNCTIONAL SCHEMATIC | 2.1-3 |
| 2.1.3-1 | SAS/PCG POWER FLOW AND DISTRIBUTION | 2.1-4 |
| 2.1.3-2 | POWER SYSTEM CONTROL | 2.1-5 |
| 2.1.3-3 | SAS PHYSICAL LAYOUT | 2.1-7 |
| 2.1.3-4 | SAS ELECTRICAL CONFIGURATION | 2.1-7 |
| 2.1.3-5 | TYPICAL SOLAR ARRAY GROUP/PCG INTERFACE | 2.1-8 |
| 2.1.3-6 | PCG POWER FLOW | 2.1-9 |
| 2.1.3-7 | SIMPLIFIED PCG SCHEMATIC | 2.1-10 |
| 2.1.3-8 | PCG OPERATION VOLTAGE | 2.1-11 |
| 2.1.3-9 | SIMPLIFIED BATTERY CHARGER DIAGRAM | 2.1-12 |
| 2.1.3-10 | POWER DISTRIBUTION | 2.1-14 |
| 2.1.3-11 | PCG OUTPUT SCHEMATIC | 2.1-15 |
| 2.1.3-12 | TYPICAL SHUNT/CURRENT SENSOR ARRANGEMENT | 2.1-16 |
| 2.1.3-13 | OWS POWER CONTROL | 2.1-17 |
| 2.1.3-14 | REG TRANSFER TIE | 2.1-17 |
| 2.1.3-15 | POWER DISCONNECT | 2.1-18 |
| 2.1.3-16 | ATM TRANSFER TIE | 2.1-18 |
| 2.1.3-17 | AM/CSM DISTRIBUTION INTERFACE | 2.1-19 |
| 2.1.3-18 | DEPLOY BUS CONTROL | 2.1-20 |
| 2.1.3-19 | DEPLOY BUS LOADS | 2.1-21 |
| 2.1.3-20 | SEQUENTIAL BUS CONTROL | 2.1-22 |
| 2.1.3-21 | SEQUENTIAL BUS LOADS | 2.1-23 |
| 2.1.3-22 | OA GROUNDING SYSTEM | 2.1-23 |
| 2.1.3-23 | AM-CSM SINGLE-POINT GROUND CONTROL | 2.1-24 |
| 2.1.3-24 | AM/MDA UTILITY POWER | 2.1-25 |
| 2.1.3-25 | POWER OUTLETS SCHEMATIC FOR OWS | 2.1-26 |
| 2.1.4-1 | ILLUSTRATION OF B, i, AND $\alpha$ | 2.1-27 |
| 2.1.4-2 | SAS PHYSICAL CONFIGURATION | 2.1-28 |
| 2.1.4-3 | SOLAR CELL MODULE CHARACTERISTICS | 2.1-29 |
| 2.1.4-4 | SOLAR ARRAY GROUP ELECTRICAL CHARACTERISTICS | 2.1-29 |
| 2.1.4-5 | AM-OWS ELECTRICAL POWER CAPABILITY | 2.1-30 |
| 2.1.4-6 | SAS POWER-VOLTAGE RELATIONSHIP | 2.1-30 |
| 2.1.4-7 | COMPLETE ORBIT TEMP HISTORY FOR SAS | 2.1-31 |
| 2.1.4-8 | TYPICAL BATTERY MODULE | 2.1-32 |
| 2.1.4-9 | BATTERY CHARGER FUNCTIONAL DIAGRAM | 2.1-33 |
| 2.1.4-10 | AMPERE-HOUR INTEGRATOR RETURN FACTOR | 2.1-34 |
| 2.1.4-11 | AMP-HOUR INTEGRATOR FUNCTIONAL | 2.1-34 |
| 2.1.4-12 | BATTERY CHARGER VOLTAGE LIMIT MODE | 2.1-36 |
| 2.1.4-13 | AM BATTERY DEGRADATION | 2.1-38 |
| 2.1.4-14 | BUS VOLTAGE REGULATOR POWER DIAGRAM | 2.1-38 |
| 2.1.4-15 | BUS VOLTAGE REGULATOR OUTPUT ADJUSTMENT CHARACTERISTICS | 2.1-40 |
| 2.1.4-16 | BUS VOLTAGE REGULATOR V-I CHARACTERISTICS | 2.1-40 |
| 2.1.4-17 | SHUNT REGULATOR SCHEMATIC | 2.1-41 |
| 2.1.4-18 | SHUNT REGULATOR OPERATING CHARACTERISTICS | 2.1-42 |
| 2.1.4-19 | TYPICAL POWER OUTLETS | 2.1-43 |
| 2.2.2-1 | COMMUNICATION SYSTEM INTERFACES | 2.2-1 |
| 2.2.3-1 | AUDIO SUBSYSTEM CONFIGURATION | 2.2-3 |
| 2.2.3-2 | AUDIO SUBSYSTEM POWER DISTRIBUTION | 2.2-6 |
| 2.2.3-3 | TELEVISION SUBSYSTEM CONFIGURATION | 2.2-7 |
| 2.2.3-4 | TELEPRINTING SUBSYSTEM CONFIGURATION | 2.2-8 |
| 2.2.3-5 | RANGING SUBSYSTEM CONFIGURATION | 2.2-9 |
| 2.2.3-6 | RF SUBSYSTEM CONFIGURATION | 2.2-10 |
| 2.2.4-1 | AUDIO SUBSYSTEM OPERATION | 2.2-12 |
| 2.2.4-2 | TELEVISION SUBSYSTEM OPERATION | 2.2-13 |
| 2.2.4-3 | INTERFACE ELECTRONICS UNIT OPERATION | 2.2-14 |
| 2.2.4-4 | TELEPRINTER OPERATION | 2.2-18 |
| 2.2.4-5 | RANGING SUBSYSTEM OPERATION | 2.2-19 |
| 2.2.4-6 | TRANSMITTER OPERATION | 2.2-19 |
| 2.3.2-1 | THRUSTER ATTITUDE CONTROL SYSTEM INTERFACES | 2.3-2 |
| 2.3.2-2 | SWS ATTITUDE CONTROL SYSTEM | 2.3-2 |
| 2.3.3-1 | THRUSTER ATTITUDE CONTROL SYSTEM THRUSTER MODULE | 2.3-3 |
| 2.3.3-2 | THRUSTER MODULE ORIENTATION | 2.3-4 |
| 2.3.3-3 | TACS PROPELLANT SUPPLY/DISTRIBUTION | 2.3-5 |
| 2.3.3-4 | SINGLE THRUSTER CONTROL -- SCHEMATIC | 2.3-7 |

| FIGURE | TITLE | PAGE |
|---|---|---|
| 2.3.3-5 | COMMAND TRANSFER ENABLE | 2.3-8 |
| 2.3.3-6 | BUS 1 ON/OFF COMMAND -- SCHEMATIC | 2.3-9 |
| 2.3.3-7 | IU COMMAND/THRUSTER INTERFACE | 2.3-10 |
| 2.3.3-8 | TRANSFER AND THRUSTER COMMAND -- SCHEMATIC | 2.3-11 |
| 2.3.3-9 | ATM DC/THRUSTER INTERFACE | 2.3-12 |
| 2.3.3-10 | MANUAL INHIBIT CONTROL | 2.3-13 |
| 2.3.3-11 | MANUAL INHIBIT CONTROL PANEL | 2.3-14 |
| 2.3.3-12 | TACS THRUSTER STUCK | 2.3-15 |
| 2.3.4-1 | CONTROL VALVES INTERNAL VIEW | 2.3-17 |
| 2.3.4-2 | TACS CONTROL VALVE | 2.3-17 |
| 2.3.4-3 | TACS DISCONNECT | 2.3-18 |
| 2.3.4-4 | SPHERES AND METEOROID SHIELD | 2.3-18 |
| 2.3.4-5 | STORAGE SPHERE INSTALLATION | 2.3-19 |
| 2.3.4-6 | THRUSTER SUPPLY LINE FILTER | 2.3-19 |
| 2.3.6-1 | THRUSTER VERSUS IMPULSE REMAINING | 2.3-26 |
| 2.3.6-2 | TYPICAL THRUST PROFILE | 2.3-26 |
| 2.3.8-1 | TACS INSTRUMENTATION | 2.3-31 |
| 2.4.1-1 | ENVIRONMENTAL CONTROL SYSTEM | 2.4-1 |
| 2.4.1-2 | ECS FLOW DIAGRAM | 2.4-2 |
| 2.4.2-1 | ECS INTERFACES | 2.4-3 |
| 2.4.3-1 | PRESSURIZATION AND GAS DISTRIBUTION | 2.4-5 |
| 2.4.3-2 | THERMAL CONTROL | 2.4-6 |
| 2.4.3-3 | ATMOSPHERE CONTROL | 2.4-8 |
| 2.4.3-4 | EVA/IVA SUPPORT | 2.4-9 |
| 2.4.3-5 | REFRIGERATION | 2.4-10 |
| 2.4.4-1 | PURGE AND VENTING | 2.4-12 |
| 2.4.4-2 | HABITATION AREA AND WASTE TANK VENTING | 2.4-13 |
| 2.4.4-3 | HABITATION AREA NON-PROPULSIVE VENT | 2.4-14 |
| 2.4.4-4 | O2/N2 TANK ARRANGEMENT | 2.4-17 |
| 2.4.4-5 | O2 AND N2 GAS DISTRIBUTION | 2.4-18 |
| 2.4.4-6 | AM/MDA AND OWS PRESSURIZATION | 2.4-20 |
| 2.4.4-7 | O2/N2 GAS CONTROL | 2.4-21 |
| 2.4.4-8 | ACTUATION CONTROL MODULE | 2.4-22 |
| 2.4.4-9 | HABITATION AREA VENT VALVE | 2.4-24 |
| 2.4.4-10 | WASTE TANK NPV AND CAP RELEASE | 2.4-25 |
| 2.4.4-11 | HABITATION AREA SOLENOID VENT VALVE | 2.4-26 |
| 2.4.4-12 | CABIN PRESSURE RELIEF VALVE | 2.4-27 |
| 2.4.4-13 | PRESSURE EQUALIZATION VALVE | 2.4-28 |
| 2.4.4-14 | PRESSURE REGULATOR ASSEMBLY | 2.4-29 |
| 2.4.4-15 | LATCHING SOLENOID VALVE | 2.4-30 |
| 2.4.4-16 | CABIN PRESSURE REGULATOR ASSEMBLY | 2.4-31 |
| 2.4.4-17 | WATER RESERVOIR PRESSURE REGULATOR | 2.4-32 |
| 2.4.4-18 | M509 RECHARGE STATION (PANEL 390) | 2.4-33 |
| 2.4.4-19 | PPO2 SENSOR, AMPLIFIER, CONTROLLER | 2.4-34 |
| 2.4.4-20 | SOLENOID VALVE | 2.4-35 |
| 2.4.4-20A | THREE-POSITION SELECTOR VALVE | 2.4-36 |
| 2.4.4-21 | COOLANT SYSTEM | 2.4-38 |
| 2.4.4-22 | PRIMARY COOLANT LOOP | 2.4-41 |
| 2.4.4-23 | ATM C&D PANEL COOLING SYSTEM | 2.4-43 |
| 2.4.4-24 | HEAT PIPE LOCATIONS | 2.4-44 |
| 2.4.4-25 | HEAT PIPE INSTALLATION -- OWS WALL | 2.4-45 |
| 2.4.4-26 | HEAT PIPE INSTALLATION -- FOOD FREEZER | 2.4-47 |
| 2.4.4-27 | HEAT PIPE SECTION | 2.4-47 |
| 2.4.4-28 | ELECTRICAL HEATER LOCATIONS | 2.4-48 |
| 2.4.4-29 | RADIANT HEATERS | 2.4-50 |
| 2.4.4-30 | CONVECTIVE HEATER | 2.4-51 |
| 2.4.4-31 | AM THERMAL INSTALLATION | 2.4-51 |
| 2.4.4-32 | HIGH-PERFORMANCE INSULATION | 2.4-53 |
| 2.4.4-33 | FOAM INSULATION BELOW CREW QUARTERS | 2.4-53 |
| 2.4.4-34 | AM/MDA THERMAL COATINGS | 2.4-54 |
| 2.4.4-35 | METEOROID SHIELD BOOT | 2.4-55 |
| 2.4.4-36 | FORWARD AND AFT THERMAL SHIELD | 2.4-56 |
| 2.4.4-37 | COOLANT PUMP ASSEMBLY | 2.4-58 |
| 2.4.4-38 | AUTOMATIC TEMPERATURE CONTROL LOGIC | 2.4-59 |
| 2.4.4-39 | THERMAL CAPACITOR -- COOLANT SYSTEM | 2.4-60 |
| 2.4.4-40 | GROUND COOLING HEAT EXCHANGER | 2.4-61 |

| FIGURE | TITLE | PAGE |
|---|---|---|
| 2.4.4-41 | RADIATOR BYPASS AND RELIEF VALVE | 2.4-61 |
| 2.4.4-42 | RADIATOR CONFIGURATION | 2.4-63 |
| 2.4.4-43 | TEMPERATURE CONTROL VALVE -- 47°F | 2.4-64 |
| 2.4.4-44 | TEMPERATURE CONTROL VALVE -- 40°F | 2.4-65 |
| 2.4.4-45 | REGENERATIVE-TYPE HEAT EXCHANGER | 2.4-65 |
| 2.4.4-46 | COLDPLATE (TYPICAL) | 2.4-66 |
| 2.4.4-47 | COOLANT FILTER | 2.4-66 |
| 2.4.4-48 | OXYGEN HEAT EXCHANGER | 2.4-67 |
| 2.4.4-49 | WATER PUMP AND FILTER | 2.4-68 |
| 2.4.4-50 | HEAT EXCHANGER COOLANT FLOW BYPASS VALVE | 2.4-69 |
| 2.4.4-51 | ATMOSPHERE CONTROL SYSTEM | 2.4-70 |
| 2.4.4-52 | CABIN HEAT EXCHANGER MODULE | 2.4-71 |
| 2.4.4-53 | OWS COOLING MODULE | 2.4-73 |
| 2.4.4-54 | OWS VENTILATION | 2.4-74 |
| 2.4.4-55 | OWS AIR DIFFUSERS | 2.4-75 |
| 2.4.4-56 | WMC FAN ASSEMBLY | 2.4-76 |
| 2.4.4-57 | PORTABLE FAN ASSEMBLY | 2.4-77 |
| 2.4.4-58 | CONDENSATE COLLECTION AND REMOVAL | 2.4-78 |
| 2.4.4-59 | MOLECULAR SIEVE SYSTEM | 2.4-80 |
| 2.4.4-60 | MOLECULAR SIEVE BED | 2.4-81 |
| 2.4.4-61 | PLV FAN | 2.4-83 |
| 2.4.4-62 | MOLECULAR SIEVE FAN | 2.4-85 |
| 2.4.4-63 | GAS CIRCULATION SHUTOFF VALVE | 2.4-85 |
| 2.4.4-64 | CABIN HEAT EXCHANGER | 2.4-86 |
| 2.4.4-65 | CONDENSING HEAT EXCHANGER AND WATER SEPARATOR | 2.4-87 |
| 2.4.4-66 | WATER SEPARATOR PLATE ASSEMBLY | 2.4-88 |
| 2.4.4-67 | CONDENSATE TANK ASSEMBLY | 2.4-89 |
| 2.4.4-68 | GAS SELECTOR VALVE | 2.4-90 |
| 2.4.4-69 | MOLECULAR SIEVE SORBENT CANISTER | 2.4-92 |
| 2.4.4-70 | MOLECULAR SIEVE SOLENOID & MANUAL INTERCONNECT VALVES | 2.4-93 |
| 2.4.4-71 | MOLECULAR SIEVE CYCLE TIMER | 2.4-94 |
| 2.4.4-72 | SOLIDS TRAP | 2.4-94 |
| 2.4.4-73 | CHARCOAL CANISTER | 2.4-95 |
| 2.4.4-74 | EVA/IVA SUPPORT SYSTEM | 2.4-96 |
| 2.4.4-75 | SUIT COOLING SYSTEM | 2.4-97 |
| 2.4.4-76 | SUIT COOLING SYSTEM -- COOLANT LOOP INTERFACE | 2.4-98 |
| 2.4.4-77 | EVA/IVA STATION | 2.4-100 |
| 2.4.4-78 | GAS SEPARATOR | 2.4-101 |
| 2.4.4-79 | REFRIGERATION SYSTEM | 2.4-102 |
| 2.4.4-80 | REFRIGERATION SYSTEM COOLANT LOOP | 2.4-103 |
| 2.4.4-81 | REFRIGERATION SYSTEM RADIATOR | 2.4-106 |
| 2.4.4-82 | THERMAL CAPACITOR -- REFRIGERATION SYSTEM | 2.4-106 |
| 2.4.4-83 | TEMPERATURE CONTROL VALVES | 2.4-107 |
| 2.4.4-84 | RADIATOR BYPASS VALVE | 2.4-108 |
| 2.4.4-85 | FOOD FREEZERS | 2.4-109 |
| 2.4.4-86 | WATER CHILLER | 2.4-110 |
| 2.4.4-87 | URINE FREEZER | 2.4-111 |
| 2.4.8-1 | PURGE AND VENTING | 2.4-124 |
| 2.4.8-2 | OWS VENT SYSTEM CONTROL | 2.4-126 |
| 2.4.8-3 | O2 AND N2 GAS DISTRIBUTION | 2.4-129 |
| 2.4.8-4 | COOLANT SYSTEM | 2.4-131 |
| 2.4.8-5 | THERMAL CONTROL HEATERS | 2.4-134 |
| 2.4.8-6 | ATMOSPHERE CONTROL SYSTEM | 2.4-137 |
| 2.4.8-7 | REFRIGERATION SYSTEM | 2.4-139 |
| 2.5.3-1 | GRID LOCATIONS | 2.5-3 |
| 2.5.3-2 | CREWMAN RESTRAINTS -- INTERNAL | 2.5-5 |
| 2.5.3-3 | FIXED CREWMAN HAND RESTRAINTS -- INTERNAL | 2.5-7 |
| 2.5.3-4 | EXTERNAL RESTRAINTS AND MOBILITY AIDS | 2.5-8 |
| 2.5.3-5 | EQUIPMENT RESTRAINTS -- INTERNAL | 2.5-10 |
| 2.5.3-6 | SWS SNAP PATTERN | 2.5-14 |
| 2.5.4-1 | TRACKING LIGHTS | 2.5-15 |
| 2.5.4-2 | TRACKING LIGHTS -- FUNCTIONAL DIAGRAM | 2.5-16 |
| 2.5.4-3 | DOCKING LIGHTS | 2.5-18 |
| 2.5.4-4 | DOCKING LIGHTS -- FUNCTIONAL DIAGRAM | 2.5-19 |
| 2.5.4-5 | EVA LIGHTING | 2.5-20 |
| 2.5.4-6 | EVA LIGHTING -- FUNCTIONAL DIAGRAM | 2.5-21 |
| 2.5.4-7 | SWS INTERNAL LIGHTING | 2.5-22 |
| 2.5.4-8 | INTERNAL LIGHTS | 2.5-23 |
| 2.5.4-9 | MDA INTERNAL LIGHTING -- FUNCTIONAL DIAGRAM | 2.5-24 |

| FIGURE | TITLE | PAGE |
|---|---|---|
| 2.5.4-10 | FLOODLIGHT BULB -- SCHEMATIC | 2.5-24 |
| 2.5.4-11 | I/LCA HEATER -- SCHEMATIC | 2.5-25 |
| 2.5.4-12 | AM INTERNAL LIGHTING -- FUNCTIONAL DIAGRAM | 2.5-26 |
| 2.5.4-13 | AM METER LIGHTS | 2.5-28 |
| 2.5.4-14 | OWS FORWARD AREA LIGHTING -- FUNCTIONAL DIAGRAM | 2.5-28 |
| 2.5.4-15 | OWS CREW QUARTERS LIGHTING -- FUNCTIONAL DIAGRAM | 2.5-29 |
| 2.5.4-16 | ENTRY LIGHTING -- FUNCTIONAL DIAGRAM | 2.5-30 |
| 2.5.4-17 | EMERGENCY LIGHTING -- FUNCTIONAL DIAGRAM | 2.5-31 |
| 2.5.4-18 | SLEEP COMPARTMENT LIGHT BAFFLES | 2.5-32 |
| 2.5.4-19 | PORTABLE LIGHTING | 2.5-34 |
| 2.5.4-20 | FLOODLIGHT BULB -- SCHEMATIC (PORTABLE LIGHT USAGE) | 2.5-35 |
| 2.5.4-21 | HIGH INTENSITY LIGHT -- SCHEMATIC | 2.5-35 |
| 2.5.5-1 | SWS STOWAGE NUMBERING SYSTEM | 2.5-36 |
| 2.5.5-2 | SWS EQUIPMENT STOWAGE | 2.5-37 |
| 2.5.5-3 | MDA STOWAGE | 2.5-38 |
| 2.5.5-4 | AM STOWAGE | 2.5-39 |
| 2.5.5-5 | OWS STOWAGE | 2.5-41 |
| 2.5.5-6 | OWS STOWAGE COMPARTMENTS | 2.5-42 |
| 2.5.5-7 | TISSUE DISPENSER -- INSTALLATION | 2.5-43 |
| 2.5.5-8 | FECAL BAG DISPENSER | 2.5-43 |
| 2.5.5-9 | TOWEL DISPENSER | 2.5-44 |
| 2.5.5-10 | TRASH CONTAINER | 2.5-44 |
| 2.5.5-11 | FOOD BOXES | 2.5-45 |
| 2.5.5-12 | FOOD FREEZERS AND FOOD CHILLER | 2.5-46 |
| 2.5.5-13 | URINE FREEZER | 2.5-46 |
| 2.5.5-14 | FILM VAULT (F10) | 2.5-47 |
| 2.5.6-1 | SHIRTSLEEVE CLOTHING | 2.5-48 |
| 2.5.6-2 | SHIRTSLEEVE CLOTHING ALLOCATION | 2.5-49 |
| 2.5.6-3 | CLOTHING BAG | 2.5-50 |
| 2.5.7-1 | EVA TASKS TIMELINE | 2.5-50 |
| 2.5.7-2 | EVA WORKSTATIONS | 2.5-52 |
| 2.5.7-3 | EVA WORKSTATION PROVISIONS | 2.5-53 |
| 2.5.7-4 | EXTENDIBLE BOOM CONTROL -- SCHEMATIC | 2.5-55 |
| 2.5.7-5 | LIFE SUPPORT PROVISIONS | 2.5-57 |
| 2.5.7-6 | CREWMAN EVA EQUIPMENT | 2.5-58 |
| 2.5.7-7 | LIFE SUPPORT SYSTEMS -- FUNCTIONAL DIAGRAM | 2.5-60 |
| 2.5.7-8 | ALSA SOP -- FUNCTIONAL DIAGRAM | 2.5-60 |
| 2.5.7-9 | ALSA PCU -- FUNCTIONAL DIAGRAM | 2.5-62 |
| 2.5.7-10 | LSU/PCU SERVICING -- FUNCTIONAL DIAGRAM | 2.5-63 |
| 2.5.7-11 | SUIT DRYING FACILITIES | 2.5-65 |
| 2.5.7-12 | SUIT DRYER | 2.5-66 |
| 2.5.8-1 | OFF-DUTY EQUIPMENT | 2.5-68 |
| 2.5.9-1 | TRASH COLLECTION BAGS | 2.5-70 |
| 2.5.9-2 | TRASH DISPOSAL AIRLOCK | 2.5-72 |
| 2.5.9-3 | TRASH DISPOSAL AIRLOCK -- FUNCTIONAL DIAGRAM | 2.5-73 |
| 2.5.9-4 | TRASH DISPOSAL AIRLOCK -- SEQUENTIAL OPERATION | 2.5-74 |
| 2.5.9-5 | WASTE TANK TRASH DISPOSAL | 2.5-75 |
| 2.5.10-1 | AMBIENT FOOD STORAGE | 2.5-76 |
| 2.5.10-2 | AMBIENT FOOD SUPPLY -- DAILY | 2.5-78 |
| 2.5.10-3 | CHILLED AND FROZEN FOOD STORAGE AND SUPPLY | 2.5-79 |
| 2.5.10-4 | STOWAGE FREEZERS -- FUNCTIONAL DIAGRAM | 2.5-80 |
| 2.5.10-5 | WARDROOM FREEZERS/FOOD CHILLER -- FUNCTIONAL DIAGRAM | 2.5-81 |
| 2.5.10-6 | FOOD PREPARATION AND CONSUMPTION EQUIPMENT | 2.5-82 |
| 2.5.10-7 | FOOD TRAY -- FUNCTIONAL DIAGRAM | 2.5-84 |
| 2.5.11-1 | WASTE MANAGEMENT COLLECTION BAGS | 2.5-85 |
| 2.5.11-2 | FECAL COLLECTOR -- FUNCTIONAL DIAGRAM | 2.5-86 |
| 2.5.11-3 | COLLECTION BAG USAGE SCHEME | 2.5-87 |
| 2.5.11-4 | FECAL/URINE COLLECTOR | 2.5-89 |
| 2.5.11-5 | FECAL/URINE COLLECTOR -- BLOCK DIAGRAM | 2.5-90 |
| 2.5.11-6 | FECAL AND URINE COLLECTION FACILITIES | 2.5-91 |
| 2.5.11-7 | TYPICAL URINE DRAWER -- SCHEMATIC | 2.5-93 |
| 2.5.11-8 | URINE CHILLER -- FUNCTIONAL DIAGRAM | 2.5-94 |
| 2.5.11-9 | FECAL/URINE COLLECTOR -- SCHEMATIC | 2.5-95 |
| 2.5.11-10 | URINE SEPARATOR -- EXPLODED VIEW | 2.5-95 |
| 2.5.11-11 | WASTE PROCESSING AND URINE MANAGEMENT FACILITIES | 2.5-97 |
| 2.5.11-12 | TYPICAL WASTE PROCESSOR -- FUNCTIONAL DIAGRAM | 2.5-98 |
| 2.5.11-13 | URINE FREEZER -- FUNCTIONAL DIAGRAM | 2.5-99 |
| 2.5.11-14 | RETURN CONTAINERS | 2.5-101 |

| FIGURE | TITLE | PAGE |
|---|---|---|
| 2.5.11-15 | VACUUM CLEANER AND ACCESSORIES | 2.5-102 |
| 2.5.12-1 | WATER SYSTEM -- FUNCTIONAL FLOW | 2.5-104 |
| 2.5.12-2 | WATER STORAGE PROVISIONS | 2.5-105 |
| 2.5.12-3 | WATER TANK BUDGET | 2.5-106 |
| 2.5.12-4 | TYPICAL WATER TANK -- SCHEMATIC | 2.5-106 |
| 2.5.12-5 | TYPICAL WATER TANK HEATER BLANKET -- SCHEMATIC | 2.5-107 |
| 2.5.12-6 | PORTABLE WATER TANK -- SCHEMATIC | 2.5-108 |
| 2.5.12-7 | WATER DISTRIBUTION | 2.5-109 |
| 2.5.12-8 | WATER HOSE CONFIGURATIONS | 2.5-110 |
| 2.5.12-9 | WATER PORT LOCATIONS | 2.5-111 |
| 2.5.12-10 | CAT ION CARTRIDGE | 2.5-112 |
| 2.5.12-11 | WARDROOM AND WMC H2O HEATERS | 2.5-114 |
| 2.5.12-12 | WATER HEATER -- FUNCTIONAL DIAGRAM | 2.5-115 |
| 2.5.12-13 | WATER CHILLER | 2.5-116 |
| 2.5.12-14 | WATER CHILLER -- FUNCTIONAL DIAGRAM | 2.5-117 |
| 2.5.12-15 | WATER MANAGEMENT DISPENSERS -- INSTALLATION | 2.5-119 |
| 2.5.12-16 | WATER MANAGEMENT DISPENSERS | 2.5-120 |
| 2.5.12-17 | PARTIAL BODY CLEANSING FACILITIES -- HANDWASHER | 2.5-123 |
| 2.5.12-18 | WATER PURIFICATION EQUIPMENT | 2.5-124 |
| 2.5.12-19 | WATER SAMPLER | 2.5-125 |
| 2.5.12-20 | REAGENT CONTAINER | 2.5-126 |
| 2.5.12-21 | COLOR COMPARATOR | 2.5-126 |
| 2.5.12-22 | WASTE SAMPLE CONTAINER | 2.5-127 |
| 2.5.12-23 | IODINE ADDITION CHART | 2.5-128 |
| 2.5.12-24 | IODINE CONTAINER | 2.5-128 |
| 2.5.12-25 | IODINE INJECTOR | 2.5-129 |
| 2.5.13-1 | CREWMAN COLOR CODING | 2.5-130 |
| 2.5.13-2 | PERSONAL HYGIENE PROVISIONS | 2.5-131 |
| 2.5.14-1 | VACUUM DUMP AND VACUUM EXHAUST SYSTEMS | 2.5-135 |
| 2.5.14-2 | DUMP HEATER PROBE | 2.5-136 |
| 2.5.14-3 | TYPICAL VACUUM PROVISION SCHEMATIC | 2.5-137 |
| 2.5.14-4 | WASTE TANK LIQUID DUMP AREA | 2.5-139 |
| 2.5.15-1 | PORTABLE MAINTENANCE EQUIPMENT | 2.5-141 |
| 2.5.15-2 | SPARE PARTS AND MAINTENANCE SUPPLIES | 2.5-144 |
| 2.5.15-3 | SL-3 AND SL-4 SCHEDULED MAINTENANCE TASKS TIMELINE | 2.5-145 |
| 2.5.15-4 | UNSCHEDULED MAINTENANCE TASKS | 2.5-146 |
| 2.5.16-1 | SWS FIRE FIGHTING PROVISIONS | 2.5-149 |
| 2.5.16-2 | FIRE EXTINGUISHER DETAIL | 2.5-151 |
| 2.5.16-3 | VABD INSTALLATION | 2.5-152 |
| 2.5.16-4 | VABD SCHEMATIC | 2.5-152 |
| 2.6.2-1 | SYSTEM INTERFACES | 2.6-1 |
| 2.6.3-1 | FUNCTIONAL SCHEMATIC | 2.6-3 |
| 2.6.3-2 | POWER SUBSYSTEMS | 2.6-4 |
| 2.6.3-3 | PCM SUBSYSTEM | 2.6-6 |
| 2.6.3-4 | RECORDING SUBSYSTEM | 2.6-7 |
| 2.6.3-5 | TAPE RECORDING FLOW DIAGRAM | 2.6-9 |
| 2.6.3-6 | TRANSMISSION SUBSYSTEM | 2.6-11 |
| 2.6.3-7 | OPERATIONAL FLOW DIAGRAM | 2.6-13 |
| 2.6.3-8 | PCM FORMAT (SAMPLE RATES) | 2.6-16 |
| 2.6.3-9 | PCM FORMAT | 2.6-17 |
| 2.6.3-10 | PROTON SPECTROMETER | 2.6-18 |
| 2.6.4-1 | MDA SIGNAL CONDITIONER | (TBS) |
| 2.6.4-2 | AM DC-DC CONVERTER | 2.6-19 |
| 2.6.4-3 | AM PANEL INDICATOR DC-DC CONVERTER | 2.6-19 |
| 2.6.4-4 | OWS DC-DC CONVERTER | 2.6-20 |
| 2.6.4-5 | TEMPERATURE TRANSDUCERS | 2.6-21 |
| 2.6.4-6 | PRESSURE TRANSDUCERS | 2.6-23 |
| 2.6.4-7 | PARTIAL PRESSURE TRANSDUCERS | 2.6-24 |
| 2.6.4-8 | FLOW TRANSDUCERS | 2.6-25 |
| 2.6.4-9 | WATER LEVEL TRANSDUCER | 2.6-27 |
| 2.6.4-10 | MULTIPLEXING/ENCODING COMPONENTS SIGNAL FLOW | 2.6-28 |
| 2.6.4-11 | MULTIPLEXER BLOCK DIAGRAM | 2.6-29 |
| 2.6.4-12 | PROGRAMMER BLOCK DIAGRAM | 2.6-30 |
| 2.6.4-13 | INTERFACE BOX BLOCK DIAGRAM | 2.6-30 |
| 2.6.4-14 | LOW-LEVEL ANALOG CHANNELS | 2.6-32 |
| 2.6.4-15 | HIGH-LEVEL ANALOG CHANNELS | 2.6-32 |
| 2.6.4-16 | BILEVEL AND BILEVEL PULSE CHANNELS | 2.6-33 |
| 2.6.4-17 | DIGITAL TIME CHANNELS | 2.6-34 |
| 2.6.4-18 | TAPE RECORDER BLOCK DIAGRAM | 2.6-35 |

| FIGURE | TITLE | PAGE |
|---|---|---|
| 2.7.2-1 | DCS/TRS INTERFACES | 2.7-2 |
| 2.7.3-1 | DCS CONFIGURATION | 2.7-2 |
| 2.7.3-2 | TRS CONFIGURATION | 2.7-3 |
| 2.7.3-3 | TRS POWER DISTRIBUTION | 2.7-4 |
| 2.7.3-4 | DCS CONTROL -- RCVR/DCDR CONTROL SWITCHING LOGIC | 2.7-5 |
| 2.7.3-5 | DCS CONTROL -- OPERATING MODE | 2.7-6 |
| 2.7.3-6 | COMMAND CODE FORMAT | 2.7-7 |
| 2.7.4-1 | RCVR/DCDR OPERATION | 2.7-8 |
| 2.7.4-2 | RELAY MODULE OPERATION | 2.7-10 |
| 2.7.4-3 | CRDU OPERATION | 2.7-11 |
| 2.7.4-4 | ELECTRONIC TIMER OPERATION | 2.7-12 |
| 2.7.4-5 | TCB OPERATION | 2.7-13 |
| 2.7.4-6 | GMT CLOCK OPERATION | 2.7-13 |
| 2.7.4-7 | EVENT TIMER OPERATION | 2.7-14 |
| 2.7.4-8 | PORTABLE TIMER OPERATION | 2.7-16 |
| 2.8.2-1 | SYSTEM INTERFACES | 2.8-2 |
| 2.8.2-2 | CSM CAUTION/WARNING SUBSYSTEM | 2.8-2 |
| 2.8.3-1 | SWS C&W SYSTEM | 2.8-3 |
| 2.8.3-2 | C&W AUDIBLE ALARMS | 2.8-6 |
| 2.8.3-3 | CAUTION (WARNING) DETECTION | 2.8-7 |
| 2.8.3-4 | C&W SUBSYSTEM SELF-TEST | 2.8-8 |
| 2.8.3-5 | RAPID $\Delta$P DETECTION | 2.8-10 |
| 2.8.3-6 | FIRE DETECTION SUBSYSTEM | 2.8-11 |
| 2.8.3-7 | FIRE DETECTION FUNCTIONAL | 2.8-12 |
| 2.8.3-8 | FIRE SENSOR TEST | 2.8-13 |
| 2.8.3-9 | EMERGENCY SUBUNITS 1 AND 2 FIRE ELECTRONICS TEST | 2.8-14 |
| 2.8.3-10 | C&W SUBSYSTEM POWER DISTRIBUTION | 2.8-15 |
| 2.8.3-11 | C&W SUBSYSTEM CONTROL SIGNAL DISTRIBUTION | 2.8-17 |
| 2.8.3-12 | EMERGENCY SUBSYSTEM POWER DISTRIBUTION | 2.8-18 |
| 2.8.3-13 | FIRE SENSOR CONTROLS & POWER DISTRIBUTION (MDA/STS GROUP TYPICAL) | 2.8-19 |
| 2.8.4-1 | RAPID $\Delta$P SENSOR 1 (2) | 2.8-20 |
| 2.8.4-2 | UV FIRE SENSOR | 2.8-21 |
| 2.8.4-3 | C&W SUBUNITS 1 AND 2 | 2.8-22 |
| 2.8.4-4 | C&W SUBUNITS DC/DC CONVERTERS | 2.8-23 |
| 2.8.4-5 | EMERGENCY SUBUNITS 1 AND 2 | 2.8-24 |
| 2.8.4-6 | EMERGENCY SUBUNITS DC/DC CONVERTERS | 2.8-25 |
| 2.8.7-1 | CREW ALERT | 2.8-30 |
| 2.8.9-1 | C&W PARAMETERS | 2.8-32 |
| 2.8.9-2 | EMERGENCY PARAMETERS | 2.8-36 |
| 2.9-1 | TRACKING AND DOCKING LIGHTS | 2.9-1 |
| 2.9-2 | CREWMAN OPTICAL ALIGNMENT SIGHT (COAS) | 2.9-2 |
| 2.9-3 | MDA DOCKING SEQUENCE | 2.9-2 |
| 2.9-4 | DROGUE REMOVAL | 2.9-4 |
| 2.9-5 | DROGUE AND PROBE STOWAGE | 2.9-5 |
| 2.11.3-1 | SWS SEQUENTIAL CONTROL | 2.11-2 |
| 2.11.3-2 | OWS SWITCH SELECTOR POWER | 2.11-3 |
| 3.0-1 | CREW STATION/PANEL DESIGNATION | 3.0-2 |

TABLES

| TABLE | TITLE | PAGE |
|---|---|---|
| 2.0.3.5-1 | PAYLOAD SHROUD - FAILURE MODES | 2.0-13 |
| 2.0.3.6-1 | TIME OF SEGMENT SEPARATION | 2.0-17 |
| 2.0.3.6-2 | SEGMENT ROLL AND YAW WITH TRANSITION | 2.0-17 |
| 2.0.3.8-1 | PS LATCH ACTUATOR INSTRUMENTATION | 2.0-18 |
| 2.0.3.8-2 | PS THRUSTING JOINT INSTRUMENTATION | 2.0-18 |
| 2.0.3.8-3 | PS JETTISON INSTRUMENTATION | 2.0-18 |
| 2.0.4-1 | DISCONE ANTENNA BOOMS - FAILURE MODES | 2.0-23 |
| 2.0.6.5-1 | ATM-DA - FAILURE MODES | 2.0-34 |
| 2.0.6.8-1 | DA INSTRUMENTATION | 2.0-39 |
| 2.0.7.4-1 | MDA STRUCTURAL AND MECHANICAL - FAILURE MODES | 2.0-49 |
| 2.0.8.4-1 | AM STRUCTURAL AND MECHANICAL - FAILURE MODES | 2.0-66 |
| 2.0.10.5-1 | OWS STRUCTURES AND MECHANISMS - FAILURE MODES | 2.0-110 |
| 2.1.3-1 | CAUTION AND WARNING PARAMETERS | 2.1-6 |
| 2.1.4-1 | BATTERY CHARGER OPERATION MODES | 2.1-36 |
| 2.1.5-1 | EPS - FAILURE MODES | 2.1-44 |
| 2.1.8-1 | INSTRUMENTATION LIST | 2.1-48 |
| 2.1.8-2 | EPS DCS COMMAND LIST | 2.1-52 |
| 2.2.5-1 | COMMUNICATION SYSTEM -- FAILURE MODES | 2.2-15 |
| 2.3.5-1 | TACS - FAILURE MODES | 2.3-20 |
| 2.3.6-1 | TACS IMPULSE BUDGET | 2.3-23 |
| 2.3.6-2 | CONTROL VALVE CHARACTERISTICS | 2.3-27 |
| 2.3.8-1 | TACS INSTRUMENTATION | 2.3-29 |
| 2.4.4-1 | O2 AND N2 SUMMARY | 2.4-16 |
| 2.4.8-1 | PURGE AND VENTING | 2.4-123 |
| 2.4.8-2 | HABITATION AREA AND WASTE TANK INSTRUMENTATION | 2.4-125 |
| 2.4.8-3 | SWS VENTING | 2.4-127 |
| 2.4.8-4 | O2 AND N2 GAS DISTRIBUTION INSTRUMENTATION | 2.4-128 |
| 2.4.8-5 | O2 AND N2 GAS DISTRIBUTION COMMANDS | 2.4-130 |
| 2.4.8-6 | COOLANT SYSTEM INSTRUMENTATION | 2.4-130 |
| 2.4.8-7 | THERMAL CONTROL INSTRUMENTATION | 2.4-133 |
| 2.4.8-8 | COOLANT SYSTEM COMMANDS | 2.4-133 |
| 2.4.8-9 | THERMAL CONTROL HEATER COMMANDS | 2.4-135 |
| 2.4.8-10 | ATMOSPHERE CONTROL INSTRUMENTATION | 2.4-136 |
| 2.4.8-11 | REFRIGERATION INSTRUMENTATION | 2.4-138 |
| 2.4.8-12 | REFRIGERATION SYSTEM COMMANDS | 2.4-140 |
| 2.5.17-1 | CREW SYSTEMS -- INSTRUMENTATION LIST | 2.5-153 |
| 2.5.17-2 | DCS COMMAND LIST | 2.5-154 |
| 2.6.5-1 | INSTRUMENTATION SYSTEM -- FAILURE MODES | 2.6-36 |
| 2.7.5-1 | DCS/TRS FAILURE MODES | 2.7-14 |
| 2.10-1 | SKYLAB EXPERIMENTS | 2.10-3 |

## FOREWORD

Skylab Operations Handbooks (SLOH) describe the spacecraft and experiment systems and provide the crew procedures necessary for their safe and efficient operation throughout three scheduled Skylab missions. The handbooks comprise four publications:

Command and Service Module (CSM)

Orbital Workshop (OWS), Airlock Module (AM), and Multiple Docking Adapter (MDA)

Apollo Telescope Mount (ATM)

Experiments

Each handbook consists of two volumes, separately bound: Volume 1 describes the systems, Volume 2 details the operational procedures. This handbook is Volume 1 of the OWS, AM, and MDA.

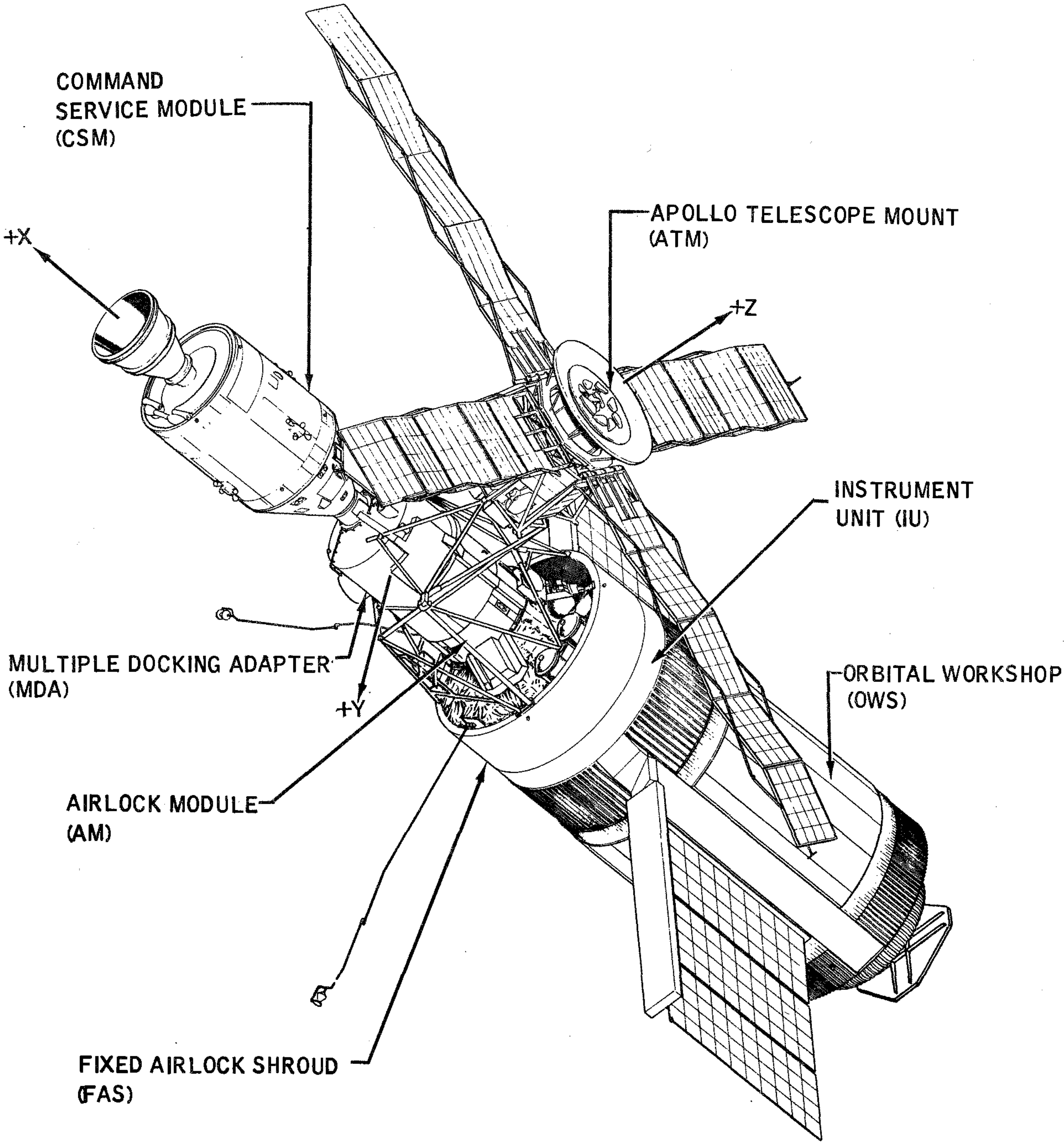
NASA comments and suggested changes to this handbook should be directed to M. E. Dement, MSC CG2, phone 713/483-5558, Crew Procedures Division, Systems Procedure Branch, Building 4, MSC, Houston, Texas 77058.

MDAC and MMC comments should be directed to E. A. Thompson, phone 713/488-5660, Ext. 212, McDonnell Douglas Astronautics Company, 16915 El Camino Real, Houston, Texas 77058.

Acknowledgement is made to the Martin-Marietta Corporation, Flight Crew Operations, Houston, Texas, and to the North American Rockwell Corporation, Space Division, for technical assistance and documentation received pertinent to respective interface responsibilities for the Experiments, and the MDA, ATM, and CSM systems.

# ORBITAL ASSEMBLY CONFIGURATION

9002




| | |
|---|---|
| SWS (SATURN WORKSHOP) = OWS/AM/MDA/ATM | |
| OA (ORBITAL ASSEMBLY) = CSM/SWS | |

| | | |
|---|---|---|
| OA LENGTH | - | 116.2 FT |
| OWS SAS WING SPAN | - | 93 FT |
| ATM SAS WING SPAN | - | 98 FT |

Figure 1.0-1 Orbital Assembly Configuration

SECTION 1.0

INTRODUCTION

The Skylab Program consists of three low-earth-orbit missions of the Orbital Assembly (OA) (figure 1.0-1), extending over an 8-month period. The OA consists of the CSM docked to the Saturn Workshop (SWS). This handbook describes the systems for three of the four major components of the SWS (OWS, AM, and MDA), and also discusses significant interfaces with the Instrument Unit (IU), ATM, and CSM. The other major component of the SWS, the ATM, is treated separately in its own handbook.

The OWS, AM, MDA, ATM Deployment Assembly (ATM-DA), Fixed Airlock Shroud (FAS), Payload Shroud (PS), and IU are addressed throughout this document as individual modules from a structural standpoint only. Although normally considered a part of the launch vehicle, the IU is treated in this document as part of the SWS because of its function in preparing the SWS for orbital operation.

Section 1.0 describes vehicle and mission configurations of the Skylab program and provides general descriptions of the various systems.

Section 2.0 provides detailed systems data covering system interfaces, functional description, subsystems and major components description, component operation, failure modes, performance and design data, operational limitations and restrictions, and instrumentation, and briefly outlines the experiments.

Section 3.0 contains illustrations of all panels and identifies the contols and displays, panels, reference designators, nomenclature, functions, circuit breakers, and power sources.

The Table of Contents lists in order of appearance all sections, subsections, major paragraphs, illustrations, and tables and provides their respective page locations.

Appendix A defines the abbreviations and acronyms employed throughout this handbook, and Appendix B explains the symbols used. Appendix C is a locator index that references component controls contained in Section 3.0. Appendix D is an alphabetical index of paragraph headings, illustrations, and tables, according to the key word, with applicable page numbers. Additional items of significance to the user have been included in the index.

The technical level to which this document is written assumes the reader to have general knowledge of engineering terms and principles.

SUBSECTION 1.1

MISSIONS

### 1.1.1 GENERAL

Three Skylab missions (SL-1/2, SL-3, and SL-4) are scheduled over an 8-month period. The mission profiles are summarized in figure 1.1-1, with the launch configurations shown in figure 1.1-2.

### 1.1.2 MISSION OBJECTIVES

Establish the SWS in earth orbit
- o Operate the SWS as a habitable, reusable space structure for long-duration missions
- o Obtain data for evaluating the performance of the OA
- o Obtain data for evaluating astronaut mobility and work capability in both intra- and extra-vehicular activity

Extend the duration of manned spaceflight
- o Obtain medical data to determine effects on crew resulting from spaceflights lasting up to 56 days
- o Determine the feasibility of manned spaceflight missions with durations greater than 56 days

Perform inflight experiments
- o Obtain solar astronomy data for continuing and extending solar studies beyond the limits of earth-based observations
- o Perform scientific, engineering, technological, and earth resources experiments.

### 1.1.3 SL-1/2 MISSION

The first mission, SL-1/2, consists of two launches, approximately 1 day apart, with a total duration of 28 days. The launch configuration for SL-1 consists of the following:

- o Saturn IC stage
- o Saturn II stage
- o Payload Shroud
- o Payload (SWS)

The SL-1 launch uses a modified Saturn V launch vehicle to place the unmanned SWS in a 50-degree inclination orbit at a nominal altitude of 235 nautical miles. After insertion, the S-II stage is separated by retrorockets, and the SWS begins a pitchover maneuver, using the Thruster Attitude Control System (TACS). As the SWS passes through the 90-degree nosedown attitude, the PS is jettisoned. Once the SWS attains retrograde attitude, the ATM is deployed and the TACS orients the SWS to a solar inertial attitude. The solar inertial attitude (figure 1.1-3) is defined as the +Z axis pointing toward the sun and the X axis in (or near) the orbit plane. The Z-local vertical attitude (Z/LV) is defined as the -Z axis pointing toward the earth with the X axis in the orbit plane. After the ATM solar arrays are deployed, the solar inertial attitude is acquired, and activation of the ATM Control Moment Gyros (CMG) begins. The OWS solar arrays and the OWS meteoroid shield are deployed during CMG spinup.

The SL-2 launch configuration, which is identical for SL-3 and SL-4, consists of the following:

- o Saturn 1B stage
- o Saturn S-1VB stage
- o IU
- o Spacecraft Lunar Module Adapter (SLA)
- o Payload (CSM)

The SL-2 launch uses a Saturn 1B launch vehicle to place the manned CSM into its initial orbit (81 x 120 NM). The CSM Service Propulsion System (SPS) is used to alter the initial orbit to rendezvous with the orbiting SWS. During this phase, the SWS is in the Z-local vertical attitude. The final rendezvous and docking maneuvers are performed using the CSM Reaction Control System (RCS) with the SWS in the solar inertial attitude. Docking, which normally take place during the fifth orbit (M-5), is identical for all missions. The crew then transfers from the CSM and activates the OA.

### 1.1.4 SL-3 MISSION

The second mission, SL-3, consists of one launch, using a Saturn 1B launch vehicle, approximately 80 days after the SL-2 launch. This mission has a planned duration of 56 days.

### 1.1.5 SL-4 MISSION

The final mission, SL-4, uses a Saturn 1B launch vehicle, with the launch occuring approximately 103 days after the SL-3 launch. The last mission has a planned duration of 56 days.

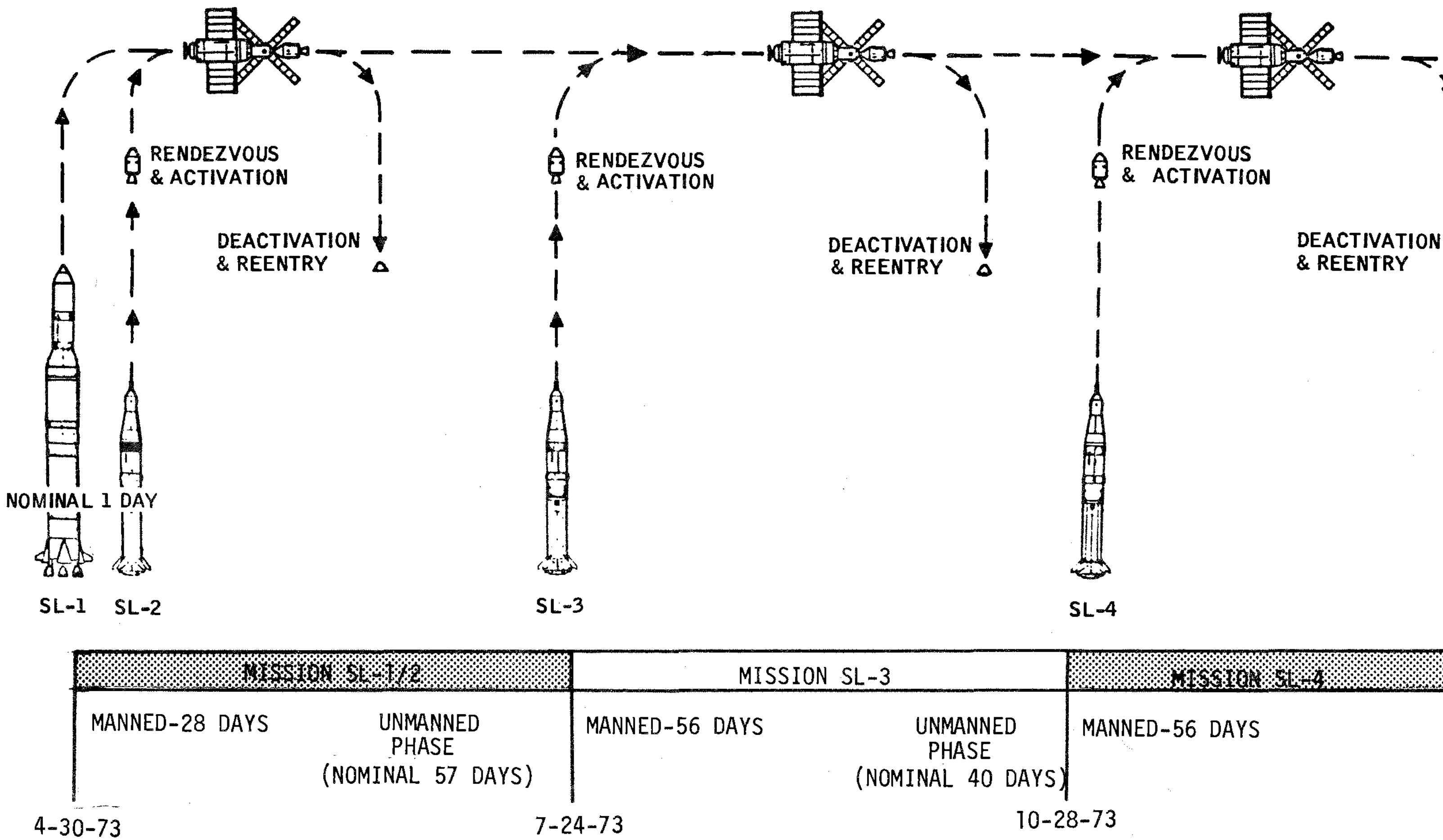



Figure 1.1-1 Skylab Mission Profile

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# SKYLAB LAUNCH CONFIGURATION

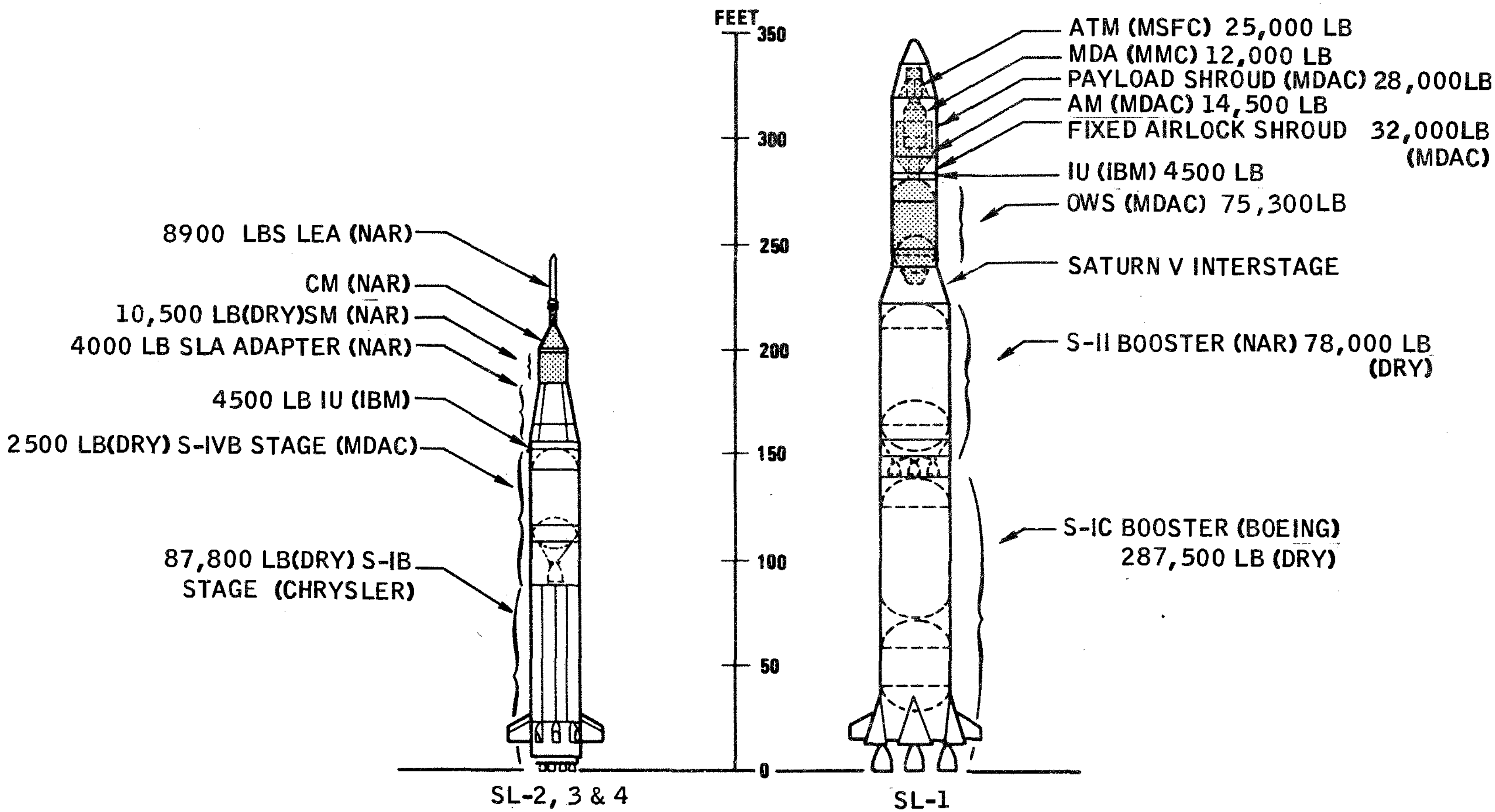



Figure 1.1-2 Skylab Launch Configuration

7500

# OA ORIENTATIONS

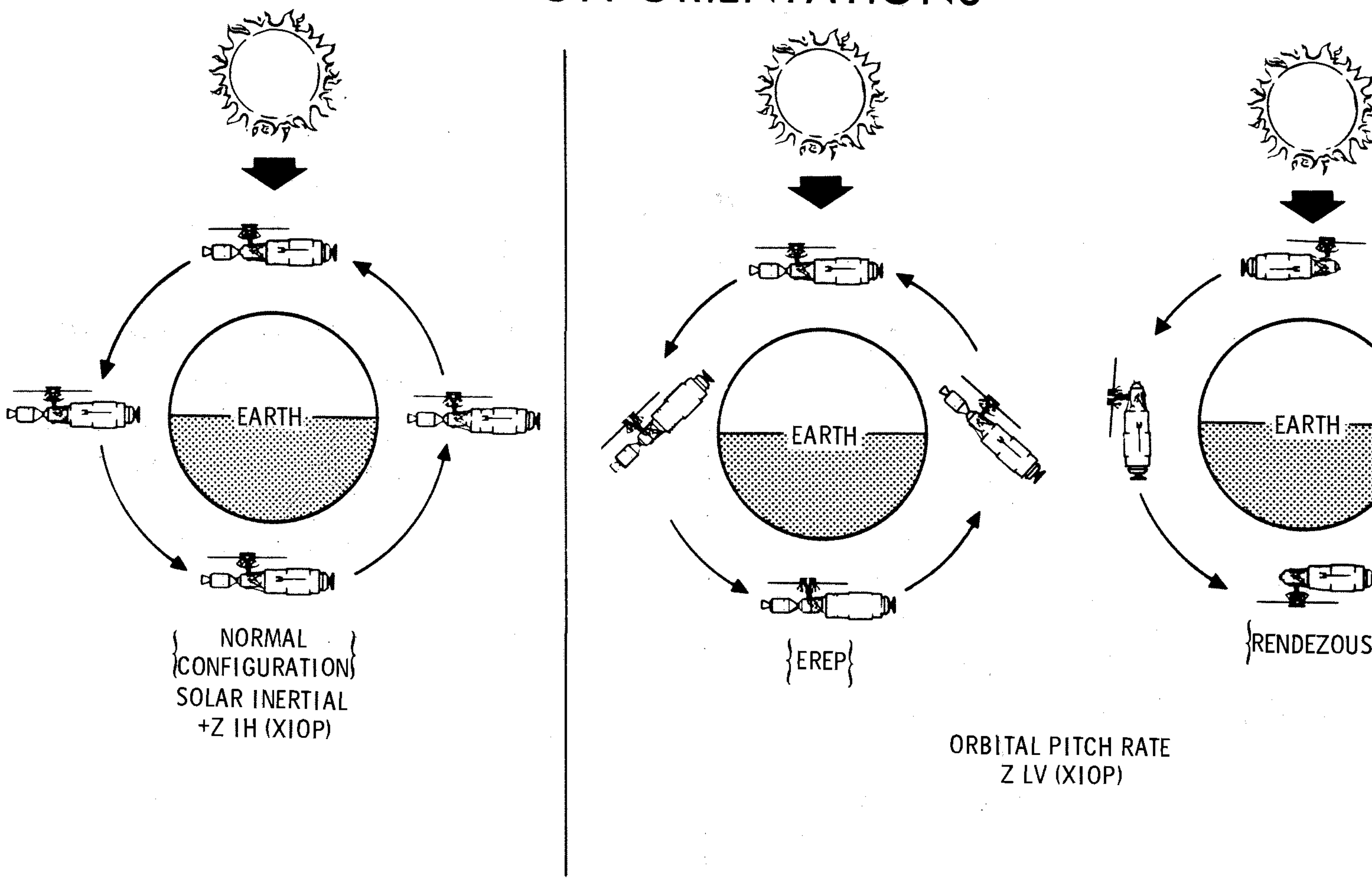



Figure 1.1-3 OA Orientation

SUBSECTION 1.2

SWS SYSTEMS

1.2.1 CONFIGURATION AND STRUCTURES

The modules and assemblies discussed in section 2.0 are listed below with a functional description of each. Although a part of the SWS, the ATM will not be discussed in section 2.0 (refer to SLOH-ATM, Vol I, MSC 04728).

ATM
- o Accomodates solar astronomy experiments
- o Provides attitude control for orbital assembly

MDA
- o Provides docking capability for CSM
- o Provides crew work area
- o Provides for stowage and operation of experiments

AM
- o Provides lock compartment, hatch, and support equipment for EVA
- o Contains systems for environmental control, electrical power, instrumentation, communication, and operational management of SWS

OWS
- o Provides living quarters and provisions for a three-man crew
- o Contains experiment stowage and work area

PS
- o Provides aerodynamic envelope for ATM, MDA, and part of AM during boost phase
- o Provides structural support for ATM loads, prelaunch, and boost

ATM-DA
- o Provides means of deploying ATM in orbit
- o Provides structural support for ATM after PS jettison

FAS
- o Provides structural support for the ATM-DA, MDA, and AM
- o Supports six O2 tanks and discone antennas

IU
- o Contains guidance, navigation and control equipment, which guide the launch vehicle from liftoff through S-II separation
- o Contains pre-programmed commands to activate specific SWS systems.

1.2.2 ELECTRICAL POWER SYSTEM (EPS)

The EPS contains equipment required to generate, condition, and distribute electrical power to the various loads. Solar arrays convert solar energy into electrical power. Power conditioning groups condition the electrical power from either the solar arrays or batteries to provide a constant source of power during all phases of the orbit. Electrical power is then distributed by a series of buses.

1.2.3 COMMUNICATION SYSTEM

The communication system provides the capability to transfer information between the OA and the MSFN, and consists of five basic subsystems:

| | |
|---|---|
| Audio | - provides voice communication and caution and warning (C/W) tones |
| Ranging | - facilitates rendezvous of CSM with SWS |
| Radio frequency | - used for transmission of PCM and recorded voice and reception of ground commands |
| Teleprinter | - provides hard-copy printout to crew |
| Television | - provides video coverage of certain events |

1.2.4 THRUSTER ATTITUDE CONTROL SYSTEM (TACS)

The TACS provides control of the SWS prior to and during the ATM Attitude and Pointing Control System (APCS) activation or whenever gross attitude changes are required. The TACS consists of 22 GN2 spheres, two thruster assemblies, and one power and control switching assembly.

1.2.5 ENVIRONMENTAL CONTROL SYSTEM (ECS)

The ECS provides the SWS with a controlled environment that maintains temperature-critical equipment, such as batteries and electronics, within its operating storage limits. In addition, the ECS maintains a life-supporting atmosphere during the manned phases.

1.2.6 CREW SYSTEMS

Crew systems cover mobility aids, lighting, stowage, food, water, waste management, trash disposal, wearing apparel, personal hygiene, vacuum provisions, and orbital maintenance.

1.2.7 INSTRUMENTATION SYSTEM

The instrumentation system monitors the various systems and provides data for on-board displays and for real-time and delayed-time transmission of data. The instrumentation system contains transducers and signal conditioners, which provide input to the Pulse Code Modulation (PCM) System. The outputs of the PCM system are either tape recorded for subsequent delayed-time transmission or transmitted real-time to the MSFN.

1.2.8 DIGITAL COMMAND SYSTEM (DCS) AND TIME REFERENCE SYSTEM (TRS)

The DCS receives and decodes real-time commands from the MSFN, providing ground control of various SWS systems. The DCS contains receiver/decoders that receive and process commands, relay modules that activate specific SWS system logic, and a command relay driver unit (CRDU) that activates other SWS system relays.

The TRS generates on-board time displays, provides time correlation for the instrumentation system and Earth Resources Experiment Package (EREP), and provides two, time-dependent, control switching functions to the DCS. The TRS consists of electronic timers, time correlation buffers, an event timer, two clocks, and a portable timer.

1.2.9 CAUTION AND WARNING SYSTEM (C&W)

C&W monitors performance of various SWS systems and provides an audio and visual indication of an out-of-limits condition. The system consists of malfunction detectors that provide an input to the control logic that in turn drives the audio and visual indicators.

1.2.10 DOCKING AND CREW TRANSFER

Docking and crew transfer provisions are provided by the Apollo-type docking probe and drogue. The probe, a docking ring, and a pressure hatch are provided on the CSM. The drogue and a pressure hatch are located on the MDA. The hatch has an equalization valve and pressure gage to equalize and monitor the pressure between the CSM and the MDA. During the habitation period, both the CSM hatch and the MDA hatch will remain open.

1.2.11 EXPERIMENTS

During the three scheduled missions, experiments will be performed in the following categories:

- o Medical - gathering biomedical data to determine effects of spaceflight on functions and processes of living organisms
- o Technical and engineering - to evaluate engineering developments and demonstrate various scientific phenomena
- o Solar and stellar - gathering data primarily in areas invisible or obscured by the earth's atmosphere
- o Earth resources techniques - to evaluate designs that scan the earth's surface and record radiation patterns in various wavelengths, exploring wide portions of the electromagnetic spectrum for pattern recognition studies in the earth sciences

1.2.12 SEQUENTIAL

Sequential defines the flight sequence of events required to convert the SWS from the launch to orbital configuration. The descriptions begin with launch of SL-1 and end with CSM docking on SL-2. Sequential control of the SWS is provided by the IU, AM DCS, and ATM DCS.

# SECTION 2.0

## CONFIGURATIONS AND STRUCTURES

### 2.0.1 INTRODUCTION

This section covers the general arrangement and structure for the Instrument Unit (IU), Payload Shroud (PS), Apollo Telescope Mount (ATM), Deployment Assembly (DA), Multiple Docking Adapter (MDA), Airlock Module (AM), Fixed Airlock Shroud (FAS), and Orbital Workshop (OWS).

### 2.0.2 INSTRUMENT UNIT (IU)

The IU is a cylindrical structure, 21.6 feet in diameter and 3 feet in height, located between the OWS and the FAS. The IU contains the guidance, navigation, and control equipment that guide the launch vehicle from liftoff through the boost phase to S-II stage separation. After S-II stage separation, the IU controls the vehicle attitude by using the thruster attitude control system until the ATM attitude pointing and control system is commanded to take over altitude control of the SWS.

In addition to the guidance, navigation, and control equipment, the IU contains telemetry, communications, tracking, and range safety systems, along with their supporting electrical power and environmental control system. The IU issues preprogrammed commands to turn on the refrigeration subsystems, latch open both waste tank vent valves, open both habitation area vent valves, jettison the payload shroud and initiate deployment of the ATM. After termination of the retrograde maneuver, the IU issues commands to jettison the refrigeration system radiator, position the SWS to the solar inertial attitude, deploy the ATM solar array, deploy the OWS solar array, initiate CMG spinup, deploy the OWS meteoroid shield, vent the MDA and AM, and pressurize the MDA, AM, and OWS to 5 psia. All of these activities take place during the 7.5 hours lifetime of the IU. The only IU function after the IU batteries expire is to provide a structural interface between the OWS and FAS.

The basic IU structure is a short cylinder fabricated of an aluminum alloy honeycomb sandwich material (figure 2.0.2-1). The structure consists of three 120-degree segments joined together by splice plates. The top and bottom edges are made from extruded aluminum channels bonded to the honeycomb sandwich. The channels are bolted to the OWS forward skirt and the aft end of the FAS to form part of the integral SWS structure.

### 2.0.3 PAYLOAD SHROUD (PS)

#### 2.0.3.1 INTRODUCTION

The PS (figure 2.0.3-1) provides an aerodynamic envelope for the ATM, MDA, and AM during the boost phase. The PS also provides structural support for the ATM during prelaunch, launch, and boost. After orbital insertion, the PS separates upon command into four segments or quadrants at radial velocities sufficient to prevent recontact with the payload. The separation system incorporates latch actuators and longitudinal thrusting joints. Separation and jettisoning of the PS releases the ATM and allows spring-loaded rigidifying mechanisms to pull the ATM into a rigid position prior to ATM deployment. This is a totally passive system which is activated by separation of the payload shroud.

#### 2.0.3.2 SYSTEM INTERFACES

The PS has a mechanical interface with the ATM and the FAS. The PS also interfaces with the EPS, IU/OWS switch selector, AM DCS, and the Instrumentation System.

#### 2.0.3.3 FUNCTIONAL DESCRIPTION

The general configuration of the PS, as shown in figure 2.0.3-2, is a double-angle nose cone mounted on a 260-inch diameter cylindrical section, 350 inches long. The forward nose cone has a 25-degree cone angle, and is 182 inches long including the nose cap. The aft cone is 142 inches long with a cone angle of 12 1/2 degrees. The total length of the shroud is 674 inches.

The conical sections are internal ring stiffened structural shells. Skins on both sections are 0.250-inch thick 2014-T651 aluminum sheet, with internal rings that are formed Z-sections of 7075-T6 aluminum. The cylinder is an internal ring stiffened heavy skin shell. The skins are 2024-T351 aluminum 0.375-inch thick on the lower one-third and 0.313-inch thick on the upper two-thirds. Ring frames are formed 7075-T73 aluminum I-beam extrusions spaced approximately 23 inches apart.

Extruded longitudinal rail segments of 7075-T7351 aluminum are installed at four positions, 90 degrees apart for radial separation. Steel tension links are provided at the separation joints of both the upper and lower interface locking rings of the cylindrical section. Redundant retractable pins allow separation of the rings into four segments. The PS is mated to the FAS interface ring by shimmed tension cleats which provide a load-carrying capability. Radial movement of the PS segments during jettison releases this attachment.

9203

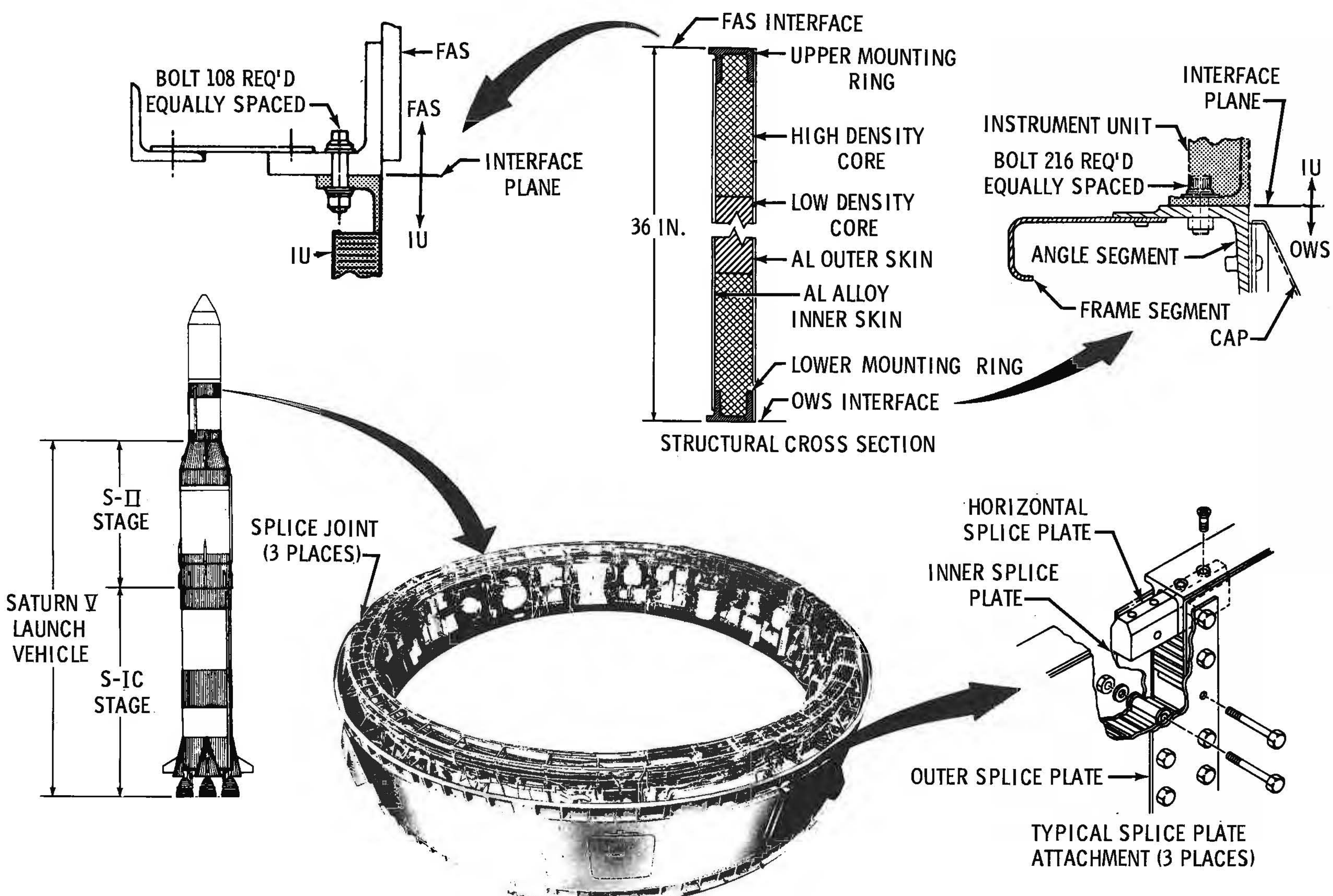



Figure 2.0.2-1 Instrumentation Structural Arrangement

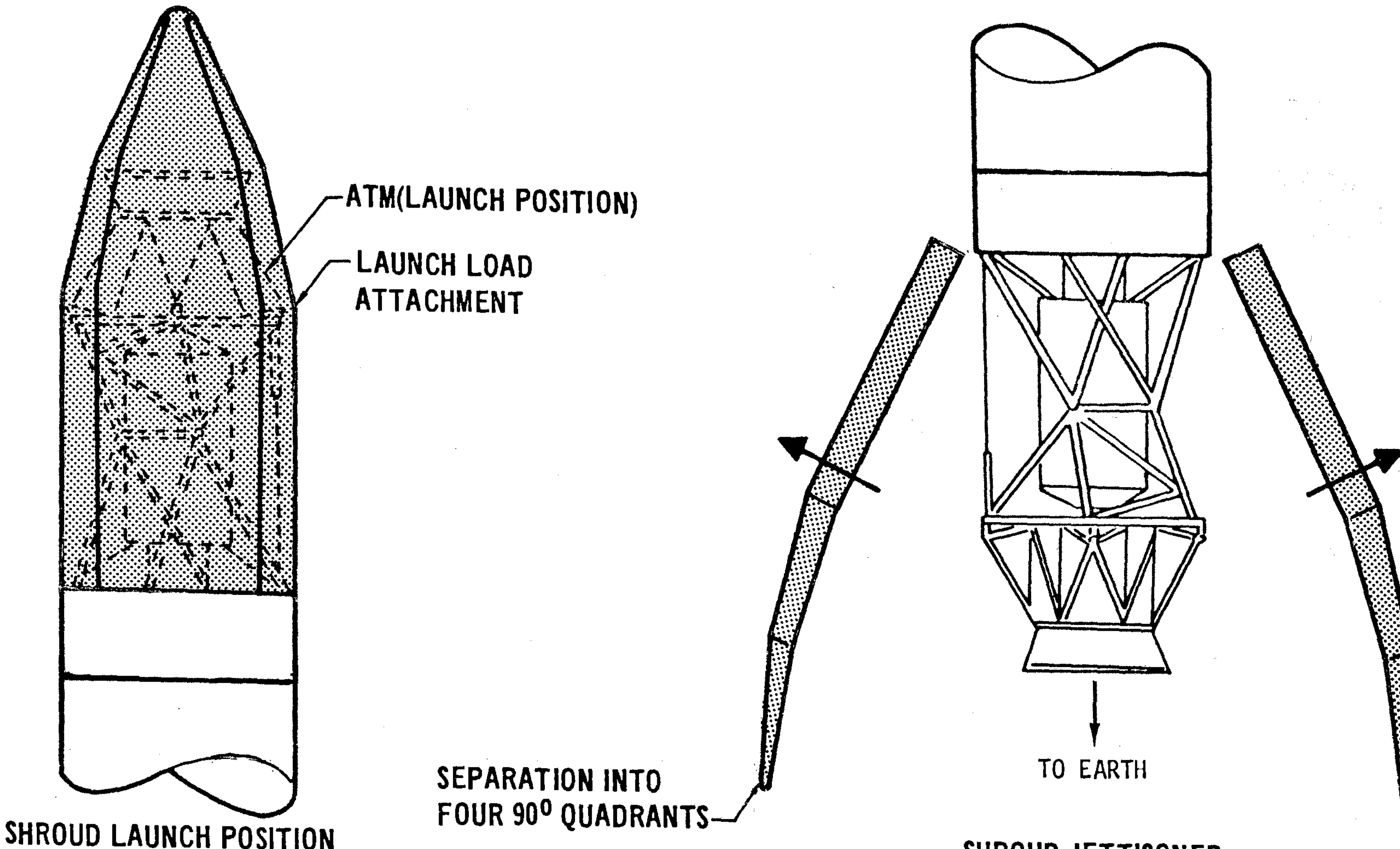
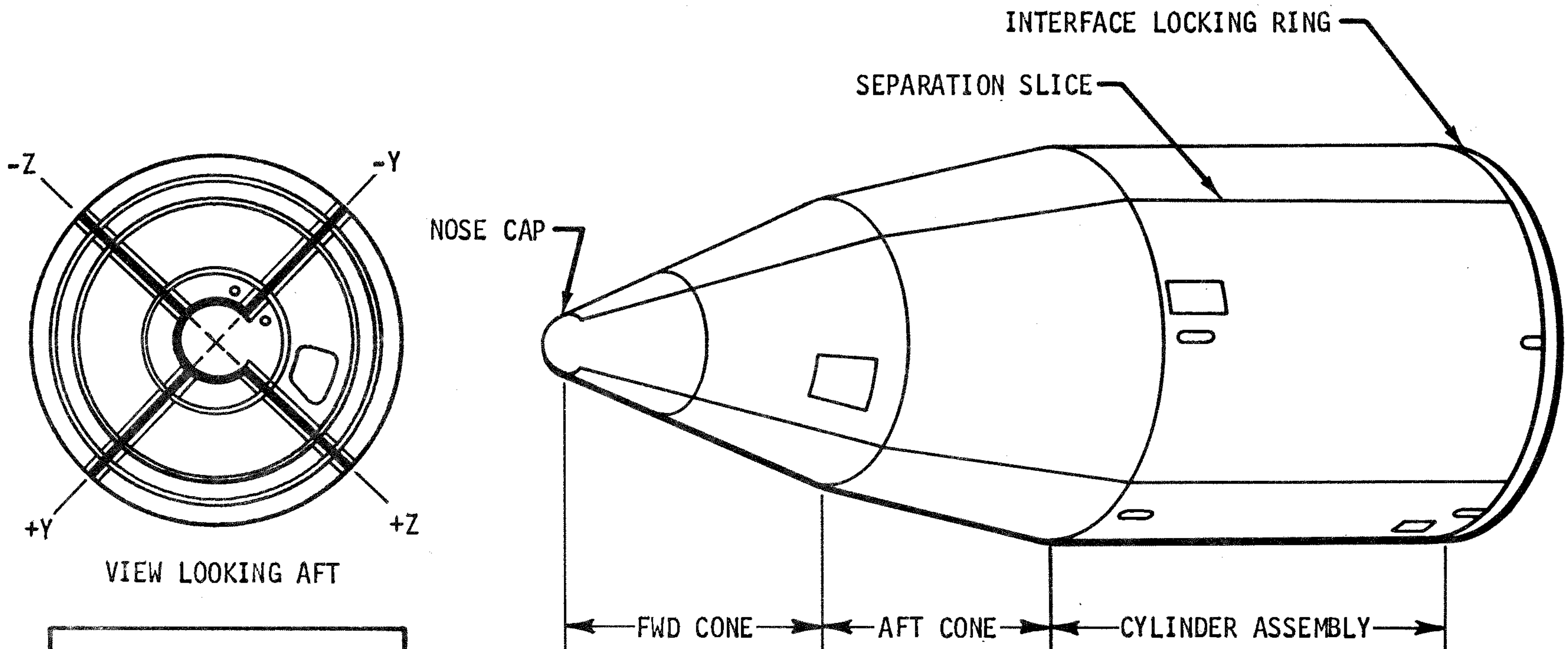



Figure 2.0.3-1 Payload Shroud

9024




WEIGHT; 28,000 LBS
DIAMETER: 22 FT
LENGTH; 56 FT

Figure 2.0.3-2 PS General Configuration

2.0.3.4 SUBSYSTEMS AND MAJOR COMPONENT DESCRIPTION

2.0.3.4.1 Mechanical

ATM Support - ATM launch loads are carried by the PS support structure located at 90-degree intervals on the forward end of the cylindrical section. ATM interface fittings, secured between vertical support fittings by semi-cylindrical slots, provide for attachment of the ATM outrigger fittings through eccentric bushings which have a 0.125-inch radial adjustment capability. This installation is shown in figure 2.0.3-3. During PS jettison, movement of the support fittings at 45-degree angles to the axes of the shroud releases the ATM. The support link remains attached to the ATM during subsequent orbital operations.

FAS Interface - The mechanical interface between the PS and FAS is shown in figure 2.0.3-4. Movement of the PS relative to the FAS is also shown. The aft shroud lower stiffening ring bolts to the upper ring of the FAS. With the PS stacked on the FAS, tension cleats hold the PS to the FAS frame assembly. Shims provide a nominal 0.010-inch gap between the tension cleats and the lower lip of the support frame to facilitate separation. Electrical lanyard disconnects are located at this interface. Access to make this connection during checkout is gained through the openings provided in the PS. An air-conditioning duct, from the FAS umbilical across the PS/FAS interface to a diffuser in the nose cap of the PS, provides clean air for the ATM sun end during ground operations.

2.0.3.4.2 Pyrotechnics

Latch Actuators - The PS segments are joined structurally by tie plates maintained in the latched position by actuators. These tie plates are provided at segment interfaces at the lower cylindrical ring interface and at the nose cone/cylinder section interface (8 places). Each tie plate assembly is capable of being released by either of two latch actuators. The latch actuators are basically pins attached to a piston that retracts when the pressure in its reaction chamber increases sufficiently. The pressure increase is provided by the detonation of pentaerythritol tetranitrate (PETN), restrained within 1/8-inch stainless steel tubes. Each of the four PS segment pyrotechnics consists of four latch actuators connected to a common manifold containing four strands of PETN. The PETN is detonated through redundant Exploding Bridge-wire (EBW) circuits. The PETN, when initiated, produces sufficient pressure in the manifold to operate all four latch actuators under maximum loading conditions. The EBW circuits are configured with a detonator at each end of the manifold (figure 2.0.3-5).

Jettisoning of the PS is normally accomplished during the programmed pitch maneuver after insertion as the SWS passes through the gravity gradient attitude. To initiate the sequence, the IU issues commands to arm sequential buses 1 and 2, which are monitored by measurements K194 and K195. PS separation and jettison begins with the IU issuing two commands, PS jettison enable primary and secondary, that enable the PS jettison circuits (figure 2.0.3-6). Two preprogrammed commands are then sent to charge the eight PS segment latch actuator EBW firing units (Payload Shroud Latch Charge No. 1 and 2). These commands (SS41 and SS86 in the Automatic Control System) each latch two relay contacts to apply redundant charge power to the EBW circuits from sequential buses 1 and 2.

The EBW firing unit consists of a DC-DC converter, an energy storage unit, a trigger circuit, and a switching device (figure 2.0.3-7). Voltage on the energy storage units of the eight EBW units are monitored by measurements M001, M002, M003, M004, M007, M008, M009, and M010. The firing unit reaches full charge when the power from sequential buses 1 and 2 is applied to the DC-DC converter for 1.5 seconds. The DC-DC converter then charges the energy storage unit to 2300±100 vdc. Maximum charge current is 2 amperes. After charging, the steady state average charge current drops to a maximum of 250 milliamperes. The energy storage unit will remain charged until the trigger signal is received. The EBW firing units will be triggered by preprogrammed commands (SS83 and SS38 Payload Shroud latch triggers 1 and 2), which allows the energy storage unit to discharge to the EBW detonators. The EBW detonator consists of a small wire resistance element and a spark gap (figure 2.0.3-8). When the 2300-vdc from the EBW firing unit is applied to the detonator, the energy jumps the spark gap and explodes the wire element, releasing sufficient energy to ignite the PETN. The PETN burns and increases the pressure within the stainless steel manifold and causes the latch actuators to release at the eight points on the forward tie plate assembly and at the eight points on the aft tie plate assembly. By monitoring the voltage on the eight EBW firing units, proper operation of the unit is determined.

PS Separation System - PS segments are riveted together at the separation rails. After the forward and aft tie plate assemblies separate, PS segments are separated by shearing the rivets at the separation rails. To effect separation, force is applied between the separation rails by pressurizing rubber-coated nylon bellows. Pressurization of the bellows results from igniting seven strands of PETN contained within a double tube manifold arrangement with small perforations provided to allow gas to escape into the bellows. These manifolds are of 5/8-inch stainless steel outer tube with 7/16-inch stainless steel inner tube. The arrangement of the manifolds and the nylon bellows is presented in figure 2.0.3-9.

Four longitudinal separation joint firing units are provided at the aft end of the cylindrical section adjacent to each of the four separation seams. As shown in figure 2.0.3-9, an EBW firing unit and detonator is provided at each end of a manifold that joins two separation seams. The separation system is two separate trains of ordnance, each of which will separate two of the four seams. The four EBW firing units are charged by two preprogrammed commands through the OWS switch selector (Payload Shroud Thrusting Joint 1 Charge No. 1 and 2). This function is verified by monitoring the voltage on the four measurements M005, M006, M011, and M012. These charged firing units are then triggered by two more preprogrammed commands (Payload Shroud Thrusting Joint Triggers 1 and 2) which ignite the PETN in the separation bellows (figure 2.0.3-6). The bellows expand and shear the attaching rivets and propel the PS segments away from the SWS.

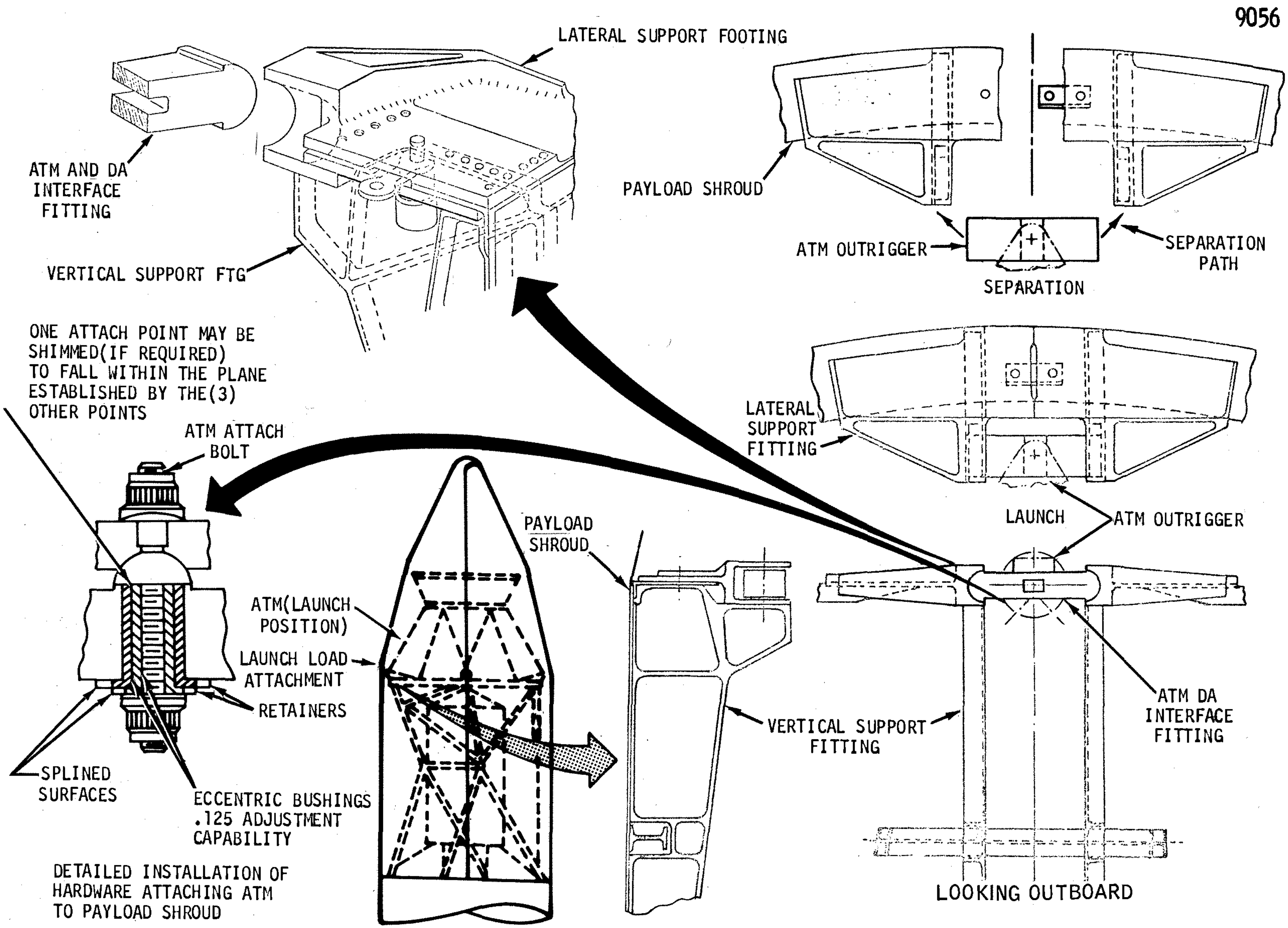



Figure 2.0.3-3 Payload Shroud ATM Support Structures

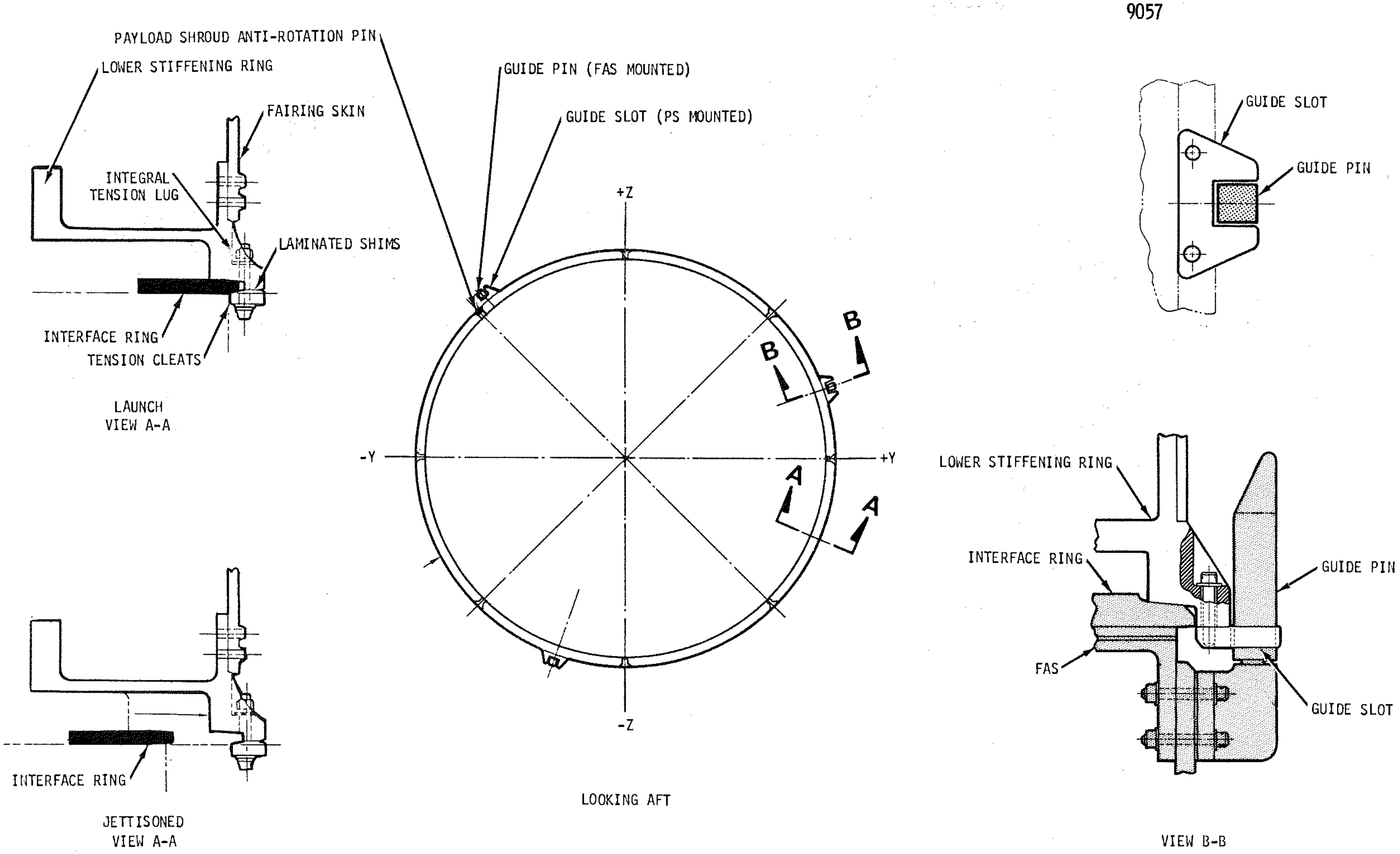



Figure 2.0.3-4 Payload Shroud to FAS Interface

9054

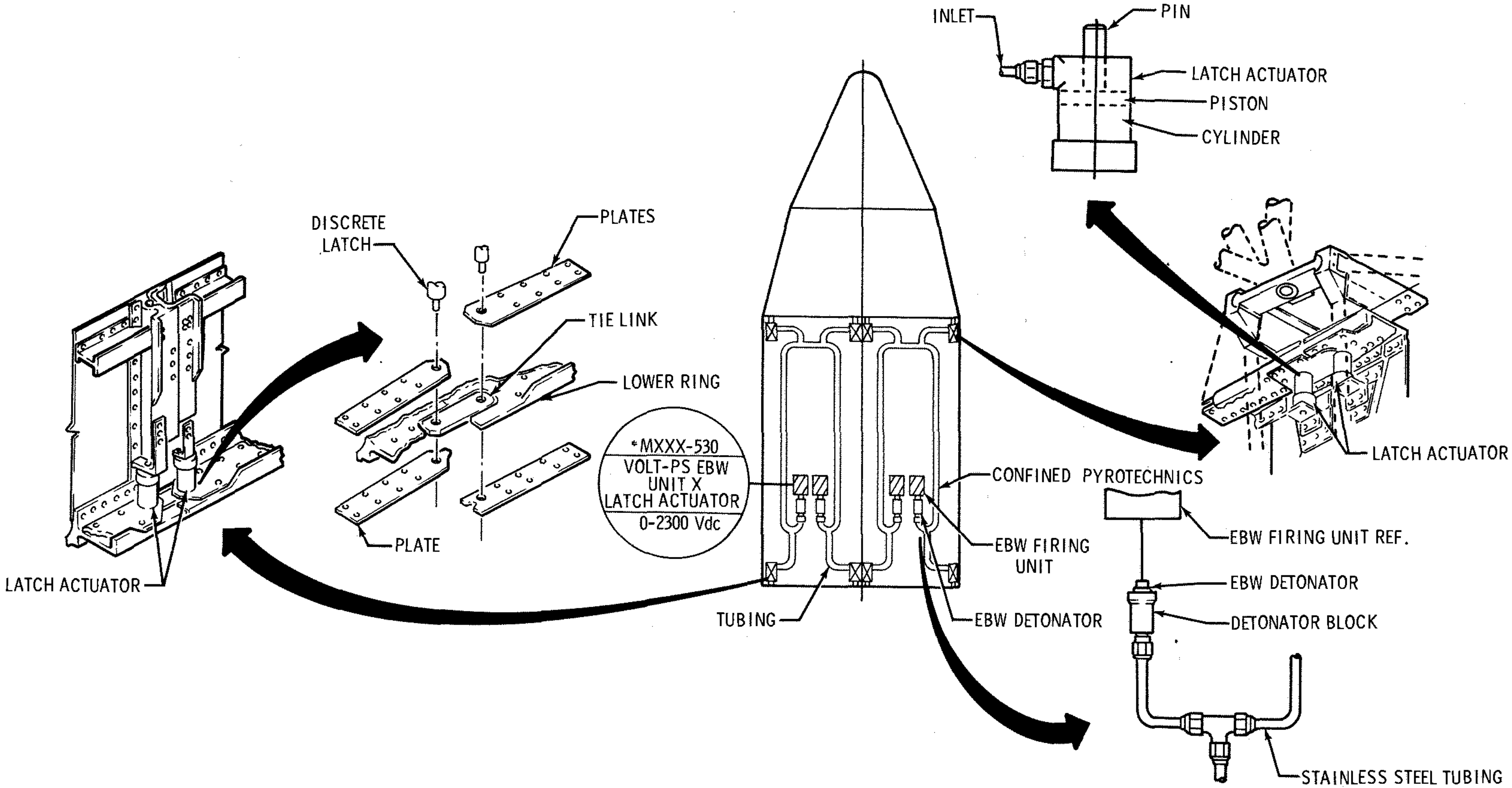
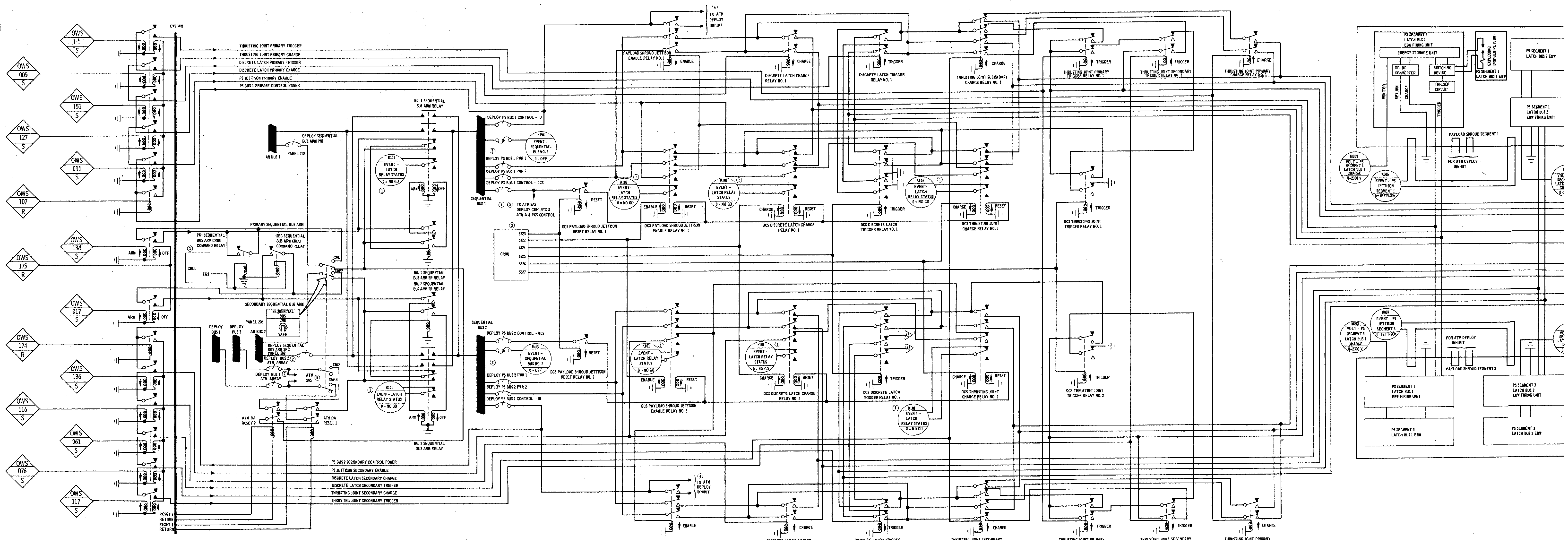



Figure 2.0.3-5 Payload Shroud Latch Actuator System



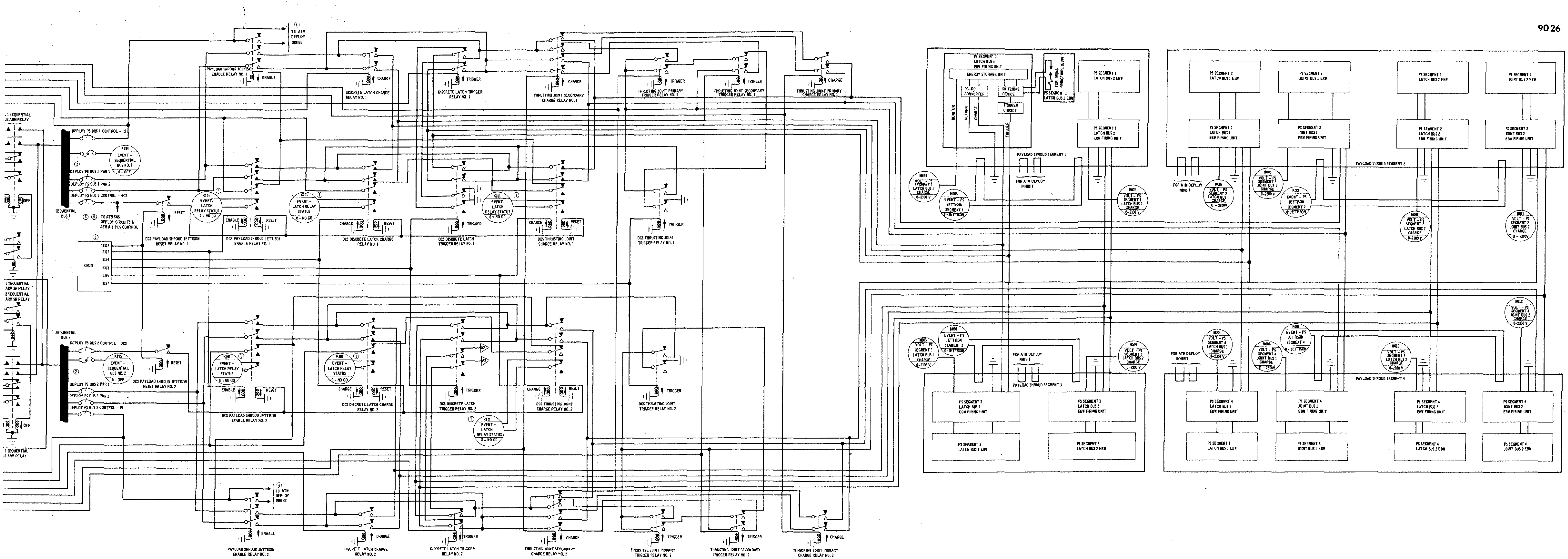

③

| CRDU COMMAND NO. | COMMAND TITLE | OCTAL CODE |
|---|---|---|
| S328 | AM SEQUENTIAL BUS ARM | 40644 |
| S323 | PS JETTISON RESET | 46244 |
| S322 | PAYLOAD SHROUD JETTISON ENABLE | 42244 |
| S324 | PAYLOAD SHROUD LATCH CHARGE | 41244 |
| S325 | PAYLOAD SHROUD LATCH TRIGGER | 45244 |
| S326 | PS THRUSTING JOINT CHARGE | 43244 |
| S327 | PS THRUSTING JOINT TRIGGER | 47244 |

NOTES:

1. K101, LATCH RELAY STATUS MEASUREMENT, OPERATIONAL ONLY DURING PRELAUNCH
2. DEPLOY PAYLOAD SHROUD BUS 1 AND BUS 2 CIRCUIT BREAKERS LOCATED EXTERNAL TO AM PRESSURE VESSEL
3. DIGITAL COMMAND SYSTEM
4. ATM SOLAR ARRAY DEPLOYMENT
5. ATM A & PCS AND COMMUNICATION SYSTEM

Figur



AY STATUS MEASUREMENT, OPERATIONAL ONLY DURING PRELAUNCH

SHROUD BUS 1 AND BUS 2 CIRCUIT BREAKERS LOCATED EXTERNAL
VESSEL

ND SYSTEM

Y DEPLOYMENT

) COMMUNICATION SYSTEM

Figure 2.0.3-6 Payload Shroud Deployment Schematic

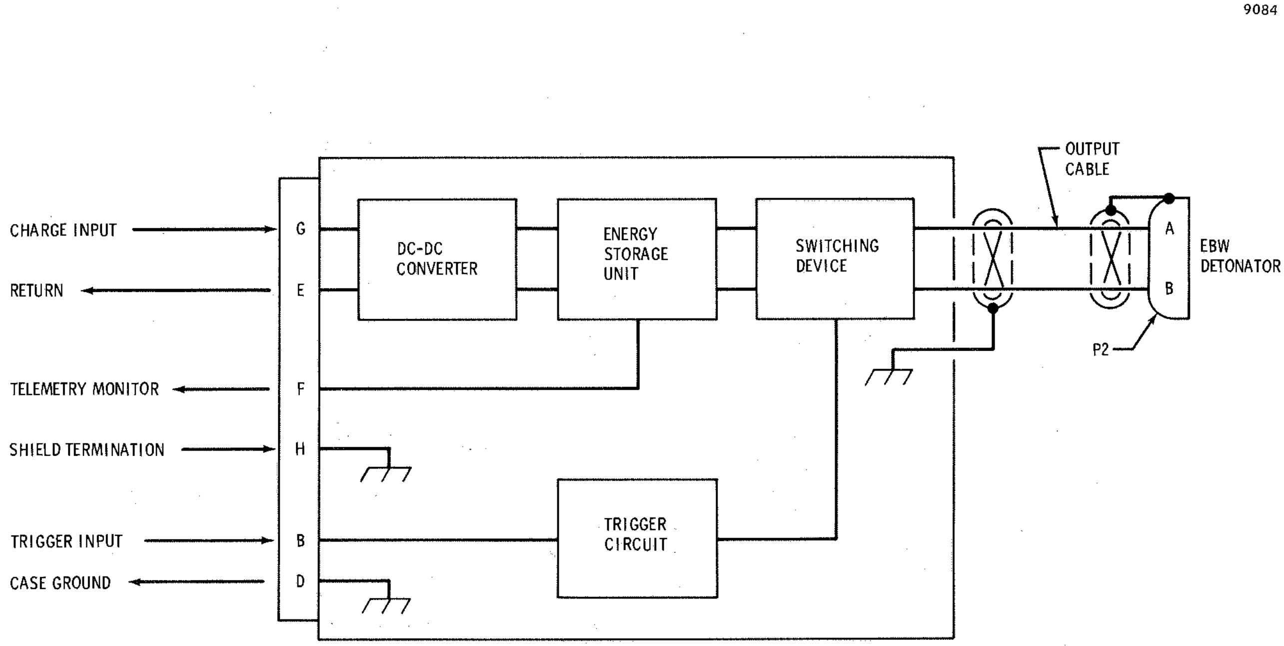
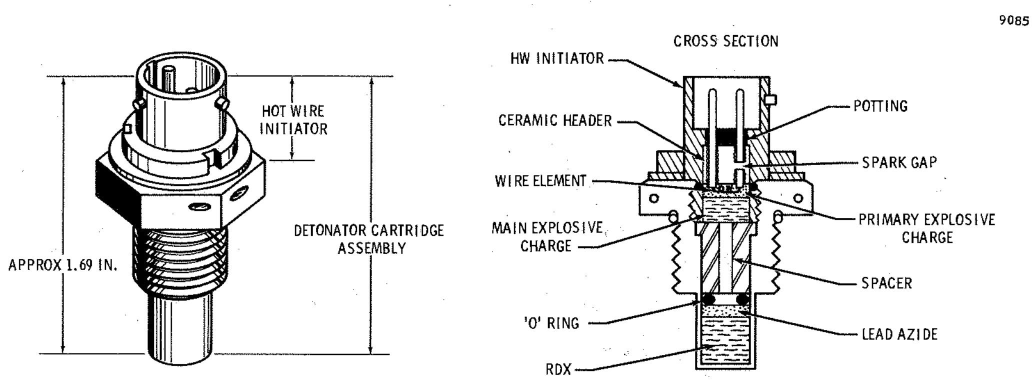



Figure 2.0.3-7 EBW Firing Unit



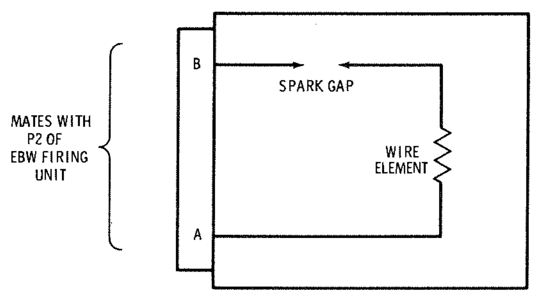




Figure 2.0.3-8 EBW Detonator

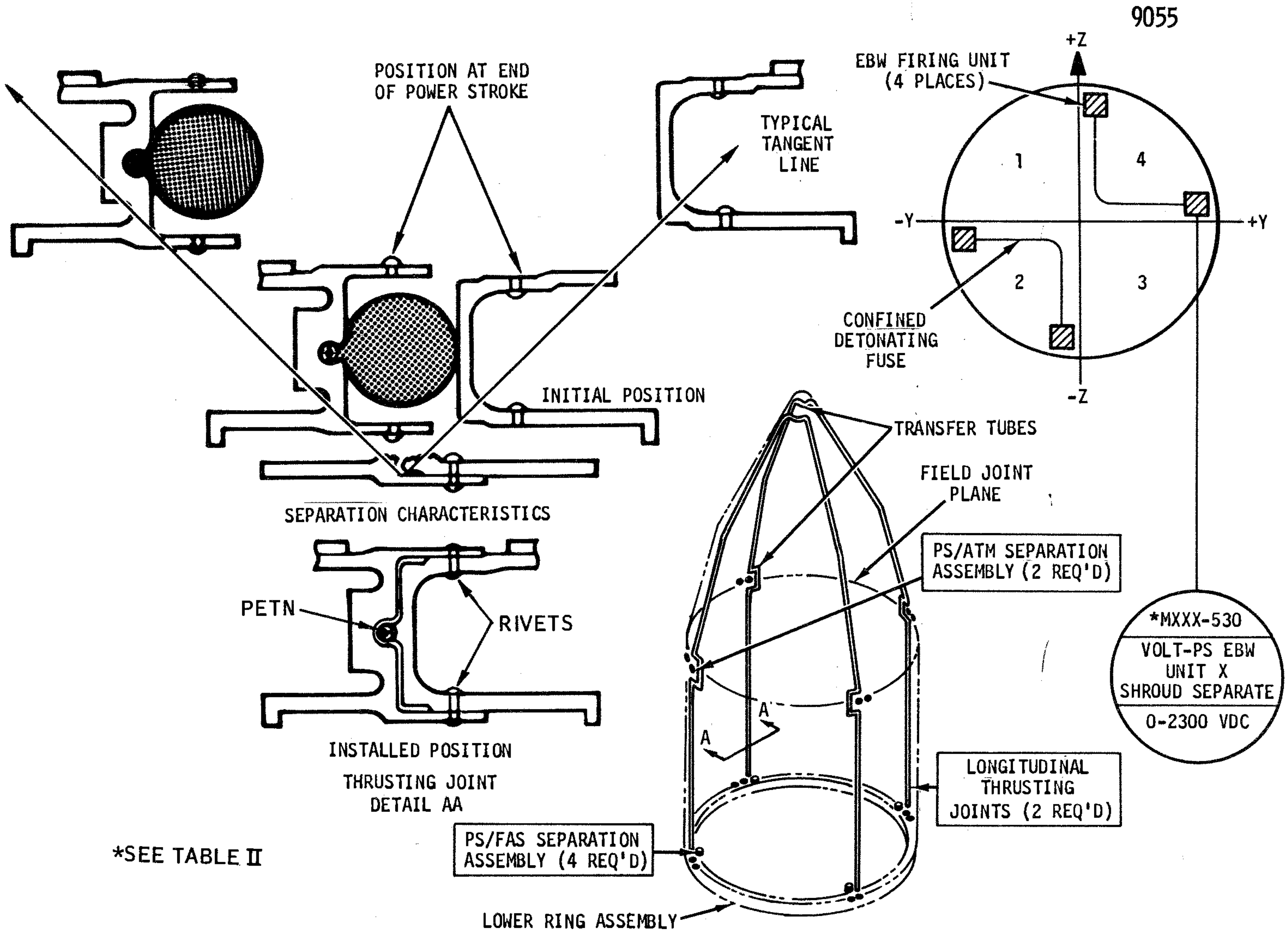



Figure 2.0.3-9 PS Separation Ordnance System

This function is verified by monitoring the four firing unit voltages and four discrete measurements (K005 through K008), which indicate that the segments have separated from the SWS (figure 2.0.3-6). Reset commands are then issued that reset the latching relays used to send commands to the AM, thus removing power from the AM PS jettison circuits.

All of the PS preprogrammed jettison commands have backup AM DCS command capability.

2.0.3.5 FAILURE MODES

The Payload Shroud failure modes and the effect on mission capability are given in table 2.0.3.5-1.

TABLE 2.0.3.5-1 PAYLOAD SHROUD - FAILURE MODES

| COMPONENT<br>a) FAILURE MODE<br>b) MOST PROBABLE FAILURE CAUSE | a) INDICATION<br>b) ACTION | FAILURE EFFECT<br>a) SYSTEMS<br>b) MISSION |
|---|---|---|
| 1. Connectors, Electrical Interface Lanyard Actuated | | |
| a) Connector fails to disconnect | a) None, unless failure resulted in damage to a function or component covered by T/M signal | a) Wire bundle would be pulled loose from connector by PS section during separations. |
| b) Mechanical binding | b) Evaluate T/M and crew report for possible change in crew EVA tasks | b) No degradation to mission is anticipated unless loose wire harness contacts and damages payload or forced separation produces debris resulting in potential contamination problem |
| a) No separation signal | a) EBW charge and trigger are monitored by T/M. Connector separation is monitored and indicates shroud separation | b) One or more EBW firing units fail to operate |
| b) Open or short in connector | b) Evaluate T/M data to determine action | b) None because each function has redundant connectors and also, the connectors are equally divided between separate power bases |
| a) Premature signal | a) Damage at launch pad | a) Results in separation of shroud panels on the launch pad with serious damage to payload and injury to crew |
| b) Failure of firing circuit, relay or programmer | b) None | b) None, requires failure of programmer, safety relays, and power signal |
| a) Premature signal | a) None, unless failure influences a component covered by T/M | a) Results in premature separation and catastrophic damage to payload |
| b) Failure of firing circuit, relay or programmer | b) N/A | b) None, requires failure of programmer, safety relays and power signal |
| 2. EBW Firing Unit for Latch Actuator | | |
| a) Fails to supply high voltage pulse to EBW detonator | a) None | a) EBW would not function to operate latch actuator |
| b) Open or short in circuit | b) None | b) None since either of two units can perform function |
| 3. EBW Detonators, Latch Actuator | | |
| a) Fails to initiate PETN | a) None | a) PETN assembly does not initiate at one end |
| b) Low output, no ignition | b) None | b) None, redundant detonators are provided |

TABLE 2.0.3.5-1 PAYLOAD SHROUD - FAILURE MODES (cont'd)

| COMPONENT<br>a) FAILURE MODE<br>b) MOST PROBABLE FAILURE CAUSE | a) INDICATION<br>b) ACTION | FAILURE EFFECT<br>a) SYSTEMS<br>b) MISSION |
|---|---|---|
| 4. Detonator Block & Booster Charge, Latch Actuator | | |
| a) Fails to ignite PETN | a) None | a) PETN is not ignited at one end |
| b) Ignition failure due to contamination, excessive gap, or defective charge | b) None | b) None, PETN assembly is ignited at both ends by separate detonator assemblies |
| 5. PETN Linear Explosive, Latch Actuator (1 of 1 required per quad section) | | |
| a) Low output energy or failure to ignite | a) None | a) Low output would not release latch actuators |
| b) Low order ignition or a defective strand | b) None | b) None, a force margin of (2) is provided to release latches. Also, multiple strands of PETN are redundantly ignited, i.e. each end. All latch actuators in a quad section can fail and shroud still separate |
| 6. Pressure Transfer Tubes, Latch Actuator (1 of 1 per quad section) | | |
| a) Tubes leak or rupture | a) None, unless failure results in damage to a function covered by a T/M signal | a) Release combustion by-products or debris into payload area |
| b) Defective seal or improper installation | b) None | b) Damage or contamination of payload would be dependent on degree of leakage |
| a) Low output pressure force | a) None | a) Low pressure force would not release latch actuators |
| b) Defective seal or improper installation that results in loss of actuation pressure force | b) None | b) None, redundant pressure tubes in adjacent quad section will release latch actuators |
| 7. Pin Puller, Discrete Latch Actuator (8 joints of 2 each; 1 of 2 required for separation at each joint) | | |
| a) Fails to release tension link | a) None | a) Tension strap not released at one end |
| b) Binding in pin seat or piston | b) None | b) None since release at one end of strap is adequate |
| a) Pressure chamber leaks combustion products or does not contain all parts | a) None | a) Release combustion by-products or debris into payload area |
| b) Seal failure | b) None | b) Contaminates or damages payload to varying degree |
| 8. Tension Link, Latch Actuator (1 of 1, each of 8 joints); | | |
| a) Does not properly disengage | a) None | a) Possible small change to separation path and/or small reduction in separation velocity |
| b) Binding | b) None | b) None, shroud attitude and separation velocity remains adequate for separation |

TABLE 2.0.3.5-1 PAYLOAD SHROUD - FAILURE MODES (cont'd)

| COMPONENT<br>a) FAILURE MODE<br>b) MOST PROBABLE FAILURE CAUSE | a) INDICATION<br>b) ACTION | FAILURE EFFECT<br>a) SYSTEMS<br>b) MISSION |
|---|---|---|
| a) Link comes loose during separation | a) None | a) None - Failure of link retention would not affect shroud separation |
| b) Retaining shear pin fails | b) None | b) None since loose link would follow same trajectory as shroud |
| 9. EBW Firing Unit for the Longitudinal Separation Joint (1 of 2 required for each length of PETN) | | |
| a) Fails to fire explosive bridge wire | a) None | a) The linear explosive assembly would be ignited from one end only |
| b) Open or short in circuit | b) None | b) None - Since the redundant ignition at other end will assure proper operation of thrusting joint |
| 10. EBW Firing Unit | | |
| a) Fires prior to receipt of trigger signal | a) Monitor of T/M signals would show premature firing but indication of subsequent problems would depend on the equipment affected and extent of damage | a) Premature ignition of one of four EBW detonators and respective linear explosive. Since Firing Units are charged (3) seconds before receipt of firing signal and full charge can be achieved in (0.5) seconds thus this mode is possible for approximately (2.5) seconds max. |
| b) Internal defect in Firing Unit | b) Review T/M data and take action indicated. Attempt ATM deployment and continue T/M monitoring for indication of need to cancel mission | b) This failure mode would result in hang-up of shroud segments at both nose cap and ATM support fittings such that successful ATM deployment and continuation of mission would be precluded |
| 11. EBW Detonator for PETN (1 of 2 required for each length of PETN) | | |
| a) Fails to initiate PETN | a) None | a) The linear explosive assembly would be ignited at one end only |
| b) Defective charge | b) None | b) None since the redundant detonator at other end will provide ignition |
| 12. Detonator Block and Booster Charge (1 of 2 required for each length of PETN ) | | |
| a) Failure to ignite or improper ignition of PETN | a) None | a) The linear explosive assembly would be ignited at one end only |
| b) Defective pyrotechnic interface | b) None | b) None since the redundant change at other end will provide ignition |
| 13. Transfer Tubes (5 of 5 required for each length of PETN). Provides pressure connection for PETN between bellows sections and from detonator to bellows | | |
| a) Tube leaks or ruptures | a) None unless failure resulted in damage to function or equip-covered by T/M signal | a) Explosive by-products blown into payload area resulting in possible payload damage from contamination or debris |

TABLE 2.0.3.5-1 PAYLOAD SHROUD - FAILURE MODES (cont'd)

| COMPONENT<br>a) FAILURE MODE<br>b) MOST PROBABLE FAILURE CAUSE | a) INDICATION<br>b) ACTION | FAILURE EFFECT<br>a) SYSTEMS<br>b) MISSION |
|---|---|---|
| b) Defective seal | b) None | b) Effect on mission would be dependent on degree of leakage and extent of contamination. Could compromise mission objectives |
| 14. Attenuator Tubes (4 of 4 sections required for each length of PETN). Provides attenuation for PETN detonation | | |
| a) Tube ruptures | a) None | a) None since assembly is composed of dual tubes and failure of either one would not cause problems |
| b) Damaged or defective tube | b) None | b) None |
| 15. Bellows (4 of 4 sections required for each length of PETN). Contains gas pressure and explosive by-products and transmits force to separate shroud segment | | |
| a) Bellows leaks or ruptures | a) None unless failure resulted in damage to a function or equipment covered by T/M signal | a) Would allow contamination of payload and reduction in separation force resulting in low separation velocity and unbalanced force on |
| b) Bellows damaged during installation | b) Would depend on degree of damage and could require cancellation of mission and SL-2 launch | b) Would not prevent P.S. separation Effect of payload conamination would depend on equipment affected and nature of contaminant |
| 16. PETN Linear Explosive (2 of 2 required for shroud); | | |
| a) Low output energy or failure to ignite | a) None | a) Full pressure would not be developed in joint. Shroud section affected would not separate with full velocity |
| b) Low order ignition or defective strands | b) None | b) None, energy available is sufficient to shear twice the number of rivets involved. Seven PETN strands are redundantly ignited, i.e., each end. Four of seven strands provide sufficient energy. |
| 17. Piston and cylinder Assembly (4 of 4 required for linear explosive assembly) | | |
| a) Fails to separate properly | a) None unless shroud fails to separate the interface electrical connector which is monitored by T/M or causes damage to equipment of function covered by T/M | a) Would result in increased resistance to separation with possible distortion of shroud segments |
| b) Binding due to loads induced by thermal gradients, manufacturing tolerances and release of tension links | b) Monitor T/M and take action as required | b) Shroud distortion and resultant separation velocity loss due to energy dissipated in yielding structure could cause hang up of one or more shroud sections. Failure of shroud to separate properly could result in loss of primary mission objectives |

2.0.3.6 PERFORMANCE AND DESIGN DATA

2.0.3.6.1 Design Data

The following list contains specific data on components in the PS.

Exploding Bridgewire Units (1) - 2300-vdc nominal detonator charge, Trigger relay operating time 2 to 6 milliseconds over temperature range and voltage range, fairing unit trigger circuit operating time 4.0±1.0 milliseconds.

2.0.3.6.2 Performance Data

The PS performance is presented on tables 2.0.3.6-1 and 2.0.3.6-2.

TABLE 2.0.3.6-1 TIME OF SEGMENT SEPARATION

| SEP. JOINT (BETWEEN SEGMENTS) | (BREAKWIRE) SEPARATION FROM TIME ZERO (SEC) | TOP TO BOTTOM TIME (SEC) | SEPARATION FROM TIME ZERO (SEC) | TOP TO BOTTOM TIME (SEC) |
|---|---|---|---|---|
| I & II | TOP .0138 | .0024 | TOP .016 ± .002 | .002 |
| (-Y) | BOT .0114 | + | BOT .014 ± .001 | ±003 |
| II & III | TOP .0090 | .0068 | TOP .014 ± .002 | .001 |
| (-Z) | BOT .0158 | - | BOT .013 ± .001 | ±003 |
| III & IV | TOP .0110 | .0016 | TOP .014 ± .002 | .000 |
| (+Y) | BOT .0126 | - | BOT .014 ± .001 | ±003 |
| IV & V | TOP .0090 | .0066 | TOP .014 ± .002 | * |
| (+Z) | BOT .0156 | - | BOT * | |

* TIMING DATA MISSING ON FILM

SKYLAB I P.S. FULL SCALE SEP. TEST NO. 1 PLUM BROOK

TABLE 2.0.3.6-2 SEGMENT ROLL & YAW WITH TRANSITION

| SEGMENT (QUAD) | C. G. TRANS. VELOCITY FT/SEC | YAW RATE DEG/SEC | ROLL RATE DEG/SEC |
|---|---|---|---|
| I | 17.2 | 2.0 | 6.5 |
| II | 17.1 | 6.0 | 10.9 |
| III | 18.1 | 6.5 | 24.0 |
| IV | 17.8 | 4.0 | 12.0 |

SKYLAB I P.S. FULL SCALE SEP. TEST NO. 1 PLUM BROOK

2.0.3.7 OPERATIONAL LIMITATIONS AND RESTRICTIONS

The operational limitations and restrictions for the PS are as follows:

- o PS segments must be jettisoned in the gradity gradient attitude, ± 10 degrees. (pitch rate 0.3 deg/sec)
- o Sequential buses 1 or 2 must be armed
- o IU and OWS switch selector must be operational for prime mode (Backup via the AM DCS)
- o PS jettison circuits must be armed
- o Charge command to eight latch joint EBW's must precede trigger command
- o Latch joints must be separated prior to sending charge command to thrusting joint EBW's

2.0.3.8 INSTRUMENTATION

TABLE 2.0.3.8-1 PS LATCH ACTUATOR INSTRUMENTATION

| PS SEGMENT | MEAS NO. | MEASUREMENT DESCRIPTION | TM RANGE | ONBOARD DISPLAY DISPLAY RANGE | ONBOARD DISPLAY PANEL NO. |
|---|---|---|---|---|---|
| 1 | M001-530 | VOLT, PS EBW UNIT 1 LATCH ACTUATOR | 0-2300 vdc | | None |
| 1 | M007-530 | VOLT, PS EBW UNIT 7 LATCH ACTUATOR | 0-2300 vdc | | None |
| 2 | M002-530 | VOLT, PS EBW UNIT 2 LATCH ACTUATOR | 0-2300 vdc | | None |
| 2 | M008-530 | VOLT, PS EBW UNIT 8 LATCH ACTUATOR | 0-2300 vdc | | None |
| 3 | M003-530 | VOLT, PS EBW UNIT 3 LATCH ACTUATOR | 0-2300 vdc | | None |
| 3 | M009-530 | VOLT, PS EBW UNIT 9 LATCH ACTUATOR | 0-2300 vdc | | None |
| 4 | M004-530 | VOLT, PS EBW UNIT 4 LATCH ACTUATOR | 0-2300 vdc | | None |
| 4 | M010-530 | VOLT, PS EBW UNIT 10 LATCH ACTUATOR | 0-2300 vdc | | None |

TABLE 2.0.3.8-2 PS THRUSTING JOINT INSTRUMENTATION

| PS SEGMENT NO. | MEAS NO. | MEASUREMENTS DESCRIPTION | TM RANGE | ONBOARD DISPLAY DISPLAY RANGE | ONBOARD DISPLAY PANEL NO. |
|---|---|---|---|---|---|
| 2 | M005-530 | VOLT, PS EBW UNIT 5 | 0-2300 vdc | | None |
| 2 | M011-530 | VOLT, PS EBW UNIT 11 | 0-2300 vdc | | None |
| 4 | M006-530 | VOLT, PS EBW UNIT 6 | 0-2300 vdc | | None |
| 4 | M012-530 | VOLT, PS EBW UNIT 12 | 0-2300 vdc | | None |

TABLE 2.0.3.8-3 PS JETTISON INSTRUMENTATION

| PS SEGMENT NO. | MEAS NO. | MEASUREMENT DESCRIPTION | TM RANGE | ONBOARD DISPLAY DISPLAY RANGE | ONBOARD DISPLAY PANEL NO. |
|---|---|---|---|---|---|
| 1 | K005-530 | EVENT, PS JETTISON | OPEN = JETTISON | | None |
| 2 | K006-530 | EVENT, PS JETTISON | OPEN = JETTISON | | None |
| 3 | K007-530 | EVENT, PS JETTISON | OPEN = JETTISON | | None |
| 4 | K008-530 | EVENT, PS JETTISON | OPEN = JETTISON | | None |

## 2.0.4 DISCONE ANTENNA BOOMS

### 2.0.4.1 INTRODUCTION

Two discone antenna booms position the discone antennas away from the vehicle for unobstructed RF communication. The solar arrays and the deployed ATM have a degrading effect on the radiation patterns of body-mounted antennas. One discone antenna is mounted on the end of each boom. The discone antenna booms are mounted in two places to the FAS at NASA station No. 3348.1. Discone antenna boom No. 1 is located 45 degrees from +Y toward -Z and No. 2 is located 45 degrees from -Z toward -Y (Figure 2.0.4-1).

### 2.0.4.2 SYSTEM INTERFACES

The discone antenna booms interface with the AM DCS, EPS, instrumentation system, and communication system and have mechanical interfaces with the Fixed Airlock Shroud and ATM DA.

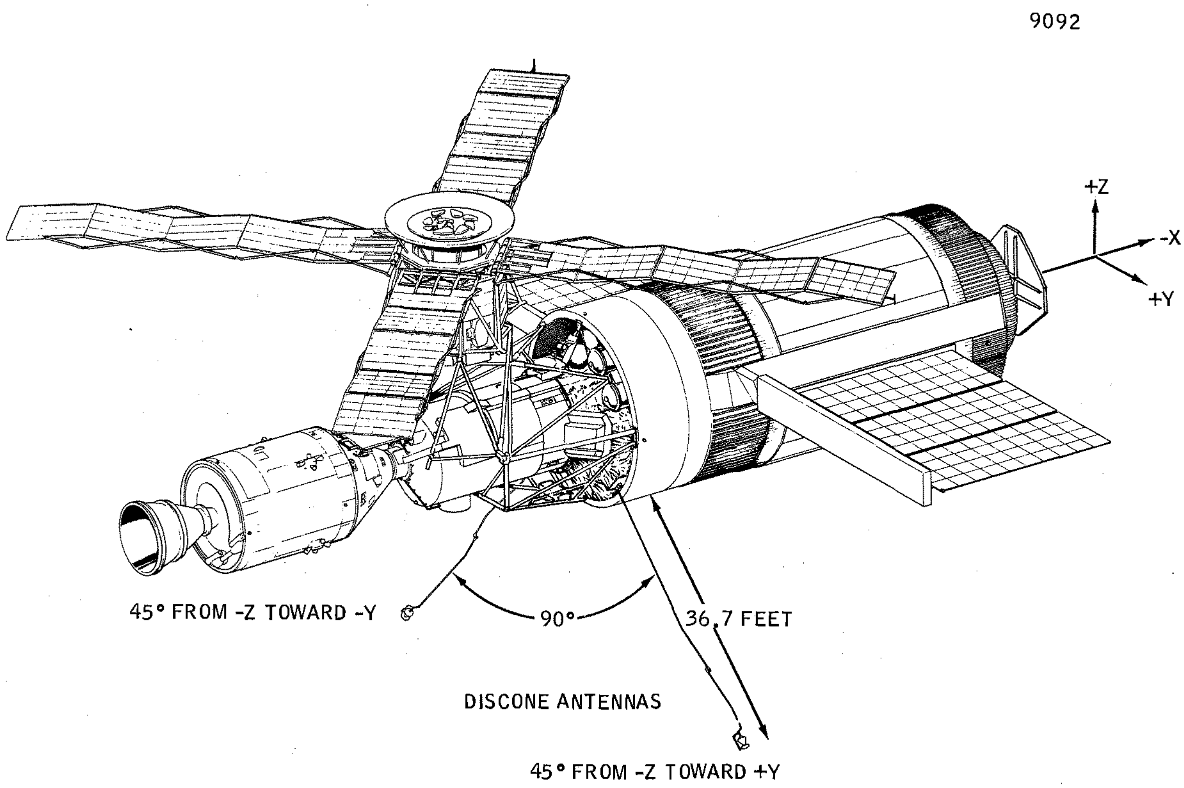



Figure 2.0.4-1 Discone Antenna Booms

2.0.4.3 FUNCTIONAL DESCRIPTION

Each discone boom consists of an inner and outer boom, which together when deployed extend to 36 feet 8 inches. During launch, the booms are stowed within the envelope of the PS and are attached to the ATM deployment assembly. The booms are retained in the stowed configuration by two strap assemblies (figure 2.0.4-2). Each strap assembly consists of two straps (one for each boom), a spring, and a hinged retainer. To retain the inner and outer booms, the straps are secured at one end to the DA and at the other end, which is provided with a "D" ring, by the hinged retainer, which is spring loaded to the open position (figure 2.0.4-3).

A cable restrains each hinged retainer to hold the straps in the captured position. A bead is positioned at the end of each cable and is retained in a scissor device prior to deployment. The scissor assembly maintains the cable in tension until the release actuators are electrically commanded to release the scissor. Release of the scissor assembly allows the cables to slacken, which in turn releases the straps restraining the booms.

The inner boom is connected to the structure by a spring-operated rotary joint, which rotates a full 90 degrees. At approximately 80 degrees of rotation, mechanical clearance is adequate for release of the outer boom, which rotates 180 degrees relative to the inner boom (figure 2.0.4-4). Limit switches in the outer rotary joint of each antenna boom indicate when the outer boom is locked in place.

The discone antenna boom deployment sequence is powered from the AM deploy buses 1 and 2. The IU issues commands through the OWS switch selector to arm the deploy buses. Voltage-on commands are available for this function and are DEPLOY BUSES PERMISSION - ON (3-1) and DEPLOY BUSES ARM (8-1) both of which are required. The antenna booms may then be deployed only by AM DCS command. Two commands exist for this function, DISCONE ANTENNA BUS 1 - DEPLOY (S124) and DISCONE ANTENNA BUS 2 - DEPLOY (S126), either of which will initiate antenna boom deployment. Deployment is indicated by a measurement (K102) that indicates the relays have been operated to apply power to the actuators and, finally, by two measurements (K167 and K168) that indicate that the outer rotary joints of the antenna booms are rotated and locked.

Onboard control of the deployment of the antenna booms exists through two switches on panel 205, one to power the deploy buses and the other to deploy the antenna booms (figure 2.0.4-5).

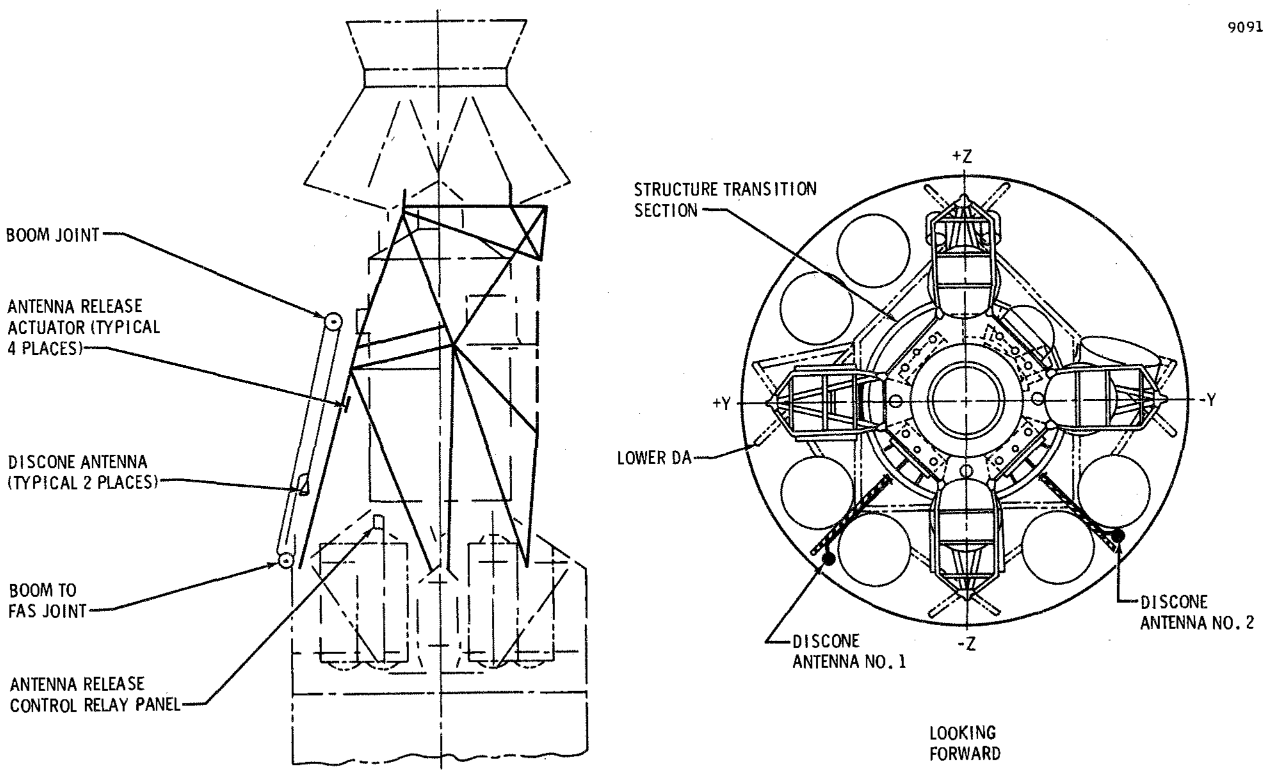



Figure 2.0.4-2 Discone Antenna Booms -- Configuration

2.0.4.4 SUBSYSTEM AND MAJOR COMPONENT DESCRIPTION

2.0.4.4.1 Release Actuator

Two release actuators retain the scissors assembly on each boom assembly. Each actuator consists of a plunger that engages the scissors assembly, a retraction spring, a split collet, and a wire wound around the collet. Prior to releasing the plunger, the two halves of the split collet are secured by a wire that is wound around the perimeter of the collet. The plunger is extended with the retraction spring compressed and is retained by the secured split collet. The wire winding around the collet is attached to an electrical connector. Upon receiving 20 to 28 vdc on the wire, the wire separates, releasing the two halves of the collet. The retraction spring then extends, retracting the plunger into the actuator casing (Figure 2.0.4-6).

2.0.4.4.2 Rotary Joint

The rotary joint is a spring-actuated rotation mechanism that is fluid damped. Two rotary joints are provided for each boom assembly. One rotary joint is provided at the FAS/boom interface and one at the inner/outer boom hinge point. The rotary joint is a trunnion with an internal spring, which imparts rotational force to the trunnion to deploy the boom. A fluid damper enhances smooth deployment. A locking mechanism is contained in the rotary joint to lock the boom in the deployed position. Actuation of the outer joint locking mechanism causes a limit switch to be switched on (figure 2.0.4-7). This limit switch provides telemetry indications that the booms are deployed and locked.

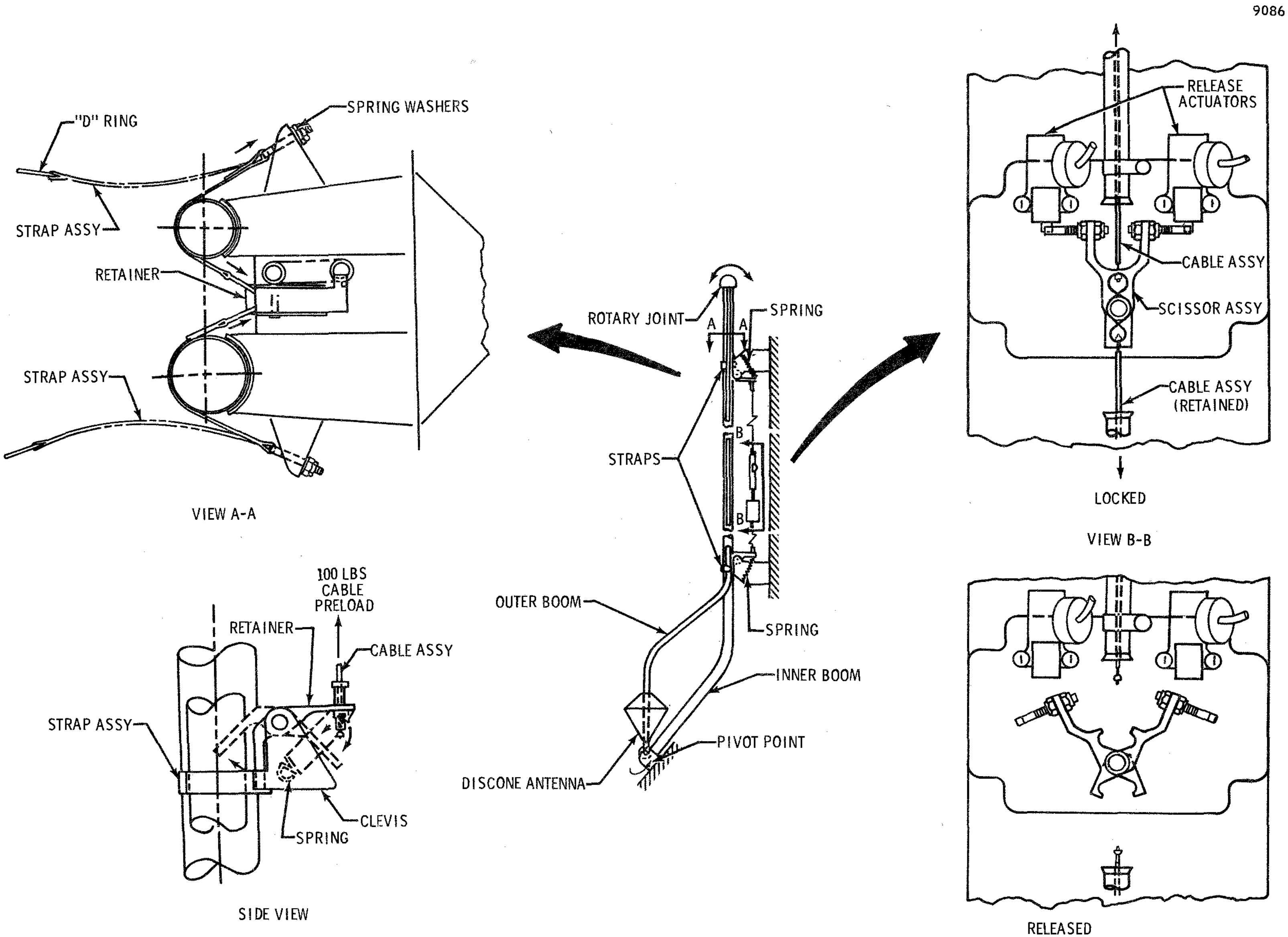



Figure 2.0.4-3 Discone Antenna Release Mechanisms

9087

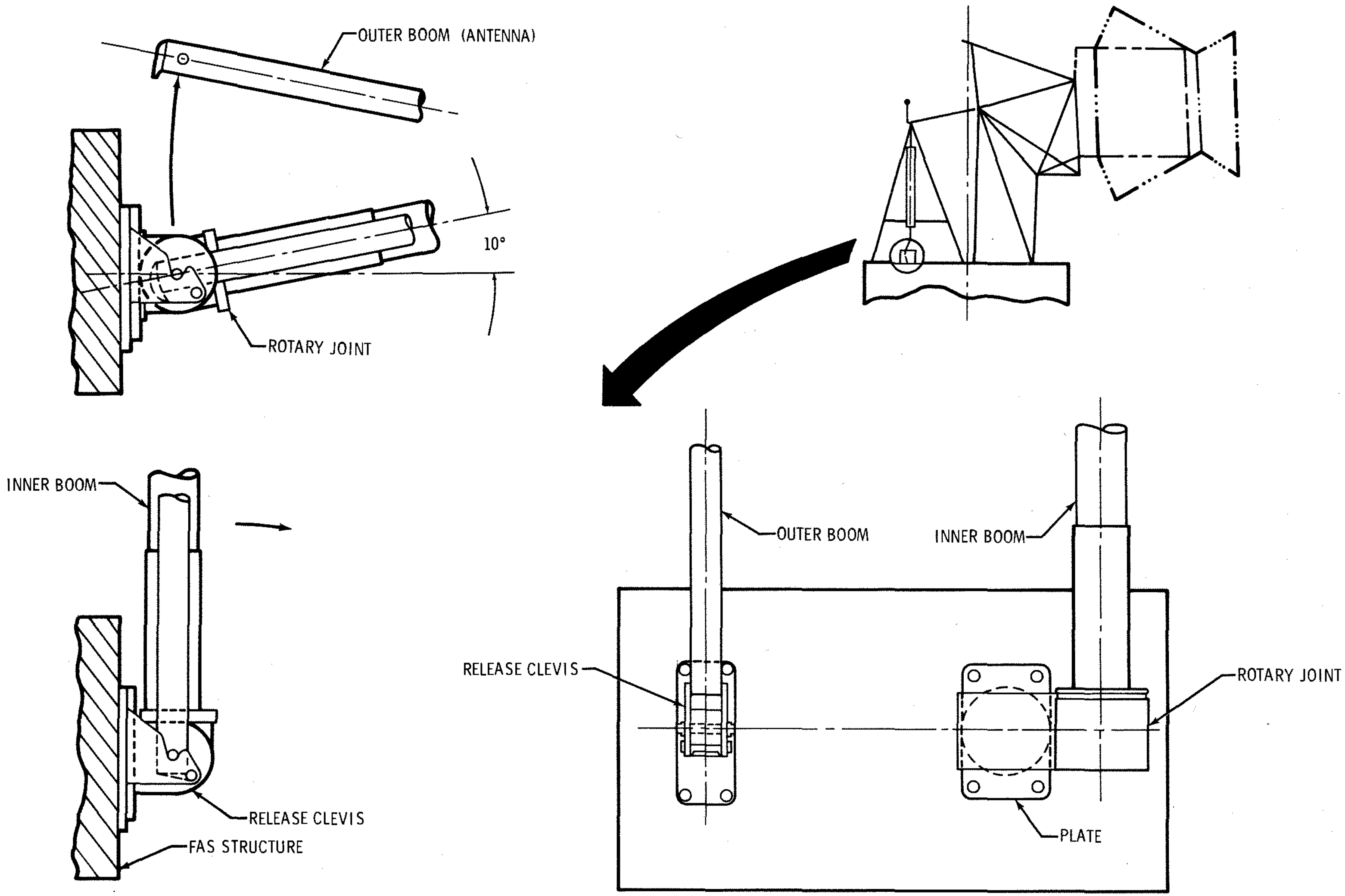



Figure 2.0.4-4 Discone Antenna Rotation Assembly

9829

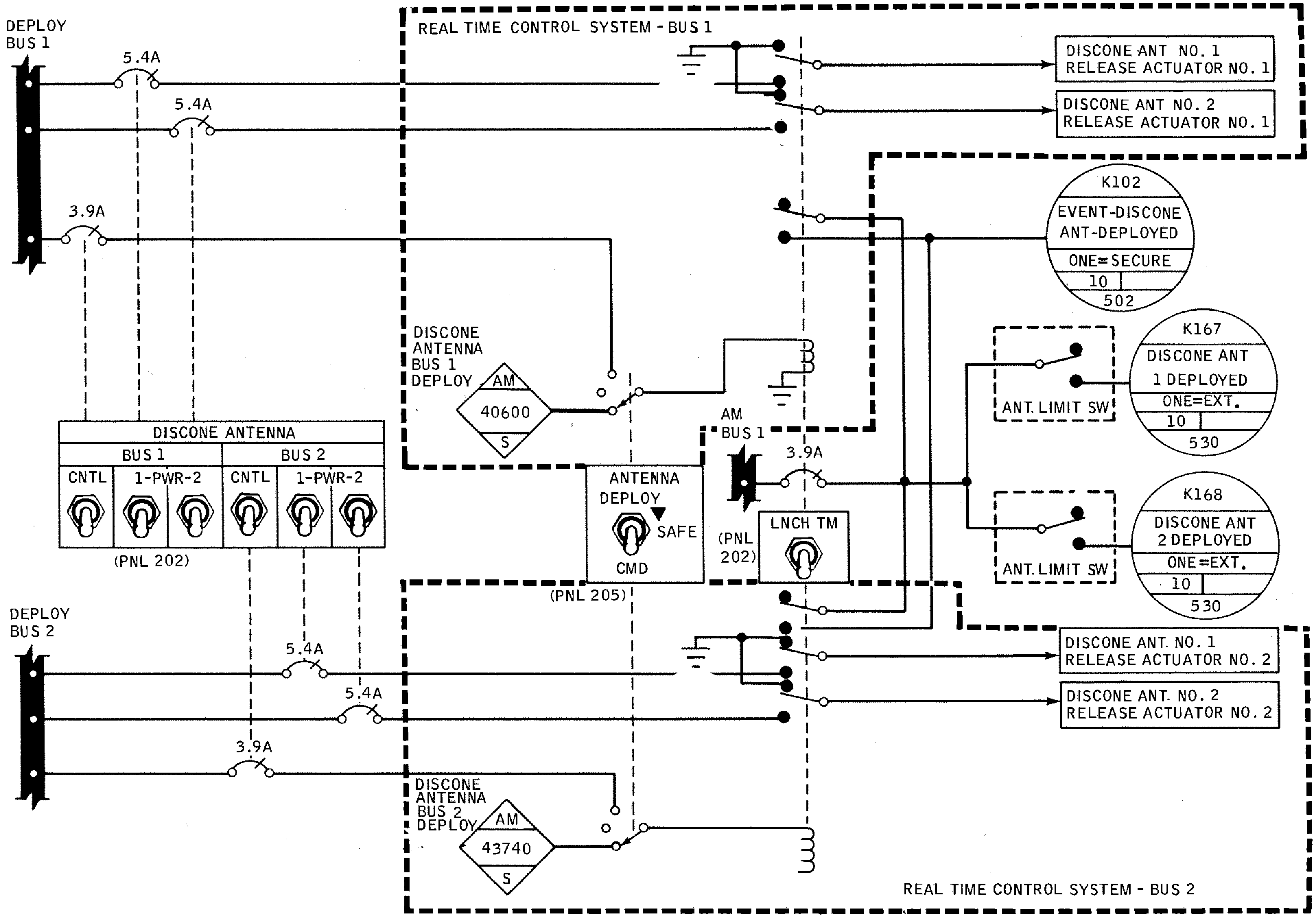



Figure 2.0.4-5 Discone Antenna Deployment

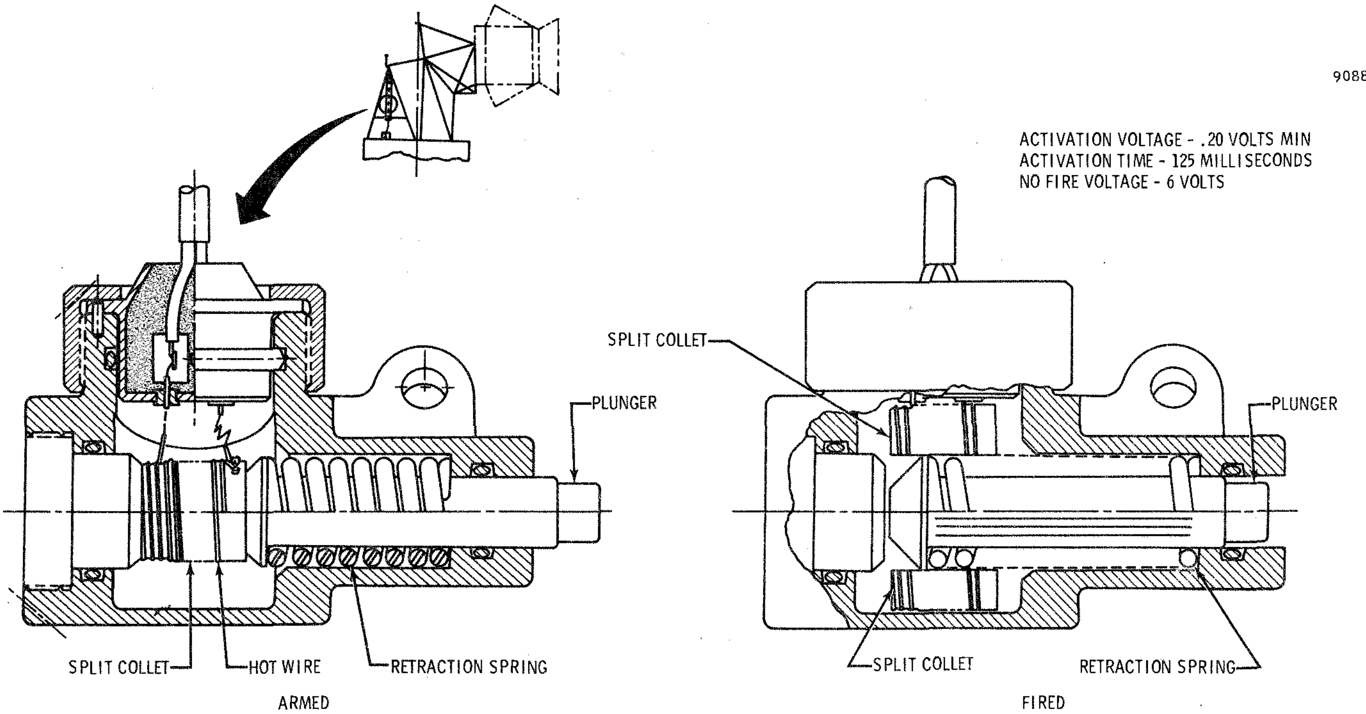



Figure 2.0.4-6 Release Actuator

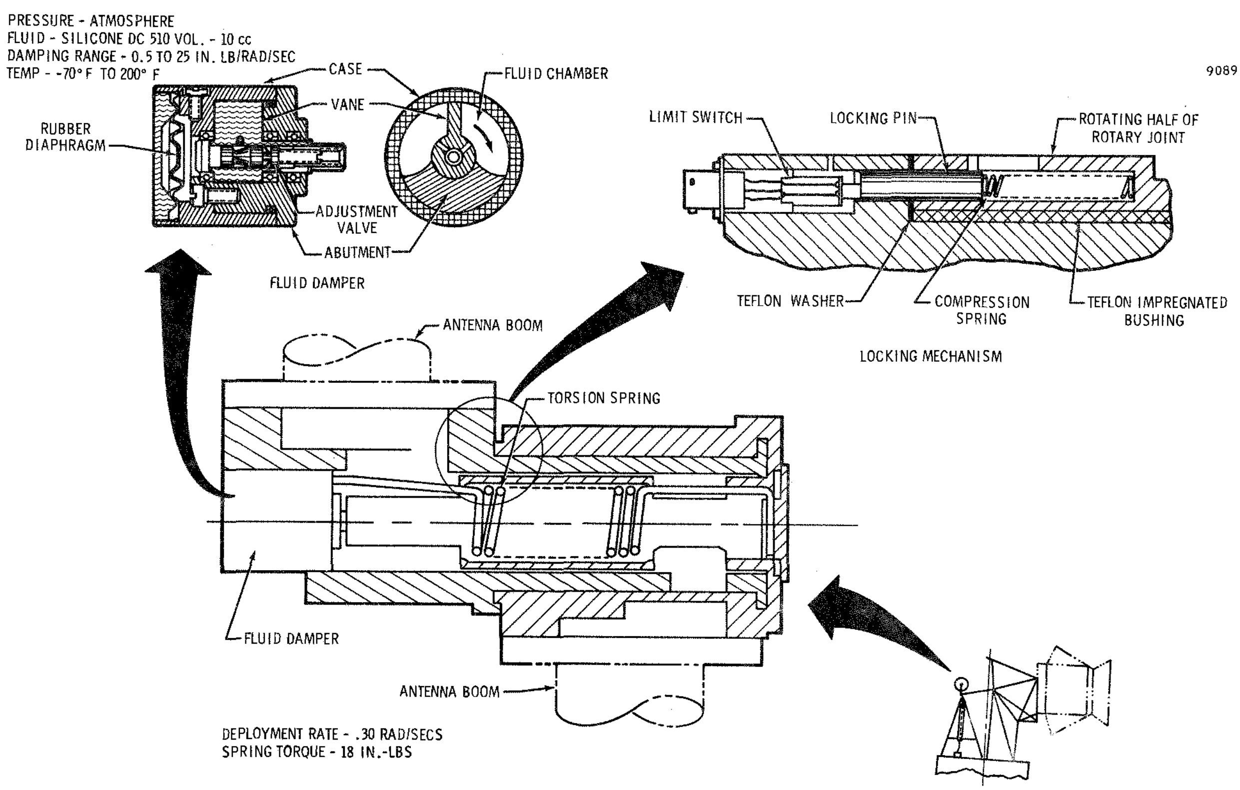



Figure 2.0.4-7 Rotary Joint

2.0.4.5 FAILURE MODES

The discone antenna boom failure modes and the effect on mission capability are given in table 2.0.4-1.

TABLE 2.0.4-1 DISCONE ANTENNA BOOMS - FAILURE MODES

| FAILURE | INDICATIONS | VEHICLE CAPABILITY |
|---|---|---|
| 1. Both Discone Antennas fail to Deploy | | |
| a) Four circuit breakers fail open:<br>Discone Antenna Bus 1 Pwr 1<br>Discone Antenna Bus 1 Pwr 2<br>Discone Antenna Bus 2 Pwr 1<br>Discone Antenna Bus 2 Pwr 2<br>or<br>Four release actuators must fail to release the antennas:<br>Antenna 1 Release Actuator 1<br>Antenna 1 Release Actuator 2<br>Antenna 2 Release Actuator 1<br>Antenna 2 Release Actuator 2<br>or<br>Mechanical binding in release mechanism or rotary joints | a) Primary<br>K102 = 1 (indicating at least 1 of 2 redundant release relays has latched)<br><br>K167 = K168 = 0 (Indicating neither antenna has extended)<br><br>Support:<br>TM and DCS signal strength will be weaker and more variable than predicted<br><br>Crew will note non-deployment at start of first visitation | a) System: None<br><br>Other Systems: The restricted antenna patterns of the undeployed discones will result in unpredictable variations of signal strength at the DCS receivers 2 inputs. During periods of low signal strength from the command stub with the discone in use, the DCS may not respond to MCC commands<br><br>Mission: The restricted discone antenna patterns will also result in periods of low signal strength TM from the discone. Mission operations will be impeded whenever the DCS fails to respond to MCC commands<br><br>Crew: The crew may have to perform some activities normally performed by DCS commands |
| b) Release Relays No. 1 and No. 2 fail to operate | b) K102 = 0 (Indicating that neither relay has operated)<br>and<br>K167 and K168 = 0 (Indicating neither antenna has extended) | b) Same as (a) |
| c) CRDU fails to issue relay driver pulses to release Relays | c) Same as (b)<br>and<br>K301 thru K311 may indicate that the commands were not received and decoded | c) Same as (a) |
| d) Both antennas fail to lock in the deployed position | d) Both K167 and K168 continue to read zero<br>and<br>K102 = 1 (Indicating at least 1 of 2 Release Relays has closed) | d) Effects should be negligible since the spring torque in the affected rotary joints will be in the direction to maintain the antennas in the deployed position |
| 2. One discone antenna fails to deploy | | |
| a) Two circuit breakers fail open:<br>Deploy Antenna Bus 1 Pwr 1 and<br>Deploy Antenna Bus 2 Pwr 1<br>or<br>Deploy Antenna Bus 1 Pwr 1 and<br>Discone Antenna Bus 2 Pwr 2<br>or<br>Two release actuators fail to release on discone antenna:<br>Antenna 1 Release Actuator 1<br>Antenna 1 Release Actuator 2<br>or<br>Mechanical binding in release mechanism or rotary joints | a) Primary:<br>K102 = 1 (Indicates at least one of the two redundant Release Relays has closed)<br><br>Either K167 or K168 = 0 (Indicates either Discone Antenna 1 or 2 not extended)<br><br>Support: Low TM and DCS Rcvr 2 signal strength when utilizing the undeployed antenna<br><br>Crew can verify antenna position visually after rendezvous | a) Same as for failure to deploy Discone 1 and 2 except at a lower frequency of occurrence |
| b) One outer rotary joint fails to rotate | b) Same as a) | b) Same as a) except for increased frequency of occurrence |

TABLE 2.0.4-1 DISCONE ANTENNA BOOMS - FAILURE MODES (cont'd)

| COMPONENT | INDICATIONS | FAILURE EFFECT |
|---|---|---|
| c) Failure of one antenna to lock in the deployed position | c) Either K167 or K168, depending on which antenna failed to lock, will read zero (indicating not extended), the other will remain equal to 1<br><br>K102 = 1 (Indicating at least 1 of 2 Release Relays has closed)<br><br>TM and DCS signal strength will not be adversely affected | c) Effects should be negligible since the spring torque in the affected rotary joint will be in the direction to maintain the antenna in the deployed position |

2.0.4.6 PERFORMANCE AND DESIGN DATA

2.0.4.6.1 Design Data

The following list contains specific data on the components in the discone antenna boom.

Release Actuators (2)- -70°F to 250°F operating temperature range, 24 to 30 vdc input voltage, 20±0.5 vdc for 125 milliseconds activation, 125 milliseconds activation time, 0.25 inch/min. actuator shaft travel. The actuator is a "one-time" operation device.

Cables (2) - 38.12 inch length, 1/16-inch diameter stainless steel, nylon coated to 3/32 diameter

Booms - inner boom 2.00 inch diameter 2024 T3 tubing, outer boom 1.50 inch diameter 2024 T3 tubing

2.0.4.7 OPERATIONAL LIMITATIONS AND RESTRICTIONS

The operational limitations and restrictions for the discone antenna booms are as follows:

- o PS must be jettisoned prior to discone antenna deployment
- o Deploy bus 1 or 2 must be armed
- o Deployment is by ground command via AM DCS
- o Backup deploy capability provided by manual command by the crew at the STS C&D panel 205.
- o AM buses 1 and 2 must be up to provide telemetry indications of deployment

2.0.4.8 INSTRUMENTATION

| MEAS. NO. | MEASUREMENT DESCRIPTION | TM RANGE | ONBOARD DISPLAY DISPLAY RANGE | ONBOARD DISPLAY PANEL NO. |
|---|---|---|---|---|
| K102-502 | EVENT-DISCONE ANTENNAS DEPLOYED | ONE = SECURED | None | None |
| K167-530 | EVENT-DISCONE ANTENNA 1 EXTEND | ONE = EXT & LOCK | None | None |
| K168-530 | EVENT-DISCONE ANTENNA 2 EXTEND | ONE = EXT & LCK | None | None |
| K179-509 | EVENT-DEPLOY BUS 1 POWER ON/OFF | ONE = ON | None | None |
| K180-509 | EVENT-DEPLOY BUS 2 POWER ON/OFF | ONE = ON | None | None |

2.0.5 APOLLO TELESCOPE MOUNT (ATM)

2.0.5.1 GENERAL DESCRIPTION

The ATM (figure 2.0.5-1) consists of a rack, an experiment canister, a solar array, and various support subsystems. The ATM provides SWS and OA attitude control electrical power for ATM experiments and sharing of the OA electrical loads and equipment required to perform the solar astronomy experiments.

The ATM is in a stowed position during launch, with the ATM forward of MDA axial port 5. At a command from the IU, the deployment assembly rotates the ATM into place, with the ATM X-axis parallel to the OWS Z-axis. After the ATM is locked into position, the ATM solar arrays are deployed.

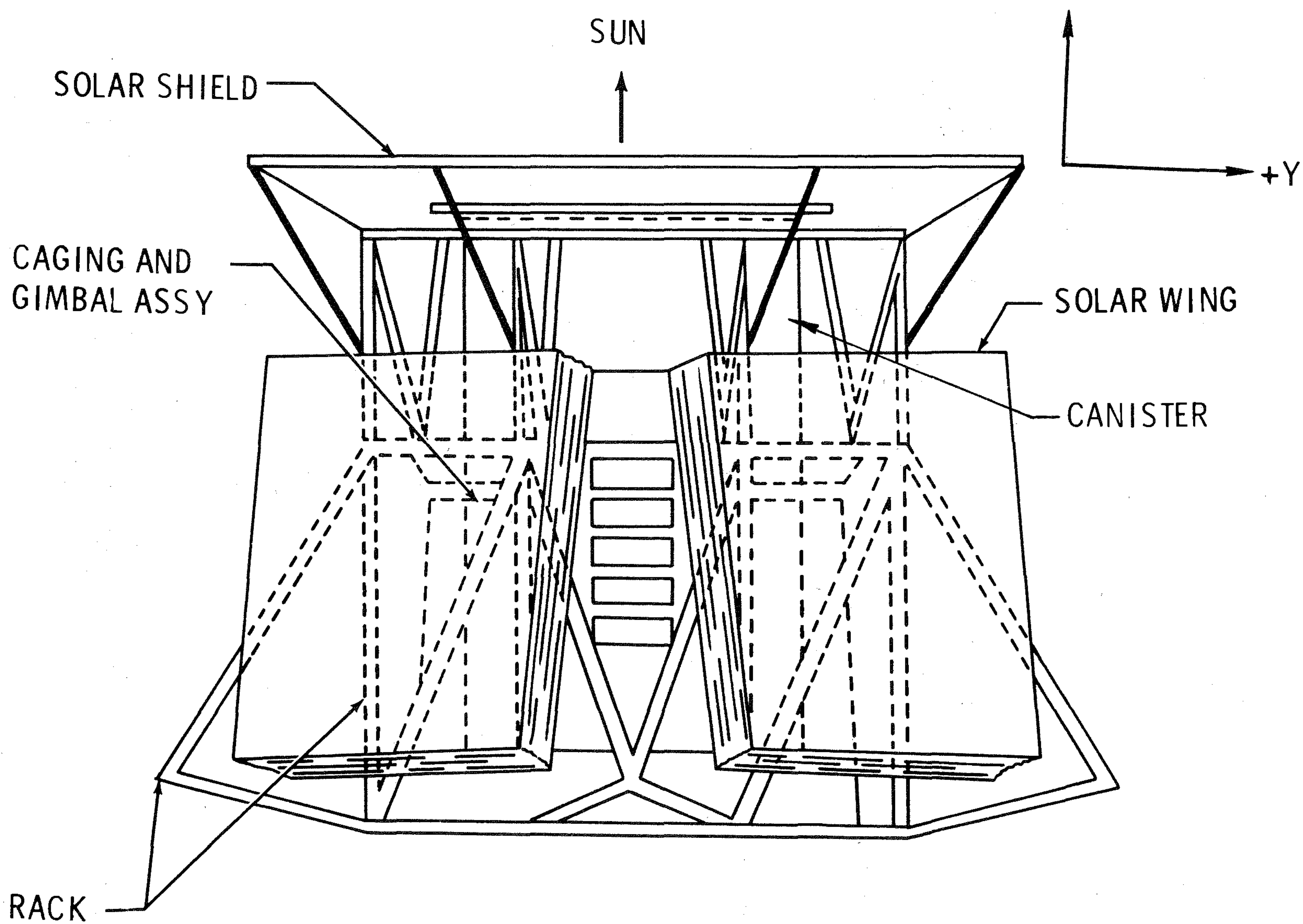



Figure 2.0.5-1 Apollo Telescope Mount

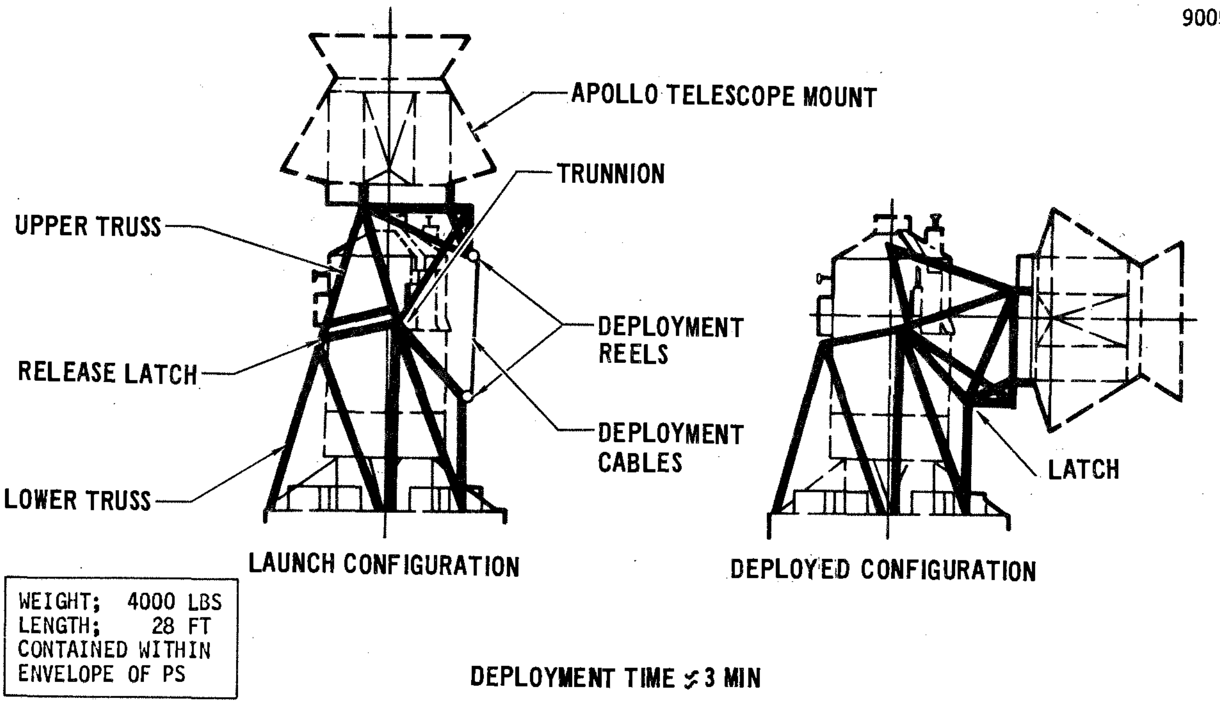



Figure 2.0.6-1 ATM Deployment Assembly

2.0.5.2 ATM RACK

The ATM rack is an octagonal structure approximately 11 feet across and 12 feet high, with a 14-foot diameter sun shield at one end, and four truss-type structural members extending from four of its sides. The rack is open in the center to accomodate the experiment canister and has attachment points for the solar array and most of the ATM subsystem equipment on its external sides and one end. It is mounted to the ATM-DA.

2.0.5.3 EXPERIMENT CANISTER

The experiment canister is a cylinder approximately 7 feet in diameter, 10 feet long, and is closed at both ends except for experiment viewing doors. It has a cruciform space inside, to provide mounting for experiments. The canister is attached to the rack by means of a two-degree-of-freedom gimbal and roll mechanism. Some subsystem equipment is also mounted on the MDA end of the canister.

2.0.5.4 SOLAR ARRAY

The ATM solar array is the electrical power generation source for the ATM. The array consists of four wings covered with solar cells, and the means to deploy them in orbit. The wings are attached to the sun end of the rack perpendicular to the long axis of the SWS, and their span is approximately 100 feet.

For a more detailed description of the ATM, refer to the SLOH-ATM, Volume I.

2.0.6 ATM - DEPLOYMENT ASSEMBLY (ATM-DA)

2.0.6.1 INTRODUCTION

The ATM/DA provides structural support during launch, and deployment capabilities in orbit, for the ATM. It has installation mounts for the rendezvous lighting, rendezvous antenna, earth resources experiment package (EREP), and solar noise burst monitor experiments. The ATM-DA (figure 2.0.6-1) consists of an upper and a lower tubular truss assembly, a release ordnance, a rotation system, and a means to latch the DA in the deployed position.

2.0.6.2 SYSTEM INTERFACES

The ATM/DA structurally interfaces with the ATM and FAS. It also interfaces with the EPS, AM DCS, and instrumentatic system.

2.0.6.3 FUNCTIONAL DESCRIPTION

The ATM DA deploys the ATM after orbital insertion and provides the structural support necessary for ATM operation. The Deployment Assembly is isolated from launch loads by a nonrigid attachment to the ATM. After orbital insertion, jettisoning of the Payload Shroud allows four, spring-loaded, DA-rigidifying mechanisms to retract and rigidify the ATM. Upon receiving an automatically switched IU/OWS switch selector command, two pyrotechnic release mechanisms are actuated that release the Deployment Assembly upper and lower truss attachment points to allow for rotation of the DA around two trunnion points. Each trunnion is equipped with a spring that resists the rotation of the Deployment Assembly for the complete 90-degree rotation of the ATM. Deployment is initiated by IU/OWS switch selector command. Redundant motors attached to the reel system are turned on to overpower the trunnion springs and pull the ATM, via cables, into the deployed position. The complete rotation takes a nominal time of 3 minutes. A latch mechanism is engaged as the ATM completes its rotation into the deployed position. AM DCS commands provide a backup means of deploying the ATM.

2.0.6.4 SUBSYSTEM AND MAJOR COMPONENT DESCRIPTION

2.0.6.4.1 Lower Truss Assembly

The lower truss assembly (figure 2.0.6-2) is made up of five bipods connected by framing members. The bases of the bipods are attached to the FAS in eight places. Rod ends are used to provide adjustment when mating the ATM DA to the FAS.

2.0.6.4.2 Upper Truss Assembly

The upper truss assembly (figure 2.0.6-2) is made up of the upper truss frame assembly, launch stabilization strut assembly, and rigidifying frame assembly. The upper truss frame assembly consists of two inverted bipods with their apexes at the trunnion points and one inverted tripod with its apex at the deployment latch. An additional bipod with its apex also at the deployment latch point provides support for the rigidifying frame.

2.0.6.4.3 Rigidifying Mechanism

The launch stabilization strut assemblies stabilize the upper truss for overturning loads before deployment. The upper truss frame attaches to the rigidifying frame assembly. This tubular frame provides mounts for the four floating ATM attach joints (rigidifying mechanisms). These rigidifying mechanisms attach to the ATM through four adapter fittings with bolted field connections. Figure 2.0.6-3 shows the rigidifying mechanism. During launch, the DA does not support the ATM but is attached to the ATM in the floating position. Following PS separation, the springs of the four rigidifying mechanisms retract and rigidify the ATM to the DA interface. ATM alignment adjustment is also provided for by the rigidifying mechanism prior to launch.

2.0.6.4.4 Deployment Assembly Release System

The deployment assembly release system consists of four pin retractors, a redundant pyrotechnic manifold, two detonators, and two EBW firing units ((figure 2.0.6-4). The four pin retractors are used for attaching the upper truss to the lower truss during launch. These retractors are pneumatically operated piston pin arrangements that are actuated upon the detonation of the pyrotechnics attached to each retractor. A cross section of a pin retractor is shown in figure 2.0.6-5.

The detonation of the train of confined detonating fuse (CDF) triggers four pressure cartridges (one at each pin retractor). The pressure cartridge (figure 2.0.6-6) attaches to the CDF. Detonation of the CDF drives a firing pin within the pressure cartridge into a primer, which in turn detonates a charge of ammonium perchlorate. The detonation of the ammonium perchlorate increases the pressure within the pin retractor to release the upper truss at the release mechanism.

The ATM deployment is inhibited and subsequently enabled by circuits that detect if the PS has been successfully jettisoned. The IU begins the ATM deployment sequence by issuing commands through the OWS switch selector (figure 2.0.6-7). ATM DA ENABLE is issued through the OWS switch selector to set redundant relays providing sequential bus 1 and sequential bus 2 power to the contacts of the charge and trigger relays for the release system. LATCH CHARGE is then issued through the OWS switch selector to close the ATM DA LATCH CHARGE RELAY 1 and 2. This provides sequential bus 1 power to charge EBW firing unit 1 and sequential bus 2 power to charge EBW firing unit 2. The charge voltages on the storage units of the EBW firing units 1 and 2 are monitored by measurement M013 and M014. Three seconds later, LATCH TRIGGER 1 is issued to trigger EBW firing unit 1. All of the release mechanisms CDF should nominally detonate to retract all four pin retractors. LATCH TRIGGER 2 is issued 200 milliseconds after LATCH TRIGGER 1 as a backup. AM DCS control of the DA release ordnance is provided as a backup to the IU automatically sequenced commands. The AM DCS commands that backup the IU functions are:

- ATM DA enable (S336)
- Deploy Control - DCS (S340)
- Latch Release Charge (S337)
- Latch Release Trigger (S350)

Sending ATM DA enable and then the Deploy Control DCS through the AM DCS disables the IU automatic sequence. The Deploy Control - DCS command drives a relay that changes the command mode from IU to DCS. This can be reset by issuing DEPLOY CONTROL - IU (S341) to re-enable the IU automatic sequence to command the DA deployment.

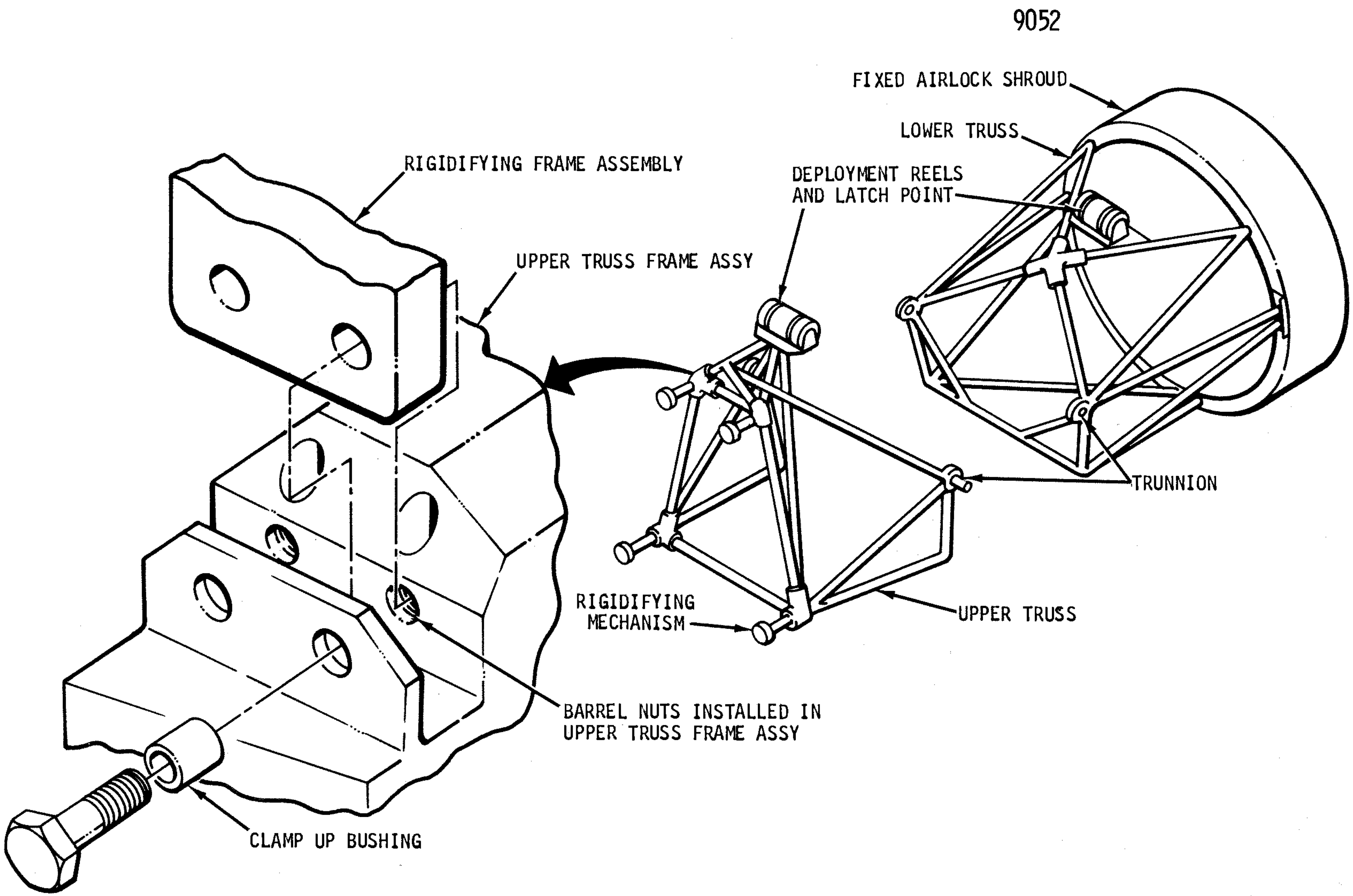



Figure 2.0.6-2 DA Truss Assembly

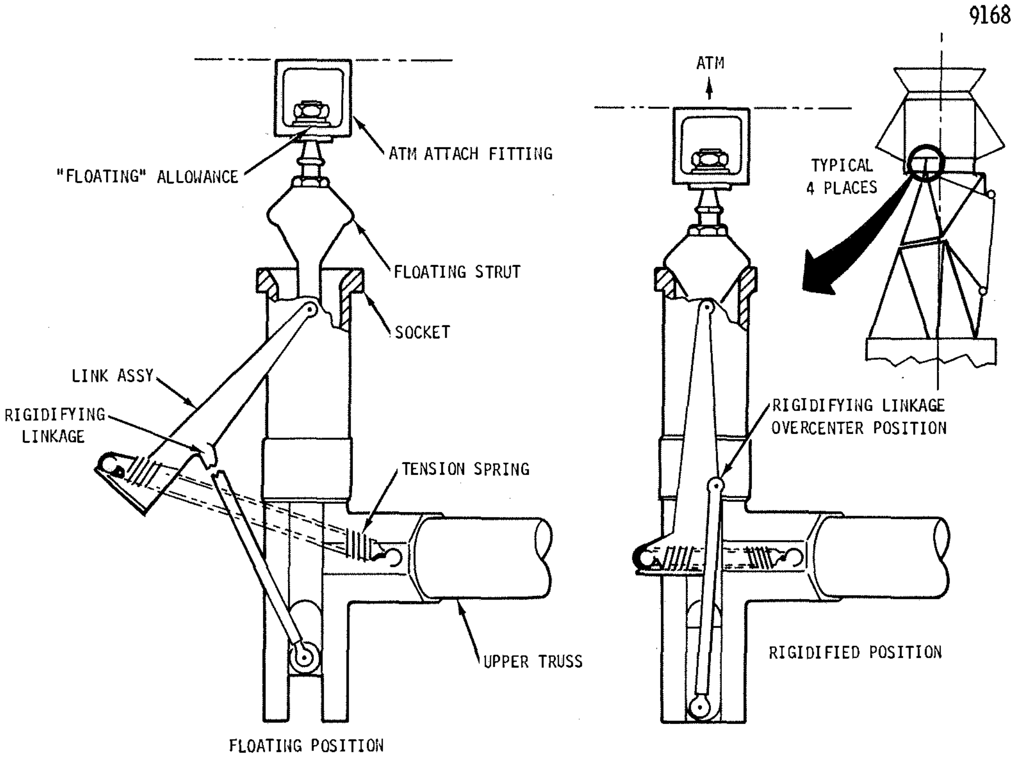



Figure 2.0.6-3 Rigidifying Mechanism

2.0.6.4.5 Rotation System

The ATM-DA rotation system consists of two redundant trunnions with negator type springs, redundant deployment reels, cables, gear trains, and motors (figure 2.0.6-8). The trunnions consist of pins attached to the upper truss and bearing surfaces on the lower truss. A spring is attached to the lower truss portion of the trunnions. Rollers are provided on the upper truss that make contact with the springs to act as followers. These springs are used to resist deployment and maintain tension in the deployment cables (figure 2.0.6-9).

The deployment reels, one on the upper truss assembly and one on the lower, consist of four spools and have two redundant cables running between them (figure 2.0.6-10). The spools lock against reverse rotation by using the antiback drive ratchet and are sized to be capable of reeling in all the cable required for total deployment with one reel inoperative. Slack control springs are provided to keep the cables taut on the spools. Both reel systems normally operate to deploy the ATM-DA. Each system is capable of total deployment regardless of the point of failure of the other system. The reels rotate in opposite directions, each reeling in cable. As soon as the latching mechanism on the upper truss engages the lower truss, a switch is tripped, initiating an 18-second time delay to shut off the motors.

Following the release of the pin retractors, the deployment motors are commanded on by IU automatically sequenced (motor ON) (figure 2.0.6-11). The ATM is rotated 90 degrees to a center line that is parallel $\pm$ 1 degree to the +Z coordinate of the SWS.

Measurements K003 and K004 indicate that the deployment motors are operating. Once the ATM has rotated 90 degrees, down discretes are issued over telemetry (K001 and K002), which are limit switch indications that the ATM has been pulled into the first position of the latch. At this time, time delay relays are started, allowing time for the ATM to go to the last position of the latch before turning the motors off (figure 2.0.6-12). Reset commands are then issued that reset the OWS latch relays used for the ATM deployment commands.

The DCS commands that back up the IU for each of the ATM deployment functions are:

- o ATM DA MOTORS - ON (S338)
- o ATM DA MOTORS - OFF (S362)
- o ATM DEPLOY CONTROL - IU-OWS (S341)

Control of the deployment of the ATM is initially transferred from the IU to the AM DCS by the command ATM DEPLOY CONTROL - AM DCS (S340).

9081

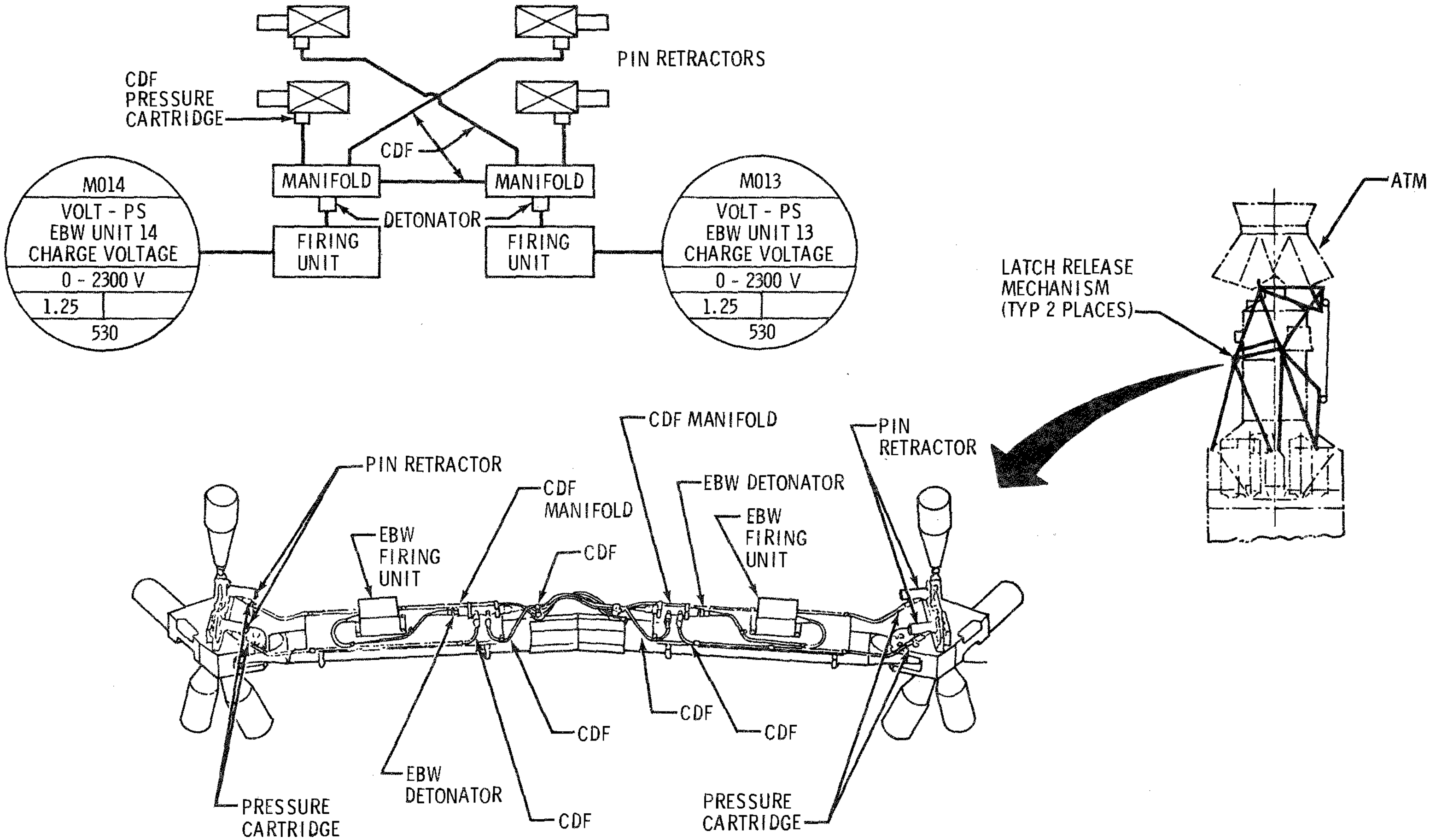



Figure 2.0.6-4 ATM Deployment Release Mechanism

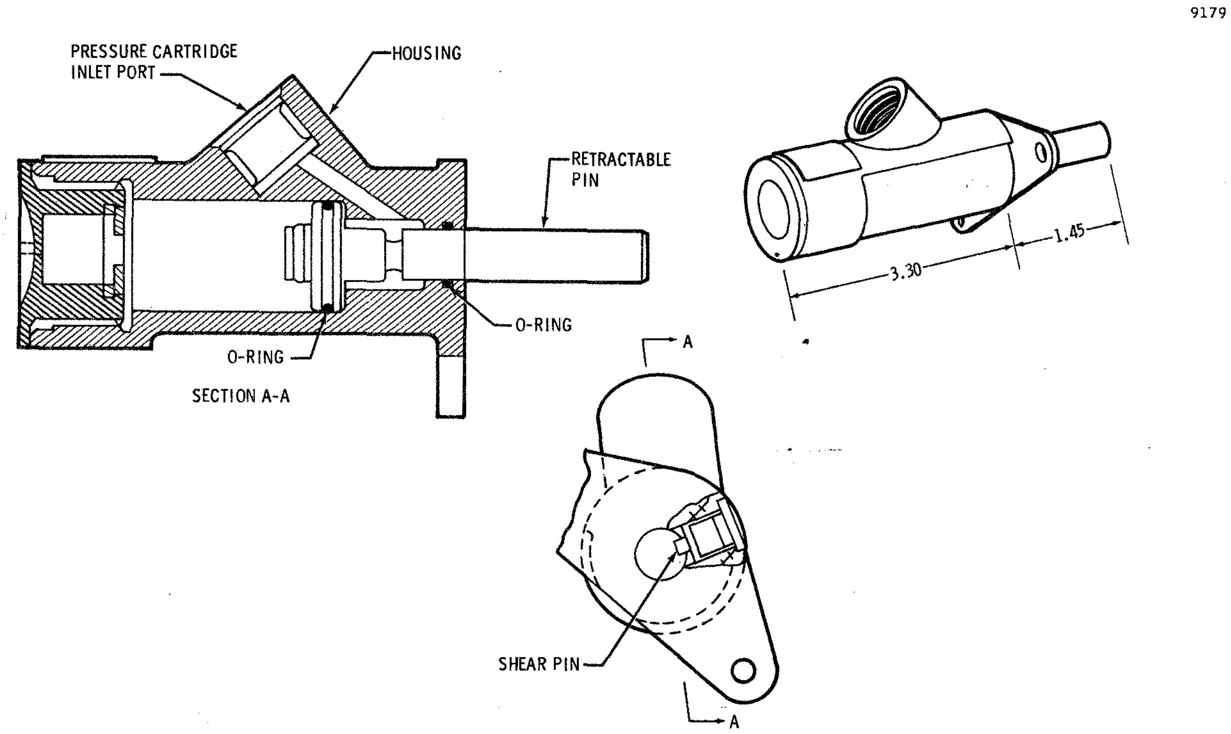



Figure 2.0.6-5 Pin Retractor

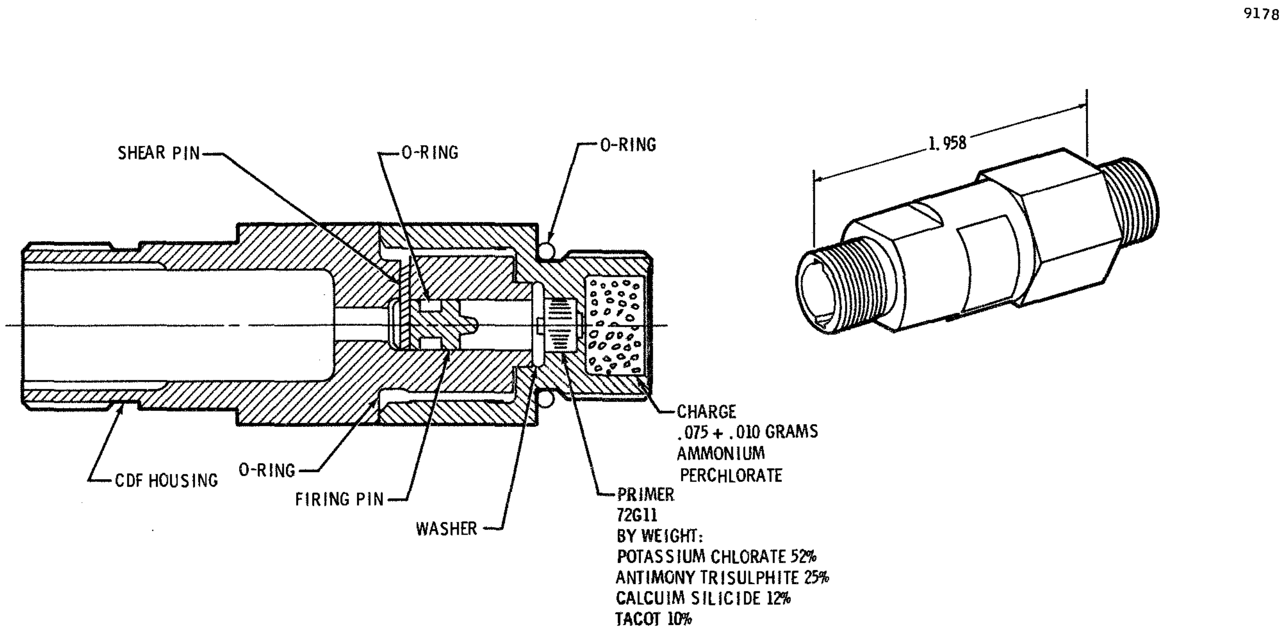
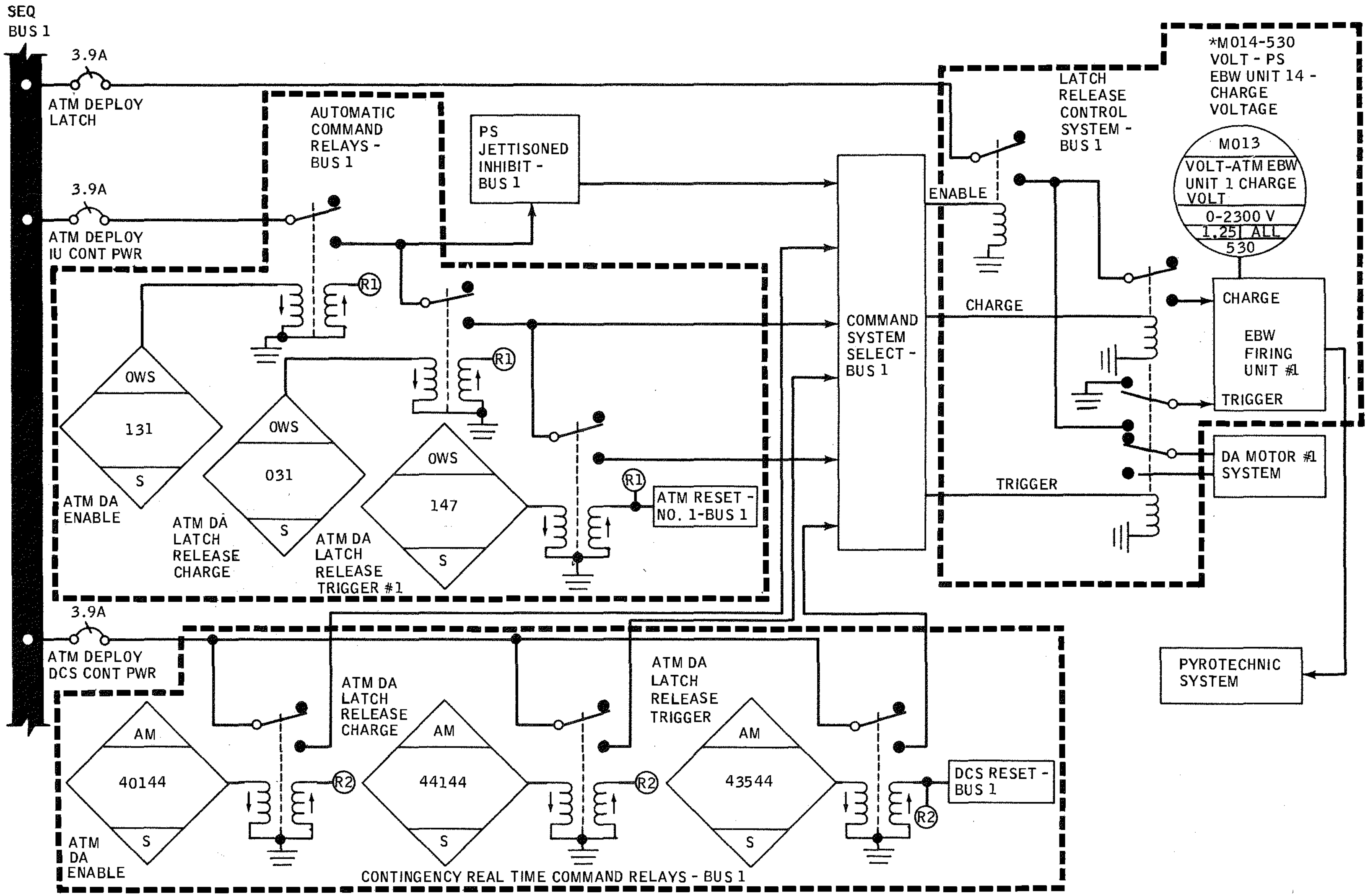



Figure 2.0.6-6 Pressure Cartridge



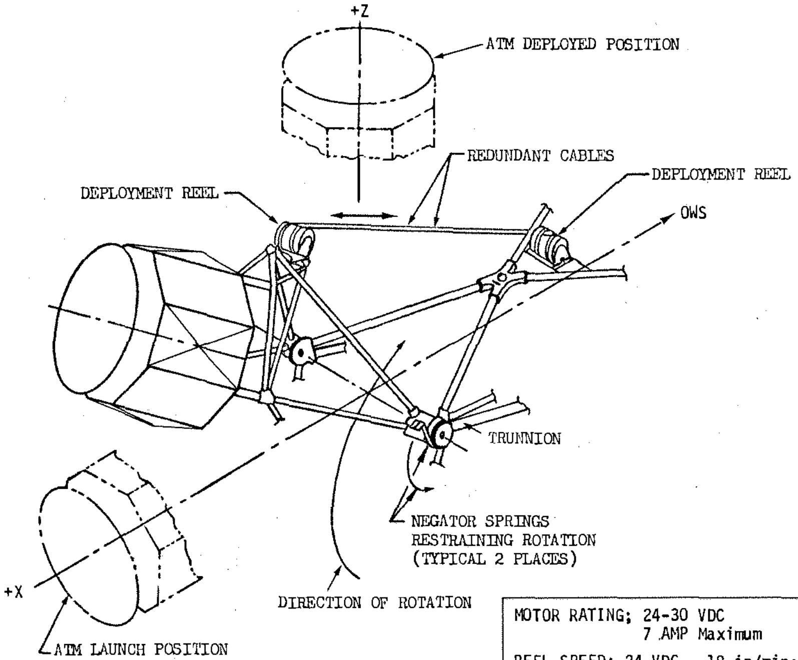

NOTE: LATCH RELEASE SYSTEM BUS 2 SAME AS SHOWN EXCEPT WITH (176) ATM DA LATCH RELEASE TRIGGER #2 (057) AND ATM DA RESET #2 (176)

R1 ATM DA RESET 1 (147)

R2 ATM DEPLOY RELAY RESET
ATM DEPLOY CONTROL IU-OWS

Figure 2.0.6-7 ATM Deployment Latch Release System Bus 1

9053




| | |
|---|---|
| MOTOR RATING; | 24-30 VDC<br>7 AMP Maximum |
| REEL SPEED; | 24 VDC - 18 in/min; 45 lb Cable Load<br>30 VDC - 40 in/min; 25 lb Cable Load |
| CABLE LENGTH; | 183 Inch |

Figure 2.0.6-8 DA Rotation Mechanism

9046

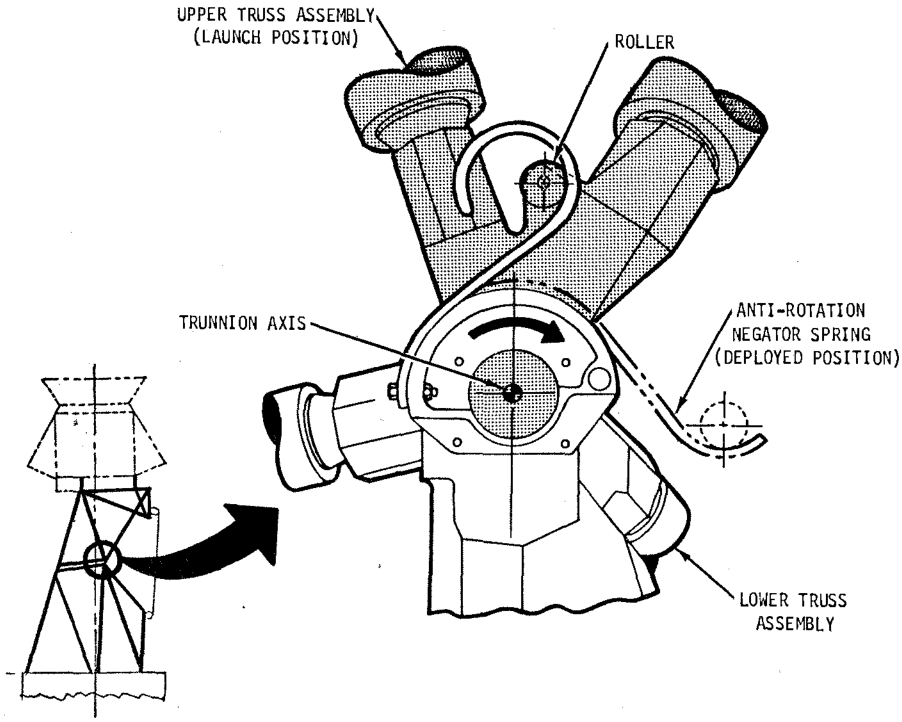



Figure 2.0.6-9 Trunnion

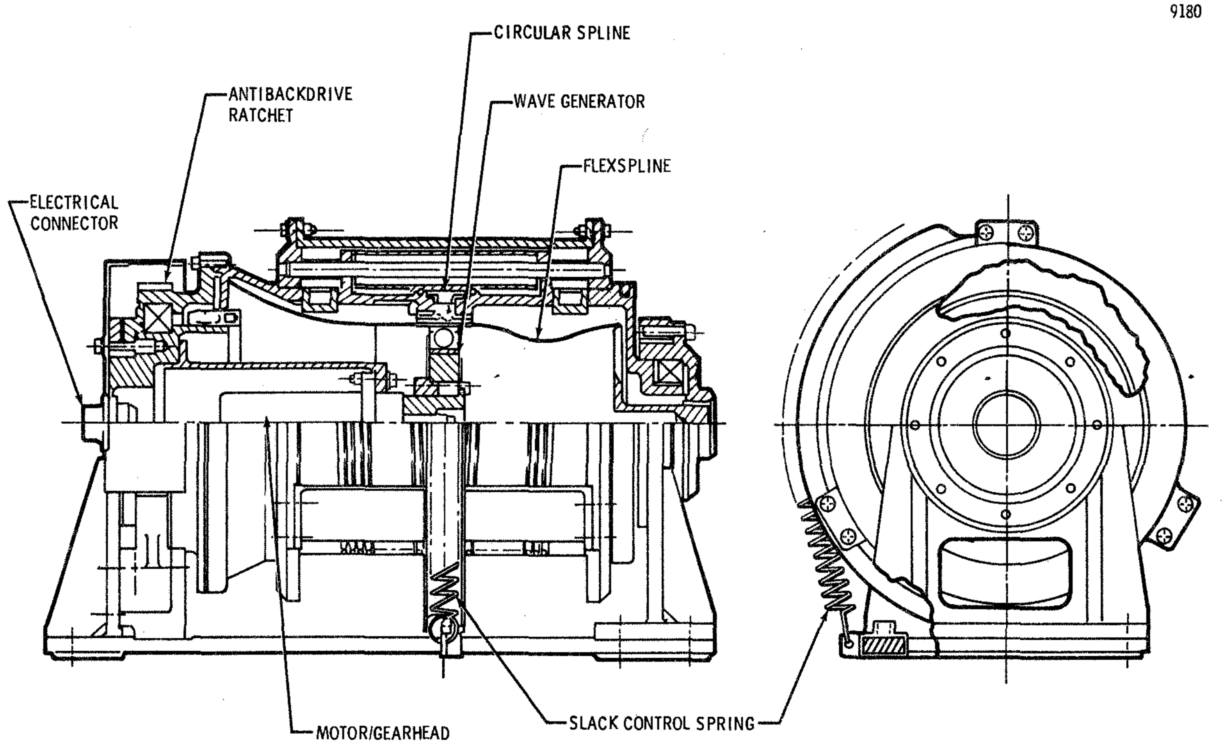



Figure 2.0.6-10 Deployment Reel

2.0.6.4.6 Latching Mechanism

A spring-loaded latching mechanism (figure 2.0.6-13) retains the ATM-DA in the deployed position. The latch mechanism or hook contacts the lower truss assembly just prior to full deployment and is cocked back as the upper and lower truss move together. As the trusses make contact, the spring-loaded hook pivots under and hooks the apex of one of the bipods on the lower truss assembly.

2.0.6.5 FAILURE MODES

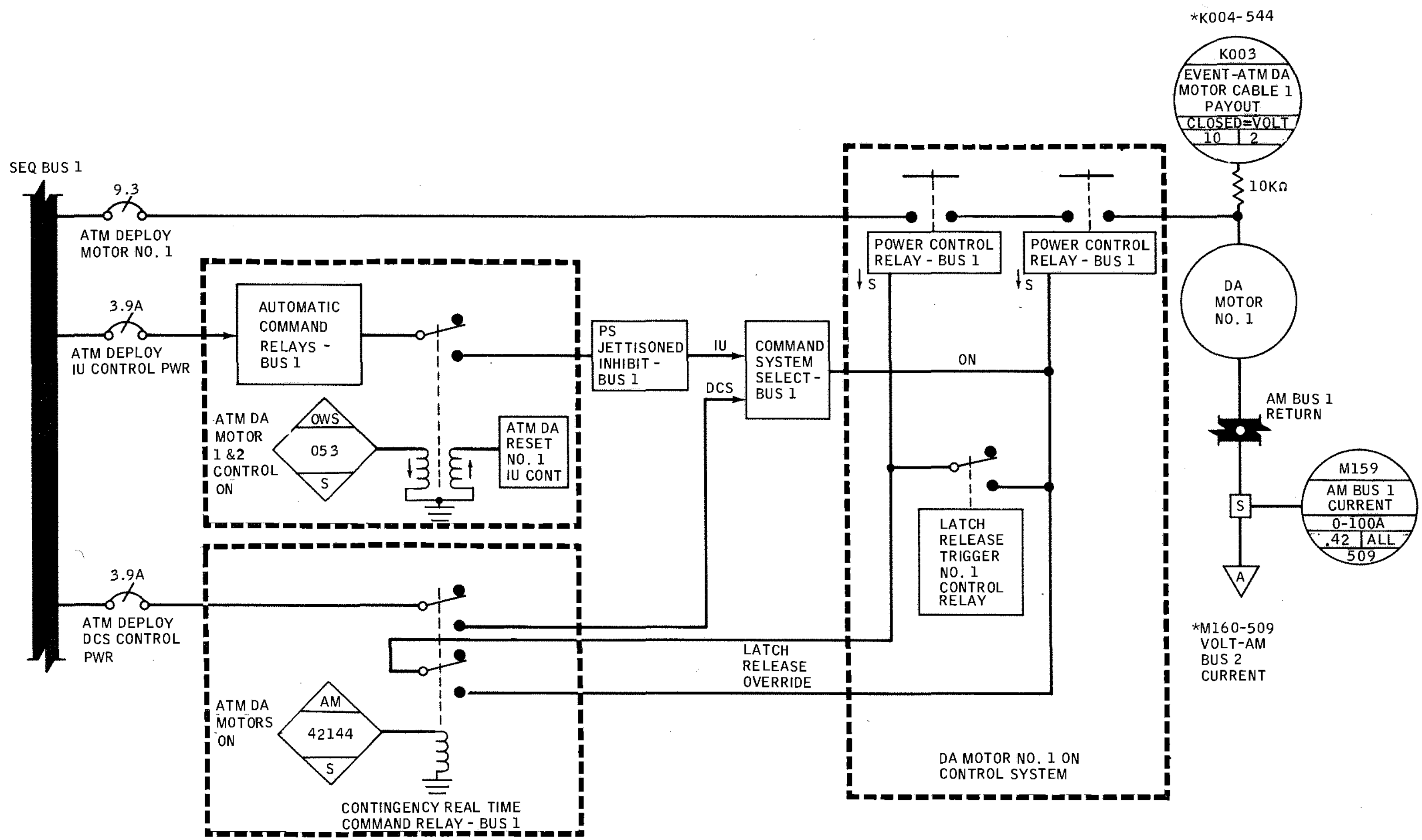
The ATM-DA failure modes and the effect on mission capability are given in table 2.0.6.5-1.

TABLE 2.0.6.5-1 ATM-DA - FAILURE MODES

| FAILURE | INDICATIONS | VEHICLE CAPABILITY |
|---|---|---|
| 1. Failure to release the DA pin retractors | | |
| a) IU/OWS switch selector system fails to issue signals to ATM DA enable relay or ATM DA latch release charge relays | a) Primary: M013 and M014 remain at 0 vdc<br>Normal: 2300±100 vdc | a) System: the DA latch release firing units will not be charged<br>Mission: All mission objectives will be precluded |
| b) ATM DA enable relay fails to latch or ATM DA latch release charge relays fail | b) Same as (a) | b) Same as (a) |
| c) ATM DA latch release trigger relays fail | c) M013 and M014 do not drop to 0±200 vdc | c) System: The DA latch release firing units will not be triggered<br>Mission: All mission objectives will be precluded |

TABLE 2.0.6.5-1 ATM-DA - FAILURE MODES (cont'd)

| FAILURE | INDICATIONS | VEHICLE CAPABILITY |
|---|---|---|
| d) Multiple failures of adjacent pin retractor assemblies and ordnance system | d) M013 and M014 may not indicate EBW firing units operated properly. K001 thru K004 will indicate ATM-DA did not deploy | d) System: ATM-DA deployment will be precluded |
| 2. Failure of DA deployment | | |
| a) Failure of one cable | a) None | a) No effect |
| b) IU/OWS switch selector system fails to issue signals to DA motors ON | b) K003 and K004 will remain open | b) System: ATM-DA motors will not operate<br><br>Mission: DA will not deploy until motors are operated |
| c) ATM-DA motors ON relay fails to latch | c) Same as (b) | c) Same as (b) |
| d) Multiple failure of motors, reel assemblies and both mechanisms | d) K001 thru K004 may not indicate deployment<br><br>With single reel or motor failure deployment time will more than double | d) System: ATM-DA may or may not deploy<br><br>Deployment time may be more than doubled |
| 3. Failure of rigidifying mechanism assembly | | |
| a) The strut assembly does not completely seat in rigidified position | a) None other than visual observation after rendezvous | a) None since adequate rigidifing is achieved with any 3 of 4 assemblies functioning properly |
| b) Misalignment between the cam receptacle fitting and strut assembly | b) None | b) None |
| a) The locking mechanism does not complete travel to the over center position | a) None other than visual observation after rendezvous | a) None since adequate rigidifing is achieved with any 3 of 4 assemblies functioning properly |
| b) Mechanical binding due to misalignment or foreign material becoming lodged in mechanism | b) None | b) None |
| 4. Deployment Reel | | |
| a) Low or zero output torque | a) Time between application of power and actuation of time delay relays which turn off motors is approximately 7 plus minutes or 2 times the normal time required for the deployment cycle with both reels operating | a) Time required to deploy ATM is doubled |
| b) Internal mechanical or electrical failure | b) None | b) None |
| 5. Latching Mechanism | | |
| a) Failure of mechanism to lock hook to lower truss fitting | a) None | a) None since hook is held in place by a multiple leaf spring and friction force between hook and lower truss fitting |
| b) Mechanical failure of the ratchet | b) None | b) None |




NOTE: DA MOTORS ON CONTROL SYSTEM - BUS 2 SAME AS SHOWN WITH DA MOTOR NO. 2. *INST MEAS. FOR BUS 2 SYSTEM.

Figure 2.0.6-11 ATM Deployment DA Motors ON Control System - Bus 1

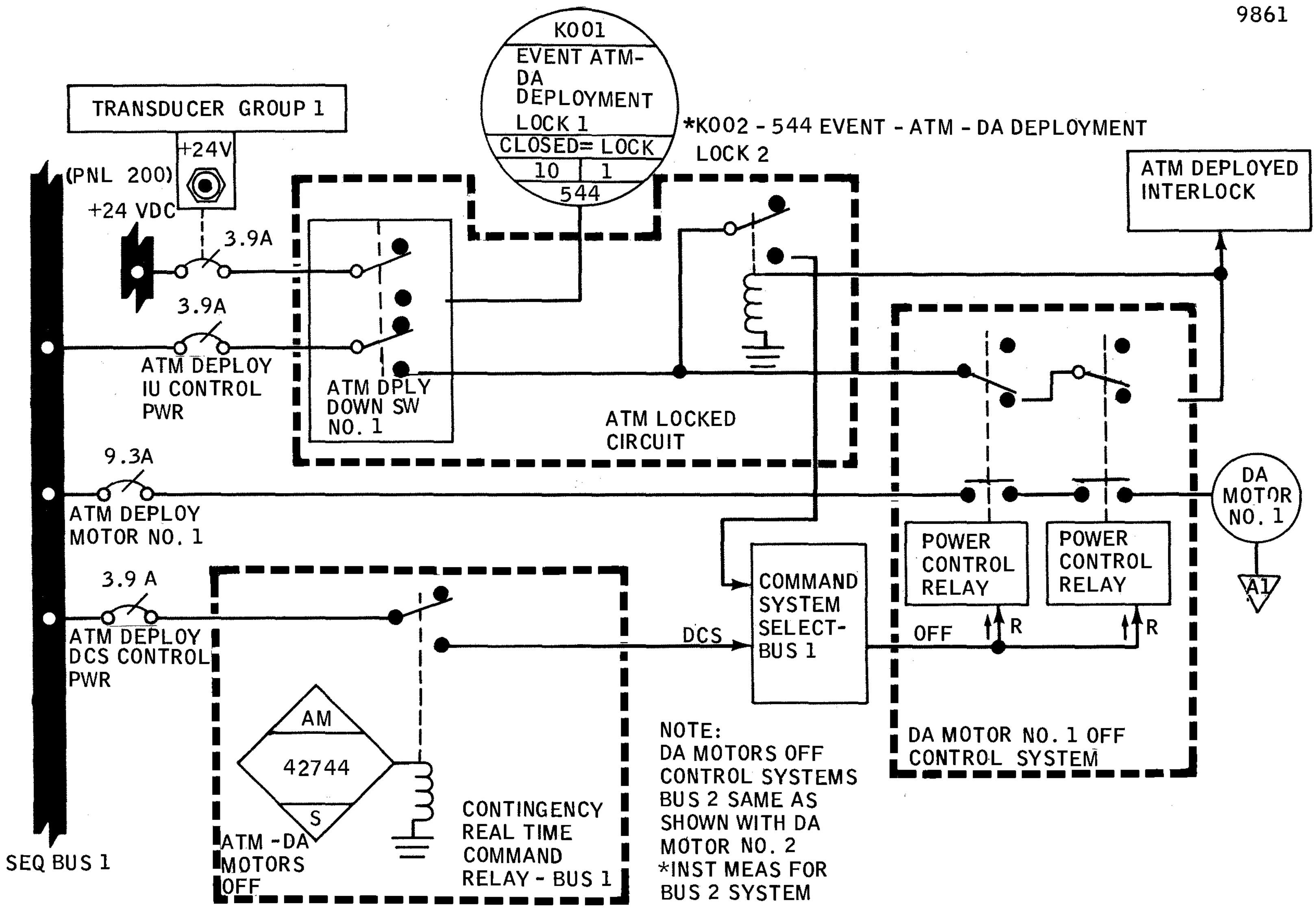
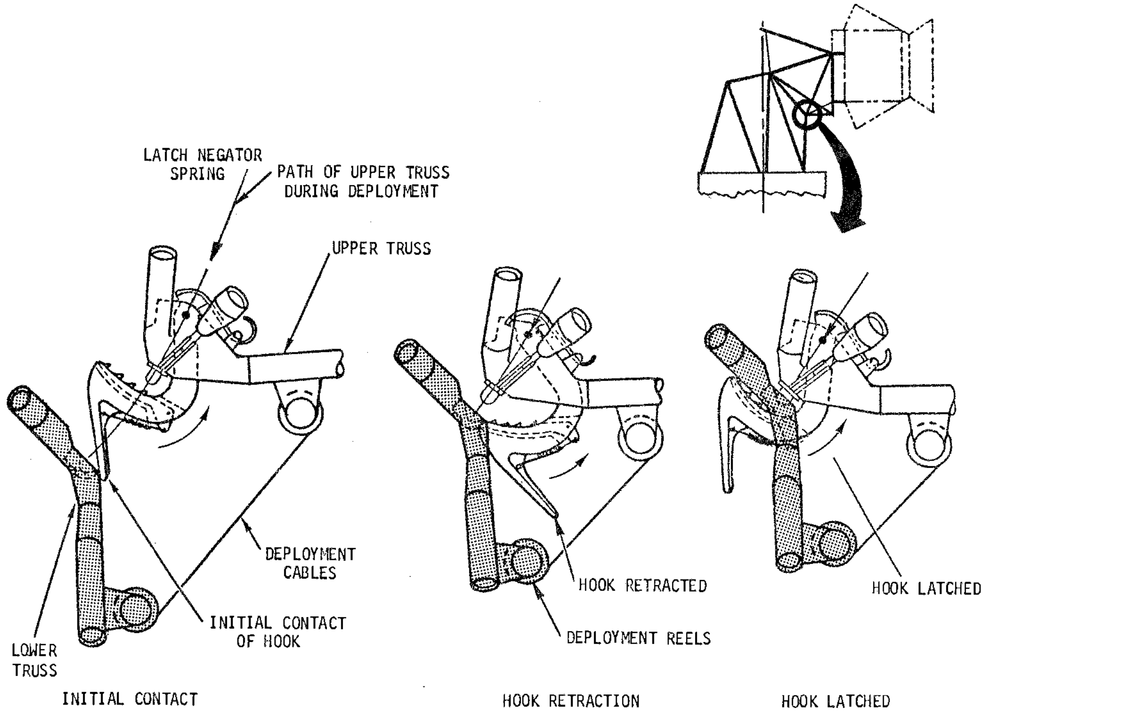



Figure 2.0.6-12 ATM Deployment DA Motors OFF Control System - Bus 1

9047




9048

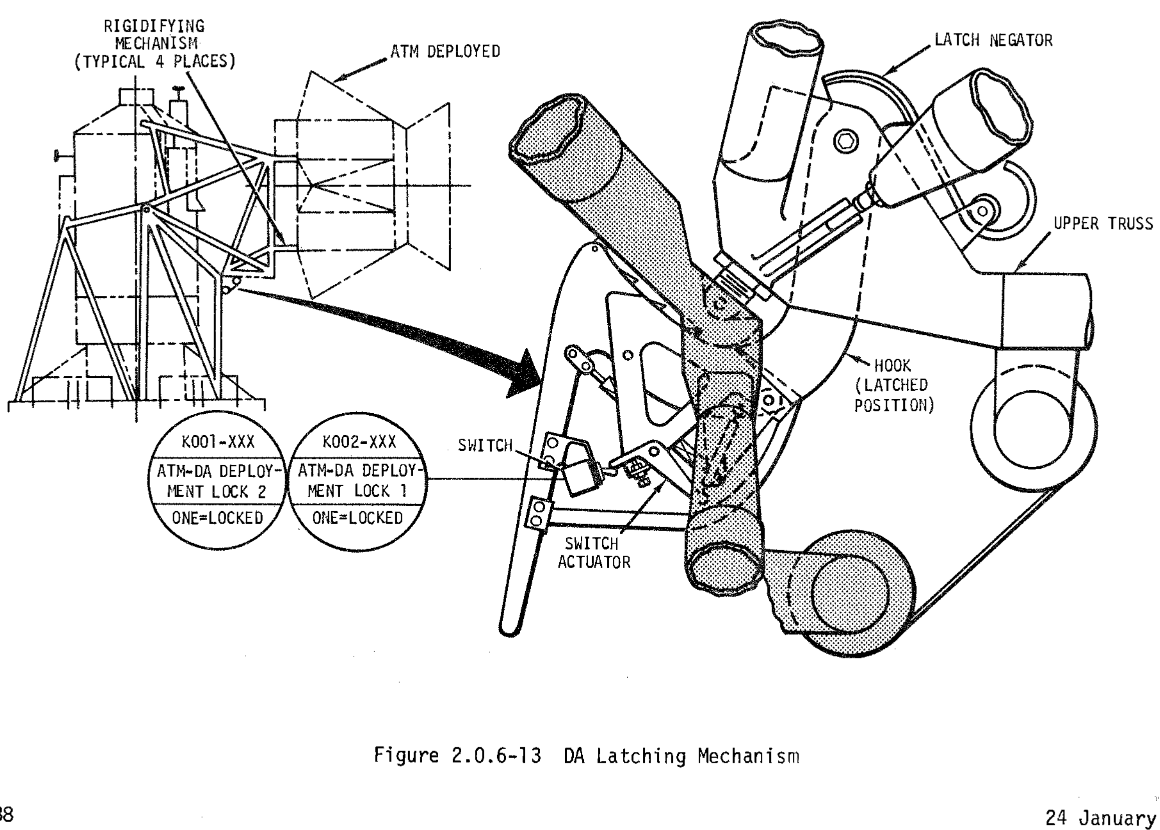



Figure 2.0.6-13 DA Latching Mechanism

2.0.6.6 PERFORMANCE AND DESIGN DATA

2.0.6.6.1 Design Data

The following list contains specific data on components in the ATM-DA.

Exploding Bridgewire Units (2) - 2300 vdc nominal detonator charge;trigger relay operating time 2 to 6 milliseconds, over temperature range and voltage range; firing unit trigger circuit operating time,4.0± 1.0 milliseconds.

Detonator (2) - Firing time 0.04 to 0.10 milliseconds, velocity 18/22 k ft/sec, time 3.4 to 2.78 milliseconds for 1/2 length of linear explosive (CDF).

Deployment Motors (2) - 24.0 to 30.0 vdc input voltage, 7.0 ampere maximum input current, 7.0 ampere stall current, 2.0 ampere starting current, 500 milliampere running current

Cable (2) - 1760 lbf/cable cable strength, 230±1 inch length each cable, 183 inch nominal amount of cable reeled in

Reels (2) - 2 spools per reel, 24 vdc input -- 18 in/min for cable load 45 lbf, 30 vdc input -- 40 in/min for cable load of 25 lbf, 200 inch spool capacity

2.0.6.7 OPERATIONAL LIMITATIONS AND RESTRICTIONS

The operational limitations and restrictions for the ATM-DA are as follows:

- o PS must be jettisoned prior to ATM-DA deployment
- o Sequential buses 1 and 2 must be armed
- o IU and OWS switch selector must be operational for prime mode
- o ATM DA enable must be sent before DA can be deployed
- o Charge command to two EBW's to release pin retractors must precede trigger command
- o Pin retractors must be released prior to deployment of DA
- o One motor must be operational
- o Three out of four rigidifying mechanisms must work
- o One of the two deployment cables must be intact
- o If one motor fails, additional time must be allowed for operational motor to take up additional cable normally reeled up by failed motor

2.0.6.8 INSTRUMENTATION

TABLE 2.0.6.8-1 DA INSTRUMENTATION

| MEAS NO. | MEASUREMENT DESCRIPTION | TM RANGE | ONBOARD DISPLAY DISPLAY RANGE | ONBOARD DISPLAY PANEL NO. |
|---|---|---|---|---|
| M013-530 | VOLT-ATM DA LATCH BUS 1 CHARGE | 0-2300 vdc | | None |
| M014-530 | VOLT-ATM DA LATCH BUS 2 CHARGE | 0-2300 vdc | | None |
| K003-544 | EVENT-ATM DA MTR/CBL 1 PAYOUT | CLOSED = PAYOUT | | None |
| K004-544 | EVENT-ATM DA MTR/CBL 2 PAYOUT | CLOSED = PAYOUT | | None |
| K001-544 | EVENT-ATM DA DEPLOYMENT LOCK 1 | CLOSED = LOCK | | None |
| K002-544 | EVENT-ATM DA DEPLOYMENT LOCK 2 | CLOSED = LOCK | | None |

2.0.7 MULTIPLE DOCKING ADAPTER (MDA)

2.0.7.1 INTRODUCTION

The MDA (figure 2.0.7-1) is a pressure vessel, approximately 17 feet long and 10 feet in diameter, that provides a permanent interface with the AM and a docking interface with the CSM. For the external configuration (figure 2.0.7-1) and for the internal configuration, see figures 2.0.7-2 and 2.0.7-3. The MDA provides the OA with the following:

- o A pressurized passageway between the AM and the CSM.
- o Two docking interfaces for the CSM,Port 5, axial; and Port 3, radial. Port 5 provides complete interface equipment and electrical umbilicals, allowing an integration of the docked CSM with the AM. Port 3 provides only physical docking capability.
- o Storage of hardware and support equipment for experiments.
- o Mounts and interface equipment for the ATM C&D panel. This panel is used to control and monitor the ATM and the Thruster Attitude Control System (TACS).

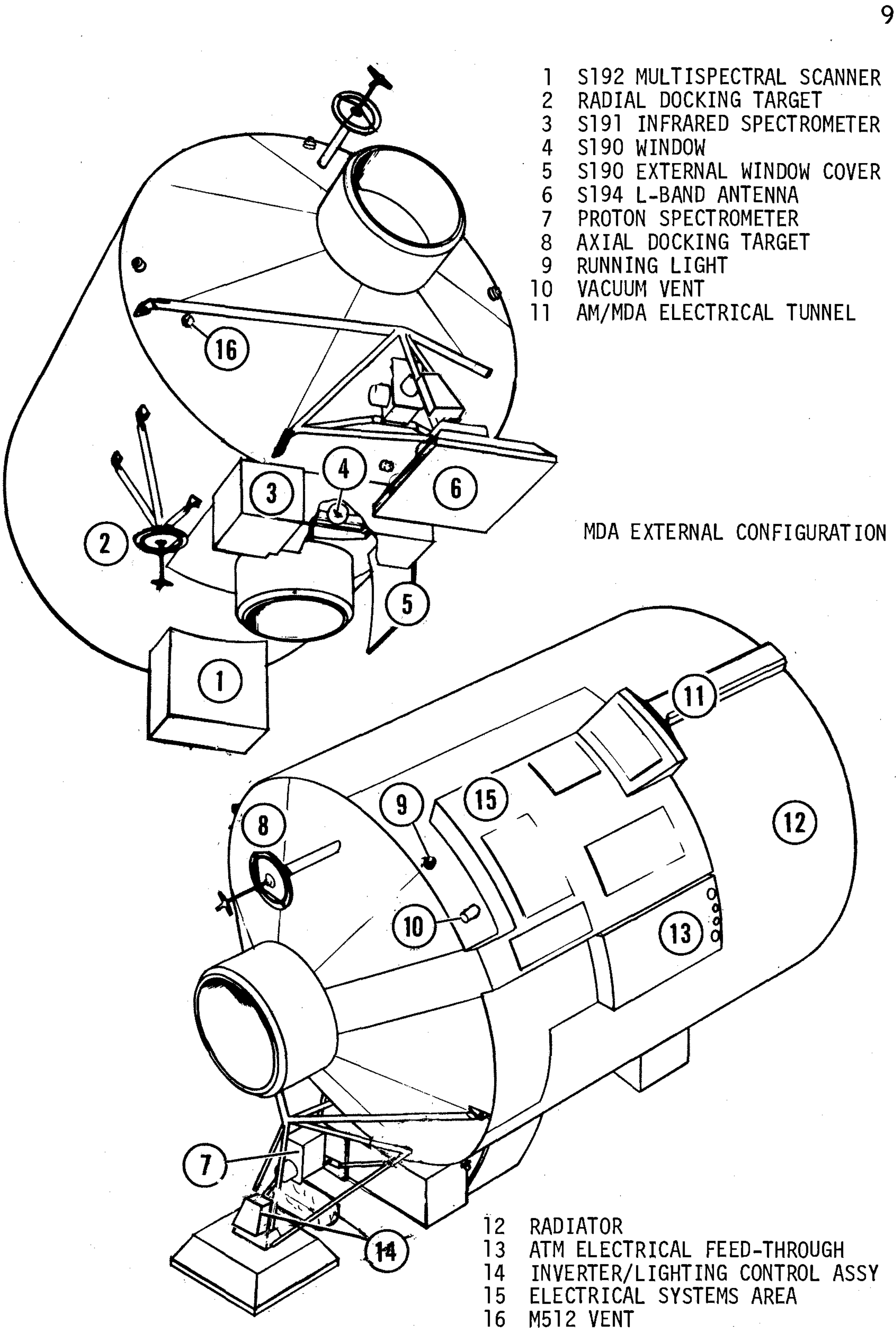
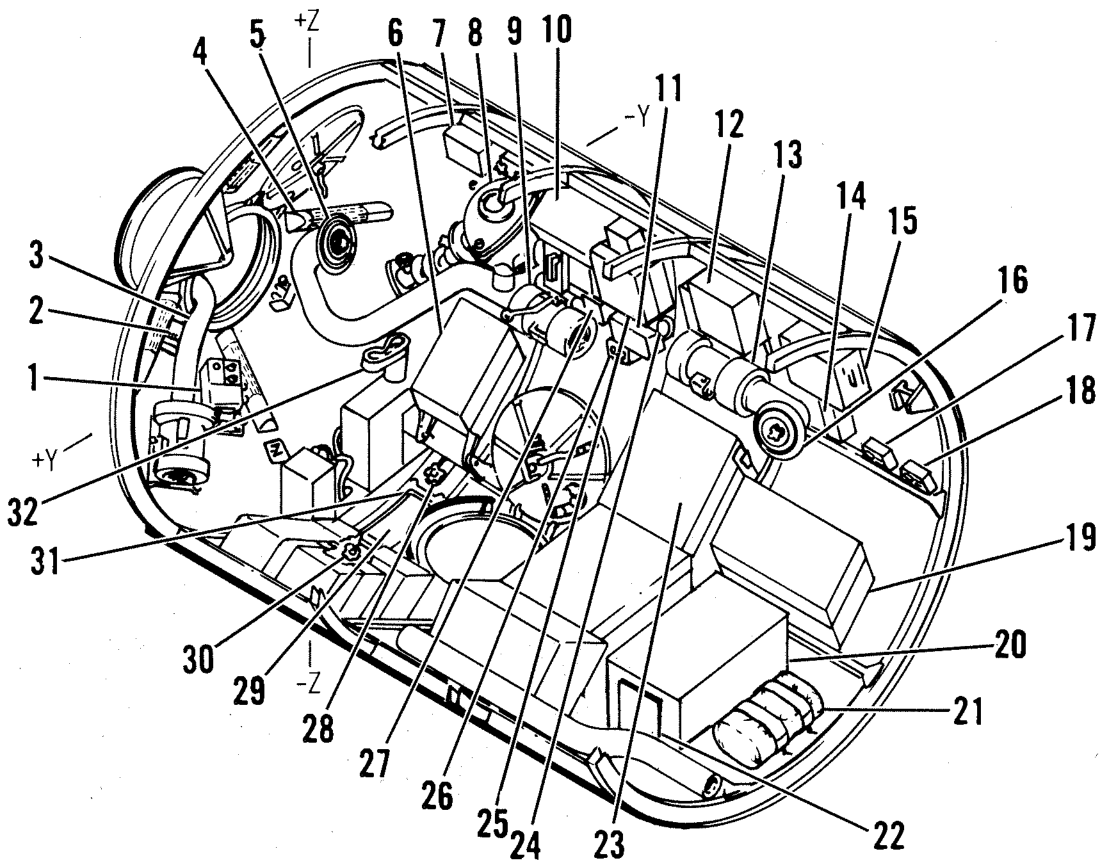



Figure 2.0.7-1 MDA External Configuration

9225

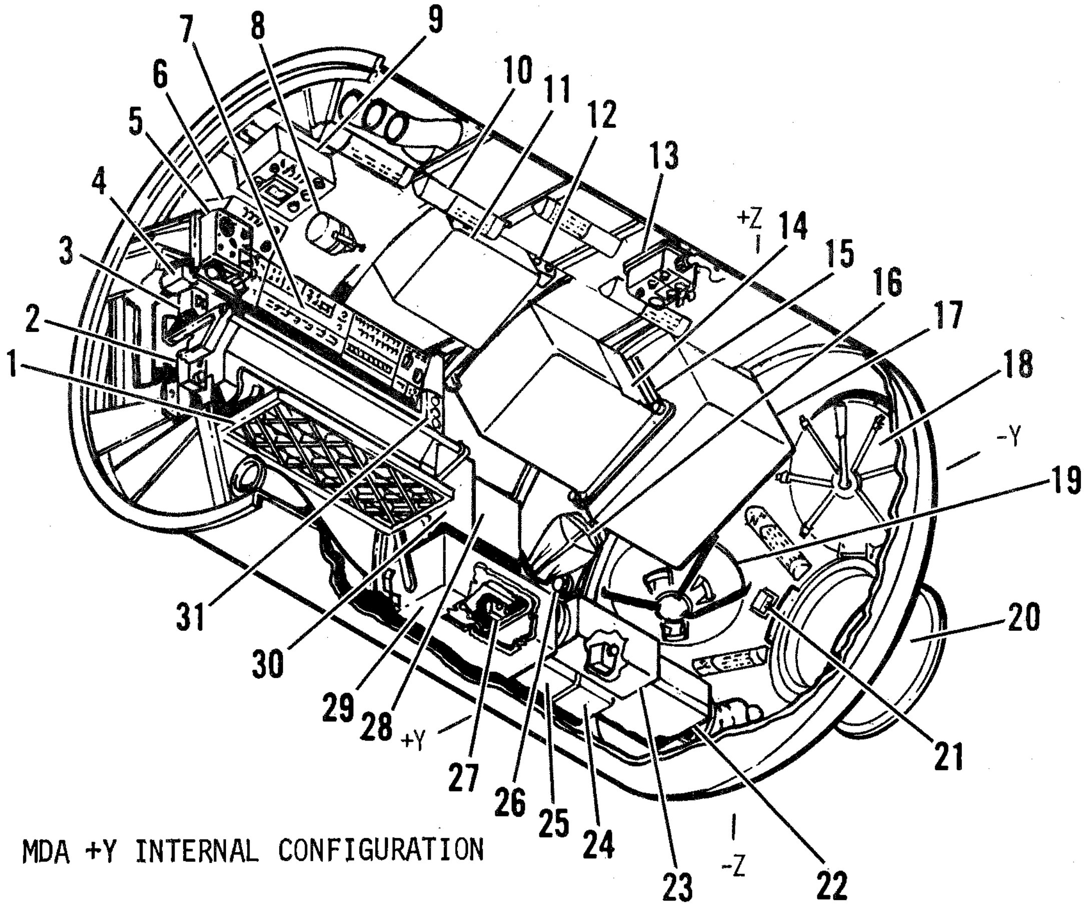



MDA -Y INTERNAL CONFIGURATION

1 SPEAKER INTERCOM ASSY
2 WINDOW HEATER CONTROL PANEL
3 DEPLOYED CSM/MDA INTERCHANGE DUCT
4 FORWARD LIGHT
5 AIR DIFFUSER 1
6 S190A MULTISPECTRAL CAMERAS
7 M479 FLAMMABILITY SPECIMEN CONT (M122)
8 M512 MATERIALS PROCESSING FACILITY
9 MDA AREA FAN 1
10 M512 CONTROL PANEL
11 M555 CRYSTAL SAMPLE CONT (M132)
12 S082B FILM CANISTER, FWD
13 MDA AREA FAN 2
14 VS TREE (M170)
15 S082A FILM CANISTER, AFT
16 AIR DIFFUSER 2
17 UTILITY OUTLET 4
18 HIGH POWER ACCESSORY OUTLET 2
19 CONTAINER M168
20 S192 MULTISPECTRAL SCANNER
21 SECONDARY OXYGEN PACK (M165)
22 VC TREE
23 CONTAINER M152
24 M554 COMPOSITE CASTING CONT (M134)
25 M551 METALS MELTING ACCESSORIES (M136)
26 UTILITY OUTLET 2
27 M552 EXOTHERMIC BRAZING CONT (M120)
28 WINDOW COVER LATCH
29 S190 WINDOW
30 WINDOW COVER CRANK
31 INSTALLED S190 WINDOW PROTECTOR
32 EREP VIEWFINDER TRACKER

Figure 2.0.7-2 -Y Half Internal Configuration

9226




MDA +Y INTERNAL CONFIGURATION

| | | | |
|---|---|---|---|
| 1 | ATM C&D FOOT RESTRAINT | 17 | CONTAINER M124 |
| 2 | UTILITY OUTLET 2 | 18 | STOWED AXIAL HATCH |
| 3 | TV INPUT STATION | 19 | STOWED DROGUE |
| 4 | VIDEO SWITCH | 20 | AXIAL TUNNEL |
| 5 | SPEAKER INTERCOM ASSY | 21 | INTERIOR LIGHTS SWITCH |
| 6 | RADIO NOISE BURST MONITOR PANEL | 22 | EREP C&D PANEL |
| 7 | ATM C&D PANEL | 23 | S190 STOWAGE CONTAINER |
| 8 | FIRE EXTINGUISHER | 24 | S192 ELECTRONICS ASSY |
| 9 | RADIO NOISE BURST MONITOR PANEL | 25 | EREP TAPE RECORDER |
| 10 | AFT EMERGENCY LIGHT | 26 | VENT PANEL |
| 11 | CONTAINER M157 | 27 | UTILITY OUTLET 1 |
| 12 | HIGH POWER ACCESSORY OUTLET 1 | 28 | CONTAINER M125 |
| 13 | SPEAKER INTERCOM ASSEMBLY | 29 | CONTAINER M143 |
| 14 | CONTAINER M141 | 30 | CONTAINER M126 |
| 15 | STOWED S190 WINDOW PROTECTOR | 31 | DIGITAL ADDRESS SYSTEM |
| 16 | STOWED PROBE | | |

Figure 2.0.7-3 +Y Half Internal Configuration

- o Control valves for venting the AM/MDA during ascent.
- o Stowage vaults for the ATM film and cameras.
- o Fans and heaters that are part of the ECS.

2.0.7.2 INTERFACES

The MDA structurally interfaces with the structural transition section of the AM and the CSM when it is docked. Electrically, the MDA interfaces with the CSM communication system and the CSM EPS. Also it electrically interfaces with all of the related subsystems of the ATM. The MDA also interfaces with the SWS communication system, EPS, instrumentation system, C&W, DCS/TRS, ECS, and TACS.

2.0.7.3 SUBSYSTEM AND MAJOR COMPONENT DESCRIPTION

2.0.7.3.1 Structure

The MDA structure is a welded aluminum alloy pressure vessel, 17 feet long and 10 feet in diameter. The enclosed volume of the MDA is 1140 cu. ft. The MDA structure has five basic sections; axial docking port and conical forward bulkhead; forward cylindrical section, center cylindrical section, radial docking port, and aft cylindrical section (figure 2.0.7-4). The MDA pressure vessel is of monocoque construction having five integral machined rings distributed along the cylindrical section. Eight internal longerons are provided equally spaced around the periphery of the cylinder. A cone is attached to the forward end of the cylinder, which has a 30-degree apex angle. The docking port 5 is attached to the forward end of this cone. The radial docking port 3 is attached to the cylinder with its axis parallel to the -Z coordinate (figure 2.0.7-5).

Thermal and micro-meteoroid protection to the MDA structure is provided by an outer shield. The shield is mounted to the pressure vessel with 3-inch fiberglass standoffs and stiffeners to minimize the heat losses from the MDA (figure 2.0.7-6). The shield consists of both meteoroid shield and radiator. The radiator area is about 350 square feet and is constructed of a magnesium alloy skin with bulb-tee shaped magnesium alloy extrusions welded to the skin. The extrusions provide a flow path for the coolant fluid from the ECS to reject heat generated within the OWS, AM, and MDA. The meteoroid shield portion covers the remaining area of the MDA. The darkened areas on figure 2.0.7-1 show the meteoroid shielded areas and the lighter area the radiator. The meteoroid shield on the cylinder is 0.020-inch thick aluminum alloy sheet and the cone shield is 0.050-inch thick aluminum alloy sheet.

A multilayer high-performance insulation blanket is placed between the MDA pressure skin and the radiator/ meteoroid shield. This blanket is constructed of 91 layers of perforated double aluminized mylar with dacron net spacers (figure 2.0.7-5).

2.0.7.3.2 S190 Window Assembly

The S190 window is installed in the forward cylinder section forward of the radial docking port on the -Z coordinate and provides an environmentally controlled optical port for the S190 experiment. The window consists of the optical window assembly, a removeable safety glass, an outer window cover, and a window cover mechanism.

The optical window assembly includes the glass, the supporting frame, and seals. The glass has an infra-red reflective coating on the inner surface. The removable safety glass is a transparent, internally removable cover that protects the optical window glass from scratches and provides ultra violet protection to the crew. This glass is removed when S190 equipment is in use. The outer window cover protects the window from micrometeoroid impact, contamination, radiation, and thermal gradients. This cover is normally closed, but is opened when the S190 experiment is in use by a mechanism that is geared to a 2:1 ratio, requiring 292 degrees of rotation to full open (figure 2.0.7-7). A latch is provided to restrain the cover in the closed position.

2.0.7.3.3 Docking Alignment Targets

Docking alignment targets provide the CSM crew with visual cues for controlling precontact alignment and position. The docking alignment targets are of the Apollo LM type and are mounted on the MDA at each CSM docking port. The target base and stand-off cross are painted with "Day Glo" paint, and include self-illuminating devices or attachments. The docking alignment target for the principal port, the axial port, is located 46 inches from the port, center to center, and is 75 degrees from the -Y axis toward the -Z axis.

The target consists of an inner circle and standoff cross of black with self-illuminating discs within an outer circumference of white (figures 2.0.7-8 and 2.0.7-1). The target-base diameter is 17.68 inches. The standoff cross is centered 11 inches higher than the base and, as seen at the intercept, is parallel to the X-axis and perpendicular to the Y-axis and the Z-axis.

2.0.7.3.4 Docking Ports and Mechanisms

The MDA has 2 docking ports. The axial docking port, which is the prime docking port, is located at the forward end of the MDA and centered about the X-axis. The radial (secondary) docking port is located 103 inches forward of the MDA/AM interface on the -Z axis.

Both the axial and the radial docking ports have standard Apollo drogues and docking rings to permit CSM docking. The radial docking port, however, does not have provisions for the transfer of electrical power, communications, and conditioned air. The components that make up the MDA port are the tunnel structure, the drogue, and pressure hatches.

9227

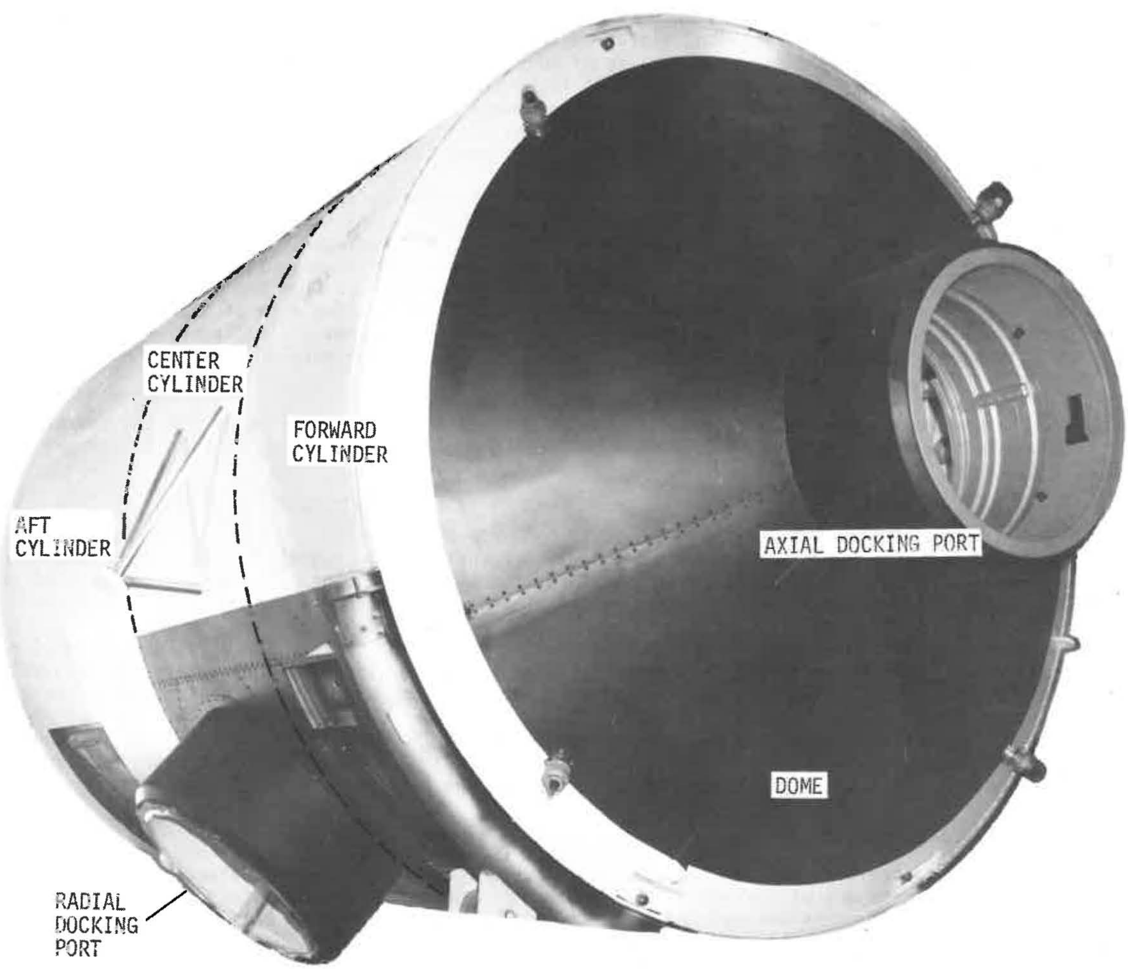



Figure 2.0.7-4 Structural Configuration

9061

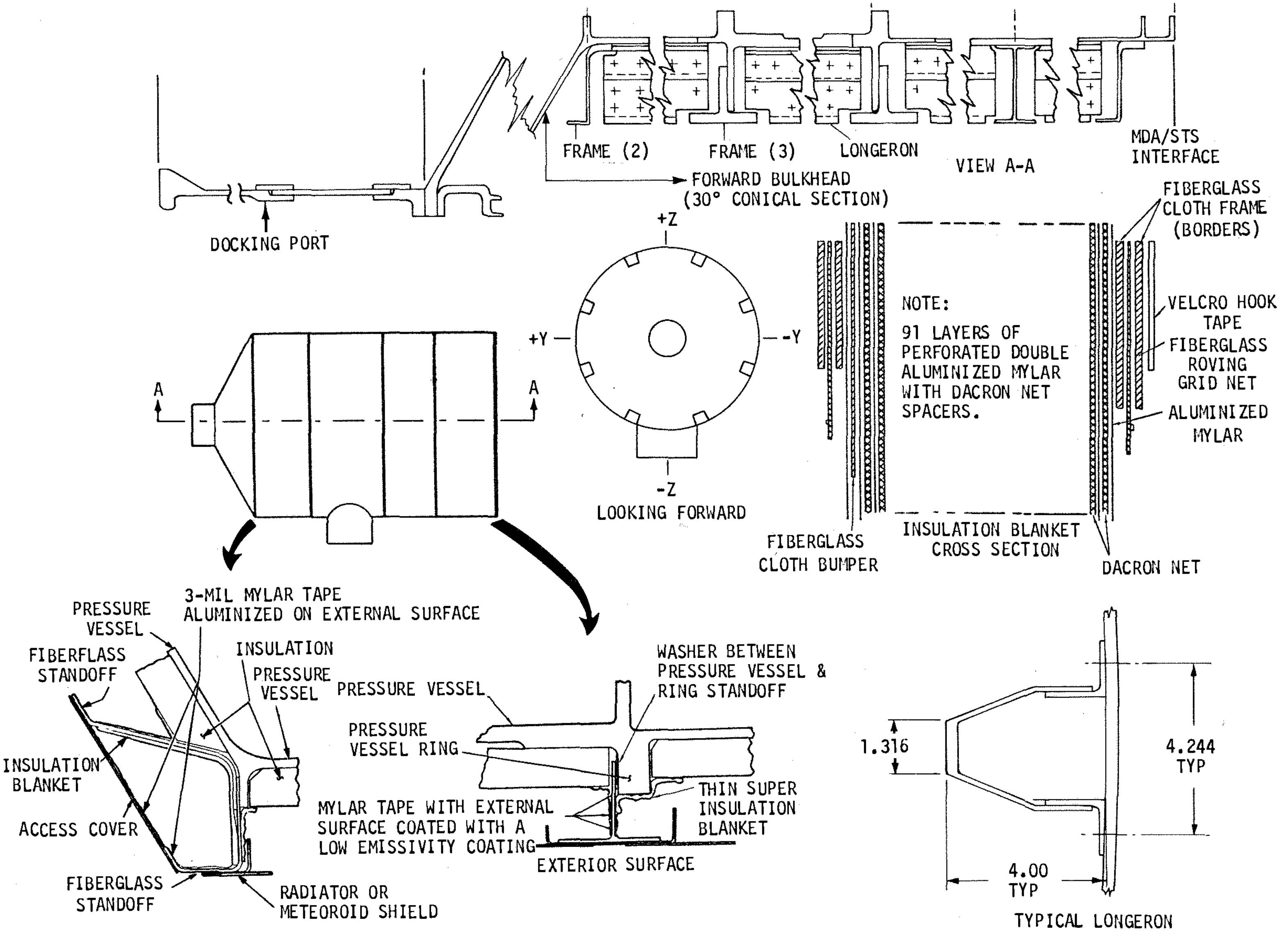



Figure 2.0.7-5 MDA Structure

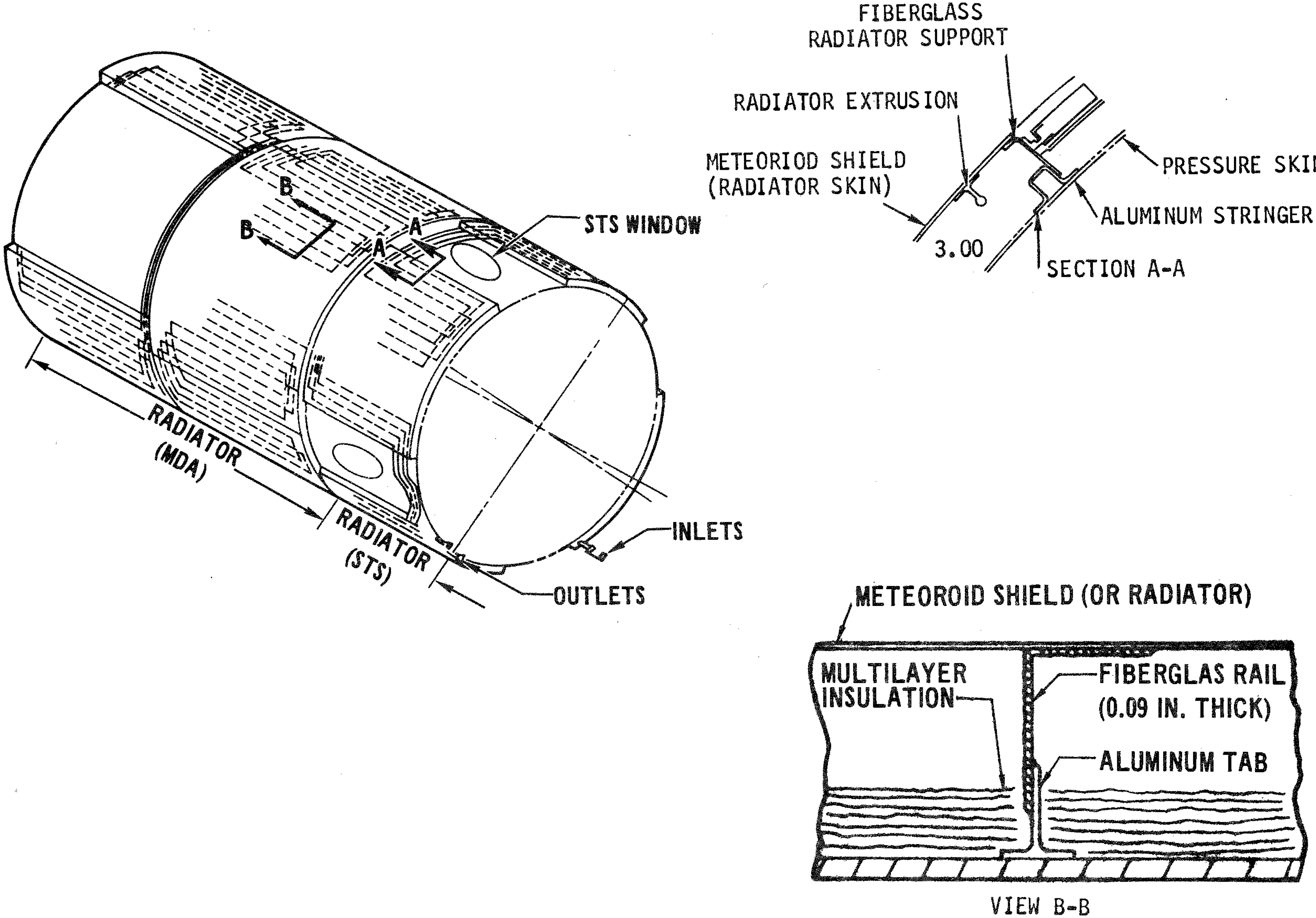



Figure 2.0.7-6 Radiator/Meteoroid Shield Configuration

9223

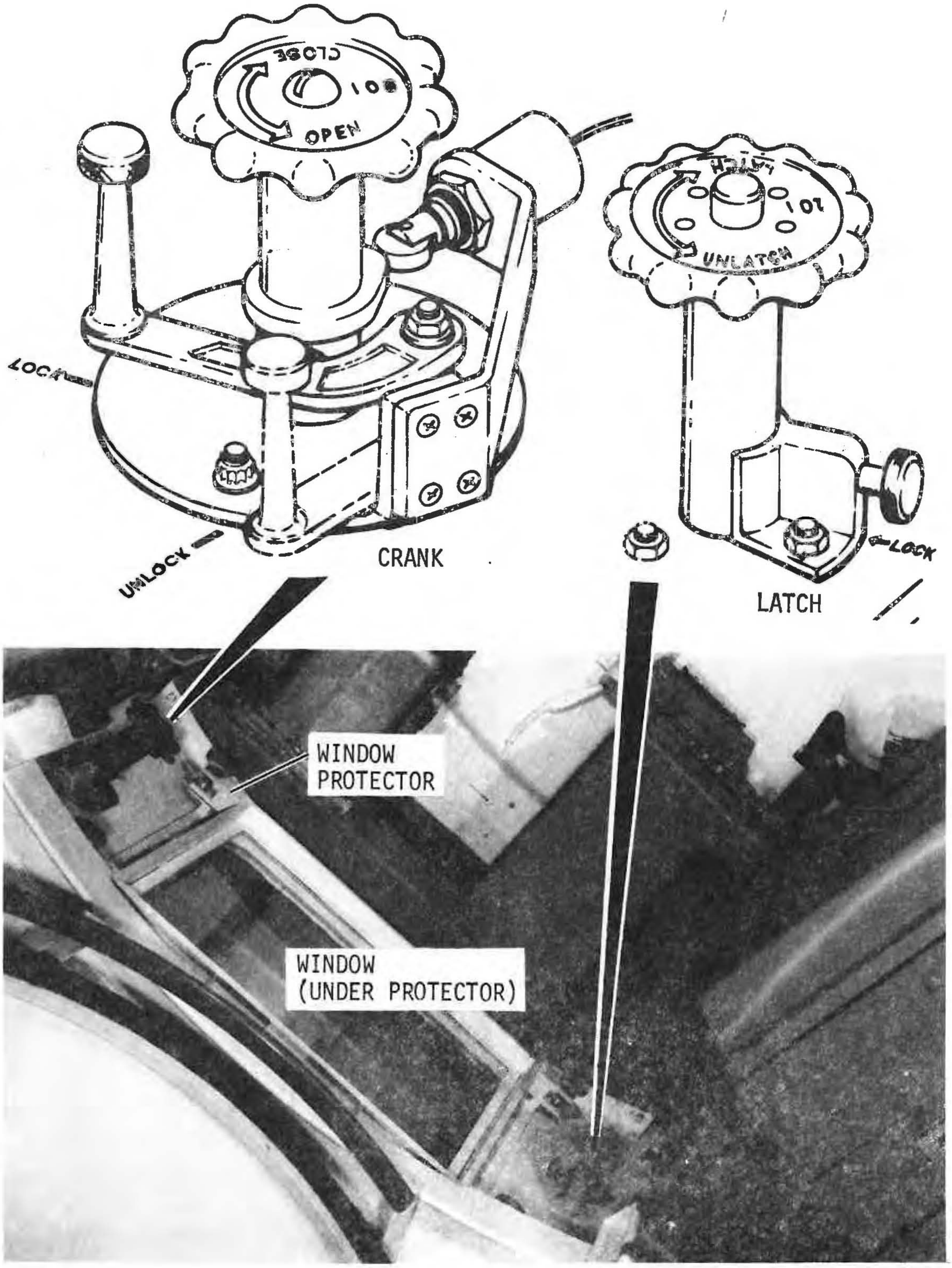



Figure 2.0.7-7 S190 Window

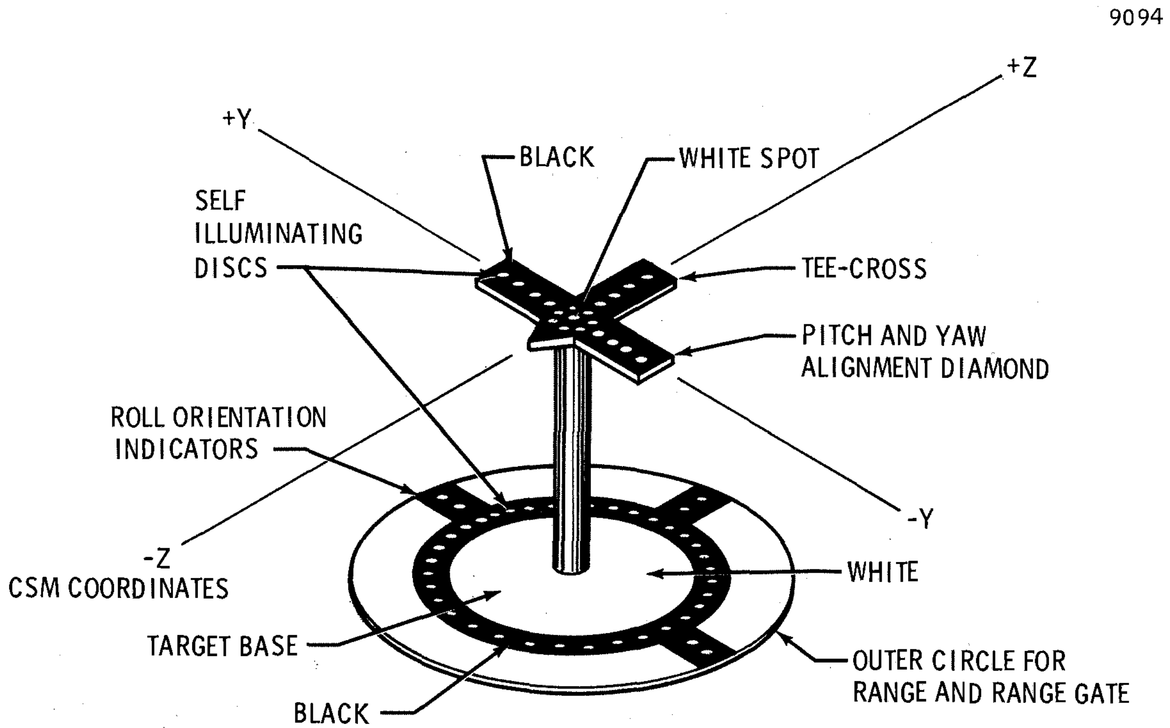



Figure 2.0.7-8 MDA Mounted Docking Target

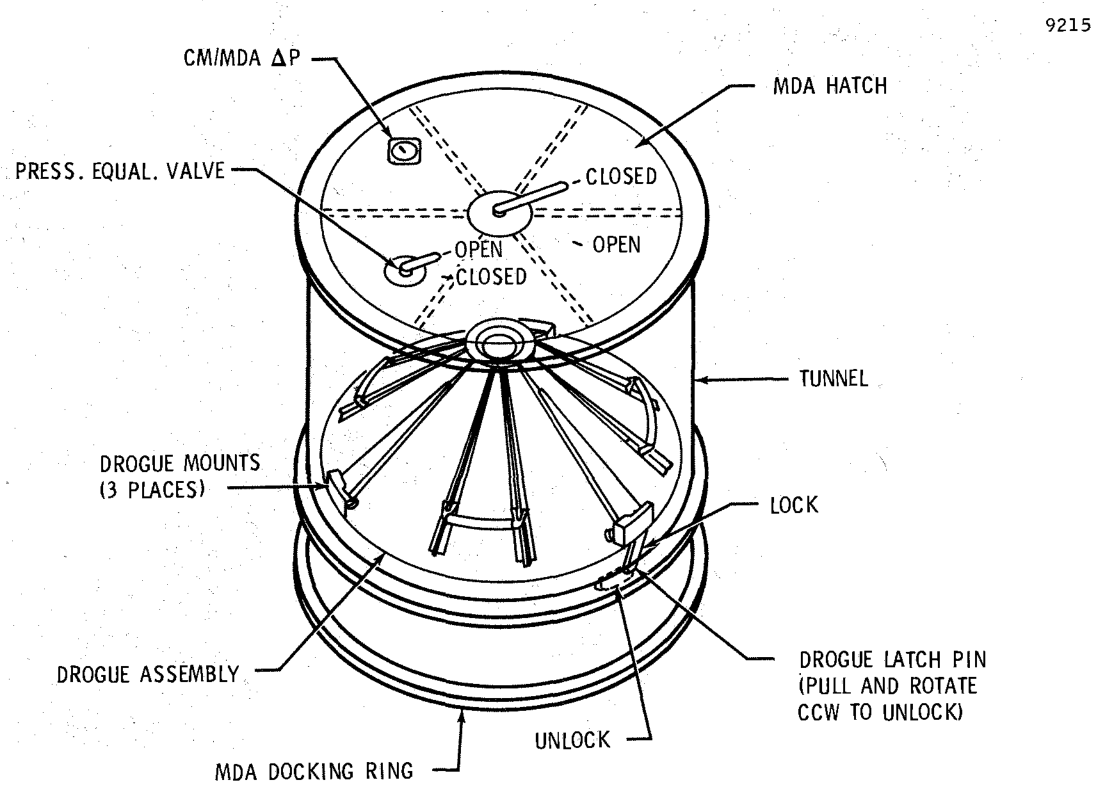



Figure 2.0.7-9 MDA Drogue

Tunnel

Two tunnels are provided on the MDA. The axial tunnel is located on the +X coordinate on the forward end of the MDA and the radial tunnel is located on the -Z coordinate of the MDA. The axial tunnel extends from the MDA tunnel ring, aft to the MDA upper hatch. The tunnel ring provides the connecting interface between the CSM docking ring and the MDA (figure 2.0.7-9). The radial port tunnel extends from the MDA cylindrical structure radially outboard along the -Z coordinate. The radial tunnel is identical to the axial tunnel except no umbilical provisions are supplied.

Docking Drogue

The drogue assembly, a conical structure with provisions for mounting in the docking tunnel outside of the pressure hatch, accepts the docking probe of the CSM. Structurally the drogue consists of an internal conical surface facing the CM and support structure mounting provisions that interface with three mounts in the MDA tunnel. One of the tunnel mounts contains a locking mechanism to secure the drogue and prevent it from turning during the docking maneuvers. Unlocking and removing the drogue may be accomplished from either end of the crew transfer tunnel. To aid in the removal and installation, three handles are provided on the MDA side (figure 2.0.7-10).

Pressure Hatches

There are two MDA 30-inch diameter pressure hatches. One is located at the axial docking port tunnel and the second at the radial docking port tunnel. The hatch is constructed of honeycomb to provide stiffness. The hinges are designed so that the hatch swings into the MDA to engage a detent latch for stowage. The locking mechanism is a spider arrangement that goes over "dead-center" in the lock position. A thumb release attachment is provided to ensure that the hatch remains locked during the ascent phase of the launch. The spider arrangement drives six hatch latch assemblies when the center-mounted hatch handle is rotated. To read pressure across the hatch, a CSM/MDA P gage is provided on either side of each hatch. The gages are marked to read in tenths of a psi from +1 to -1 psia. Equalizing the pressure across the hatch can be accomplished by using the hatch-mounted EQUALIZATION VALVE. This is a butterfly-type valve that can be manually operated from either side of the hatch. Details of the MDA hatches are shown in figures 2.0.7-11 and 2.0.7-12.

## 2.0.7.4 FAILURE MODES

The MDA structural and mechanical failure modes and the effect on mission capability are given in table 2.0.7.4-1.

TABLE 2.0.7.4-1 MDA STRUCTURAL AND MECHANICAL - FAILURE MODES

| FAILURE | INDICATIONS | VEHICLE CAPABILITY |
|---|---|---|
| 1. MDA S190 Window Cover | | |
| a) Cover will not open when reasonable loads are applied to crank | a) Inability to open window cover | a) Viewing from subject window would be eliminated |
| b) Cover binding at hinges due to contamination or physical distortion of cover or hinges resulting from thermal stress | b) Try operation of window cover under different outside thermal conditions and investigate problem during EVA. Cover should not be fully opened unless mechanism is operating properly to insure against jamming in open position | b) None other than the restriction imposed by not being able to observe outside area associated with subject window |
| c) Cover will not close when reasonable loads are applied to crank | c) Inability to close window cover | c) The temp of internal surface of glass could drop below MDA dew point and result in water collecting on inside surface. General compartment heat balance might be effected. Loss of meteoroid protection |
| d) Cover binding at hinges due to contamination or physical distortion of cover or guides resulting from thermal stress | d) Try operation of window cover under different outside thermal conditions and investigate problem during EVA. If cover can be closed as result of EVA or other special procedures it should be left closed unless problem has been corrected | d) Mission effect would essentially be loss of experiment unless loss of meteoroid protection resulted in damage to window. Window damage could effect mission duration |

TABLE 2.0.7.4-1 MDA STRUCTURAL AND MECHANICAL - FAILURE MODES (cont'd)

| FAILURE | INDICATIONS | VEHICLE CAPABILITY |
|---|---|---|
| 2. MDA Window Cover Control Crank | | |
| a) Mechanism jammed or exhibits excessive drag. (Cover closed) | a) Inability to open window cover | a) Window cover can not be opened, thus viewing from subject window would be eliminated |
| b) Misalignment of gear mechanism or contamination | b) Try to determine cause of problem including EVA investigation. Do not attempt to move cover to open position unless mechanism is operating properly to insure against having cover jammed in the open position | b) S190 experiment can not be accomplished |
| a) Mechanism jams or exhibits excessive drag. (Cover open) | a) Inability to close window cover | a) The temp of internal surface of glass could drop below MDA dew point and result in water collecting on inside surface. General compartment heat balance might be effected |
| b) Misalignment of gear mechanism contamination | b) Try to determine cause of problem comparing position of mechanism components with other windows for possible indication of problem. Evaluate condition during EVA. If cover can be closed as result of special procedure it should be left closed unless problem has been corrected | b) Mission effect would essentially be only minor inconvenience unless loss of meteoroid protection resulted resulted in damage to window. Window damage could effect mission duration |
| a) MDA pressure loss thru drive assembly | a) Gross leakage of shaft seal would probably produce an audible indication | a) TBS |
| 3. MDA Hatch Latch Mechanism | | |
| a) Mechanism will not release | a) Crew unable to open hatch | a) Prevent opening hatch until linkage freed |
| b) Linkage jammed due to foreign object | b) Remove cover and free latches | b) If failure occurred during activation it would delay MDA activity until crew could release latches |
| c) Fail to latch on closing | c) Mechanism handle can not be rotated to the locked position | c) Prevent following the normal hatch closure procedure for deactivation |
| 4. MDA Hatch Seal | | |
| a) Leakage | a) None | a) Excessive loss of O2/N2 |
| b) Seal material damaged or deteriorated | b) Crew observation of damaged or deteriorated condition of seal following opening of MDA Hatch | b) Possible change in mission timeline |

## 2.0.8 AIRLOCK MODULE (AM)

### 2.0.8.1 INTRODUCTION

The AM (figure 2.0.8-1) is situated between the MDA and the OWS and contains systems for environmental control, instrumentation, electrical power, communications, and operational management for the OA. It also has a lock compartment, a hatch, and support systems for extravehicular activities (EVA).

Operational management capability for OA systems is provided by means of control and display consoles located within the AM's pressurized volume and by a digital command system (DCS) for ground control of SWS systems.

9944

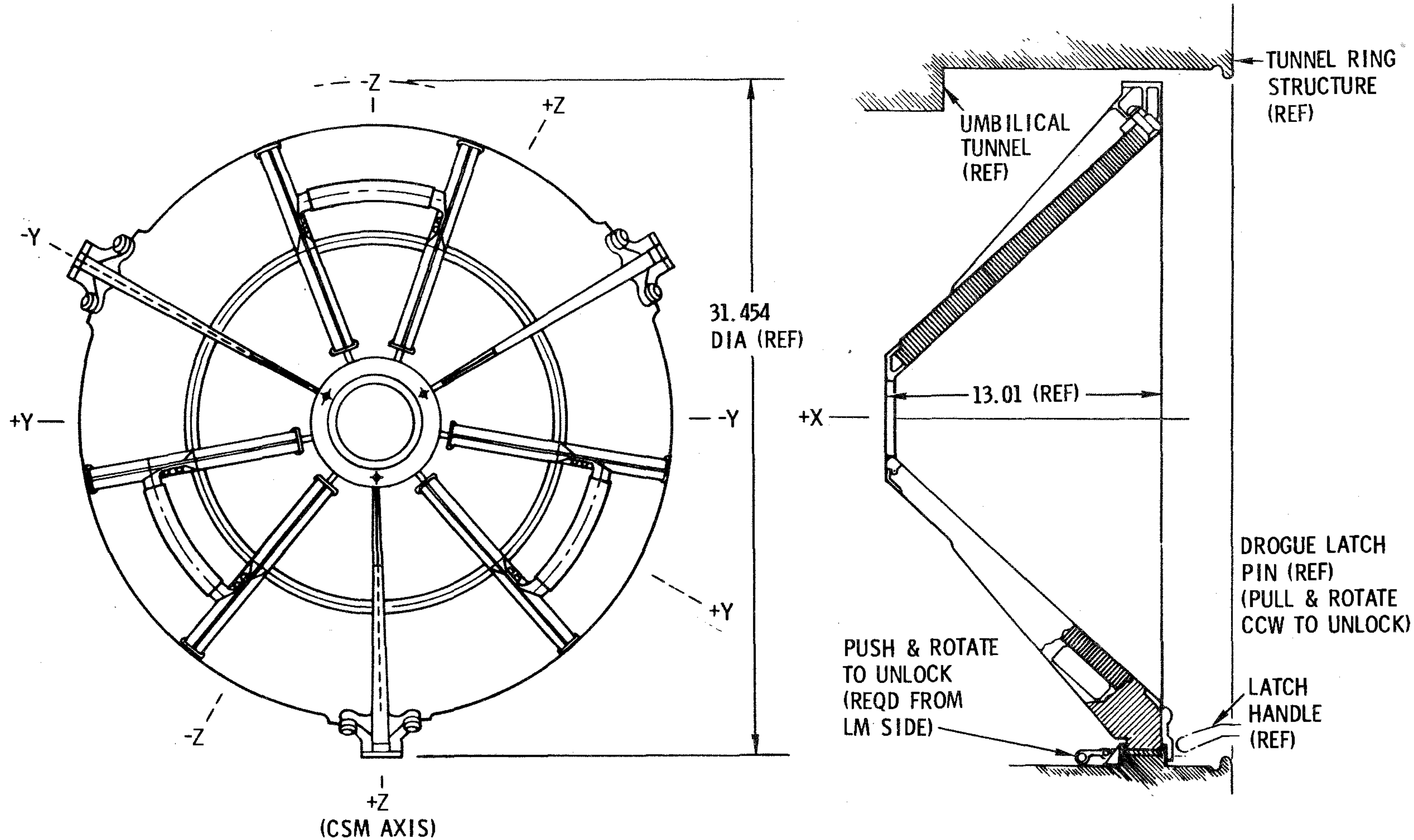



Figure 2.0.7-10 Drogue Assembly

9224

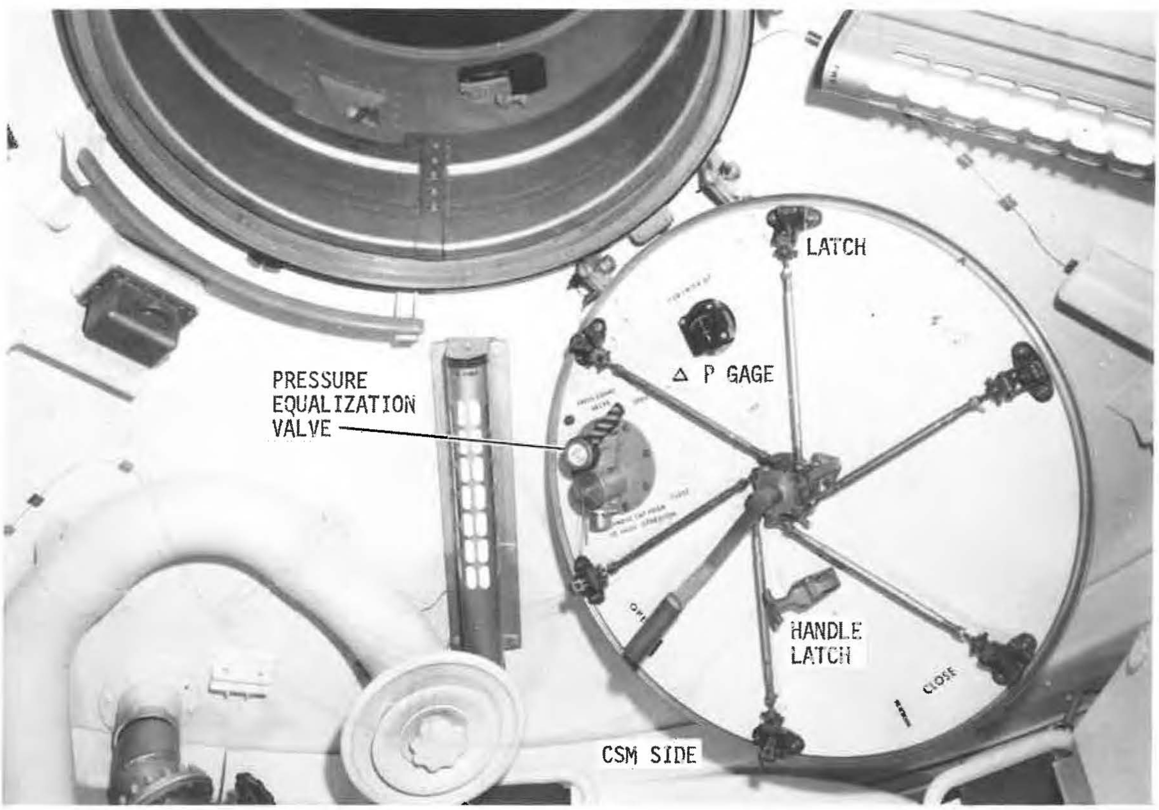




Figure 2.0.7-11 MDA Hatch

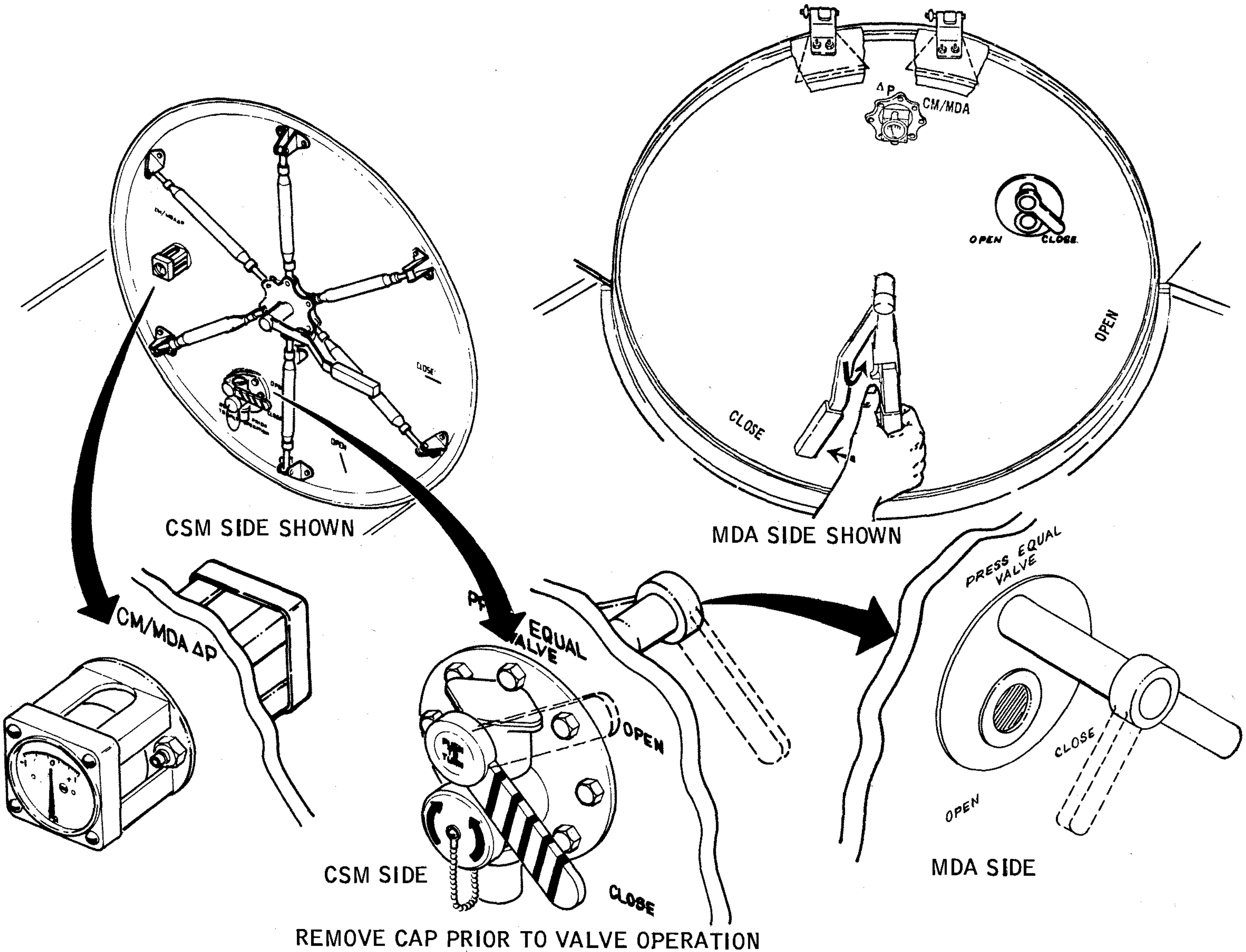
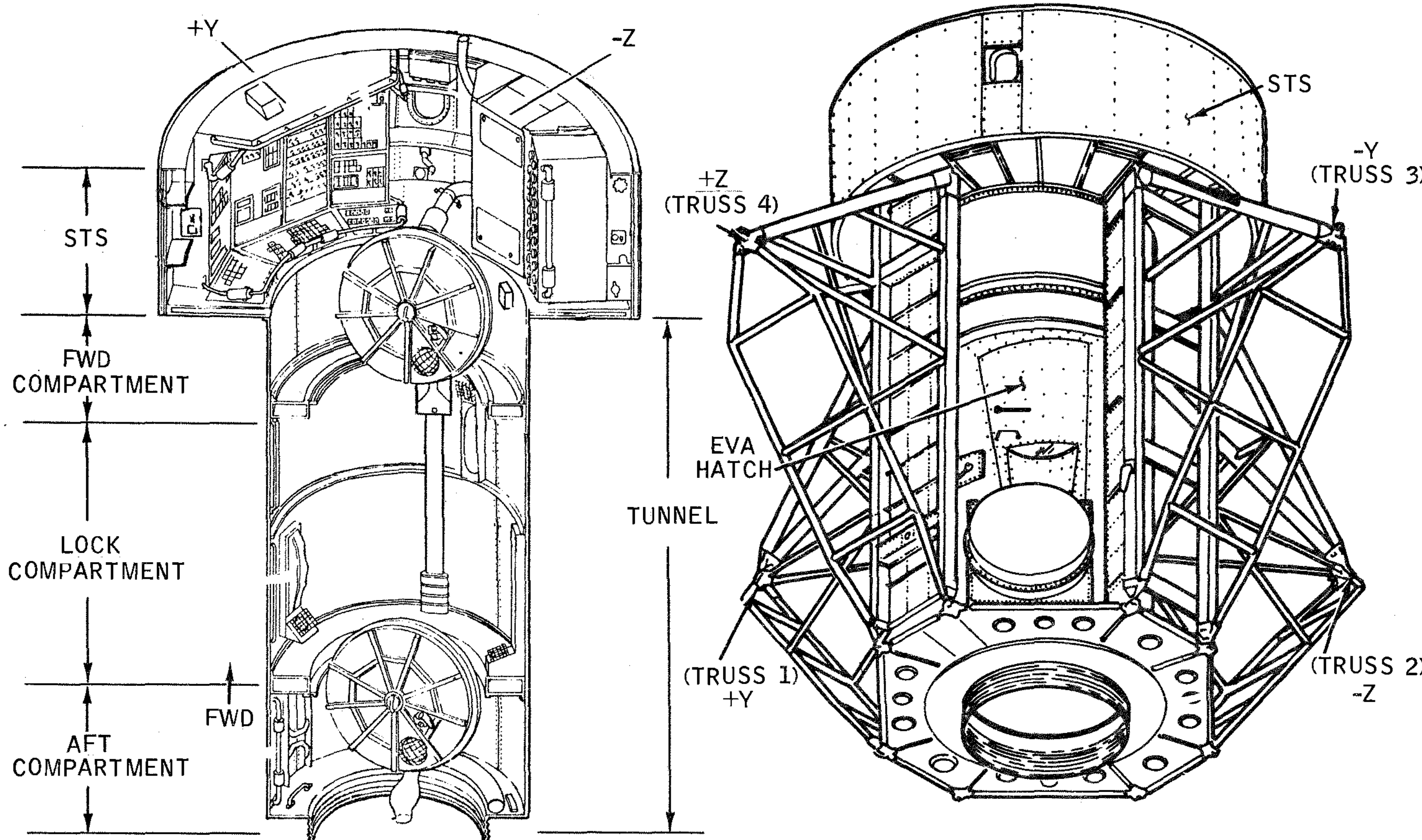



Figure 2.0.7-12 MDA Hatch Details




| | |
|---|---|
| WEIGHT; | 14,500 LBS |
| VOLUME; | 624 CU. FT. |
| HEIGHT; | 17.5 FT. |
| DIAMETER: | 10 FT. STS<br>5.5 FT. TUNNEL |

Figure 2.0.8-1 AM Configuration

The AM provides the OA with the following:

- o Conditioning, management and distribution of electrical power for the MDA, AM, OWS, and quiescent CSM.
- o Management and control for paralleling the AM and ATM electrical power systems.
- o Environmental control of the OA atmosphere
- o Storage of N2 and controls for OA atmospheric supplies (O2 and N2).
- o Accumulation and conditioning of housekeeping, vehicle status, and experiments data for real-time transmission to the MSFN and for storage on tape recorders for delayed transmission to the MSFN.
- o DCS command capability with the MSFN.
- o Transport equipment for traversing ATM film magazines from the EVA hatch area to the ATM work stations.
- o Audio-visual alert system for caution and warning.
- o Cluster intercommunications via the CSM for transmission to the MSFN.
- o Hard copy messages from the MSFN using the teleprinter.
- o Life supporting oxygen, cooling and communications capabilities for EVA crewmen.
- o Experiment D024 installation.

2.0.8.2 SYSTEM INTERFACES

The MDA mating flange bolts to a mating flange on the STS of the AM to provide the AM/MDA structural interface. The flexible tunnel extension assembly of the AM mates to the OWS dome. All loads are transmitted through the four AM truss assemblies to the FAS.

2.0.8.3 SUBSYSTEM AND MAJOR COMPONENT DESCRIPTION

The AM consists of four major structural components (figure 2.0.8-2):

- o Structural Transition Section (STS)
- o Tunnel Assembly
- o Flexible Tunnel Extension
- o Four Airlock Truss Assemblies

The MDA is attached to the AM at the forward end of the STS and the OWS via the flexible tunnel extension. The four AM truss assemblies attach to the FAS at each axis.

Equipment located outside the AM is shown in figure 2.0.8-3, and equipment located inside the AM is shown in figure 2.0.8-4.

2.0.8.3.1 Structural Transition Section

The STS structure provides the structural transition from the MDA to the tunnel assembly. The enclosed volume of the STS is 279 cu. ft.

The STS structure (figure 2.0.8-5) is a welded aluminum cylinder, 46 inches long and 120 inches in diameter, of stressed skin, semi-monocoque construction. A machined mating ring, which mates with the MDA, is at the forward end. Stringers and longerons are resistance welded externally to the skin to carry bending and axial lcads. Intermediate internal rings add support and eight internal intercostals along with the truss attachment fittings transfer STS shell loads to the support trusses. The STS bulkhead provides the transition from the 120-inch diameter of the STS to the 65-inch diameter of the Tunnel Assembly. Machined rings are utilized on the bulkhead to make a typical, flanged, bolted interface. The bulkhead, along with the tunnel shear webs and the aft octagonal ring, provides shear continuity of the AM and redistributes loads to the AM support trusses. Eight radial sheet metal channels and eight machined titanium radial fittings, which include lugs for attaching the STS to the trusses, stiffen the STS bulkhead pressure skin.

There are four 8x12-inch oval windows in the STS, equally spaced around the periphery of the STS. The STS windows consist of an inner and an outer pane of glass and a window cover. The outer pane is 0.42-inch Corning Vycor #7913 glass with an infra-red reflective coating on the inner surface. A 0.15-inch gap separates the inner and outer panes. The inner pane is 0.24-inch Corning aluminosilicate #1723 glass with an ultra-violet reflective coating on the outer surface of the inner pane. The windows are protected when not in use by an external movable cover assembly (figure 2.0.8-6), which can be operated from inside the STS by the crew. The cover serves to protect the window from meteoroid impacts and minimizes heat loss from the STS. The space between the inner and outer panes can be vented with the WINDOW VENT control.

2.0.8.3.1.1 AM Radiator Assembly

The AM radiator (figure 2.0.8-7) serves as a meteroid shield for the MDA and STS in addition to its function as a heat radiator.

Bulb-tee shaped magnesium alloy extrusions, which provide a flow path for the coolant fluid, are seam welded to a magnesium alloy skin. Each radiator panel is supported 3 inches outside the pressure vessel skin by fiberglass laminate angles, which minize the heat conduction from the cabin area. Welded joints connecting most of the radiator coolant tubes minimize the possibility of leakage. Mechanical connectors connect the radiator to the coolant loop and join the radiator panel assemblies together.

9170

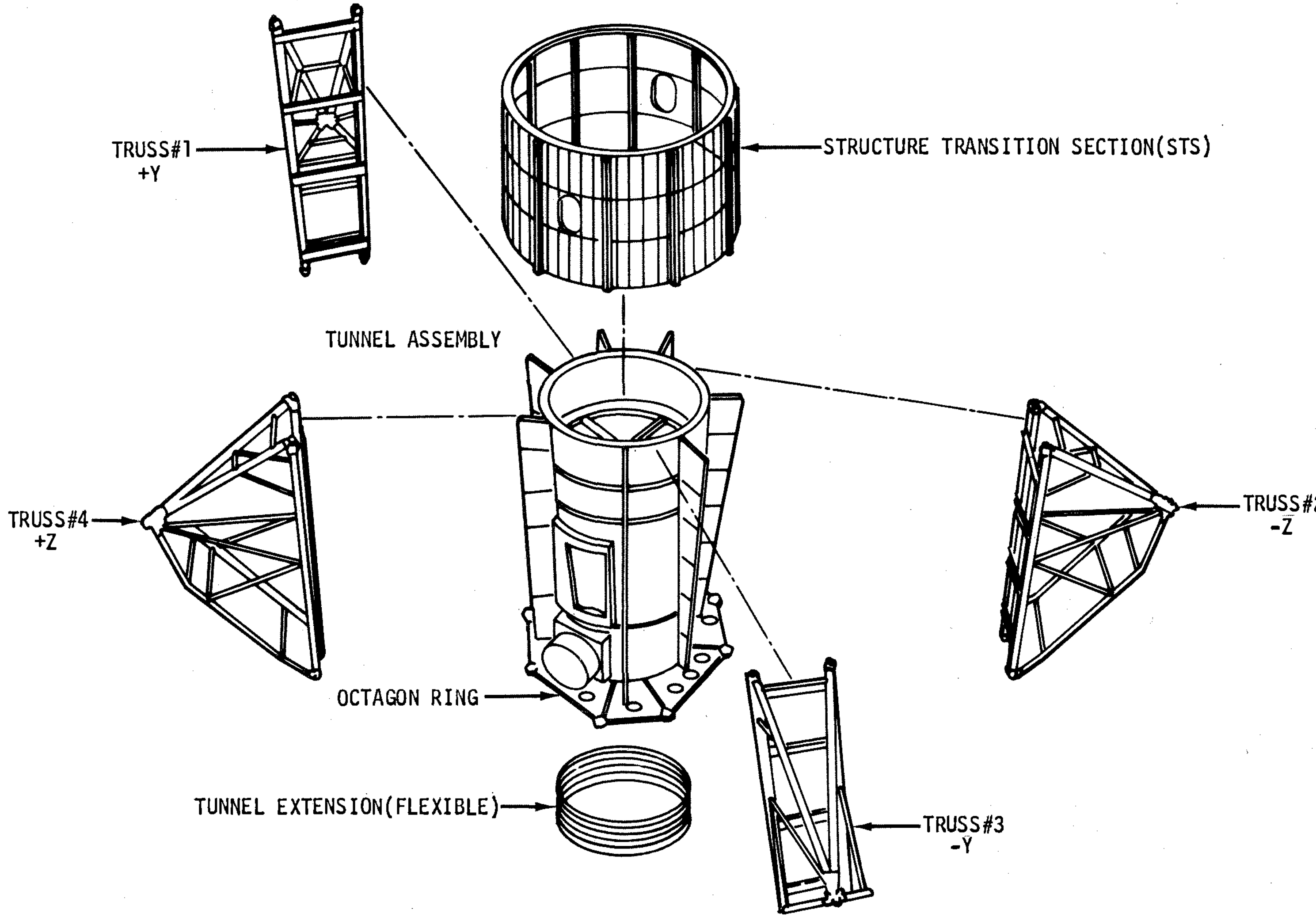



Figure 2.0.8-2 AM Major Structure Assembly

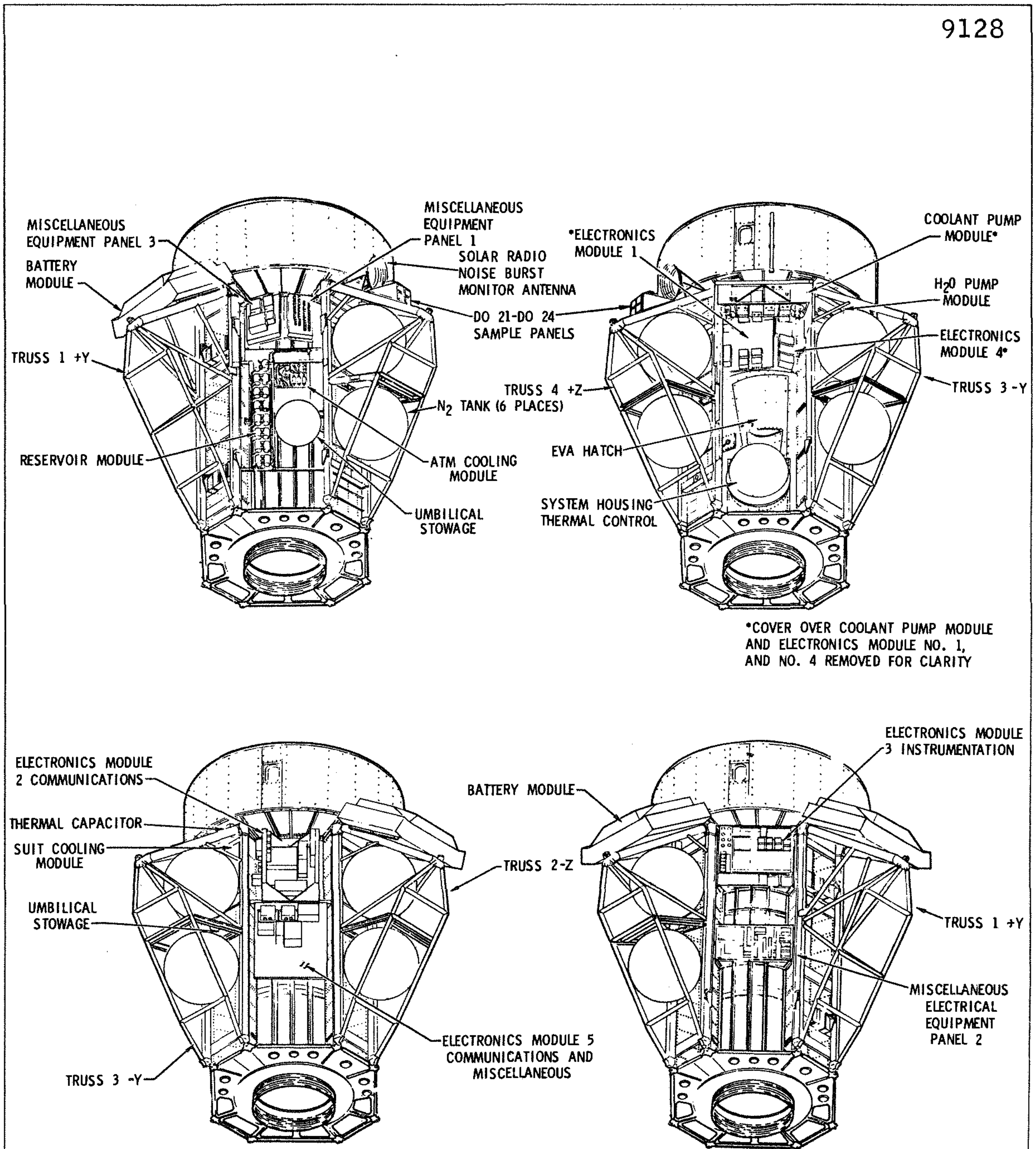



Figure 2.0.8-3 AM External Configuration

9072

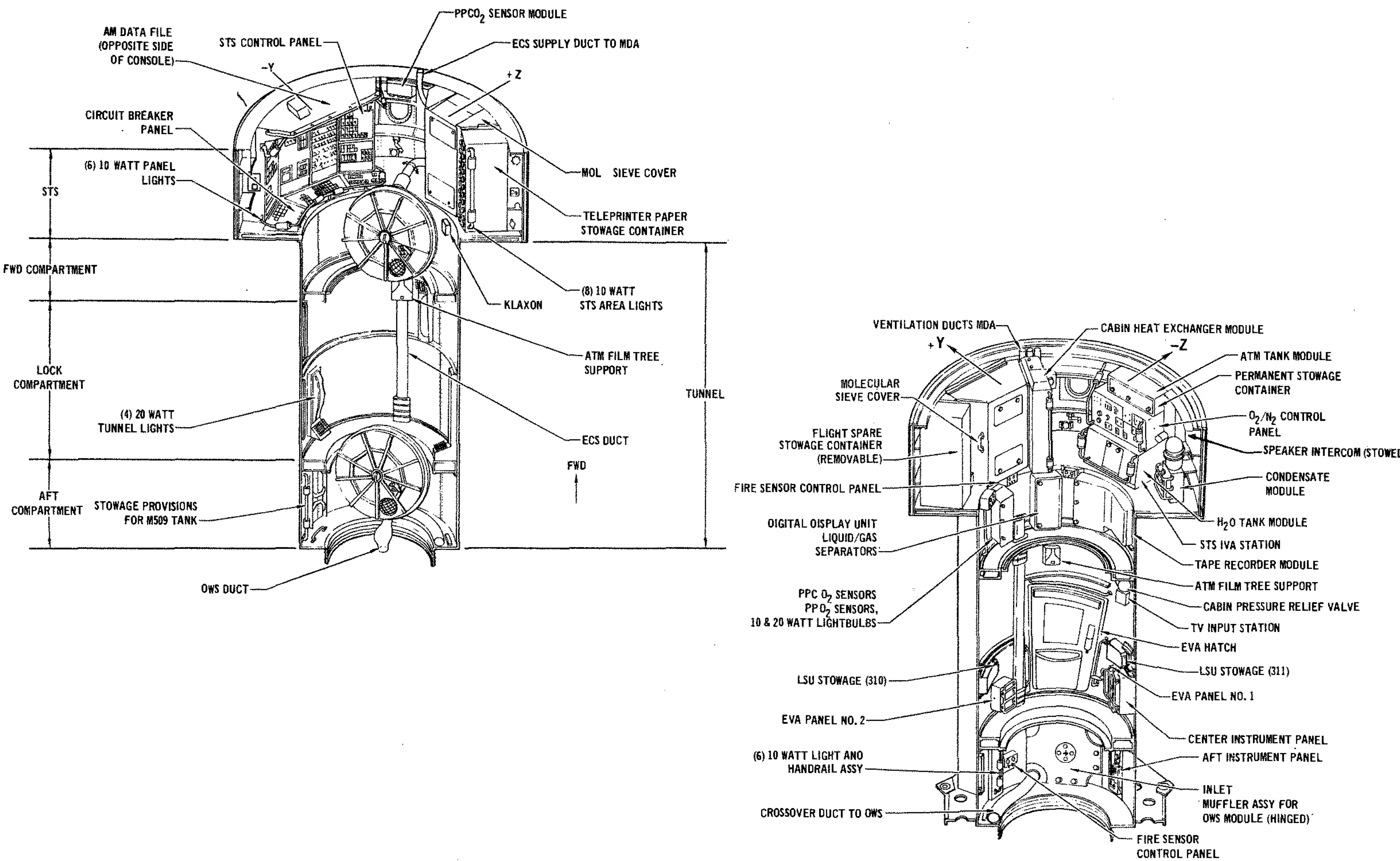



Figure 2.0.8-4 AM Interior Layout

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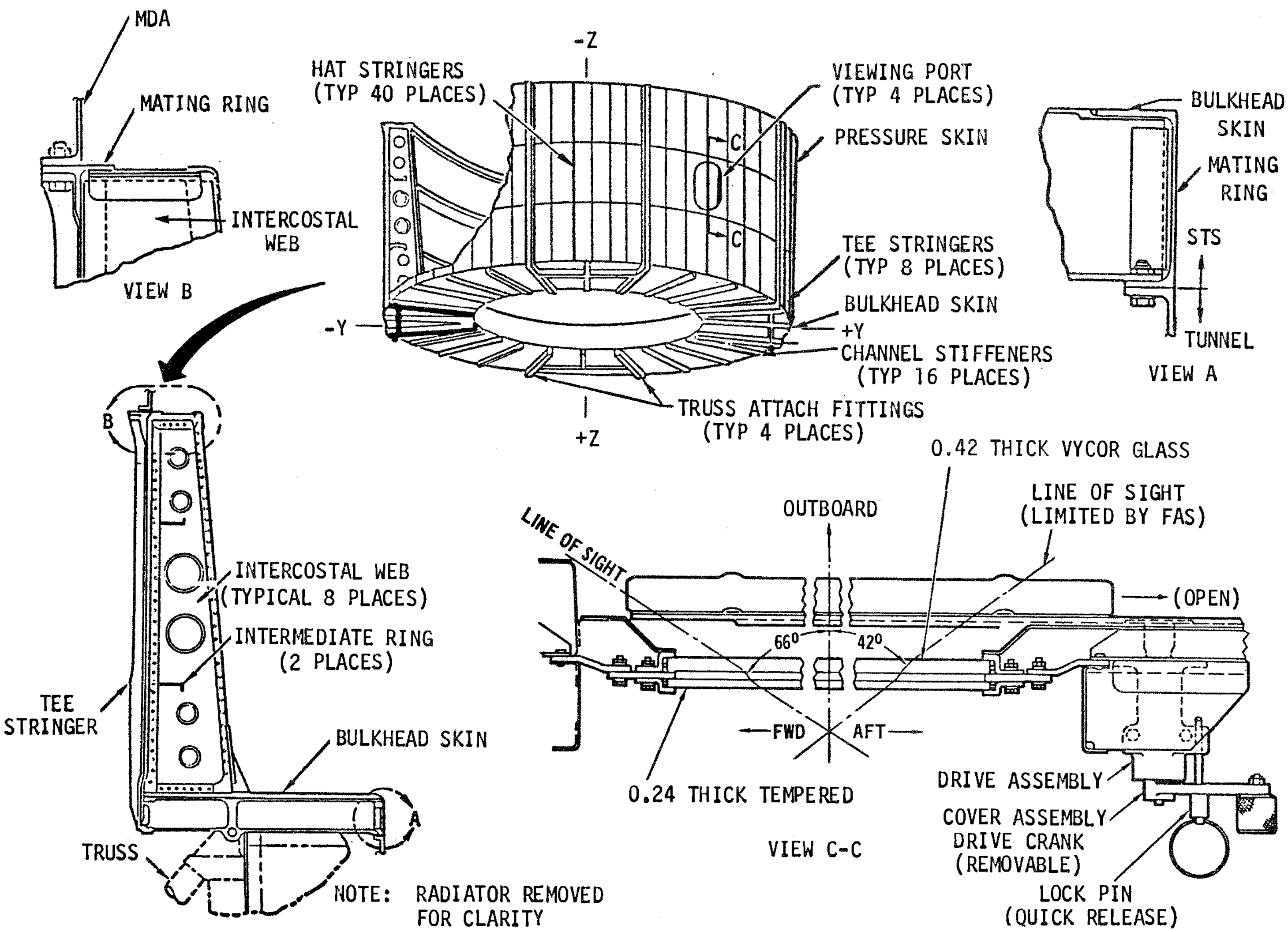


Figure 2.0.8-5 Structural Transition Section

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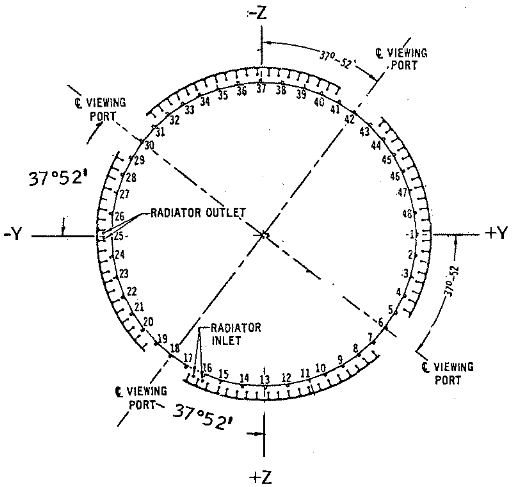


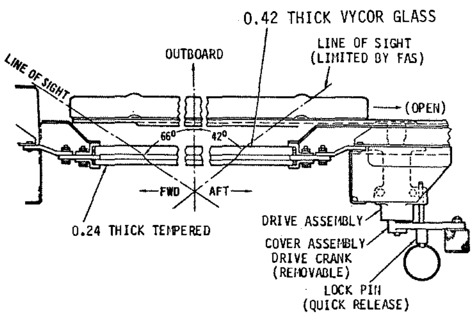


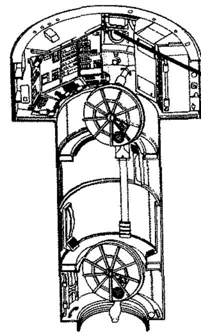

TO OPEN

STEP 1

REMOVE LOCKPIN AND STOW IN HOLE PROVIDED IN LEFT SIDE OF CRANK SHAFT MOUNTING BRACKET.

STEP 2

ROTATE WINDOW CRANK CW 2 1/4 TURNS

TO CLOSE

STEP 1

ROTATE WINDOW CRANK CCW 2 1/4 TURNS TO FULL CLOSE POSITION

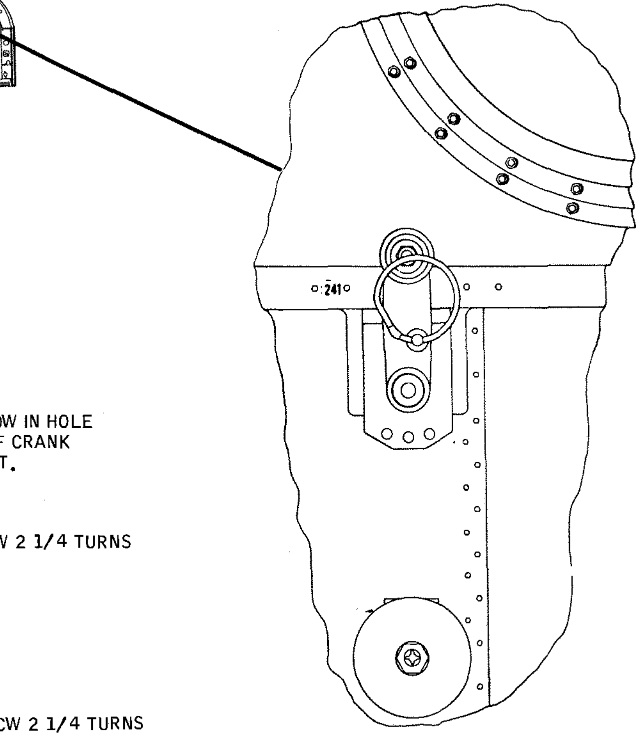


Figure 2.0.8-6 STS Window and Cover

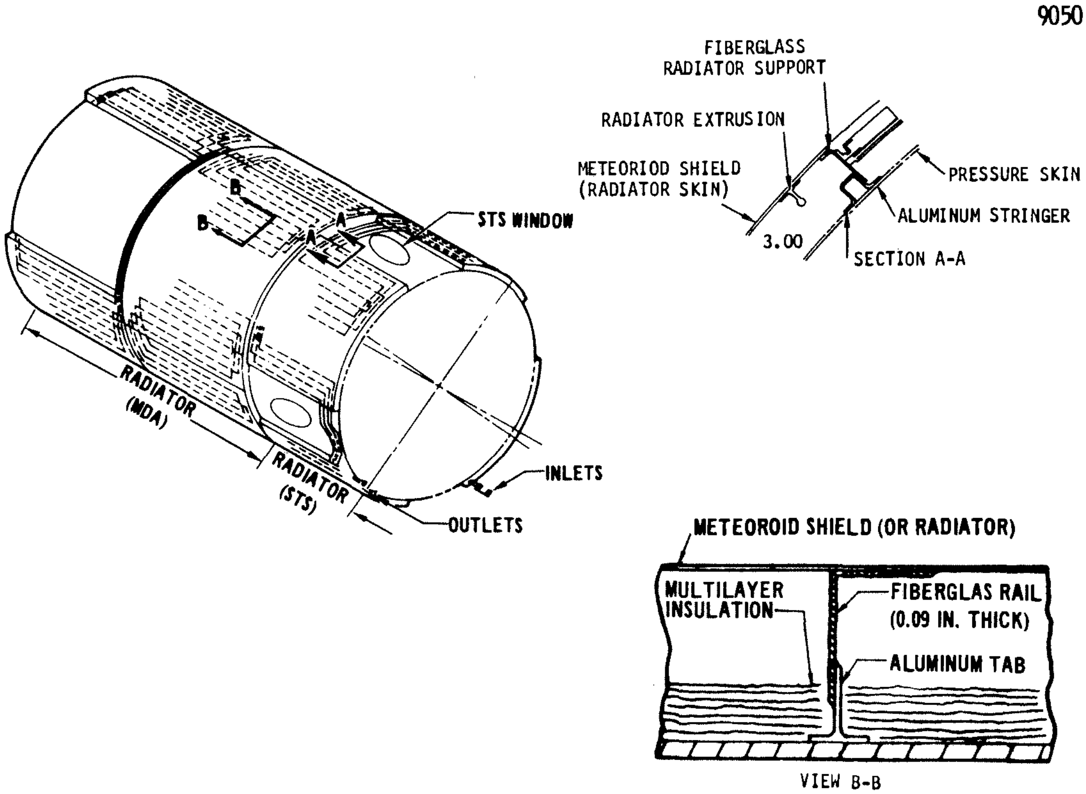


Figure 2.0.8-7 Radiator Configuration

2.0.8.3.2 AM Tunnel Assembly

The tunnel assembly is a 65-inch diameter, 153-inch long cylinder of aluminum, semi-monocoque construction, as shown in figures 2.0.8-2 and 2.0.8-8. Tunnel construction consists of three segments of aluminum skin butt fusion welded at the longitudinal splices and rolled to a 65-inch diameter. These segments are connected by resistance welding to two internal machined rings. Additional machined rings, resistance welded to each end of the tunnel assembly, provide attachment for the flexible tunnel extension and the STS bulkhead. Fusion and resistance welding is used wherever practical to minimize quantity of potential pressure leakage points.

External shear webs, an octagonal ring, and the STS bulkhead provide shear continuity between the tunnel assembly and the four truss assemblies (figure 2.0.8-9).

Various equipment inside of the tunnel is shown in figure 2.0.8-10. The tunnel assembly is divided into three compartments by two bulkheads equipped with hatches: the forward compartment, the lock compartment, and the aft compartment.

2.0.8.3.2.1 Forward Compartment

The forward compartment mates to the STS and includes a CABIN RELIEF VALVE and provisions for stowage containers, tape recorders, and miscellaneous equipment. It is approximately 65 inches in diameter and 31 inches long and has an internal volume of 67 cu. ft.

2.0.8.3.2.2 Lock Compartment

The lock compartment, 80 inches long and with a total volume of 154 cu. ft., provides an airlock for crew ingress/egress during EVA.

Internal Hatches

The two lock compartment internal hatches (figure 2.0.8-11) are used to seal off the lock compartment from the rest of the SWS during EVA. The hatches are circular machinings 49.5 inches in diameter with radially attached stiffeners. An 8.5-inch diameter double panel window in each hatch provides viewing of the lock compartment from both the forward and aft compartments. Each hatch is hinged to fold along the tunnel wall. A molded elastomer hatch seal is installed on each bulkhead. Each latching system uses a cable that runs around the periphery of each bulkhead and drives nine hatch latch assemblies. Each hatch is unlatched by rotating a handle through

9058

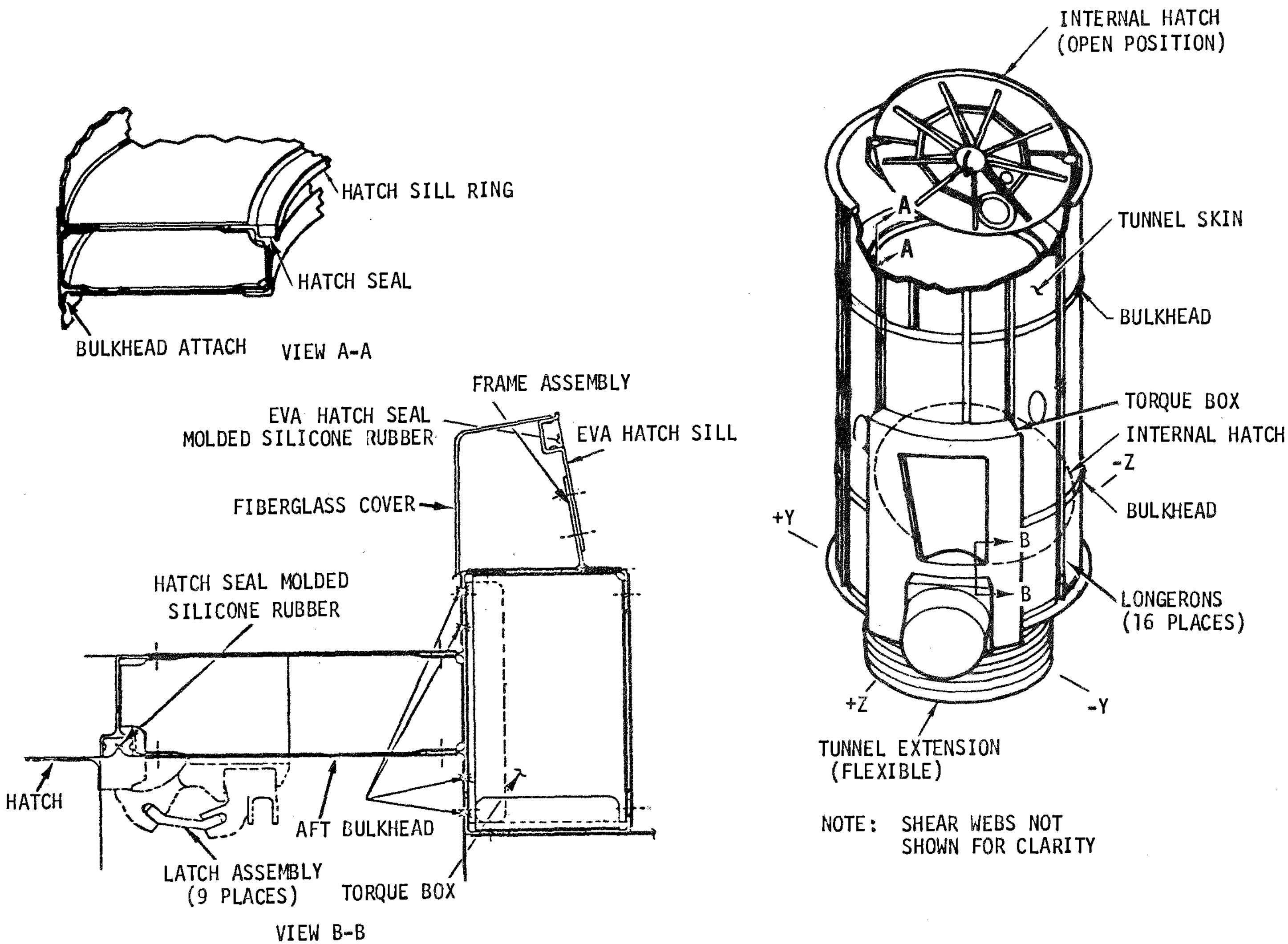


Figure 2.0.8-8 Tunnel Assembly

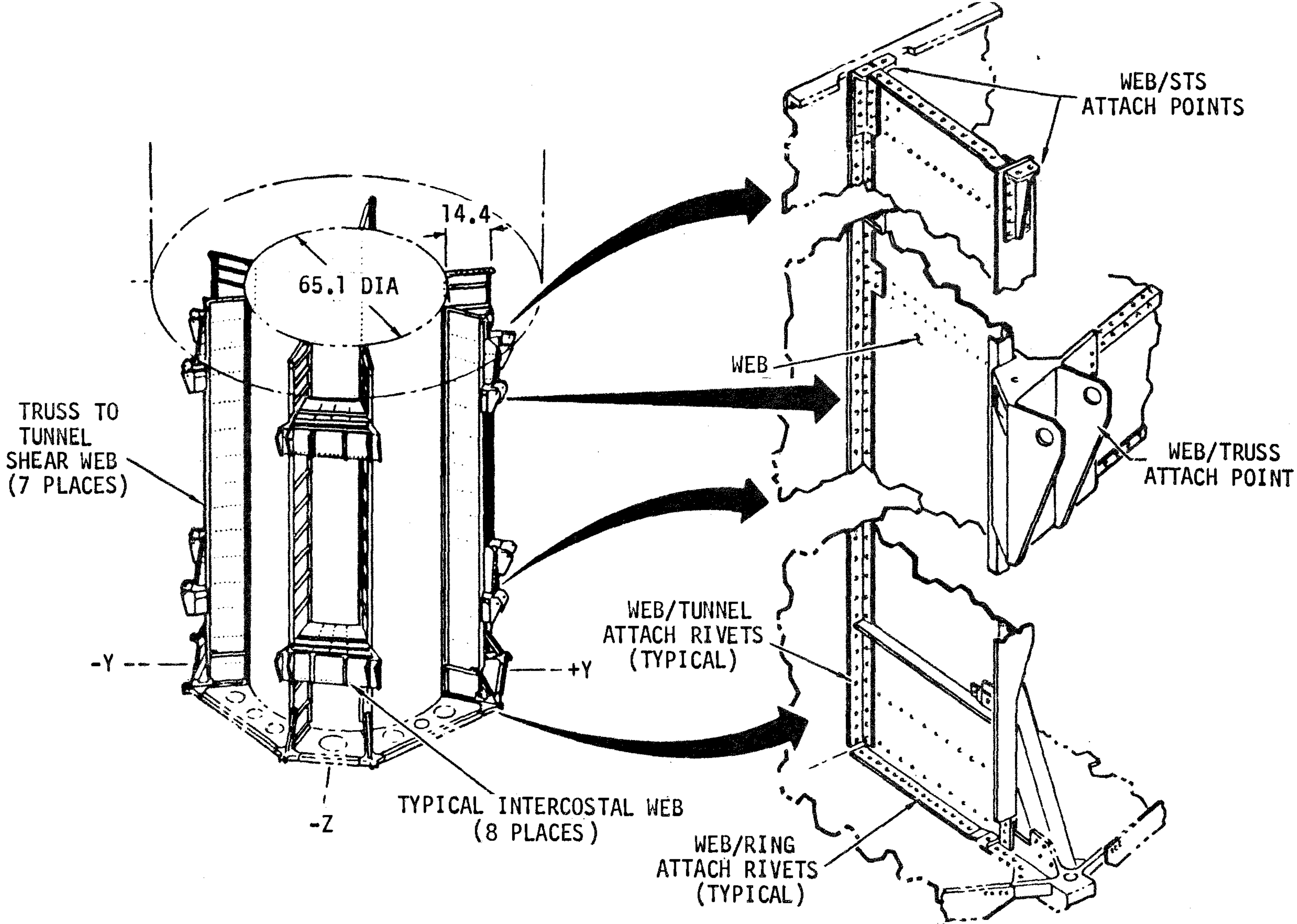


Figure 2.0.8-9 Tunnel Assembly Shear Webs

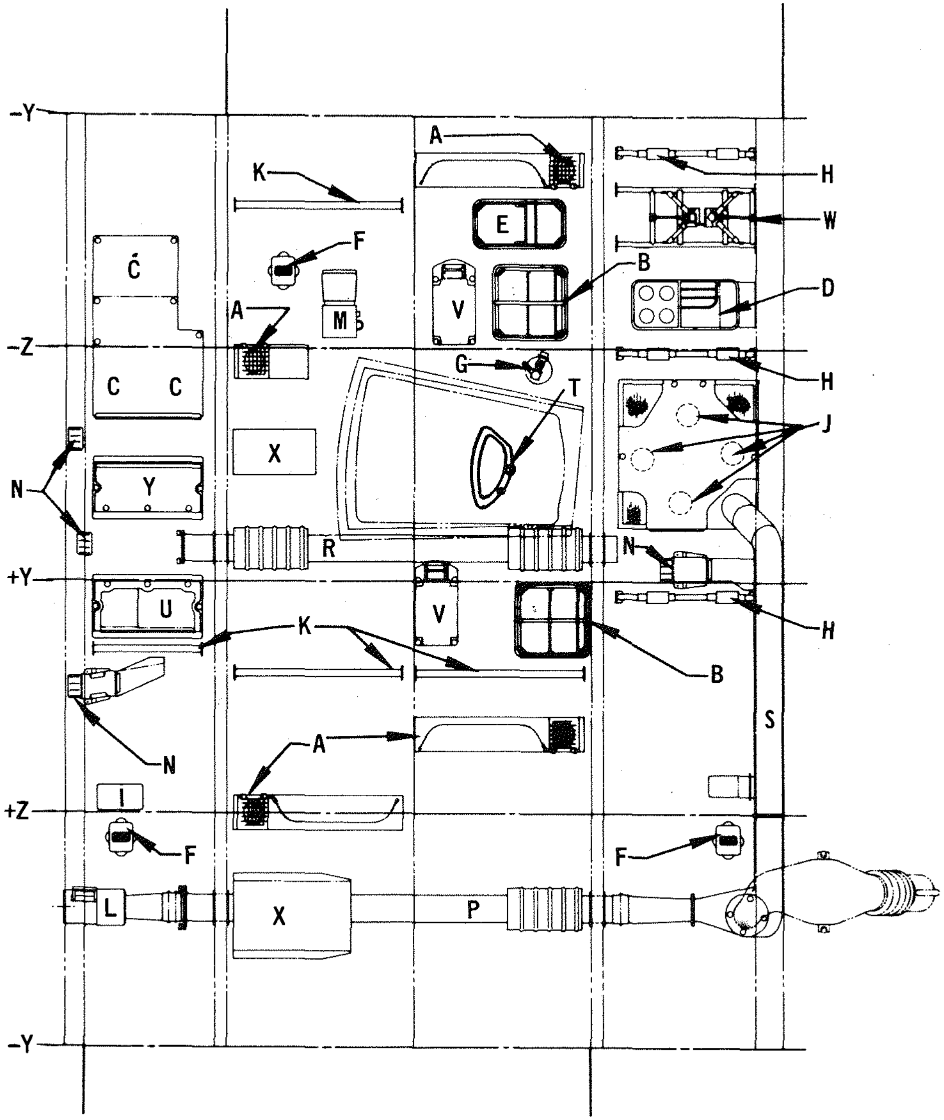


Figure 2.0.8-10 Tunnel Interior

# LEGEND

## INSTALLED EQUIPMENT

A. TUNNEL LIGHT ASSY (4).
B. EVA CONTROL PANEL (2).
C. TAPE RECORDER (3).
D. AFT INSTRUMENT PANEL.
E. CENTER INSTRUMENT PANEL.
F. CABIN PRESSURE RELIEF VALVE (3).
G. EQUALIZATION VALVE.
H. HAND RAIL/LIGHT ASSY (3).
I. KLAXON
J. OWS COOLING FANS
HEAT EXCHANGERS/VALVES.
K. HANDRAILS (4).
L. PLV FAN/MUFFLER.
M. TV INPUT STATION.
N. FIRE SENSOR CONTROL PANEL (4).
P. OWS INTERCONNECT DUCT
R. RESUPPLY DUCT
S. CROSS OVER DUCT
T. WINDOW VENT VALVE

## STOWED EQUIPMENT

U. LIGHT BULBS, $PPCO_2$
SENSORS AND $PPO_2$ SENSORS.
V. EVA UMBILICAL END
STOWAGE PROVISIONS. (2)
W. STOWAGE PROVISION FOR M509 TANK.
X. ATM FILM TREE TEMPORARY
STOWAGE PROVISIONS. (2)
Y. DIGITAL DISPLAY UNIT (1) AND
GFE LIQUID GAS SEPARATOR (2).

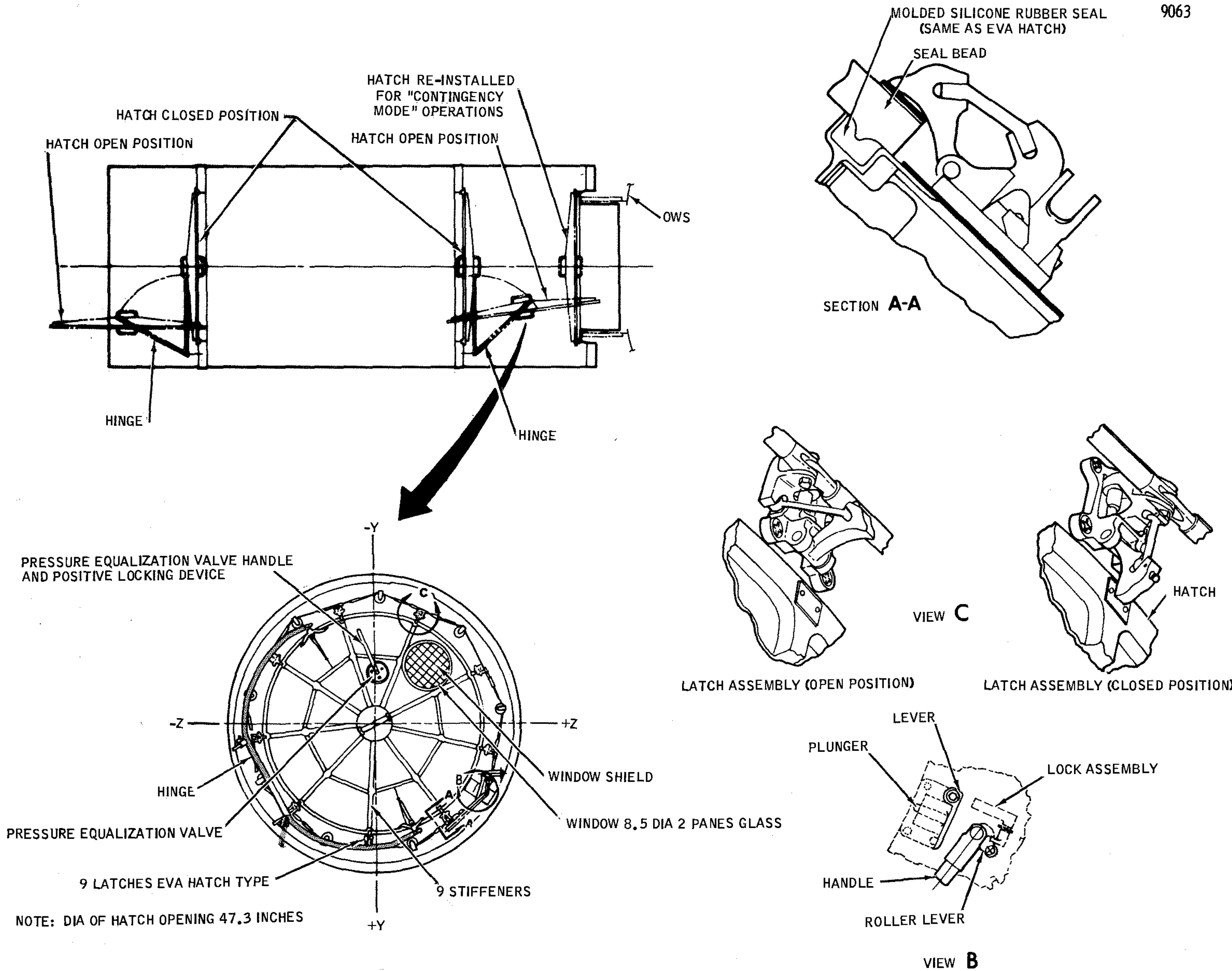


Figure 2.0.8-11 Interior Hatches

approximately 145 degrees, with a 35-pound maximum load applied on the handle. A positive lock is included in the handle mechanism on the aft hatch.

The aft internal hatch can be detached from its hinge by removing two quick-release pins and then can be re-installed at the flexible tunnel extension to isolate the AM from the OWS for "contingency mode" operations.

EVA Hatch

The EVA hatch (figure 2.0.8-12) is a titanium trapezoidal-shaped structure section that is hinged to the torque box along one edge of the hatch. A molded elastomer hatch seal is installed on the sill assembly. The hatch is latched or unlatched by rotating a handle through approximately 153 degrees with a 45-pound maximum load on the handle. A double pane window in the hatch enables viewing of the aft portion of the EVA quadrant (between +Z and -Y axes). The space between the panes can be vented with the WINDOW VENT control.

2.0.8.3.2.3 Aft Compartment

The aft compartment is 42 inches long and provides a recessed housing structure to support heat exchanger fans for the thermal control system. The compartment also houses the controls for the thermal control system and the M509 N2 recharge station. The total volume of the aft compartment is 122 cu. ft.

2.0.8.3.3 Flexible Tunnel Extension Assembly (Bellows)

A metallic convolute flexible bellows (42.5 inches inside diameter by 13.0 inches long) joins the AM to the OWS dome. This flexible tunnel extension provides continuity of the pressurized passageway between the AM and the OWS (figure 2.0.8-13). The tunnel extension is pre-attached to both the AM and the OWS dome before launch and has sufficient flexibility to accommodate the relative deflection between these two structures with minimum load transfer. The bellows is made from 0.025-inch thick aluminum to be thermally compatible with adjoining structures. A redundant seal for the aluminum bellows section is included.

Attachment of the bellows to both the AM bulkhead and the OWS hatch adapter ring is with a bolted connection with approximately a 44-inch diameter bolt center circle. The mating flanges are sealed with a molded elastomer material similar to the AM hatch seals.

A fiberglass laminate shield (approximately 40 inches inside diameter) is installed inside the bellows to protect the bellows from damage during equipment and crew transfer through the bellows.

2.0.8.3.4 AM Support Truss Assemblies

Four truss assemblies (figures 2.0.8-2 and 2.0.8-3) are used to attach the AM to the FAS, with one truss assembly being located on each axis.

The basic truss assembly (figure 2.0.8-14) is typical for three of the assemblies. The fourth assembly is similar except the secondary members were relocated and made removable since this truss is mounted near the EVA bay.

The trusses are constructed of fusion-welded aluminum tubes. Dual lug machined fittings on the tunnel longitudinal shear webs and machined fittings on the tunnel octagon ring assembly provide attachment to the tunnel. A single point on each truss attachs the assembly to the FAS.

In addition to their primary function to attach the AM to the FAS, truss assemblies 1 and 2 each support a battery module, and truss assemblies 2, 3, and 4 support two 40-inch spherical gaseous nitrogen tanks.

2.0.8.4 FAILURE MODES

The AM structural and mechanical failure modes and the effect on mission capability are given in table 2.0.8.4-1.

TABLE 2.0.8.4-1 AM STRUCTURAL AND MECHANICAL - FAILURE MODES

| FAILURE | INDICATIONS | VEHICLE CAPABILITY |
|---|---|---|
| 1. STS Viewing Port Cover Assembly | | |
| a) Cover will not open when reason able loads are applied to crank | a) Inability to retract window cover | a) Viewing from subject window would be eliminated |
| b) Cover binding in guides due to contamination or physical distortion of cover or guides resulting from thermal stress | b) Try operation of window cover under different outside thermal conditions and investigate problem during EVA. Cover should not be fully opened unless mechanism is operating properly to insure against jamming in open position | b) None other than the restriction imposed by not being able to observe outside area associated with subject window |

TABLE 2.0.8.4-1 AM STRUCTURAL AND MECHANICAL - FAILURE MODES (cont'd)

| FAILURE | INDICATIONS | VEHICLE CAPABILITY |
|---|---|---|
| c) Cover will not close when reasonable loads are applied to crank | c) Inability to close window cover | c) The temp of internal surface of glass could drop below STS dew point and result in water collecting on inside surface. General compartment heat balance might be effected. Loss of meteoroid protection. |
| d) Cover binding in guides due to contamination or physical distortion of cover or guides resulting from thermal stress | d) Try operation of window cover under different outside thermal conditions and investigate problem during EVA. If window received meteoroid damage then uses of STS section might have to be limited. If cover can be closed as result of EVA or other special procedures it should be left closed unless problem has been corrected | d) Mission effect would essentially be only minor inconvenience unless loss of meteoroid protection resulted in damage to window. Window damage could effect mission duration but since this would constitute a multiple failure condition, it is not pertinent to this analysis |
| 2. STS Viewing Port Drive Assembly | | |
| a) Mechanism jammed or exhibits excessive drag (Cover closed) | a) Inability to retract window cover | a) Window could not be opened thus viewing from subject window would be eliminated |
| b) Misalignment of gear and rack or contamination | b) Try to determine cause of problem including EVA investigation. Don't attempt to move cover to open position unless mechanism is operating properly to insure against having cover jammed in the open position | b) None other than the restrictions imposed by not being able to observe outside area associated with subject window |
| c) Mechanism jams or exhibits excessive drag (Cover open) | c) Inability to close window cover | c) The temp of internal surface of glass could drop below STS dew point and result in water collecting on inside surface. General compartment heat balance might be effected |
| d) Misalignment of pinion gear and rack or contamination | d) Try to determine cause of problem comparing position of mechanism components with other windows for possible indication of problem. Evaluate condition during EVA. If cover can be closed as result of special procedure it should be left closed unless problem has been corrected. If window receives meteoroid damage the use of STS compartment might have to be limited | d) Mission effect would essentially be only minor inconvenience unless loss of meteoroid protection resulted in damage to window. Window damage could effect mission duration but since this would constitute a multiple failure condition it is not pertinent to this analysis |
| e) STS pressure loss thru drive assembly | e) Gross leakage of shaft seal would probably produce an audible indication | e) None- crew procedure provides for corrective action |
| f) Defective O-rings on drive assembly shaft | f) Remove mechanism crank and install the cap provided. There is one cap for each of the (4) drive assemblies which are provided for installation during storage phases of mission | f) None - once detected and corrective action taken |
| 4. Forward Internal Hatch | | |
| Latch mechanism | | |
| a) Mechanism will not release | a) Crew unable to open hatch | a) Prevent opening hatch unless linkage can be freed |

TABLE 2.0.8.4-1 AM STRUCTURAL AND MECHANICAL - FAILURE MODES (cont'd)

| FAILURE | INDICATIONS | VEHICLE CAPABILITY |
|---|---|---|
| b) Linkage jammed due to foreign object | b) Remove cover and free latches if possible | b) If failure occurred during activation it would delay OWS activity until crew could remove cover and release latches. If failure occurred on return from EVA it would prevent crew transfer from OWS to forward compartments until problem is corrected |
| c) Fails to latch on closing | c) Mechanism handle can not be rotated to the locked position | c) Prevent following the normal hatch installation procedure for EVA and/or deactivation. Prevent pressurization mode in which pressure on aft side of hatch is greater than that on forward side |
| d) Mechanical binding on closing | d) Remove mechanism cover and take necessary corrective action to free the jammed linkage. If unable to correct defect hatch can still be used for EVA since differential pressure will provide force to compress seal and secure hatch during EVA | d) Could require adjustment in the planned EVA schedule and/or procedure Preclude installation of hatch for deactivation |
| 4. Forward Hatch Assembly | | |
| a) Leakage - Failure to seal | a) Crew observation of physical defect or damaged seal bead. Greater than normal O2/N2 depletion rate | a) Unable to depressurize Airlock without excessive loss of O2/N2 |
| b) Physical damage to seal bead | b) Attempt to repair defect. Depending on degree of leakage crew could modify EVA operations by reducing duration or number of cycles | b) Possible change in the number and/or duration of planned EVA operations |
| 5. Forward Hatch Seal | | |
| a) Leakage | a) Crew observation of damaged or deteriorated condition of seal prior to hatch installation. Depletion rate for O2/N2 greater than normal | a) Excessive loss of O2/N2 |
| b) Seal material damaged or deteriorated | b) None other than modification to the EVA schedule as required to conserve O2/N2 | b) Possible change in number and/or length of EVA activity |
| 6. Aft Internal Hatch | | |
| Latch Mechanism | | |
| a) Mechanism will not release | a) Crewman unable to open hatch | a) Prevent crew access to the OWS |
| b) Linkage jammed due to foreign object | b) None other than to request instruction from ground | b) Require early mission termination |
| a) Fails to latch | a) Mechanism handle cannot be rotated to the locked position | a) Prevent following the normal hatch installation procedure for EVA and/or deactivation. Prevent pressurization mode in which pressure on FWD side of hatch is greater than that on AFT side |

TABLE 2.0.8.4-1 AM STRUCTURAL AND MECHANICAL - FAILURE MODES (cont'd)

| FAILURE | INDICATIONS | VEHICLE CAPABILITY |
|---|---|---|
| b) Mechanical binding | b) Remove mechanism cover and take necessary corrective action to free the jammed linkage. If unable to correct defect hatch can still be used for EVA since differential pressure will provide force to compress seal and secure hatch during EVA. Hatch can also be installed at AMS 0.00 to separate OWS from forward compartments | b) Could require adjustment in the planned EVA schedule and/or procedure Preclude installation of hatch for deactivation |
| 7. Aft Hatch Assembly | | |
| a) Leakage - Failure to seal | a) Crew observation of physical defect or damaged seal bead. Greater than normal 02/N2 depletion rate | a) Unable to depressurize Airlock without excessive loss of 02/N2 |
| b) Physical damage to seal bead | b) Attempt to repair defect. Depending on degree of leakage crew could modify EVA operations by reducing duration or number of cycles | b) Possible change in the number and/or duration of planned EVA operations |
| 8. Aft Hatch Seal | | |
| a) Leakage | a) Crew observation of damaged or deteriorated condition of seal prior to hatch installation. Depletion rate for 02/N2 greater than normal | a) Excessive loss of 02/N2 |
| b) Seal material damaged or deteriorated | b) None other then modification to the EVA schedule as required to conserve 02/N2 | b) Possible change in number and/or length of EVA activity |
| 9. EVA Hatch | | |
| a) Hatch will not open | a) Crew unable to open hatch | a) Preclude opening of hatch |
| b) Mechanism jammed in closed position | b) Attempt to free jammed linkage and if unsuccessful request ground define the desired change in mission plan | b) Cancellation of all EVA activity thru Airlock hatch |
| c) Failure of latch mechanism to lock hatch in closed position | c) When closing hatch handle will not return to locked position | c) Preclude pressurizing of lock compartment |
| d) Mechanism obstructed by foreign object | d) Crew should attempt to free mechanism and if unable to accomplish repair then all transfers between OWS and forward compartments would have to be IVA | d) Prevent normal use of OWS and result in early mission termination due to excessive use of 02/N2 |
| 10. EVA Hatch Seal | | |
| a) Leakage | a) Crew observation of seal condition and/or thru monitoring of the 02/N2 depletion rate | a) Excessive loss of 02/N2 at EVA hatch seal |
| b) Damaged or deteriorated seal | b) For severe leakage crew could attempt to repair leak which would necessitate leaving hatch closed for remainder of mission. Evaluate possibility of continuing mission with internal hatches in place and only pressurizing lock compartment for crew transfer | b) Shorten mission due to early 02/N2 depletion and if leakage rate is very high it would restrict crew transfer thru lock compartment in shirtsleeve mode |

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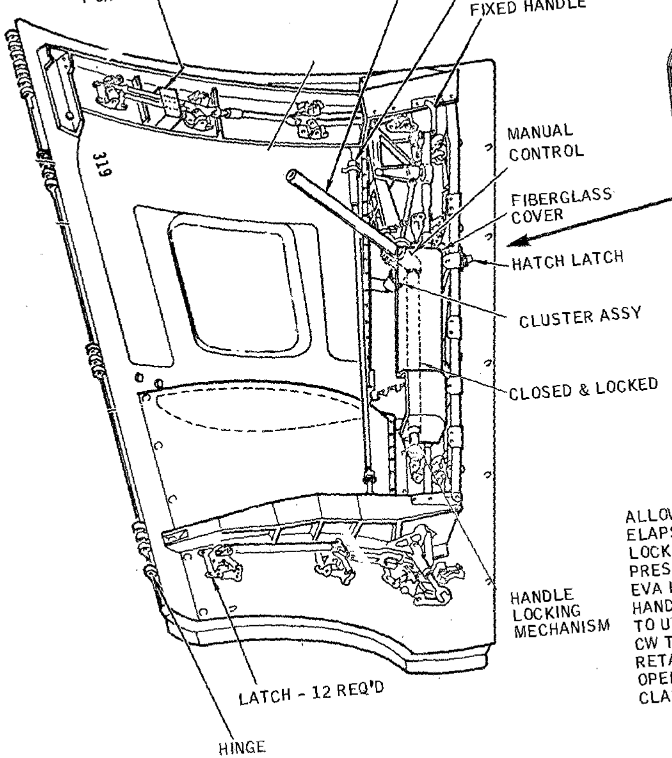
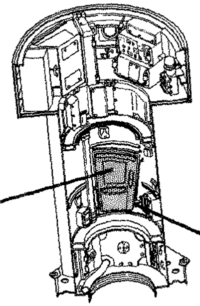



EVA HATCH 319

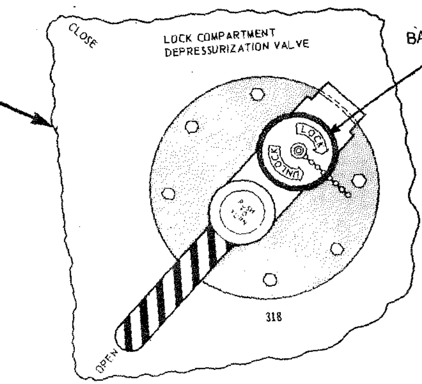


STEP 1

DEPRESSURIZATION

REMOVE BAYONET CAP AND STOW ON DUMMY RECEPTACLE ON SIDE OF EVA PANEL. PUSH CENTER BUTTON AND ROTATE LOCK COMPT DEPRESS VALVE CCW TO OPEN.

LOCK DEPRESSURIZATION VALVE 318




STEP 2

OPEN HATCH

ALLOW APPROXIMATELY 120 SECONDS TO ELAPSE FOLLOWING THE OPENING OF THE LOCK COMPT DEPRESS VALVE. WHEN LOCK PRESSURE REACHES .2 PSIA. VERIFY EVA HATCH LATCH ENGAGED. PULL OUT HANDLE LOCKING MECHANISM AND POSITION TO UNLOCK. ROTATE THE EVA HATCH HANDLE CW TO FULL OPEN. DISENGAGE EVA HATCH RETAINER. OPEN HATCH UTILIZING HATCH OPEN/CLOSE ROD AND POSITION ROD INTO CLAMP ADJACENT TO EVA HATCH OPENING.

Figure 2.0.8-12 EVA Hatch

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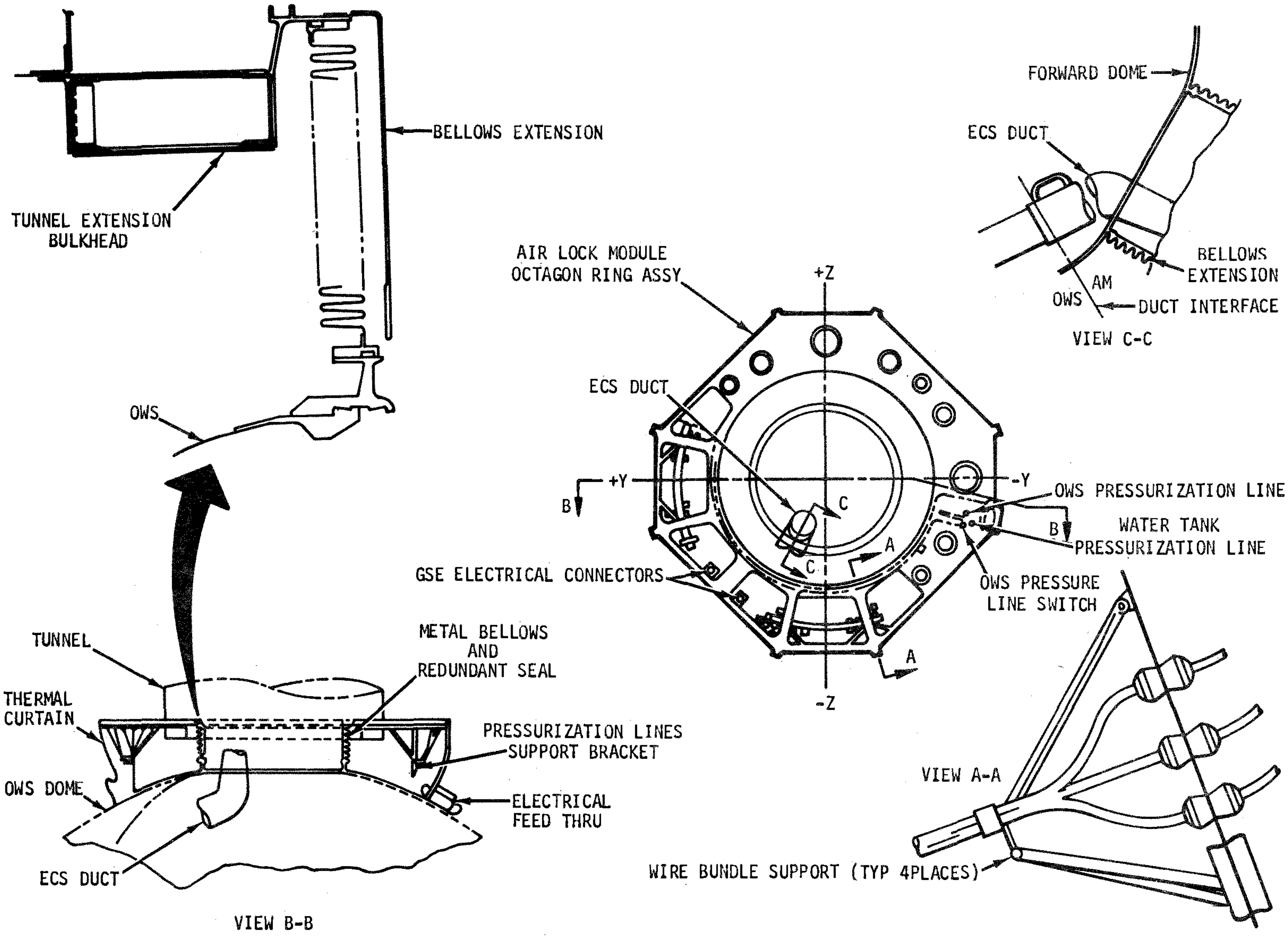


Figure 2.0.8-13 Flexible Tunnel Extension Assembly

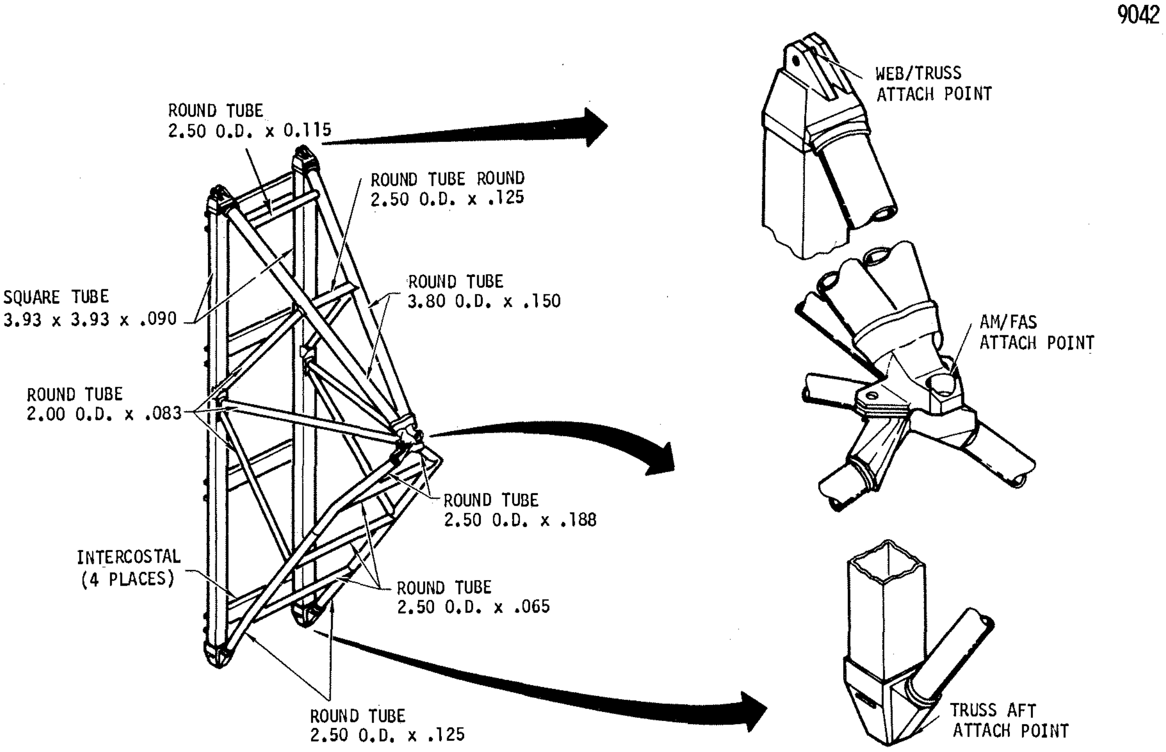


Figure 2.0.8-14 AM Support Truss Assembly

## 2.0.9 FIXED AIRLOCK SHROUD (FAS)

### 2.0.9.1 INTRODUCTION

The FAS structurally supports the ATM, AM, MDA, and PS during the launch phase of the mission. It also supports six cylindrical oxygen tanks and provides attachment points for the two discone antenna booms.

An access door is provided for ground access to the interior of the FAS and the AM egress hatch.

### 2.0.9.2 INTERFACES

The FAS structurally interfaces with the IU at its aft ring and with the PS during the launch phase at its forward ring. The FAS structurally supports the AM through the AM trusses and the ATM through the DA. The six oxygen tanks of the ECS are also mounted to the FAS.

### 2.0.9.3 SUBSYSTEMS AND MAJOR COMPONENT DESCRIPTIONS

The FAS (figure 2.0.9-1) is a cylindrical structure, approximately 80 inches long and 260 inches in diameter, consisting of thick skin and ring construction with local intercostals for structural backup of the ATM-DA and the AM truss attach fitting.

The skin is constructed of four 90-degree sections of 0.45-inch thick 2024 T851 aluminum alloy. These sections are spliced together and attached to three structural rings. The aft-most ring has a 5-inch width; the center and forward-most rings have widths of 12 inches each. Web and intercostal arrangements are provided at each of the splice joints, which occur at the Y and Z coordinates. The four AM trusses mount to the forward ring of the FAS over the splice joints webs (figure 2.0.9-1). The six oxygen tanks are divided into pairs, equally spaced between +Z and +Y, +Y and -Z, and -Z and -Y. The tanks are attached to the FAS structure through web arrangements that fasten to the intercostal mounts of the tanks.

Eight clevis fittings are provided on the forward ring for attachment of the DA lower truss. At points 45-degrees off each side of the -Z coordinate, the inner discone antenna booms are mounted to the forward ring. Webs are provided below each structural attach point for local strengthening.

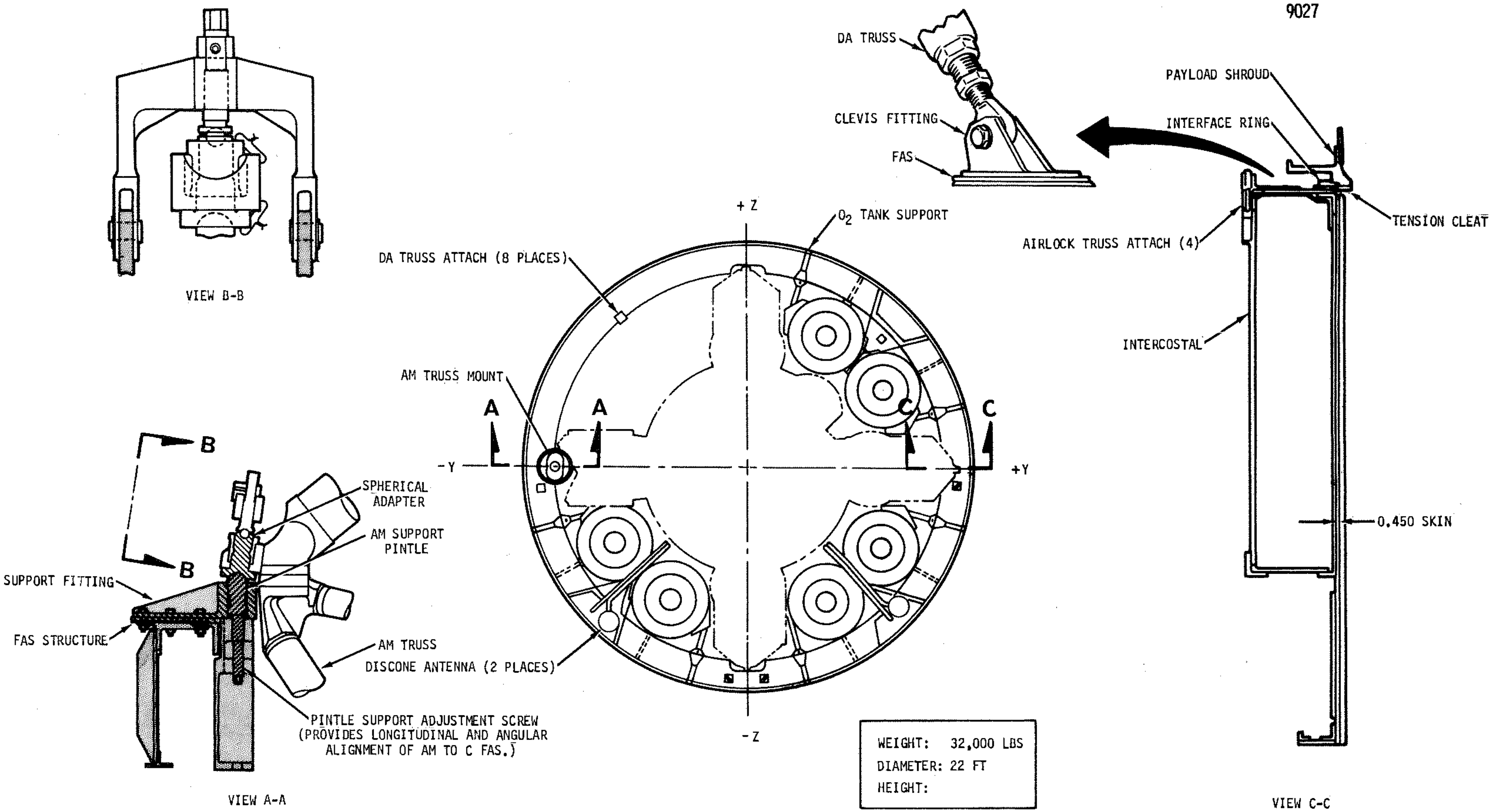


Figure 2.0.9-1 Fixed Airlock Shroud

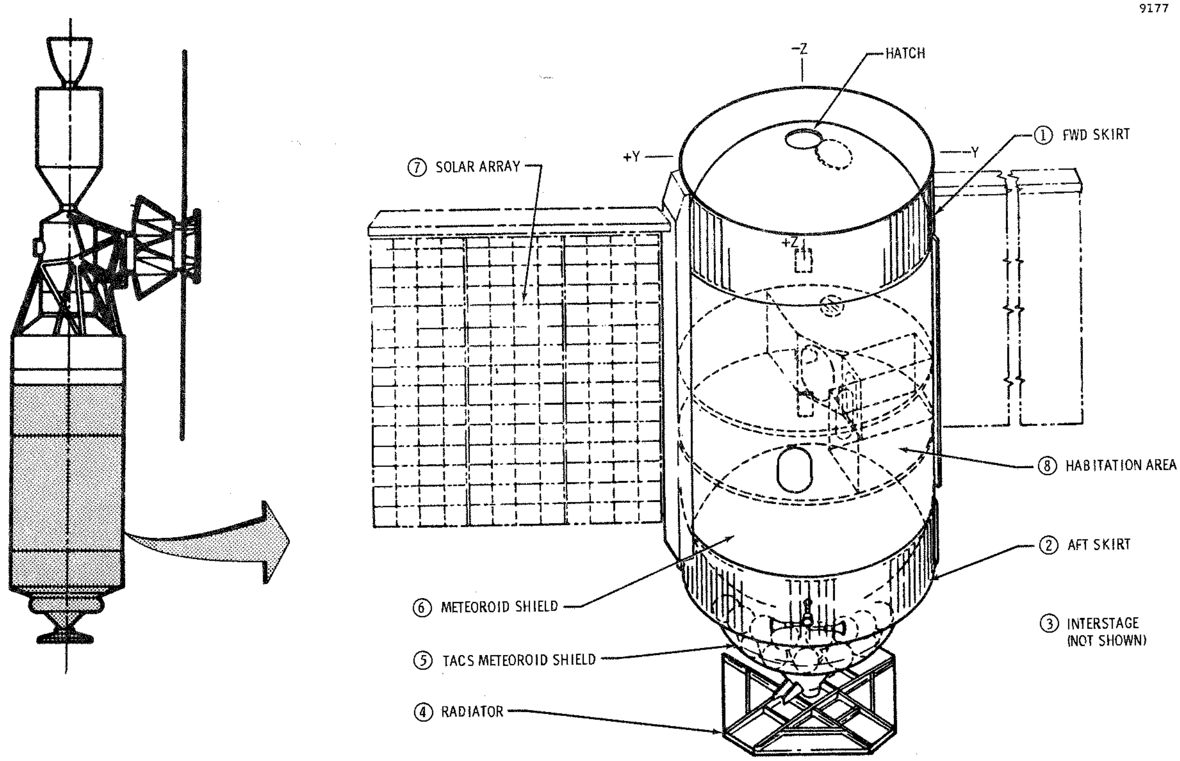


Figure 2.0.10-1 Orbital Workshop

## 2.0.10 ORBITAL WORKSHOP (OWS)

### 2.0.10.1 INTRODUCTION

The OWS is located aft of the IU and interfaces with the booster vehicle (figure 2.0.10-1). It provides the structural support for the SWS during launch and supports the SWS solar array that mounts to the forward skirt. The OWS contains the crew living quarters for the SWS, crew provisions, areas for food management and waste management, and experiment storage and work areas. In addition, the OWS contains the thruster attitude control system that controls the SWS attitude after separation from the S-II stage until the control moment gyroscopes of the ATM attitude pointing and control system are activated. The exterior of the OWS is fitted with an aluminum meteoroid shield, a solar array system (SAS), a radiator for the refrigeration system, and two rings of N2 bottles for the thruster attitude control system (TACS). The meteoroid shield is deployed in orbit and protects the OWS against micro-meteoroid penetrations. The SAS wing assemblies are also deployed in orbit and provide a source of electrical power to the SWS. The radiator is hardmounted to the thrust structure on the aft end of the OWS and is used to radiate heat absorbed by the refrigeration system.

The interior of the OWS is divided into two major areas, the habitation area and the waste tank, separated by a common bulkhead.

### 2.0.10.2 SYSTEM INTERFACES

The forward skirt of the OWS is attached to the IU and all launch loads from the AM, MDA, DA, ATM, PS are transmitted through this interface. The dome of the forward habitation area interfaces with the AM through the flexible bellows assembly. The aft end of the OWS fastens to the aft interstage. This interface is severed as the aft interstage and the S-II stage separate from the SWS.

### 2.0.10.3 CONFIGURATION

The habitation area (figure 2.0.10-2) is divided into the forward dome and forward compartment, which are used as a storage and work area, and the crew quarters, which is primarily the crew's living quarters. A third area, the aft compartment, located between the crew quarter's floor and the waste tank, is used as a plenum for the ventilation control system.

#### 2.0.10.3.1 Forward Compartment

Initial entry into the OWS from the AM is made through a hatch located at the apex of the dome in the forward compartment.

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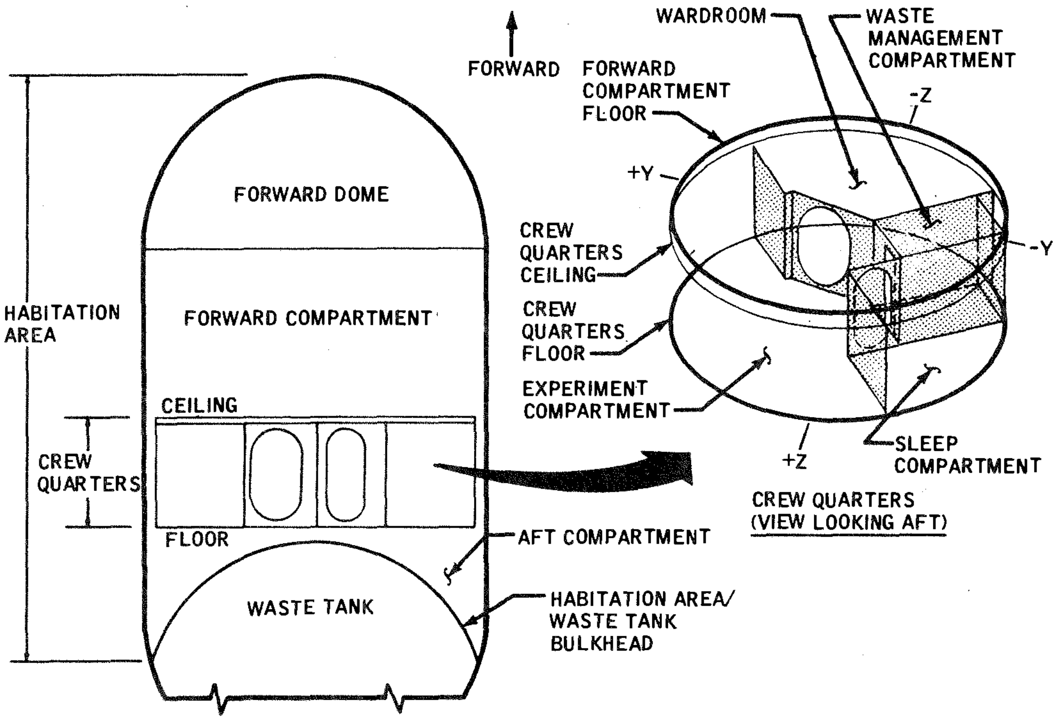


Figure 2.0.10-2 OWS Habitation Provisions

Ten water tanks are installed around the wall of the forward compartment (figure 2.0.10-3), supported by a corrugated panel between an upper and lower frame and fastened to the tank wall by means of a frame support.

Located just above the 10 water tanks are 25 stowage compartments in which are stowed waste management, personal hygiene, photographic, and maintenance equipment. There are also various stowage compartments and experiments installed on the floor (figure 2.0.10-4). All these containers are discussed in detail in paragraph 2.5.12.

In the dome area, a rectangular placard on each axis (+Y, -Y, +Z, -Z) identifies the locations of the dynamic body axes.

The forward compartment floor (figure 2.0.10-5) consists of an 8-inch beam structure sandwiched between triangular grid sections. A large hexagonal opening in the center of the floor provides ingress to or egress from the crew quarters. Two smaller openings in the floor, above the sleep compartment and wardroom, provide emergency egress from the crew quarters. The beam structure is constructed of channel beams in a triangular arrangement. The triangular grid sections are 0.4-inch thick aluminum plate, milled out to form the pattern of triangles and holes as shown in the figure. This open pattern not only allows the atmosphere to be circulated through the habitation area, but also provides a hand restraint for the crewman and a mounting surface for the various types of portable restraints and mobility aids (figure 2.0.10-4).

Two scientific airlocks (SAL) (figure 2.0.10-6) are located in the forward compartment, one on the -Z axis and one on the +Z axis.

These SAL's provide a means of deploying various pieces of experiment hardware through the OWS wall and exposing the hardware to space without depressurizing the entire habitation area.

The SAL is bolted directly to a flange on the OWS wall over a 8.25-inch square hole in the tank.

For more detailed information on the operation of the SAL, refer to SLEOH, Volume I.

2.0.10.3.2 Crew Quarters

The crew quarters contain the sleep compartment, waste management compartment, wardroom, and experiment compartment, and provides the crew with an area where they can conduct their normal daily activities and special tasks under living conditions approximating those experienced at 1-g (figure 2.0.10-7).

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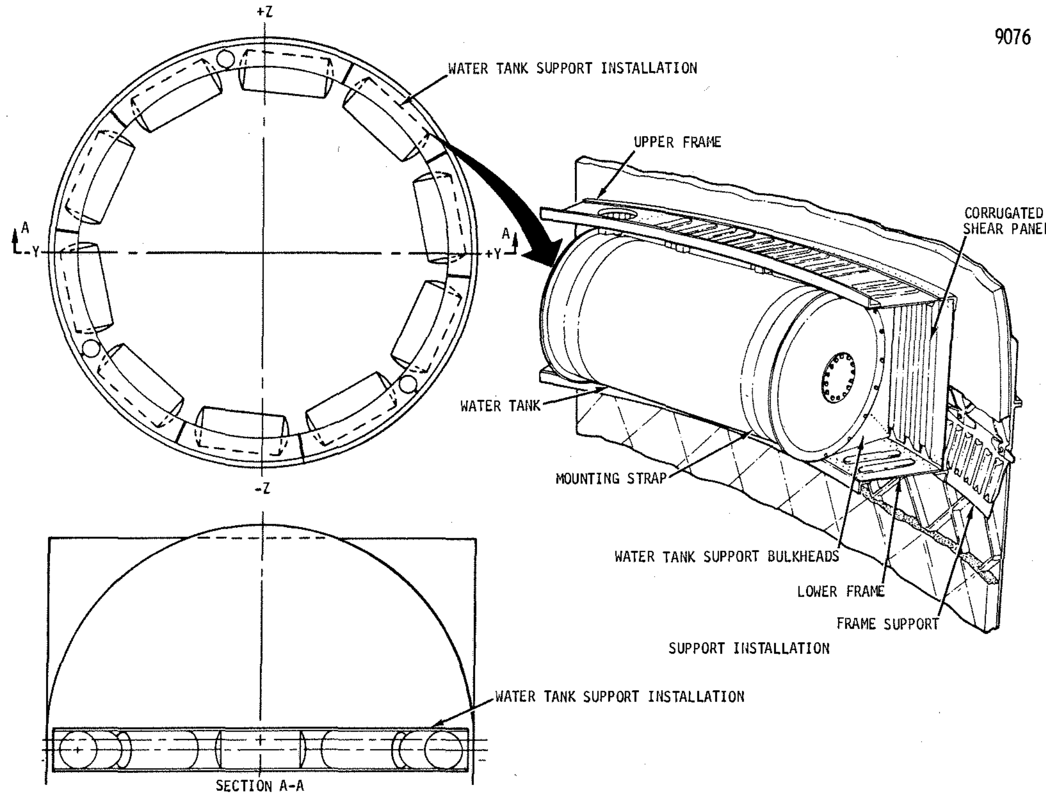


Figure 2.0.10-3 Water Tanks Configuration

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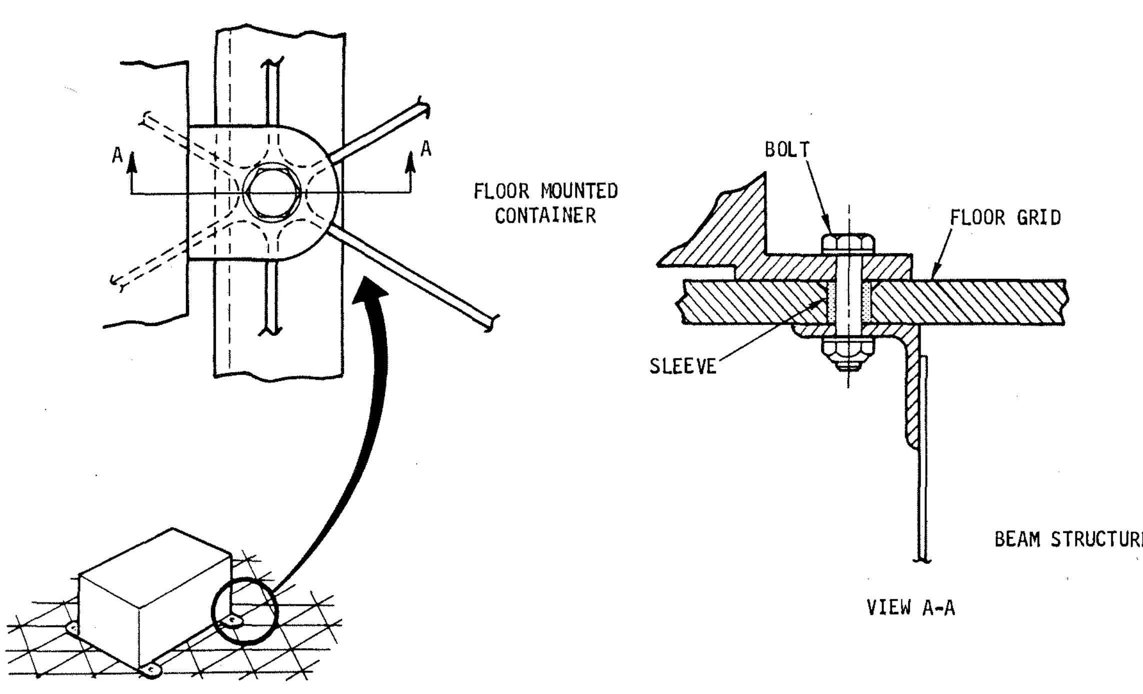


Figure 2.0.10-4 Container Floor Mounting

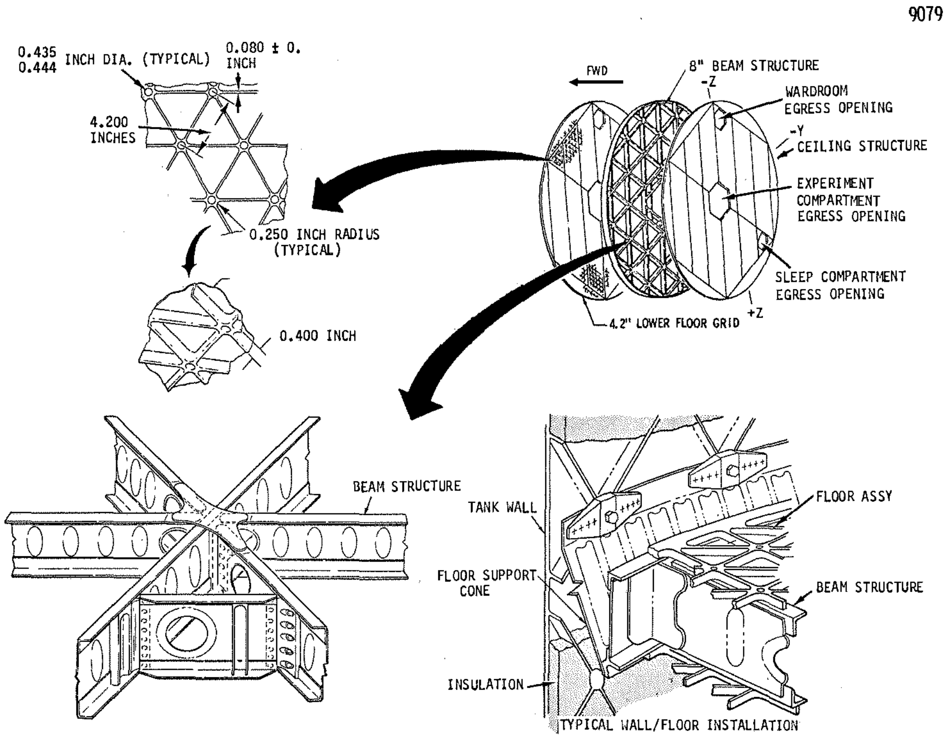


Figure 2.0.10-5 Forward Compartment Floor Structure

There are two types of partitions for walls dividing the crew quarters into compartments (figure 2.0.10-8). Both use triangular grid panels similiar to the grid sections used on the floor, except these panels have an integral skin 0.015 inch thick on one side, making it smooth. The double grid walls have a 3-inch beam between two grid panels. The grid panels have the smooth side exposed. The single grid walls have the grid side of the panels toward the experiment compartment.

The crew quarters floor is located 6.5 feet aft of the forward compartment floor. It is similar to the forward compartment floor but has a 0.04-inch aluminum sheet on the underside, nearest to the plenum instead of the triangular grid section. The floor has three openings similar to the forward compartment floor. The large center opening provides access to the trash airlock, and the two smaller openings (opposite the emergency egress openings in the forward compartment floor) provide access to the aft compartment (figure 2.0.10-9). The trash airlock is used for disposal of waste matter. For further information on the trash airlock, refer to paragraph 2.5.9.

2.0.10.3.2.1 Wardroom

The wardroom (figure 2.0.10-10) contains the facilities and supplies necessary to prepare and consume food.

The wardroom is accessible through an opening in the wardroom/experiment compartment partition. The opening has a movable fabric door, which features a breakaway provision for an emergency egress from the wardroom. Emergency egress from the wardroom into the OWS forward compartment is provided by an egress opening in the wardroom ceiling while entry into the aft compartment from the wardroom is gained through an opening in the floor. The wardroom floor contains three, dispersed, slightly raised diffusers to diffuse and vary the air flow entering the wardroom from the plenum. The wardroom ceiling provides compartment illumination through four overhead lights. The open grid on the ceiling provides compartment ventilation and is sturdy to facilitate body stabilization. Radiant heaters located on the wall adjacent to the wardroom entrance and located on the ceiling above the viewing window provide a comfortable environment in the wardroom for OWS initial entry. The habitation area tank wall in the wardroom contains a circular viewing window (figure 2.0.10-11). The window contains two panes of fused silica, 9/16 inch thick and 18 5/16 inch in diameter. The inner surface of the outer pane has an infra-red coating, and the outer surface of the inner pane has an ultra-violet coating. The center line of the window is 25°55 from the -Z axis toward the -Y axis. An aluminum shade on the inside can be slid across the window to keep out light. An intercom station is located below the window.

The wardroom has central food preparation and food consumption area where three crewmembers can simultaneously prepare daily meals and consume the food. Storage of a limited amount of food is in the wardroom through use of freezers, a chiller, and a galley.

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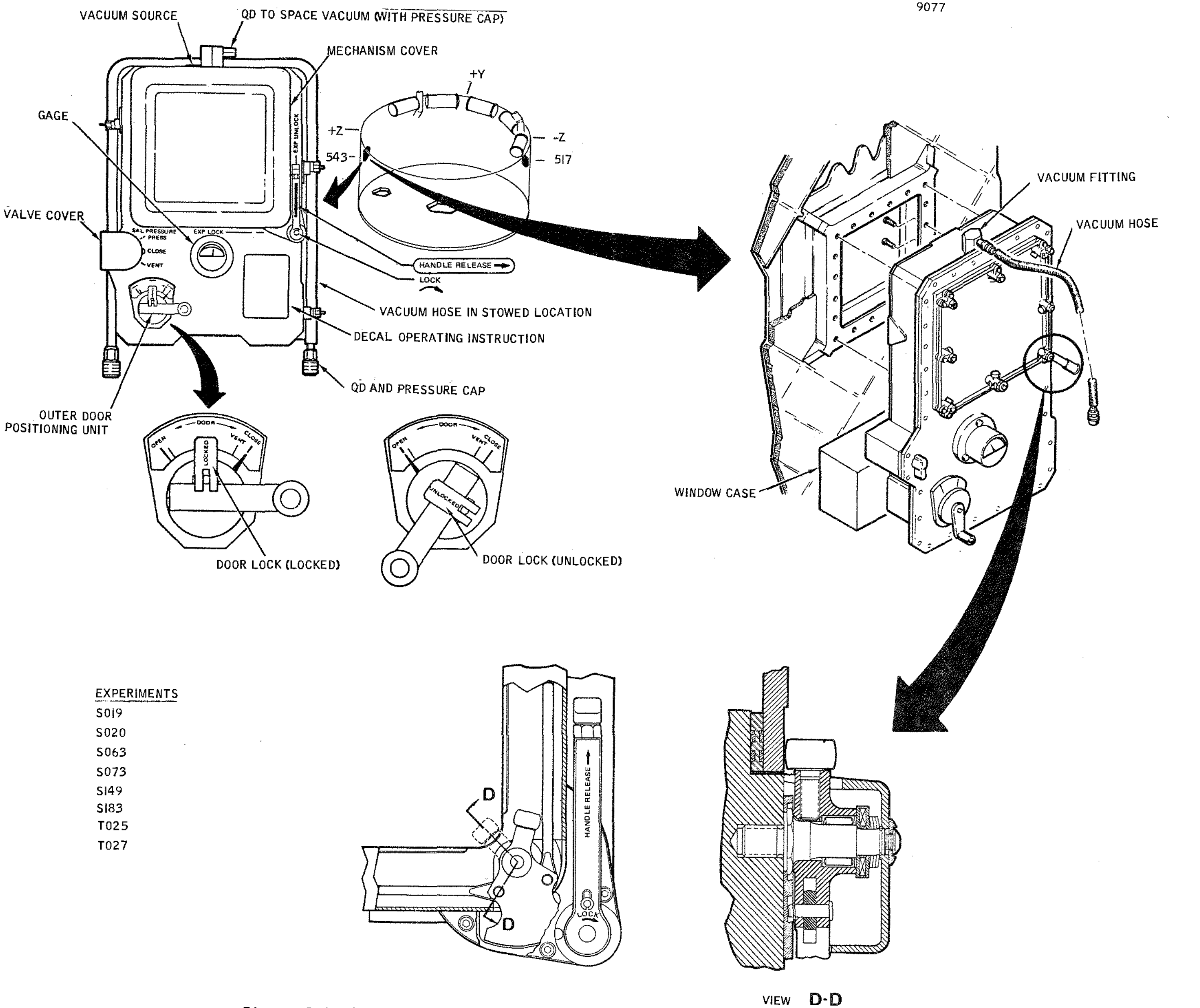


Figure 2.0.10-6 Scientific Airlock Configuration

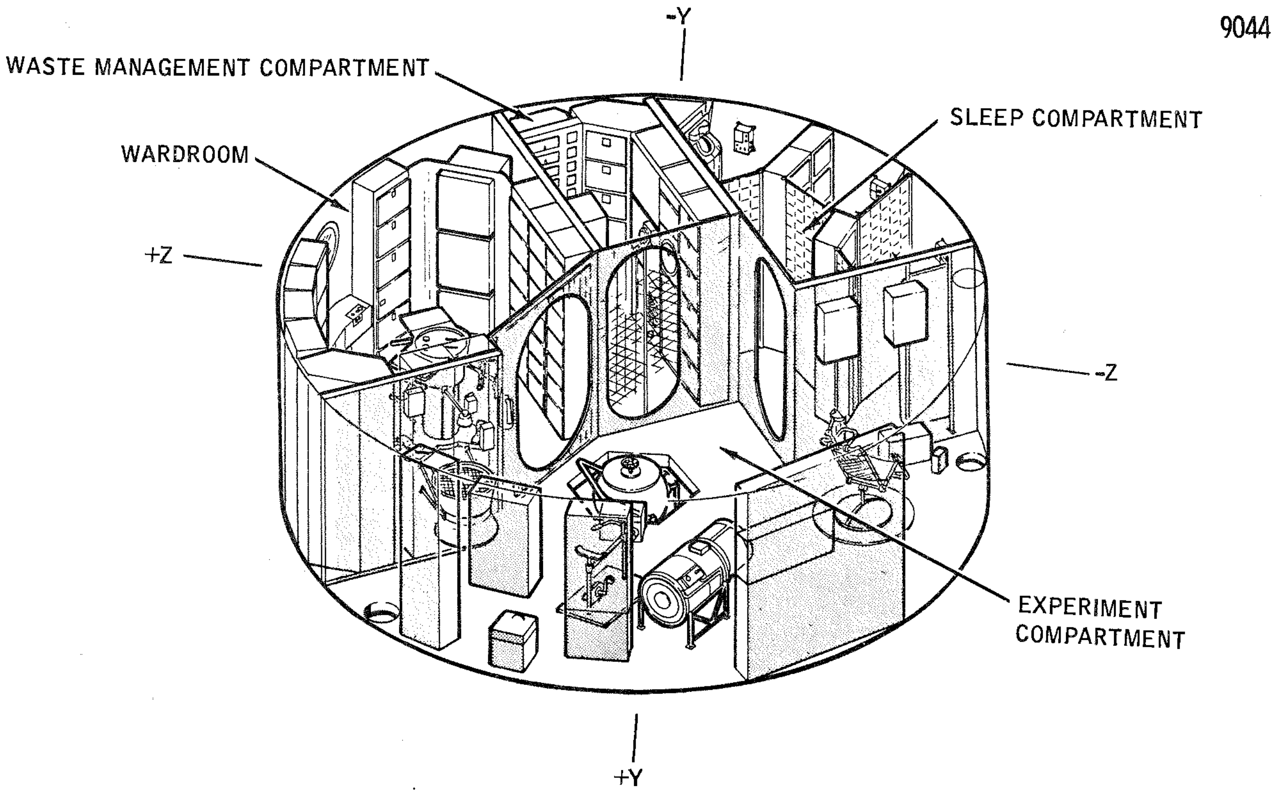


Figure 2.0.10-7 Crew Quarters Layout

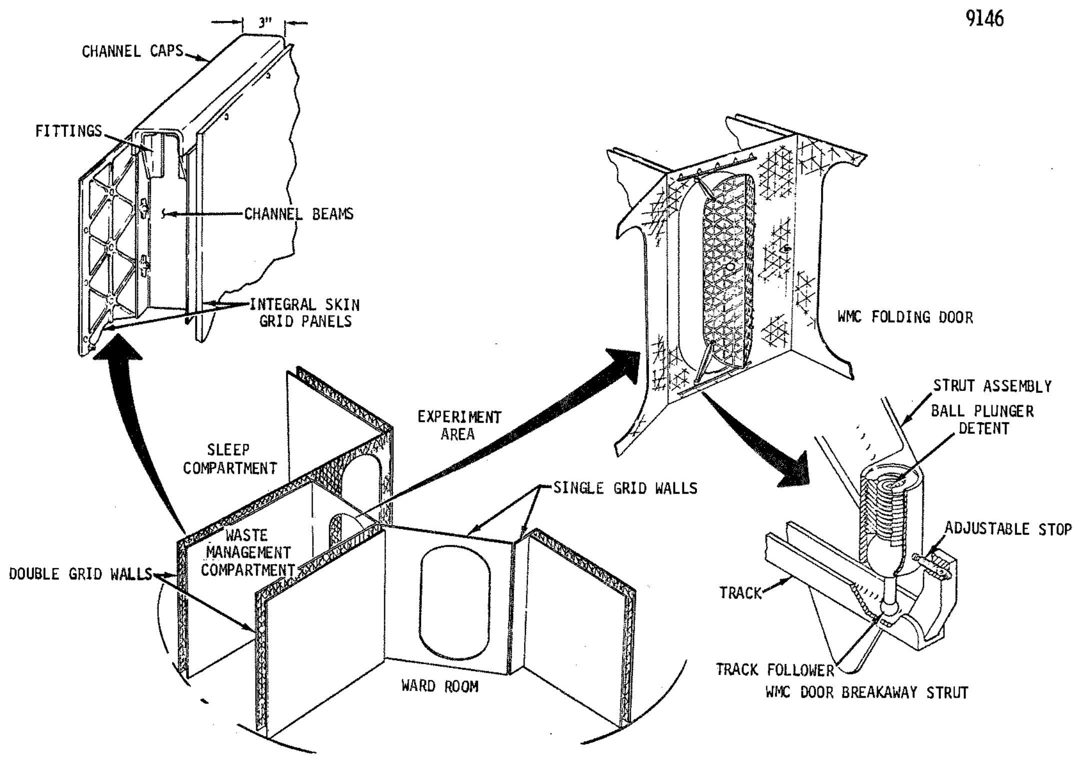


Figure 2.0.10-8 Crew Quarters Wall Arrangement

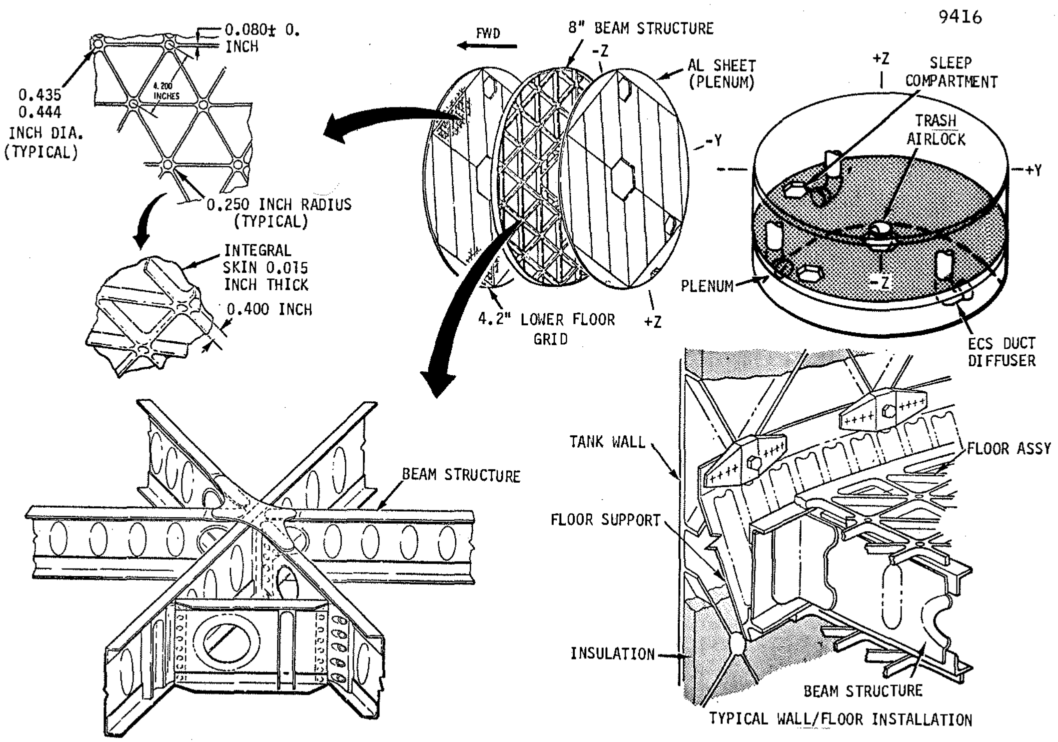


Figure 2.0.10-9 Crew Quarters Compartment Floor Structure

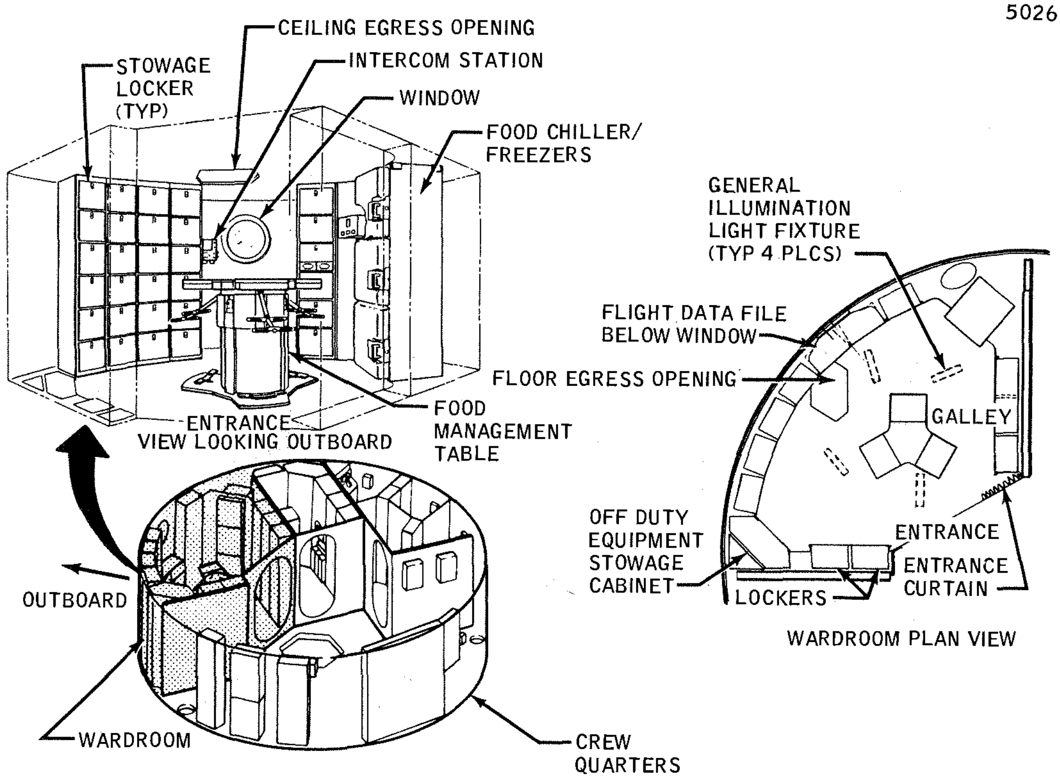


Figure 2.0.10-10 Wardroom Arrangement

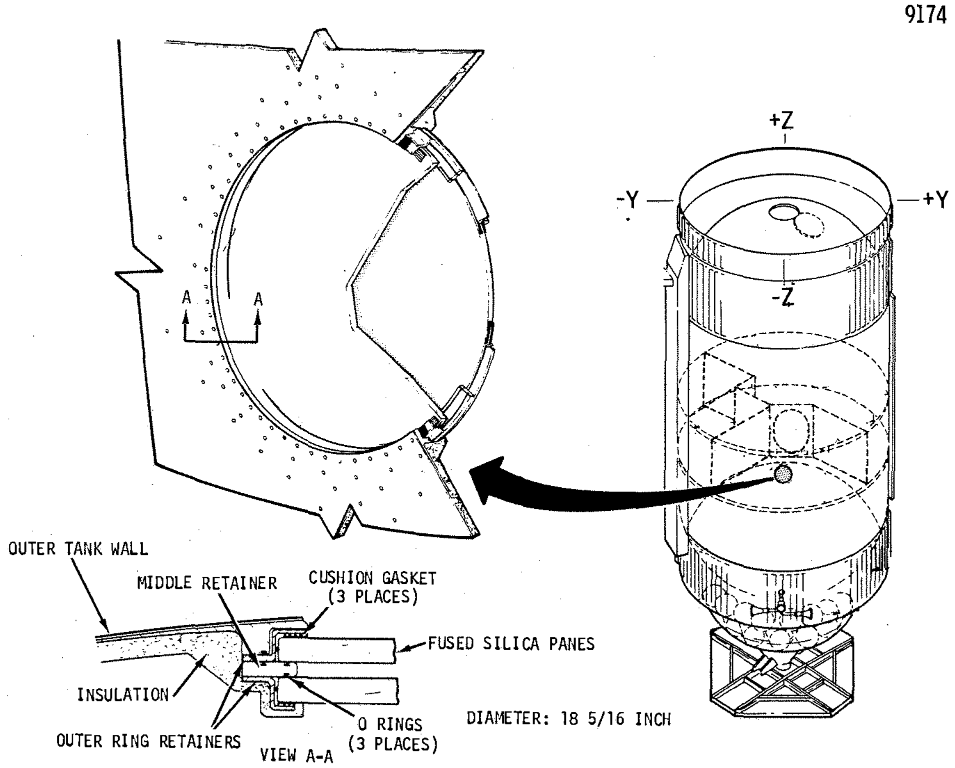


Figure 2.0.10-11 Wardroom Viewing Window

A food table is floor-mounted in the center of the wardroom and provides an eating area and off-duty table with crewmember thigh restraints. Foot restraints, located on the floor below each table thigh restraint, facilitate stabilization in the table area. The OWS wardroom water network supplies potable water to the table for drinking and for hot and cold food reconstitution.

2.0.10.3.2.2 Waste Management Compartment (WMC)

The waste management compartment (figure 2.0.10-12) contains the equipment and supplies necessary to support activities involved with the maintenance of personal hygiene and the hygienic collection and processing of body wastes.

The WMC is accessible through a "telephone booth" style door on the WMC/experiment compartment partition. Breakaway features on the door allow for emergency egress from the WMC. The compartment is completely enclosed to prevent particle and odor migration and to provide privacy. The WMC floor contains a slightly raised diffuser to diffuse and vary the air flow entering the compartment from the aft compartment. The WMC ceiling contains three overhead lights and also mounts the intake of the recirculation fan, which ventilates the compartment and removes odors in the WMC air. Two pairs of foot restraints are mounted on the floor in front of the fecal/urine collector and the handwasher. In addition, a handrail is installed on the ceiling to provide body restraint while performing tasks in the WMC. An intercom box is mounted in a stowage compartment.

A fecal/urine collector is mounted on the WMC wall and provides a gravity substitute airflow to collect feces and urine and to refrigerate the pooled urine over a 24-hour collection period. A urine freezer is located in the WMC to store and to preserve, on-orbit, the sampled urine for eventual return to earth. A six-compartment waste processor is mounted on the WMC wall and provides the equipment to dehydrate feces and vomit to facilitate on-orbit storage for eventual return to earth. Urine dump equipment mounted in a corner stowage compartment in the WMC provides an area within which residual urine is dumped into the waste tank.

A recessed handwasher, mounted on the WMC wall adjacent to the fecal/urine collector and below the mirror, provides a partial-body cleansing facility. The WMC water network supplies water to the hand-operated water dispenser in the handwasher. A washcloth and towel drying area is located on the WMC wall adjacent to the compartment entrance and contains appropriate restraints to permit air drying of wetted items.

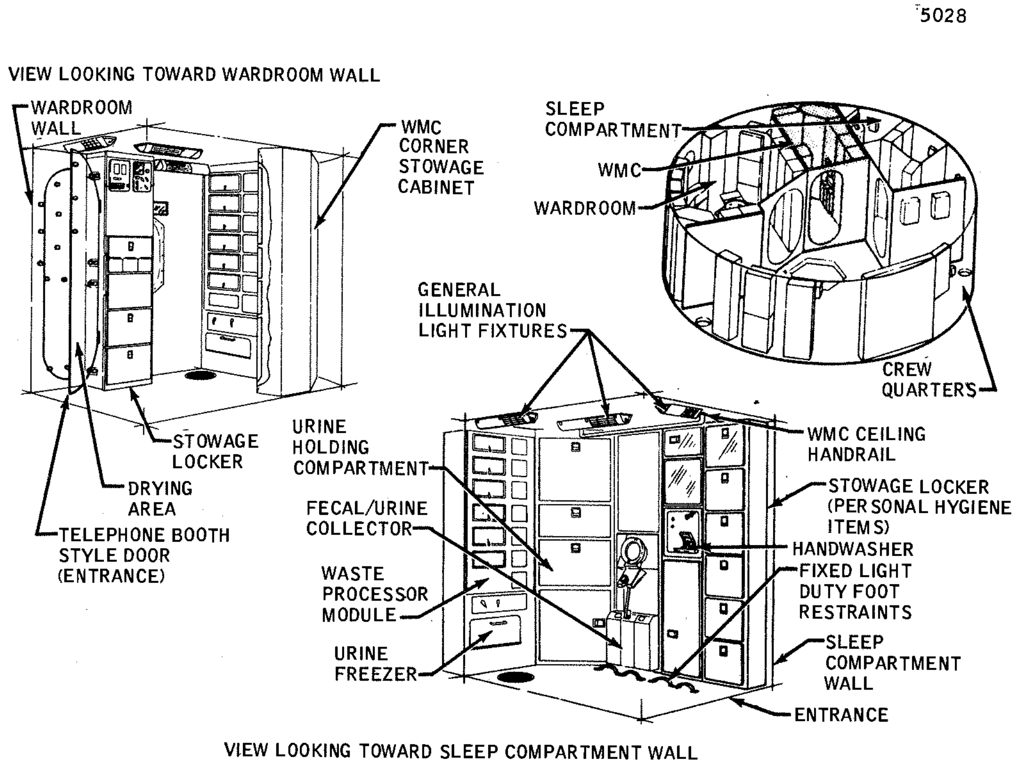


Figure 2.0.10-12 WMC Arrangement

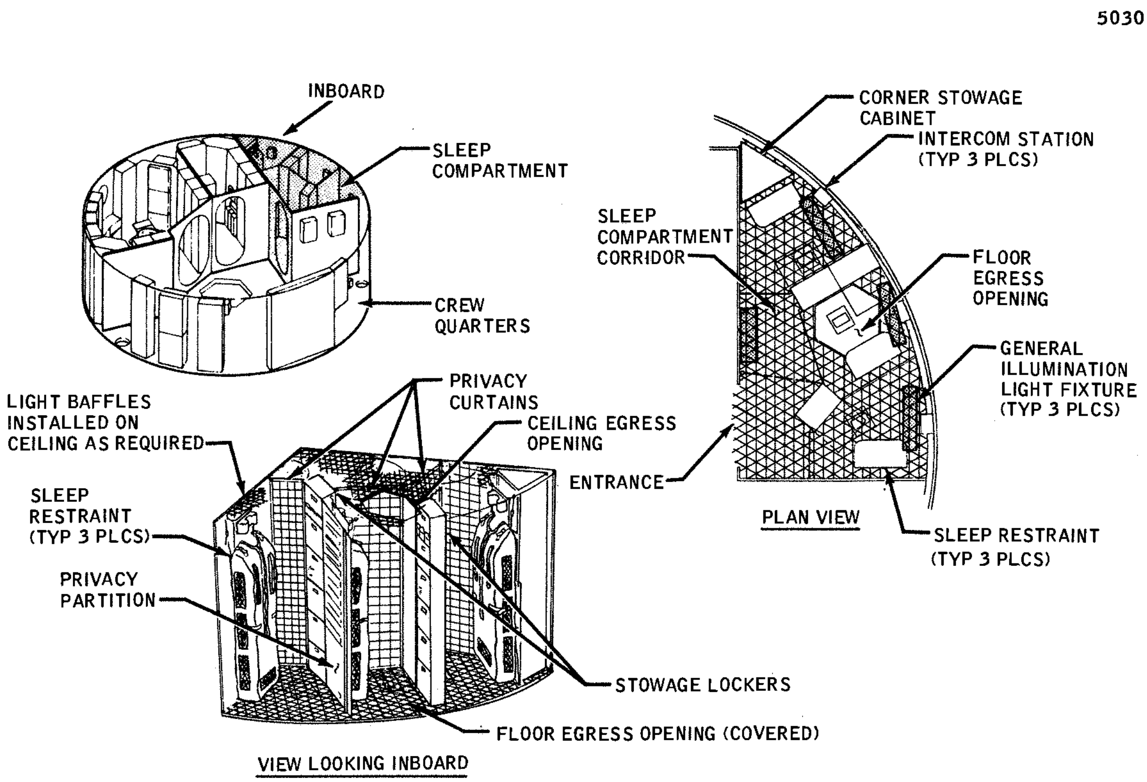


Figure 2.0.10-13 Sleep Compartment Arrangement

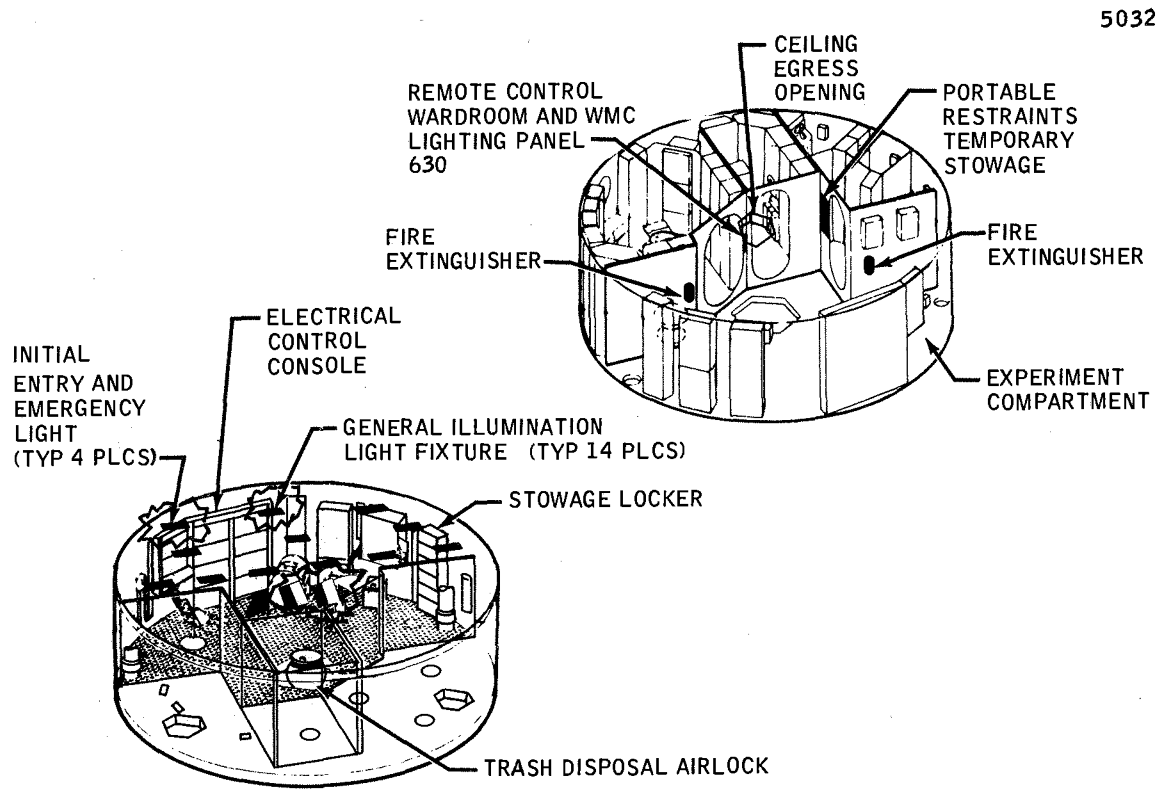


Figure 2.0.10-14 Experiment Compartment Arrangement

2.0.10.3.2.3 Sleep Compartment

The sleep compartment (figure 2.0.10-13) provides the crewmembers with individual, private sleeping accomodations.

The sleep compartment is accessible through an opening in the sleep compartment/experiment compartment partition. The interior of the compartment is divided into three isolated sleep areas with each area being accessible from the sleep compartment corridor. The corridor wall immediately adjacent to the sleep compartment entrance contains a wall-mounted radiant heater. Normally, this heater is only used prior to activation. The sleep compartment provides each of three crewmembers with individual, private sleeping accomodations, utilizing privacy curtains, partitions, and sleep restraints. The floor in each sleep area contains a slightly raised diffuser to diffuse and vary the air flow entering the compartment from the aft compartment. The central sleep area contains an opening in the floor to permit passage into the aft compartment and contains an egress opening in the ceiling to permit emergency egress into the OWS forward compartment.

The open grid on the ceiling provides compartment ventilation, is sturdy to facilitate body stabilization, and holds an overhead light in each sleep area to provide area illumination. An intercom box is located on the wall in each sleep area.

2.0.10.3.2.4 Experiment Compartment

The experiment compartment (figure 2.0.10-14) is utilized to perform duties associated with experimentation and serves as the control center of the OWS.

The experiment compartment interfaces with each crew quarters compartment through the installation of partitions. An opening in each compartment partition allows transfer to and from the experiment compartment. The floor in the experiment compartment contains an opening that provides access to the trash disposal airlock. The flooring also contains five, slightly raised diffusers that diffuse and vary the air flow entering the compartment from the aft compartment. The ceiling in the experiment compartment contains an access opening for egress into the OWS forward compartment and 14 overhead lights. The open grid on the ceiling provides compartment ventilation and a sturdy structure to facilitate body stabilization.

Two intercom boxes are located on the habitation area tank wall in the experiment compartment. Radiant heaters are mounted at three locations: one on the tank wall, one on the wardroom/experiment compartment partition, and one on the ceiling to provide a comfortable environment in the experiment compartment for initial entry. Utility outlets are installed on the tank wall and on compartment partitions to provide electrical power to operate various items of mission equipment. Two fire extinguishers are located on the compartment partitions.

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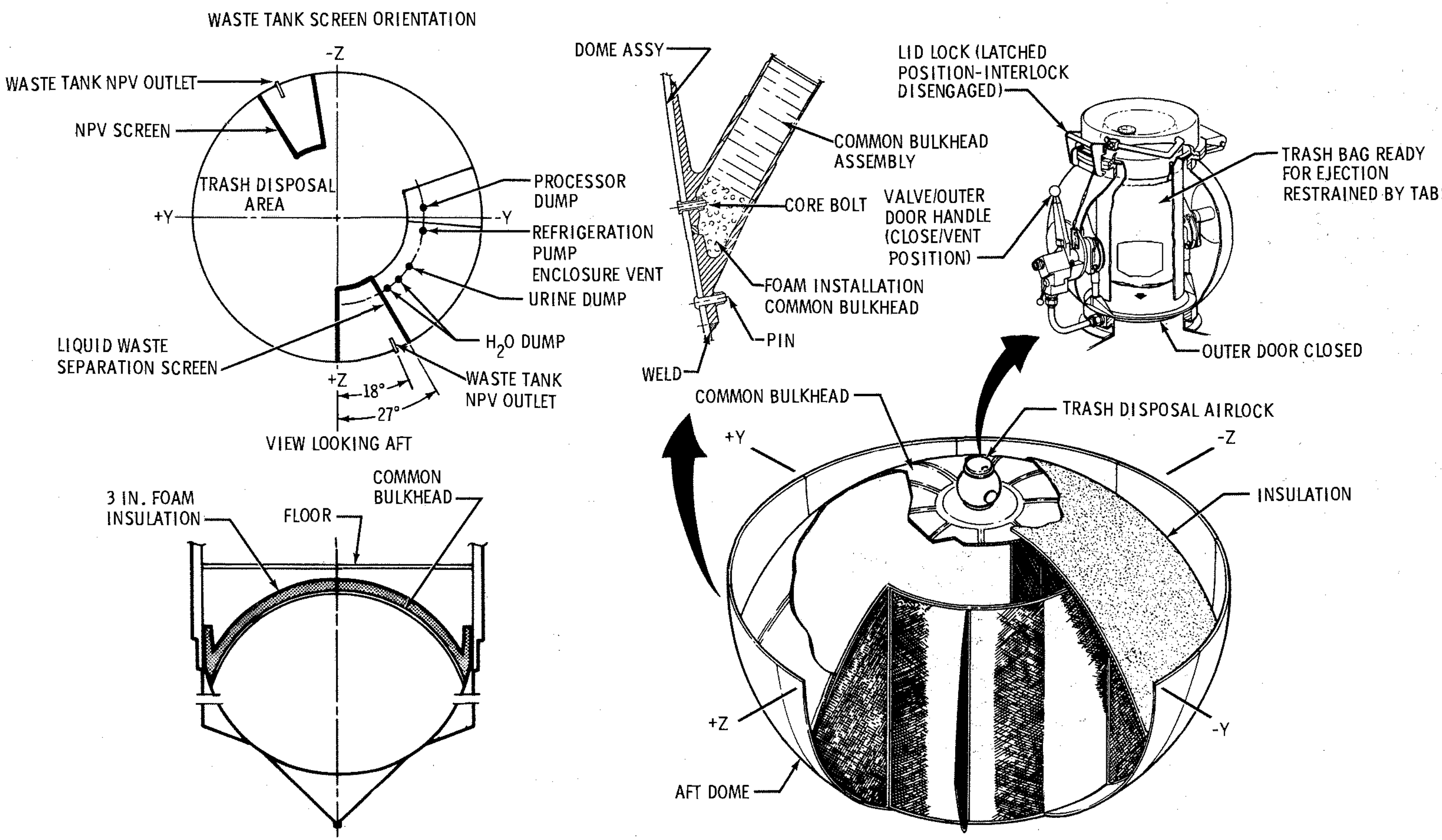


Figure 2.0.10-15 Waste Tank

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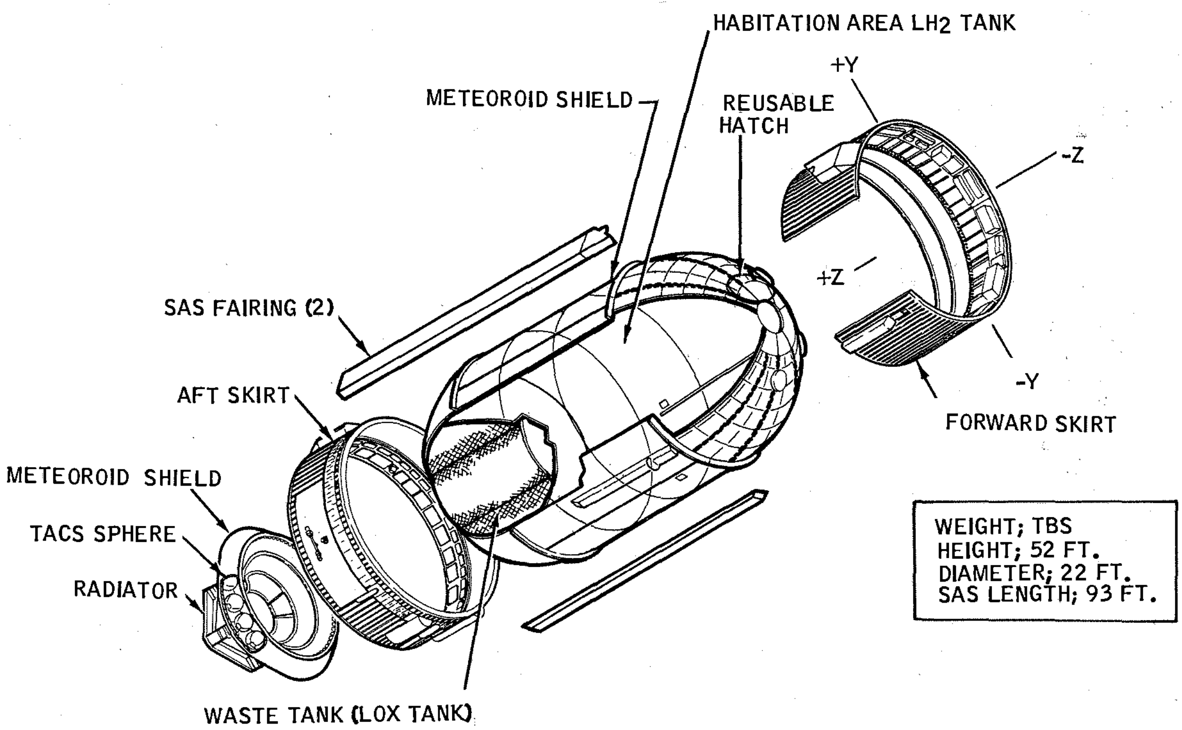



Figure 2.0.10-16 Major Structural Assemblies

2.0.10.3.2 Waste Tank

The waste tank (figure 2.0.10-15) shares a common bulkhead with the habitation area and interfaces with the crew quarters through a trash airlock. The common bulkhead is covered with a 3-inch layer of thermal insulation. The interior of the tank has a network of 16 mesh screen installed to prevent solids and liquids from migrating about. A separate screen enclosure surrounds each of the waste tank non-propulsive vent (NPV) outlets to ensure that only gases escape from the waste tank. A third screen enclosure protects the wardroom water dump, WMC water dump, urine dump, and refrigeration pump enclosure vents from becoming clogged by solid particle migration. The remaining enclosure protects the waste processor dump. For further information on the trash disposal subsystem, refer to paragraph 2.5.9.

2.0.10.4 SUBSYSTEM AND MAJOR COMPONENT DESCRIPTION

The OWS is divided into nine major structural assemblies (figure 2.0.10-16):

- o Forward skirt
- o Aft skirt
- o Habitation and waste tank
- o Thrust structure, TACS spheres and meteoroid shield
- o Refrigeration radiator
- o Solar array system
- o Meteoroid shield
- o OWS hatch
- o Aft interstage (not shown)

The aft interstage will be discussed in this section, but it actually separates with the S-II stage and is not part of the orbiting SWS.

2.0.10.4.1 Forward Skirt

The forward skirt (figure 2.0.10-17) is a cylindrical structure (21.7 feet in diameter and 10.2 feet high) located between the IU and the OWS habitation area wall. Electronics hardware is mounted to the interior of the forward skirt. The solar array system beam fairings structurally attach to the forward skirt through the forward fairing of the beams. Additionally, the meteoroid shield forward torsion links hinge off of the aft flange of the forward skirt. The structure is semi-monocoque, with three internal rings strengthened externally by hat section stringers.

At the interface the forward skirt fastens the OWS to the IU with a bolted connection of 216 bolts. The intersection of the habitation area tank to the forward skirt is insulated with a beaded aluminum and fiberglass thermal shield (figure 2.0.10-17).

2.0.10.4.2 Aft Skirt

The aft skirt (figure 2.0.10-18) is a cylindrical structure (21.7 feet in diameter and 7.2 feet high) located between the OWS habitation area wall and the aft interstage. It supports the TACS thrusters and provides a tiedown for the aft end of the SAS. The meteoroid shield aft torsion arms are also attached to the skirt. Structurally the aft skirt consists of the same configuration as the forward skirt.

2.0.10.4.3 Habitation and Waste Tank

The OWS habitation tank consists of a forward dome, a cylindrical section, a common bulkhead, and a portion of the aft dome that it shares with the waste tank. The waste tank is made up of the common bulkhead and the aft dome. The forward dome is a 260-inch diameter hemisphere constructed of 9 segments of 2014 T651 aluminum. The segments are milled to a thickness of 0.060 inch. The 42-inch diameter OWS hatch is mounted at the apex of the dome. One inch of foam insulation is internally bonded to the dome, which is then lined with a layer of fiberglass cloth, a layer of aluminum foil, and a layer of teflon to provide a fire retardant liner. Externally mounted to the forward dome is 48 layers of aluminized mylar with dacron spacers (figure 2.0.10-19).

The cylindrical portion of the habitation tank structure consists of cylindrical skin segments welded together and welded to the forward and aft domes. The cylindrical section is constructed of 2014 T651 aluminum with an internal machined waffle pattern. The webbed sections are 0.75 inch thick, the milled skin is 0.123 inch thick. To the interior of the structure is bonded a 1-inch layer of foam, fiberglass, aluminum foil, and teflon (figure 2.0.10-19). The aft dome is a 260-inch diameter hemisphere made up of nine segments of a sphere. It has a minimum skin thickness of 0.082 inch. This dome closes the aft ends of both the waste tank and the habitation tank.

A common bulkhead separates the waste tank from the habitation area. The common bulkhead has a diameter at the aft end of 125 inches and a spherical radius of 130 inches. The bulkhead is constructed of two aluminum spherical shells with phenolic honeycomb bonded between the two. The habitation side of the common bulkhead is coated with 3 inches of foam insulation.

2.0.10.4.4 Thrust Structure TACS Spheres and Meteoroid Shield

The thrust structure is a 94-degree cone-shaped structure on the aft dome of the waste tank. The thrust structure is used to support the TACS spheres, the pneumatic power control sphere, the sphere meteoroid shield, and the refrigeration system radiator (figure 2.0.10-20). Structurally, the thrust structure is made up of six skin segments of 0.032 inch thickness riveted together. Twenty-four full-length and twenty-four intermediate-length external stringers are used to stiffen the cone. The cone is 65 inches in height, with a diameter of 167 inches at the intersection with the aft dome and a small diameter of 27 inches at the aft end.

At the aft end of the thrust structure is attached the J-2/S-IVB gimbal fitting assembly, to which the refrigeration system radiator is attached.

The TACS storage sphere meteoroid shield covers 23 spheres and manifolds located on the thrust structure. The shield is an annular shape, consisting of eight identical segments attached together with screws. The shield is a sandwich structure (foam between aluminum face sheets). The annulus is bolted to frames added around the thrust structure (figure 2.0.10-20).

2.0.10.4.5 Refrigerator Radiator

The refrigeration system radiator (figure 2.0.10-21) is an irregular octagon-shaped aluminum structure attached to the OWS thrust structure at the engine mount. Its surface area, coated with zinc oxide, is 84 square feet and its surface plane is 5 degrees off the perpendicular to the OWS centerline. The slight inclination prevents the sun's rays from directly hitting the radiator surface plane while the SWS is in the solar inertial attitude.

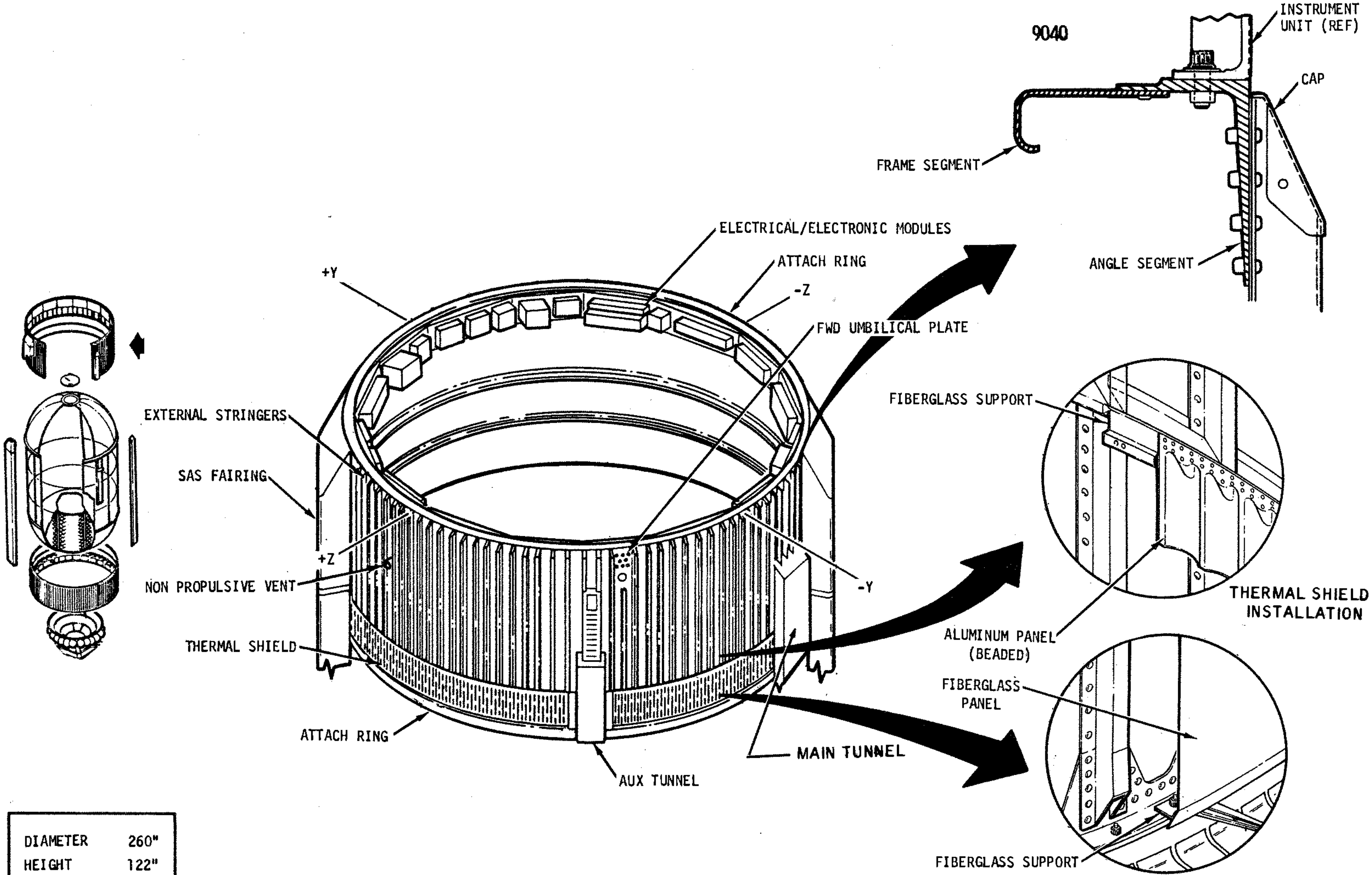
The radiator shield is jettisoned by IU automatic sequence at approximately 9 minutes after launch. The RS PROTECTIVE SHIELD JETTISON - ON command closes two magnetic latch relays, which apply sequential Bus 1 and Bus 2 power to redundant solenoid valves. A backup can be sent through the AM DCS that will actuate the control valve solenoids (figure 2.0.10-22).

The physical separation is accomplished by energizing a dual piston pneumatic actuator that operates a ball release mechanism attached to the shield. A spring mounted in the release mechanism provides enough force to eject the protective shield at a velocity sufficient to preclude stage recontact by the shield (figure 2.0.10-22).

2.0.10.4.6 Solar Array System

The OWS solar array system (SAS) consists of two deployable wing assemblies mounted on diametrically opposite sides of the OWS (figure 2.0.10-23). Each wing assembly (figure 2.0.10-24) is made up of the following:

o A forward fairing assembly attached permanently to the OWS to provide space for hinge and actuation mechanisms and to give forward-end aerodynamic shape.
o A beam fairing assembly that extends aft from the forward fairing assembly and is secured to the OWS by the hinge mechanism and explosive release devices.




| | |
|---|---|
| DIAMETER | 260" |
| HEIGHT | 122" |

Figure 2.0.10-17 Forward Skirt Assembly

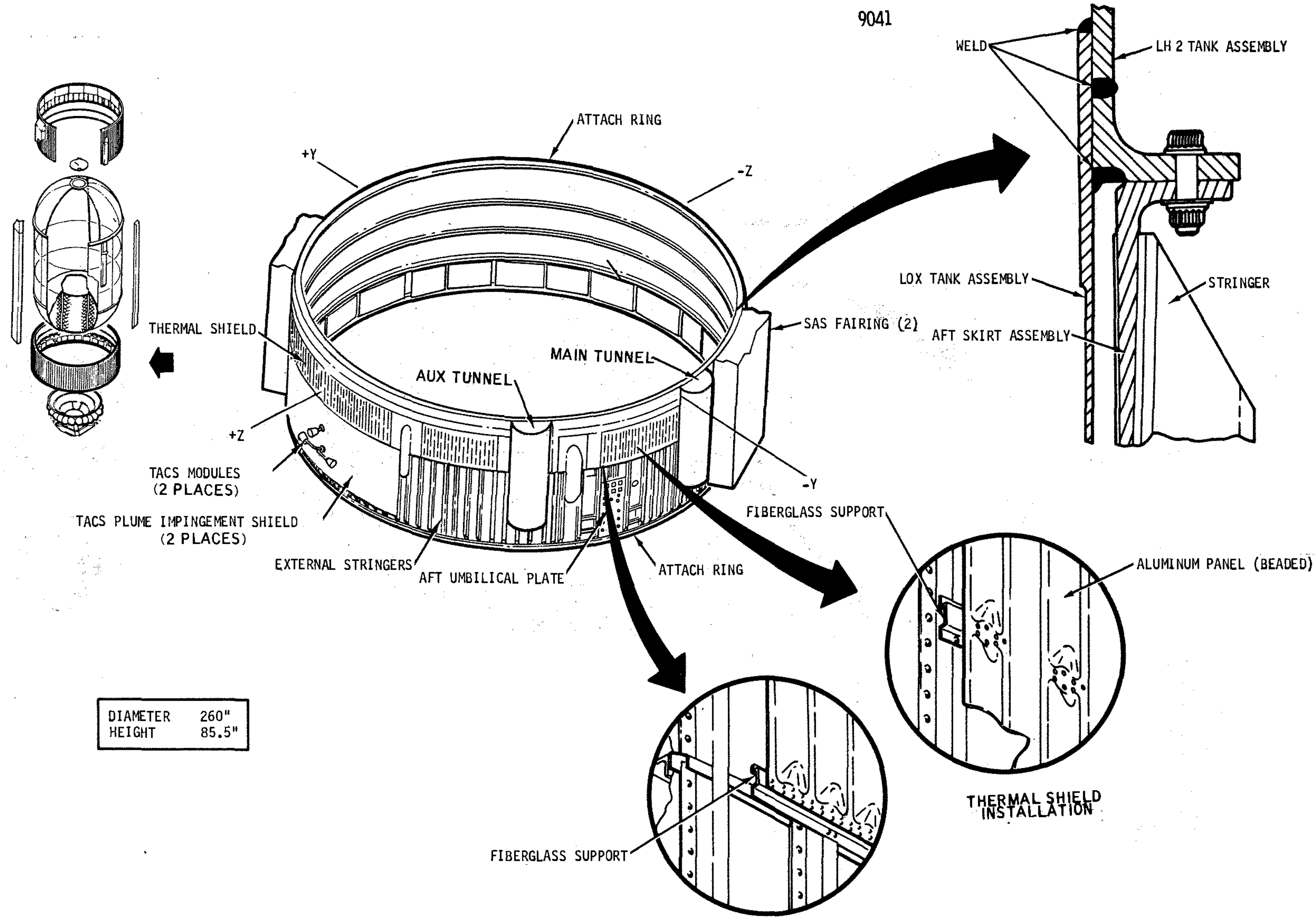



Figure 2.0.10-18 Aft Skirt Assembly

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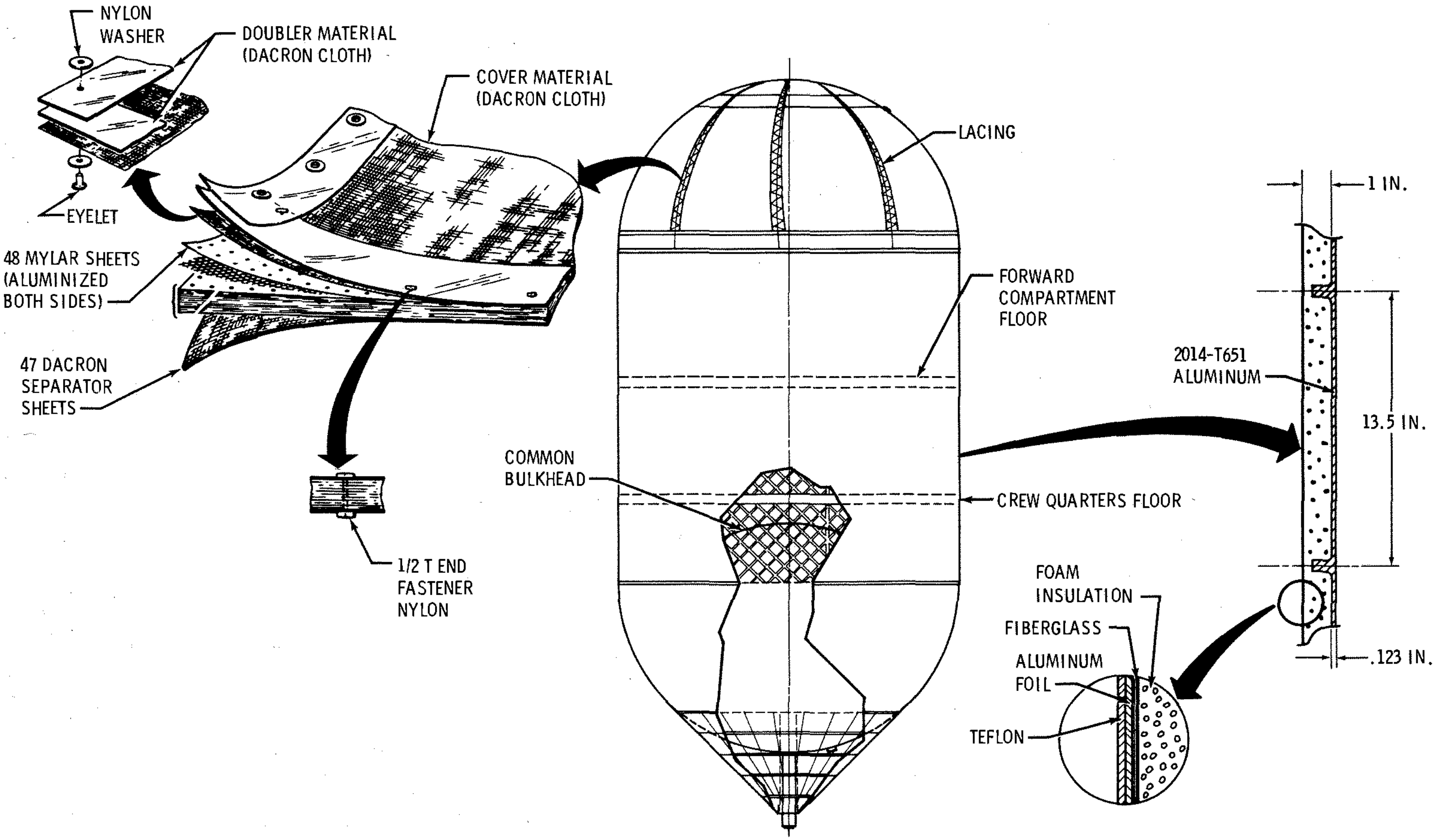


Figure 2.0.10-19 OWS Habitation Tank

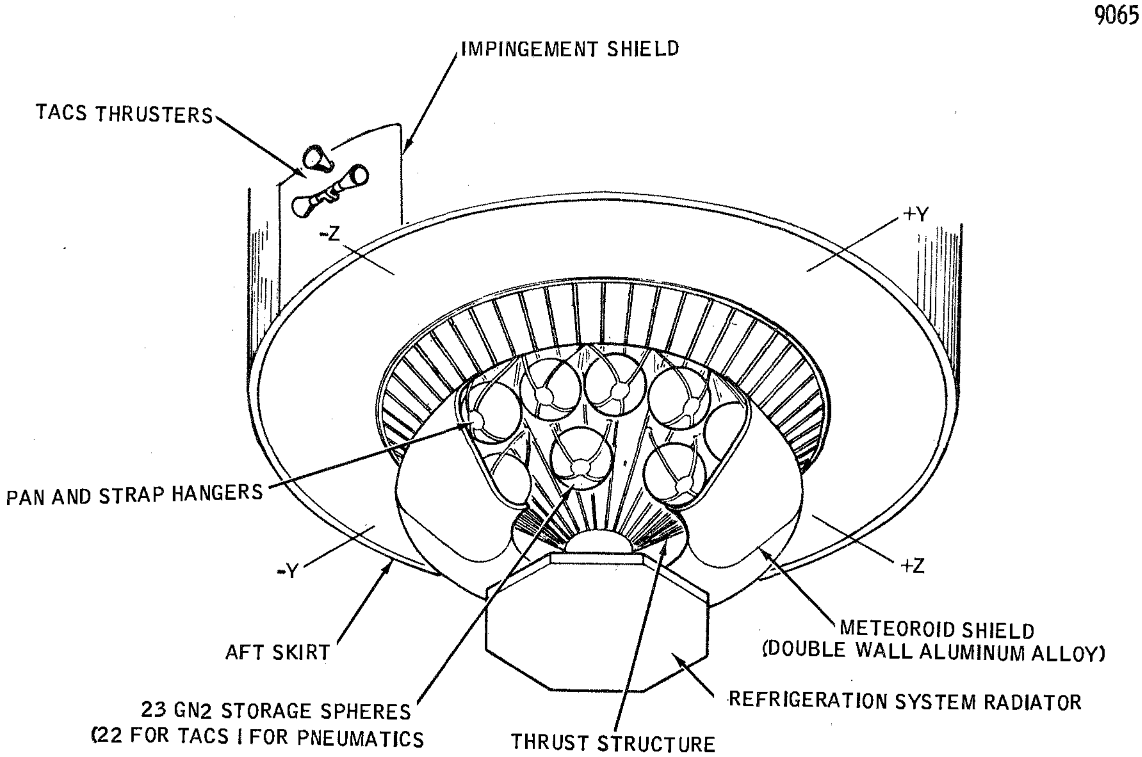


Figure 2.0.10-20 TACS Spheres and Meteoroid Shield

- o Three basically identical wing section assemblies folded and stored within an internal cavity in the beam fairing.
- o Mechanical and ordnance systems required to deploy the SAS in orbit.
- o Stabilizing beams that hold the wing sections in the deployed position.

The forward fairing assembly is a box-beam type structure (figures 2.0.10-23 and 2.0.10-25) extending from the forward end of the forward skirt aft to the hinge between the forward fairing assembly and beam-fairing assembly. The slope at the forward end of the fairing is approximately 20 degrees to withstand aerodynamic and thermal loads during boost. The box-like part of the forward fairing houses the deployment mechanism and hinge, which interfaces with the beam fairing.

The beam fairing is 4 feet wide by approximately 37 feet long and includes a dummy section, which houses the deployment actuator attach points and hinge, and the beam-fairing section, which houses the stowed wing sections. Holes for venting the fairing during the boost phases are provided in the aft portion of the beam-fairing section. The six tie-down points, using pyrotechnic separation devices, are attached to brackets mounted to the forward and aft skirts (figure 2.0.10-25).

Each wing assembly (figure 2.0.10-24) has three wing sections that are deployed out of the beam fairing. Each wing section consists of 10 solar cell panels, a dummy solar cell panel, a truss-type panel, and two parallel stabilizer beams.

The truss-type panel is fastened to the beam fairing and to the dummy panel. The dummy panel, in turn, is connected to the first of 10 active solar cell panels. All the panels are hinged together and are folded, accordion style, on one another into the beam fairing until deployment. Each panel is 120 inches by 27 inches and is connected to the stabilizer beam with a swivel fitting.

Each of the parallel stabilizer beams consists of five 54-inch sections and two 27-inch sections (one at each end). The sections are truss-type structures approximately 1.75 inches by 6 inches with machined hinge fittings at the center. The beam sections incorporate spring locks between each segment that lock when the wing section is fully deployed. Release of the beam fairings to permit their deployment is accomplished by means of an ordnance system. The beam fairings are held against the OWS by means of six separation blocks, each of which contains a frangible tension link and two explosively actuated expandable tube assemblies (figure 2.0.10-25).

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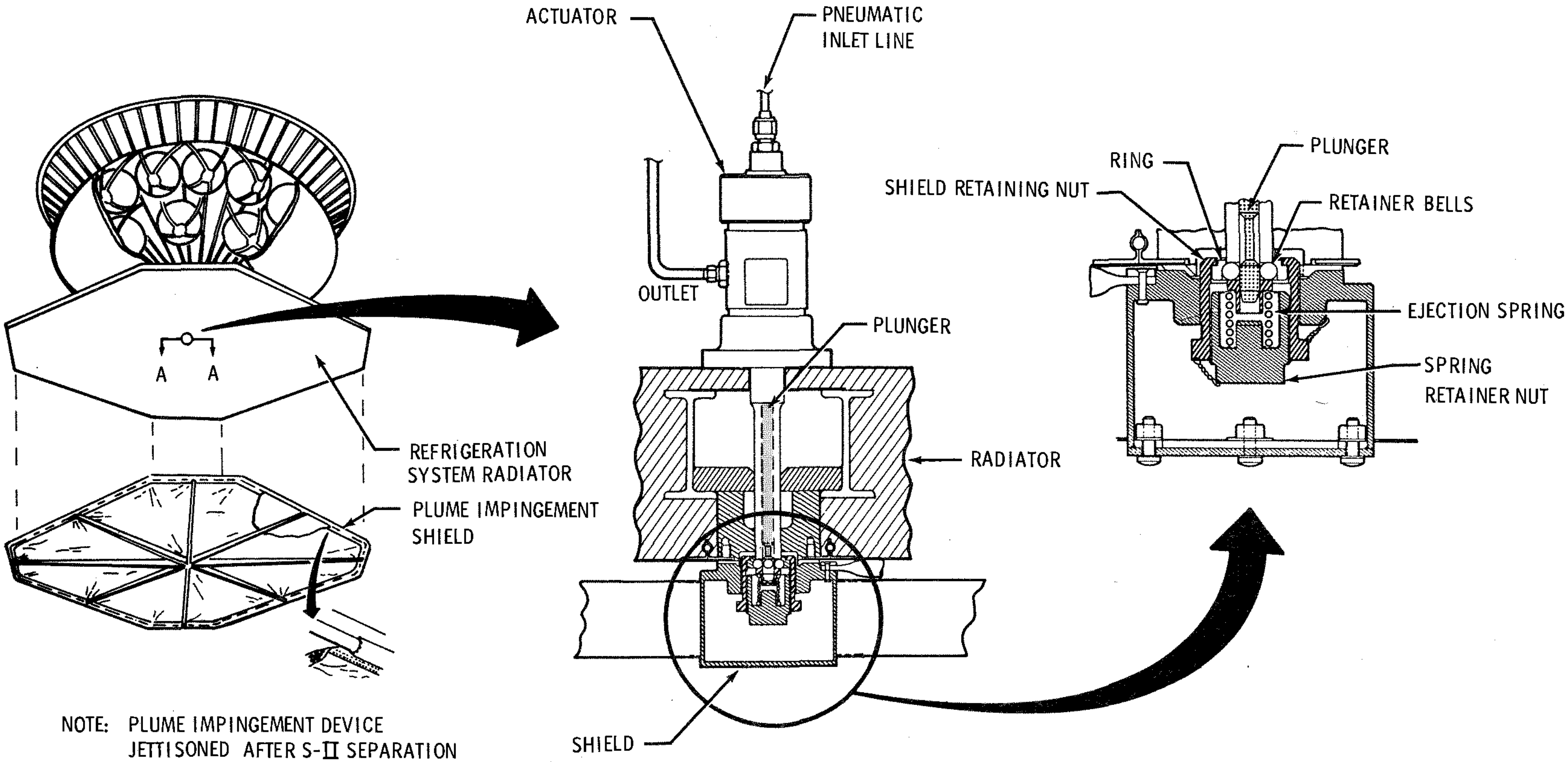


Figure 2.0.10-21 Radiator Plume Impingement Shield

9817

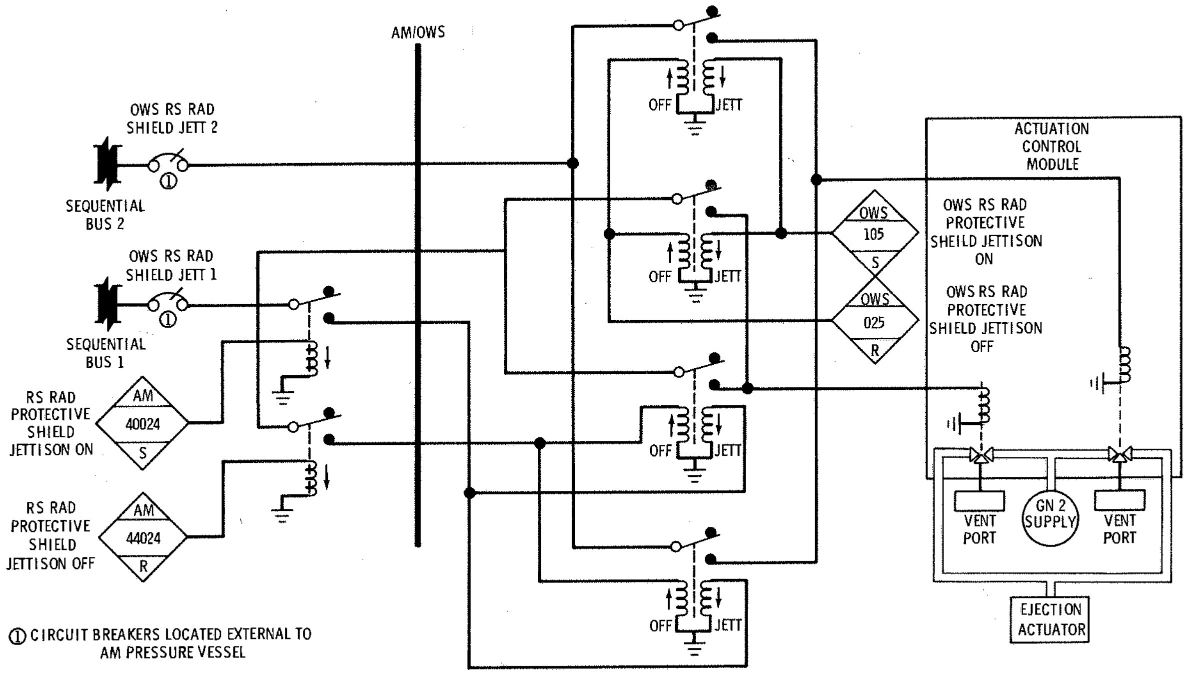


Figure 2.0.10-22 Regrigeration System Radiator Protective Shield Jettison

9186

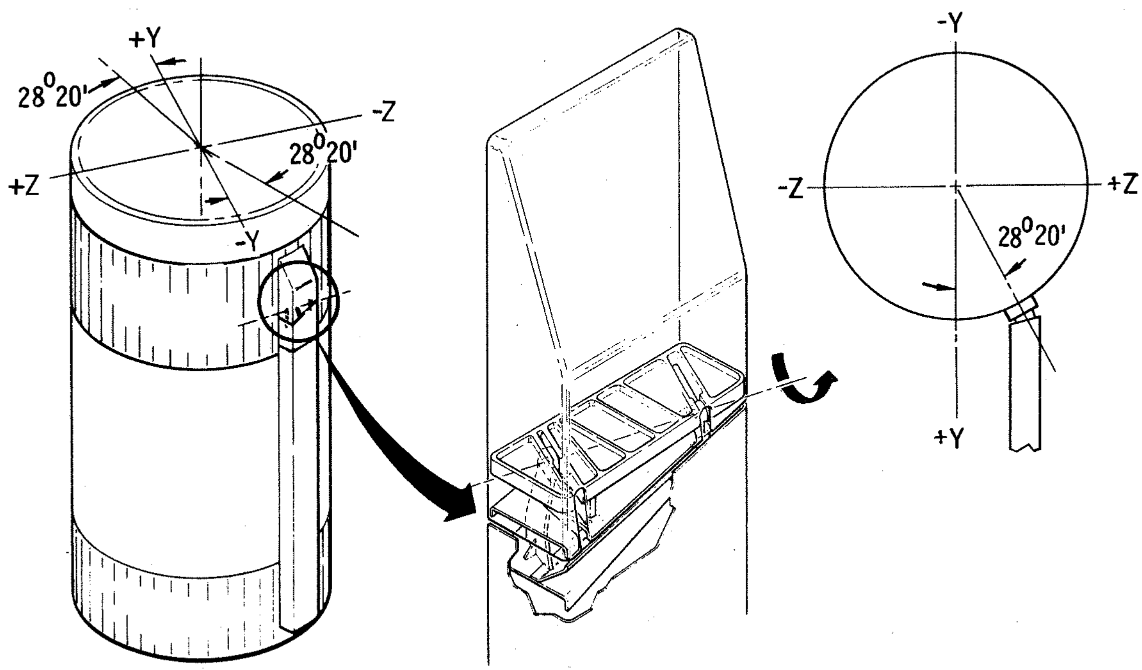


Figure 2.0.10-23 Solar Array Beam Fairing

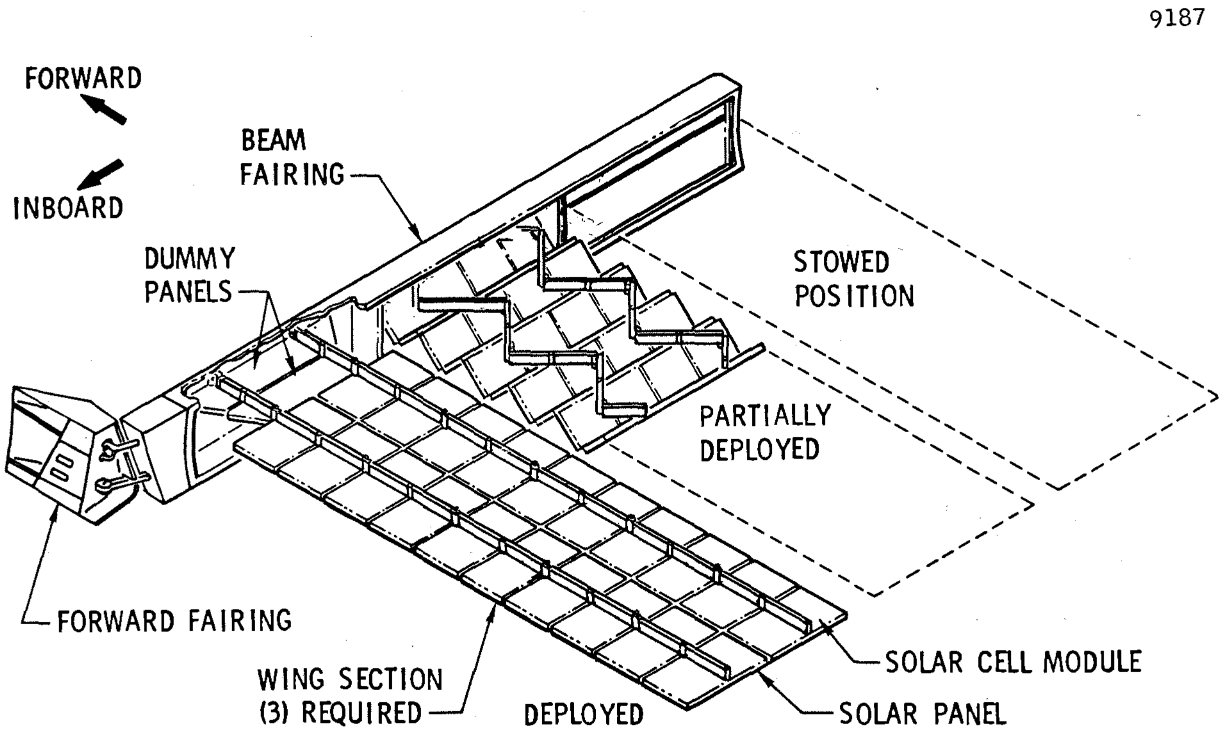


Figure 2.0.10-24 SAS Wing Assembly

The separation blocks are installed between the OWS and the beam fairings at the time of installation of the SAS on the OWS. Mounting holes on the inboard side of the separation block mate with fittings on the OWS forward and aft skirts. The outboard side of each separation block is equipped with a track and slide and has a mounting hole pattern in the track to mate with the interface hole pattern on the beam fairing (figure 2.0.10-26).

Prior to installation, the separation blocks are adjusted so that the desired pre-load is obtained in the frangible link. When installed, the separation block will resist loads in the OWS radial and tangential directions and permit relative motion between the OWS and the SAS in the fore and aft direction.

The expandable tube installed in the outboard position in each frangible link is mated with an ordnance train, designated as the primary ordnance system. Confined detonating fuse (CDF) assemblies in the primary system are routed inside the solar array fairing, across the hinge line into the fixed fairing, and through an opening in the forward skirt, terminating in a CDF manifold.

The expandable tubes are fired by means of the CDF assemblies, which mate with the tubes at the forward end and are routed across the hinge line and into the forward skirt where the CDF tees are used to join the corresponding CDF assemblies from the other wing. The CDF ordnance trains terminate at the primary EBW firing units.

The redundant expandable tube, mounted in the inboard position in the frangible link, mates with a backup ordnance system. The backup ordnance system consists of CDF assemblies and CDF manifolds installed entirely on the OWS structure. Both systems mate with exploding bridgewire (EBW) firing systems consisting of EBW detonators and EBW firing units. The firing unit for the primary system is wired to receive a command from the Instrument Unit (IU). The backup command is via the Airlock Module (AM) Digital Command System (DCS).

The deployment sequence is initiated by the IU automatic sequenced command SAS FAIRING EBW FU NO 2 CHARGE. This command applies deploy bus 2 power to charge EBW firing unit 2. Five seconds later, the SAS FAIRINGS EBW FU NO 2 FIRE command is sent, triggering firing unit 2 and detonating the CDF of the primary ordnance system (figure 2.0.10-27). The deployment of the SAS beam fairings can be redundantly deployed by the AM DCS. Firing unit 1 and the redundant expandable tube assembly are utilized in this case.

The beam fairings are deployed by the damped spring actuator located at the beam fairing hinge (figure 2.0.10-28). The damped spring actuator is essentially a spring that is compressed while the beam is in the stowed position. When the fairing releases releases at the tie points, the spring extends applying force to the hinge lever arm. This results in the beam fairing being deployed. To dampen the deploy rate, a hydraulic cylinder and piston is attached to the spring as shown in figure 2.0.10-28. The beam fairings are latched when they reach the fully

9078

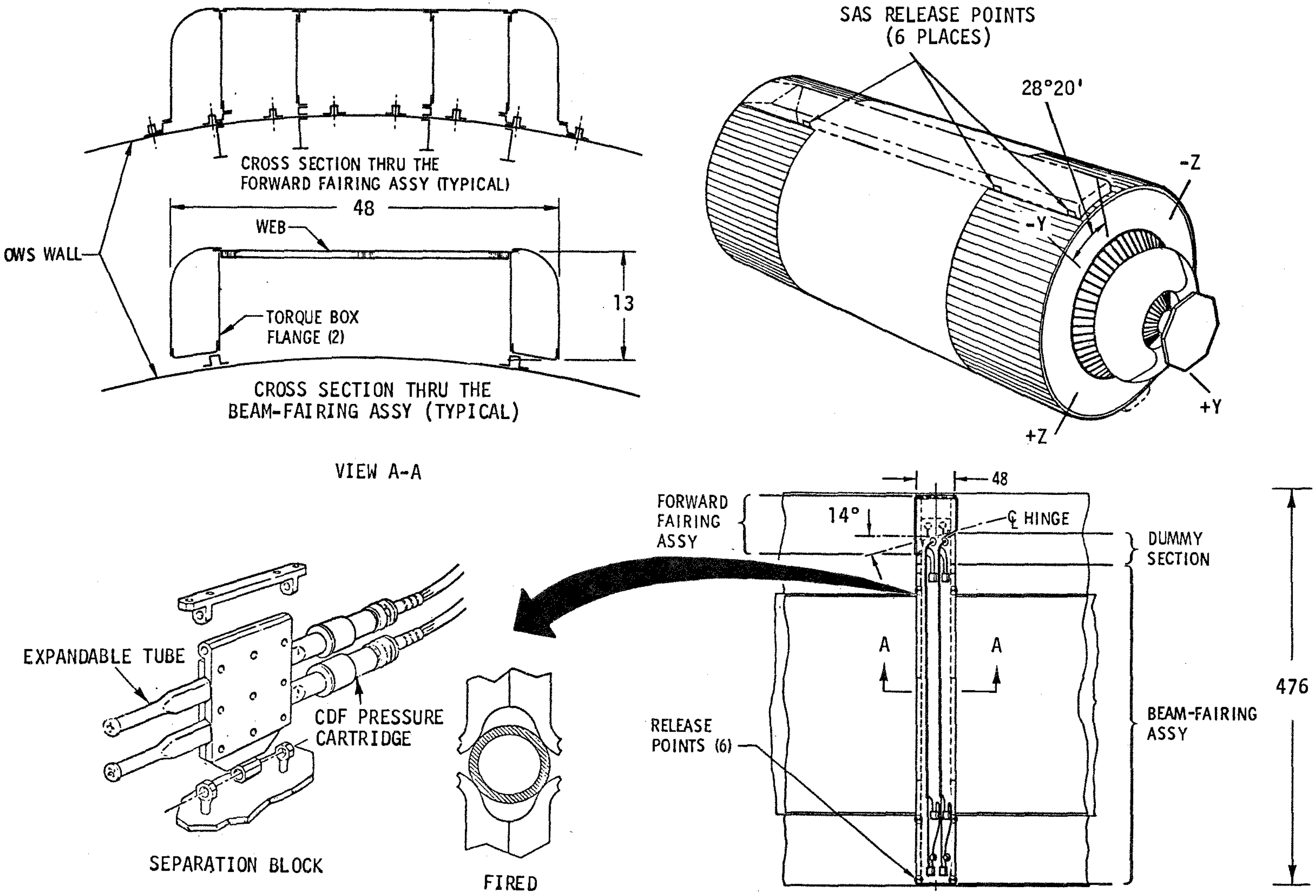


Figure 2.0.10-25 SAS Stowed Configuration

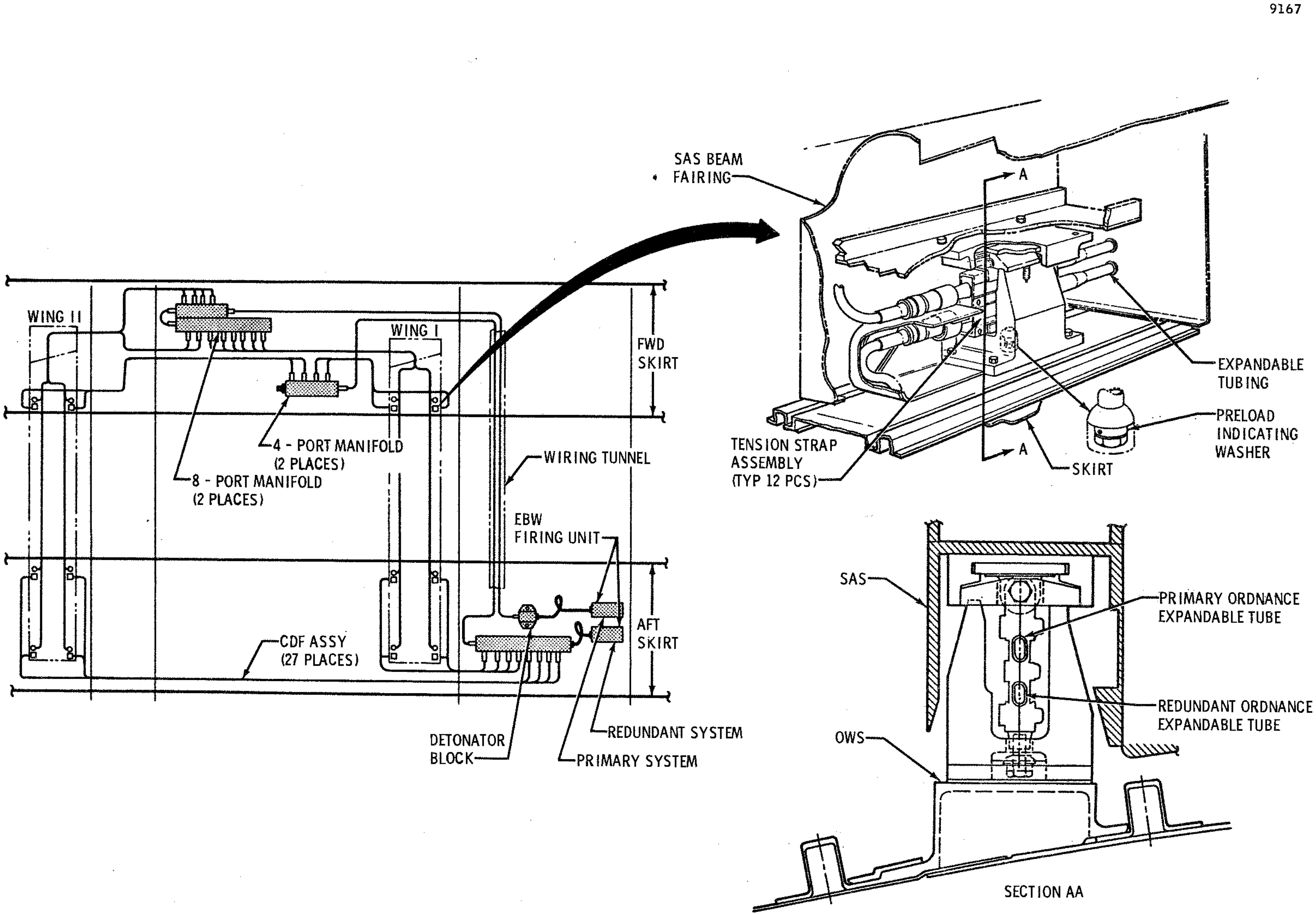


Figure 2.0.10-26 SAS Beam Fairing Release System

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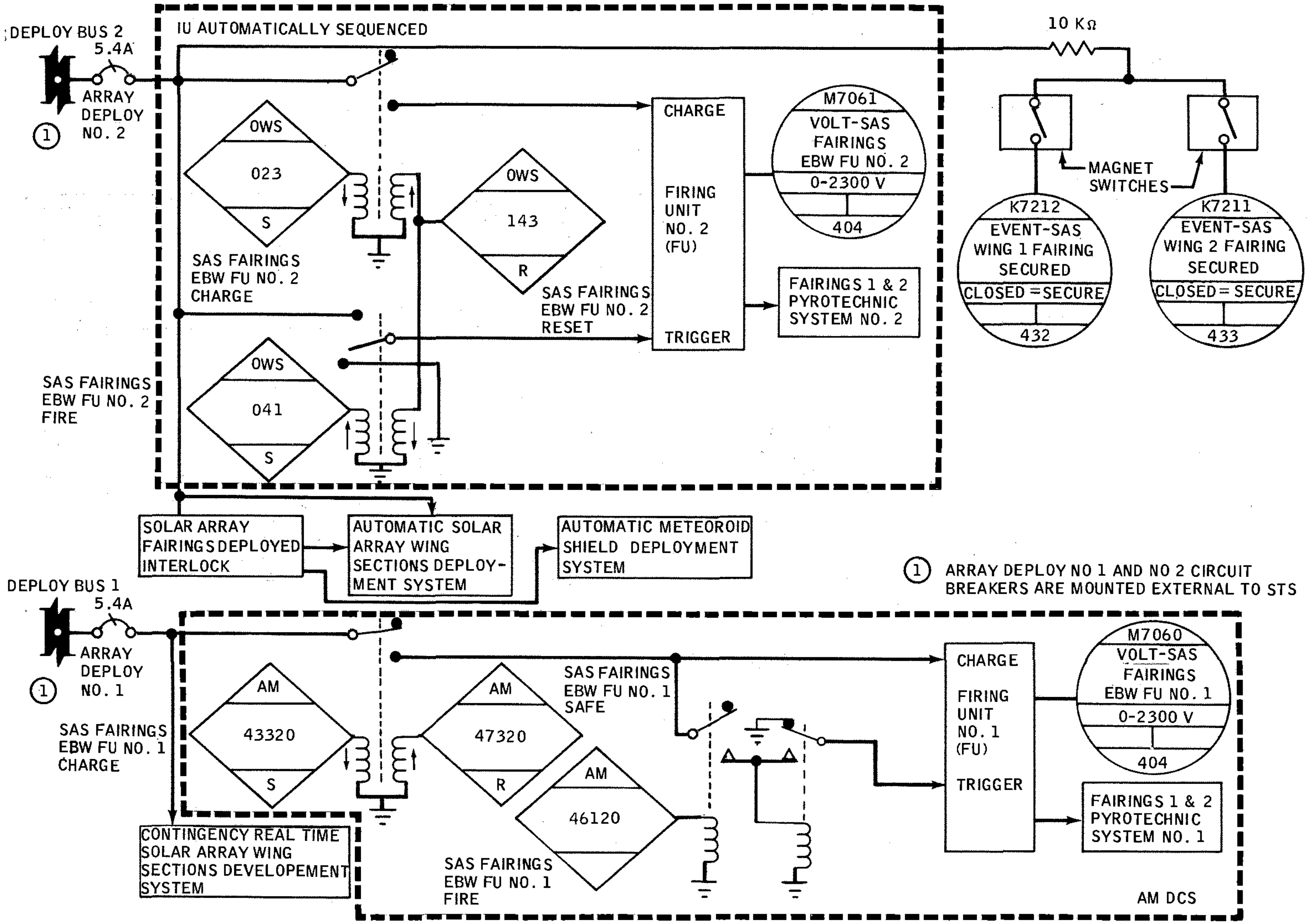


Figure 2.0.10-27 Solar Array Fairings 1 and 2 Deployment Systems

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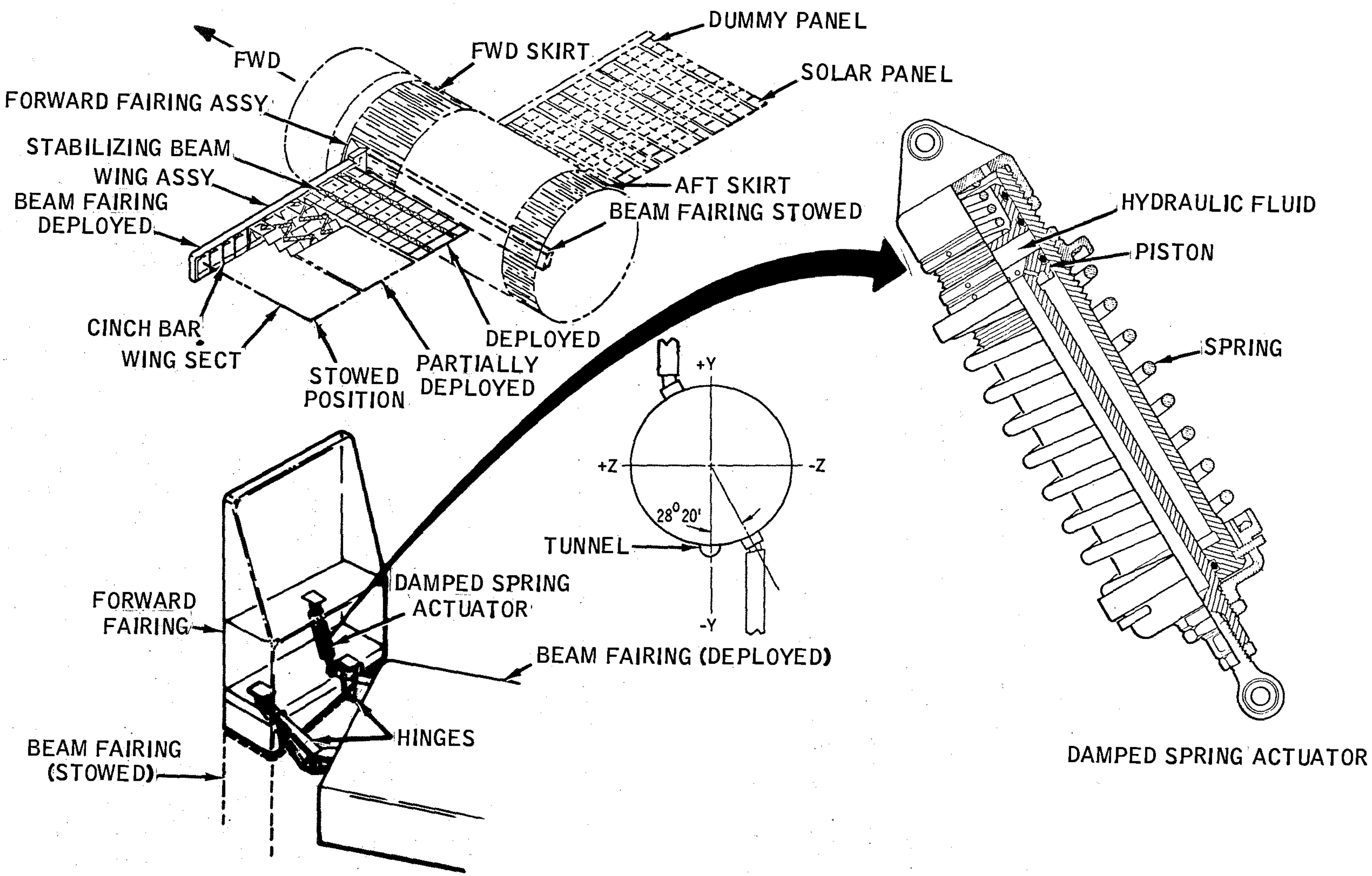


Figure 2.0.10-28 SAS Deployment Mechanism

deployed position. To prevent the solar array panels from being deployed prior to the beam fairing deployment, an interlock switch circuit is provided. Commands to deploy the wing-section panels are enabled by these switches. These same switches also are interlocked with the automatically sequenced commands to deploy the OWS meteoroid shield.

After the beam fairings are deployed and latched, the solar array panels are deployed by means of a damped mechanical system. The folded and stacked panels are stowed in the beam fairing cavity by means of mechanical latches, which retain the hinged edges of the stacked panels. The latches at each edge are interconnected by mechanical linkage to form an assembly that serves as a cinching mechanism for the panel stack.

Five cinching mechanisms are provided for each panel stack (or wing section), and each is held in the latched position by means of a frangible link, or tension strap. The panels in the stack are preloaded, one against another, by jackscrew adjustment provisions incorporated in the latches. This preload is carried in the links of the cinching mechanism such that when the tension strap is severed, the preload is relieved and the latches release the wing sections to permit deployment. A redundant pair of explosively actuated expandable tubes installed in each wing extend the length of the beam fairing cavity and mate with the 15 tension straps that retain the three wing sections (figure 2.0.10-29). Wing section deployment is initiated approximately 300 seconds after beam fairing deployment.

SAS WING SECTIONS EBW FU NO 2 CHARGE is sent by the IU. The command closes relay contacts that apply DEPLOY BUS 2 power to charge EBW firing unit 2. Five seconds later, providing the solar array fairing deployment interlock is closed, the trigger command (SAS WING SECTIONS EBW FU NO 2 FIRE) is issued. This detonates the SAS wing section deployment ordnance (figure 2.0.10-30).

The wing sections are independently deployed by torsion bars located at each of the joints of the stabilizing beams. These springs react to straighten the stabilizing beam-sections into the deployed position. The two stabilizing beams on each wing section are linked together through a damping mechanism (figure 2.0.10-31). A link is attached to the hinge point of each stabilizing beam to the beam fairing. This link, in turn, attaches to a bell crank mechanism through a push rod. Through this bell crank mechanism, both stabilizing beams are damped together by a hydraulic damper.

The SAS is monitored during the first orbit to verify deployment and operation. Deployment must occur within the IU lifetime and prior to exceeding the allowable level of discharge of both the AM or ATM batteries. Inflight anomalies can be investigated and further analysis of the SAS made based on the following measurements.

- o During ascent to verify SAS wing fairings are secure-measurements K7211-433 and K7212-432.
- o During first orbit to verify fairing deployment - measurement M7060-404, M7061-404, K7213-432, and K7214-433.
- o During first orbit to verify wing section deployment - measurements M7066-411; M7008, 9, 10-432; G7011, 12, 13-433.
- o During all mission phases for the 10 temperature measurements on each of the two wings.

The measurement locations are shown in figure 2.0.10-32.

The failure modes for SAS deployment are presented in paragraph 2.0.10.5.

2.0.10.4.7 Meteoroid Shield

The meteoroid shield (figure 2.0.10-33) is a 0.025 2014-T6 aluminum sheet, which encompasses the exterior of the habitation area over the length of the cylindrical section. The shield is designed to minimize micro-meteoroid penetration of the OWS walls and to reduce thermal radiation losses. The installation consists of the following major components:

- o Preformed aluminum panels bolted together to form a complete cylinder around the OWS.
- o Torsion bars and rotating links for deployment.
- o Two independent ordnance release systems.
- o Preformed metal fingers that close off the forward and aft end of the shield after deployment.

During ground handling and powered flight, the shield is stowed in a retracted position and held firmly against the exterior of the cylindrical section. Deployment is programmed to occur on orbit after OWS solar array deployment and before the second orbit.

After release, the meteoroid shield is deployed by preloaded torsion bars to a distance of 5 inches from the OWS exterior wall surface.

Structurally, the meteoroid shield consists of two half-cylinders, each of which is made up of eight cylindrical sections bolted together. The interior of the shield is coated with teflon. At the forward and aft ends of each half of the meteoroid shield, the eight cylindrical sections are bolted to ring flanges. These ring flanges are attached to four equally spaced torsion links at the forward end and four equally spaced torsion links at the aft end (figure 2.0.10-34). The torsion links provide the forces to deploy the shield halves.

As shown in figure 2.0.10-33, the ends of the cylindrical shield, when deployed, are enclosed by preformed metal fingers. Prior to deployment, the two halves of the meteoroid shield are restrained against the torsion links to the habitation tank wall by three tension straps. Contained within the tension straps are flattened steel tubes containing a mild detonating fuse. Upon command, the mild detonating fuse is detonated, severing the tension straps and releasing the preload torsion links to deploy the two shield halves (figure 2.0.10-35). Beneath

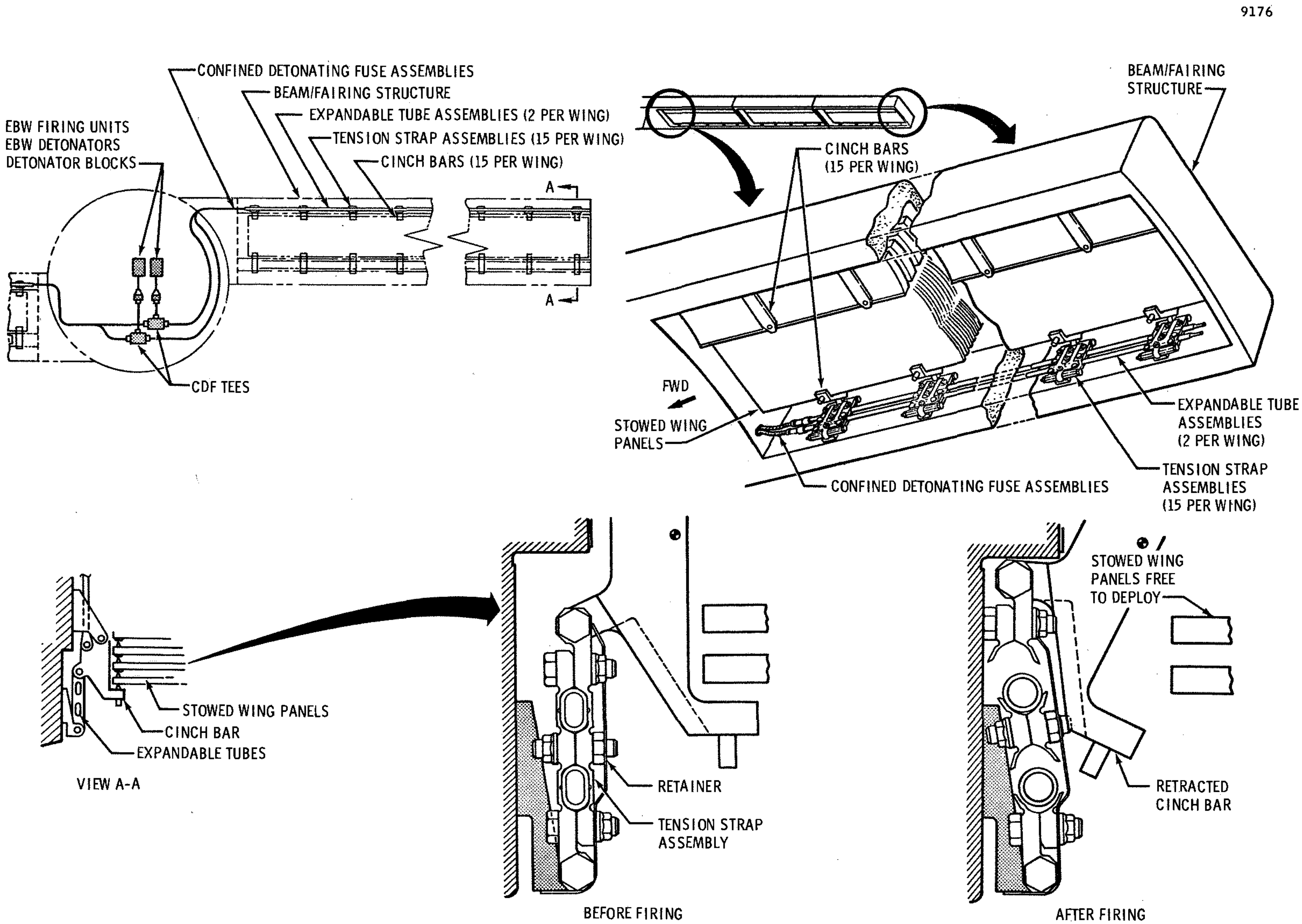


Figure 2.0.10-29 SAS Wing Panel Release System

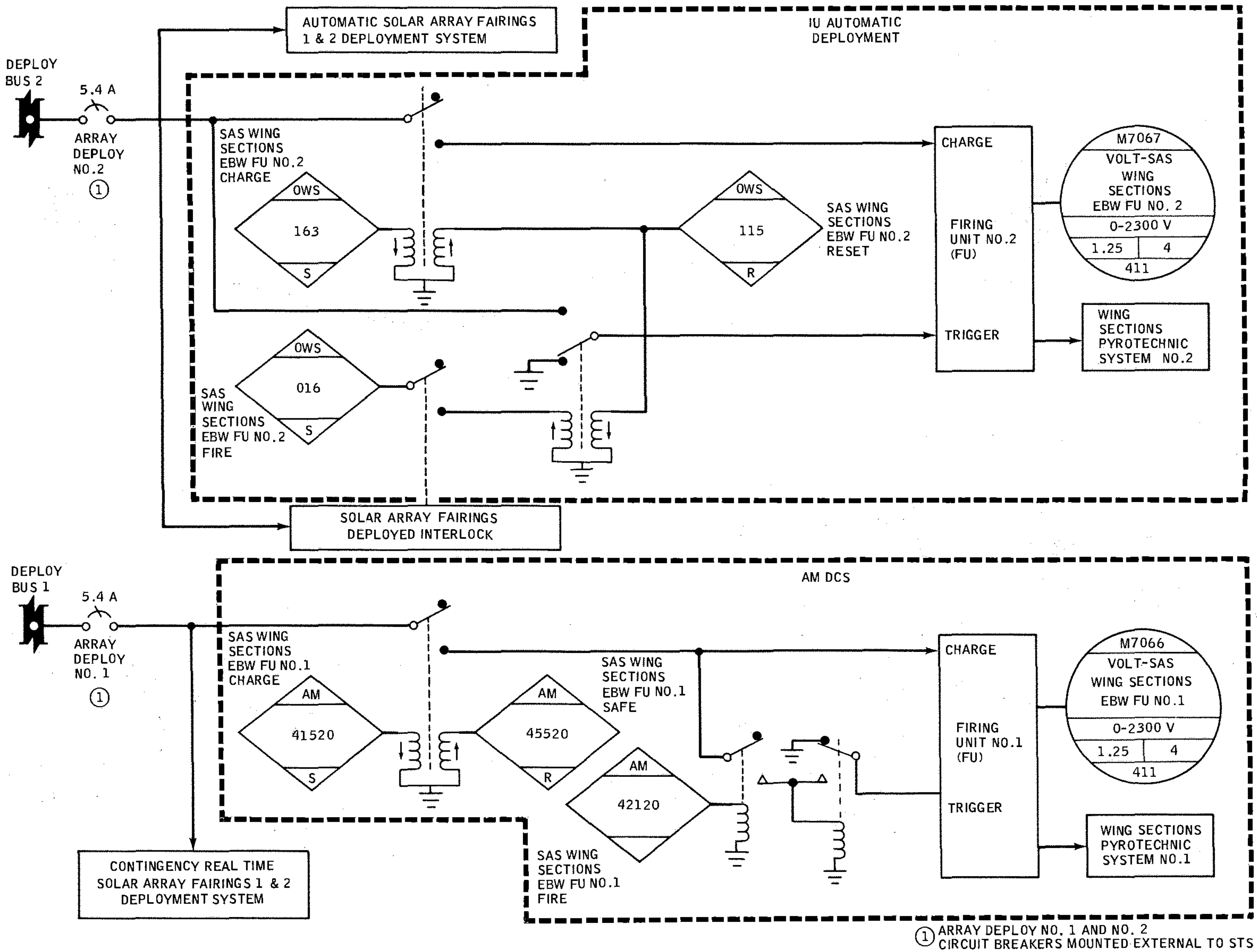


Figure 2.0.10-30 Solar Array Wing Sections Deployment System

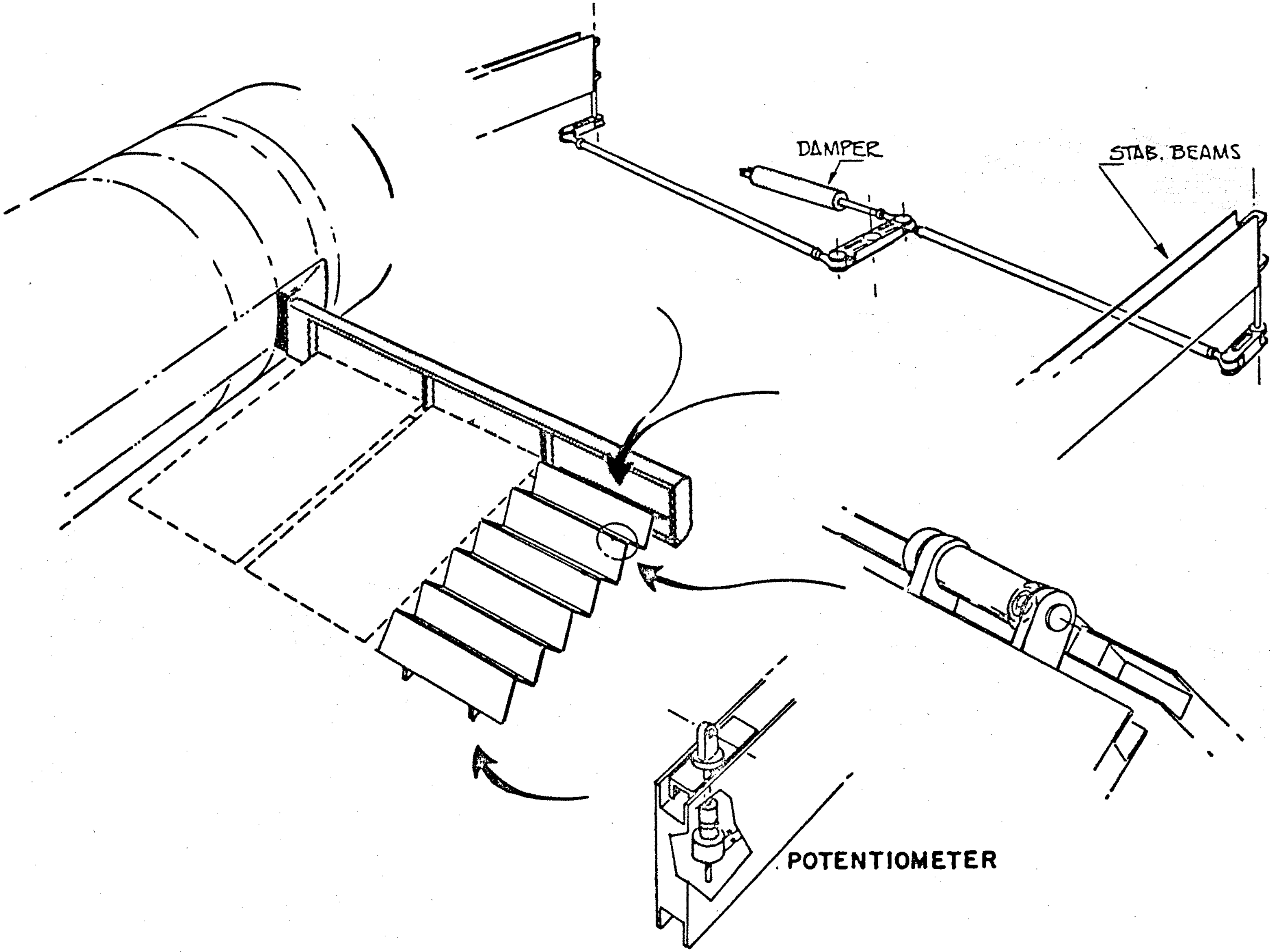


Figure 2.0.10-31  Wing Sections Partially Deployed

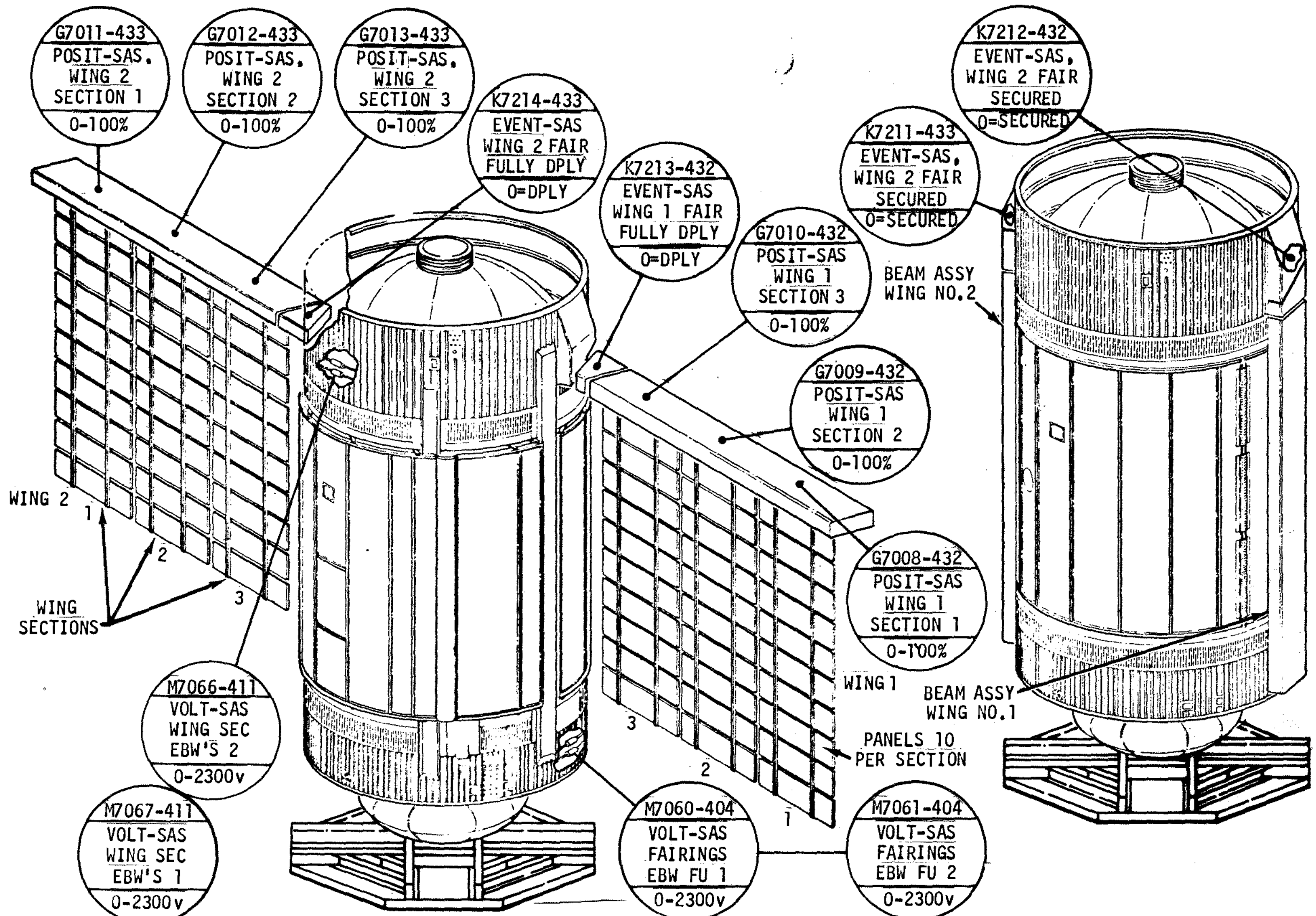


Figure 2.0.10-32 Deployment Instrumentation

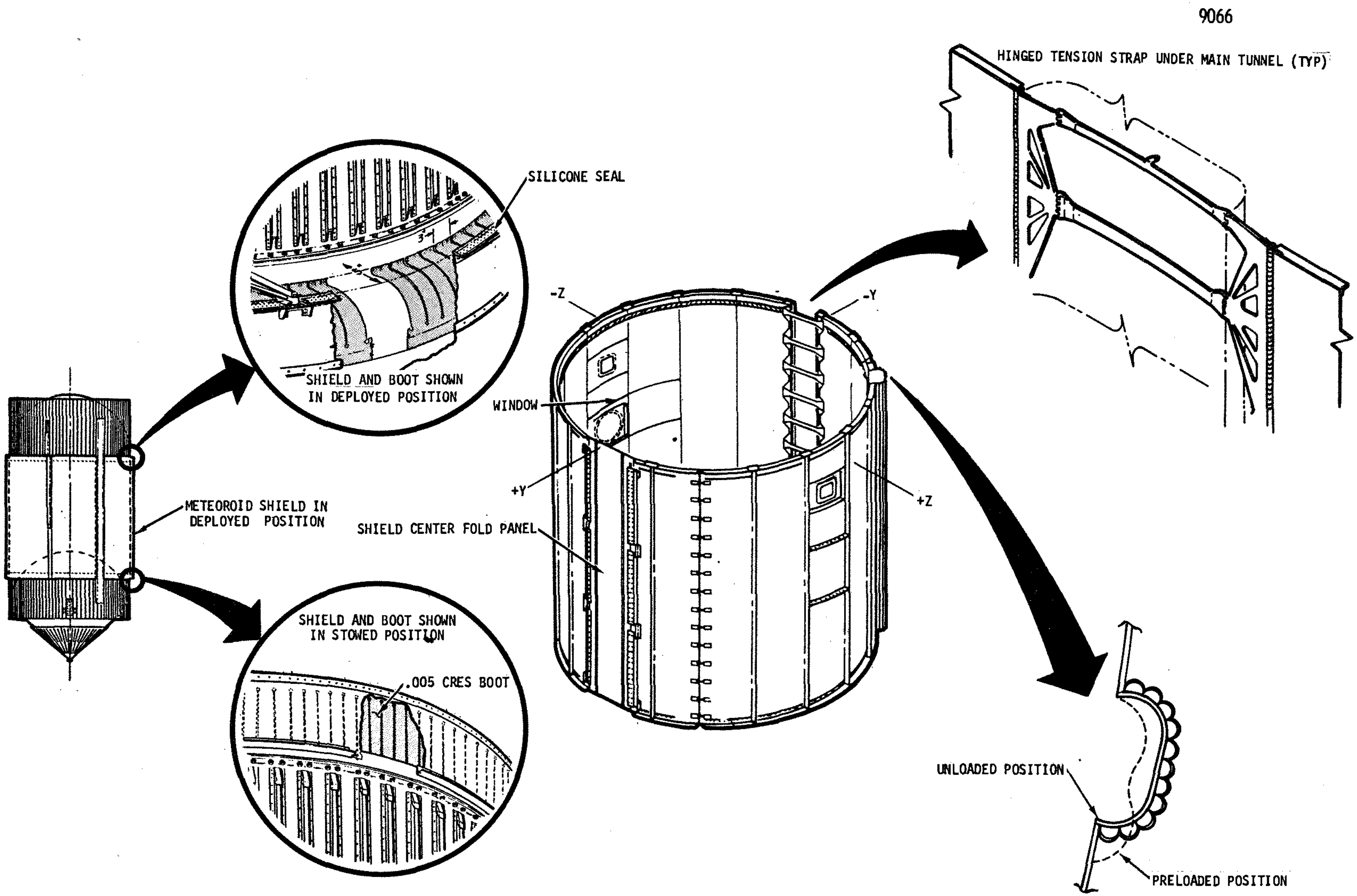


Figure 2.0.10-33 Meteoroid Shield Configuration

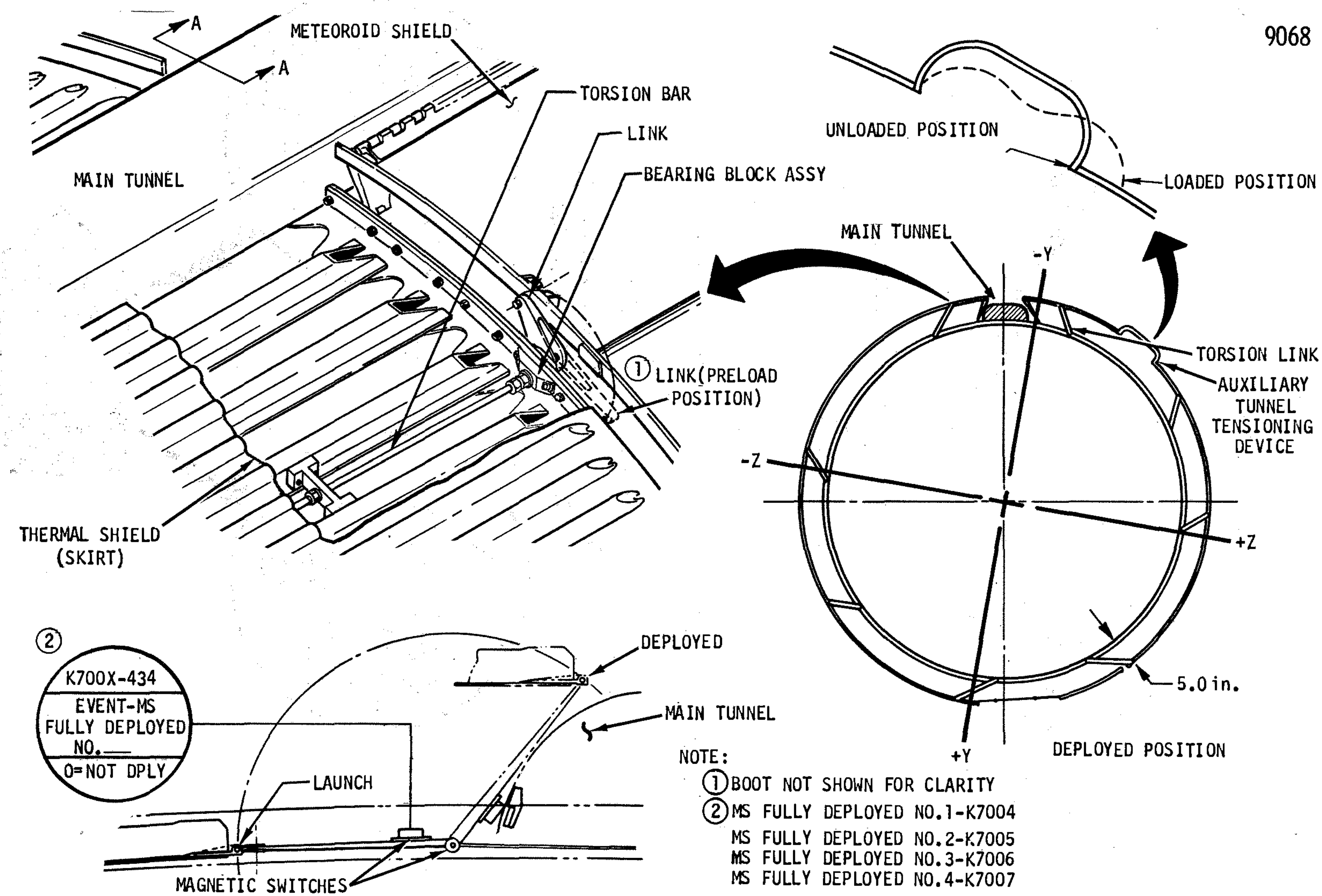


Figure 2.0.10-34 Meteoroid Shield Deployment Mechanism

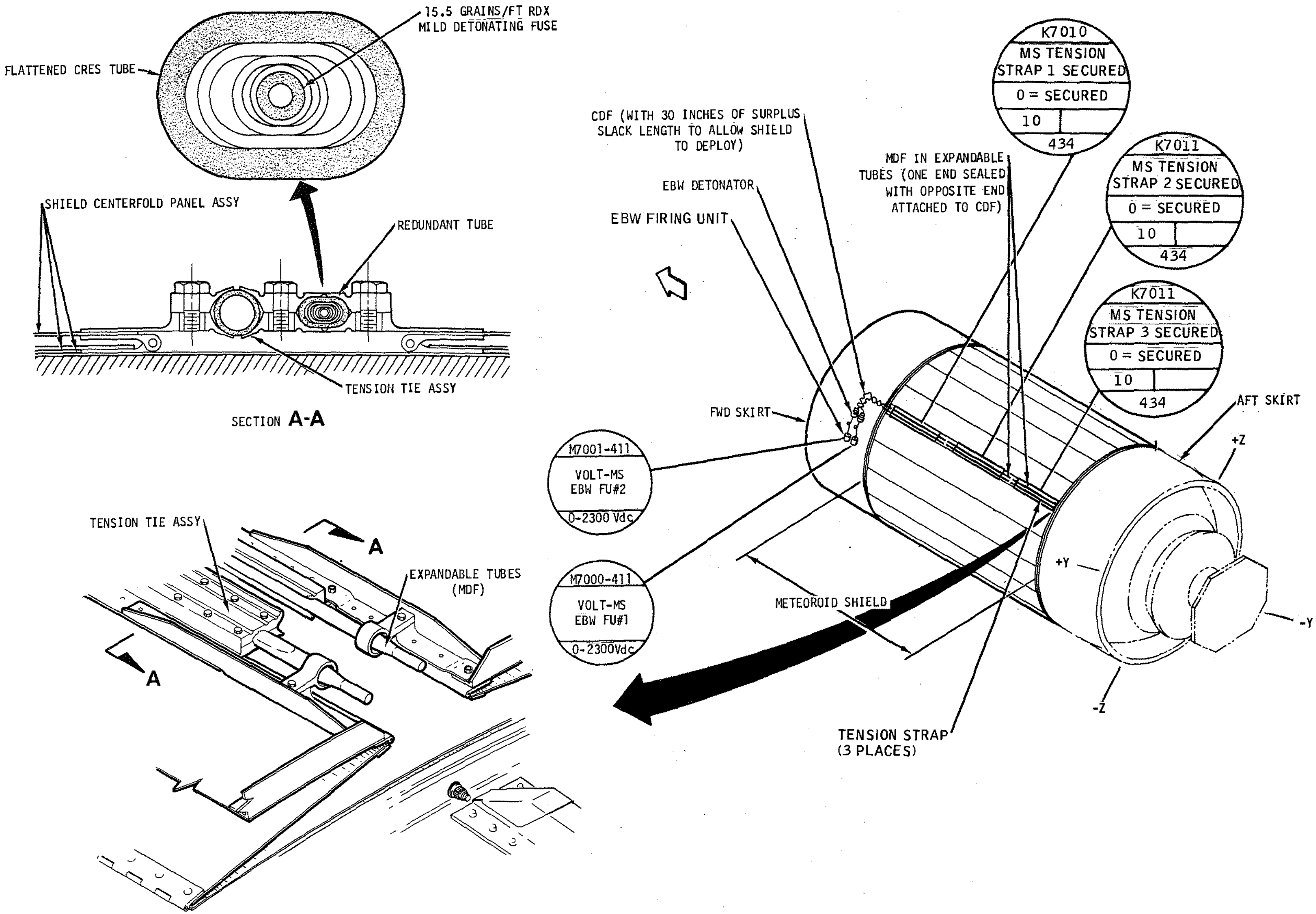


Figure 2.0.10-35 Meteoroid Shield Deployment Ordnance System

the tension straps, the two halves of the shield overlap. The overlap provides the extra dimension required when the shield circumference increases as a result of the shield being deployed 5 inches beyond the habitation tank wall.

Deployment of the meteoroid shield is initiated by an IU automatically sequenced command (MS EBW FU NO 2 CHARGE). This command applies deploy bus 2 power to charge the firing unit No. 2 (figure 2.0.10-36). Five seconds later, the MS EBW FU NO 2 FIRE command can be issued, provided the solar array fairings deployed interlock is closed. The FIRE command triggers firing unit 2. The firing unit fires the detonator, which in turn detonates the MDF and expands the primary flattened tubes in the tension straps. The expansion of the steel tubes severs the tension straps to release the meteoroid shield halves. The system is redundant in that backup ordnance and expandable tubes are provided at the tension straps. If the meteoroid shield fails to deploy by the normal automatic IU sequence commands, ground commands can be sent through the AM DCS as a backup deployment system.

The meteoroid shield is monitored to verify proper stowage during boost and timely deployment during first orbit. Four measurements (K7004, K7005, K7006, K7007) are provided to indicate its position. If the meteoroid shield fails to deploy, three event measurements located on the tension strap and two voltage measurements on the EBW firing units provide the required data. These measurements are K7010, K7011, K7012, M7000, and M7001, respectively. The location of these measurements are shown in figure 2.0.10-37.

2.0.10.4.8 OWS Hatch

Initial entry into the OWS from the AM is made through a hatch at the apex of the dome in the forward compartment (figure 2.0.10-38).

The hatch is a circular machining curved to conform to the shape of the dome. Redundant check valves in the hatch unseat at 0.2 psid and reseat at 0.1 psid, preventing positive pressure on the AM side of the OWS dome. A pressure EQUALIZATION VALVE in the center of the hatch provides a means of equalizing pressures on both sides of the hatch prior to opening. The equalization valve can be operated from either side of the hatch. An operating HANDLE is also provided on both sides of the hatch for opening or closing. The hatch opens into the OWS and can be secured against the forward dome by the hatch retainer shown in the figure. The seal on the dome is installed on a 42.5-inch diameter circle. The effective clearance through the hatch opening is 40-inches in diameter.

2.0.10.4.9 Aft Interstage

The aft interstage assembly (figure 2.0.10-39) is shaped like the frustum of a cone (a top diameter of 21.7 feet, a bottom diameter of 33 feet, and a height of 19 feet) and is located between the aft skirt and the S-II stage. It is permanently bolted to the S-II stage and remains attached subsequent to S-II separation. The interstage re-enters with the S-II and has no function after separation.

Structurally, the aft interstage assembly is semi-monocoque with internal rings and external stringers.

2.0.10.5 FAILURE MODES

Table 2.0.10.5-1 presents those failure modes related to the OWS structures.

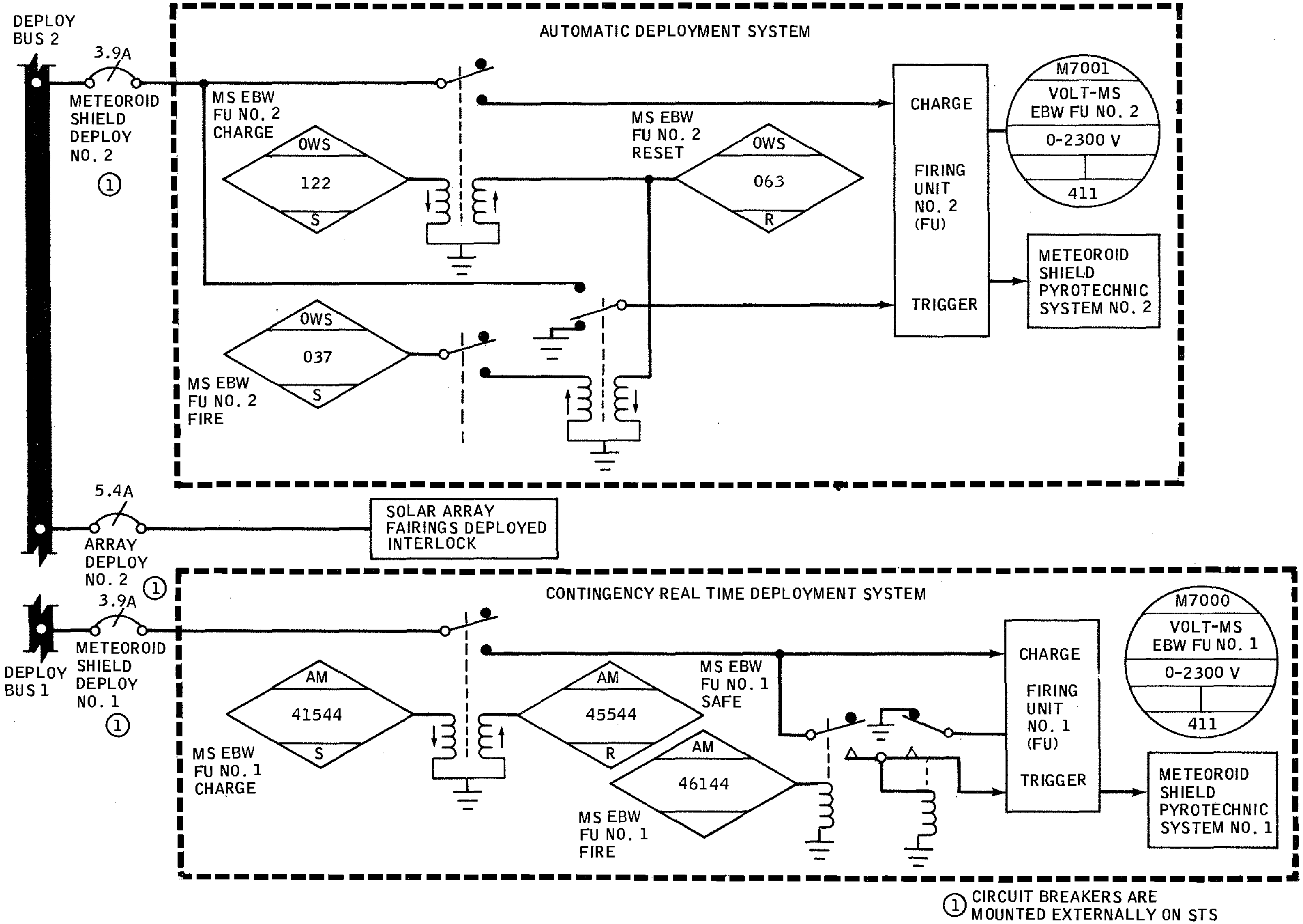


Figure 2.0.10-36 Meteoroid Shield Deployment System

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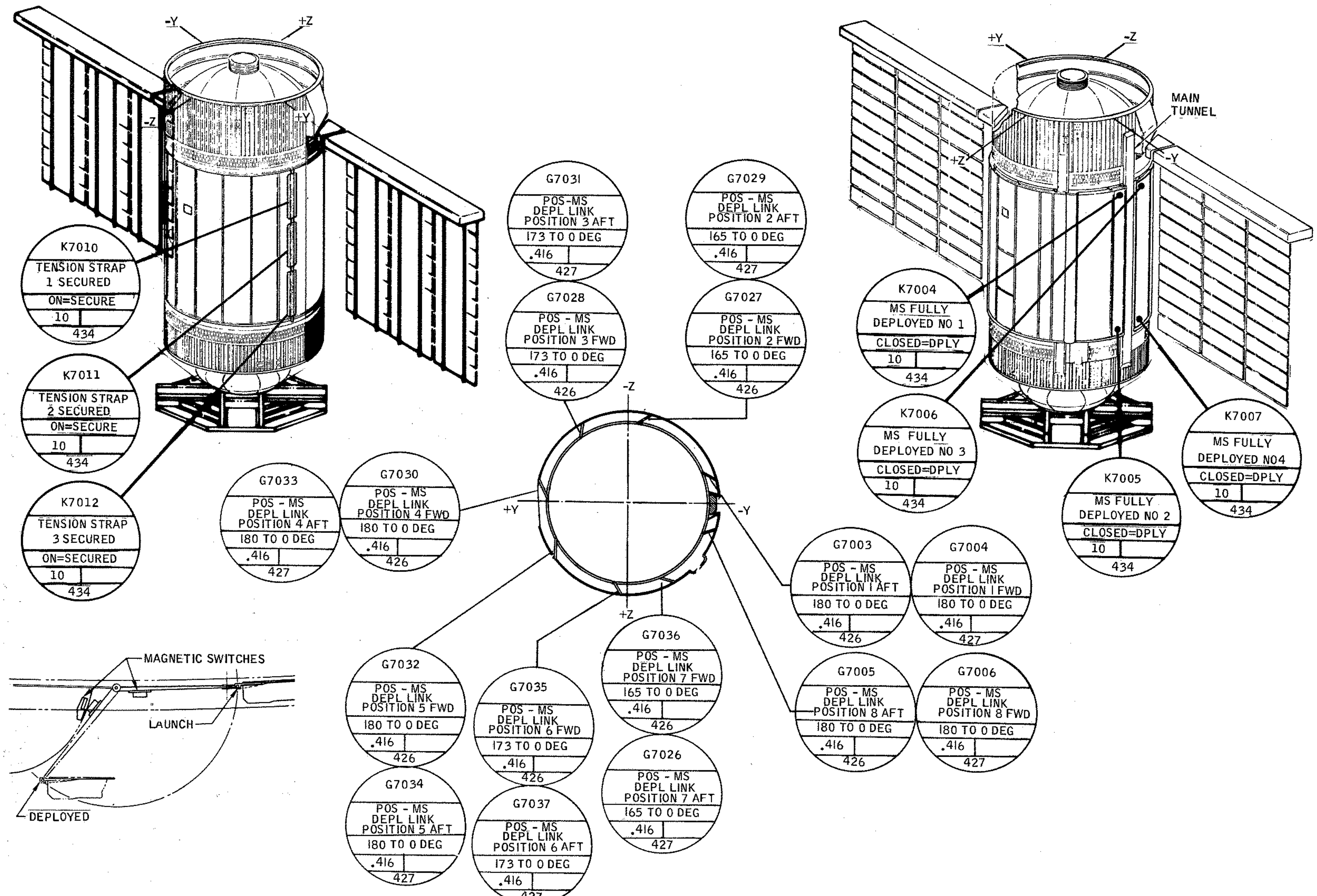


Figure 2.0.10-37 Meteoroid Shield Deployment Instrumentation

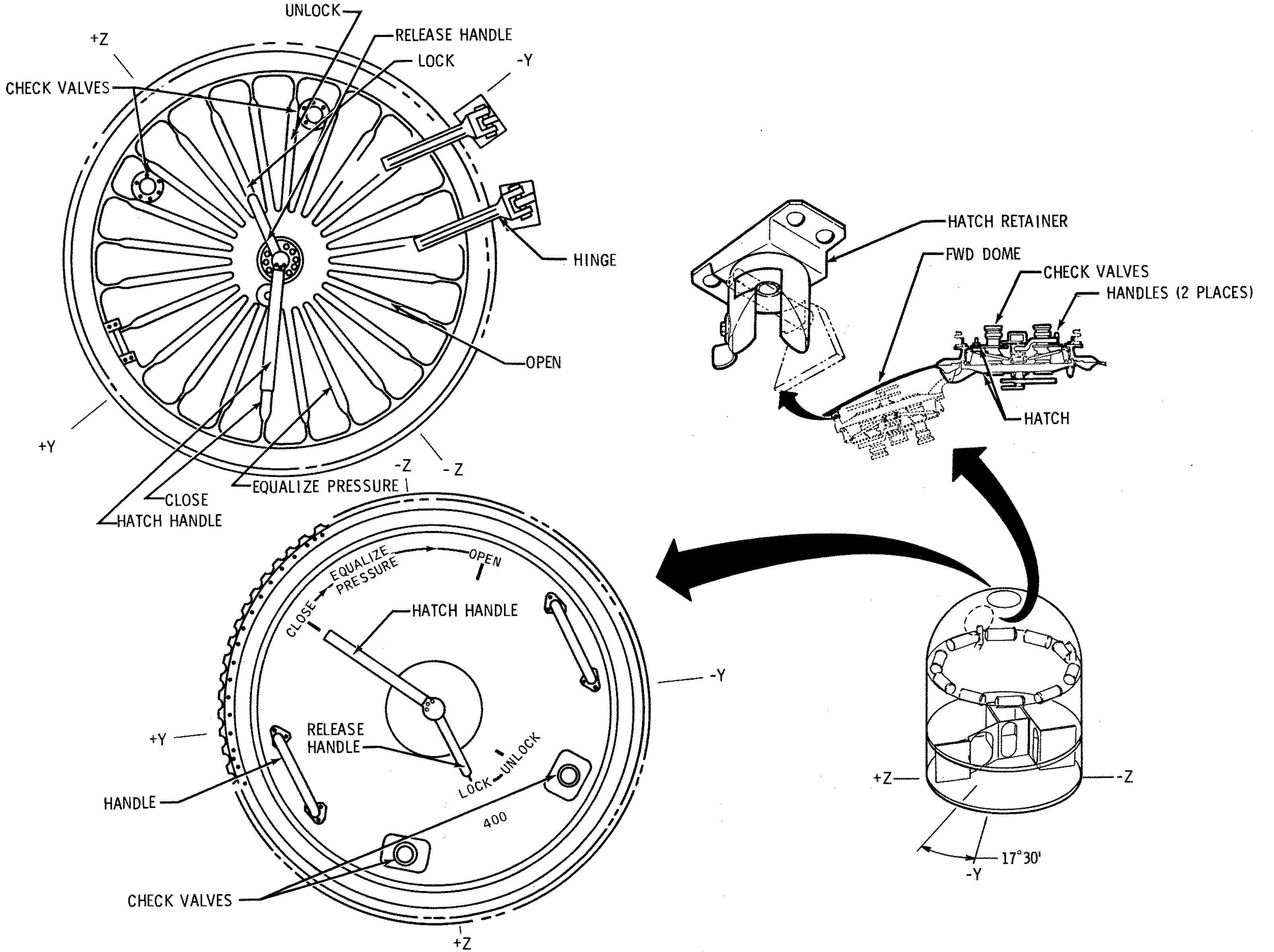


Figure 2.0.10-38 OWS Hatch

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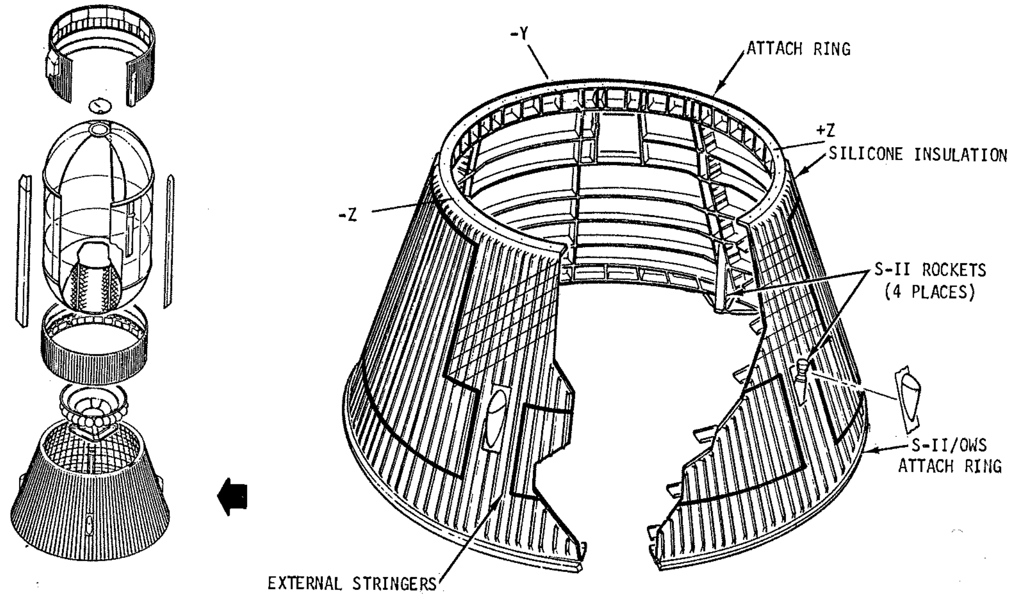



Figure 2.0.10-39 Aft Interstage

TABLE 2.0.10.5-1 OWS STRUCTURES AND MECHANISMS - FAILURE MODES

| FAILURE | INDICATION | VEHICLE CAPABILITY |
|---|---|---|
| 1. Refrigeration System Radiator | | |
| a) Actuator Assembly | | |
| Primary piston or shaft jammed (galling from contamination) | Radiator temperature is on TM | System loss: Loss of radiator heat rejection capability |
| Secondary piston or shaft jammed (galling from contamination) | Not detectable unless primary system fails | Mission loss: Ejection of shield mission critical<br>Partial system loss: Loss of redundant actuation force<br>No effect. Primary piston sufficient to provide actuation force<br>Loss of secondary piston makes primary piston and solenoid valve mission critical |
| b) Release Mechanism | | |
| Fails to release | Radiator temperature is on TM | System loss: Failure to release shield will prevent heat rejection by radiator<br>Mission loss: Ejection of shield is mission critical |

TABLE 2.0.10.5-1 OWS STRUCTURES AND MECHANISMS - FAILURE MODES (cont'd)

| FAILURE | INDICATION | VEHICLE CAPABILITY |
|---|---|---|
| 2. Solar Array system | | |
| a) Beam Fairing Deployment | | |
| Firing Unit EBW | | |
| 1) Fails to operate when intended | 1) M7061-404 does not increase to 2300 vdc | 1) Loss of automatic (IU) primary (backed up) mode of solar wing beams deployment<br><br>Backup deployment via the AM-DCS from ground station must be used. If no redundancy, loss of mission |
| 2) Operates when not intended | 2) M7061-404 indicates 2300 vdc on EBW at wrong time sequence | 2) Not a possible single point failure mode. Unit requires two properly timed inputs to operate. Therefore, failure mode would require dual, coincident failures of inputs |
| EBW Detonator fails to detonate | SAS beam fairing does not deploy K7213-432, K7214-433, K7211-433, K7212-432 | If primary EBW detonator did not fire, standby EBW unit would have to be charged and triggered by ground station (AM-DCS). Primary EBW detonator is fired by charge from primary EBW unit. Primary EBW is charged and triggered by IU |
| CDF | Same as above | If primary CDF did not fire, standby CDF would be detonated by charging and triggering standby EBW from ground station (AM-DCS). Primary EBW is charged and triggered from IU |
| Expandable Tube Assembly | | |
| Fails to ignite | SAS beams do not deploy K7213-432 and K7214-432 indicates 1 = not deployed K7211-433 and K7211-433 indicates 0 = secured | If primary expandable tube did not ignite, backup expandable tube can be commanded by charging and triggering backup EBW |
| b) Wing Section Deployment | | |
| Firing Unit, EBW | | |
| 1) Fails to operate when intended (open or short to ground of input or output) | 1) M7066-411 does not increase to 2300 vdc | 1) Loss of automatic (IU) primary (backed up) mode of Solar Wing Section deployment<br><br>Backup deployment through the AM-DCS from ground station must be used. If no redundancy. Loss of mission |
| 2) Operates when not intended | 2) M7061-404 indicates 2300 vdc on EBW at wrong time sequence | 2) Not a possible Single Point Failure Mode. Unit requires two properly timed inputs to operate. Therefore, failure mode would require dual, coincident failures of inputs |
| EBW Detonator fails to detonate | SAS wing sections do not deploy G7008, G7009, G7010, G7011, G7012, G7013 | If primary EBW detonator did not fire, standby EBW unit would be charged and triggered. Primary or backup EBW unit can be charged and triggered by IU or ground station (AM-DCS) |
| CDF fails to detonate | Same as above | If primary CDF did not fire standby, EBW unit would be charged and triggered. Primary or backup EBW unit can be charged and triggered by IU or ground station (AM-DCS) |

TABLE 2.0.10.5-1 OWS STRUCTURES AND MECHANISMS - FAILURE MODES (cont'd)

| FAILURE | INDICATION | VEHICLE CAPABILITY |
|---|---|---|
| Expandable tube assembly fails to expand | SAS wing sections do not deploy G7008-432, G7009-432, G7010-432, G7011-433, G7012-433, G7013-430 All indicate zero after deployment | If primary expandable tube did not ignite, standby expandable tube would have to be ignited by charging and triggering backup EBW. Primary or backup EBW can be charged and triggered by IU or ground station (AM-DCS) |
| 3. Meteoroid Shield | | |
| a) Fails to operate | a) M7001-411 fails to increase to 2300 vdc | a) If the primary EBW fails, the backup firing unit can be charged and fired via AM DCS |
| EBW Detonator | Meteoroid shield does not deploy K7010-434, K7011-434, K7012-434, indicate 0 = secured | If primary EBW detonator did not fire, backup system can be utilized via AM DCS |
| 4. OWS Hatch | | |
| a) Hatch handle binds with locking plunger to fitting assembly | a) Unable to position hatch handle to equalize pressure or to OPEN | a) Pressure cannot be equalized across hatch if handle binds in closed position. If handle binds in EQUALIZE PRESSURE POSITION, hatch latches cannot be released |
| b) Blockage of openings in pivot of equalization valve in OWS side may have occurred | b) OWS does not vent through hatch with HATCH HANDLE positioned to EQUALIZE PRESSURE | b) Pressure across hatch cannot be equalized utilizing hatch handle |
| 5. Scientific Airlock (SAL) | | |
| a) Outer Door - failure of door to close | a) Door crank cannot be positioned to close. Gage reads below cabin pressure. Door crank cannot be positioned to OPEN | a) Loss of SAL |
| b) SAL PRESSURE LO - possible leakage at outer door or at SAL PRESSURE valve or at vacuum qd. Possible gage failure | b) Pressure gage reads below 5 psid when SAL PRESSURE valve positioned to PRESS and outer DOOR closed | b) SAL cannot be utilized if cabin pressure within SAL cannot be obtained |
| c) SAL PRESSURE HI - failure of pressure gage, failure of valve or failure of door crank, either of which can be used to vent the SAL | c) Pressure gage does not indicate 0 psia following depressurization of SAL by positioning SAL PRESSURE to VENT or positioning DOOR crank to VENT | c) Failure of gage prevents pressure within the SAL from being monitored Failure of SAL pressure valve - no effect on depressurizing since DOOR can be utilized to depress, but with valve failed no means exists to pressurize the SAL other than releasing the experiment flange and attempting to break the seal<br><br>Failure of outer door crank prevents the use of SAL |
| d) SAL PRESSURE VALVE - Valve cabin port is blocked or valve seal failure has occurred. (blockage possibly can be removed at inlet to valve) | d) Pressure gage reading does not change when valve is positioned to PRESS when SAL is evacuated | d) SAL cannot be pressurized |
| Valve overboard port is blocked | Pressure gage reading fails to decrease when valve is positioned to VENT | SAL cannot be evacuated unless outer door crank is used |
| e) RELEASE HANDLE - Dogs do not extend or retract or handle jams | e) Dogs at experiment SAL interface flange do not retract and/or extend | e) Experiment cannot be installed and/or be removed, whichever the case |

SUBSECTION 2.1

ELECTRICAL POWER SYSTEM

2.1.1 INTRODUCTION

The Electrical Power System (EPS) consists of the equipment necessary to generate, condition, control, and distribute dc electrical power (nominal 28 vdc) to the various buses throughout the orbital assembly (OA). Equipment beyond the buses is not considered part of this system; the exception is the utility power subsystem which is described as part of this section.

The three major categories of the EPS are:

- o Power Generation: Solar array system
- o Power Conditioning: Battery charger, bus voltage regulator, and batteries
- o Power Distribution: Bus, controls, utility power, and shunt regulator

The solar array converts solar energy into dc electrical power and applies it to the battery charger. The battery charger preconditions and limits the power from the solar array and makes it available on demand to the bus voltage regulator, with the remaining power used for the battery recharge. The battery is used to store energy and, during the peak power periods and the night portion of the orbit, to supply power. The bus voltage regulator receives power from the battery and/or the battery charger (or directly from the solar array during a contingency mode) and regulates it to an adjustable voltage level. The power distribution equipment controls and distributes the power to the loads within the OA.

2.1.2 INTERFACES

2.1.2.1 MODULE INTERFACE

The EPS interfaces with the ATM and the CSM. See figure 2.1.2-1 for the interconnection between the three power systems. The common tie point is the transfer bus. During prelaunch, the EPS in parallel with the ATM EPS, receives dc electrical power from the Ground Supporting Equipment (GSE). At launch, GSE power is removed and on-board batteries are used. The batteries continue to supply power to the SWS throughout the launch phase, orbital insertion, solar array deployment, and system activation.

After solar array deployment, electrical power is generated by the solar array systems (during the daylight portion of orbit) and supplied to the conditioning equipment for application to the various buses and for recharge of the batteries. During the night portion of the orbit and during peak loads, the batteries supply the power.

The ATM EPS is similar to the AM EPS in that it receives its energy from solar arrays, supplies it to a battery charger (which in turn supplies power to a voltage regulator), and also recharges its batteries. The system is divided into 18 power groups, each group containing a solar cell panel, a battery charger, a battery, and a voltage regulator (figure 2.1.2-1). The ATM EPS and the AM EPS are connected in parallel approximately 4 1/2 hours after launch. A power transfer of 2500 watts in either direction can be made between the ATM EPS and the AM EPS.

The CSM EPS is an independent operating system, utilizing batteries and fuel cells as the power source. The fuel cells will continue to operate for some time after docking. Just prior to fuel depletion, the CSM EPS is connected to the SWS power systems. The connection is made via an inflight umbilical that is manually connected. The power transfer cable uses zero-g connectors mated at the MDA and the CSM. There is a contingency power cable stowed in the MDA. It is connected, if required, from the MDA through the tunnel to panel 230 in the CM. Both the primary and contingency cables contain 2 power buses and grounding circuitry. Maximum power transfer is 2000 watts from the AM to the CSM. The power switching control from the SWS to the CSM is controlled at panel 230 in the CM. Shortly after paralleling the three power systems, the fuel cells are shut down and the CSM then receives all its power from the SWS. For the de-orbit phase of the mission, the CSM batteries are put back on the line and the power connection between the CSM and the SWS is disconnected (figure 2.1.2-2).

Figure 2.1.2-3 shows the three power systems connected to their common tie, transfer buses 1 and 2.

2.1.2.2 SYSTEM INTERFACE

The loads throughout the system are grouped by function and tied to the various buses. A brief description of each bus is given below:

| | |
|---|---|
| EPS control bus | - Powers all equipment required for primary power system control by ground command or crew switching, lighting required for crew egress from AM/MDA/OWS in an emergency, and major portions of the C&W system and the DCS/TRS. |
| REG bus | - Powers three other buses, OWS, AM and transfer buses. |

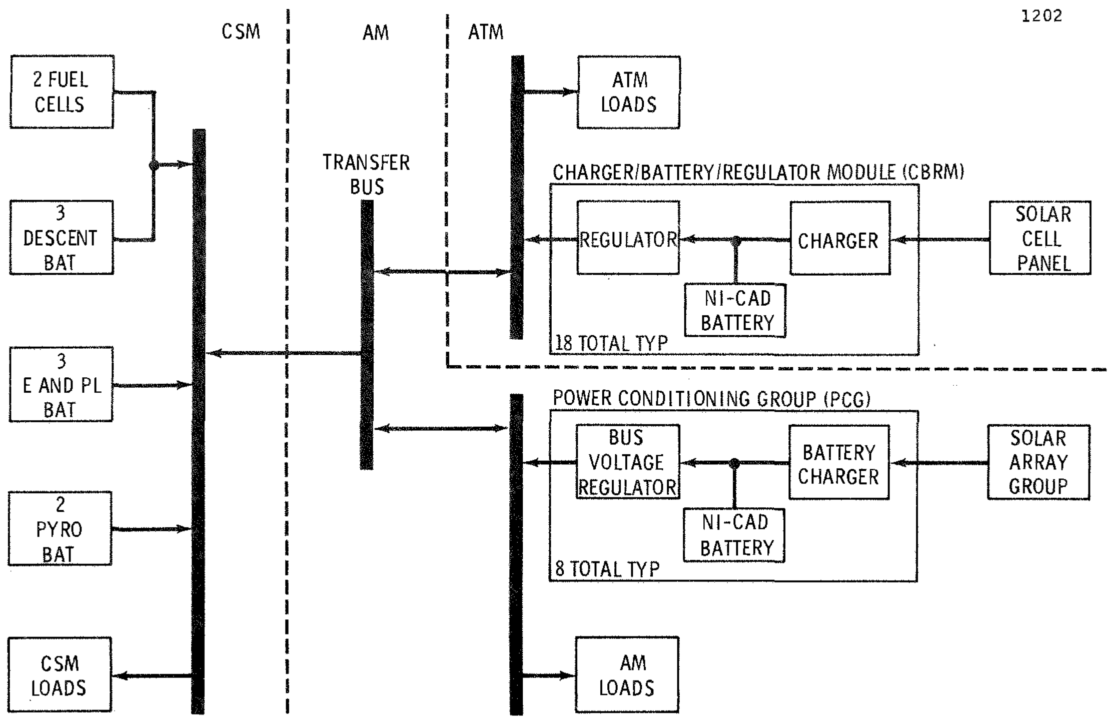



Figure 2.1.2-1 OA EPS Interfaces

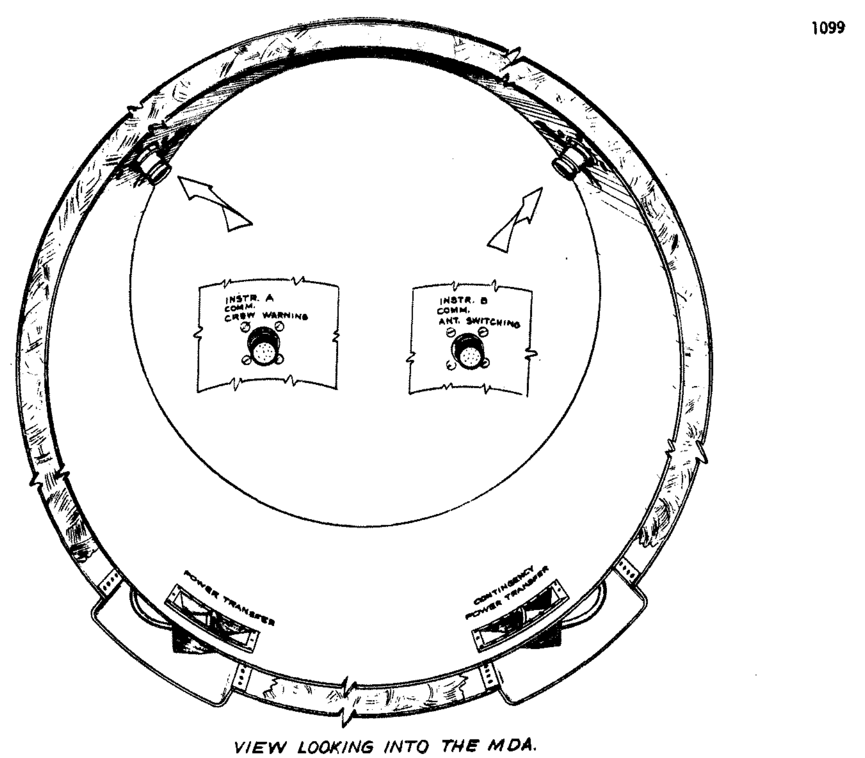



Figure 2.1.2-2 MDA Tunnel Power Connection

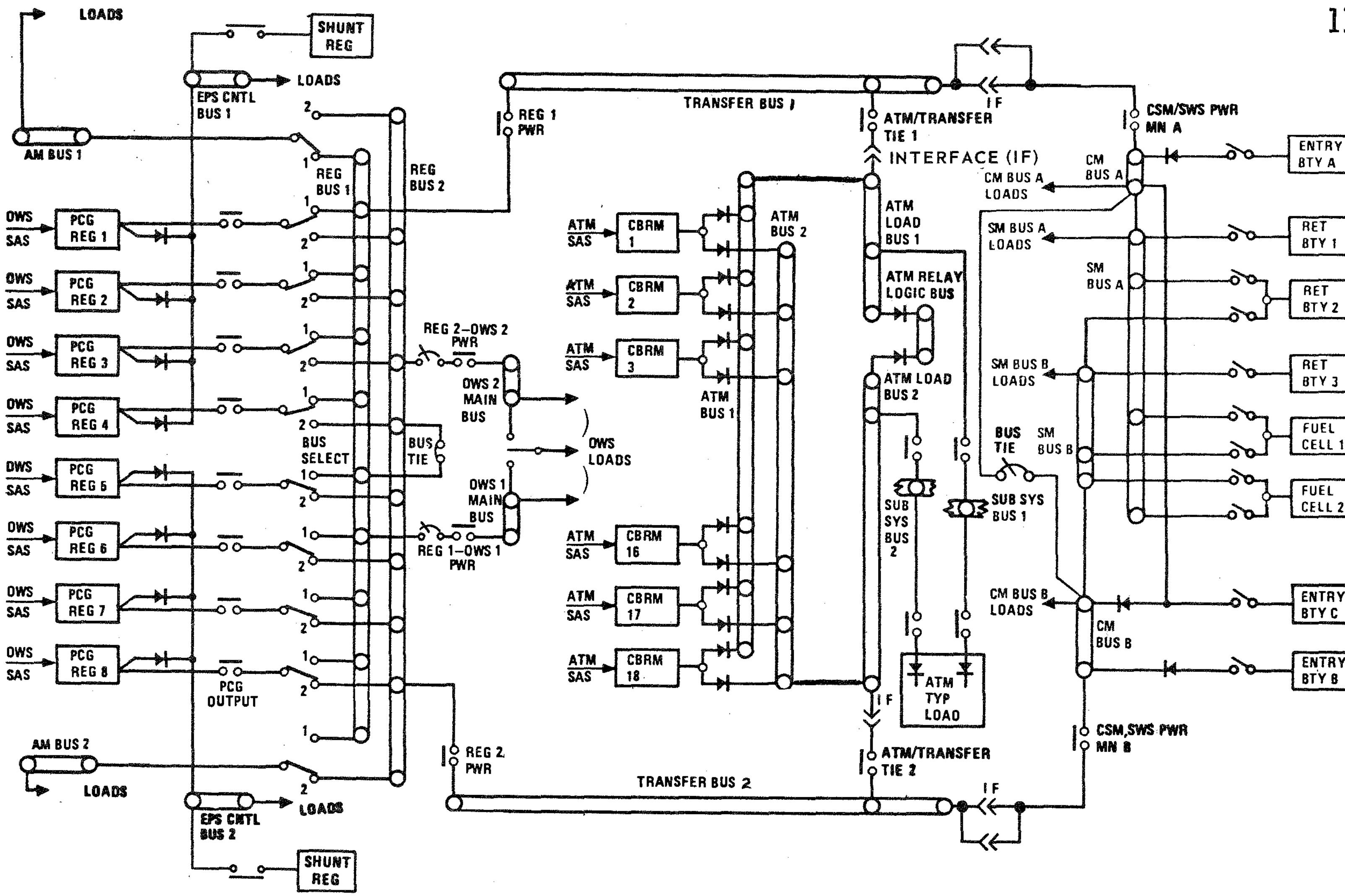



Figure 2.1.2-3 EPS Functional Schematic

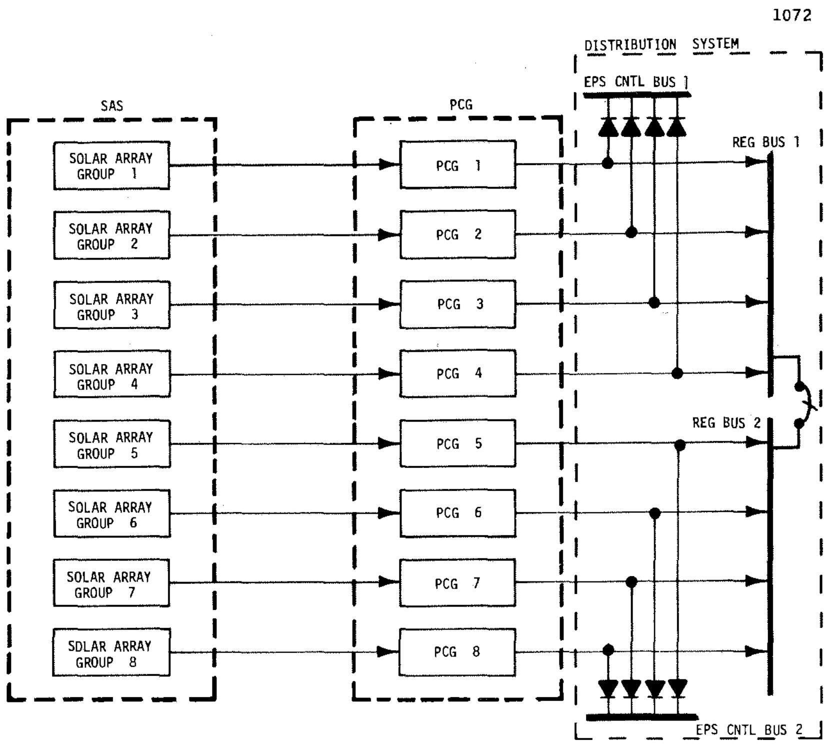



Figure 2.1.3-1 SAS/PCG Power Flow and Distribution

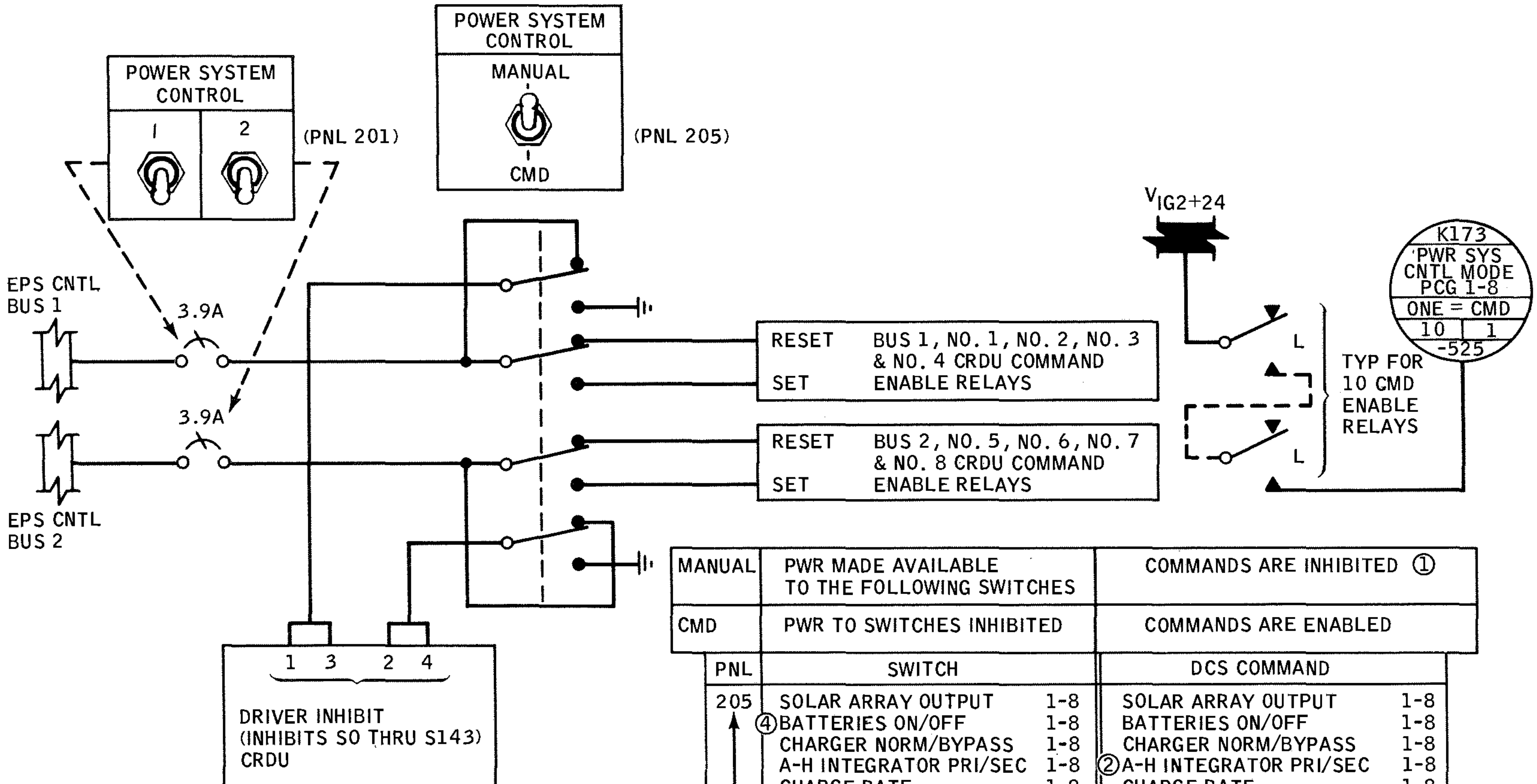
| | |
|---|---|
| AM bus | - Powers the environmental control system, caution and warning system, instrumentation system, lighting system, communication system, time reference system, experiments, thruster attitude control system, digital command system, and utility power in the AM/MDA. It additionally supplies power to the deploy bus, sequential bus, and EREP bus. |
| Transfer bus | - Inter-vehicle connection for power transfer within the OA. |
| OWS bus | - Powers the habitability support system, thermal control system, refrigeration system, lighting system, experiments, and OWS utility power |
| Deploy bus | - Powers the deployment systems for the ATM solar array, discone antenna, OWS solar array, and meteoroid shield. |
| Sequential bus | - Powers the RS radiator shield jettison system, payload shroud jettison system, and ATM deployment system |
| EREP bus | - Powers the earth resources experiment equipment in the AM and MDA. |

## 2.1.3 FUNCTIONAL DESCRIPTION

### 2.1.3.1 GENERAL

The solar array system is divided into eight electrically isolated power groups (figure 2.1.3-1), each supplying electrical power to a single power conditioning group (PCG). The PCG conditions and stores the electrical power and outputs it to the EPS control bus and the Reg bus. Power groups 1 through 4 are connected to EPS control bus 1 through isolation diodes and to Reg bus 1 through power relays. Likewise, power groups 5 through 8 are connected to EPS control bus 2 and Reg bus 2. The Reg buses are the main power collection buses for the EPS, each being a 200-amp bus. The essential loads are connected to the EPS control buses. The EPS control buses cannot be switched off.

The EPS may be controlled and monitored onboard by the crew or from the ground control via DCS and telemetry. Panels 205 and 206 in the AM are the primary control and monitor position for the crew. The POWER SYSTEM CONTROL switch (figure 2.1.3-2) on panel 205 allows the crew to override the ground commands associated with the majority of the EPS by placing the switch to the MANUAL position. With the switch in this position, the switches on panel 205 and 206 are active and controlling. Figure 2.1.3-2 lists the functions enabled and inhibited by operation of the POWER SYSTEM CONTROL switch. It can be seen from the table that, although the CHARGE MODE switch and the EPS SHUNT REG switch are activated with the POWER SYSTEM CONTROL (PSC) switch in the MANUAL position, there is no DCS capability associated with the function. Since the BATTERY switch receives its power directly from the battery and also through the PSC circuitry, the PSC switch normally has no effect on the manual operation of the BATTERY ON-OFF switch. The operation of the OWS BUS ON-OFF switch on panel 206 is affected by the PSC switch but the corresponding switch on panel 617 is not affected. The ELEC GND CSM-AIRLOCK switch and DCS commands




| | | |
|---|---|---|
| MANUAL | PWR MADE AVAILABLE TO THE FOLLOWING SWITCHES | COMMANDS ARE INHIBITED 1 |
| CMD | PWR TO SWITCHES INHIBITED | COMMANDS ARE ENABLED |

| PNL | SWITCH | | DCS COMMAND | |
|---|---|---|---|---|
| 205 | SOLAR ARRAY OUTPUT | 1-8 | SOLAR ARRAY OUTPUT | 1-8 |
| | 4 BATTERIES ON/OFF | 1-8 | BATTERIES ON/OFF | 1-8 |
| | CHARGER NORM/BYPASS | 1-8 | CHARGER NORM/BYPASS | 1-8 |
| | A-H INTEGRATOR PRI/SEC | 1-8 | 2 A-H INTEGRATOR PRI/SEC | 1-8 |
| | CHARGE RATE | 1-8 | CHARGE RATE | 1-8 |
| | CHARGE MODE | 1-8 | N/A | |
| | DISCHARGE LIMIT | 1-8 | DISCHARGE LIMIT | 1-8 |
| | PCG OUPTUT ON/OFF | 1-8 | PCG OUTPUT ON/OFF | 1-8 |
| 205 | PCG OUTPUT REG BUS 1/2 | 1-8 | PCG OUTPUT REG BUS 1/2 | 1-8 |
| 206 | AM BUS 1/2 - REG BUS 1/2 | 1-2 | AM BUS 1/2 - REG BUS 1/2 | 1-2 |
| | OWS BUS ON/OFF | 1-2 | 2 OWS BUS ON/OFF | 1-2 |
| | ATM XFER TIE | 1-2 | ATM XFER TIE | 1-2 |
| | REG XFER TIE | 1-2 | REG XFER TIE | 1-2 |
| 206 | EPS SHUNT REG | 1-2 | N/A | |
| | | | 3 DISCONE ANTENNA DEPLOY | 1-2 |

NOTES:
1. SO THRU S143 INHIBITED WITH PWR SYS CNTL-MANUAL
2. COMMANDS INHIBITED BY USE OF RELAYS
3. PWR SYS CNTL - MANUAL HAS NO EFFECT ON DISCONE ANTENNA DEPLOY SW
4. BAT SW ALSO RECEIVES PWR FROM BAT CNTL CB

Figure 2.1.3-2 Power System Control

TABLE 2.1.3-1 CAUTION AND WARNING PARAMETERS

1109

| PARAMETER NAME | NORMAL RANGE | TRIGGER LIMIT | CORRESPONDING TM MEASUREMENT | ON-BOARO METER DISPLAY | INHIBIT SW TITLE (PNL 207) | OISPLAY TITLE | |
|---|---|---|---|---|---|---|---|
| REG BUS 1 HIGH | 26 TO 30 VOC | V 31.0± 0.62 VDC | M153 & M161 FINE | PNL 206 25–32V | REG BUS 1 HIGH | REG BUS 1 HIGH (PNL 207) | WARNING |
| REG BUS 1 LOW | 26 TO 30 VDC | V 25.0± 0.5 VDC | | | REG BUS 1 LOW | REG BUS 1 LOW (PNL 207) | WARNING |
| REG BUS 2 HIGH | 26 TO 30 VDC | V 31.0± 0.62 VDC | M154 & M162 FINE | PNL 206 25–32V | REG BUS 2 HIGH | REG BUS 2 HIGH (PNL 207) | WARNING |
| REG BUS 2 LOW | 26 TO 30 VDC | V 25.0± 0.5 | | | REG BUS 2 LOW | REG BUS 2 LOW (PNL 207) | WARNING |
| OWS BUS 1 LOW | 25 TO 30 VDC | V 23.5± 0.47 VDC | M7002 | PNL 617 0–35V | OWS BUS 1 LOW | OWS BUS 1 LOW (PNL's 207 & 616) | CAUTION |
| OWS BUS 2 LOW | 25 TO 30 VDC | V 23.5± 0.47 VDC | M7003 | PNL 617 0–35V | OWS BUS 2 LOW | (OWS BUS 2 LOW (PNL's 207 & 616) | CAUTION |
| BATTERY 1 30% SOC | 50 TO 100% SOC | SOC 30% | M117 PRI M125 SEC | PNL 206 SELECTION OF PRI & SEC FOR ANY ONE OF EIGHT 0–100% | BAT CHG LOW 1 | BAT CHARGE LOW (PNL 207) | CAUTION |
| BATTERY 2 30% SOC | 50 TO 100% SOC | SOC 30% | M118 PRI M126 SEC | | BAT CHG LOW 2 | | |
| BATTERY 3 30% SOC | 50 TO 100% SOC | SOC 30% | M119 PRI M127 SEC | | BAT CHG LOW 3 | | |
| BATTERY 4 30% SOC | 50 TO 100% SOC | SOC 30% | M120 PRI M128 SEC | | BAT CHG LOW 4 | | |
| BATTERY 5 30% SOC | 50 TO 100% SOC | SOC 30% | M121 PRI M129 SEC | | BAT CHG LOW 5 | | |
| BATTERY 6 30% SOC | 50 TO 100% SOC | SOC 30% | M122 PRI M130 SEC | | BAT CHG LOW 6 | | |
| BATTERY 7 30% SOC | 50 TO 100% SOC | SOC 30% | M123 PRI M131 SEC | | BAT CHG LOW 7 | | |
| BATTERY 8 30% SOC | 50 TO 100% SOC | SOC 30% | M124 PRI M132 SEC | | BAT CHG LOW 8 | | |

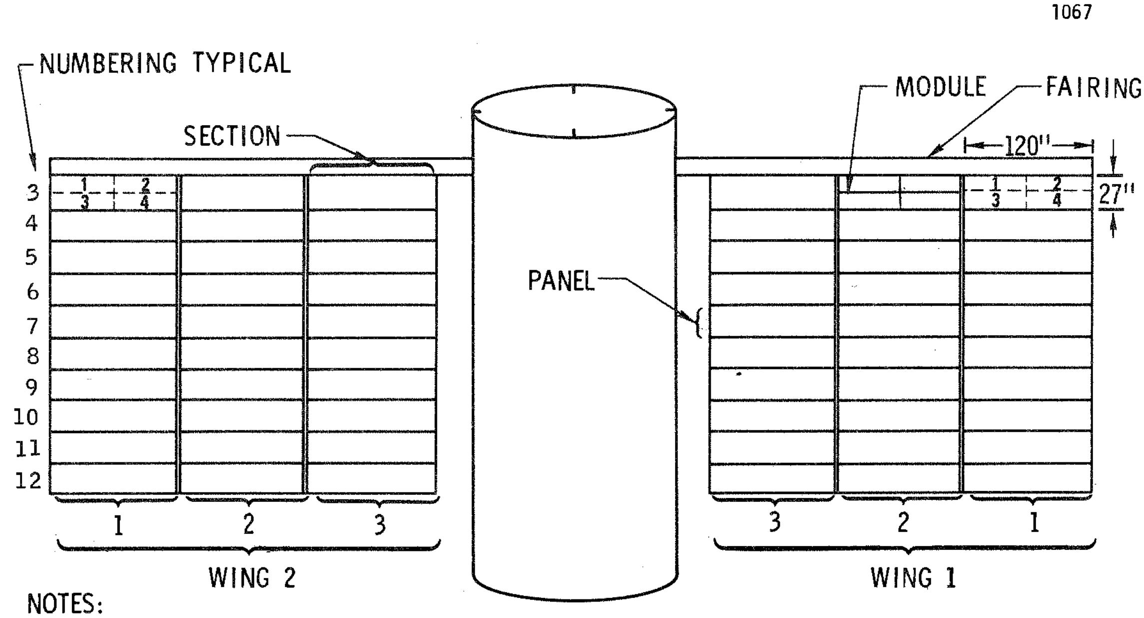
associated with it are not affected by the operation of the PSC switch. A summary of EPS caution and warning parameters is shown in table 2.1.3-1.

### 2.1.3.2 POWER GENERATION

The primary source of electrical power for the EPS is from the Solar Array System (SAS) after the deployment of the array. The deployment occurs approximately 1 hour after launch. The SAS consists of two deployable wing assemblies mounted on the forward skirt of the OWS. There is both a mechanical grouping and an electrical grouping of the solar array. The mechanical grouping is shown in figure 2.1.3-3. There are three wing sections per wing, 10 active and 2 inactive panels per section and four modules per active panel. There are 240 modules (120 per wing) in the array. The modules are divided into eight electrically isolated power groups, arranged to minimize the output power difference among the groups for the various shadowing conditions and temperature gradient expected to be encountered. Each of the eight array groups consists of 30 modules (15 located on each wing) connected in parallel, as indicated in figure 2.1.3-4. The modules are diode (dual diodes within the power unit) isolated at the point they are tied together and connected to a PCG through a selection relay. The switching logic is shown on figure 2.1.3-5. The manual or ground control switching allows solar array group 1 to be switched to PCG 1 or PCG 2. Solar array group 2 can be switched to PCG 2 or PCG 3, etc. In case of certain PCG failures, this allows two solar array groups to be connected to one PCG. By accomplishing this, one-eighth of the EPS power output is not lost (as would be the case with loss of a PCG). But, depending on the available sunlight and the output voltage setting of the PCG that has two solar array groups connected, the power loss is minimized.

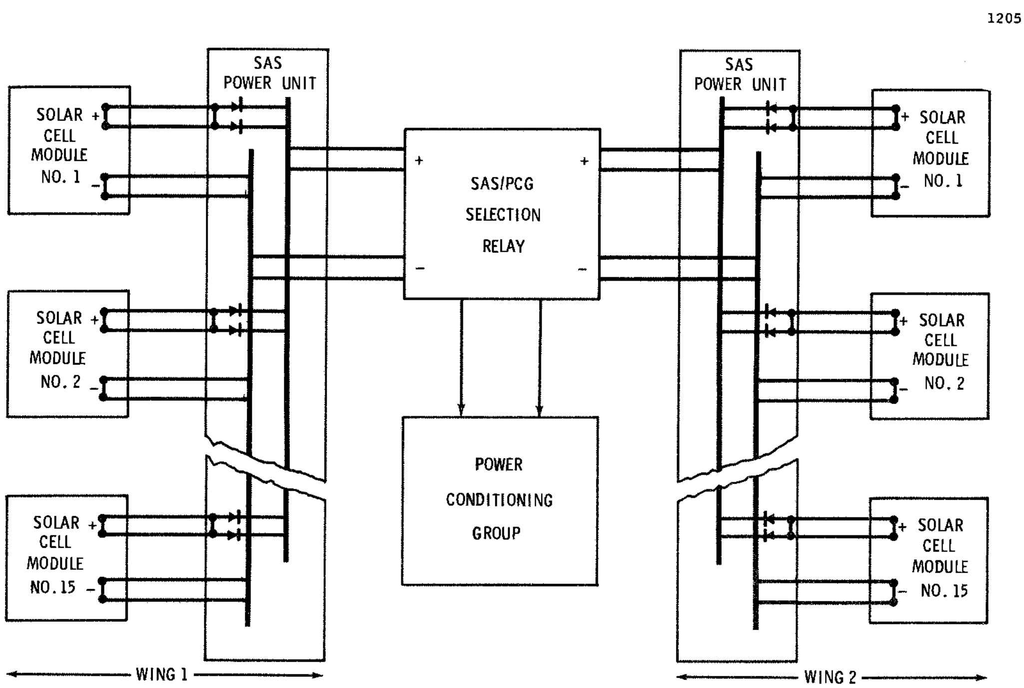
### 2.1.3.3 POWER CONDITIONING

The output of each solar array group is routed to a PCG (figure 2.1.3-1). Each PCG provides conditioned power to the distribution buses. The PCG also serves as an energy storage device (battery) by storing energy during the daylight portion of the orbit, when more energy is generated on the solar array than is required at the buses. During the orbital night, the batteries supply the power to the various buses.




NOTES:
1. 616 SOLAR CELLS MAKE UP A MODULE
2. 4 MODULES MAKE UP A PANEL
3. 10 PANELS MAKE UP A WING SECTION
4. 3 WING SECTIONS PLUS BEAM FAIRING MAKE UP A WING

Figure 2.1.3-3 SAS Physical Layout




NOTE: FIFTEEN (15) SOLAR CELL MODULES FROM EACH WING ARE COLLECTED FOR A TOTAL OF 30 MODULES PER POWER GROUP. THIS ARRANGEMENT IS TYPICAL FOR EACH OF THE EIGHT POWER GROUPS

Figure 2.1.3-4 SAS Electrical Configuration

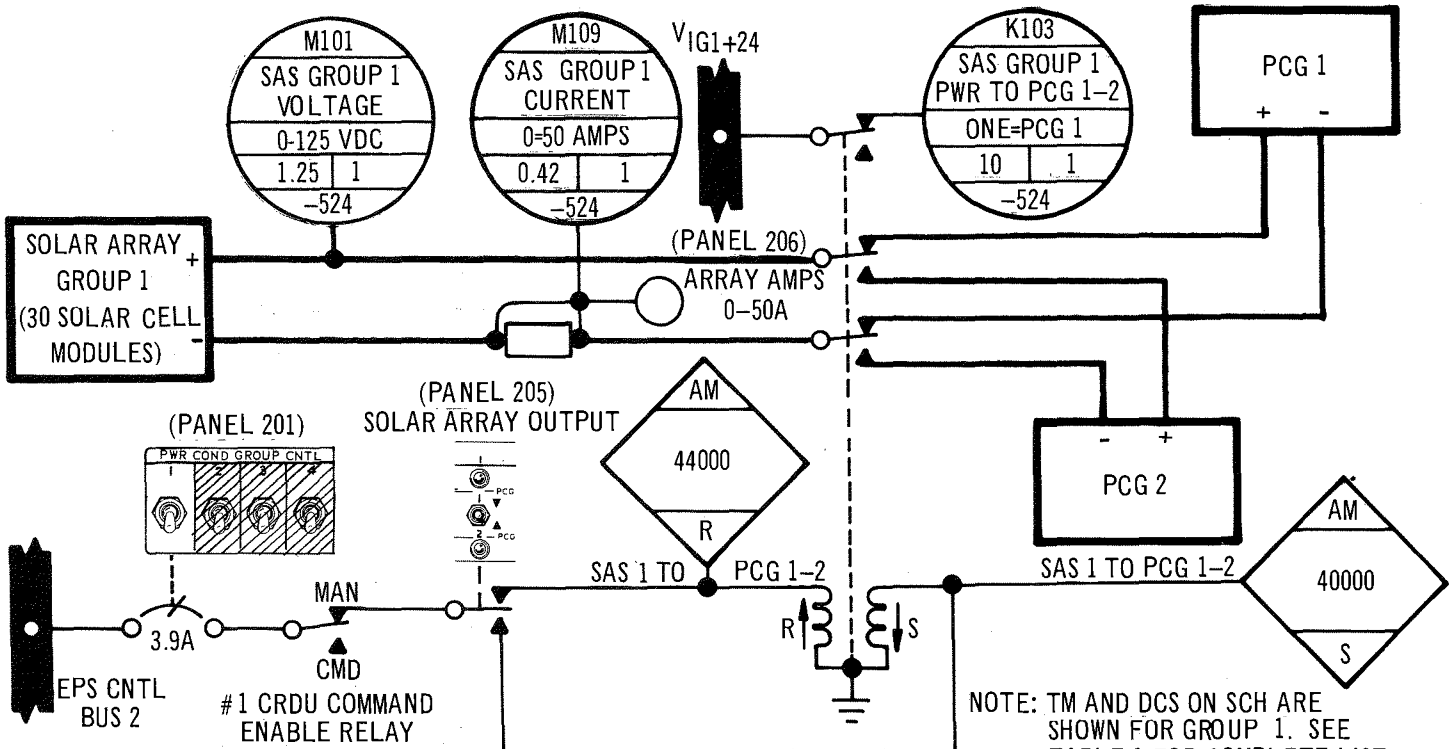



TABLE 1

| POWER GROUP NO. | VOLTAGE MEASUREMENT | CURRENT MEASUREMENT | EVENT MEASUREMENT | DCS SET | DSC RESET | SOLAR ARRAY SWITCHING | |
|---|---|---|---|---|---|---|---|
| | | | | | | NORMAL PCG | ALTERNATE PCG |
| 1 | M101 | M109 | K103 | 40000 | 44000 | 1 | 2 |
| 2 | M102 | M110 | K104 | 40200 | 44200 | 2 | 3 |
| 3 | M103 | M111 | K105 | 40040 | 44040 | 3 | 4 |
| 4 | M104 | M112 | K106 | 43240 | 47240 | 4 | 1 |
| 5 | M105 | M113 | K107 | 40100 | 44100 | 5 | 6 |
| 6 | M106 | M114 | K108 | 43500 | 47500 | 6 | 7 |
| 7 | M107 | M115 | K109 | 40140 | 44140 | 7 | 8 |
| 8 | M108 | M116 | K110 | 40340 | 44340 | 8 | 5 |

Figure 2.1.3-5 Typical Solar Array Group/PCG Interface

1211

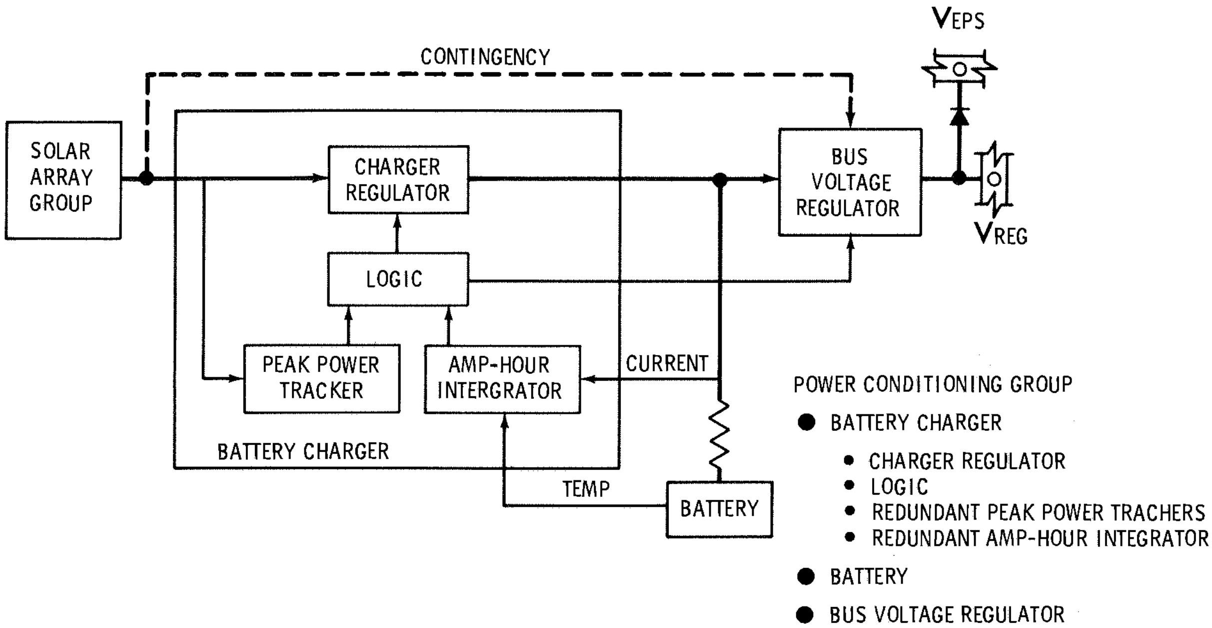



Figure 2.1.3-6 PCG Power Flow

The PCG consists of a battery, a battery charger, and a bus voltage regulator (figures 2.1.3-6 and -7). The battery charger consists of an amp-hour integrator, a peak power tracker, a charger regulator, and control logic. The output voltage of the charger regulator is controlled so that the combined loads of the bus voltage regulator and the battery charging do not exceed the power available from the array. The power demanded by the bus voltage regulator is supplied from either the charger regulator, the charger regulator and the battery in combination, or only from the battery. For example, with a particular voltage at the charger regulator output (V2 in figure 2.1.3-8) and with a subsequent increase in the power required by the bus voltage regulator, the charger regulator will decrease its output voltage, thereby reducing the current available for recharging the battery while maintaining the power demanded by the bus voltage regulator. As the bus voltage regulator loads are decreased, a greater amount of the available power from the solar array is used to recharge the battery. As the available power at the solar array is diminished, the charger regulator output voltage (V2) is decreased until the battery assumes a portion of the load. The peak power tracker allows the solar array to supply up to a maximum power point (within 4%) by restricting the charger regulator output voltage to a value such that the array is not overloaded.

Two identical amp-hour integrators are contained within each battery charger; however, only one is controlling the battery charging at any one time. Both units are actively integrating the current supplied to the battery (charging current) and the current drawn from the battery (discharge current). When the amp-hours removed from the battery equals the amp-hours returned, multiplied by a temperature compensated return factor, the unit will indicate a fully charged battery. Three thermistors in a single case located on the battery provide the temperature sensing for the compensation network for each of the amp-hour integrators. The amp-hour return factor relates (electronically) the charging efficiency to the battery temperature. With the unit starting at a predetermined point (33 amp-hours), it is able to continuously monitor the battery state-of-charge (SOC). Either the primary or the secondary unit may be selected by onboard control or by DCS command (figure 2.1.3-9). Both telemetry and onboard display of the SOC are available at all times from both the primary and secondary unit and the selection of either primary or secondary determines which unit is controlling. A 100 percent discrete signal is generated when the amp-hour integrator senses that the battery is fully charged and commands the charger to a constant current (trickle charge) charging mode of 0.75 amperes. This discrete signal may be inhibited by an onboard CHARGE MODE switch on panel 205. This allows the battery to continue to charge at a higher rate, determined only by the temperature limits of the battery and the power available for charging. In addition to the 100-percent SOC discrete signal, a 30-percent and a 50-percent SOC discrete signal is generated for control of the bus voltage regulator. A 30-percent SOC signal causes the bus voltage regulator to reduce its output voltage by 2 volts, effectively removing the regulator from the buses. Thus all of the available power from the array through the charger regulator is used to recharge the battery. Upon return to 50-percent SOC, the units resume operation in a normal mode. The 30-percent SOC signal to the bus voltage regulator may be inhibited by an onboard discharge limit control or by DCS commands. Application of this inhibit control allows the indicated battery SOC to go below the 30-percent SOC level without reduction of the bus voltage regulator output voltage. The

1030

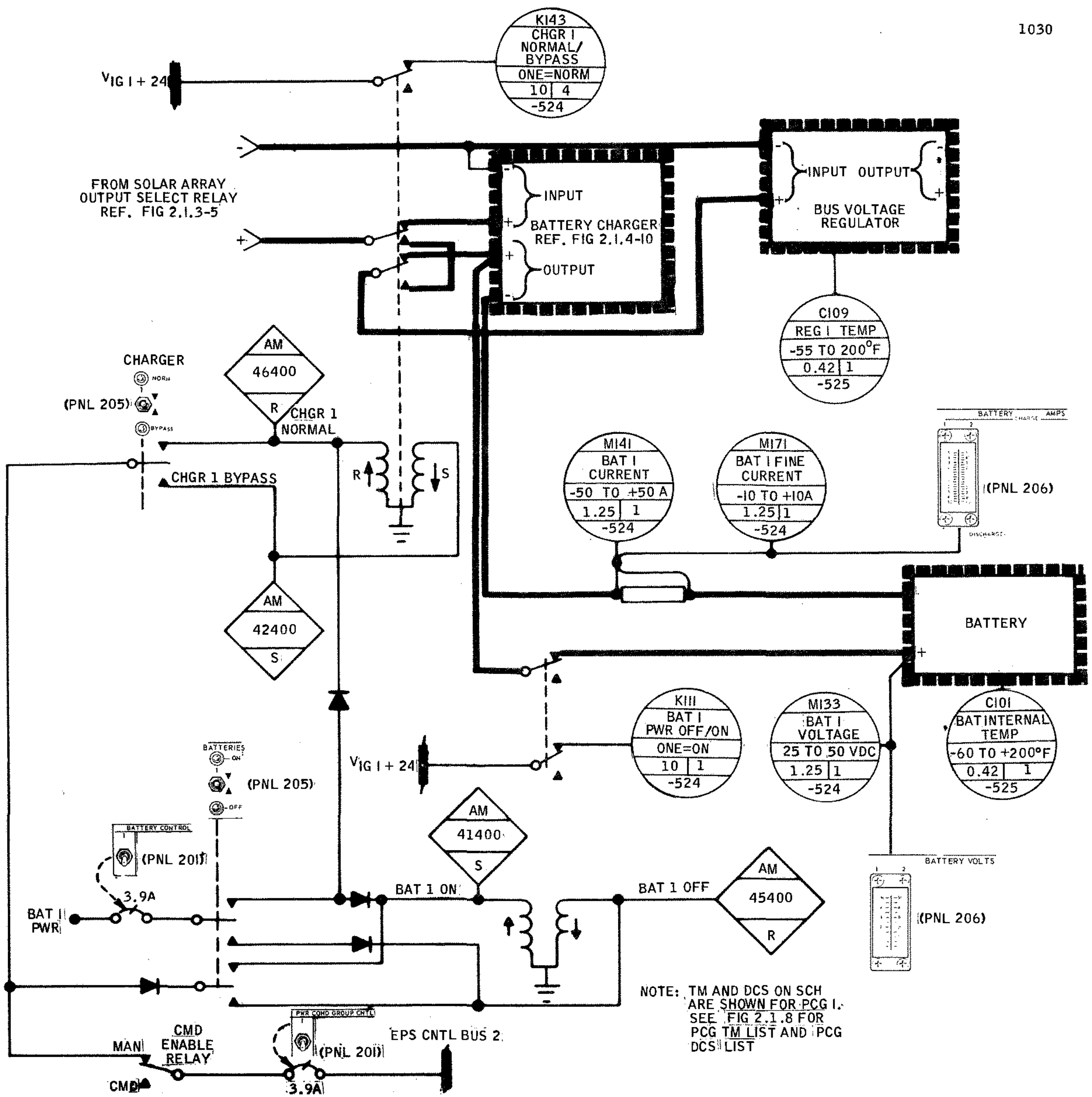



Figure 2.1.3-7 Simplified PCG Schematic

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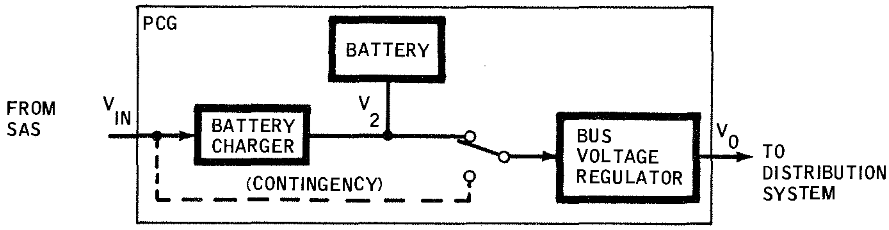


NORMAL OPERATING VOLTAGES UNDER VARIOUS CONDITIONS

| CONDITION | $V_{IN}$ | $V_2$ | $V_0$ NO LOAD | $V_0$ FULL LOAD |
|---|---|---|---|---|
| 1. WITH SUFFICIENT ARRAY POWER AVAILABLE | | | | |
| a. CONSTANT VOLTAGE MODE (BATTERY BEING CHARGED) | 51-125 V | 42.6-48 V | 26-30 V | 24-28 V |
| b. CONSTANT CURRENT MODE (BATTERY FULLY CHARGED) | 51-125 V | 36 - 39 V* | 26-30 V | 24-28 V |
| 2. ARRAY POWER PLUS BATTERY POWER | 51-125 V | 33 - 36 V | 26-30 V | 24-28 V |
| 3. BATTERY POWER ONLY | N/A | 33 - 41 V | 26-30 V | 24-28 V |
| 4. ARRAY POWER IN BYPASS MODE (CONTINGENCY) | 0**-125 V | N/A | 26-30 V | 24-28 V |

* THAT VOLTAGE NECESSARY TO SUPPLY 0.75AMPS

** SYSTEM WILL NOT OPERATE WITHIN TOLERANCE WITH VOLTAGE LESS THAN 30 V

Figure 2.1.3-8 PCG Operation Voltage

30-percent SOC signal from the controlling unit is also sent to the caution and warning system where it is displayed as BAT CHARGE LOW on panel 207.

In addition to the amp-hour integrators 100-percent SOC signal, there are two other functions that will cause the battery charger to go into a constant-current charging mode. There is an onboard CHARGE RATE control and a DCS command (figure 2.1.3-9) that will override the CHARGE MODE function of the amp-hour integrator and cause the battery charger to operate in the constant-current (trickle charge) mode. Additionally, a battery terminal voltage of less than 25 volts will command a constant current charge mode. The complete loss of the battery voltage sense will cause the battery charger output voltage to go to 52 volts. This would normally occur when the onboard battery control or DCS control (figure 2.1.3-7) is switched off. With the battery disconnected from the system, the battery charger simply acts as a pre-regulator, with active peak power tracker, supplying conditioned power to the bus voltage regulator in the daylight portion of the orbit. It is also possible to bypass the battery charger as well as the battery by operation of the onboard CHARGE BYPASS switch on panel 205 or DCS control (figure 2.1.3-7), thereby completely disconnecting the battery charger and battery in case of failure of either.

Temperature compensation of the battery charging voltage limit prevents hydrogen generation within the battery and restricts the oxygen generation rate to that level which can be recombined within the battery without venting. Two thermistors installed on the battery measure the temperature for this function. For any temperature over 120°F, the battery charging is automatically stopped. The same result is accomplished by the operation of either a DCS command (figure 2.1.3-9) off, or the activation of a thermal switch located on the battery which opens when the battery temperature reaches 125°F.

The battery is rated at 33 amp-hours and is constructed of 30 series-connected nickel cadmium sealed cells. The battery operates between 48 volts (the maximum charge voltage) and 30 volts (the complete discharge voltage level). There are nine thermistors located on each battery, three for the primary and three for the secondary amp-hour integrators, two for the charge rate control, and the ninth for telemetry. The thermal switch as previously discussed is used as a backup protective device.

The bus voltage regulator receives its power from the battery charger and/or the battery and in the contingency mode directly from the solar array. The voltage and current input to the regulator varies over a wide range, but, by employing a "buck-type" regulator, it is able to efficiently regulate the voltage to the desired level. The open circuit voltage is manually adjustable from 26 to 30 volts dc by means of REG ADJUST potentiometers on panel 206, which simultaneously adjusts all regulators tied to the same bus. Two potentiometers are provided, one for each REG bus. This adjustment is made to share loads between the EPS and the other OA power sources. A REGULATOR CONTROL FINE ADJUST potentiometer (panel 206) for each of the eight regulators allows a vernier adjustment of the load sharing between the individual regulators.

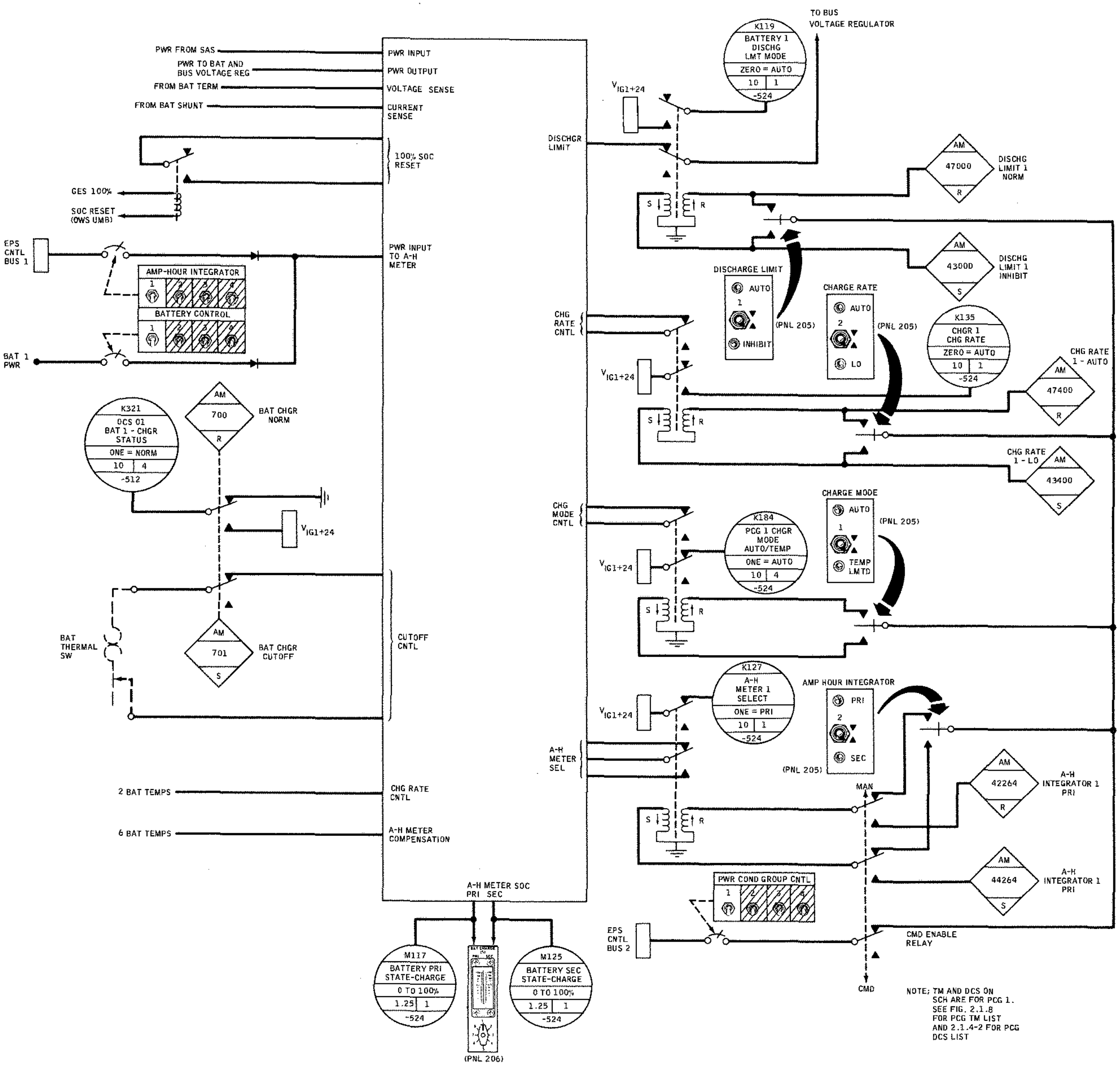


Figure 2.1.3-9 Simplified Battery Charger Diagram

2.1.3.4 POWER DISTRIBUTION

The EPS bus arrangement is illustrated in figure 2.1.3-10, with only one of eight PCG's shown and part of the bus 2 arrangement omitted for clarity. The system consists of isolated positive buses with a common return. All wire unprotected by circuit breakers or fuses is routed externally to the pressurized area. Generally, the circuit protective device is sized to protect the wire.

2.1.3.4.1 Regulated Bus

The REG buses receives their power directly from the PCG through two power relays. The PCG OUTPUT ON-OFF switch on panel 205 and associated DCS control (figure 2.1.3-11) provide the capability of disconnecting any one of the PCG's from the REG bus. See paragraph 2.1.3.4.5 for the override from the PWR DISCONNECT 1 OPEN switch, which operates on PCG 1 through 4, and switch 2, which operates on PCG 5 through 8. The output of the power relay goes to a PCG bus select power relay. The PCG OUTPUT REG BUS 1/REG BUS 2 switch on panel 205 and the associated DCS commands permit any one of the eight PCG's to be switched to either REG bus 1 or REG bus 2 (figure 2.1.3-11). Not only is the positive power line switched, but the return power line plus the voltage sense lines are switched. Normally, PCG's 1 through 4 are connected to REG bus 1 and PCG's 5 through 8 are connected to REG bus 2.

The two REG buses are normally tied together through two circuit breakers by the crew to equalize bus loading. If the breakers trip because of too great an unbalance of the two lines, the system will continue to operate as a two-bus system. REG buses 1 and 2 have a high and low caution and warning monitor, a coarse and fine telemetry voltage monitor, plus an onboard volt meter. The current is monitored on telemetry and an onboard meter. A shunt is provided in the return of each bus for current sensing (figure 2.1.3-12).

2.31.3.4.2 EPS Control Bus

Each PCG output is diode isolated, and four are tied together at each EPS control bus (figure 2.1.3-10) to power essential loads. Unlike the other buses, EPS buses 1 and 2 cannot be powered down by the crew or by ground action. Voltage and current for the EPS control bus are monitored only on telemetry. Shunt regulators are provided for each EPS control bus to prevent overvoltage conditions from occuring on the power system as a result of a bus voltage regulator failure. The shunt regulator limits the voltage at the EPS control bus, while simultaneously providing an additional current path until circuit interruption of the failed regulator module has occured. The shunt regulator may be removed from the system by the use of the EPS SHUNT REG (panel 206).

2.1.3.4.3 OWS Bus

OWS buses 1 and 2 receive power from REG buses 1 and 2 through power relays located in the AM. Each of the nine lines in each feeder circuit is protected by circuit breakers at each end of the line (figure 2.1.3-13). The manual ON-OFF switch on panel 206 and the DCS commands are interconnected with the POWER SYSTEM CONTROL MANUAL - CMD switch. The OWS BUS ON-OFF switch on panel 617 is completely independent of this function. There are three current sensors on each positive bus, one for display on OWS panel 617, one for AM display on panel 206, and the third for telemetry (figure 2.1.3-12). The voltage is monitored by telemetry and a meter on OWS panel 617. An undervoltage indication is provided by C/W OWS BUS 1 and 2 LOW (panels 207 and 616) for voltages under 23.5 vdc.

2.1.3.4.4 AM Bus

AM bus 1 normally receives power from REG bus 1, and AM bus 2 receives power from REG bus 2. With the manual controls on panel 206 and also with DCS commands, it is possible to select either REG bus as a power source or both AM buses to receive power from the same REG bus (figure 2.1.3-10). The voltage and current for the AM bus in monitored only on telemetry.

2.1.3.4.5 Transfer Bus

The transfer bus is the common tie point for the three power systems contained in the OA (figure 2.1.3-10). The power transfer from the REG bus to the transfer bus as well as the ATM bus to transfer bus tie is controlled by DCS commands and by switches on panel 206 in the AM. The power switching control from the transfer bus to the CSM is accomplished by controls located on panel 230 in the CM.

The REG to transfer tie is shown in figure 2.1.3-14. In addition to the switch on panel 206 and the DCS command, the power relay may be opened manually using the PWR DISCONNECT switch on panel 205. The PWR DISCONNECT 1 switch (figure 2.1.3-15) not only removes transfer bus 1 from REG bus 1 but also disconnects PCG 1 through 4 from the system (figure 2.1.3-11). Likewise, PWR DISCONNECT 2 disconnects transfer bus 2 from REG bus 2 and removes PCG's 5 through 8 from the system. The REG to transfer current is monitored on TM (figure 2.1.3-12).

Transfer buses 1 and 2 are connected to ATM buses 1 and 2 through power relays and circuit protective devices. Each of the 18 power lines per bus contains a fuse located in the ATM and a circuit breaker located in the AM (figure 2.1.3-16). There is individual control for bus 1 and bus 2 power transfer by manual control on panel 206 and also by DCS commands. The two power relays will normally be open at launch and will be closed by DCS command after solar array deployment, thereby allowing the ATM and the AM power systems to operate in parallel. Load sharing is accomplished by voltage adjustment of the REG ADJ BUS 1 and 2 on panel 206. This adjustment is accomplished prior to launch to a predetermined level. The magnitude and direction of current to the transfer bus from the REG bus and from the ATM bus is monitored by meters on panel 206 and by telemetry. See figure 2.1.3-12 for the six transformer coupled current sensors, all of the same basic design.

1214

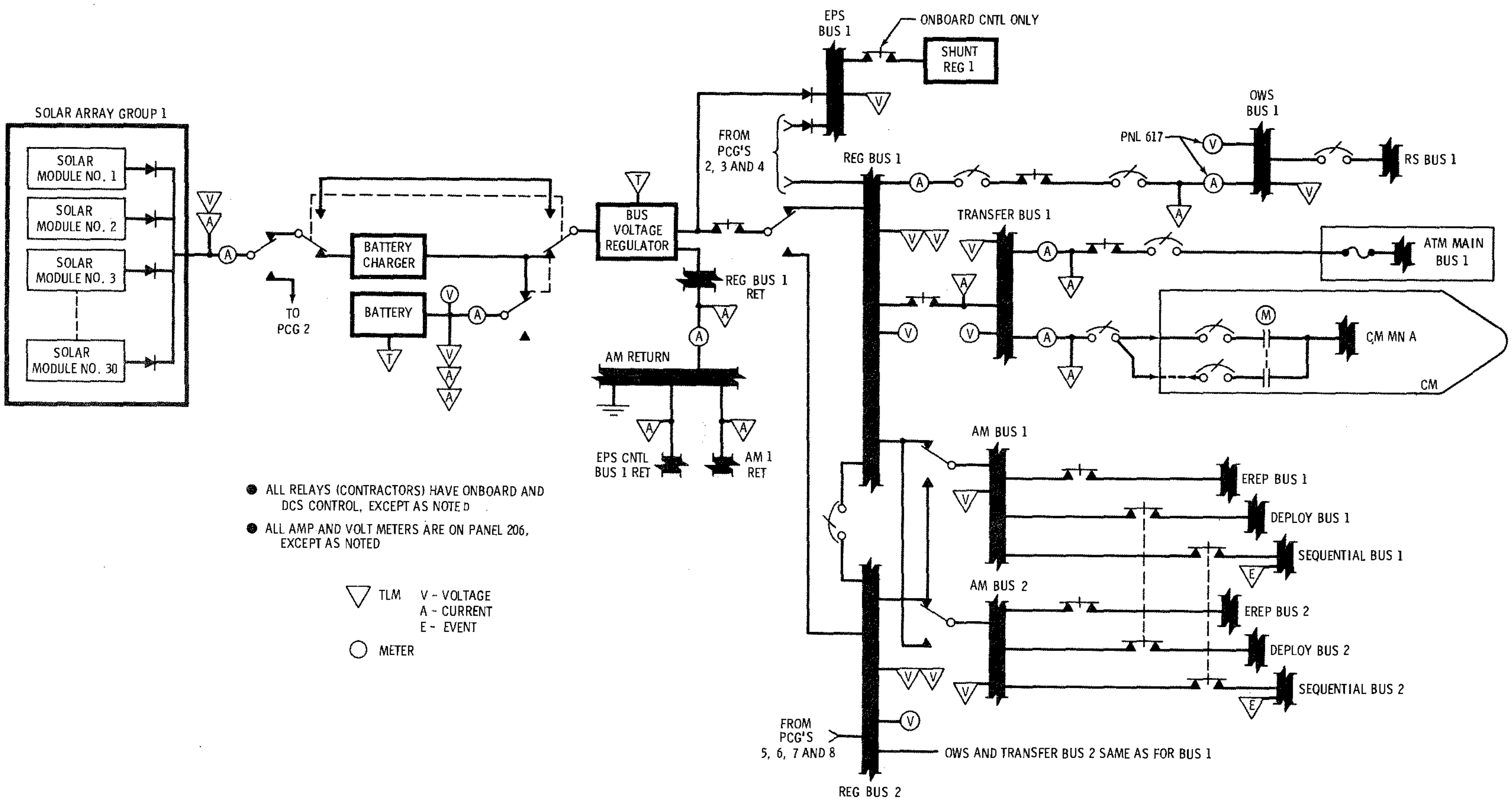


Figure 2.1.3-10 Power Distribution

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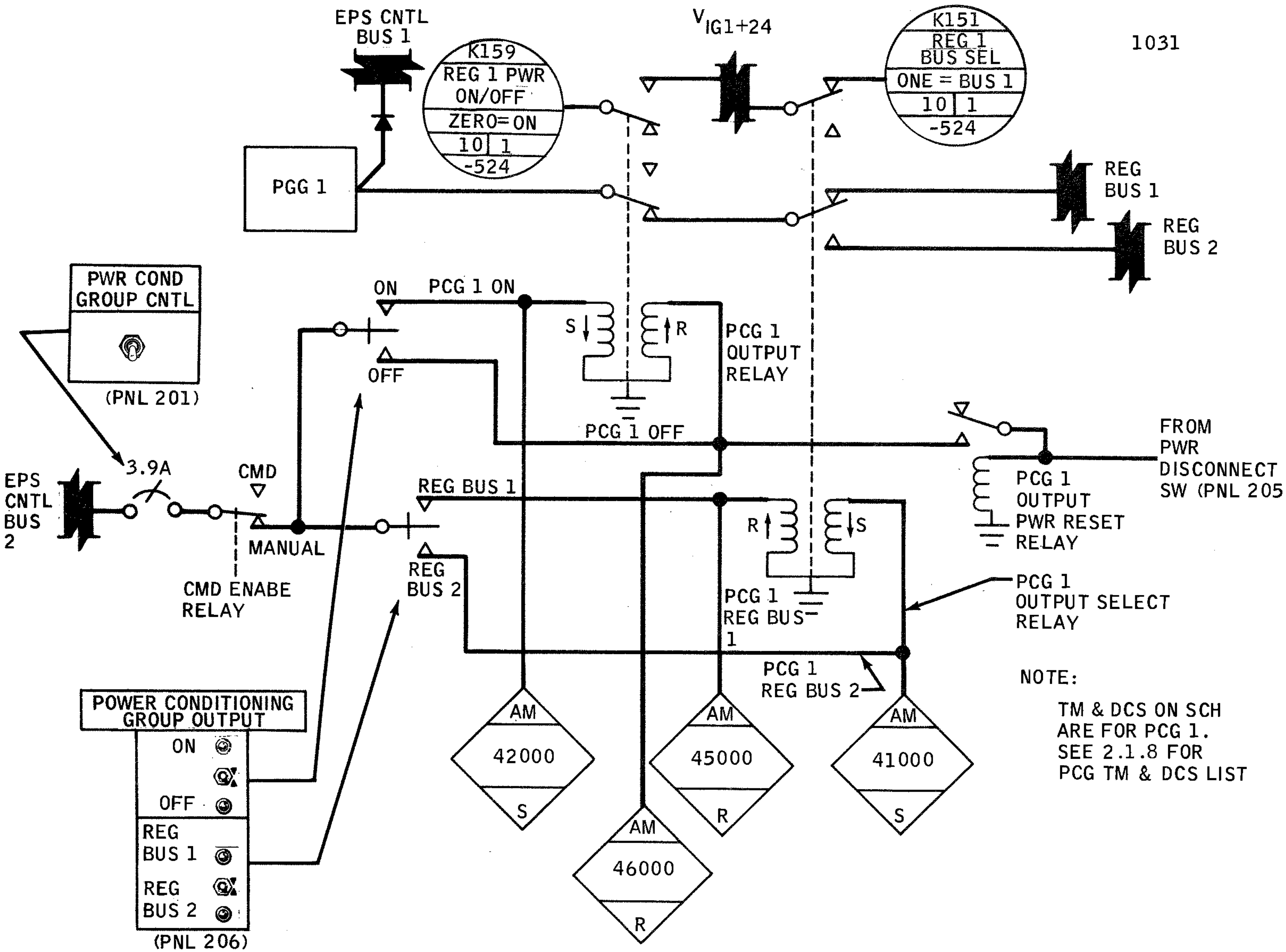



NOTE:

TM & DCS ON SCH ARE FOR PCG 1. SEE 2.1.8 FOR PCG TM & DCS LIST

Figure 2.1.3-11 PCG Output Schematic

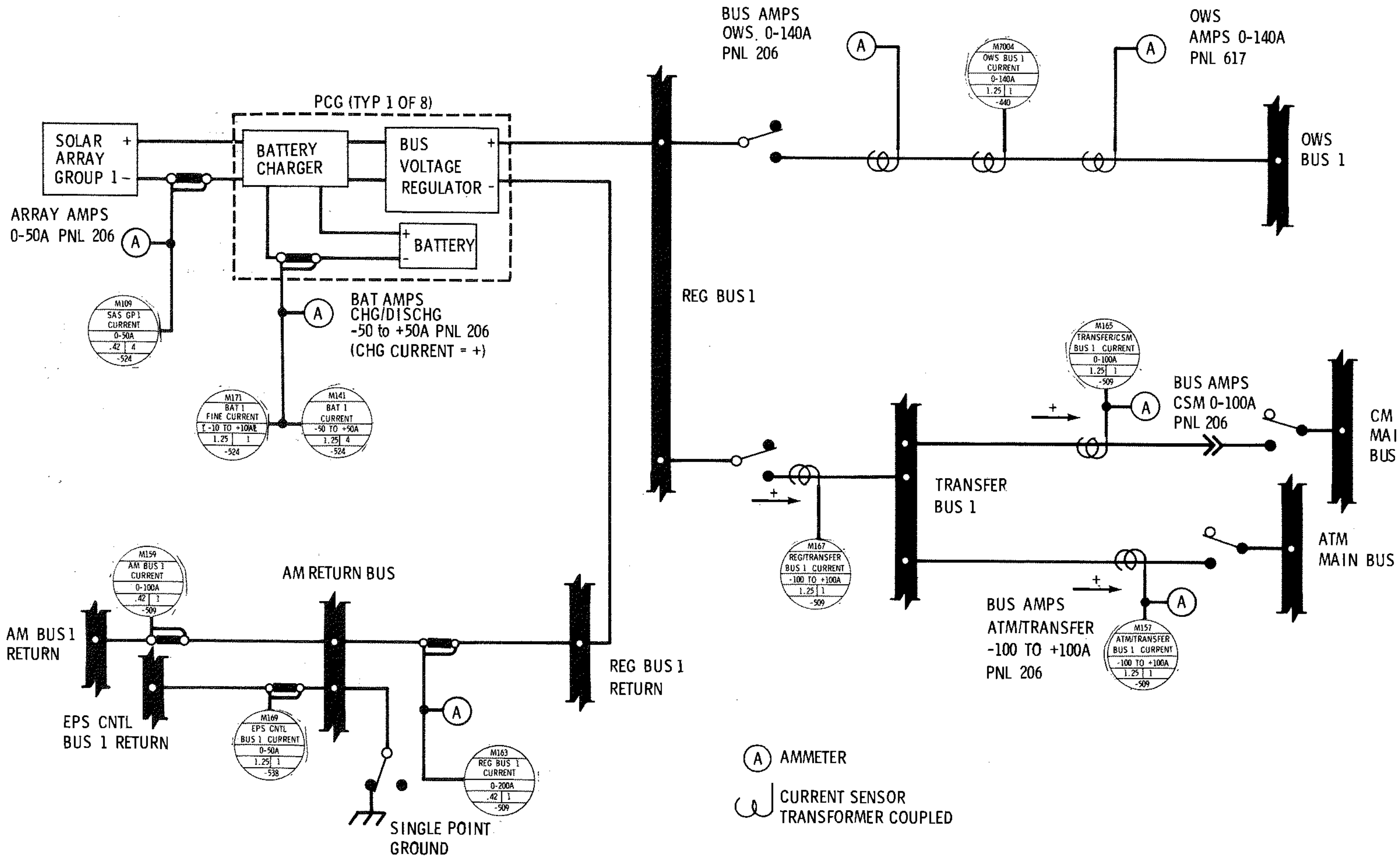



Figure 2.1.3-12 Typical Shunt/Current Sensor Arrangement

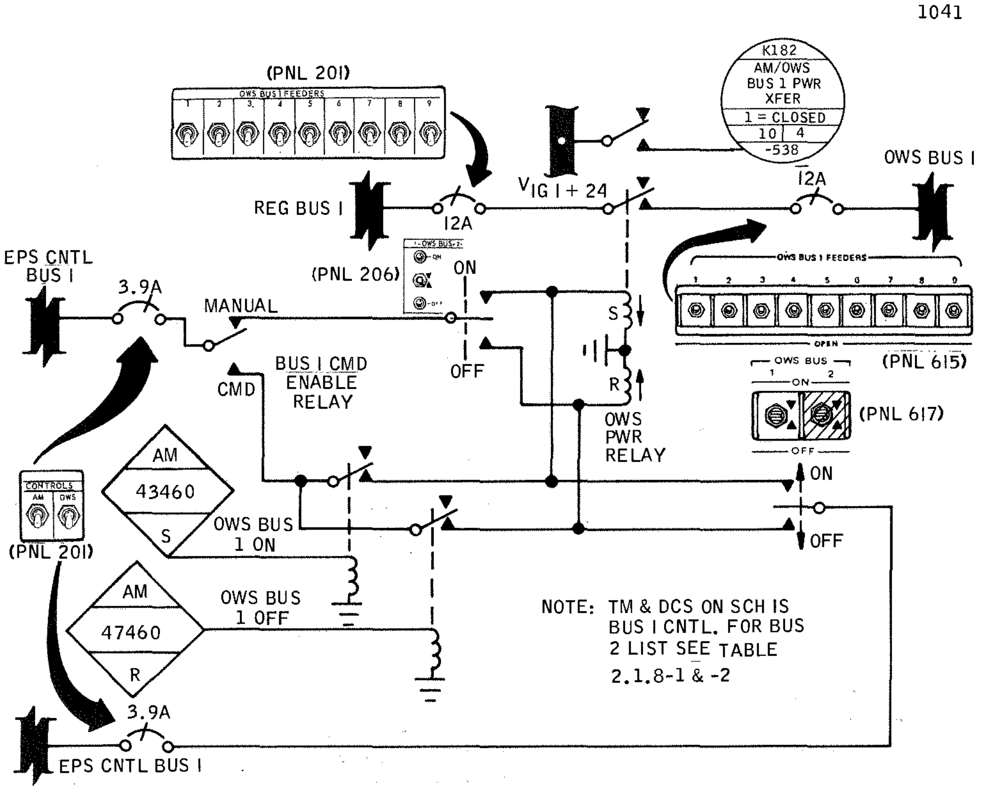



Figure 2.1.3-13 OWS Power Control

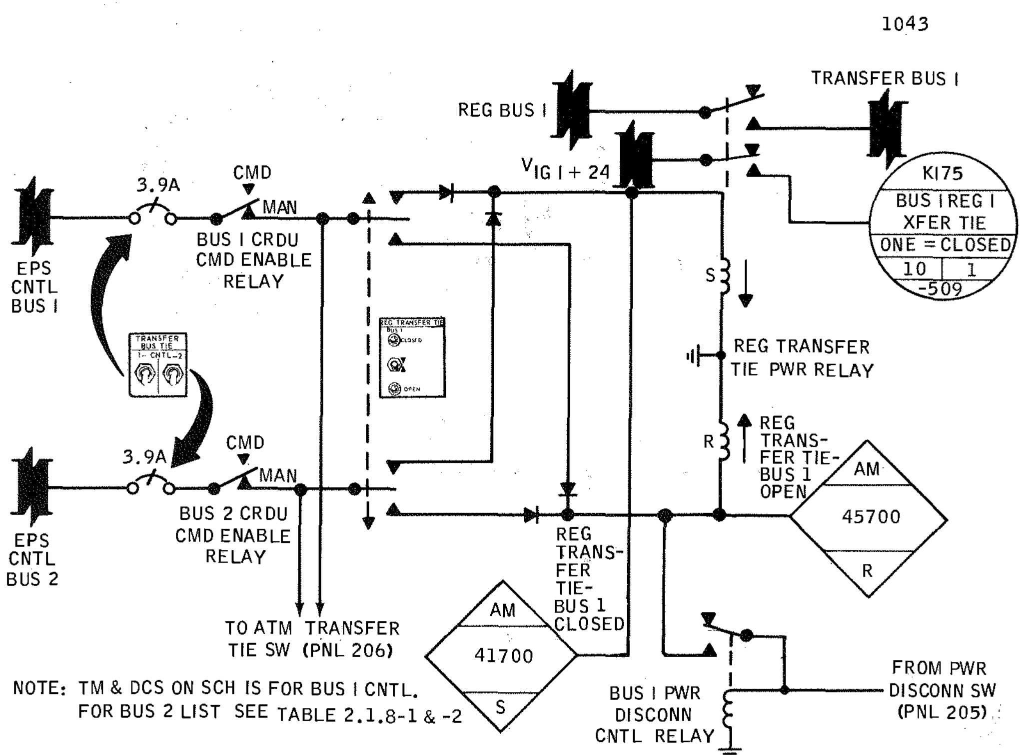



Figure 2.1.3-14 Reg Transfer Tie

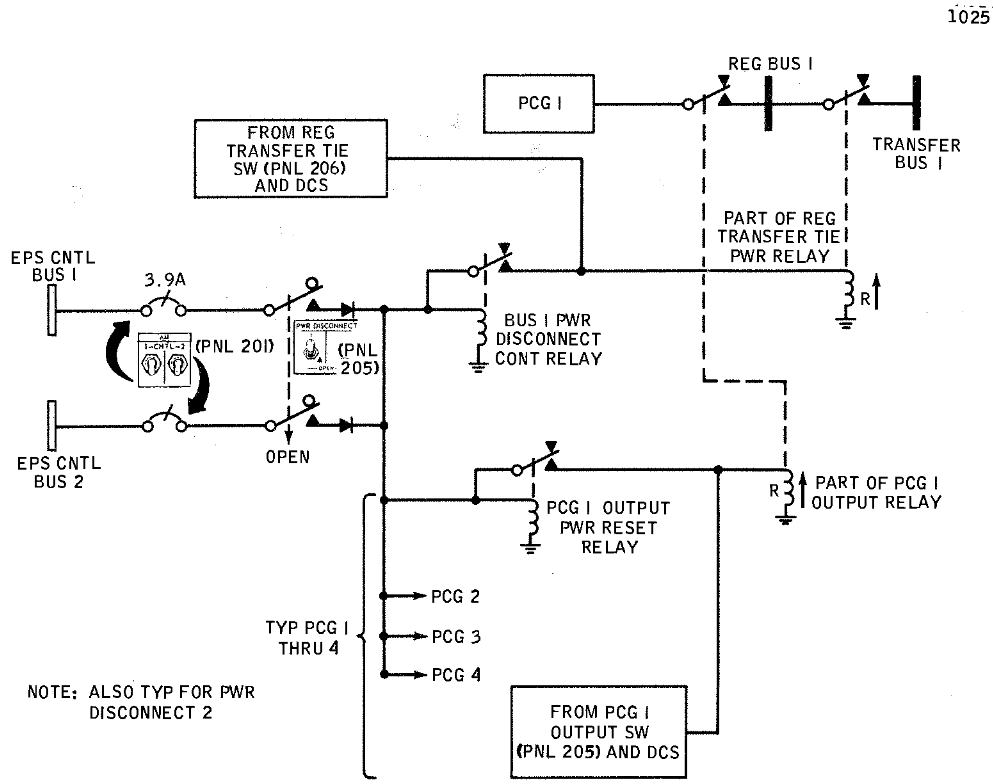



Figure 2.1.3-15 Power Disconnect

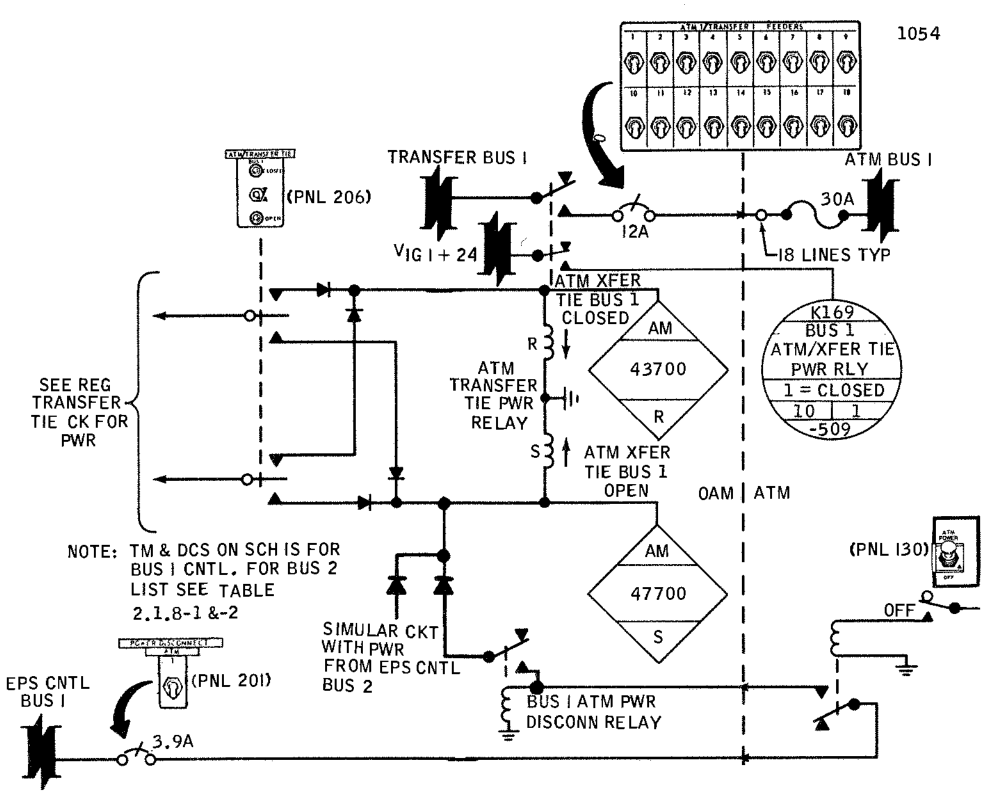



Figure 2.1.3-16 ATM Transfer Tie

1052

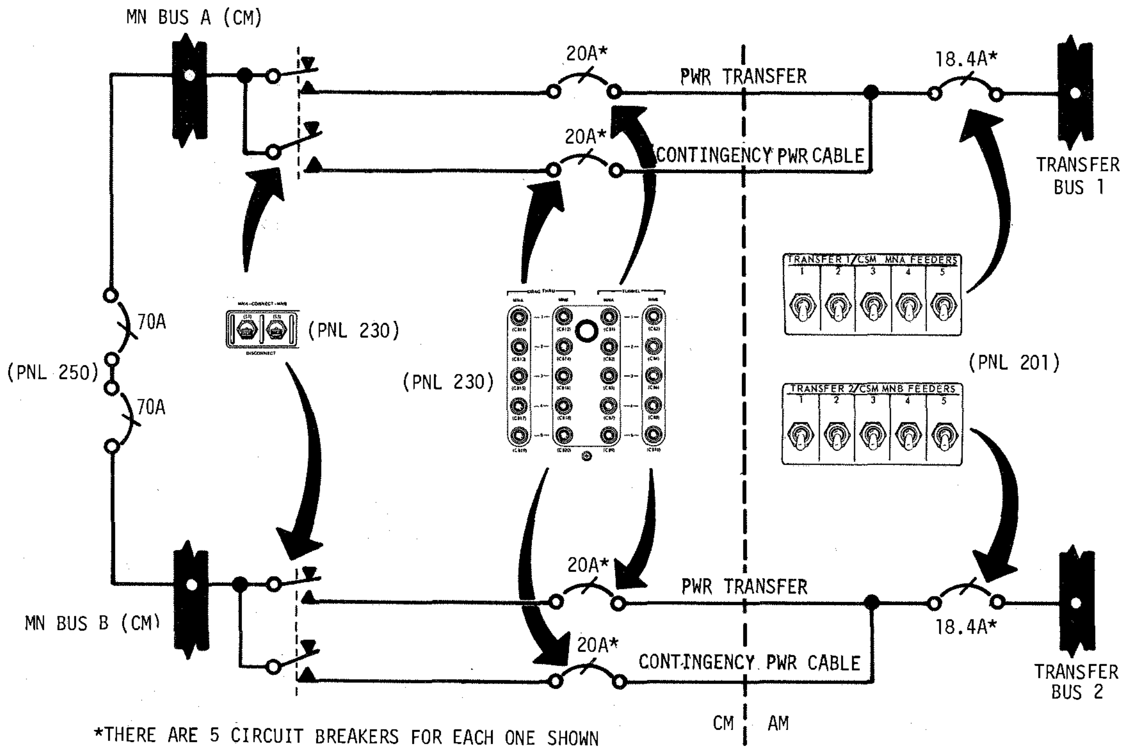



Figure 2.1.3-17 AM/CSM Distribution Interface

The ATM to transfer power tie may be overridden and opened by a single ATM PWR OFF switch on the ATM C&D panel in the MDA (panel 130). Caution and warning lights are provided to indicate C/W ATM BUS 1 and 2 LOW (panel 207).

Transfer buses 1 and 2 are tied to the CM MAIN BUS A and B (figure 2.1.3-17). For each of the buses, there are five transfer lines, each containing a circuit breaker at each end, at panel 201 in the AM, and at panel 230 in the CSM. Main buses A and B may be connected together by the use of dual 70-amp circuit breakers on panel 250 in the CM. The current supplied to the CSM is monitored on telemetry and a meter on panel 206 (figure 2.1.3-12).

2.1.3.4.6 Deploy Bus

Power to deploy buses 1 and 2 is supplied by AM buses 1 and 2, respectively, through two power relays. Actuation of either power relay accomplishes the switching of both functions. Control power is supplied through DEPLOY BUS ARM PRI and SEC circuit breakers on panel 202 to the DEPLOY BUS switch on panel 205 (figure 2.1.3-18). With the DEPLOY BUS switch in the CMD position, one power relay is actuated by an OWS switch selector command. The other power relay is actuated by the DCS and is used as a backup. Placing the DEPLOY BUS switch to the ARM position will actuate both power relays. Placing the switch to the SAFE position keeps power from being applied to either deploy bus.

Figure 2.1.3-19 shows the four types of loads on the deploy buses: ATM solar array deployment, discone antenna deployment, OWS solar array deployment, and meteoroid shield deployment.

2.1.3.4.7 Sequential Bus

Power to sequential buses 1 and 2 is supplied by AM buses 1 and 2, respectively through two power relays. Actuation of either power relay accomplishes the switching function. Control power is supplied through DEPLOY SEQ BUS ARM PRI and SEC circuit breakers on panel 202 to the SEQ BUS switch on panel 205 (figure 2.1.3-20). With the SEQ BUS switch in the CMD position, any one of the commands will arm both buses. With the switch in the SAFE position, power is removed from the command circuit (only method of disarming circuit).

Figure 2.1.3-21 shows the three types of loads connected to the sequential bus: RS-radiator shield jettison, payload shroud jettison, and ATM deployment systems.

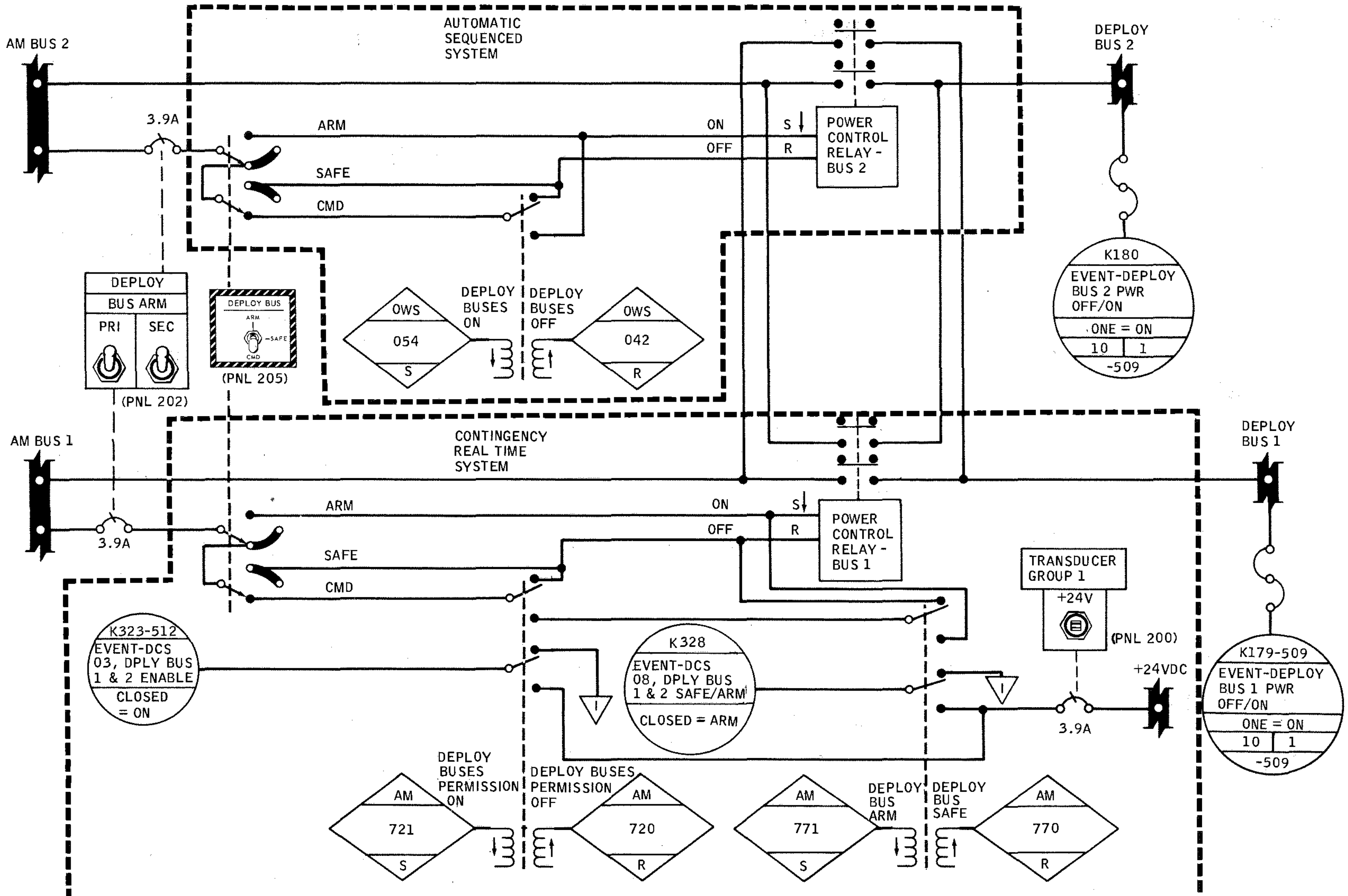



Figure 2.1.3-18 Deploy Bus Control

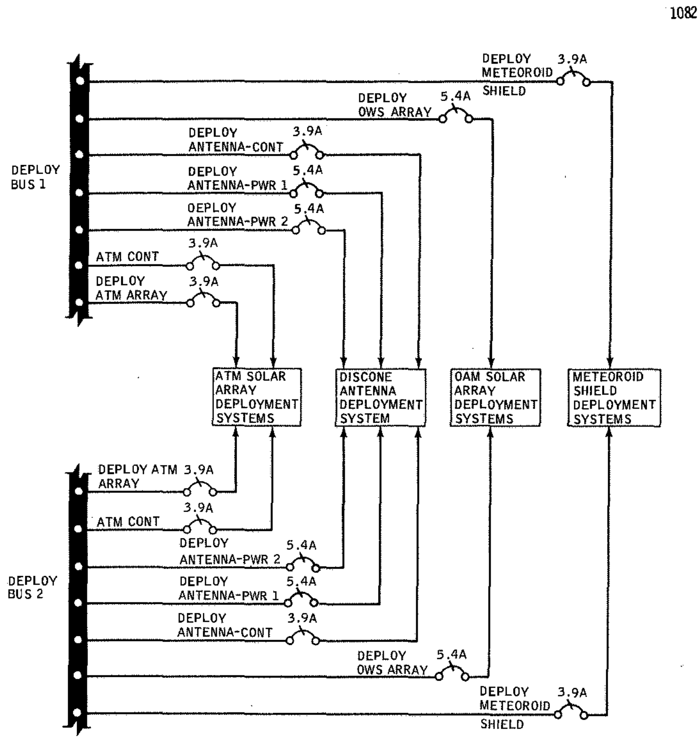



Figure 2.1.3-19 Deploy Bus Loads

2.1.3.4.8 EREP Bus

EREP buses 1 and 2 receive power from AM buses 1 and 2 through individual power relays. Control power is supplied through EREP PWR CNTL 1 and 2 circuit breakers (panel 202) to EREP PWR CONTROL switches located on EREP C&D panel 110 in the MDA, which in turn controls the two power relays (figure 2.1.3-10).

2.1.3.4.9 Power Returns and Grounds

The power return from each load is connected to a return bus designated for each supply bus. The AM return bus is the common tie point for all the various returns (figure 2.1.3-22). REG bus, EPS control bus, and AM buses 1 and 2 returns all have shunts for current monitoring. The CSM, ATM, and OWS all have a current sensor in the positive power feeder for current monitoring.

Grounding of the power system is accomplished through a single-point ground (SPG). This ground is made in the CM upon connection of the MDA power umbilical or contingency power cable from the CM to the MDA. At this time in order to maintain only one ground, it is necessary to disconnect the SPG that has been maintained in the AM through a power relay. This is accomplished either manually, with ELEC GND on panel 206, or by DCS command (figure 2.1.3-23). Since two power relays are in parallel, the making of either relay establishes an AM ground, but it is necessary to open both relays to disconnect the ground.

2.1.3.4.10 Utility Power

The utility power outlets and high-power accessory outlets provide power to remote locations within the OA, where various types of portable equipment are utilized. The zero-G connector provides a safe electrical power source of 28 vdc.

Utility power from the AM and MDA is supplied by AM buses 1 and 2, six in the AM and four in the MDA (figure 2.1.3-24). There are two HI PWR ACCESS outlets located in the MDA. Deadfacing capability for each outlet is via an ON/OFF switch that allows local control of the individual power receptacles at the outlet. The utility power outlets in the AM and MDA have a common pin used as an event marker.

Utility power from the OWS is supplied from OWS bus 1 and 2 (figure 2.1.3-25). There are 12 HI POWER ACCESSORY OUTLETS, 18 UTILITY OUTLETS, and 4 SAL outlets. Unlike the ones in the AM and MDA, the receptacles in the OWS have no deadfacing switch at the receptacle.

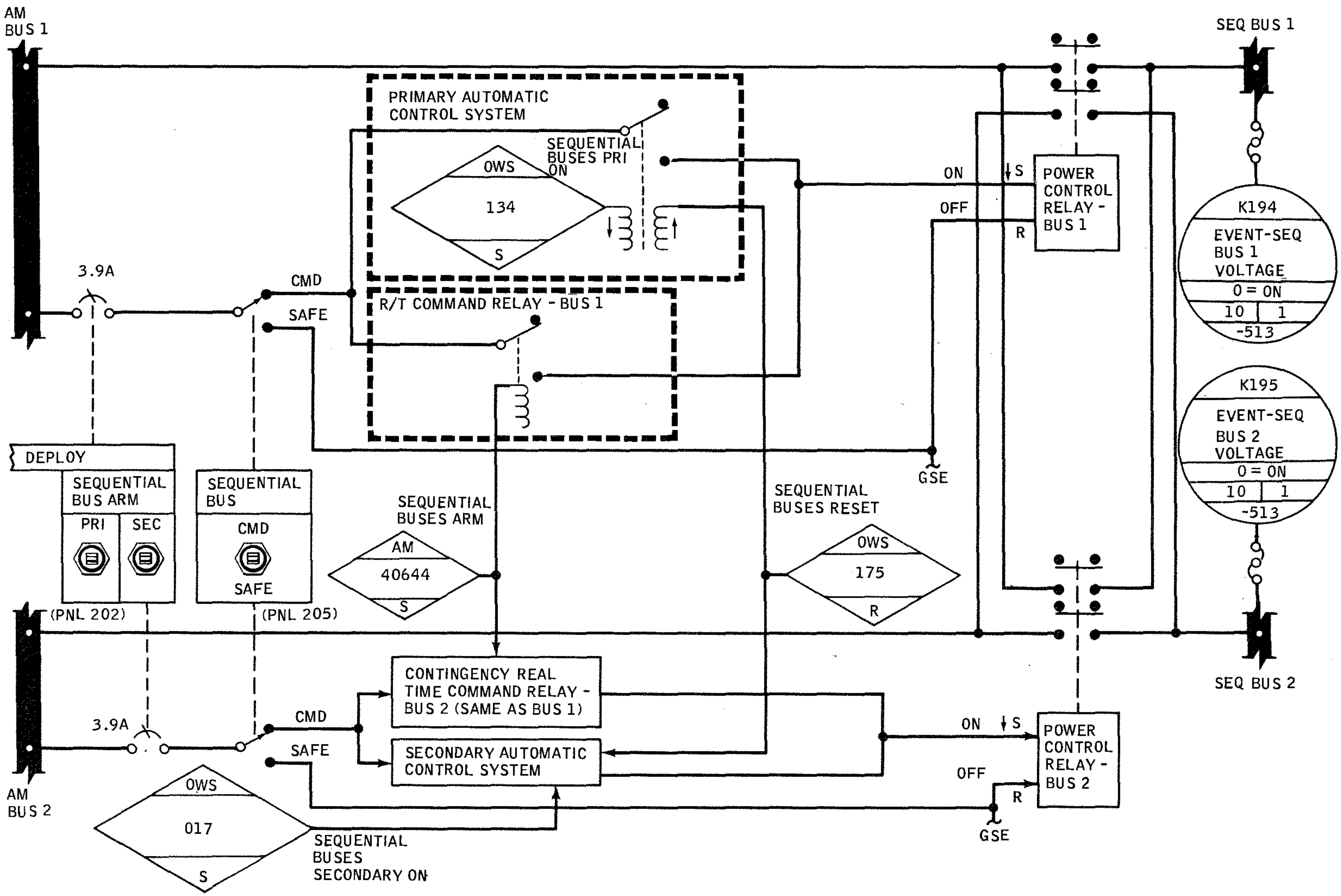



Figure 2.1.3-20 Sequential Bus Control

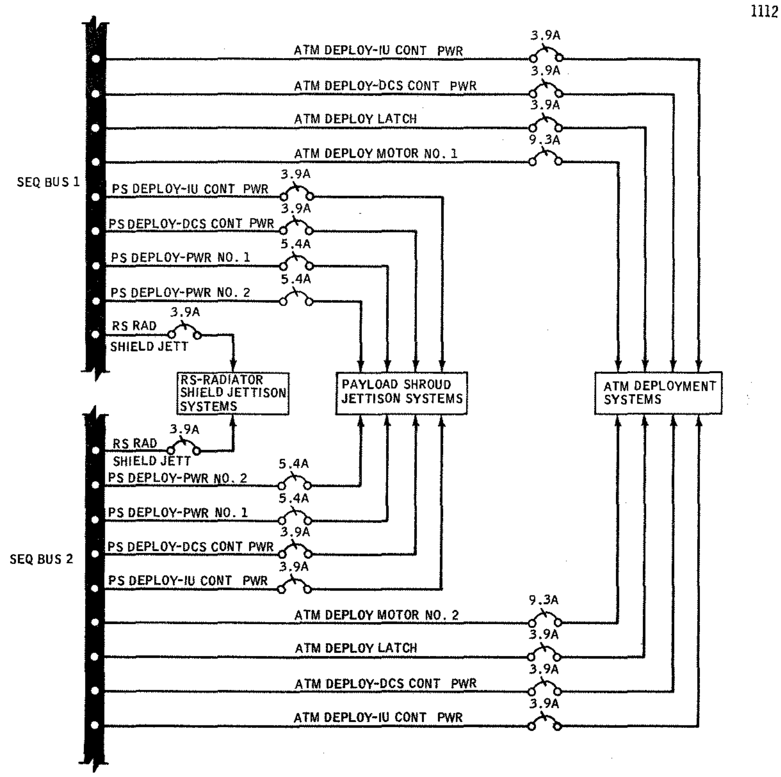



Figure 2.1.3-21 Sequential Bus Loads

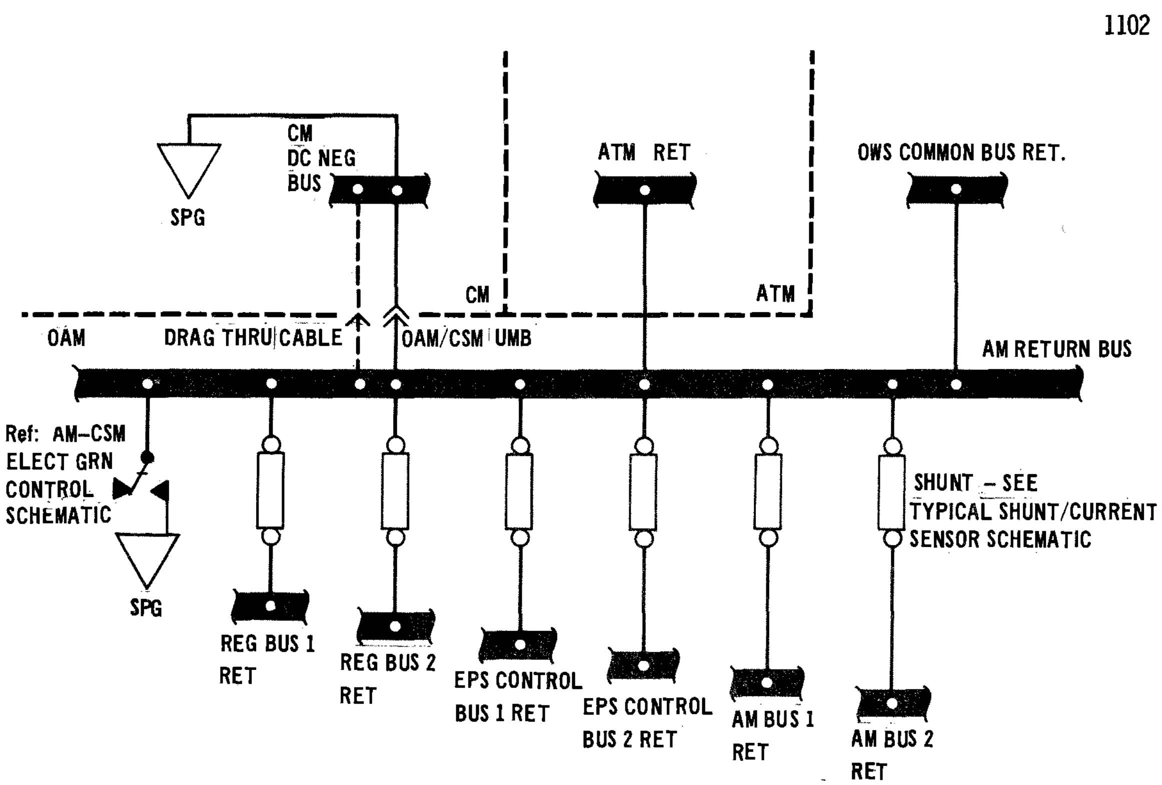



Figure 2.1.3-22 OA Grounding System

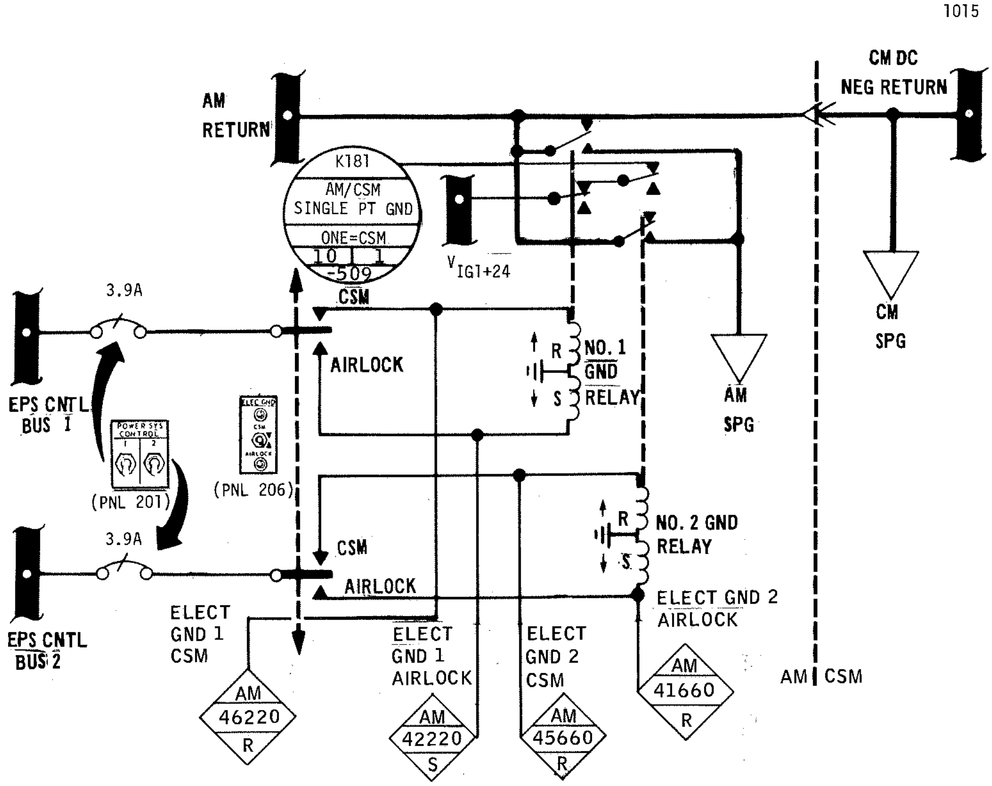



Figure 2.1.3-23 AM-CSM Single-Point Ground Control

## 2.1.4 SUBSYSTEM AND MAJOR COMPONENT DESCRIPTION

The subsequent paragraphs describe each of the various EPS components.

### 2.1.4.1 POWER GENERATION

#### 2.1.4.1.1 Solar Cells

The sun side of the solar array is covered by 147,840 silicon solar cells, each capable of producing 113 milliwatts (average of electrical power when positioned normal to the sun). The solar cell is a 2x4-cm (0.014 inch thick) semi-conductor device with a transparent fused cover (0.006 inch thick), bonded over the exposed side of the cell to protect it from charged particles and to minimize meteoroid damage.

The performance of the solar cell is affected by the following factors: temperature of the cell, amount of light available to the cell, cell degradation, and angle of incidence ($\alpha$). The amount of light that falls upon the solar cell controls the cell output capability. The light energy available to the cells depends upon shadowing of the cells and the length of the daylight period of the orbit. Either the earth or SWS equipment can produce shadowing of the cells. The length of the daylight period is a function of orbital period, orbital altitude and Beta ($\beta$) angle. The Beta angle is the angle the SWS orbital plane makes with the parallel radiation lines from the sun. As the orbital daylight period increases, a longer solar cell exposure time results, producing higher average energy available from the cells.

Charged particle damage to the silicon is the most important cause of degradation of cell output, with a maximum power loss of approximately 4.2 percent at the end of SL-4. Micrometeoroid bombardment is expected to be negligible because of the low-altitude orbit, the 0.006-inch thick coverslide protection, and the relatively short duration of the mission. However, the 4000 temperature cycles to be endured during the mission are expected to cause a 1-percent power loss at end of life (SL-4). This temperature cycling degradation is based on fatigue life tests of Kovar interconnectors attached to silicon solar cells. Other time-dependent degrading factors are overboard dumping and venting of gases and liquids, and thruster firing contamination and deterioration of the transparent cover over the cell.

1206

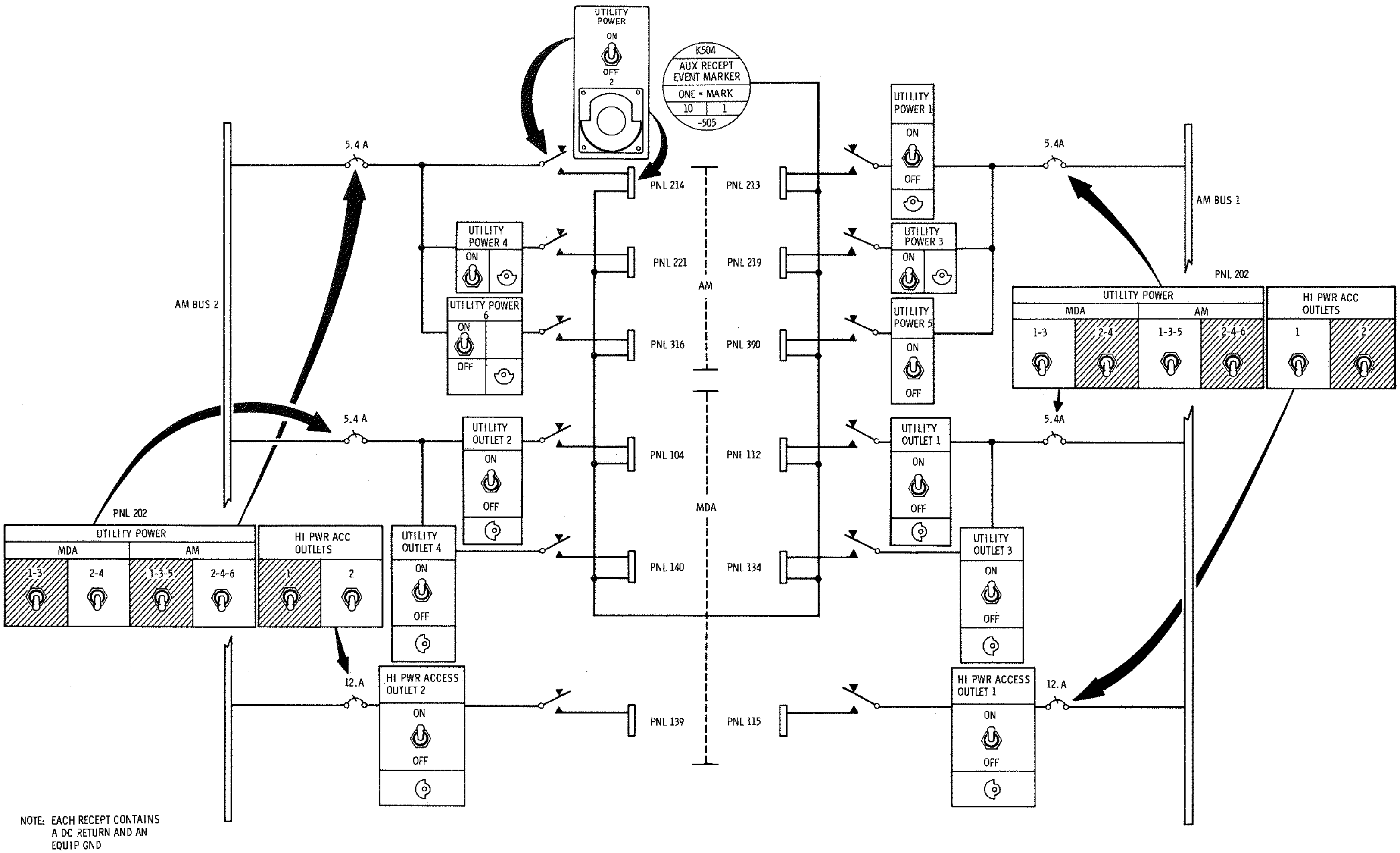



Figure 2.1.3-24 AM/MDA Utility Power

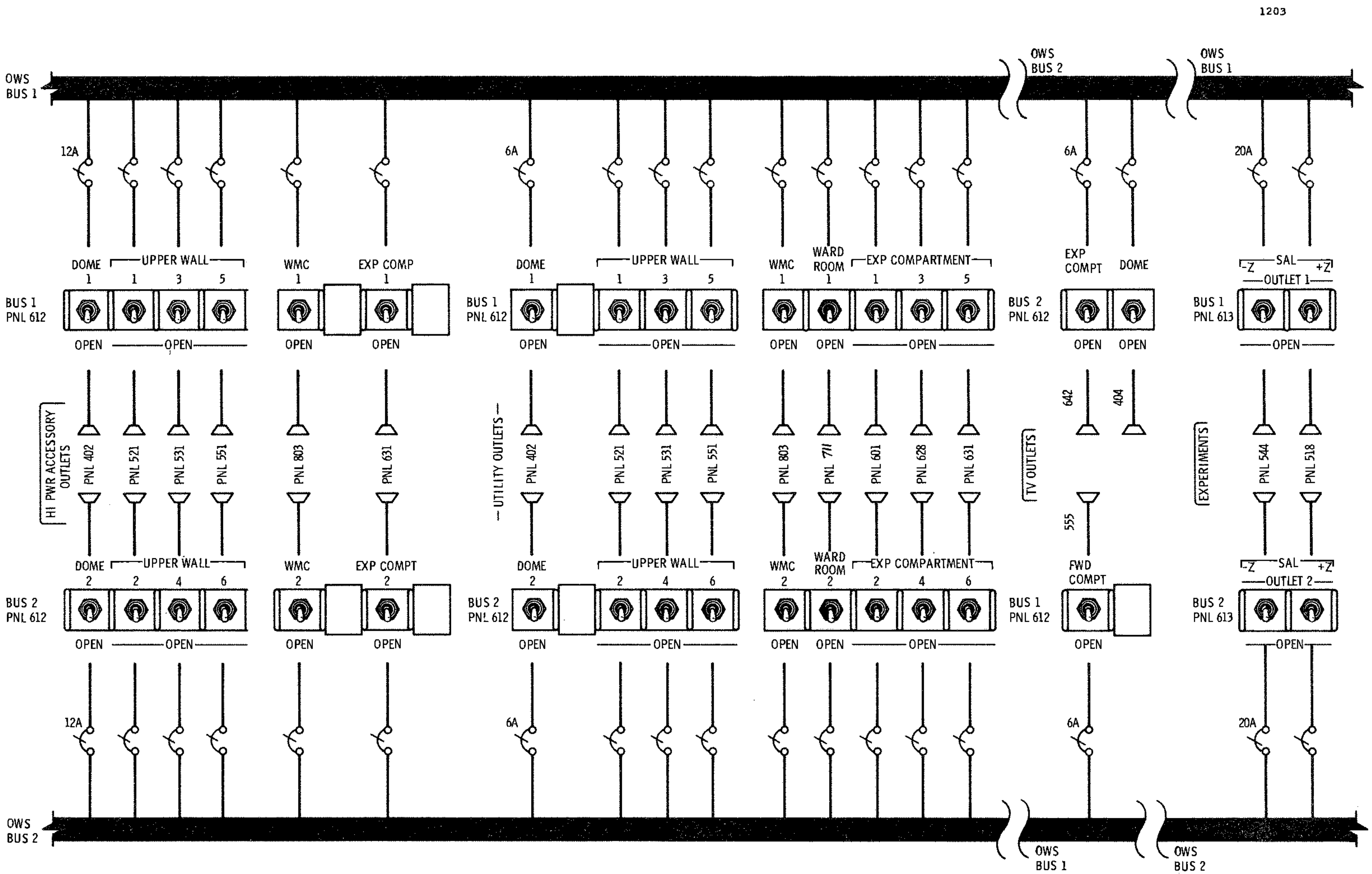



Figure 2.1.3-25 Power Outlets Schematic for OWS

1059

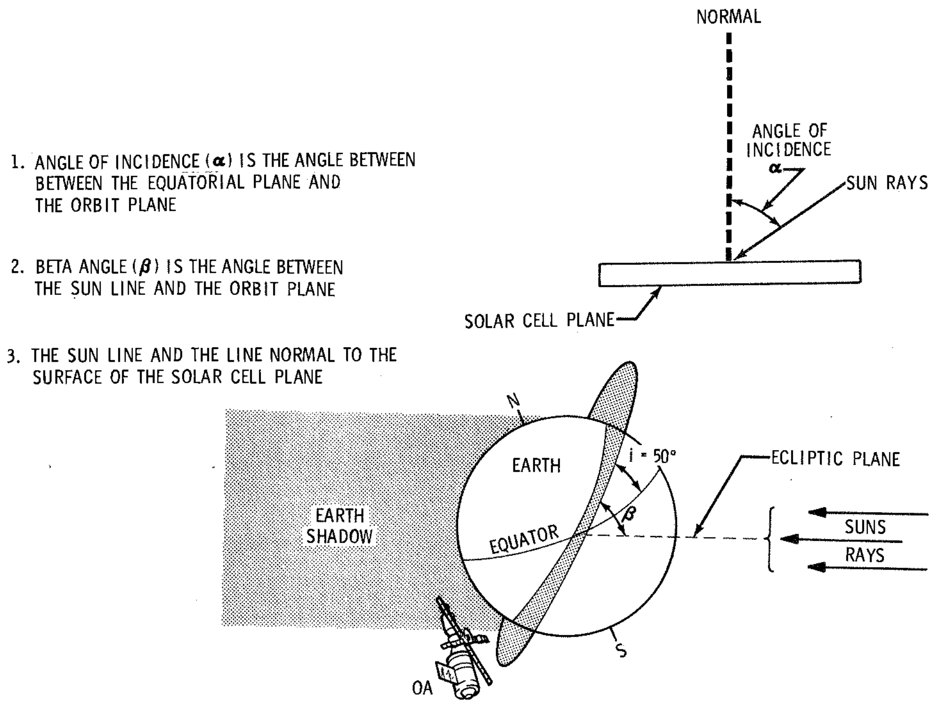



Figure 2.1.4-1 Illustration of B, i, and ∝

As mentioned earlier, the available power output of the solar cell is affected by the angle of incidence of solar light. The angle of incidence is the angle the parallel rays of sunlight make with the line normal to the surface of the solar cell (figure 2.1.4-1). The power output of a solar cell varies approximately as the cosine of the angle of incidence from the normal. Mathematically, this can be expressed as:

$$P = p \cos \alpha$$

where: P = Power output
p = Power output when light strikes the cell on the normal
$\alpha$ = Angle of incidence

2.1.4.1.2 Solar Cell Module

There are 240 solar cell modules in the SAS; the physical arrangement of the eight groups of 30 modules each is shown in figure 2.1.4-2. A solar cell module consists of 616 solar cells. The module has four parallel wired sets of 154 series-connected matched cells (figure 2.1.4-3). The cells are matched to provide the required voltage and current for a module, characteristics of which are shown in figure 2.1.4-3. The maximum power available from the module decreases with increasing temperature.

The module is sub-divided into cell groups. The cell group consists of 11 cells in series and is the smallest assembly bonded to a panel. A panel contains four solar cell modules (figure 2.1.3-3) and is built up in production with cell group assemblies. Each panel is identical within the array with respect to fit, form, and function. The cells are bonded to a substrate, fabricated from aluminum honeycomb with aluminum facing. The cell side of the substrate is covered with a sheet of electrical insulating material prior to aplication of the cells to the substrate, preventing shorting of the cells to the substrate.

2.1.4.1.3 Solar Array

The SAS consists of two wings mounted on the forward skirt of the OWS. The total array consists of 240 modules electrically connected into eight solar array groups. Collectively, the 240 modules make up an active area of 1340 square feet of solar array. The arrangement of the modules relative to the wings and the total array is shown in figure 2.1.4-2. Voltage and current characteristics as a function of temperature, plus voltage and temperature characteristics for a typical solar array group, are presented in figure 2.1.4-4. A typical solar array group has an output voltage ranging from 51 to 125 volts and currents ranging from 0 to 31 amperes dependent on array solar cell temperature and array position relative to the sun. Figure 2.1.4-1 depicts the Beta angle and its relationship to the ecliptic plane and the earth's orbit around the sun. The Beta angle varies between

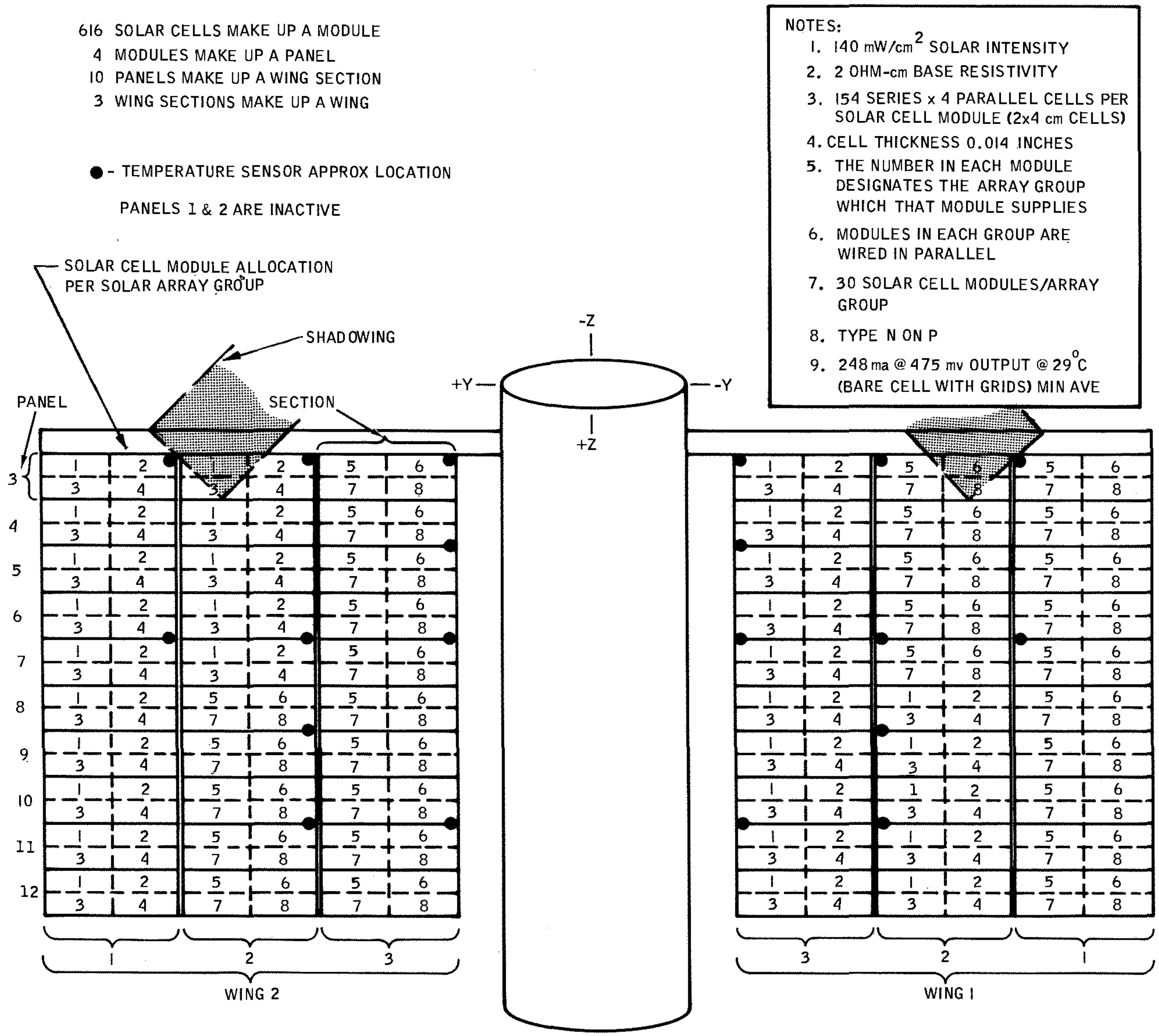



Figure 2.1.4-2 SAS Physical Configuration

1209

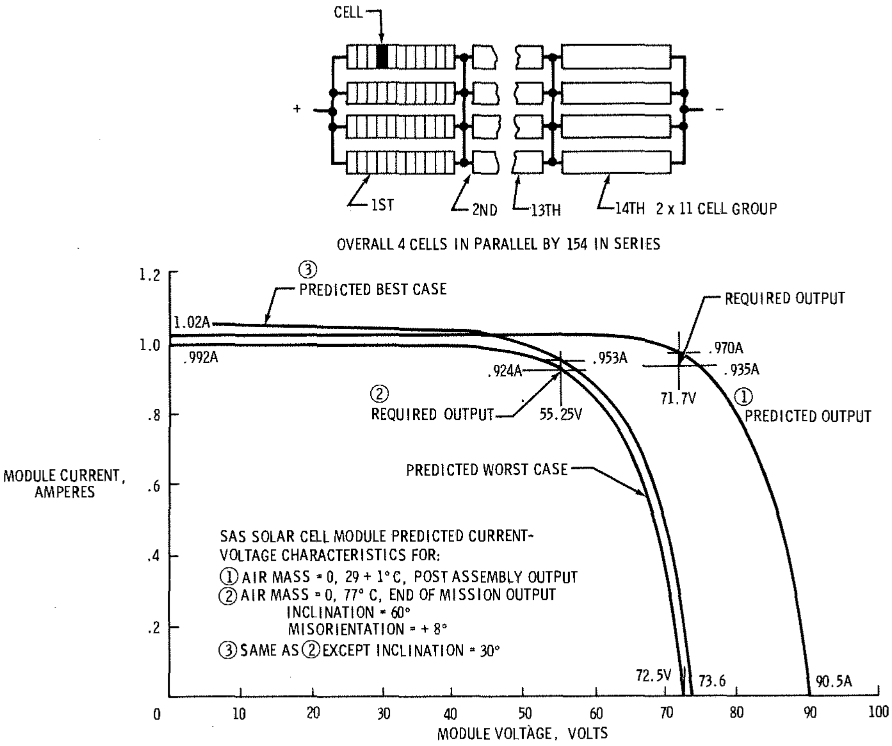
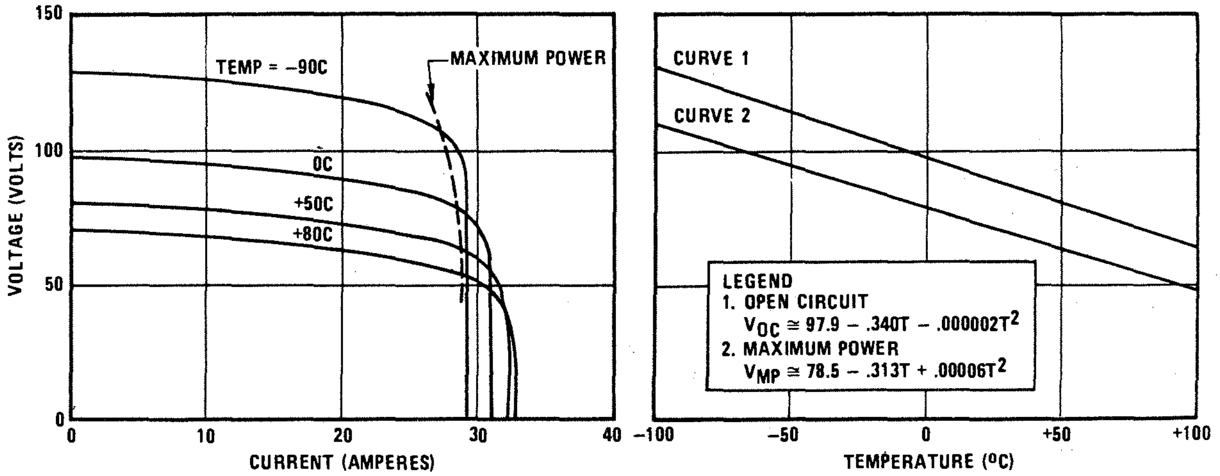



Figure 2.1.4-3 Solar Cell Module Characteristics

1065




TYPICAL FOR SOLAR ARRAY GROUP (30 SOLAR CELL MODULES)

START OF MISSION

Figure 2.1.4-4 Solar Array Group Electrical Characteristics

1217

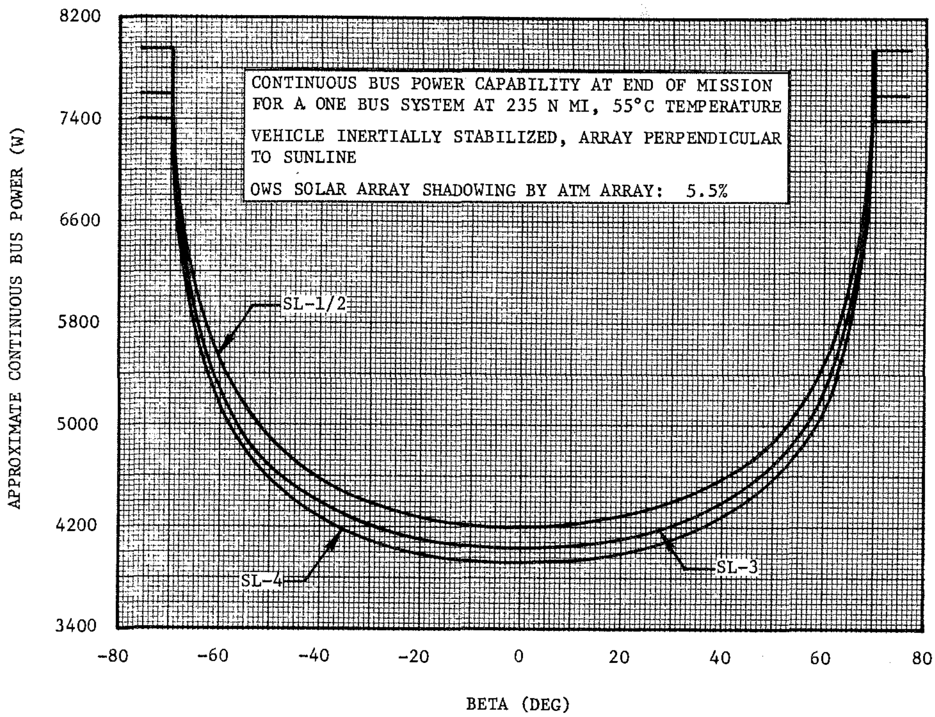



Figure 2.1.4-5 AM-OWS Electrical Power Capability

1216

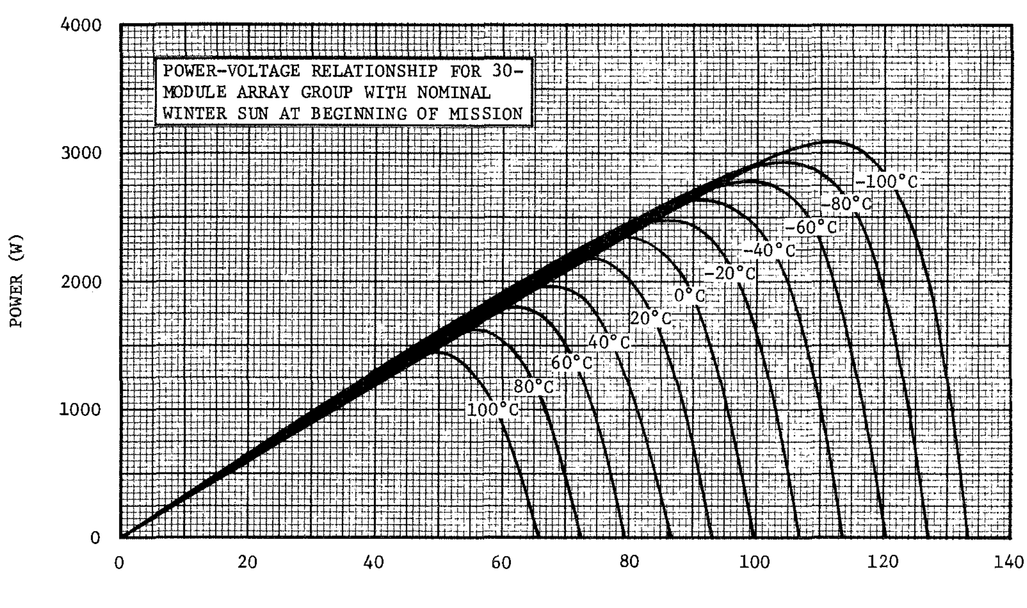



Figure 2.1.4-6 SAS Power-Voltage Relationship

1204

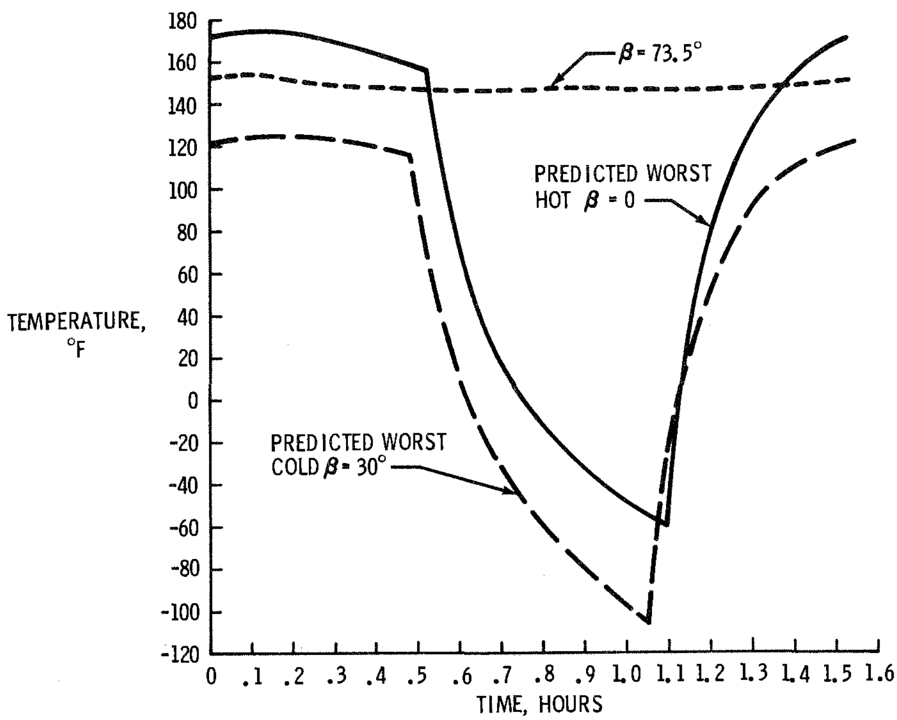



Figure 2.1.4-7 Complete Orbit Temp History for SAS

zero degrees and ± 73.5 degrees (maximum). Continuous power capability of the entire EPS as a function of Beta angle, is shown in figure 2.1.4-5. The available average power output of the SAS varies proportionally to the amount of time the SAS is shadowed by the earth. The Beta angle can also be expressed as the ratio of day to night. Figure 2.1.4-6 shows the power output at the various voltages and temperatures.

Figure 2.1.4.1.4 <u>Array Instrumentation</u>

SAS temperature instrumentation provides accurate temperature measurements of the SAS wings for power output evaluation. The arrangement of the sensor locations is shown in figure 2.1.4-2. The sensors are attached to the channel portion of the panel under a cell in order not to disturb the thermal coupling between cell and exposed substrate face sheet. The sensor is bonded to the channel with a thin adhesive to provide good coupling with the surface to be measured. The telemetry range is from -160° to 240°F. The complete orbit temperature history is shown in figure 2.1.4-7.

2.1.4.1.5 <u>Power Unit</u>

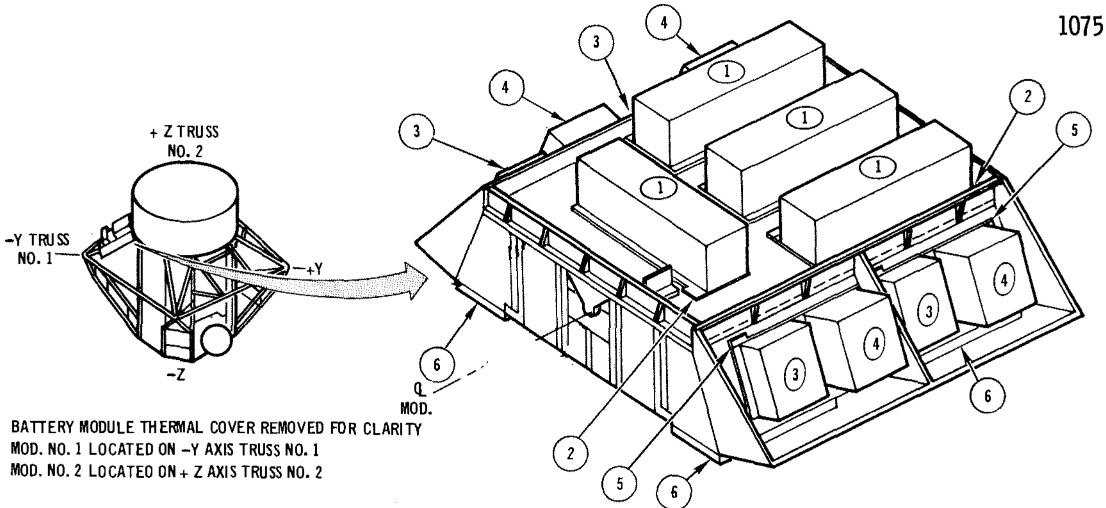
The two power units (one for each wing) are the collection points for the wiring from the solar cell modules. They contain the isolation diodes, busing devices, and output connections to the AM (figure 2.1.3-4). There are redundant wires in both the positive and negative line from each cell module. The positive lines contain a pair of isolation diodes. The diodes are divided into eight groups of 30 diodes each.

The 240 return lines from the solar cell modules are collected on eight different buses on each power unit. Two positive and two negative lines from each of the eight collection buses are distributed to the PCG.

GSE power inputs and test points are provided by connectors on each power unit. An input test point is provided on one positive lead from each module on the SAS side of the diode. Test points are also provided for each of the eight return buses.

2.1.4.2 POWER CONDITIONING

Eight separate PCG's are provided in the EPS to control, store, and condition the unregulated power received from the solar array groups and to subsequently provide regulated dc power to the buses. The PCG's are mounted on two battery modules located on the -Z truss and the +Y truss of the AM structure (figure 2.1.4-8). The equipment for four PCG's (four batteries, four battery chargers, and four bus voltage regulators) is mounted on each battery module. The battery modules are actively cooled by coldplates. Coolant flow through the two battery modules coldplates is paralleled to reduce pressure drops. The three major modules of the PCG will be discussed: the battery charger, the battery, and the bus voltage regulator.




EQUIPMENT LIST

| KEY | QTY | PART NOMENCLATURE |
|---|---|---|
| 1 | 4 | BATTERY |
| 2 | 4 | C/P ASSY. BATTERY |
| 3 | 4 | VOLTAGE REGULATOR |
| 4 | 4 | BATTERY CHARGER |
| 5 | 4 | C/P ASSY. REG. & CHGR |
| 6 | 4 | RELAY PANEL |

Figure 2.1.4-8 Typical Battery Module

2.1.4.2.1 Battery Charger

The battery charger consists of three major components: redundant ampere-hour integrators for battery charge control, a peak power tracker to cause operation at the array peak power point, and a charger regulator to control battery charging voltage (figure 2.1.4-9). The output voltage of the charger regulator is controlled such that the combined requirements of the load and battery charging do not exceed the peak power available from the array. The battery charging voltage is limited to prevent battery damage. The ampere-hours delivered to the battery during the charging cycle are measured by the ampere-hour integrator which causes the charger to switch to a constant current charge mode (0.75 amperes) when the battery is returned to full charge. This charging mode is maintained until battery power is required.

2.1.4.2.1.1 Charger Regulator

The charger regulator is of the buck-type, composed of individual modules to provide high reliability, reduce parasitic losses at low load conditions, and give high efficiency operation. The charger regulator output voltage is variable, with the level consistent with available array power or limited as a function of battery temperature. This assures that the equipment load is satisfied and the balance of the available power is supplied to the battery. Temperature compensation for limiting the voltage of battery recharge prevents hydrogen generation within the battery and restricts the oxygen generation rate to that level which can be recombined within the battery without venting. The temperature transducers installed in the battery case provide temperature sensing to the battery charger for this function. If the battery temperature exceeds 120°F, the charging current is reduced to zero. The same effect may be achieved by a thermal switch within the battery that actuates at 125°F. When the ampere-hour integrator senses that the battery has been fully charged, the battery is charged at a 0.75 ampere constant current rate. The constant current charging mode may be selected if desired by a DCS command or by positioning the CHARGE RATE switch to LO (panel 205).

2.1.4.2.1.2 Peak Power Tracker

The output characteristic of the array is such that when it is loaded beyond its peak power point, the output collapses to a zero power condition. This maximum power point could be exceeded by many variations of external regulator load demands, battery charging conditions, and array conditions.

The peak power tracker restricts the charger regulator output voltage to a value that limits the total output power of the charger to within 4 percent of the array peak power point. This prevents array voltage collapse resulting from overload application.

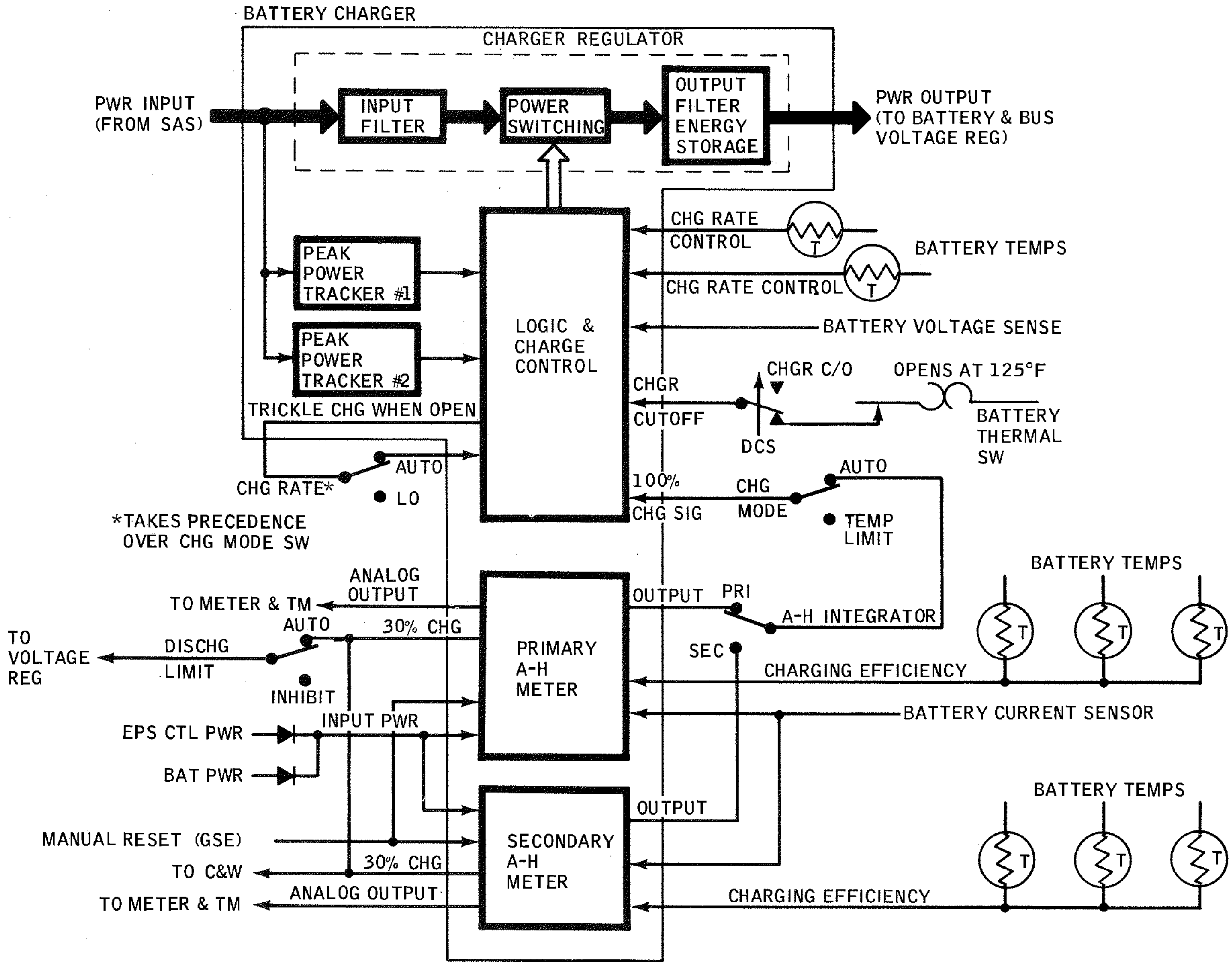



Figure 2.1.4-9 Battery Charger Functional Diagram

1081

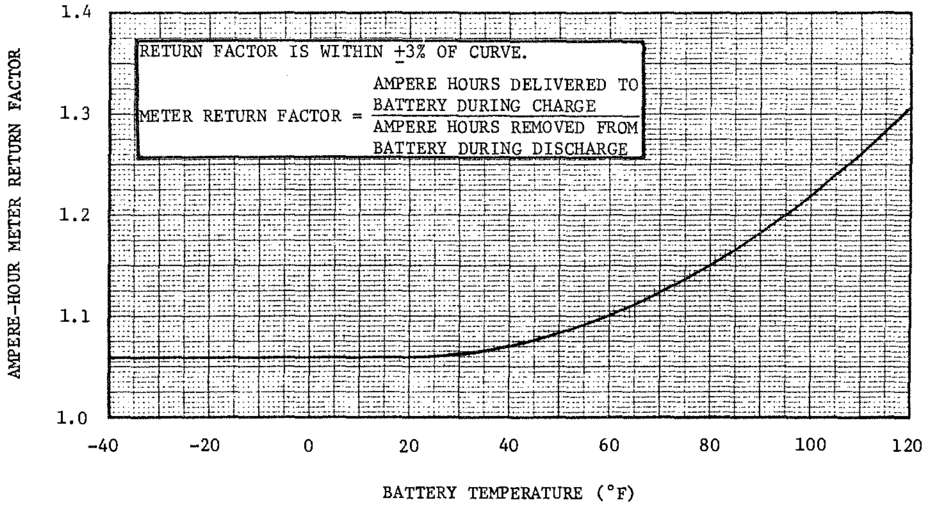



Figure 2.1.4-10 Ampere-Hour Integrator Return Factor

1200

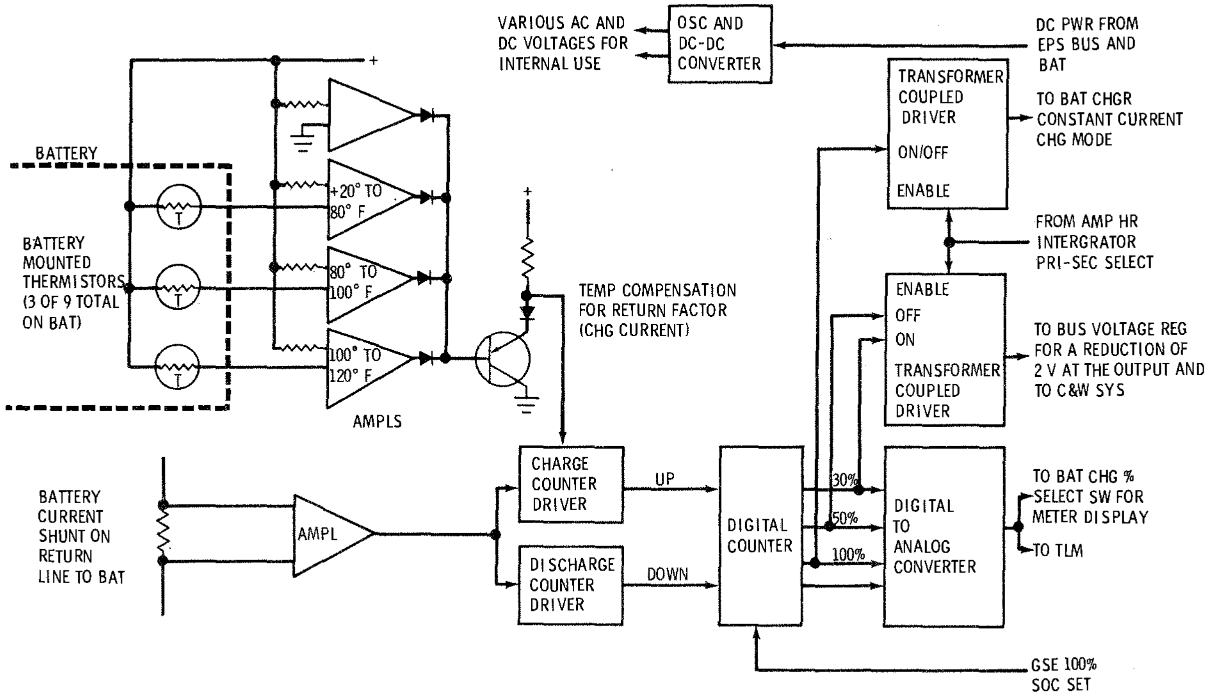



Figure 2.1.4-11 Amp-Hour Integrator Functional

The peak power tracker is designed such that if it fails, only the peak power tracking function is affected. The charger can still route array power through the logic and control circuit, and all other functions of the charger remain normal.

2.1.4.2.1.3 Ampere-Hour Integrator

Two identical ampere-hour integrators are contained within the charger. Both are actively monitoring the battery state-of-charge but only one is connected to the charge control logic. Power to both amp-hour integrators is supplied from an EPS control bus and from the PCG battery. Selection of the backup unit is accomplished by DCS command or by positioning the AMP-HOUR INTEGRATOR switch to SEC (panel 205).

The ampere-hour integrator integrates the current flowing from the battery during the discharge cycle, and the current flowing to the battery during the charge cycle. When the ampere-hours returned to the battery are equal to the ampere-hours removed, multiplied by a factor which is a function of battery temperature (figure 2.1.4-10), a signal is generated to switch the charger to the constant current charge mode (figure 2.1.4-11). Temperature compensation accounts for the interrelationship between charging efficiency and battery temperature. Six transducers in the battery provide temperature sensing for the compensating network, three for each amp-hour meter. A 0 to 5 volt analog signal, analogous to 0 to 100 percent state-of-charge, is provided for the eight primary and secondary battery state-of-charge status. All 16 signals are available for ground and on-board (panel 206) monitoring. The amp-hour integrator generates an output signal to the bus voltage regulator if the battery state of charge drops to 30 percent of full charge. The bus voltage regulator drops its output voltage by 2 volts, effectively removing it from the load and the array power is used for recovery of battery capacity. Recovery of the battery capacity to 50 percent removes the signal, allowing normal PCG operation. The latter sequence may be inhibited by DCS or by positioning the DISCHARGE LIMIT switch to INHIBIT (panel 205).

2.1.4.2.1.4 Charge Control Logic

Battery charger control is accomplished by the charge control logic circuitry within the battery charger. The charge control logic receives inputs from the peak power tracker, battery thermal switch, charger voltage limit transducers, amp-hour integrators state of charge, charge rate control relays, and battery power relays. The charger regulator receives the controlling signals from the charge control logic to provide efficient operation.

2.1.4.2.1.5 Battery Charger Operation

The operation of the battery charger is influenced by the following:

| Conditions Sensed | Sense Signal Source |
|---|---|
| Battery temperature | Battery-installed transducers and thermal switch |
| Battery voltage | Battery terminal voltage |
| Computed battery state charge | Charger amp-hour integrator |
| Charger input power | Charger peak power tracker |
| PCG control system status | Battery power, charge rate control, and battery charge disable relay positions |

Four distinct charger operational modes may occur under the influence of the sensed conditions described and summarized in table 2.1.4-1.

o <u>Voltage-Limited Charging Mode</u>

This charger operational mode results whenever the battery state-of-charge as measured by the amp-hour integrator is less than 100 percent. In this charger operational mode, the charger has essentially a constant-voltage output to the battery, resulting in a high rate of battery recharge. The charger output voltage in this mode is temperature compensated such that the maximum battery charging voltage is reduced as battery temperature increases. The charger output voltage, as measured at the battery terminals, varies linearly between 42.6 and 48 volts, as the battery temperature varies between 120°F and 0°F respectively (figure 2.1.4-12).

o <u>Constant Current Charging Mode</u>

This charger mode results whenever the battery state-of-charge, as sensed by the amp-hour integrator, equals 100 percent. The output may be inhibited by placing the CHARGE MODE switch (panel 205) to TEMP LMTD, which allows continued recharge of the battery, limited only by the temperature of the battery and the array power available. Current limited mode can also result whenever the CHARGE RATE switch is positioned to LO (panel 205) or whenever a battery terminal voltage of less than 25 volts is sensed by the charger. In this mode, the charger output voltage level provides a charging current of $0.75\pm0.5$ ampere.

o <u>Charging-Off Mode</u>

This charger operational mode results whenever battery temperature is excessive (above 120°F as sensed by the battery-installed transducers and/or above 125°F as sensed by the thermal switch). This mode can also result when the DCS-operated battery charge disable relay is positioned to the cutoff position. In this operational mode, the charger regulator output voltage level provides a charging current of $0\pm0.5$ ampere.

TABLE 2.1.4-1 BATTERY CHARGER OPERATION MODES

| | Charger Output Characteristics | | | |
|---|---|---|---|---|
| Operation Mode | Voltage Output | Current Output to Battery | Current Output to Regulator | PCG System Conditions Required for Charge Mode* |
| Constant current charge | Voltage level required to provide battery current indicated in next column | 0.75±0.5 amp continuous | 0 to 75 amp max. | Ampere-hour meter indicates 100% battery state-of-charge<br>Mode is manually selected<br>Battery voltage sensed is 25+0, -2 vdc |
| Voltage limit charge mode | See figure 2.1.4-12 | N/A | 0 to 75 amp max | Ampere-hour meter indicates less than 100% battery state-of-charge<br>Mode is manually selected |
| Termination of battery charge | Voltage level required to maintain zero amperes to battery | Zero | 0 to 75 amp max. | Battery temperature sensed is less than 120+0°, -12°F<br>An open thermal switch circuit (battery temperature 117° to 121°F)<br>Commanded off by DCS command |
| Battery leads open | 52±1 vdc | N/A | 0 to 75 amp max. | Battery voltage sense lead and battery power positive connection circuit open |

*Solar array power must be sufficient for each operation mode.

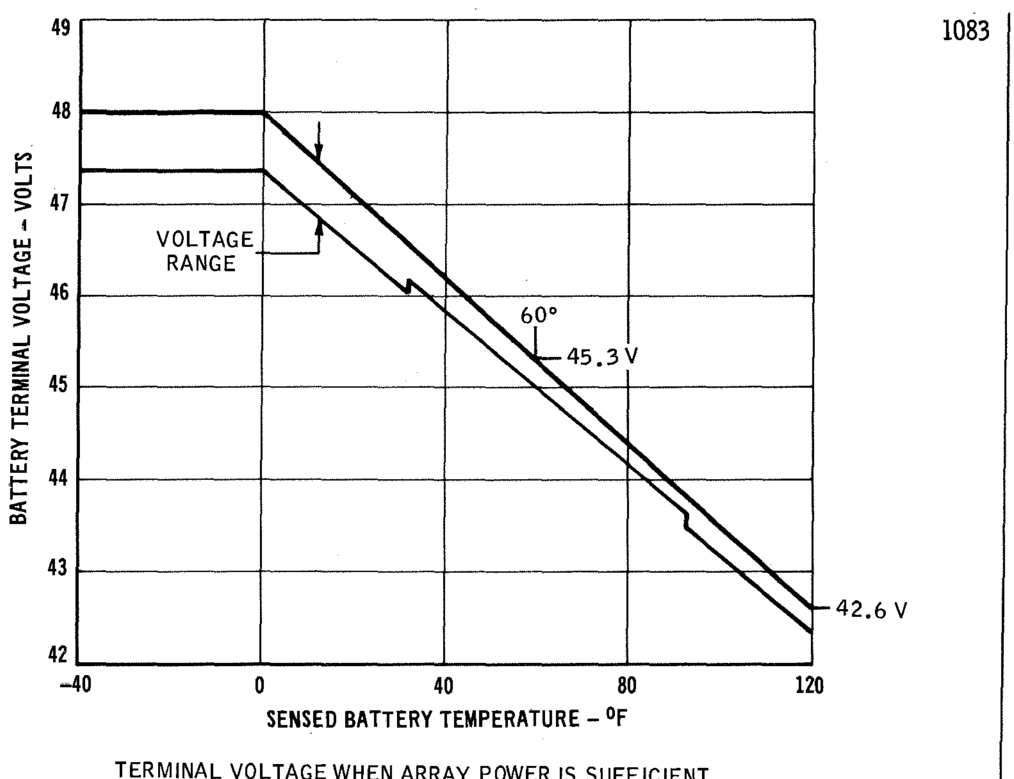



Figure 2.1.4-12 Battery Charger Voltage Limit Mode

o Battery-Disconnected Mode

This charger operational mode results whenever the positive power connection from the battery to the charger is opened by positioning the BATTERIES switch to OFF (panel 205). This condition is sensed by the charger as a complete loss of the battery voltage signal. Under this operational mode, the charger output voltage is 52±1 vdc.

o Power Availability Effects on Charging Modes

The charger regulator output voltage levels normally associated with the above charger operational modes are predicated upon the availability of sufficient power input to the charger to meet all battery charging as well as the PCG external load demands. If sufficient power is not available at the charger input to meet all system power demands, the peak power tracking feature of the charger becomes active. This results in lowering the charger output voltage level to reduce the total charger output load to a level compatible with input power. Three modes of operation occur automatically with normal operation of the peak power sensor:

- Array Power Sufficient to Supply Battery Charging and the Bus Voltage Regulator Input - In this condition, the charger output voltage to the bus voltage regulator is determined by the required battery terminal voltage for the charging method being employed.
- Array Power Sufficient to Supply the Bus Voltage Regulator Demand and a Portion of the Battery Charge Requirements - In this condition, the charger output voltage is reduced to a value that limits the power drawn by the battery so that the bus voltage regulator load demand is met while the combined bus voltage regulator and battery load is slightly less than the peak power capability of the array.
- Array Power Insufficient to Supply Bus Voltage Regulator Demand - In this condition, the charger output voltage is reduced to a point where load sharing between the battery and the charger regulator output supplies the bus voltage regulator demand. The portion of power supplied by the battery is the power that maintains the array operating point at slightly less than its peak power point.

2.1.4.2.2 Battery

Each of the eight PCG's contains one nickel cadmium battery to supply power to its related bus voltage regulator. The battery is rated at 33 ampere-hours and is made up of 30 series-connected nickel-cadmium cells. Each cell case is of stainless steel; the case of the battery is aluminum. The case is cooled by the active thermal control system to remove the heat generated during charging and discharging.

Each cell is fitted with a self-resealing pressure relief valve to prevent cell rupture or seal failure due to overpressurization if a battery or battery charger malfunctions. Each of the 30 cells vent into the case, which has a non-propulsive type valve that vents overboard. The cell relief valve opens at 200 psid and reseats at 100 psid minimum. The battery case self-reseating pressure relief valve actuates to relieve the internal pressure as it increases because of individual cell pressure relief. This valve opens at 35 psid and reseats at 20 psid minimum.

Nine temperature transducers and a thermal switch are installed in the battery to furnish temperature information to the related battery charger and to telemetry. Two of the transducers are used for charge rate control and three are used for each of the two ampere-hour integrators. The remaining transducer is used for a telemetry monitor. The normally closed thermal switch is set to open at 125°F, providing a signal to the charger to terminate charging.

It is anticipated that cyclic operation during solar inertial attitude will cause the battery to vary its state-of-charge (SOC) from 70 percent to 100 percent SOC (fully charged); during normal operations throughout Z-local vertical rendezvous periods the SOC may go as low as 50 percent. A typical curve showing degradation as a function of charge and discharge cycles is shown in figure 2.1.4-13. This type of curve in an expanded form can be used for estimating remaining life in the battery at the end of the mission.

2.1.4.2.3 Bus Voltage Regulator

The bus voltage regulators furnish regulated DC power to the REG buses and to the EPS control buses. The bus voltage regulator is a buck-type remote sensing regulator with modular construction (figure 2.1.4-14). Adjustment of the open circuit output voltage over a range of 26 to 30 volts is accomplished by the REG ADJ potentiometers (panel 206), which simultaneously adjust all regulators connected to the same bus. In addition, trimming ("fine tuning") REG CONT FINE ADJ potentiometers are provided for each regulator to more closely achieve equal load sharing among individual regulators. Regulator output voltage is adjusted to provide the desired load sharing between the EPS and other cluster power sources when the sources are operating in parallel. When the EPS operates independently of other sources, the voltage is adjusted as low as possible for equipment operation to effectively reduce total load requirements.

Regulator input power is supplied from either the battery charger or directly from the solar array group. The power obtained from the battery charger is supplied from one or both of two parallel power sources: the related NI-CD battery and the regulated voltage from the charger regulator. The magnitude of the regulated voltage available from the charger is determined by the battery and the power available from the solar array group. There are four possible sources of power for the bus voltage regulator:

(1) Charger regulator output power only - All of the bus voltage regulator input power is obtained from the array group through the charger regulator.
(2) The parallel combination of the charger regulator output and the NI-CD battery - As noted previously, the battery charger reduces its output voltage to the point where the power drawn from the connected array group is within 4 percent of the peak power available.

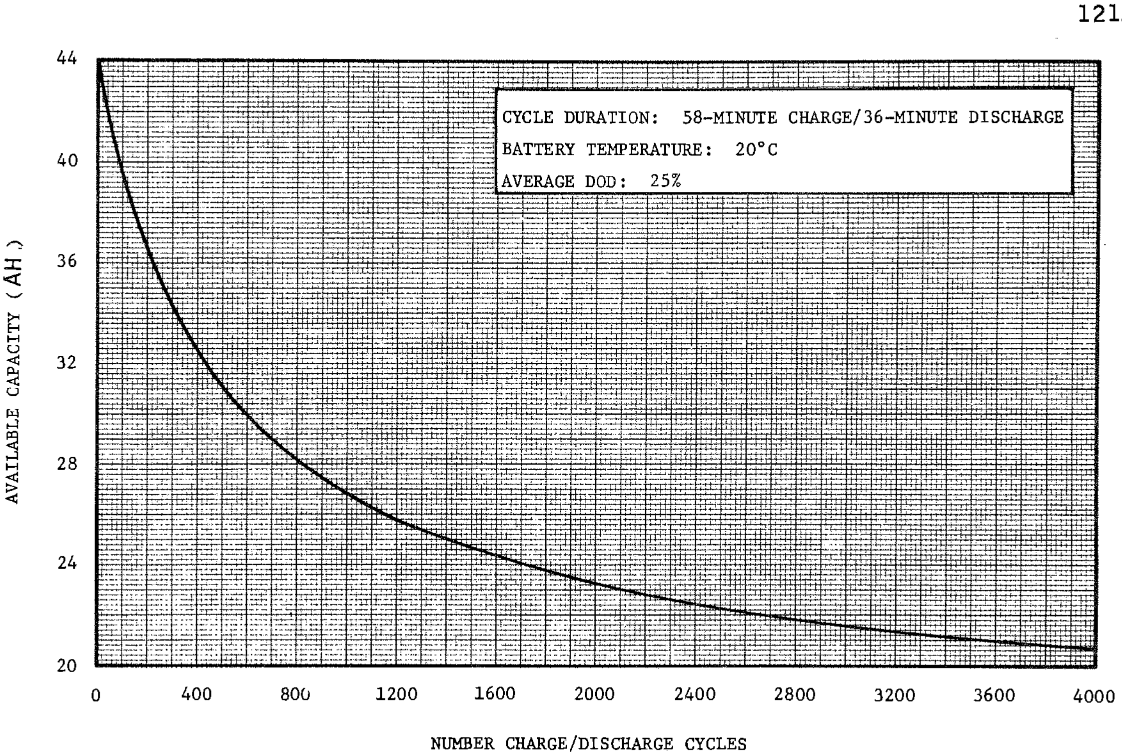
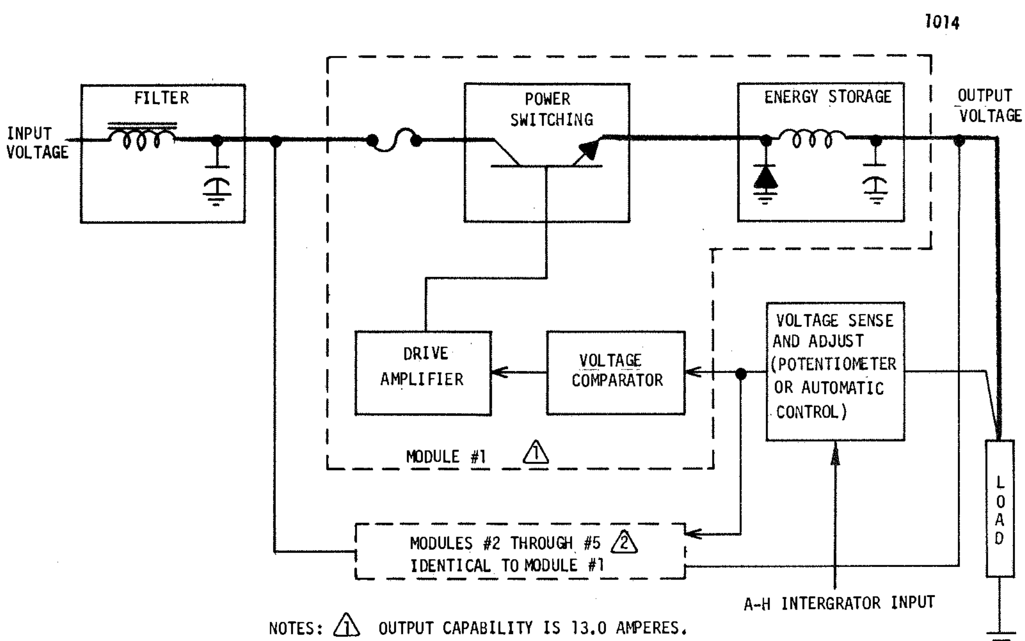



Figure 2.1.4-13 AM Battery Degradation




NOTES: 1 OUTPUT CAPABILITY IS 13.0 AMPERES.

2 OUTPUT VOLTAGE LEVELS DIFFER BY A SMALL VALUE SUCH THAT THE NUMBER OF OPERATING MODULES IS PROPORTIONAL TO THE LOAD.

Figure 2.1.4-14 Bus Voltage Regulator Power Diagram

(3) The NI-CD battery only - This condition exists when no array power is available.
(4) Array power only (charger bypassed) - Unregulated array group voltage connected directly to the bus voltage regulator input.

The regulator input voltage range applicable for the three modes (1) through (3) is from 33 to 48 vdc, depending on battery state-of-charge and temperature, and on array power availability. The unregulated array group voltage range applicable to mode (4) is from 0 to 125 vdc.

2.1.4.2.3.1 Regulation Characteristics

The no-load output voltage of each regulator is adjustable over a range between 26 and 30 vdc. Under rated full load conditions of 50 amperes per regulator, a REG bus voltage range between 24 and 28 vdc is supplied, the specific value being dependent on the no-load voltage selected and the specific regulator characteristics (figure 2.1.4-15).

The regulator operates normally with an input voltage range from 33 to 48 vdc. With an input voltage to the regulator of less than 33 vdc, the regulator is capable of maintaining an output voltage within 1 volt of the input voltage to the regulator.

The nominal full load current (with coolant flow) is 50 amperes continuous. Each regulator limits the maximum-current output to 65±3 amperes maximum, regardless of loading conditions. At short circuit conditions, the current reduces to 26 ±8 amperes. Upon removal of the load condition that resulted in the high current loading, normal performance again results (figure 2.1.4-16).

A reduced regulator output voltage mode prevents excessive discharge of the related PCG battery. When the battery reaches 30 percent state-of-charge, a 10-vdc signal from the battery charger is sent to the regulator, and the regulator output voltage is reduced by two volts, which essentially removes it from the bus. Upon termination of the signal, normal regulator output voltage operation is resumed.

2.1.4.2.3.2 Physical Construction

The regulator is constructed of five power modules, each with a current output capability of 13.0 amperes. The output voltage levels of each module differs a small amount such that the number of operating modules is proportional to the load. Fuses are provided internal to each power module such that a shorted module will clear itself by blowing its fuse. Under a module failure condition that tends to cause high voltage, essentially all of the bus load will be assumed by the failed module. The remaining modules and other regulators will be essentially unloaded as the output voltage of the failed module increases.

2.1.4.3 POWER DISTRIBUTION

The major components of power distribution discussed in this paragraph are: shunt regulator, power outlets, and circuit breakers. The characteristics of the various power buses were discussed previously in section 2.1.3.4.

2.1.4.3.1 Shunt Regulator

Each EPS control bus is provided with a shunt regulator (figure 2.1.4-17), which restricts transient overvoltage conditions caused by failure of a bus voltage regulator. Bus voltage regulator component failures can result in a power module short circuit condition, which permits the bus voltage regulator output voltage (26 to 30 vdc) to rise toward the input voltage level. The shunt regulator limits the voltage at the EPS bus by providing an additional current path until circuit interruption takes place in the failed bus voltage regulator.

The regulation capability of the shunt regulator is illustrated by its characteristic, as shown in figure 2.1.4-18. Below its sense voltage, the shunt regulator draws negligible current (less than 100 milliamperes). Above the sense voltage, the shunt regulator rapidly increases its current demands. This is produced by the high gain from the sense circuit input voltage to the transistor regulator bank load current. This high gain, provides the capability to draw sufficient load current to limit the bus voltage to the desired level. The shunt regulator consists basically of a sense circuit, a drive circuit, and a transistor regulator bank of eight power transistors in parallel. The sense circuit monitors the terminal voltage of the shunt regulator, which is essentially the same as the EPS bus voltage. When this voltage exceeds a preset level, the sense circuit provides an output current signal to the drive circuit. The drive circuit amplifies this current input and drives the base circuit of the eight parallel regulator transistors. Each regulator transistor amplifies its base current, producing an increased collector current flow. Since the regulator transistors are connected across the EPS bus, their increased collector currents produce an increased load on the bus. The effect of this increased load is to reduce the bus voltage because of the loading effect on the power source.

The design of the parallel transistor regulator bank is such that only six of the eight transistors are required for proper operation, increasing the probability of successful operation. The thermal switches are included in the design to provide for the abnormal condition where the failing bus voltage regulator is operating from a low voltage battery. The bus voltage regulator input in this case may be between 31 and 36 volts. Under such conditions, the shunt regulator might not draw sufficient current to clear the bus voltage regulator protective fuses. Each thermal switch is mounted to an individual power regulator transistor heat sink. If current flows through the regulator transistors for an extended period of time, the temperature of the heat sink will rise until the thermal switch closes. The switch actuates (closes) at 217±5°F and opens at 205±5°F. Closure of the thermal switch reduces the sense voltage of the shunt regulator by approximately 2 volts. This causes an

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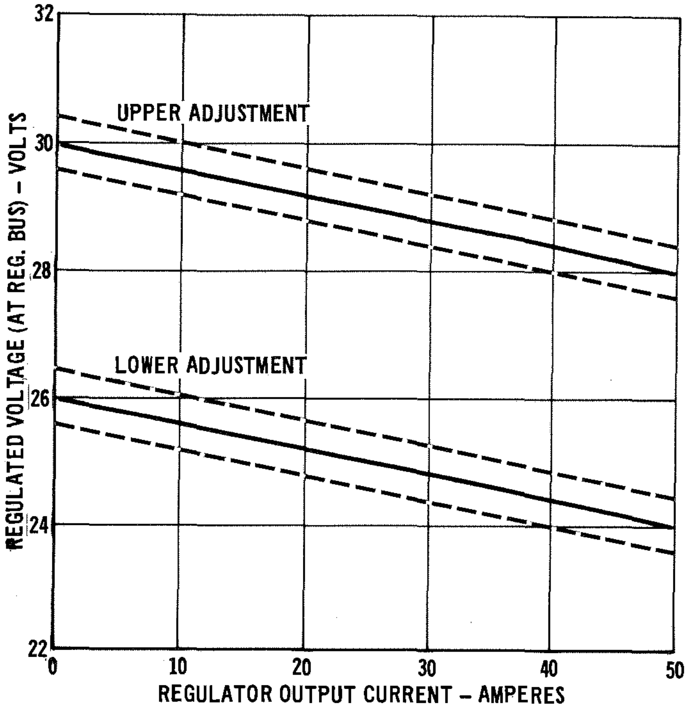


NOTES:

1) DOTTED LINES SHOW ADJUSTMENT RANGE OF FINE ADJUST POTENTIOMETERS = ± 0.45 VOLTS ABOUT THE REG. BUS POT ADJUSTMENT.
2) NO LOAD BUS ADJUST RANGE = 26-30 VOLTS
3) SLOPE FACTOR = 0.04 ± 0.002 VOLTS/AMP
4) ACCURACY (DRIFT FROM OPERATING POINT) = ± 0.05 VOLTS

Figure 2.1.4-15 Bus Voltage Regulator Output Adjustment Characteristics

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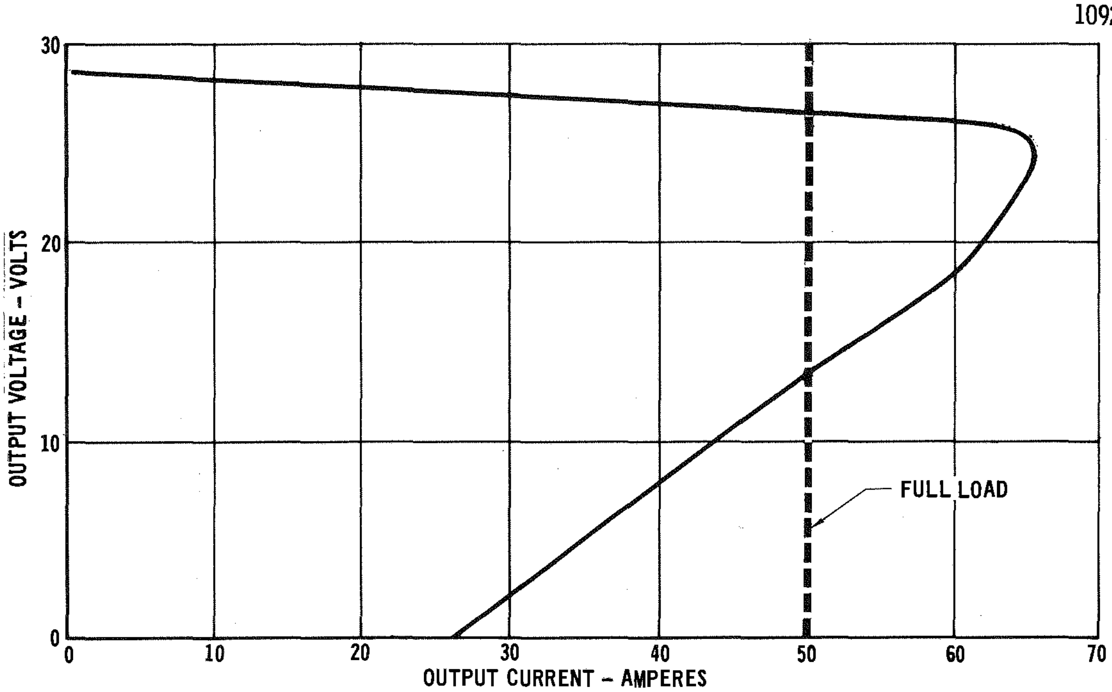


• REGULATION POINT ADJUSTED TO 29 VDC OPEN CIRCUIT

Figure 2.1.4-16 Bus Voltage Regulator V-I Characteristics

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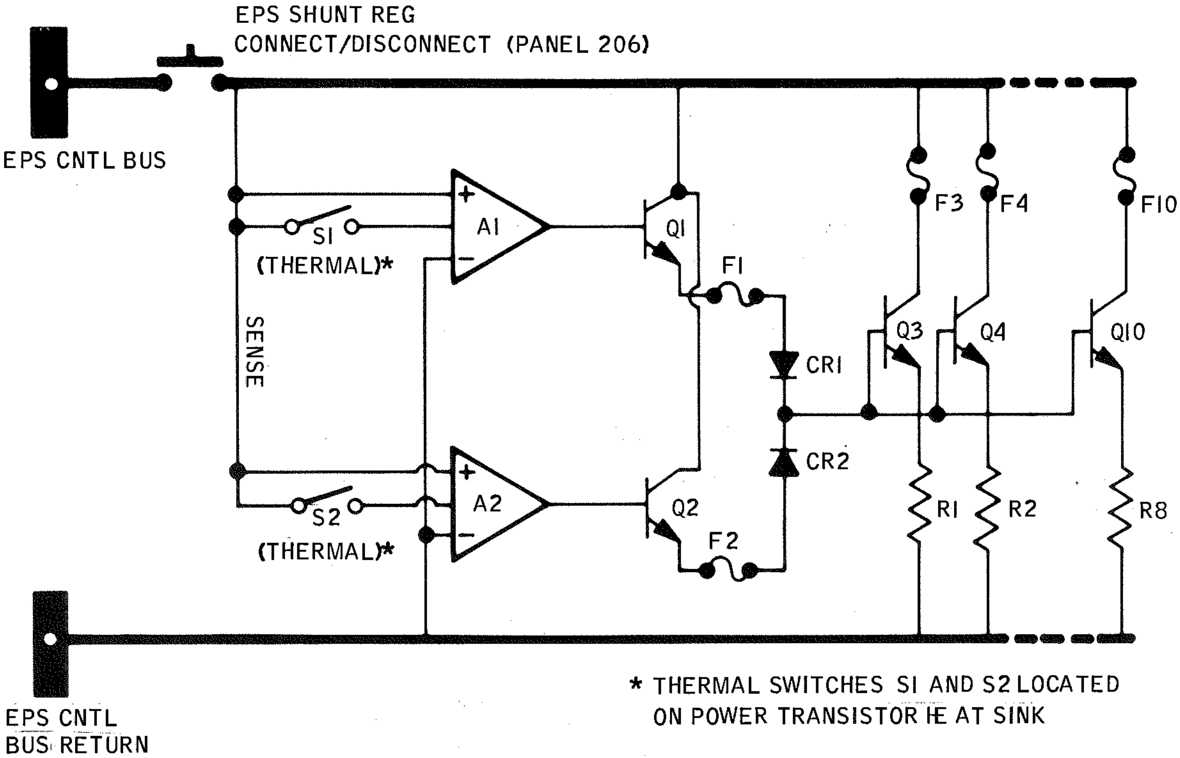



MAXIMUM TURN-ON TIME: 10 MICROSECONDS

MINIMUM TURN-ON VOLTAGE SENSE LEVEL: 31.5 VDC

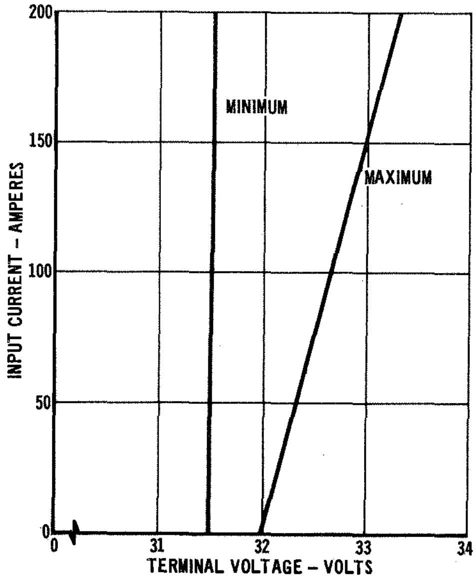
MAXIMUM TURN-ON VOLTAGE SENSE LEVEL: 32 VDC

CURRENT - TIME CAPABILITY:

200 AMPERES FOR 0.05 SECONDS

40 AMPERES FOR 100 SECONDS

Figure 2.1.4-17 Shunt Regulator Schematic




*NOTE: NORMAL MODE of operation. With thermal switch closure the sense voltage is reduced by approximately 2 volts.

Figure 2.1.4-18 Shunt Regulator Operating Characteristics

additional increment of load current to be drawn by the shunt regulator. The load current level is then sufficient to clear the bus voltage regulator fuses. The thermal switches thus enhance the probability of successful operation under this special condition.

2.1.4.3.2 Power Outlets

Two configurations of power outlets are utilized in the OA: (1) those located within the AM/MDA and (2) those located in the OWS (figure 2.1.4-19). The AM/MDA outlet is provided with a deadfacing switch. Both types of outlets utilize a zero-G receptacle to interface with the plug of the portable equipment.

The utility power outlets and high-power accessory outlets provide power to remote locations within the OA where various types of portable equipment are utilized. The utility power outlets in the AM/MDA provide +28 vdc through 5.4-ampere circuit breakers, and the MDA high-power accessory outlets provide +28 vdc through 12.0-ampere circuit breakers. The utility power outlets in the OWS provide +28 vdc through 6.0-ampere circuit breakers, and the OWS high-power accessory outlets provide +28 vdc through 12.0-ampere circuit breakers. See figures 2.1.3-24 and 2.1.3-25 for a schematic of the outlets.

2.1.4.3.3 Circuit Breakers

The AM and OWS circuit breakers are magnetically actuated and are of trip free construction. The following is a table of the name plate ratings of the circuit breakers used in the AM and the OWS:

| AM | OWS |
|---|---|
| | 3.0A |
| 3.9A | |
| 5.4A | 6.0A |
| 9.3A | 12.0A |
| 12.0A | 15.0A |
| 18.4A | 20.0A |
| 26.4A | |

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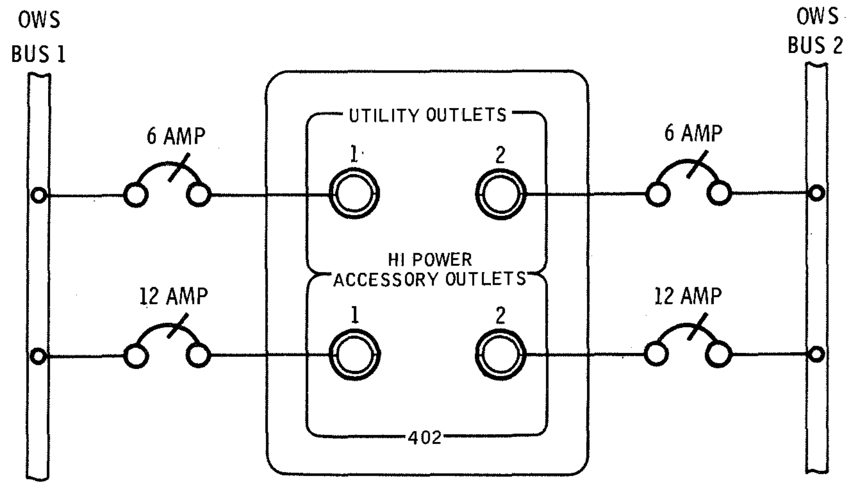
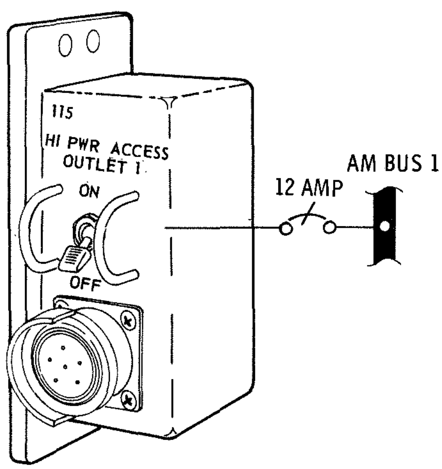



TYPICAL HABITATION AREA POWER OUTLET




TYPICAL MDA HIGH POWER ACCESS OUTLET

Figure 2.1.4-19 Typical Power Outlets

2.1.5 FAILURE MODES

The EPS failure modes and effect of major components are identified in table 2.1.5-1.

TABLE 2.1.5-1 EPS - FAILURE MODES

| FAILURE | INDICATION | VEHICLE CAPABILITY |
|---|---|---|
| 1. SOLAR ARRAY | | |
| a) Solar array module or output shorted to ground | No indication | Loss of output from one of 240 solar cell modules (4% loss of electrical power supply). |
| b) Solar array diode module (one diode open) | No indication | No effect |
| c) Solar array diode module (one diode output shorted to ground same as 30 outputs shorted to ground | Array current and voltage goes to zero. Current monitored on board and on TM. Voltage monitored only on TM. | Loss of 12 1/2% of SAS electrical power |
| 2. BATTERY CHARGER | | |
| a) Peak power tracker (redundant circuit failed) | Reduction of associated solar array voltage and power output during early portion or orbital daylight and peak power demand periods | Possible degradation of battery state of charge Possible mission constraint due to reduction of total power capability. Associated PCG load must be reduced by rotating REGULATOR CONTROL FINE ADJUST POT - CCW. (amount of rotation determined by evaluation of power system status by MSFN) |
| b) Amp-Hour Indicator (Loss of counting function, voltage limited mode | No change in amp-hour integrator indicator indication with battery charge/discharge current normal. Possible high battery temperature indication of end of orbital daylight via TM at MSFN | Secondary (backup) amp-hour indicator must be selected. Mission is not constrained. |
| c) Amp-Hour Integrator (loss of counting function, constant current mode | Low battery voltage and charge current during light portion of orbit. No change in amp hour indicator indication with normal battery discharge current during dark portion of orbit | Secondary (backup) amp-hour indicator must be selected. Mission is not constrained |
| d) Primary and secondary amp-hour integrator (one or both in voltage limited mode | Battery charge/discharge current normal. No change in amp-hour indicator indication. Possible high battery temperature indicated at end of orbital daylight | Select PRI or SEC amp-hour indicator which allows high charge current at beginning of orbital daylight. Control charging manually. Mission will be constrained during additional crew activity required to control battery charging. |
| e) Primary and secondary amp-hour integrator failed (in constant current mode) | Low battery voltage and charge current at beginning of orbital daylight | Battery charging may be controlled manually. Mission will be constrained due to additional crew activity required to control battery charging |

TABLE 2.1.5-1 EPS - FAILURE MODES (cont'd)

| FAILURE | INDICATION | VEHICLE CAPABILITY |
|---|---|---|
| | | Note: Alternative is to allow battery to charge in voltage limited mode for entire daylight period and live with the degradation induced in the battery due to heating. Thermal switch in battery will control charging at very high temperatures. Mission will be constrained due to eventual battery degradation. |
| f) Battery temp sense logic (redundant circuits failed) | Battery volts high (48 vdc) during terminal charge period. Possible high battery temp indication at end of orbital daylight via telemetry at MSFN | Loss of battery temperature compensated output and subsequence degradation of battery life. Eventual mission contraint due to degradation of battery life |
| g) Charger regulator module failed (1 of 5) | No indication | No affect on system operation |
| h) Charger regulator module failed (2 of 5, 3 of 5, etc.) | Solar array voltage and battery charge current low at beginning of orbital daylight | Associated PCG load must be reduced by rotating REGULATOR CONTROL FINE ADJUST POT - CCW (amount of rotation is determined by evaluation of power system status by MSFN). Mission will be constrained due to reduction of total power capability |
| i) Charger regulator (loss of output) | Battery charge current is zero. PCG total amperes is zero. | System must be operated in the CHARGER BYPASS mode by performing the following operations with the affected PCG controls:<br>a) CHARGER sw - BYPASS<br>b) REG CONTROL FINE ADJUST POT - fully clockwise<br>c) BATTERY CONTROL cb - OPEN<br>Mission is constrained due to reduced power capability during orbital darkness. |
| 3. BATTERY | | |
| a) Battery (shorted cells) | Battery voltage low during orbital darkness | Increase load on PCG by rotating REGULATOR CONTROL FINE ADJUST POT - CW. Amount of rotation determined by system status evaluation by MSFN. Possible eventual mission constraint due to battery degradation and reduction of total power capability during orbital darkness |
| b) Battery (loss of output) | Reduction in battery voltage and/or absence of current drain from battery | Degraded ability to provide power during periods of darkness |
| c) Battery (case vent valve failed closed) | None | "O" ring seal will provide secondary relief path in the event of excessive pressure |
| 4. BUS VOLTAGE REGULATOR | | |
| a) Regulator power module failed (1 of 5) | No indication | No effect on system operation |
| b) Regulator power module failed (2 of 5) | No indication | No effect on system operation |
| c) Regulator power module failed (3 of 5) | Reduced battery discharge current and solar array current during peak load | Possible mission constraint during peak load periods due to reduction in total power capability |

TABLE 2.1.5-1 EPS - FAILURE MODES (cont'd)

| FAILURE | INDICATION | VEHICLE CAPABILITY |
|---|---|---|
| d) Loss of output | Loss of battery discharge current and solar array current | Mission will be constrained due to reduction of total power capability. Solar array group may be switched to alternate PCG during peak power periods. Both primary and secondary coolant loops must be on while operating in this mode to prevent battery charger overheating |
| e) Loss of voltage sensing (redundant circuits failed) | Reduced PCG TOTAL AMPS and battery DISCHARGE AMPS | Regulator will sense at regulator terminals (28.6-volt open circuit) with reduced output. Mission will be constrained due to reduction of total power capability |
| 5. SHUNT REGULATOR (redundant circuit failure) | No indication | Loss of shunt regulation capability. No effect on system operation |
| 6. LOSS OF REG BUS 1 or 2 (bus shorted) | C&W REG BUS LOW and OWS BUS LOW indication. REG BUS VOLTS indicator reads low | Failed bus must be isolated from TRANSFER BUS TIE sw to OPEN. Switch affected PCG's to alternate REG BUS by placing appropriate PCG output switch to REG BUS 1 or REG BUS 2. Switch affected AM BUS to its alternate REG BUS. Failure will lead to early termination of mission |

## 2.1.6 PERFORMANCE AND DESIGN DATA

### 2.1.6.1 SOLAR ARRAY PHYSICAL CHARACTERISTIC

Array
- Size . . . . . . . . . . 372 in. long 328 in. wide (per wing)
- Weight . . . . . . . . . . 4056 lb (including deployment and storage structures)
- Panels per wing. . . . . . . . . . 30
- Panels per SAS . . . . . . . . . . 60
- Modules per SAS. . . . . . . . . . 240
- Modules per array group. . . . . . . . . . 30 (parallel connected, 15 per wing, total 18,480 cells)
- Array groups per SAS array . . . . . . . . . . 8 (total solar cells per SAS 147,840)

Solar Panel
- Size . . . . . . . . . . 27.13 in. wide, 120.70 in. long
- Weight . . . . . . . . . . 28 lb
- Cell groups per module . . . . . . . . . . 56
- Cells per module . . . . . . . . . . 616 (4 strings of 154 cells in series, connected in parallel at end of strings only)
- Modules per panel. . . . . . . . . . 4
- Total cells per panel. . . . . . . . . . 2464
- Substrate. . . . . . . . . . aluminum facesheet/aluminum honeycomb
- Dielectric insulation. . . . . . . . . . perforated 0.002 in. Kapton

Solar Cell Group
- Type . . . . . . . . . . overlapped
- Cells per group. . . . . . . . . . 11
- Cell interconnector. . . . . . . . . . 0.001 in. Kovar (solder plated)
- Group interconnector . . . . . . . . . . 0.003 in. Kovar (solder plated)
- Cell to substrate adhesive . . . . . . . . . . RTV 3145
- Size (cm). . . . . . . . . . 2 x 4
- Active area (cm2). . . . . . . . . . 7.6
- Thickness (in.). . . . . . . . . . $0.014 \pm 0.002$
- Cover slide
  - Material . . . . . . . . . . corning 0211 microsheet
  - Thickness (in.). . . . . . . . . . $0.006 \pm 0.001$
  - Cut on wavelength (UV reflective filter) . . . . . . . . . . $0.410 \mp 0.015$
  - Circuit arrangement. . . . . . . . . . 4 separate strings of 154 cells in series, connected in parallel at the ends
- Antireflective coating . . . . . . . . . . M8F2

2.1.6.2 SAS POWER PERFORMANCE

| Beta (deg) | Average Power in Sunlight (W) | | Energy (W-hr/orbit) | | Minimum Voltage (V) | |
|---|---|---|---|---|---|---|
| | BOM | EOM * | BOM | EOM | BOM | EOM |
| 0.0 | 1720 | 1620 | 1640 | 1550 | 56.7 | 55.2 |
| 30.0 | 1720 | 1620 | 1690 | 1600 | 57.5 | 55.9 |
| 60.0 | 1710 | 1620 | 1990 | 1880 | 58.2 | 56.5 |
| 73.5 | 1620 | 1530 | 2520 | 2380 | 58.9 | 56.8 |

* BOM - Beginning of mission
EOM - End of mission

2.1.6.3 BATTERY CHARGER INPUT

Input voltage
- Array. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 0 to 125 vdc
- Battery. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 30 to 42 vdc

Input current (array) . . . . . . . . . . . . . . . . . . . . . . . 31 amp max.
Input power (array) . . . . . . . . . . . . . . . . . . . . . . . . 2580 W

2.1.6.4 AMP-HOUR INTEGRATOR

Output signal (to telemetry)
- Signal range . . . . . . . . . . . . . . . . . . . . . . . . . . . 0 to 100% state-of-charge
- Signal level . . . . . . . . . . . . . . . . . . . . . . . . . . . 0 to 5 vdc
- Accuracy . . . . . . . . . . . . . . . . . . . . . . . . . . . . . ±1.5% of AMP-HR integrator (±0.5 AMP-HR)
- Output impedance . . . . . . . . . . . . . . . . . . . . . . . . . 5k ohms max.

Output signal to bus voltage regulator
- Signal level . . . . . . . . . . . . . . . . . . . . . . . . . . . 10±2 vdc

2.1.6.5 BATTERY

The battery characteristics are:

- Charging voltage range . . . . . . . . . . . . . . . . . . . . . . 30 to 48 vdc
- Discharge voltage range . . . . . . . . . . . . . . . . . . . . . 30 to 36 vdc
- Environmental temperature. . . . . . . . . . . . . . . . . . . . . -10° to 120°F
- Thermal switch
  - Opens (increasing temp). . . . . . . . . . . . . . . . . . . . . 119° to 125°F
  - Close (decreasing temp). . . . . . . . . . . . . . . . . . . . . 117° to 121°F
- TM temperature range . . . . . . . . . . . . . . . . . . . . . . . -60° to 200°F
- Pressure relief valve
  - Cell
    - Opens. . . . . . . . . . . . . . . . . . . . . . . . . . . . . 119° to 125°F
    - Closes . . . . . . . . . . . . . . . . . . . . . . . . . . . . 110 psid minimum
  - Case
    - Opens. . . . . . . . . . . . . . . . . . . . . . . . . . . . . 35±5 psid
    - Closes . . . . . . . . . . . . . . . . . . . . . . . . . . . . 20 psid minimum
- Number of cells. . . . . . . . . . . . . . . . . . . . . . . . . . 30
- Rated capacity . . . . . . . . . . . . . . . . . . . . . . . . . . 36 AH @ 40°F, 36 AH @ 80°F, 33 AH @ 120°F

Note: The capacities stated above are at an 18 ampere discharge rate to 30 vdc.

2.1.6.6 BUS VOLTAGE REGULATOR

Regulator temperature limits (operating). . . . . . . . . . . . . . . -40° to 160°F (200°F for 0.5 hr; requires coolant flow)

Regulator input
- From charger . . . . . . . . . . . . . . . . . . . . . . . . . . . 33 to 48 vdc (normal operation)
- From array . . . . . . . . . . . . . . . . . . . . . . . . . . . . 30 to 125 vdc (charger bypass operation)

V-I output. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . See figures 2.1.4-15 and -16

Coarse adjustment accuracy
- Maximum. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . +0.4, -0.0 vdc centered about max. no load volt
- Minimum. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . ±0.3 vdc centered about min. full load volts

Trim potentiometer adjustment range . . . . . . . . . . . . . . . . . 0.9±0.48, -0.0 V (centered about the maximum coarse adjustment)
0.9±0.24 V (centered about the minimum coarse adjustment)

Voltage accuracy. . . . . . . . . . . . . . . . . . . . . . . . . . . ±0.05 vdc drift with a coldplate temperature between 40° and 125°F; ±0.10 vdc drift with a coldplate temperature between 36° and 40°F

Voltage droop . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 0.04±0.002 V/A
Reduced regulator output mode (contingent upon receipt of a 10±2 vdc signal from battery charger). . . . . . . . . . . . . . 2±0.35 vdc below the normal voltage
Current output range. . . . . . . . . . . . . . . . . . . . . . . . . . 0 to 50 A continuous with coolant flow (current limited to 65±3 A; short circuit = 26±8 A; see figure 2.1.4-16)
Regulator service life. . . . . . . . . . . . . . . . . . . . . . . . . No less than 15,000 hours

2.1.6.7 AM/MDA/OWS POWER DISTRIBUTION BUS VOLTAGE

| Bus | Undervoltage | Overvoltage | Voltage Limits (Steady State) | | Voltage Limits (Transient) | | |
|---|---|---|---|---|---|---|---|
| | | | Min. | Max. | Min. | Max. | Recovery |
| EPS Control Buses | 23-26 | 30-33 | 26.0 | 30.0 | +50.0 vdc about steady state | | 10 usec |
| AM Regulated Buses | 23-26 | 30-33 | 26.0 | 30.0 | | | 10 usec |
| AM Buses | 23-26 | 30-33 | 26.0 | 30.0 | | | 10 usec |
| OWS Buses | 21.8-24.8 | 30-33 | 24.8 | 30.0 | | | 10 usec |

For open circuit REG BUS ADJUSTMENT of 29 to 30 vdc. Levels are referenced to the corresponding return bus. The OWS BUS 1 is in relation to the OWS BUS 1 return.

## 2.1.7 EPS OPERATIONAL LIMITATIONS AND RESTRICTIONS

The maximum continuous bus power capability of the AM Solar Array/Battery system for a one bus system at an orbital altitude of 235 NM, array temperature 55°C and the vehicle inertially stabilized with the array plane perpendicular to the sunline at a Beta angle of 0° is 4200, 4030, and 3930 at the end of Skylab 1/2, Skylab 3, and Skylab 4 missions, respectively. The maximum continuous bus power capability under the above conditions for the 620°F maximum Z-LV rendezvous period is 2270, 2220, and 2170 for Skylab 1/2, Skylab 3, and Skylab 4 missions, respectively.

Power system operation with two solar array groups powering 1 PCG requires the operation of both primary and secondary coolant loops to prevent battery charger overheating. Operation of the power system in this mode must be limited to peak power periods.

Anticipated battery depth of discharge is 30% maximum. Repetitive depth of discharge below 30% indicates system overload. Changes in mission activities may be required to reduce dark period power requirements. The battery state of charge must be greater than 60% of rated capacity at SL-1 lift-off.

When the system is operated in the TEMP LMTD charge mode, ground monitoring of the battery temperature is required.

## 2.1.8 INSTRUMENTATION AND GROUND COMMANDS

See table 2.1.8-1 for a complete listing of the EPS measurements. Table 2.1.8-2 is a complete list of the digital commands associated with the EPS.

TABLE 2.1.8-1 INSTRUMENTATION LIST

| NO. | MEASUREMENT NUMBER | DESCRIPTION | TELEMETER RANGE | ONBOARD DISPLAY DISPLAY RANGE | ONBOARD DISPLAY PANEL NO. |
|---|---|---|---|---|---|
| | C101-524 | BATTERY 1 INTERNAL TEMP | -60 to 200°F | | NONE |
| | C102-524 | BATTERY 2 INTERNAL TEMP | -60 to 200°F | | NONE |
| | C103-524 | BATTERY 3 INTERNAL TEMP | -60 to 200°F | | NONE |
| | C104-524 | BATTERY 4 INTERNAL TEMP | -60 to 200°F | | NONE |
| | C105-525 | BATTERY 5 INTERNAL TEMP | -60 to 200°F | | NONE |
| | C106-525 | BATTERY 6 INTERNAL TEMP | -60 to 200°F | | NONE |
| | C107-525 | BATTERY 7 INTERNAL TEMP | -60 to 200°F | | NONE |
| | C108-525 | BATTERY 8 INTERNAL TEMP | -60 to 200°F | | NONE |
| | C109-524 | REGULATOR 1 TEMP | -55 to 200°F | | NONE |
| | C110-524 | REGULATOR 2 TEMP | -55 to 200°F | | NONE |
| | C111-524 | REGULATOR 3 TEMP | -55 to 200°F | | NONE |
| | C112-524 | REGULATOR 4 TEMP | -55 to 200°F | | NONE |
| | C113-525 | REGULATOR 5 TEMP | -55 to 200°F | | NONE |
| | C114-525 | REGULATOR 6 TEMP | -55 to 200°F | | NONE |
| | C115-525 | REGULATOR 7 TEMP | -55 to 200°F | | NONE |
| | C116-525 | REGULATOR 8 TEMP | -55 to 200°F | | NONE |

TABLE 2.1.8-1 INSTRUMENTATION LIST (cont'd)

| NO. | MEASUREMENT NUMBER | DESCRIPTION | TELEMETER RANGE | ONBOARD DISPLAY DISPLAY RANGE | ONBOARD DISPLAY PANEL NO. |
|---|---|---|---|---|---|
| | C7146-432 | TEMP-SAS, WG 1, SE 1, PNL 3 | -160 to 240°F | | NONE |
| | C7147-432 | TEMP-SAS, WG 1, SE 1, PNL 7 | -160 to 240°F | | NONE |
| | C7148-432 | TEMP-SAS, WG 1, SE 2, PNL 3 | -160 to 240°F | | NONE |
| | C7149-432 | TEMP-SAS, WG 1, SE 2, PNL 7 | -160 to 240°F | | NONE |
| | C7150-432 | TEMP-SAS, WG 1, SE 2, PNL 9 | -160 to 240°F | | NONE |
| | C7151-432 | TEMP-SAS, WG 1, SE 2, PNL 11 | -160 to 240°F | | NONE |
| | C7161-432 | TEMP-SAS, WG 1, SE 3, PNL 3 | -160 to 240°F | | NONE |
| | C7240-432 | TEMP-SAS, Wg 1, SE 3, PNL 5 | -160 to 240°F | | NONE |
| | C7241-432 | TEMP-SAS, WG 1, SE 3, PNL 7 | -160 to 240°F | | NONE |
| | C7242-432 | TEMP-SAS, WG 1, SE 3, PNL 11 | -160 to 240°F | | NONE |
| | C7243-433 | TEMP-SAS, WG 2, SE 1, PNL 3 | -160 to 240°F | | NONE |
| | C7244-433 | TEMP-SAS, WG 2, SE 1, PNL 7 | -160 to 240°F | | NONE |
| | C7245-433 | TEMP-SAS, WG 2, SE 2, PNL 3 | -160 to 240°F | | NONE |
| | C7246-433 | TEMP-SAS, WG 2, SE 2, PNL 7 | -160 to 240°F | | NONE |
| | C7247-433 | TEMP-SAS, WG 2, SE 2, PNL 9 | -160 to 240°F | | NONE |
| | C7246-433 | TEMP-SAS, WG 2, SE 2, PNL 11 | -160 to 240°F | | NONE |
| | C7249-433 | TEMP-SAS, WG 2, SE 3, PNL 3 | -160 to 240°F | | NONE |
| | C7250-433 | TEMP-SAS, WG 2, SE 3, PNL 5 | -160 to 240°F | | NONE |
| | C7251-433 | TEMP-SAS, WG 2, SE 3, PNL 7 | -160 to 240°F | | NONE |
| | C7252-433 | TEMP-SAS, WG 2, SE 3, PNL 11 | -160 to 240°F | | NONE |
| | K103-524 | SAS GROUP 1 PWR TO PCG 1-2 | ONE = PCG 1 | DISCRETE | 205 |
| | K104-524 | SAS GROUP 2 PWR TO PCG 2-3 | ONE = PCG 2 | DISCRETE | 205 |
| | K105-524 | SAS GROUP 3 PWR TO PCG 3-4 | ONE = PCG 3 | DISCRETE | 205 |
| | K106-524 | SAS GROUP 4 PWR TO PCG 4-1 | ONE = PCG 4 | DISCRETE | 205 |
| | K107-525 | SAS GROUP 5 PWR TO PCG 5-6 | ONE = PCG 5 | DISCRETE | 205 |
| | K108-525 | SAS GROUP 6 PWR TO PCG 6-7 | ONE = PCG 6 | DISCRETE | 205 |
| | K109-525 | SAS GROUP 7 PWR TO PCG 7-8 | ONE = PCG 7 | DISCRETE | 205 |
| | K110-525 | SAS GROUP 8 PWR TO PCG 8-5 | ONE = PCG 8 | DISCRETE | 205 |
| | K111-524 | BATTERY 1 POWER ON/OFF | ONE = ON | DISCRETE | 205 |
| | K112-524 | BATTERY 2 POWER ON/OFF | ONE = ON | DISCRETE | 205 |
| | K113-524 | BATTERY 3 POWER ON/OFF | ONE = ON | DISCRETE | 205 |
| | K114-524 | BATTERY 4 POWER ON/OFF | ONE = ON | DISCRETE | 205 |
| | K115-525 | BATTERY 5 POWER ON/OFF | ONE = ON | DISCRETE | 205 |
| | K116-525 | BATTERY 6 POWER ON/OFF | ONE = ON | DISCRETE | 205 |
| | K117-525 | BATTERY 7 POWER ON/OFF | ONE = ON | DISCRETE | 205 |
| | K118-525 | BATTERY 8 POWER ON/OFF | ONE = ON | DISCRETE | 205 |
| | K119-524 | BATTERY 1 DISCHRG LMT MODE | ZERO = AUTO | DISCRETE | 205 |
| | K120-524 | BATTERY 2 DISCHRG LMT MODE | ZERO = AUTO | DISCRETE | 205 |
| | K121-524 | BATTERY 3 DISCHRG LMT MODE | ZERO = AUTO | DISCRETE | 205 |
| | K122-524 | BATTERY 4 DISCHRG LMT MODE | ZERO = AUTO | DISCRETE | 205 |
| | K123-525 | BATTERY 5 DISCHRG LMT MODE | ZERO = AUTO | DISCRETE | 205 |
| | K124-525 | BATTERY 6 DISCHRG LMT MODE | ZERO = AUTO | DISCRETE | 205 |
| | K125-525 | BATTERY 7 DISCHRG LMT MODE | ZERO = AUTO | DISCRETE | 205 |
| | K126-525 | BATTERY 8 DISCHRG LMT MODE | ZERO = AUTO | DISCRETE | 205 |
| | K127-524 | AMP-HR METER 1 SELECT | ONE = PRI | DISCRETE | 205 |
| | K128-524 | AMP-HR METER 2 SELECT | ONE = PRI | DISCRETE | 205 |
| | K129-524 | AMP-HR METER 3 SELECT | ONE = PRI | DISCRETE | 205 |
| | K130-524 | AMP-HR METER 4 SELECT | ONE = PRI | DISCRETE | 205 |
| | K131-525 | AMP-HR METER 5 SELECT | ONE = PRI | DISCRETE | 205 |
| | K132-525 | AMP-HR METER 6 SELECT | ONE = PRI | DISCRETE | 205 |
| | K133-525 | AMP-HR METER 7 SELECT | ONE = PRI | DISCRETE | 205 |
| | K134-525 | AMP-HR METER 8 SELECT | ONE = PRI | DISCRETE | 205 |
| | K135-524 | CHARGER 1 CHARGE RATE MODE | ZERO = AUTO | DISCRETE | 205 |
| | K136-524 | CHARGER 2 CHARGE RATE MODE | ZERO = AUTO | DISCRETE | 205 |
| | K137-524 | CHARGER 3 CHARGE RATE MODE | ZERO = AUTO | DISCRETE | 205 |
| | K138-524 | CHARGER 4 CHARGE RATE MODE | ZERO = AUTO | DISCRETE | 205 |
| | K139-525 | CHARGER 5 CHARGE RATE MODE | ZERO = AUTO | DISCRETE | 205 |
| | K140-525 | CHARGER 6 CHARGE RATE MODE | ZERO = AUTO | DISCRETE | 205 |
| | K141-525 | CHARGER 7 CHARGE RATE MODE | ZERO = AUTO | DISCRETE | 205 |
| | K142-525 | CHARGER 8 CHARGE RATE MODE | ZERO = AUTO | DISCRETE | 205 |
| | K143-524 | CHARGER 1 NORMAL/BYPASS | ONE = NORMAL | DISCRETE | 205 |
| | K144-524 | CHARGER 2 NORMAL/BYPASS | ONE = NORMAL | DISCRETE | 205 |
| | K145-524 | CHARGER 3 NORMAL/BYPASS | ONE = NORMAL | DISCRETE | 205 |
| | K146-524 | CHARGER 4 NORMAL/BYPASS | ONE = NORMAL | DISCRETE | 205 |
| | K147-525 | CHARGER 5 NORMAL/BYPASS | ONE = NORMAL | DISCRETE | 205 |
| | K148-525 | CHARGER 6 NORMAL/BYPASS | ONE = NORMAL | DISCRETE | 205 |
| | K149-525 | CHARGER 7 NORMAL/BYPASS | ONE = NORMAL | DISCRETE | 205 |
| | K150-525 | CHARGER 8 NORMAL/BYPASS | ONE = NORMAL | DISCRETE | 205 |

TABLE 2.1.8-1 INSTRUMENTATION LIST (cont'd)

| NO. | MEASUREMENT NUMBER | DESCRIPTION | TELEMETER RANGE | ONBOARD DISPLAY DISPLAY RANGE | ONBOARD DISPLAY PANEL NO. |
|---|---|---|---|---|---|
| | K151-524 | REG 1 BUS SELECT | ONE = BUS 1 | DISCRETE | 205 |
| | K152-524 | REG 2 BUS SELECT | ONE = BUS 1 | DISCRETE | 205 |
| | K154-524 | REG 3 BUS SELECT | ONE = BUS 1 | DISCRETE | 205 |
| | K154-524 | REG 4 BUS SELECT | ONE = BUS 1 | DISCRETE | 205 |
| | K155-525 | REG 5 BUS SELECT | ONE = BUS 2 | DISCRETE | 205 |
| | K156-525 | REG 6 BUS SELECT | ONE = BUS 2 | DISCRETE | 205 |
| | K157-525 | REG 7 BUS SELECT | ONE = BUS 2 | DISCRETE | 205 |
| | K158-525 | REG 8 BUS SELECT | ONE = BUS 2 | DISCRETE | 205 |
| | K159-524 | REG 1 PWR ON/OFF | ZERO = ON | DISCRETE | 205 |
| | K160-524 | REG 2 PWR ON/OFF | ZERO = ON | DISCRETE | 205 |
| | K161-524 | REG 3 PWR ON/OFF | ZERO = ON | DISCRETE | 205 |
| | K162-524 | REG 4 PWR ON/OFF | ZERO = ON | DISCRETE | 205 |
| | K163-525 | REG 5 PWR ON/OFF | ZERO = ON | DISCRETE | 205 |
| | K164-525 | REG 6 PWR ON/OFF | ZERO = ON | DISCRETE | 205 |
| | K165-525 | REG 7 PWR ON/OFF | ZERO = ON | DISCRETE | 205 |
| | K166-525 | REG 8 PWR ON/OFF | ZERO = ON | DISCRETE | 205 |
| | K169-509 | BUS 1 ATM/TRANSFER TIE PWR RLY | ONE = CLOSED | DISCRETE | 206 |
| | K170-509 | BUS 2 ATM/TRANSFER TIE PWR RLY | ONE = CLOSED | DISCRETE | 206 |
| | K173-525 | PWR SYS CNTL MODE PCG 1-8 | ONE = CMD | | NONE |
| | K175-509 | BUS 1 REG/TRANSFER TIE PWR RLY | ONE = CLOSED | DISCRETE | 206 |
| | K176-509 | BUS 2 REG/TRANSFER TIE PWR RLY | ONE = CLOSED | DISCRETE | 206 |
| | K177-509 | AM BUS 1 SOURCE SELECT | ONE = BUS 1 | DISCRETE | 206 |
| | K178-509 | AM BUS 2 SOURCE SELECT | ONE = BUS 2 | DISCRETE | 206 |
| | K179-509 | DEPLOY BUS 1 PWR OFF/ON | ONE = ON | DISCRETE | 206 |
| | K180-509 | DEPLOY BUS 2 PWR OFF/ON | ONE = ON | DISCRETE | 206 |
| | K181-509 | AM/CSM SGL PT GND | ONE = ON | DISCRETE | 206 |
| | K182-538 | AM/OWS BUS 1 PWR TRANSFER | ZERO = OFF | DISCRETE | 206 |
| | K183-538 | AM/OWS BUS 2 PWR TRANSFER | ZERO = OFF | DISCRETE | 206 |
| | K184-524 | PCG 1 CHGR MODE AUTO/TEMP | ONE = AUTO | DISCRETE | 205 |
| | K185-524 | PCG 2 CHGR MODE AUTO/TEMP | ONE = AUTO | DISCRETE | 205 |
| | K186-524 | PCG 3 CHGR MODE AUTO/TEMP | ONE = AUTO | DISCRETE | 205 |
| | K187-525 | PCG 4 CHGR MODE AUTO/TEMP | ONE = AUTO | DISCRETE | 205 |
| | K188-525 | PCG 5 CHGR MODE AUTO/TEMP | ONE = AUTO | DISCRETE | 205 |
| | K189-525 | PCG 6 CHGR MODE AUTO/TEMP | ONE = AUTO | DISCRETE | 205 |
| | K190-525 | PCG 7 CHGR MODE AUTO/TEMP | ONE = AUTO | DISCRETE | 205 |
| | K191-525 | PCG 8 CHRG MODE AUTO/TEMP | ONE = AUTO | DISCRETE | 205 |
| | K192-538 | EREP BUS 1 VOLTAGE OFF/ON | ONE = ON | | NONE |
| | K193-538 | EREP BUS 2 VOLTAGE OFF/ON | ONE = ON | | NONE |
| | K194-513 | SEQUENTIAL BUS NO. 1 VOLTAGE | ZERO = OFF | | NONE |
| | K195-513 | SEQUENTIAL BUS NO. 2 VOLTAGE | ZERO = OFF | | NONE |
| | K321-512 | DCS 01 BAT 1 CHGR-STATUS | ZERO = CUTOFF | | NONE |
| | K327-512 | DCS 07 BAT 2 CHGR-STATUS | ZERO = CUTOFF | | NONE |
| | K337-512 | DCS 17 BAT 3 CHGR-STATUS | ZERO = CUTOFF | | NONE |
| | K338-512 | DCS 18 BAT 4 CHGR-STATUS | ZERO = CUTOFF | | NONE |
| | K329-512 | DCS 09 BAT 5 CHGR-STATUS | ZERO = CUTOFF | | NONE |
| | K334-512 | DCS 14 BAT 6 CHGR-STATUS | ZERO = CUTOFF | | NONE |
| | K349-512 | DCS 29 BAT 7 CHGR-STATUS | ZERO = CUTOFF | | NONE |
| | K350-512 | DCS 30 BAT 8 CHGR-STATUS | ZERO = CUTOFF | | NONE |
| | K504-TBD | AUX RECEPT-EVENT MARKER | ONE = MARK | | NONE |
| | M101-524 | SOLAR ARRAY GROUP 1 VOLTAGE | 0 to 125 V | | NONE |
| | M102-524 | SOLAR ARRAY GROUP 2 VOLTAGE | 0 to 125 V | | NONE |
| | M103-524 | SOLAR ARRAY GROUP 3 VOLTAGE | 0 to 125 V | | NONE |
| | M104-524 | SOLAR ARRAY GROUP 4 VOLTAGE | 0 to 125 V | | NONE |
| | M105-525 | SOLAR ARRAY GROUP 5 VOLTAGE | 0 to 125 V | | NONE |
| | M106-525 | SOLAR ARRAY GROUP 6 VOLTAGE | 0 to 125 V | | NONE |
| | M107-525 | SOLAR ARRAY GROUP 7 VOLTAGE | 0 to 125 V | | NONE |
| | M108-525 | SOLAR ARRAY GROUP 8 VOLTAGE | 0 to 125 V | | NONE |
| | M109-524 | SOLAR ARRAY GROUP 1 CURRENT | 0 to 50 A | 0 to 50 A | 206 |
| | M110-524 | SOLAR ARRAY GROUP 2 CURRENT | 0 to 50 A | 0 to 50 A | 206 |
| | M111-524 | SOLAR ARRAY GROUP 3 CURRENT | 0 to 50 A | 0 to 50 A | 206 |
| | M112-524 | SOLAR ARRAY GROUP 4 CURRENT | 0 to 50 A | 0 to 50 A | 206 |
| | M113-525 | SOLAR ARRAY GROUP 5 CURRENT | 0 to 50 A | 0 to 50 A | 206 |
| | M114-525 | SOLAR ARRAY GROUP 6 CURRENT | 0 to 50 A | 0 to 50 A | 206 |
| | M115-525 | SOLAR ARRAY GROUP 7 CURRENT | 0 to 50 A | 0 to 50 A | 206 |
| | M116-525 | SOLAR ARRAY GROUP 8 CURRENT | 0 to 50 A | 0 to 50 A | 206 |

TABLE 2.1.8-1 INSTRUMENTATION LIST (cont'd)

| NO. | MEASUREMENT NUMBER | DESCRIPTION | TELEMETER RANGE | ONBOARD DISPLAY | |
|---|---|---|---|---|---|
| | | | | DISPLAY RANGE | PANEL NO. |
| | M117-524 | BAT 1 PRI STATE CHARGE | 0 to 100% | 0 to 100% | 206 |
| | M118-524 | BAT 2 PRI STATE CHARGE | 0 to 100% | 0 to 100% | 206 |
| | M119-524 | BAT 3 PRI STATE CHARGE | 0 to 100% | 0 to 100% | 206 |
| | M120-524 | BAT 4 PRI STATE CHARGE | 0 to 100% | 0 to 100% | 206 |
| | M121-525 | BAT 5 PRI STATE CHARGE | 0 to 100% | 0 to 100% | 206 |
| | M122-525 | BAT 6 PRI STATE CHARGE | 0 to 100% | 0 to 100% | 206 |
| | M123-525 | BAT 7 PRI STATE CHARGE | 0 to 100% | 0 to 100% | 206 |
| | M124-525 | BAT 8 PRI STATE CHARGE | 0 to 100% | 0 to 100% | 206 |
| | M125-524 | BAT 1 SEC STATE CHARGE | 0 to 100% | 0 to 100% | 206 |
| | M126-524 | BAT 2 SEC STATE CHARGE | 0 to 100% | 0 to 100% | 206 |
| | M127-524 | BAT 3 SEC STATE CHARGE | 0 to 100% | 0 to 100% | 206 |
| | M128-524 | BAT 4 SEC STATE CHARGE | 0 to 100% | 0 to 100% | 206 |
| | M129-525 | BAT 5 SEC STATE CHARGE | 0 to 100% | 0 to 100% | 206 |
| | M130-525 | BAT 6 SEC STATE CHARGE | 0 to 100% | 0 to 100% | 206 |
| | M131-525 | BAT 7 SEC STATE CHARGE | 0 to 100% | 0 to 100% | 206 |
| | M132-525 | BAT 8 SEC STATE CHARGE | 0 to 100% | 0 to 100% | 206 |
| | M133-524 | BATTERY 1 VOLTAGE | 25 to 50V | 0 to 50V | 206 |
| | M134-524 | BATTERY 2 VOLTAGE | 25 to 50V | 0 to 50 VDC | 206 |
| | M135-524 | BATTERY 3 VOLTAGE | 25 to 50V | 0 to 50 VDC | 206 |
| | M136-524 | BATTERY 4 VOLTAGE | 25 to 50V | 0 to 50 VDC | 206 |
| | M137-525 | BATTERY 5 VOLTAGE | 25 to 50V | 0 to 50 VDC | 206 |
| | M138-525 | BATTERY 6 VOLTAGE | 25 to 50V | 0 to 50 VDC | 206 |
| | M139-525 | BATTERY 7 VOLTAGE | 25 to 50V | 0 to 50 VDC | 206 |
| | M140-525 | BATTERY 8 VOLTAGE | 25 to 50V | 0 to 50 VDC | 206 |
| | M141-524 | BATTERY 1 CURRENT (COARSE) | -50 to +50A | -50 to +50 VDC | 206 |
| | M142-524 | BATTERY 2 CURRENT (COARSE) | -50 to +50A | -50 to +50 VDC | 206 |
| | M143-524 | BATTERY 3 CURRENT (COARSE) | -50 to +50A | -50 to +50 VDC | 206 |
| | M144-524 | BATTERY 4 CURRENT (COARSE) | -50 to +50A | -50 to +50 VDC | 206 |
| | M145-525 | BATTERY 5 CURRENT (COARSE) | -50 to +50A | -50 to +50 VDC | 206 |
| | M146-525 | BATTERY 6 CURRENT (COARSE) | -50 to +50A | -50 to +50 VDC | 206 |
| | M147-525 | BATTERY 7 CURRENT (COARSE) | -50 to +50A | -50 to +50 VDC | 206 |
| | M148-525 | BATTERY 8 CURRENT (COARSE) | -50 to +50A | -50 to +50 VDC | 206 |
| | M149-513 | TRANSFER BUS NO 1 VOLTAGE | 15 to 35 VDC | 25 to 32 VDC | 206 |
| | M150-513 | TRANSFER BUS NO 2 VOLTAGE | 15 to 35 VDC | 25 to 32 VDC | 206 |
| | M151-513 | EPS CNTL BUS NO 1 VOLTAGE | 15 to 35 VDC | | NONE |
| | M152-513 | EPS CNTL BUS NO 2 VOLTAGE | 15 to 35 VDC | | NONE |
| | M153-513 | REGULATED BUS NO 1 VOLTAGE | 15 to 35 VDC | | NONE |
| | M154-513 | REGULATED BUS NO 2 VOLTAGE | 15 to 35 VDC | | NONE |
| | M155-513 | AM BUS NO. 1 VOLTAGE | 15 to 35 VDC | | NONE |
| | M156-513 | AM BUS NO. 2 VOLTAGE | 15 to 35 VDC | | NONE |
| | M157-509 | ATM TRANSFER BUS 1 CURRENT | ±100A | -100 to +100A | 206 |
| | M158-509 | ATM TRANSFER BUS 2 CURRENT | ∓100A | -100 to +100A | 206 |
| | M159-509 | AM BUS NO. 1 CURRENT | 0 to 100A | 0 to 100A | 206 |
| | M160 509 | AM BUS NO. 2 CURRENT | 0 to 100A | 0 to 100A | 206 |
| | M161-513 | REG BUS 1 (FINE) VOLTAGE | 25 to 32 vdc | 25 to 32 vdc | 206 |
| | M162-513 | REG BUS 2 (FINE) VOLTAGE | 25 to 32 vdc | 25 to 32 vdc | 206 |
| | M163-509 | REG BUS 1 CURRENT | 0 to 200A | 0 to 200A | 206 |
| | M164-534 | REG BUS 2 CURRENT | 0 to 200A | 0 to 200A | 206 |
| | M165-509 | TRANSFER CSM BUS 1 CURRENT | 0 to 100A | 0 to 100A | 206 |
| | M166-509 | TRANSFER CSM BUS 2 CURRENT | 0 to 100A | 0 to 100A | 206 |
| | M167-509 | REG TRANSFER BUS 1 CURRENT | ±100A | -100 to +100A | 206 |
| | M168-509 | REG TRANSFER BUS 2 CURRENT | ∓100A | -100 to +100A | 206 |
| | M169-538 | EPS CNTL BUS 1 CURRENT | 0 to 50A | | NONE |
| | M170-538 | EPS CNTL BUS 2 CURRENT | 0 to 50A | | NONE |
| | M171-524 | BATTERY 1 FINE CURRENT | -10 to +10A | | NONE |
| | M172-524 | BATTERY 2 FINE CURRENT | -10 to +10A | | NONE |
| | M173-524 | BATTERY 3 FINE CURRENT | -10 to +10A | | NONE |
| | M174-524 | BATTERY 4 FINE CURRENT | -10 to +10A | | NONE |
| | M175-524 | BATTERY 5 FINE CURRENT | -10 to +10A | | NONE |
| | M176-524 | BATTERY 6 FINE CURRENT | -10 to +10A | | NONE |
| | M177-524 | BATTERY 7 FINE CURRENT | -10 to +10A | | NONE |
| | M178-524 | BATTERY 8 FINE CURRENT | -10 to +10A | | NONE |
| | M7002-440 | OWS BUS 1 VOLTAGE | 0 to 35 vdc | 0 to 35 vdc | 617 |
| | M7003-440 | OWS BUS 2 VOLTAGE | 0 to 35 vdc | 0 to 35 vdc | 617 |
| | M7004-440 | OWS BUS 1 CURRENT | 0 to 140A | 0 to 140A | 206 & 617 |
| | M7005-440 | OWS BUS 2 CURRENT | 0 to 140A | 0 to 140A | 206 & 617 |

TABLE 2.1.8-2 EPS DCS COMMAND LIST

| DCS COMMAND | COMMAND TITLE | FUNCTION | OCTAL CODE |
|---|---|---|---|
| S1 | SOLAR ARRAY OUTPUT-1 | PCG 1 | 44000 |
| S0 | | PCG 2 | 40000 |
| S17 | SOLAR ARRAY OUTPUT-2 | PCG 2 | 44200 |
| S16 | | PCG 3 | 40200 |
| S65 | SOLAR ARRAY OUTPUT-3 | PCG 3 | 44040 |
| S64 | | PCG 4 | 40040 |
| S87 | SOLAR ARRAY OUTPUT-4 | PCG 4 | 47240 |
| S86 | | PCG 1 | 43240 |
| S33 | SOLAR ARRAY OUTPUT-5 | PCG 5 | 44100 |
| S32 | | PCG 6 | 40100 |
| S47 | SOLAR ARRAY OUTPUT-6 | PCG 6 | 47500 |
| S46 | | PCG 7 | 43500 |
| S97 | SOLAR ARRAY OUTPUT-7 | PCG 7 | 44140 |
| S96 | | PCG 8 | 40140 |
| S113 | SOLAR ARRAY OUTPUT-8 | PCG 8 | 44340 |
| S112 | | PCG 5 | 40340 |
| S13 | BATTERIES - 1 | OFF | 45400 |
| S12 | | ON | 41400 |
| S29 | BATTERIES - 2 | OFF | 45600 |
| S28 | | ON | 41600 |
| S75 | BATTERIES - 3 | OFF | 46440 |
| S74 | | ON | 42440 |
| S95 | BATTERIES - 4 | OFF | 47640 |
| S94 | | ON | 43640 |
| S43 | BATTERIES - 5 | OFF | 46500 |
| S42 | | ON | 42500 |
| S57 | BATTERIES - 6 | OFF | 44700 |
| S56 | | ON | 40700 |
| S107 | BATTERIES - 7 | OFF | 46540 |
| S106 | | ON | 42540 |
| S123 | BATTERIES - 8 | OFF | 46740 |
| S122 | | ON | 42740 |
| S11 | CHARGER - 1 | NORM | 46400 |
| S10 | | BYPASS | 42400 |
| S27 | CHARGER - 2 | NORM | 46600 |
| S26 | | BYPASS | 42600 |
| S79 | CHARGER - 3 | NORM | 47440 |
| S78 | | BYPASS | 43440 |
| S89 | CHARGER - 4 | NORM | 44640 |
| S88 | | BYPASS | 40640 |
| S41 | CHARGER - 5 | NORM | 44500 |
| S40 | | BYPASS | 40500 |
| S55 | CHARGER - 6 | NORM | 47300 |
| S54 | | BYPASS | 43300 |
| S105 | CHARGER - 7 | NORM | 44540 |
| S104 | | BYPASS | 40540 |
| S121 | CHARGER - 8 | NORM | 44740 |
| S120 | | BYPASS | 40740 |
| S450 | AMP HOUR INTEGRATOR - 1 | PRI | 42264 |
| S449 | | SEC | 44264 |
| S149 | AMP HOUR INTEGRATOR - 2 | PRI | 45220 |
| S148 | | SEC | 41220 |
| S231 | AMP HOUR INTEGRATOR - 3 | PRI | 47160 |
| S230 | | SEC | 43160 |
| S233 | AMP HOUR INTEGRATOR - 4 | PRI | 44560 |
| S232 | | SEC | 40560 |
| S165 | AMP HOUR INTEGRATOR - 5 | PRI | 45120 |
| S164 | | SEC | 41120 |
| S167 | AMP HOUR INTEGRATOR - 6 | PRI | 47120 |
| S166 | | SEC | 43120 |
| S243 | AMP HOUR INTEGRATOR - 7 | PRI | 46004 |
| S242 | | SEC | 42004 |
| S245 | AMP HOUR INTEGRATOR - 8 | PRI | 45004 |
| S244 | | SEC | 41004 |

TABLE 2.1.8-2 EPS DCS COMMAND LIST (cont'd)

| DCS COMMAND | COMMAND TITLE | FUNCTION | OCTAL CODE |
|---|---|---|---|
| S15 | CHARGE RATE - 1 | AUTO | 47400 |
| S14 | | LO | 43400 |
| S31 | CHARGE RATE - 2 | AUTO | 47600 |
| S30 | | LO | 43600 |
| S77 | CHARGE RATE - 3 | AUTO | 45440 |
| S76 | | LO | 41440 |
| S93 | CHARGE RATE - 4 | AUTO | 45640 |
| S92 | | LO | 41640 |
| S45 | CHARGE RATE - 5 | AUTO | 45500 |
| S44 | | LO | 41500 |
| S59 | CHARGE RATE - 6 | AUTO | 46700 |
| S58 | | LO | 42700 |
| S109 | CHARGE RATE - 7 | AUTO | 45540 |
| S108 | | LO | 41540 |
| S125 | CHARGE RATE - 8 | AUTO | 45740 |
| S124 | | LO | 41740 |
| 1-1 | NICD BATTERY 1 CHARGER | NORM | 700 |
| 1-1 | | CUTOFF | 701 |
| 7-1 | NICD BATTERY 2 CHARGER | NORM | 730 |
| 7-1 | | CUTOFF | 731 |
| 17-3 | NICD BATTERY 3 CHARGER | NORM | 702 |
| 17-3 | | CUTOFF | 703 |
| 18-3 | NICD BATTERY 4 CHARGER | NORM | 742 |
| 18-3 | | CUTOFF | 743 |
| 9-2 | NICD BATTERY 5 CHARGER | NORM | 704 |
| 9-2 | | CUTOFF | 705 |
| 14-2 | NICD BATTERY 6 CHARGER | NORM | 754 |
| 14-2 | | CUTOFF | 755 |
| 29-4 | NICD BATTERY 7 CHARGER | NORM | 716 |
| 29-4 | | CUTOFF | 717 |
| 30-4 | NICD BATTERY 8 CHARGER | NORM | 756 |
| 30-4 | | CUTOFF | 757 |
| S7 | DISCHARGE LIMIT - 1 | AUTO | 47000 |
| S6 | | INHIBIT | 43000 |
| S23 | DISCHARGE LIMIT - 2 | AUTO | 47200 |
| S22 | | INHIBIT | 43200 |
| S71 | DISCHARGE LIMIT - 3 | AUTO | 47040 |
| S70 | | INHIBIT | 43040 |
| S85 | DISCHARGE LIMIT - 4 | AUTO | 45240 |
| S84 | | INHIBIT | 41240 |
| S39 | DISCHARGE LIMIT - 5 | AUTO | 47100 |
| S38 | | INHIBIT | 43100 |
| S53 | DISCHARGE LIMIT - 6 | AUTO | 45300 |
| S52 | | INHIBIT | 41300 |
| S103 | DISCHARGE LIMIT - 7 | AUTO | 47140 |
| S102 | | INHIBIT | 43140 |
| S119 | DISCHARGE LIMIT - 8 | AUTO | 47340 |
| S118 | | INHIBIT | 43340 |
| S3 | POWER CONDITIONING GROUP OUTPUT - 1 | OFF | 46000 |
| S2 | | ON | 42000 |
| S19 | POWER CONDITIONING GROUP OUTPUT - 2 | OFF | 46200 |
| S18 | | ON | 42200 |
| S67 | POWER CONDITIONING GROUP OUTPUT - 3 | OFF | 46040 |
| S66 | | ON | 42040 |
| S81 | POWER CONDITIONING GROUP OUTPUT - 4 | OFF | 44240 |
| S80 | | ON | 40240 |
| S35 | POWER CONDITIONING GROUP OUTPUT - 5 | OFF | 46100 |
| S34 | | ON | 42100 |
| S49 | POWER CONDITIONING GROUP OUTPUT - 6 | OFF | 44300 |
| S48 | | ON | 40300 |
| S99 | POWER CONDITIONING GROUP OUTPUT - 7 | OFF | 46140 |
| S98 | | ON | 42140 |
| S115 | POWER CONDITIONING GROUP OUTPUT - 8 | OFF | 46340 |
| S114 | | ON | 42340 |

TABLE 2.1.8-2 EPS DCS COMMAND LIST (cont'd)

| DCS COMMAND | COMMAND TITLE | FUNCTION | OCTAL CODE |
|---|---|---|---|
| S5 | POWER CONDITIONING GROUP OUTPUT - 1 | REG BUS 1 | 45000 |
| S4 | | REG BUS 2 | 41000 |
| S21 | POWER CONDITIONING GROUP OUTPUT - 2 | REG BUS 1 | 45200 |
| S20 | | REG BUS 2 | 41200 |
| S69 | POWER CONDITIONING GROUP OUTPUT - 3 | REG BUS 1 | 45040 |
| S68 | | REG BUS 2 | 41040 |
| S83 | POWER CONDITIONING GROUP OUTPUT - 4 | REG BUS 1 | 46240 |
| S82 | | REG BUS 2 | 42240 |
| S37 | POWER CONDITIONING GROUP OUTPUT - 5 | REG BUS 2 | 45100 |
| S36 | | REG BUS 1 | 41100 |
| S51 | POWER CONDITIONING GROUP OUTPUT - 6 | REG BUS 2 | 46300 |
| S50 | | REG BUS 1 | 42300 |
| S101 | POWER CONDITIONING GROUP OUTPUT - 7 | REG BUS 2 | 45140 |
| S100 | | REG BUS 1 | 41140 |
| S117 | POWER CONDITIONING GROUP OUTPUT - 8 | REG BUS 2 | 45340 |
| S116 | | REG BUS 1 | 41340 |
| S9 | AM BUS - 1 | REG BUS 1 | 44400 |
| S8 | | REG BUS 2 | 40400 |
| S111 | AM BUS - 2 | REG BUS 2 | 47540 |
| S110 | | REG BUS 1 | 43540 |
| S207 | OWS BUS 1 | OFF | 47460 |
| S206 | | ON | 43460 |
| S247 | OWS BUS - 2 | OFF | 47004 |
| S246 | | ON | 43004 |
| S147 | ELEC GND 1 | CSM | 46220 |
| S146 | | AIRLOCK | 42220 |
| S221 | ELEC GND 2 | CSM | 45660 |
| S220 | | AIRLOCK | 41660 |
| S63 | ATM TRANSFER TIE - BUS 1 | OPEN | 47700 |
| S62 | | CLOSED | 43700 |
| S73 | ATM TRANSFER TIE - BUS 2 | OPEN | 44440 |
| S72 | | CLOSED | 40440 |
| S61 | REG TRANSFER TIE - BUS 1 | OPEN | 45700 |
| S60 | | CLOSED | 41700 |
| S91 | REG TRANSFER TIE - BUS 2 | OPEN | 46640 |
| S90 | | CLOSED | 42640 |

SUBSECTION 2.2

COMMUNICATION SYSTEM

## 2.2.1 INTRODUCTION

The communication system provides a transfer of information between the SWS and the Manned Spaceflight Network (MSFN) during all phases of the mission in addition to providing a transfer of information between crewmen in the orbital assembly (OA) during the manned phases. The information transferred during all mission phases includes instrumentation system data transmitted to MSFN and messages for the Digital Command System (DCS) received from MSFN. During the manned phases of the mission, The communication system provides the following: voice communication between crewmen in the OA and MSFN, indications of a caution or warning alert, range information between the CSM and the SWS, hard-copy, printed messages from MSFN to the crew, and transmission of television data to MSFN.

## 2.2.2 SYSTEM INTERFACES

The communication system provides the radio frequency (RF) link between the SWS and MSFN. Instrumentation data is downlinked to MSFN and ground commands to the DCS are uplinked from MSFN through the communication system (figure 2.2.2-1). The communication system provides the CSM with ranging data from the SWS during the rendezvous maneuver in addition to providing voice and television data for real-time (R/T) downlinking to MSFN. The interface with the Caution and Warning System (C&WS) enables the communication system to provide an indication of a caution or warning condition. Active and passive thermal control over components within the communication system is maintained by the Environmental Control System (ECS).

## 2.2.3 FUNCTIONAL DESCRIPTION

The communication system is divided into five subsystems: audio, television, teleprinting, ranging, and RF.

### 2.2.3.1 AUDIO SUBSYSTEM

The audio subsystem provides R/T voice communication between the crewmen and MSFN via CSM S-band equipment. The audio subsystem also provides for delayed time (D/T) voice communication to MSFN via an interface with the instrumentation system in addition to providing audio tones and visual displays indicative of a caution or warning condition.

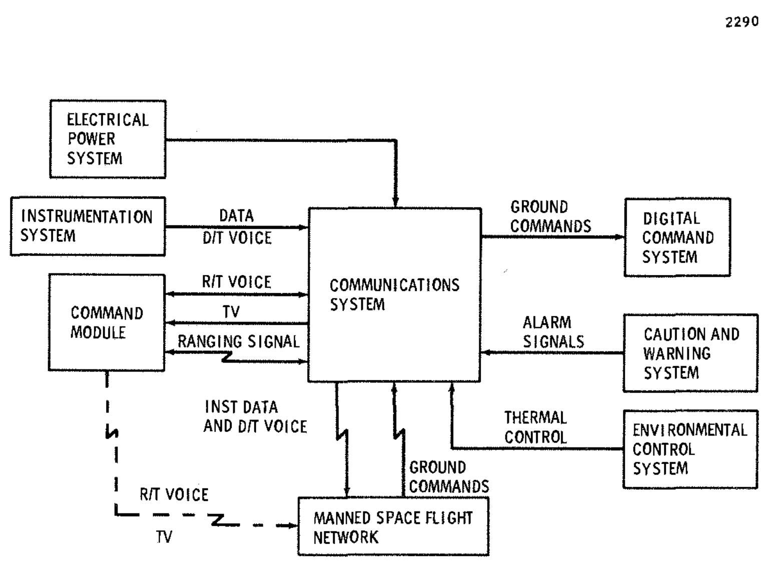



Figure 2.2.2-1 Communication System Interfaces

The audio subsystem consists of the following: 13 intercom boxes, two Extra-vehicular activity (EVA) panels, one Intra-vehicular activity panel (IVA), two Audio Load Compensators (ALC), three CSM Audio Centers (A/C), and a CSM speaker box (figure 2.2.3-1).

The intercom boxes provide the voice communication capability for crewmen in an unsuited mode throughout the MDA/AM/OWS. This is accomplished via a speaker and microphone, or through a headset and Crewman Communications Umbilical (CCU). They also provide audio tones and a visual display indicative of a caution or warning condition.

The EVA panels (located in lock compartment) and the IVA panel (located in the structural transition section) provide the voice communication capability for crewmen in a suited mode.

The ALC's, located external to the SWS habitable areas, provide automatic compensation for varying audio loads by supplying regulated audio signal levels to the audio subsystem components. The ALC's may also provide the audio signal to the instrumentation system where it can be recorded (D/T voice).

The CSM A/C's provide the voice communication capability for crewmen in an unsuited mode in the CSM. This is accomplished through a headset and the CSM communications umbilical. The CSM A/C's also provide control over the redundant audio subsystem channels.

The CSM speaker box provides the voice input and output capability for crewmen in an unsuited mode in the CSM via a speaker and microphone.

Two independent channels, A and B, provide redundant voice communication capability throughout the OA. Voice input into an intercom box, EVA panel, or IVA panel can be routed through either channel. Channel A and Channel B are each associated with a separate ALC (ALC A and ALC B, respectively). The ALC connected to the selected channel receives a microphone signal from an intercom box, EVA panel, or IVA panel and routes it to the CSM A/C associated with the selected channel.

CSM A/C CMN 3 is normally linked to channel A while CSM A/C CMN 1 is normally linked to channel B. The CSM A/C CMN 2 is used as a backup to CSM A/C CMN 3 and CMN 1 and can route the microphone signal to the CSM speaker box. The appropriate CSM A/C (which can downlink the microphone signal to MSFN via the CSM S-band system) receives the microphone signal from the corresponding ALC and routes it back as an earphone signal to the same ALC for distribution to all intercom boxes, EVA panels, and the IVA panel to complete the intercom "loop". The ALC also routes the earphone signal to the tape recorder audio control logic in the instrumentation system for D/T transmission to MSFN via the RF subsystem. An earphone signal may be uplinked from the MSFN to a CSM A/C via the CSM S-band system and routed to the corresponding ALC for distribution to all intercom boxes, EVA panels, and the IVA panel.

Each intercom box (panels 102, 116, 131, 401, 520, 540, 600, 627, 702, 801, 901, 902, 903) contains the following controls and displays: a COMM CHAN selector switch, an [ICOM/XMIT] switch, a SPKR VOL control, a [CALL] switch, two CCU connectors, a CHAN A and CHAN B selector switch, a [RECORD/OFF] switch and record light, and a MASTER ALARM light.

The COMM CHAN selector switch enables selection of channel A or B to the ON or SLEEP mode. The COMM CHAN selector switch in the A ON or B ON mode links the intercom box to ALC A or ALC B, respectively. The COMM CHAN selector switch in the A SLEEP or B SLEEP mode disables the speaker output of the respective intercom box except when a CALL signal or ground-commanded crew alert is received.

The intercom box [ICOM/XMIT] switch is momentary in both positions and must be manually maintained in a push-to-talk fashion. The [ICOM/XMIT] switch in the ICOM position enables the intercom box microphone and disables the speaker (to preclude audio feedback into the activated microphone). The ICOM position thereby activates the intercom "loop" by allowing the microphone signal to be routed from the intercom box to ALC A or ALC B as selected by the COMM CHAN selector switch discussed above. The ALC corresponding to the selected channel routes the microphone signal to the respective CSM A/C which provides an earphone signal back to the same ALC. The ALC routes the earphone signal through the SPKR VOL control of each intercom box selected to the corresponding channel. The SPKR VOL control allows the crewmen to vary the intercom box speaker output sound level. The ALC also provides the earphone signal to both EVA panels and the IVA panel to complete the intercom "loop" for crewmen in a suited mode.

The [ICOM/XMIT] switch in the XMIT position enables the intercom "loop" as discussed above in addition to enabling the CSM S-band system to transmit R/T voice to MSFN (for a discussion of the CSM S-band system see CSM-SLOH Vol I).

The intercom box [CALL] switch is momentary and must be manually maintained in a push-to-talk fashion. The [CALL] switch in the CALL position enables the intercom "loop" on both channels by supplying the microphone signal to both ALC's simultaneously. The resulting CALL signal overrides the SLEEP mode of the COMM CHAN selector switch as well as that of the CHAN A select switch and CHAN B select switch discussed below.

Each intercom box contains a CCU connector associated with Channel A and a CCU connector associated with Channel B, which correspond to CHAN A select switch and CHAN B select switch. A 15-foot CCU or a lightweight CCU (LCCU) mates with the intercom box CCU connectors to provide audio communication capability via a headset as opposed to the intercom box speaker and microphone discussed previously. The CCU also routes biomedical data to the instrumentation system via the intercom box (the LCCU provides a communication capability only). The CCU and LCCU contain an [ICOM/XMIT] switch, used in conjunction with the CHAN A or CHAN B select switches. The CHAN A or CHAN B select switches in the SLEEP mode disables inputs to the headset. As mentioned previously, a CALL signal overrides the CHAN A or CHAN B selector SLEEP mode. The CHAN A or CHAN B selector OFF mode disables all outputs and inputs at the CCU connector. CHAN A selector or CHAN B selector ICOM/PTT mode enables "hot mike" communication through the intercom "loop" without activation of the CCU or LCCU [ICOM/XMIT] switch. The CHAN A

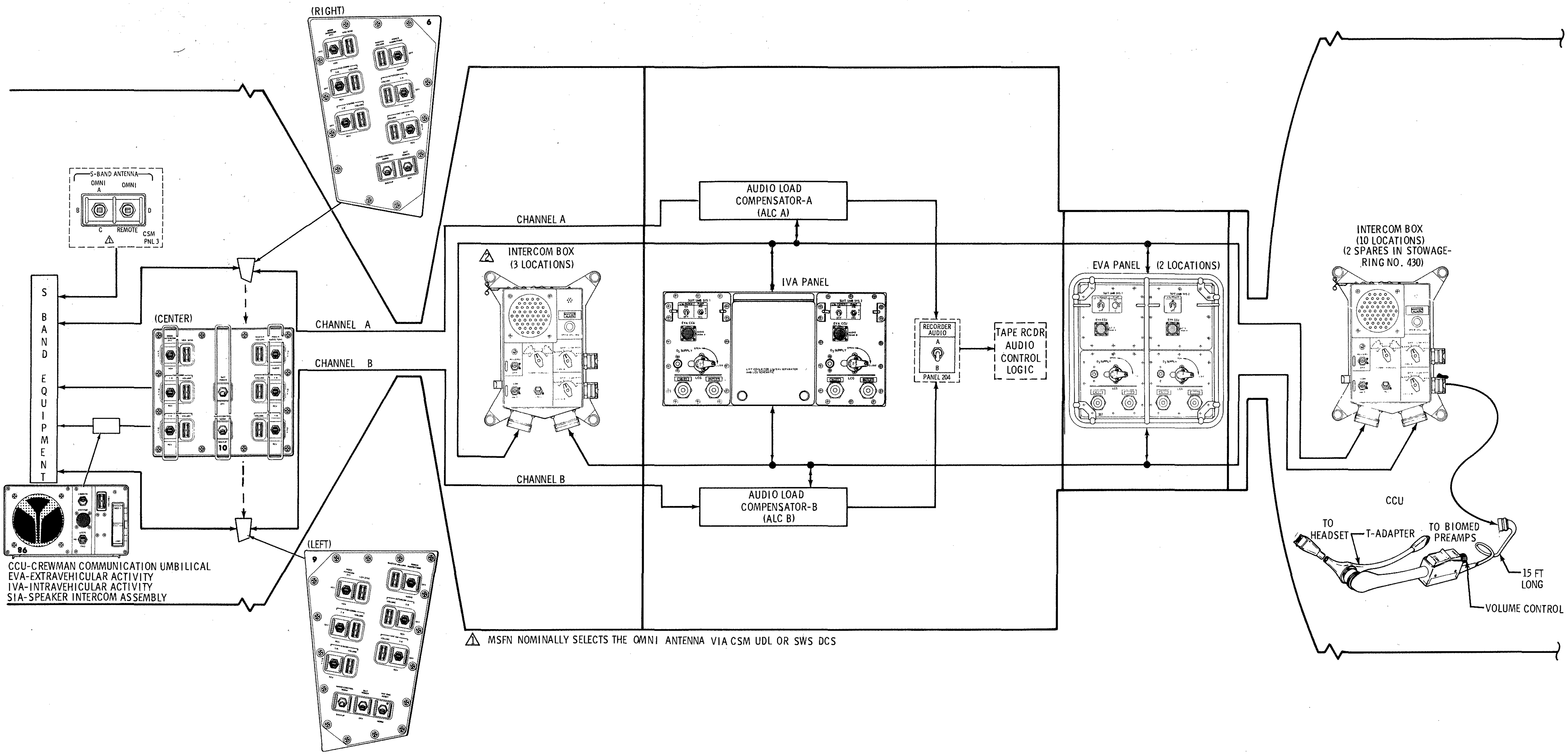



Figure 2.2.3-1 Audio Subsystem Configuration

selector or CHAN B selector ICOM/PTT mode enables the CSM transmitter to downlink the audio signal to MSFN when the CCU or LCCU [ICOM/XMIT] switch is activated to XMIT. The CHAN A selector or CHAN B selector PTT mode enables the intercom "loop" when the integral CCU or LCCU [ICOM/XMIT] switch is activated to ICOM position. The CCU or LCCU [VOL] control varies the headset earphone output. Biomedical data are routed to the instrumentation system through the CCU and intercom box without activation of the CCU [ICOM/XMIT] switch when the CHAN A selector or CHAN B selector is in any position other than OFF.

The intercom box [RCD/OFF] switch enables the channel A or channel B audio signal to be recorded by the instrumentation system as selected by the INSTR SYS RCDR AUDIO switch (panel 204). When the [RCD/OFF] switch is activated to the momentary RCD position, a green light will come on to indicate that the data tape recorder is in the voice record mode. Recording is terminated when any [RCD/OFF] switch is activated to OFF and will cause the record light to go off.

The EVA [RCD/OFF] switch and record light, located in the lock compartment (panel 316), is used in conjunction with the INST SYS RCDR AUDIO switch in the same manner as the intercom box [RCD/OFF] switch discussed above.

Each EVA panel (panels 317 and 323) and IVA panel (panel 217) contains an EVA CCU connector associated with channel A and an EVA CCU connector associated with channel B that correspond to SUS 1 LSU PWR switch and SUS 2 LSU PWR switch, respectively. A 60-foot EVA CCU (part of the LSU) mates with the EVA CCU connectors to provide audio communication capability for crewmen in a suited mode. The EVA CCU also routes biomedical data to the instrumentation system. The SUS 1 LSU PWR or SUS 2 LSU PWR switch in the OFF position disables all outputs and inputs at the EVA CCU connector. The SUS 1 LSU PWR or SUS 2 LSU PWR switch in the ON position enables "hot mike" communication through the intercom "loop".

Each of the three CSM A/C's contains identical controls that include the following: [SUIT POWER/OFF] switch, AUDIO CONTROL switch, MODE switch, INTERCOM switch, S-BAND switch, VHF switch, and MASTER VOLUME CONTROL potentiometer.

The [SUIT POWER/OFF] switch in the SUIT POWER mode enables the headset microphones (the CSM headset earphones are always enabled).

The CSM AUDIO CONTROL switch in the NORM mode enables communication through the CSM A/C that corresponds to its respective channel (A/C CMN 3 corresponds to channel A, and A/C CMN 1 corresponds to channel B). A/C CMN 3 or the A/C CMN 1 AUDIO CONTROL switch in the BACKUP mode routes the audio signal through A/C CMN 2. The A/C CMN 2 AUDIO CONTROL switch in the backup mode routes the audio signal to A/C CMN 1.

The MODE switch in the INTERCOM/PTT mode enables "hot mike" OA intercommunication and push-to-transmit communication to MSFN capability via an integral [ICOM/XMIT] switch in the CSM communication umbilical. The MODE switch in the PTT mode enables push-to-intercommunicate and push-to-transmit capability via the integral [ICOM/XMIT] switch when keyed to the ICOM and XMIT position, respectively. The MODE switch in the VOX mode enables "hot mike" intercommunication and simultaneous transmission of the audio signal to MSFN.

The INTERCOM switch in the T/R mode enables the respective A/C to receive inputs and provide outputs to an intercom bus. When A/C CMN 3 (channel A) and A/C CMN 1 (channel B) are both on the intercom bus, the channels are tied together. The INTERCOM switch in the RCV mode enables the respective A/C to receive (only) an audio signal on the intercom bus. The INTERCOM switch in the OFF mode disables the capability of the respective A/C to provide inputs or receive outputs from the intercom bus. A volume control associated with the INTERCOM switch adjusts the audio level output to the respective ALC.

The S-BAND switch in the T/R mode enables the respective A/C to transmit and receive audio signals to and from MSFN via the CSM S-band equipment. The S-BAND switch in the RCV mode enables the respective A/C headset to receive (only) an audio signal from MSFN via the CSM S-band equipment. The S-BAND switch in the OFF mode disables the capability of the respective A/C to provide inputs or receive outputs over the CSM S-band equipment. A volume control associated with the S-BAND switch adjusts the S-band audio level (receive) to the respective A/C.

The CSM VHF equipment provides a backup RF link to the CSM S-band equipment. The T/R, RCV, and OFF modes of the VHF switch and associated volume control provide the same functional control over the CSM VHF equipment as the S-BAND switch provides over the CSM S-band equipment discussed previously.

The MASTER VOLUME potentiometer overrides the respective A/C audio level output of the INTERCOM, VHF, and S-BAND volume controls simultaneously.

The CSM speaker box, associated with A/C CMN 2, contains the following controls: A [SPEAKER/HEADSET] switch, a [CALL/ON/SLEEP] switch, an [ICOM/XMIT] switch, and a volume control.

The CSM speaker box [SPEAKER/HEADSET] switch in the SPEAKER position enables the audio output of A/C CMN 2 to be routed to the CSM speaker box. The audio signal is routed through a volume control that allows the crewmen to vary the audio output level of the speaker. The [SPEAKER/HEADSET] switch in the HEADSET position enables the audio output of A/C CMN 2 to be routed to the headset earphone as well as to A/C CMN 3 and A/C CMN 1 AUDIO CONTROL switch discussed above.

The CSM speaker box [CALL/ON/SLEEP] switch in the ON mode applies power to the CSM speaker box. The [CALL/ON/SLEEP] switch in the CALL mode allows an audio signal from the speaker box to be routed through the intercom "loop" on channels A and B simultaneously. The [CALL/ON/SLEEP] switch in the SLEEP mode disables power to the CSM speaker box.

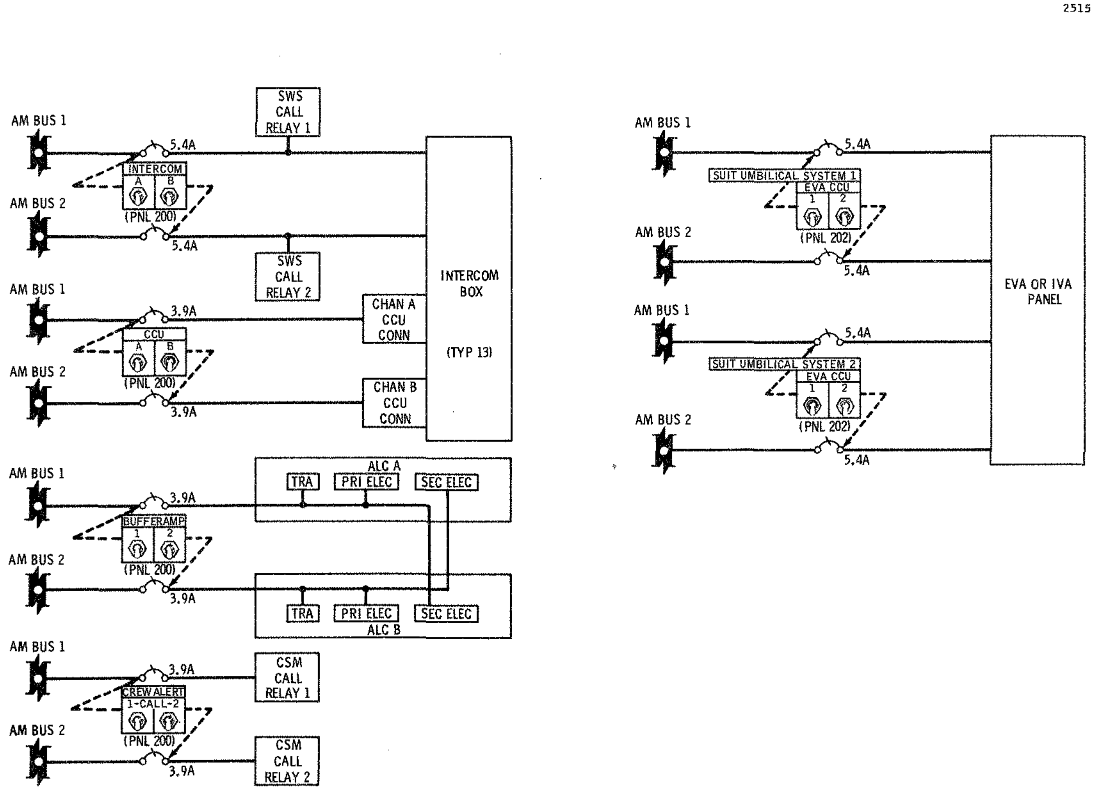



Figure 2.2.3-2 Audio Subsystem Power Distribution

The CSM speaker box [ICOM/XMIT] switch is momentary in both positions and must be manually maintained in a push-to-talk fashion. The [ICOM/XMIT] switch in the ICOM position enables the CSM speaker box to route an audio signal through the intercom "loop" on channel A or B as selected by the AUDIO CONTROL switch of the respective A/C. The [ICOM/XMIT] switch in the momentary XMIT position enables intercom "loop" communication in addition to downlinking the audio signal to MSFN via the CSM S-band equipment or the CSM VHF backup equipment.

AUDIO SYS ICOM A and AUDIO SYS ICOM B circuit breakers on panel 200 supply electrical power to each intercom box for channel A or channel B operation from AM bus 1 and AM bus 2, respectively (figure 2.2.3-2). AUDIO SYS CCU A and AUDIO SYS CCU B circuit breakers, on panel 200, supply electrical power to CCU A and CCU B connectors on all intercom boxes for channel A or channel B intercom box headset communication, respectively. SUS 1 EVA 1 and SUS 2 EVA 2, on panel 202, supply electrical power to each EVA and IVA panel for operation on EVA CCU A from AM bus 1 and AM bus 2, respectively. SUS 2 EVA 1 and SUS 2 EVA 2, on panel 202, supply electrical power to each EVA AND IVA panel for operation on EVA CCU B from AM Bus 1 and AM Bus 2, respectively. AUDIO SYS BUFFER AMPS 1 circuit breaker, on panel 200, supplies electrical power to ALC A primary electronics and tape recorder amplifiers as well as to ALC B secondary electronics from AM Bus 1. AUDIO SYS BUFFER AMPS 2 circuit breaker, on panel 200, supplies electrical power to ALC B primary electronics and tape recorder amplifier as well as to ALC A secondary electronics from AM bus 2. AUDIO SYS CSM CREW ALERT CALL-1 and AUDIO SYS CSM CREW ALERT CALL-2 circuit breakers, on panel 200, supply electrical power to the CSM call logic from AM bus 1 and AM bus 2, respectively. VHF/CREW STATION AUDIO circuit breakers L, CTR, and R provide power from the Flight and Postlanding bus to CSM panels 9, 10, and 6, respectively.

### 2.2.3.2 TELEVISION SUBSYSTEM

The television (TV) subsystem provides a distribution of connections for the Apollo portable color TV camera, conditions video signals from the TV camera, and provides for the selection of an ATM or AM/OWS video output to the CSM for transmission to MSFN. The TV subsystem consists of five TV input stations and a VIDEO selector switch (figure 2.2.3-3). Implementation of an onboard video recorder is currently being evaluated for Skylab, but is TBS for this publication.

The TV input stations (panels 133, 320, 404, 555, and 542) provide power to the Apollo color TV camera and monitor in addition to conditioning the video signal from the camera. The TV input station is deadfaced when the TELEVISION POWER switch is in the OFF position; power to the camera is applied in the ON position (see CSM-SLOH for discussion of portable TV camera and monitor).

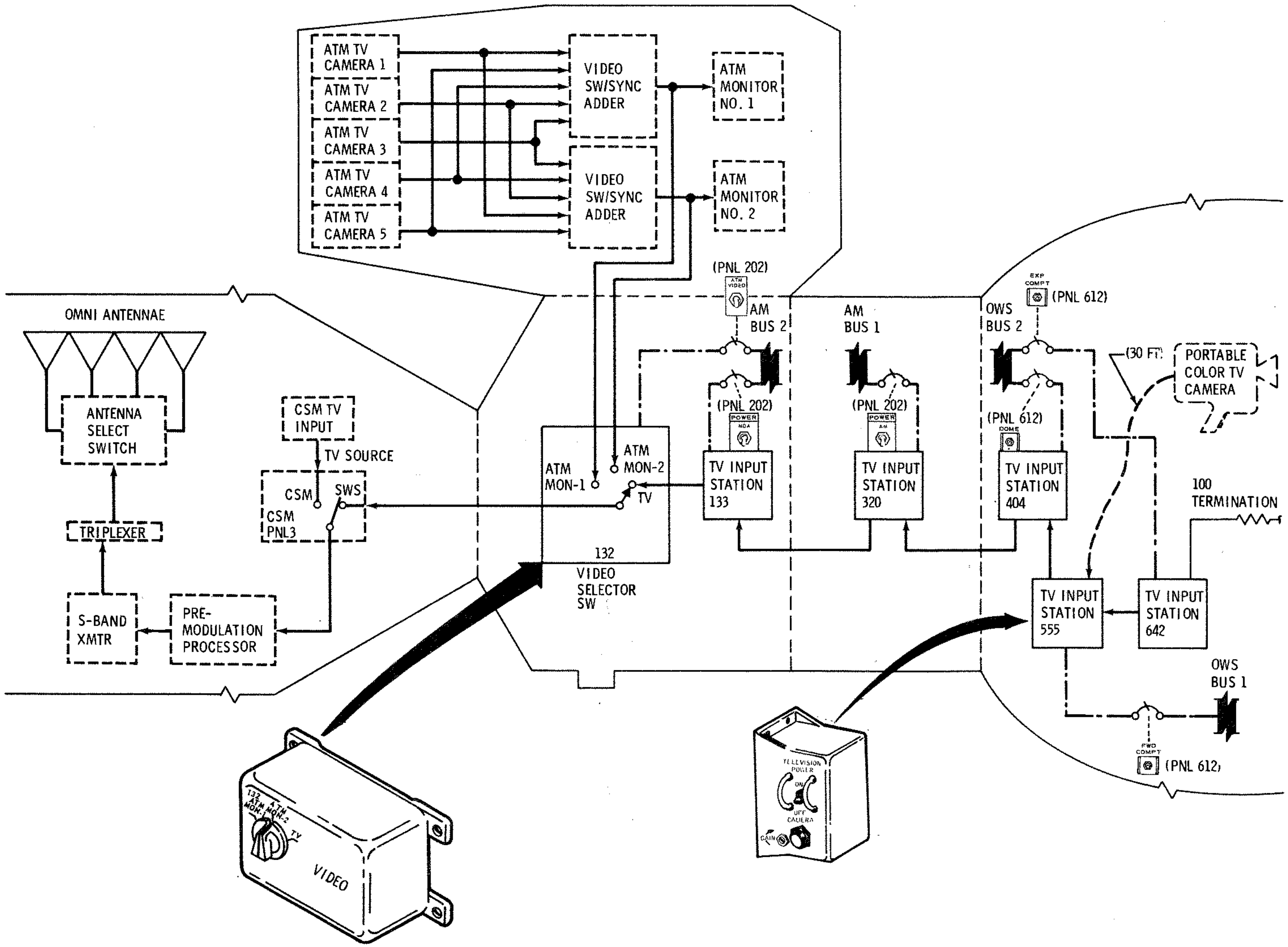



Figure 2.2.3-3 Television Subsystem Configuration

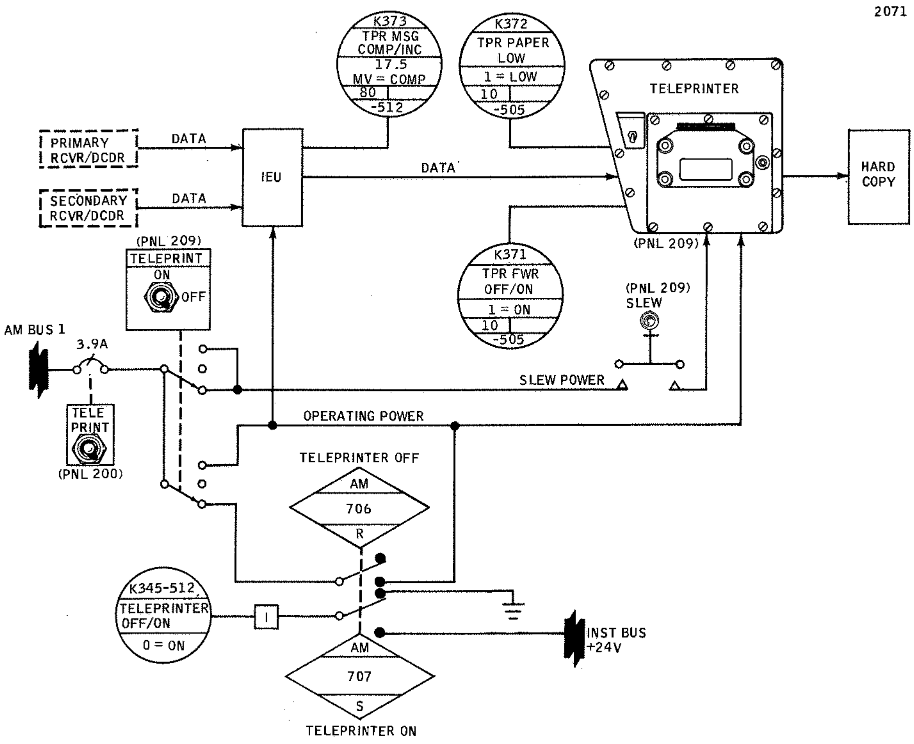



Figure 2.2.3-4 Teleprinting Subsystem Configuration

The VIDEO selector switch (panel 132) provides for the selection of a single video signal output to the CSM for downlinking to MSFN. The ATM monitor 1 or ATM monitor 2 video signal is selected for downlinking via the CSM when the VIDEO selector switch is in the respective ATM MON-1 or ATM MON-2 position. The video output of a TV input station is routed to the CSM for downlinking to MSFN when the VIDEO selector switch is in the TV position and all unused TV input station TELEVISION POWER switches (discussed above) are in the OFF position.

FWD COMPT (OWS bus 1), DOME (OWS bus 2), and EXP COMPT (OWS bus 2) TV OUTLETS circuit breakers on panel 612 supply electrical power to TV input stations 555,404, and 642, respectively. TELEVISION POWER AM and POWER MDA circuit breakers on panel 202 supply electrical power to TV input station 320 and 133 from AM bus 1 and AM bus 2, respectively. ATM VIDEO circuit breaker on panel 202 supplies electrical power to the VIDEO selector switch from AM bus 2.

2.2.3.3 TELEPRINTING SUBSYSTEM

The teleprinting subsystem provides printed messages to the crew from MSFN. The messages are transmitted from MSFN to the DCS, which transfers the data to the teleprinting subsystem (figure 2.2.3-4). The Interface Electronics Unit (IEU) accepts and decodes binary data from the DCS and transfers the data to the teleprinter for message printout. A message sent from MSFN is composed of 30 bits with the first three bits representing the vehicle address and the second three bits the system address (section 2.7.3).

The TELEPRINT switch (panel 209) enables power to the IEU and teleprinter in the ON position and disables power in the OFF position. The CMD position enables MSFN control of power via the DCS. The SLEW switch (panel 209) is a pushbutton which enables the teleprinter to advance the paper when the switch is activated (154 rolls of spare paper, 60 ft. per roll, is stowed onboard). Electrical power is obtained from AM Bus 1 through the TELEPRINT circuit breaker (panel 200).

2.2.3.4 RANGING SUBSYSTEM

The SWS ranging subsystem (figure 2.2.3-5) transponds the ranging signal generated by the CSM ranging subsystem to enable the CSM ranging subsystem to compute and display range and range rate between the CSM and the SWS during rendezvous. The SWS ranging subsystem consists of a ranging antenna, a VHF transceiver and a range tone transfer assembly (RTTA).

The SWS ranging antenna receives the CSM generated ranging signal and routes it to the VHF transceiver which in turn routes it to the RTTA. The RTTA receives the ranging tone from the VHF transceiver. The VHF transceiver receives the reconstructed ranging signal from the RTTA and routes it to the SWS ranging antenna for retransmission to the CSM.

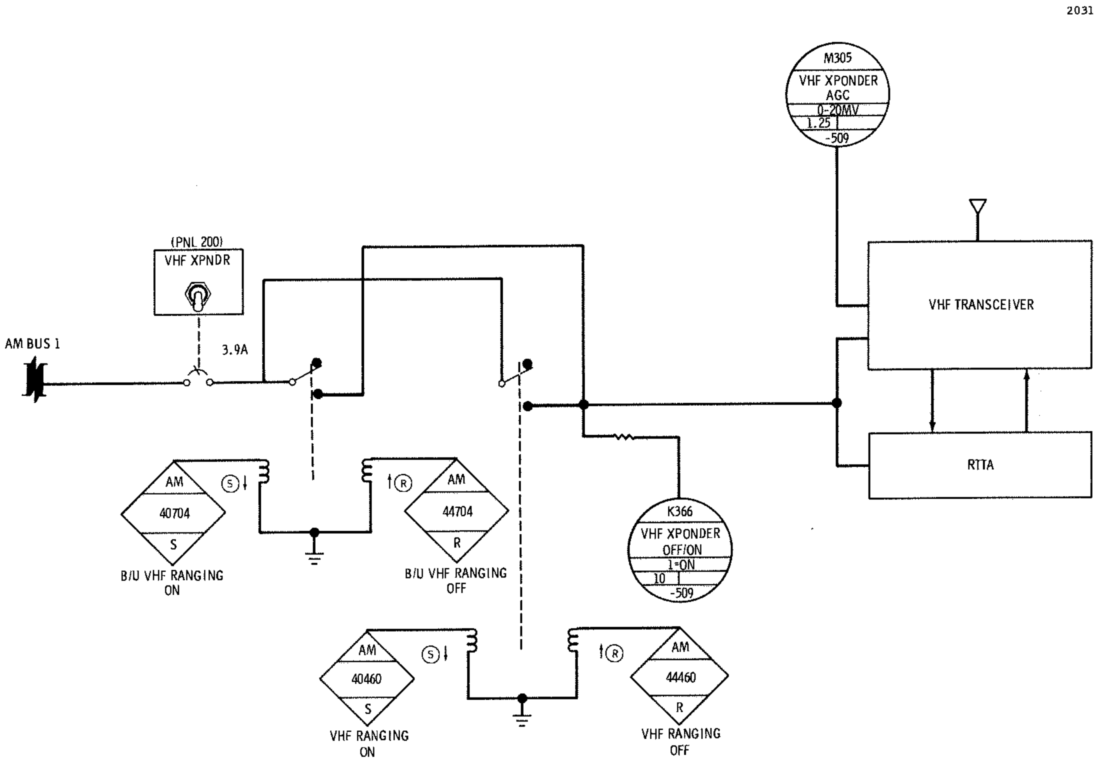



Figure 2.2.3-5 Ranging Subsystem Configuration

The ON/OFF control of the SWS ranging subsystem is by redundant DCS command only. Electrical power is routed from AM bus 1 through VHF XPNDR circuit breaker (panel 200).

2.2.3.5 RF SUBSYSTEM

The RF subsystem provides for the transmission of data to MSFN and the reception of ground commands from MSFN.

The RF subsystem consists of three 10-watt transmitters, one 2-watt transmitter, a quadriplexer, two hybrid rings, four coaxial switches, a command stub antenna, a launch stub antenna, and two discone antennas (figure 2.2.3-6).

The 2-watt transmitter (as opposed to a 10-watt transmitter) is used during the launch phase to transmit data through the launch stub antenna to preclude corona. After orbital insertion, the 2-watt transmitter is deactivated by ground command and the 10-watt transmitters are activated (see section 2.6 for discussion of transmitter power and input modulation).

The discone antennas are inactive and in a stowed configuration during the launch phase of the mission. After orbital insertion, the 40-foot discone antenna booms are deployed via IU command. The ANTENNA switch (panel 205) in the DEPLOY position enables manual backup to the IU deploy command (section 2.0.4).

The command stub antenna receives ground commands from MSFN. The launch stub antenna also receives ground commands in addition to downlinking the transmitter outputs until discone antenna No. 1 is selected for use.

The quadriplexer combines the transmitter outputs into one signal for downlinking via a single antenna. The quadriplexer also isolates the 450-MHz ground command carrier frequency received for input to the DCS from the downlink transmissions.

The hybrid rings isolate the receivers of each receiver/decoder and insure that each receives equal RF signal strength.

Prior to liftoff, the DCS RF/hardline coax switch transfers the command signal path from the ground support equipment (GSE) hardline to the command stub antenna. The discone antenna coax switch is controlled by the ANTENNA [(DISC 1/STUB)/DISC 2/CMD] switch (panel 204). Manual control of the launch/orbit coax switch is enabled via the ANTENNA [DISC 1/STUB/CMD] switch (panel 204) when the ANTENNA [(DISC 1/STUB)/DISC 2/CMD] switch is in the DISC 1/STUB position. Discone antenna No. 2 is enabled when the ANTENNA [(DISC 1/STUB)/DISC 2/CMD] switch is in the 2 position. Discone antenna No. 1 or the launch stub antenna is enabled when the ANTENNA [(DISC 1/STUB)/DISC 2/CMD] switch is in the DISC 1/STUB position and the ANTENNA -[DISC 1/STUB/CMD] switch is in the DISCONE or STUB position, respectively. The CMD position of both switches (normal position) enables MSFN selection of the antennas.

2264

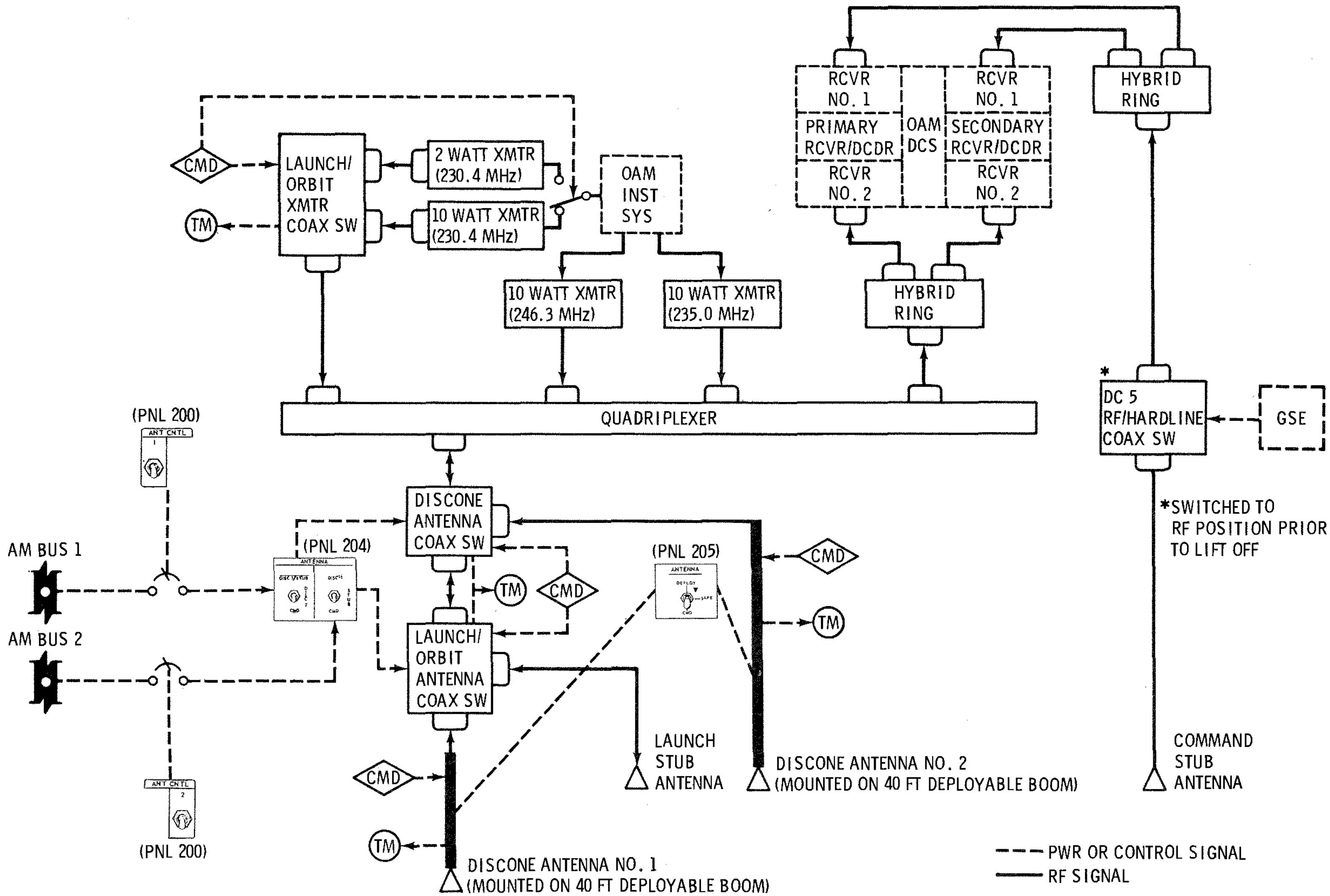



Figure 2.2.3-6 RF Subsystem Configuration

Electrical power is routed to the ANTENNA [(DISC 1/STUB)/DISC 2/CMD] switch and ANTENNA-[DISC 1/STUB/CMD] switch from AM bus 1 and AM bus 2 via circuit breakers ANT CNTL 1 and ANT CNTL 2 (panel 200), respectively.

## 2.2.4 SUBSYSTEM AND MAJOR COMPONENT DESCRIPTION

### 2.2.4.1 AUDIO SUBSYSTEM

Each intercom box contains a microphone amplifier, which amplifies the microphone audio output; this signal is routed to the appropriate ALC (figure 2.2.4-1). The microphone amplifier is enabled when the [CALL] or [ICOM/XMIT] switches are activated. The speaker amplifier of each intercom box receives the earphone signal from the appropriate ALC and drives the speaker. The speaker amplifier is disabled when the microphone amplifier is enabled to preclude feedback from the speaker into the microphone. The intercom box [CALL] switch ties the channel A and channel B microphone signals together by activating the SWS call relay. The CSM [SLEEP/ON/CALL] switch ties the channel A and channel B earphone signals together when a CSM CALL is initiated. Either a SWS call or CSM call will activate the internal intercom box call relay, which overrides the SPKR VOL control and the SLEEP position of the COMM CHAN selector switch.

The C&W system drives the speaker of each intercom box by simultaneously enabling the speaker amplifier with low-level audio signals and driving the speaker directly with high-level audio signals. The C&W high-level audio signals drive the intercom box speaker even if intercom box power is not available or if the intercom box electronics malfunctions. The red MASTER ALARM light on each intercom box will come on whenever a caution, warning, or emergency alert is initiated. A C&W crew alert signal (section 2.8) activates the CSM call relay, enables the high- and low-level audio signals and illuminates the intercom box MASTER ALARM light.

Each ALC contains redundant microphone amplifiers and earphone amplifiers in addition to a single tape recorder amplifier. The redundant microphone amplifiers of the appropriate ALC receives the microphone signal from an intercom box, EVA panel, or IVA panel; amplifies it; and routes it to the associated CSM A/C. The redundant earphone amplifiers of the appropriate ALC receive the earphone signal from the associated CSM A/C, amplify it, and distribute it to all intercom boxes, EVA panels, and IVA panels. The tape recorder amplifier of each ALC conditions the earphone signal from the associated CSM A/C and routes it to the instrumentation system where it can be recorded (D/T voice).

Each CSM A/C contains a microphone amplifier, which receives the microphone signal from the associated ALC microphone amplifiers, amplifies it, and routes it to the XMTR/RCVR control logic for R/T downlinking when enabled via the PTT relay. The CSM A/C microphone amplifier also routes the microphone signal to the earphone amplifier, which amplifies it to generate the earphone signal that is routed to the associated ALC. The earphone amplifier also conditions the voice signals from the MSFN.

The EVA panels and IVA panelscontain no electronics. They merely route the power and data discussed in paragraph 2.2.3.1.

### 2.2.4.2 TELEVISION SUBSYSTEM

A TV input station enables power to the TV camera and monitor when the TELEVISION POWER switch is in the ON position (figure 2.2.4-2). The internal power supply provides regulated power to the variable gain amplifier and enables the output of the variable gain amplifier to be routed to the VIDEO selector (panel 132) when the TELEVISION POWER switch is ON. Prior to liftoff, each TV input station variable gain amplifier is adjusted to compensate for the impedance between each TV input station and the VIDEO selector. In addition to powering the variable gain amplifiers, the internal power supply activates a relay, which enables the output of the variable gain amplifier to be routed to the VIDEO selector. When the relay is not activated (TELEVISION POWER switch is OFF), the video signal from an active TV input station is enabled to the VIDEO selector.

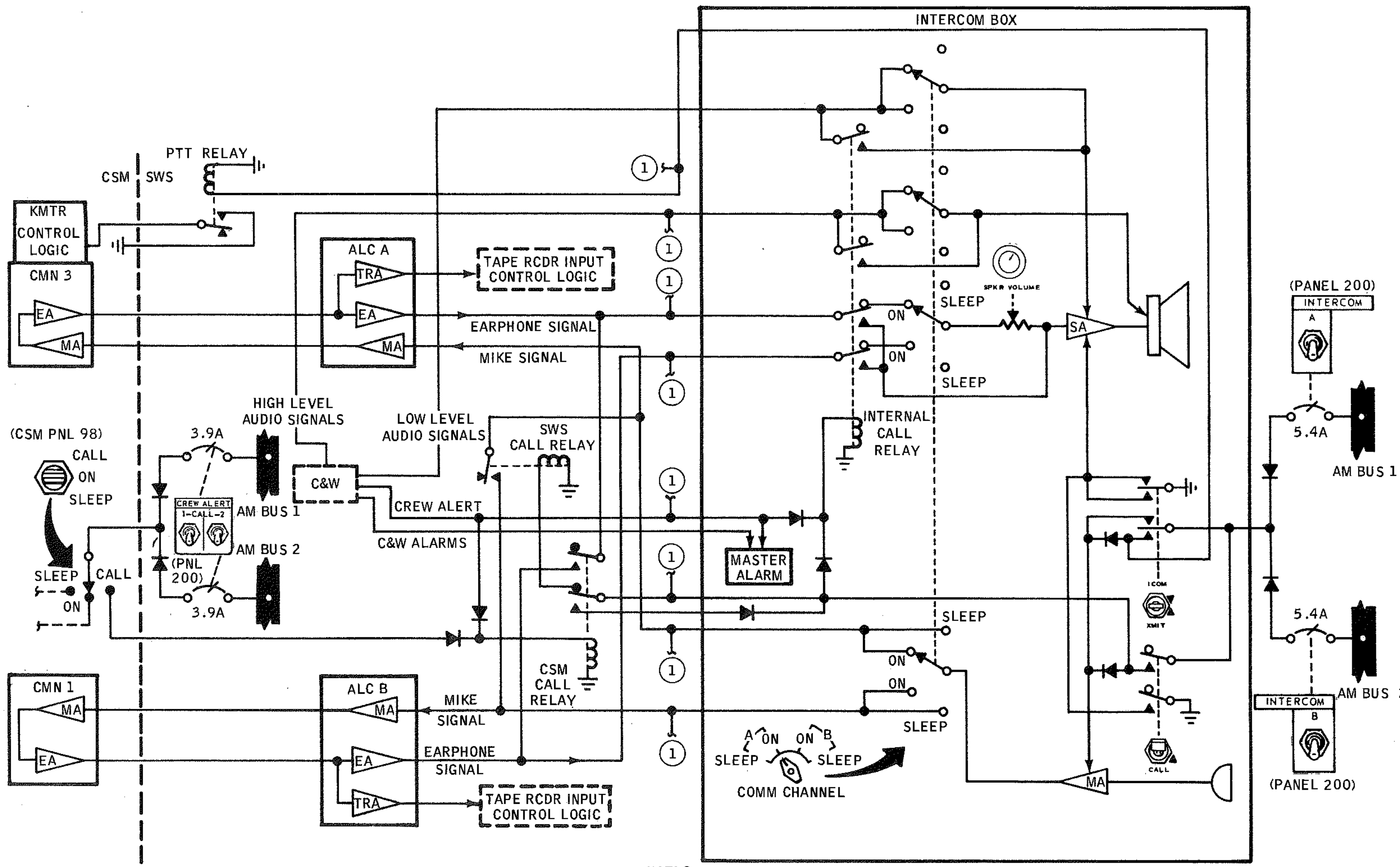
The VIDEO selector (panel 132) contains an internal power supply and an amplifier (figure 2.2.4-2). The gain of the amplifiers can be individually adjusted prior to launch. The conditioned ATM monitor 1 video signal, ATM monitor 2 video signal, or the TV input station video signal is transferred to the CSM for downlinking when the selector switch is in the ATM MON-1, ATM MON-2, or TV position, respectively. The selector switch positions are monitored by the instrumentation system.

### 2.2.4.3 TELEPRINTING SUBSYSTEM

The IEU has an identical interface with both the primary and secondary receiver/decoder (figure 2.2.4-3). The IEU receiver/decoder select/lockout logic enables the data interface with the receiver/decoder that sends a vehicle address recognition signal. The receiver/decoder systems address interrogate signal enables the IEU system address decoder to verify that the data is intended for the teleprinting subsystem. The system address decoder then enables the data to be shifted into the input register and the message complete detector, which indicates via telemetry whether the proper number of bits has been received.

The input register shifts the data into the 180-bit storage register when the transfer register indicates (via a ready signal) that a previous message has been sufficiently processed. The data is transferred to the transfer register when subsequent messages fill the 180-bit storage register with enough data for a full line of print or when a print execute message is received. The transfer register and decoder is divided into side A and side B. Side A decodes the binary, alphanumeric data while side B routes the information required to print one row of each character line (each character is printed as a 5x7 dot matrix) and sends the information required to generate the other rows of each character line back to side A to repeat the process. The character generator, dot row counter, dot register, and data driver convert the output of the transfer register into the form required to generate the 5x7 dot matrix characters and transfer the data to the teleprinter.

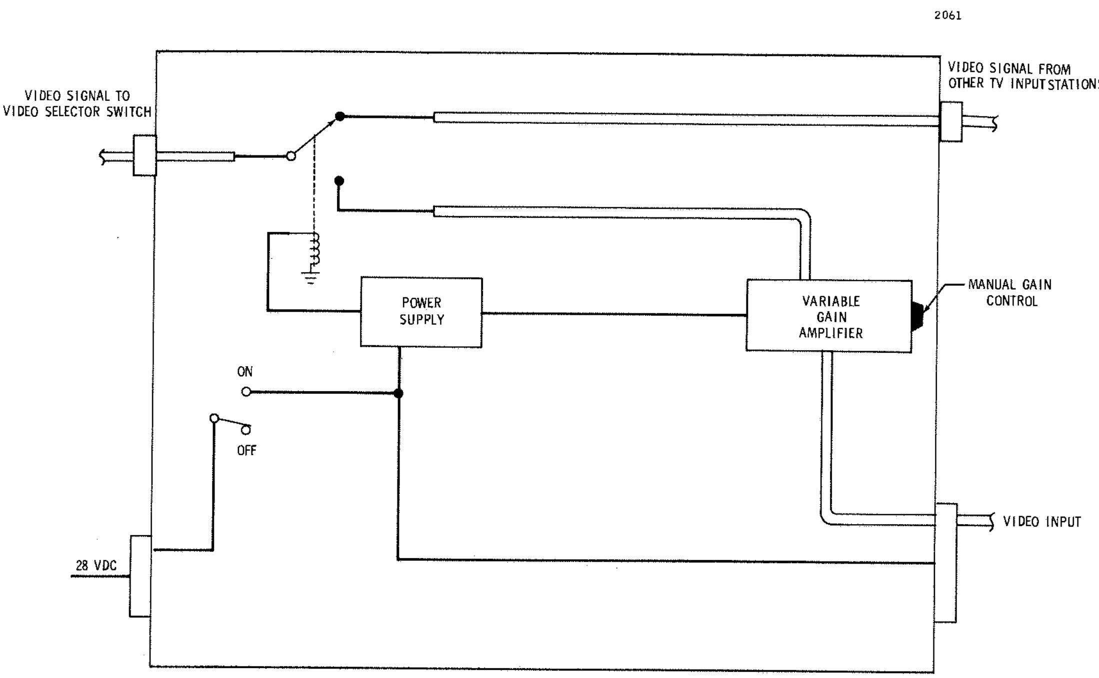
2070



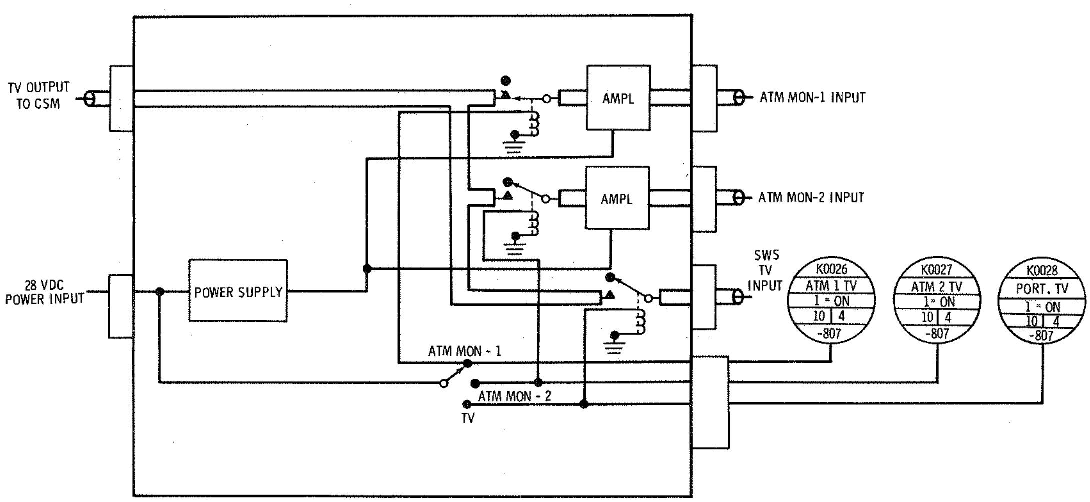

NOTES:

(1) OTHER INTERCOM BOXES EVA, OR IVA PANEL INTERFACES

Figure 2.2.4-1 Audio Subsystem Operation




TV INPUT STATION




VIDEO SELECTOR SWITCH

Figure 2.2.4-2 Television Subsystem Operation

**INTERFACE ELECTRONICS UNIT BLOCK DIAGRAM**

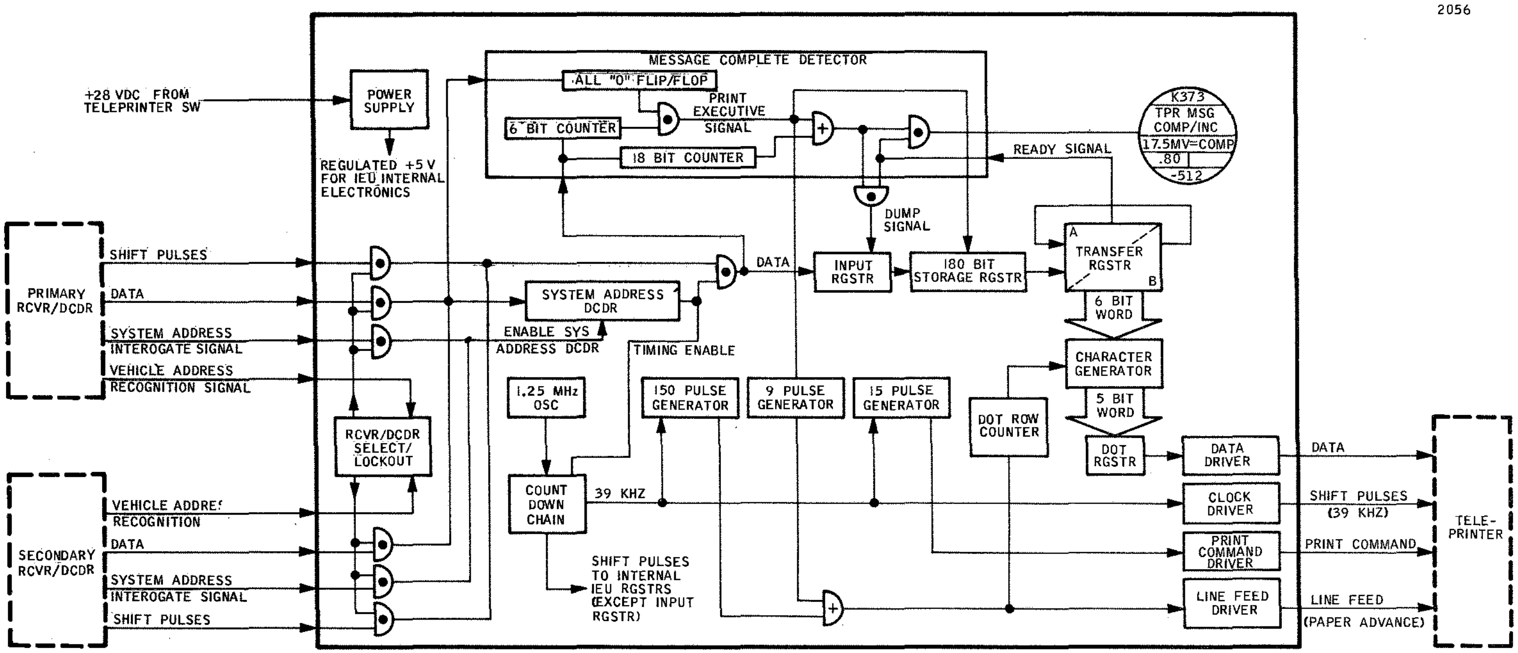



Figure 2.2.4-3 Interface Electronics Unit Operation

The clock driver, print command driver, and line feed driver are enabled as a function of time from the oscillator and countdown chain to provide the teleprinter with shift pulses, print enable commands, and paper advance commands, respectively. The IEU contains an internal power supply that provides the IEU internal electronics with a regulated +5vdc.

The teleprinter receives data from the IEU to enable a maximum of 15 heating elements at a time (figure 2.2.4-4). The print command signal enables the print pulse generators, one of ten counter logic, and one of 10 drivers logic to enable one of 10 heating element groups (each heating element group contains 15 heating elements). The line feed circuit enables the stepping motor to advance the paper when the line feed signal is received or when the SLEW pushbutton switch (panel 209) is maintained. The paper level low micro switch indicates to MSFN via telemetry when there is 12 feet of paper left on the paper roll (a red stripe on each side of the paper indicates to the crew that 3 feet of paper remain). The teleprinter contains an internal power supply that provides the teleprinter internal electronics with +5vdc and +16vdc. The ON/OFF status of the power supply input is monitored on telemetry.

2.2.4.4 RANGING SUBSYSTEM

The VHF transceiver contains a receiver that routes the CSM ranging signal to the RTTA and a transmitter that transmits the output of the RTTA to the CSM (figure 2.2.4-5). The VHF transceiver also contains a diplexer that allows the ranging signal to be received and transmitted on the SWS ranging antenna (after reconstruction of the signal in the RTTA).

The RTTA contains an amplifier that amplifies the ranging signal transferred from the VHF transceiver and routes it to the product detector. The product detector computes the phase difference between the received ranging signal and a reference signal from the control logic. The phase difference is sent to the Voltage Controlled Oscillator (VCO), which enables the control logic to activate the range gate. The range gate keys the VHF transceiver on and off to retransmit a properly phased and reconstructed ranging signal. The RTTA contains an internal power supply that provides regulated voltage to the RTTA internal electronics.

2.2.4.5 RF SUBSYSTEM

Each transmitter contains a modulation amplifier that amplifies the input modulation received from the instrumentation system (figure 2.2.4-6). A VCO varies the carrier frequency such that there is a 0.1 MHz peak deviation for a 1.0 volt peak signal input to the transmitter. A power amplifier amplifies the frequency modulated carrier wave and routes it to a band pass filter that attenuates those frequencies that are not in the modulation frequency bands. A regulated power supply provides 6 vdc to the transmitter internal electronics.

Each hybrid ring contains two coaxial cables, which isolate command receivers by phase cancellation of the command signal.

The quadriplexer contains four resonant cavities which provide isolation between the command and telemetry signals by phase cancellation.

2.2.5 FAILURE MODES

The significant failure modes for the communication system equipment is summarized in the following table:

TABLE 2.2.5-1 COMMUNICATION SYSTEM - FAILURE MODE

| FAILURE | INDICATIONS | VEHICLE CAPABILITY |
|---|---|---|
| Intercom Box | Degraded intercommunication and/or MSFN communication capability using the intercom box microphone/speaker or a CCU | An intercom box electronics failure, except for certain switching failures, renders the intercom box inoperative on both audio channels. Electronics failure will not affect CCU operation through the intercom box. Certain passive component failures in the intercom box will disable CCU operation. The intercom box must be replaced by one of two spares carried onboard to regain full audio capability at the intercom box station. |
| Audio Load Compensator (ALC) (Assumes Single Failure) | Received audio level throughout OA drops a maximum of 6 db on one audio channel. Tape recording capability from one audio channel is lost (apparent only to MSFN). | Audio level drop can be compensated for by increasing appropriate CSM audio center MASTER VOLUME or INTERCOM VOLUME control. The alternate audio channel must be used for voice recording, if tape recording electronics fails, by selecting the RECORDER AUDIO switch (panel 204). |
| EVA Panel (317 or 323) (audio portion) | IVA communication capability is lost. | Alternate EVA CCU receptacle on same EVA panel must be used by turning SUS 1 (2) LSU POWER switch OFF, disconnecting the EVA CCU from AUDIO CHAN A (B) receptacle, plugging the CCU into the AUDIO CHAN B (A) receptacle and turning SUS 2 (1) LSU POWER switch ON. This configuration will have both EVA crewmen connected to the same audio channel. The same bio-med data channels are routed through both EVA CCU receptacles on each EVA panel. |

TABLE 2.2.5-1 FAILURE MODES (cont'd)

| FAILURE | INDICATIONS | VEHICLE CAPABILITY |
|---|---|---|
| IVA Panel (217) (audio portion) | IVA communication capability is lost. | The same procedure must be used as for an EVA panel failure. |
| AM VHF Ranging System (Includes failure of the VHF Transceiver Range Tone Transfer Assembly or the Ranging Antenna) | Loss of ranging data by the CSM. | Onboard navigation must be accomplished using ground tracking and onboard sextant sighting data only. Loss of VHF ranging data does not significantly effect onboard navigation. Reliance upon the computed range and range rate for velocity match (braking and line-of-sight control) may incur a CSM propellant penalty. |
| 2-Watt VHF Transmitter (230.4 MHz) | MSFN loses real-time TM during ascent. All AM/MDA/OWS PCM data is lost from time of failure through SL-1 orbit insertion | Data recording is commanded on insertion and real-time TM downlink can be restablished with the activation of a 10-watt transmitter shortly after discone antenna deployment. |
| 10-Watt VHF Transmitter (Transmitter A, 230.4 MHz; B, 246.3 MHz; C, 235.0 MHz) | MSFN loses real-time data, delayed time data, or delayed time voice depending on the modulation source selected. | The two remaining 10-watt transmitters must be utilized for all AM/MDA/OWS downlink requirements. Modulation/transmission selection is accomplished by DCS commands, or by manual configuration of the TRANSMITTER INPUT A, B, C selection switches with TRANSMITTERS switch to ON. Loss of one transmitter may present some data management constraints depending on the mission phase. |
| Hybrid Rings | | The Hybrid rings are passive coax cable/connector arrangements used for power dividing into each of the DCS Receiver/Decoders. Failure of this equipment is considered highly unlikely. |
| Quadriplexer | Total failure (e.g. port 5 detuned) will cause the loss of all AM/MDA/OWS telemetry transmitter carrier outputs to MSFN and reduce command coverage due to the loss of uplinked RF to the DCS via the launch stub/discone antenna system. Partial failure can cause the loss of any one transmitter output or the redundant input to the DCS | The loss of all telemetry due to a total failure will severely constrain the mission, the extent of which depends on the mission phase at the time of failure. Data management can minimize partial failure by appropriate command or manual transmission/modulation selection. Quadriplexer failure will not severely impact command coverage. (separate DCS RF signal path available through the command stub antenna). |
| Launch/Orbit Transmitter Coax Switch (Coil opens or contacts fail open) | Either the 2-watt or 10-watt 230.4 MHz transmitter carrier is absent depending on the failed switch position. A telemetry bilevel parameter indicates the position of the switch. | The 10-watt transmitter is used after orbit insertion. There is no mission impact if the 2-watt position is failed. Failure of the 10-watt transmitter position limits downlink capability to two 10-watt transmitters and one 2-watt transmitter (as opposed to three 10-watt transmitters) with no loss of data. |
| Discone Antenna Coax Switch (Coil opens or contacts fail open) | Carrier signal strength at MSFN does not change when switching between discone No. 2 and discone No. 1/launch stub antennas. Two telemetry bilevels are used to indicate the switch position. | Antenna coverage is limited to either discone No. 2, or discone No. 1 and the launch stub antenna. Loss in coverage will not appreciably affect the mission. |
| Launch/Orbit Antenna Coax Switch (Coil opens or contacts fail open) | Carrier signal strength at MSFN does not change when switching between discone No. 1 and the launch stub antennas is attempted. A telemetry bilevel is used to indicate the switch position. | Antenna coverage is limited to that provided by discone No. 2 and either discone No. 1 or the launch stub antennas depending on the failed switch position. Loss of coverage will not appreciably affect the mission. |
| DCS/RF Hardline Coax Switch (assumes failure to switch from DCS hardline to the command stub antenna) | DCS Primary and Secondary DCS Receiver No. 1 signal strengths (telemetry indications) do not respond to the presence of a 450 MHz carrier when the GSE commands a switch to the command stub antenna. | DCS/RF hardline coax switch failure will not severely impact command coverage (separate DCS RF signal path is available through the launch stub antenna) |

TABLE 2.2.5-1 FAILURE MODES (cont'd)

| FAILURE | INDICATIONS | VEHICLE CAPABILITY |
|---|---|---|
| Interface Electronics Unit (IEU) | MSFN is unable to uplink information via teleprinter. | Use of the teleprinter is lost for the duration of the mission. All uplinked crew information must be by voice. |
| Teleprinter | MSFN is unable to uplink information via teleprinter. | The spare teleprinter must be installed. |

2.2.6 PERFORMANCE AND DESIGN DATA

2.2.6.1 AUDIO SUBSYSTEM

Intercom Box
- o Input Voltage. . . . . . . . . . . . . . . . . . . . . . . 22 to 30 vdc
- o Input Power
  - o Status Listen Mode (no audio signal present) . . . . 2.7 watts @ 27 vdc
  - o Normal Listen Mode (audio signal present). . . . . . 6.2 watts @ 27 vdc
  - o Call Listen Mode (call audio signal present) . . . . 15.1 watts @ 27 vdc
  - o Normal Talk Mode (voice input) . . . . . . . . . . . 5.7 watts @ 27 vdc
  - o Call Talk Mode (call input). . . . . . . . . . . . . 15.9 watts @ 27 vdc
- o Minimum microphone Input . . . . . . . . . . . . . . . 75-db sound pressure level
- o Speaker Output . . . . . . . . . . . . . . . . . . . . 0 to 106 db sound pressure level @ 5 psia
- o Typical Harmonic Distortion
  - o Intercom Box Microphone. . . . . . . . . . . . . . . 5%
  - o Intercom Box Speaker . . . . . . . . . . . . . . . . 7%
  - o Audio System . . . . . . . . . . . . . . . . . . . . 10%
- o Frequency Response . . . . . . . . . . . . . . . . . . 300 Hz to 3000 Hz

ALC
- o Input Voltage. . . . . . . . . . . . . . . . . . . . . . 22 to 30 vdc
- o Input Power. . . . . . . . . . . . . . . . . . . . . . . 5.4 watts @ 27 vdc
- o Frequency Response . . . . . . . . . . . . . . . . . . 300 Hz to 3000 Hz
- o Microphone Amplifier
  - o Input Impedance. . . . . . . . . . . . . . . . . . . 600 ± 100 ohms
  - o Frequency Response . . . . . . . . . . . . . . . . . 300 to 3000 Hz
  - o Harmonic Distortion. . . . . . . . . . . . . . . . . Typically 1%
  - o Output Impedance . . . . . . . . . . . . . . . . . . 600 ± 50 ohms
  - o Output . . . . . . . . . . . . . . . . . . . . . . . 2.5 db linear amplification (15 dbm maximum)
- o Earphone Amplifier
  - o Input Impedance. . . . . . . . . . . . . . . . . . . 600 ± 20 ohms
  - o Frequency Response . . . . . . . . . . . . . . . . . 300 to 3000 Hz
  - o Distortion . . . . . . . . . . . . . . . . . . . . . Typically 2%
  - o Output Impedance . . . . . . . . . . . . . . . . . . 600 ± 50 ohms
  - o Output . . . . . . . . . . . . . . . . . . . . . . . 3 db gain to AVC threshold (15 dbm), then attenuates such that a 10-dbm input is reduced to a 7.5 dbm output
- o Tape Recorder Amplifier
  - o Frequency Response . . . . . . . . . . . . . . . . . 300 to 3000 Hz
  - o Distortion . . . . . . . . . . . . . . . . . . . . . 5% maximum
  - o Output . . . . . . . . . . . . . . . . . . . . . . . 1.5 volts rms
  - o Output . . . . . . . . . . . . . . . . . . . . . . . 8.3 db gain to AVC threshold (-10 dbm), then attenuates such that a 20-dbm input is reduced to a 2-dbm output

2.2.6.2 TV SUBSYSTEM

TV Input Station
- o Input Voltage. . . . . . . . . . . . . . . . . . . . . . 22 to 30 vdc
- o Input Power. . . . . . . . . . . . . . . . . . . . . . . 9.1 watts @ 27 vdc
- o Power Transmitted to TV Camera Monitor . . . . . . . . 37.8 watts @ 27 vdc
- o Frequency Response . . . . . . . . . . . . . . . . . . 9 MHz to 4 MHz
- o Video Amplification. . . . . . . . . . . . . . . . . . Variable from 6 db to 14 db
- o Video Output . . . . . . . . . . . . . . . . . . . . . 4 volts peak-to-peak (nominal)

Video Selector
- o Input Voltage. . . . . . . . . . . . . . . . . . . . . . 22 to 30 vdc
- o Input Power. . . . . . . . . . . . . . . . . . . . . . . 5.0 watts @ 27 vdc
- o Frequency Response . . . . . . . . . . . . . . . . . . 0 MHz to 4 MHz
- o Video Amplification. . . . . . . . . . . . . . . . . . Variable from 0 db to 12 db
- o Video Output . . . . . . . . . . . . . . . . . . . . . 3.5 volts peak-to-peak (nominal)

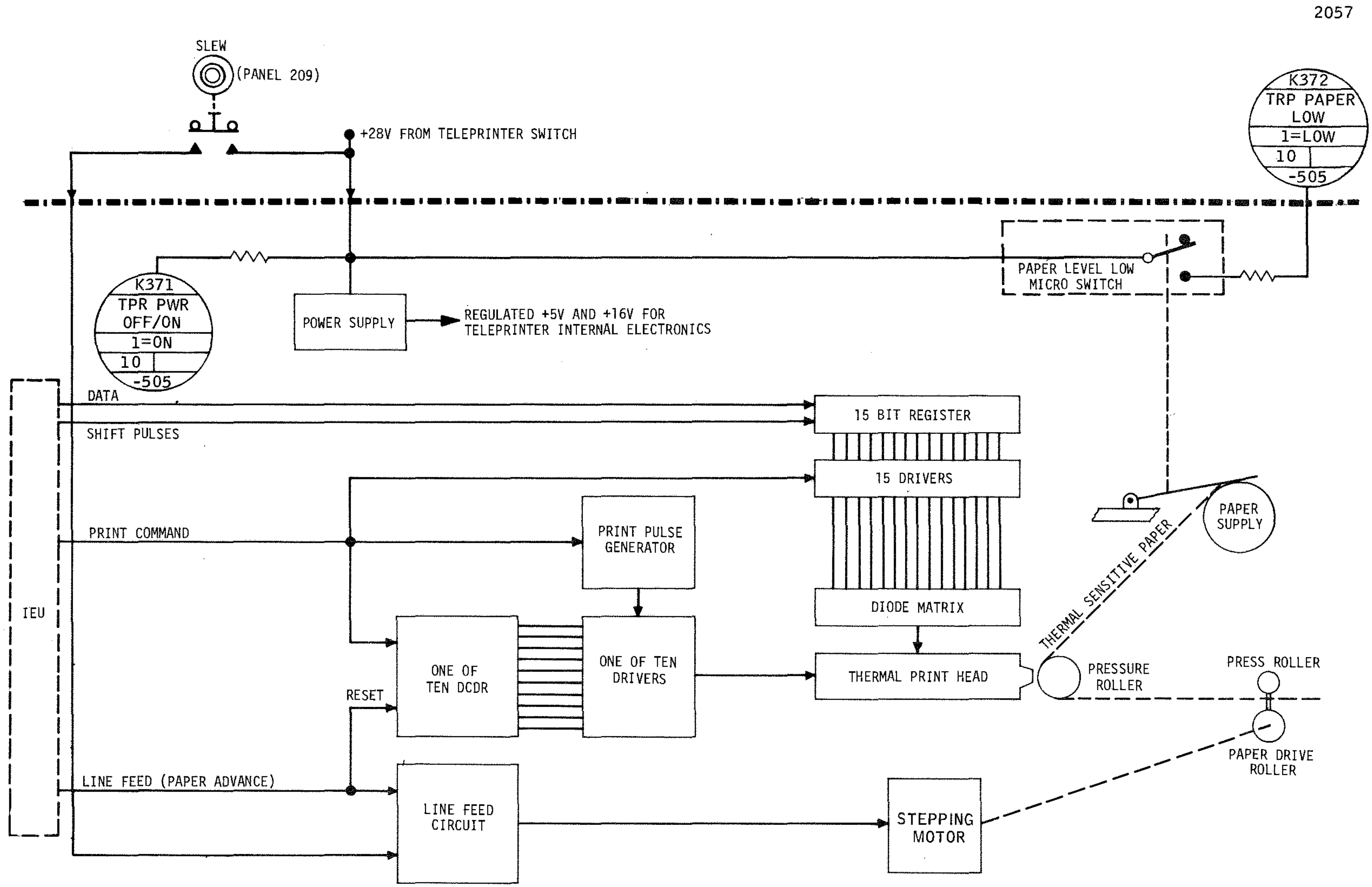



Figure 2.2.4-4 Teleprinter Operation

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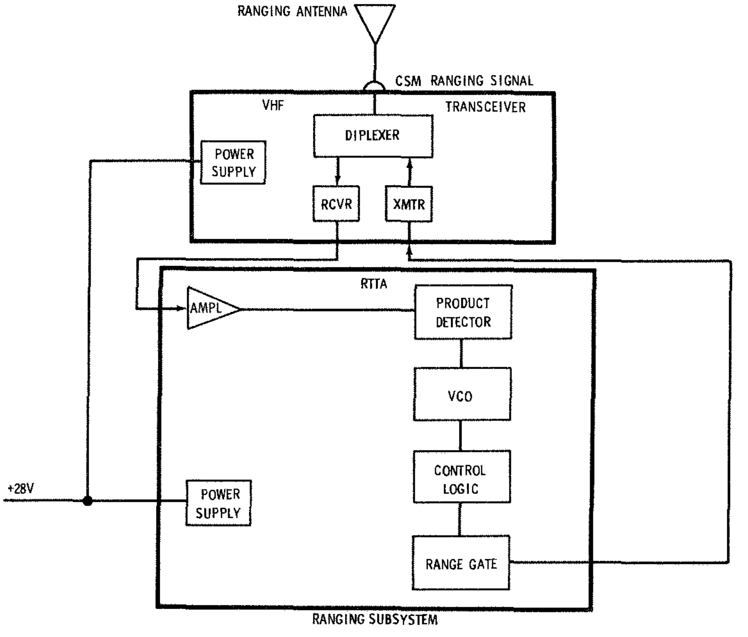


Figure 2.2.4-5 Ranging Subsystem Operation

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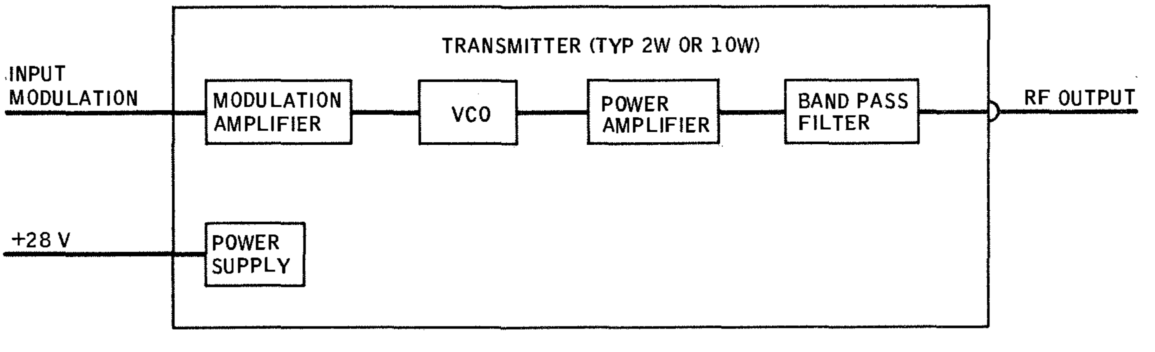



Figure 2.2.4-6 Transmitter Operation

2.2.6.3 TELEPRINTING SUBSYSTEM

IEU
- o Input Voltage. . . . . . . . . . . . . . . . . . . . . . 22 to 30 vdc
- o Input Power. . . . . . . . . . . . . . . . . . . . . . . 10 watts @ 27 vdc
- o Uplink Capacity. . . . . . . . . . . . . . . . . . . . . 18 bits (maximum)

Teleprinter
- o Input Voltage. . . . . . . . . . . . . . . . . . . . . . 28 to 30 vdc
- o Input Power
  - o No Print Mode. . . . . . . . . . . . . . . . . . . . . 5.0 watts @ 27 vdc
  - o Print Mode . . . . . . . . . . . . . . . . . . . . . . 25.0 watts @ 27 vdc
  - o Slew Mode. . . . . . . . . . . . . . . . . . . . . . . 20.0 watts @ 27 vdc
- o Print Characteristics
  - o 63 Alphanumeric Characters Available
  - o 18 Characters per second Print Rate
  - o 30 Characters per line (3.5-inch wide paper)
  - o 5x7-dot Matrix for Each Character (.017 inch spacing between dots)
  - o 0.153-inch Character Height

2.2.6.4 RANGING SUBSYSTEM

AM Ranging Antenna
- o 5-turn Helix (right hand, circularly polarized)
- o Frequency. . . . . . . . . . . . . . . . . . . . . . . . 259.7 MHz to 269.5 MHz

VHF Transceiver
- o Input Voltage. . . . . . . . . . . . . . . . . . . . . . 24.8 to 31.5 vdc
- o Input Power. . . . . . . . . . . . . . . . . . . . . . . 32.4 watts @ 27 vdc
- o Receiver Frequency . . . . . . . . . . . . . . . . . . . 259.7 MHz
- o Transmitter Frequency. . . . . . . . . . . . . . . . . . 296.8 MHz

RTTA
- o Input Voltage. . . . . . . . . . . . . . . . . . . . . . 24.8 to 31.3 vdc
- o Input Power. . . . . . . . . . . . . . . . . . . . . . . 4.5 watts @ 27 vdc
- o Amplifier Output . . . . . . . . . . . . . . . . . . . . 3 V rms (constant)

2.2.6.5 RF SUBSYSTEM

Command and Launch Stub Antennas
- o Linearly Polarized
- o Frequency
  - o Command Stub Antenna . . . . . . . . . . . . . . . . . 450 MHz
  - o Launch Stub Antenna. . . . . . . . . . . . . . . . . . 230.4 to 450 MHz

Discone No. 1 and No. 2 Antennas
- o Linearly Polarized
  - o Receive. . . . . . . . . . . . . . . . . . . . . . . . 450 MHz
  - o Transmit . . . . . . . . . . . . . . . . . . . . . . . 230.4 to 246.3 MHz

Launch/Orbit XMTR, Discone Antenna, Launch Orbit Antenna and DCS RF/Hardline Coax Switches
- o Input Voltage. . . . . . . . . . . . . . . . . . . . . . 18.0 to 30.5 vdc
- o Input Power. . . . . . . . . . . . . . . . . . . . . . . 16.2 watts @ 27 vdc for 20 ms
- o RF Power Capability. . . . . . . . . . . . . . . . . . . 50 watts peak, 40 watts average

Quadriplexer
- o Power Handling Capability. . . . . . . . . . . . . . . . 20 watts per channel (average)
- o Passive (no electronics)
- o Vented

2 Watt Transmitter
- o Input Voltage. . . . . . . . . . . . . . . . . . . . . . 22 to 30 vdc
- o Input Power. . . . . . . . . . . . . . . . . . . . . . . 18.9 watts @ 27 vdc
- o Output Power . . . . . . . . . . . . . . . . . . . . . . 2 watts minimum (3 watts maximum)
- o Frequency. . . . . . . . . . . . . . . . . . . . . . . . 230.4 MHz
- o Modulation . . . . . . . . . . . . . . . . . . . . . . . FM, 0.1 MHz peak power deviation for 1.0 volt peak signal input for frequencies from 25 Hz to 0.15 MHz
- o Sealed at Ambient Pressure

10-Watt Transmitter

- o Input Voltage. . . . . . . . . . . . . . . . . . . . . . . 24 to 30 vdc
- o Input Power. . . . . . . . . . . . . . . . . . . . . . . 81 watts @ 27 vdc
- o Output Power . . . . . . . . . . . . . . . . . . . . . . 18 watts minimum (13 watts maximum)
- o Frequency
  - o Transmitter A. . . . . . . . . . . . . . . . . . . . . 230.4 MHz
  - o Transmitter B. . . . . . . . . . . . . . . . . . . . . 246.3 MHz
  - o Transmitter C. . . . . . . . . . . . . . . . . . . . . 235.0 MHz
- o Modulations. . . . . . . . . . . . . . . . . . . . . . . FM, 0.1 MHz peak carrier deviation for 1.0 volt peak signal input for frequencies from 100 Hz to 0.125 MHz
- o Vented

2.2.7 OPERATIONAL LIMITATIONS AND RESTRICTIONS

The limitations and restrictions imposed on the communication system during the mission are as follows:

- o At least one intercom box within audible range must remain on at all times (including sleep periods) to enable audible C&W tones. This restriction does not apply to a Crew Alert condition.

- o To allow sufficient time for the quadriplexer to vent to space (thereby precluding a potential corona), the 10-watt VHF transmitters must not be powered up before the discone antennas are deployed.

- o All AM VHF Telemetry Transmitters must be powered down when activating a coax switch during the time period from SL-1 launch to 24 hours after the launch to preclude possible corona damage to the coax switch.

- o Manual selection of the discone No. 1 or launch stub antennas requires the ANTENNA [(DISC 1/STUB)/DISC 2/CMD] switch to be in the DISC 1/STUB position.

- o An unused TV input station must be turned off to enable the video signal from an active TV input station to be routed to the video selector switch.

2.2.8 INSTRUMENTATION AND GROUND COMMANDS

| MEASUREMENT NUMBER | DESCRIPTION | TELEMETRY RANGE | ONBOARD DISPLAY DISPLAY RANGE | PANEL NO. | FUNCTION |
|---|---|---|---|---|---|
| TV Subsystem | | | | | |
| K0026-807 | Event, ATM 1, TV Camera, Switch Position | 1=ON | none | none | Used to verify that the video selector switch is in the ATM MON 1 position (black and white video from one of five ATM cameras selected for downlinking). |
| K0027-807 | Event, ATM 2, TV Camera-Switch Position | 1=ON | none | none | Used to verify that the video selector switch is in the ATM MON 2 position (black and white video from one of the five ATM ATM cameras selected for downlinking). |
| K0028-807 | Event, Portable TV Camera-Switch Position | 1=ON | none | none | Used to verify that the video selector switch is in the TV position (color video from portable TV camera selected for downlinking). |
| Teleprinting Subsystem | | | | | |
| K345-512 | Event DCS 25, Teleprinter OFF/ON | 0=ON | none | none | Used to verify that the IEU and Teleprinter have been commanded ON. This verifies the Teleprint on DCS command. |
| K371-505 | Event, Input PWR Teleprinter | 1=ON | none | none | Used to verify that voltage is being applied to the teleprinter |
| K372-505 | Event, Teleprinter Paper Low | 1=LOW | none | none | Indicates that less than 12 feet of paper remain in the Teleprinter (a red strip on both sides of the paper indicates to the crew that less than 3 feet of paper remain). |

| MEASUREMENT NUMBER | DESCRIPTION | TELEMETRY RANGE | ONBOARD DISPLAY RANGE | DISPLAY PANEL NO. | FUNCTION |
|---|---|---|---|---|---|
| K373-512 | Event, Teleprinter COMP/INCOMP | 17.5 MV=COMP | none | none | Used to verify that the IEU has received a complete message. |
| Ranging Subsystem | | | | | |
| K366-509 | Event, VHF XPONDER-INPUT V Monitor | 1=ON | none | none | Used to verify that voltage is being applied to the VHF Transceiver and RTTA. This verifies the redundant DCS on commands. |
| M305-TBD | Volt VHF XPONDER-RECEIVER AGC | 0 to 20 MV | none | none | Used to monitor the VHF Transceiver's AGC. This gives a gross indication of distance between the SWS and CSM. |
| RF Subsystem | | | | | |
| C301-512<br>C302-512<br>C303-512<br>C304-512 | TEMP, TM XMTR No. A (2w), B, C, A (10w) Case Sensor-Temperature | 0 to 200°F | none | none | Used to monitor the temperatures of each of the three 10 watt (A (10w), B, C) and the 2 watt (A (2w)) Telemetry Transmitters |
| K355-509 | Event, Launch/Orbit Antenna Coax switch Position | 1=STUB | | | Used to verify that the launch orbit antenna coax switch is in the launch stub antenna position. This verifies the Ant. Select - Stub DCS Command. |
| K356-509 | Event, Discone Coax switch Position (A) | 1=DISC No. 2 | | | Used to verify that the Discone Antenna Coax switch is in the Discone No. 2 position. This verifies the Ant. Discone Select 2 DCS Command. |
| K357-509 | Event, Discone Coax switch Position (B) | 1=1/STUB | none | none | Used to verify that the Discone Antenna Coax switch is in the DISC 1/STUB position. This verifies the Antenna Discone Select - 1/stub DCS Command. |
| K374-538 | Position, Coax switch-2W or 10W | 1=10 WATT | none | none | Used to verify that the Launch/Orbit XMTR Coax switch is in the 10 Watt XMTR position. This verifies the Orbit (10 watt)/Launch (2 watt) DCS Command. |

GROUND COMMANDS

| DCS COMMANDS | FUNCTION | OCTAL CODE |
|---|---|---|
| S271 | CSM S-Band OMNI Ant Select - 1 (A-B) | 47604 |
| S270 | CSM S-Band OMNI Ant Select - 2 (C-D) | 43604 |
| S201 | VHF Ranging - OFF | 44460 |
| S200 | VHF Ranging - ON | 40460 |
| S297 | Backup VHF Ranging - OFF | 44704 |
| S296 | Backup VHF Ranging - ON | 40704 |
| S225 | Antenna Select - STUB | 44160 |
| S224 | Antenna Select - DISCONE 1 | 40160 |
| S223 | Antenna Discone Select - 1/STUB | 47660 |
| S222 | Antenna Discone Select - 2 | 43660 |
| S195 | Launch/Orbit Transmitter Select - Launch (2W) | 46060 |
| S194 | Launch/Orbit Transmitter Select - Launch (10W) | 42060 |
| 25-4 | TELEPRINT - OFF | 706 |
| 25-4 | TELEPRINT - ON | 707 |

SUBSECTION 2.3

THRUSTER ATTITUDE CONTROL SYSTEM

## 2.3.1 INTRODUCTION

The Thruster Attitude Control System (TACS) provides impulse for attitude control of the Saturn Workshop (SWS) both in rate and rotation in all axes (X, Y, and Z) following separation from the boost vehicle. Upon activation of the Control Moment Gyroscopes (CMG) in the Apollo Telescope Mount (ATM), the TACS augments the ATM's Attitude Pointing and Control System (APCS).

Commands to TACS are accepted from the Instrument Unit (IU) Flight Control Computer (FCC), ATM Digital Computer (ATMDC), Digital Command System (DCS), and Orbital Workshop (OWS) switch selector, depending upon the mode of operation and phase of the mission.

The TACS provides control:

o Prior to and during ATM APCS activation until the CMG's have attained 90 percent of their nominal operating speed

o When the TACS only control configuration is selected by Digital Address System (DAS) or DCS command

o When the TACS only control configuration is selected by redundancy management due to a CMG system failure

o When the CMG/TACS nested configuration is selected by DAS or DCS command, and one of the following conditions exists:
  1. CMG momentum relief is required
  2. Attitude error and attitude rate deadbands are exceeded
  3. Attitude rate deadbands are exceeded during special CMG reset routine execution.

## 2.3.2 SYSTEM INTERFACES

The SWS systems that interface with the TACS are presented in figure 2.3.2-1. Electrical power is provided to the TACS from AM buses. Instrumentation is provided to monitor system operation and system status. The IU attitude control system, ATM APCS, and AM DCS all interface with the TACS to provide control commands and firing commands.

The thruster command interfaces with the TACS are described in the following paragraphs.

### 2.3.2.1 INSTRUMENT UNIT ATTITUDE CONTROL MODE

The attitude of the SWS from launch until switchover to the ATM APCS is controlled by the IU. The attitude control components of the IU measure and compute the necessary corrections to be made to the vehicle attitude. Commands derived from the correction calculations are sent to the TACS to command the appropriate thrusters for the attitude correction.

The major attitude control components of the IU are a stable platform, rate gyroscope assembly, launch vehicle digital computer (LVDC) and data adapter, and flight control computer (FCC) (figure 2.3.2-2). The LVDC receives three axis (X, Y, and Z) vehicle attitude references from the stable platform and computes attitude errors which are then sent to the FCC. The FCC, also supplied with vehicle rate information from the rate gyro assembly, combines the attitude errors and rates, and generates attitude commands, which are sent to the Power and Control Switching Assembly (PCSA) of the TACS for commanding thrusters.

### 2.3.2.2 ATM ATTITUDE CONTROL MODE

The ATM APCS interfaces with the TACS to provide attitude reference and correction commands after control is transferred from the IU to the ATM APCS. In this mode, the TACS is considered part of the APCS.

The principle components of the ATM APCS are the sun sensor, star tracker, experiment pointing and control system, rate gyro assembly, digital computers and data adapter, three CMG's, and the TACS (figure 2.3.2-2). Attitude control commands from the ATM come from the ATM digital computer (ATMDC). Two digital computers make up the ATMDC. One acts as the primary ATMDC and the other as the secondary ATMDC. The secondary ATMDC is inactive until the primary fails. Upon sensing a failure in any portion of the primary computer network, a transfer to the secondary ATMDC is made. Primary attitude control corrections of the SWS are supplied by the CMG's and augmented by the TACS.

Commands from the ATMDC for the entire APCS are in the form of gimbal angle rates, and consist of CMG steering, rotation, and distribution information. For TACS, these commands consist of electrical pulses for firing computer selected thrusters.

3006

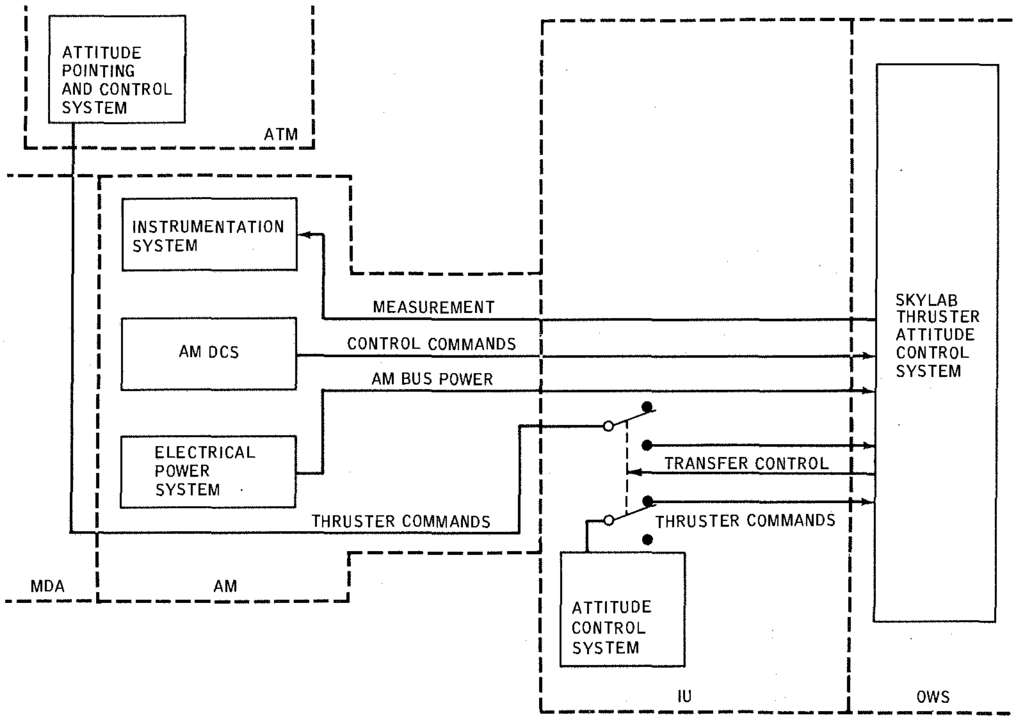



Figure 2.3.2-1 Thruster Attitude Control System Interfaces

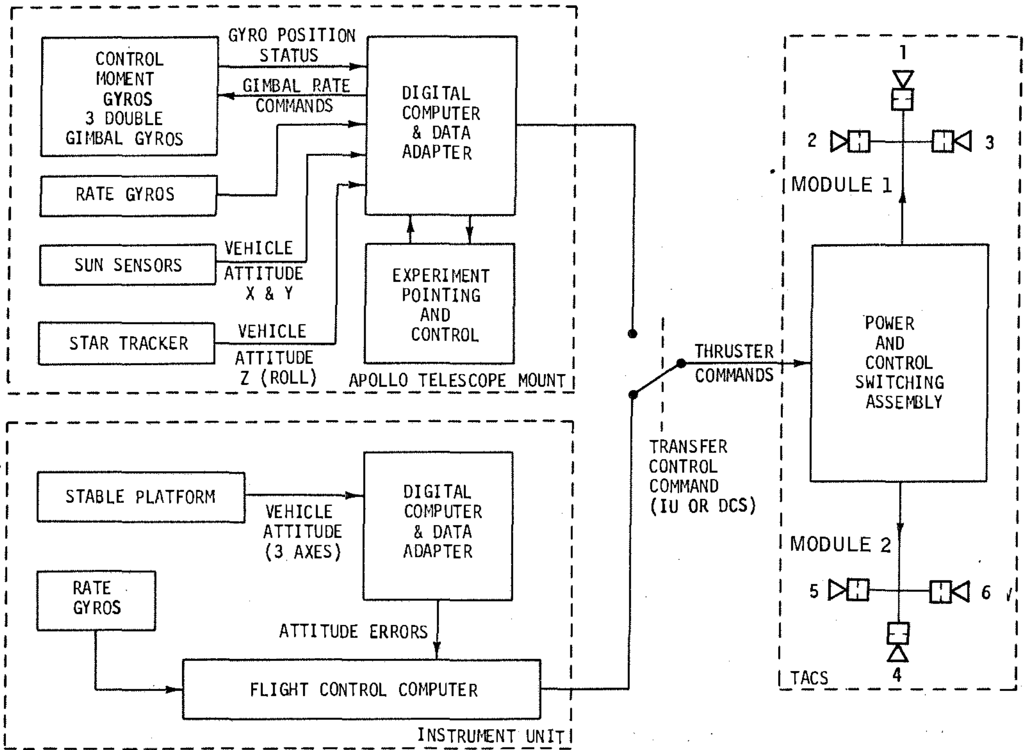



Figure 2.3.2-2 SWS Attitude Control System

9182

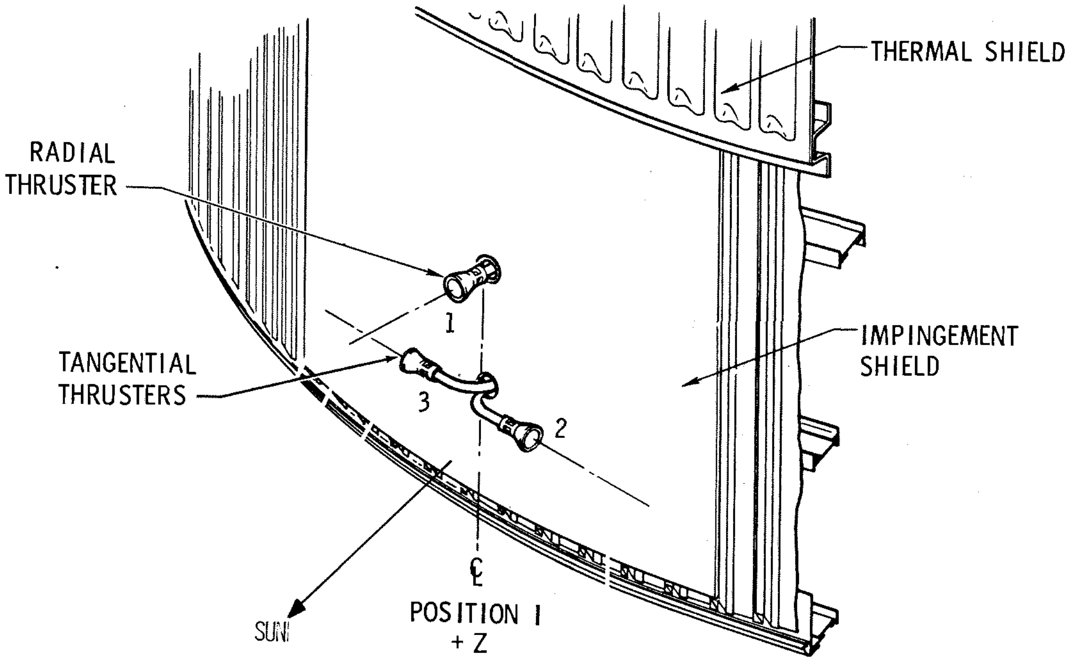



Figure 2.3.3-1 Thruster Attitude Control System Thruster Module

The ATMDC, supplied with vehicle rate information from rate gyros and attitude data from the sun sensor and star tracker, maintains attitude reference by reference update. ATMDC integration errors, and hardware errors of the rate gyros, are corrected by reference update, utilizing the sun sensor (having pitch and roll axes update capability) and the star tracker (having roll axis [z axis] update capability). Attitude reference update is also accomplished through a CMG gyro position status calculation in the ATMDC. A more detailed discussion of the ATM portion of the APCS is provided in the SLOH-ATM Volume I.

## 2.3.3 FUNCTIONAL DESCRIPTION

The TACS utilizes two thruster modules. These modules are located on the OWS aft skirt, diametrically opposite each other, slightly off position planes I and III (+Z and -Z, respectively). Each thruster module provides three thrusters (two tangential and one radial) for rate and rotation control. A typical thruster arrangement is shown on figure 2.3.3-1. Selected combinations of the thrusters at each module provide impulse along the -Z, +Z axis and the -Y, +Y axis for control of the SWS attitude (figure 2.3.3-2).

Functionally, the TACS can be divided into two subsystems, propellant supply and distribution, and thruster control.

### 2.3.3.1 PROPELLANT SUPPLY/DISTRIBUTION PROPULSION

Propellant supply/distribution hardware of the TACS consists of storage bottles, filters, control valves, and thrusters. The TACS is a positive pressure nitrogen gas ($N_2$) expulsion system (sometimes identified as blowdown system) utilizing four control valves for each thruster. Figure 2.3.3-3 presents a functional schematic of the propellant supply/distribution hardware. Nitrogen gas at 3100 psia is stored in twenty-two 4.5 cubic foot titanium spheres. These spheres are manifolded together to form the propellant supply for the TACS. High-pressure lines from the manifold route the nitrogen gas to each TACS module through filters (10 micron). From the filter in each of the two supply lines, the line divides and routes nitrogen gas through additional filters (100 micron) integral within each TACS control valve. If a command is received at 2 series control valves, the solenoids are energized, actuating the valves to the open position. High-pressure nitrogen gas then flows to the thruster nozzle and is expended into space, providing thrust at that nozzle.

Each of the six thruster units consists of quad-redundant solenoid operated control valves and a converging-diverging nozzle. The quad-redundant valves protect the TACS against a single-point valve malfunction.

3036

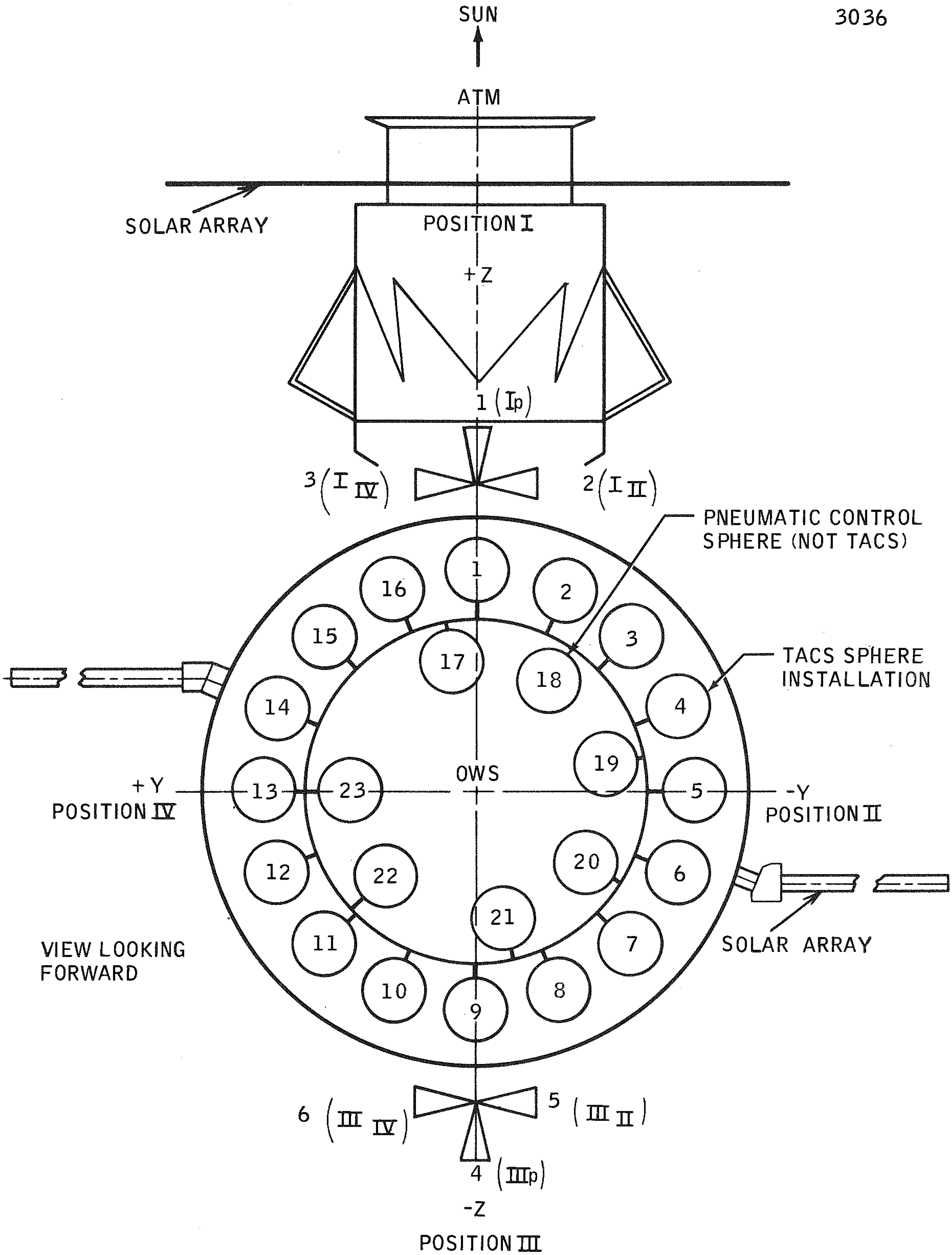
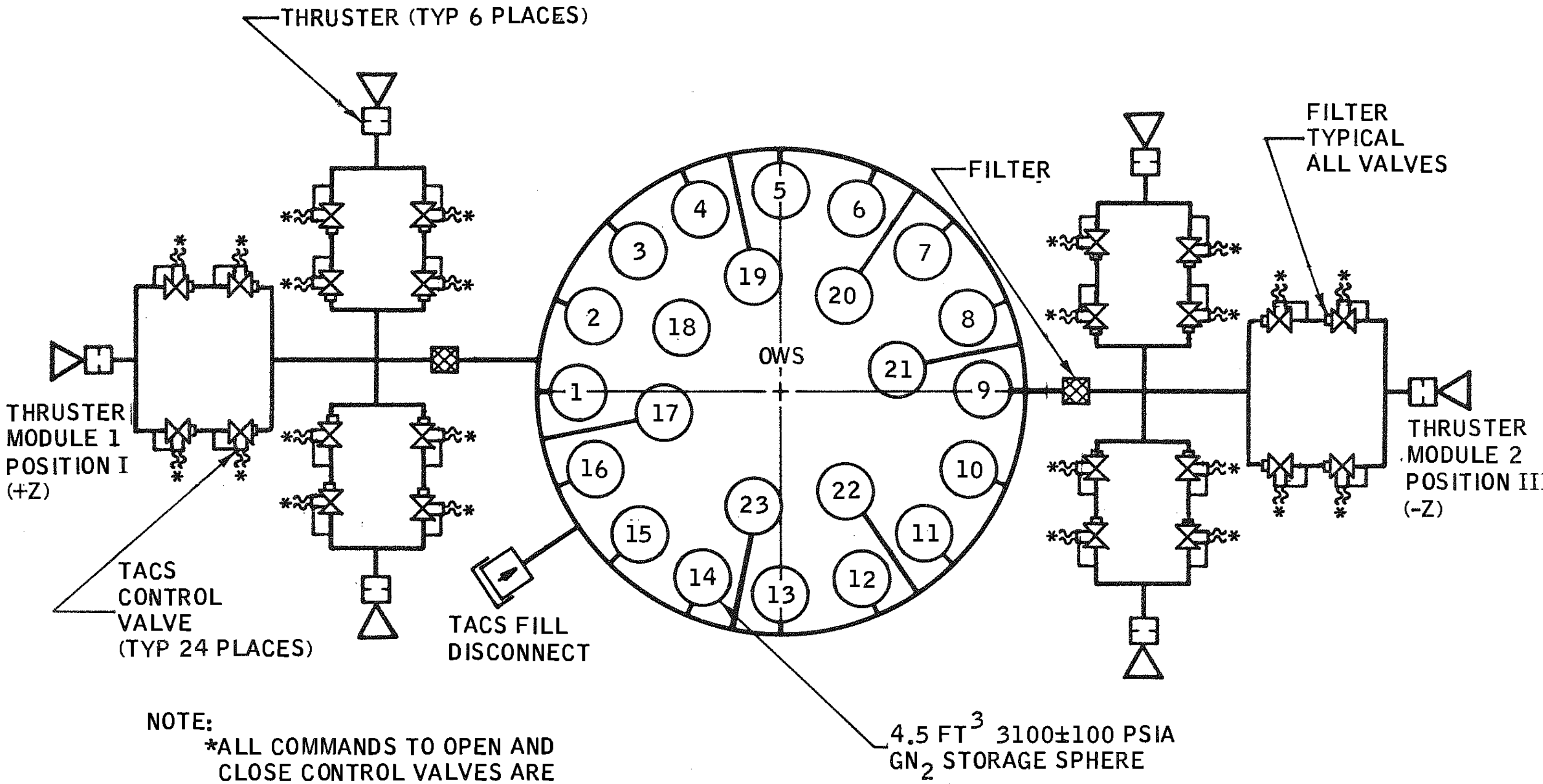



Figure 2.3.3-2 Thruster Module Orientation




NOTE:
*ALL COMMANDS TO OPEN AND CLOSE CONTROL VALVES ARE SENT FROM IU OR ATM THROUGH THE POWER AND CONTROL SWITCHING ASSEMBLY.

Figure 2.3.3-3 TACS Propellant Supply/Distribution

Redundancy is designed into the thruster unit for both closing and opening the thruster. During the opening sequence, the failure of any single control valve to open does not prevent propellant flow to the thruster. Two paths of flow are provided through the control valves to the thruster. In the closing sequence, the failure of any single valve to close does not hamper the closing off of the propellant flow to the thruster. Two control valves are arranged in series in each of the two paths of flow to provide the closing sequence redundancy.

2.3.3.2 THRUSTER CONTROL

Thruster control of TACS is provided by the PCSA. The PCSA receives discrete commands for thruster operation, and routes these commands to the respective control relay or thruster control valve solenoid. Figure 2.3.3-4 is a simplified schematic showing the controls to a single thruster module.

Power for the PCSA is supplied by AM buses 1 and 2 through 20 circuit breakers on panel 202 in the AM STS. Power is supplied to the BUS ON/OFF logic and the thruster buses through 12 circuit breakers, THRUSTER 1 through 6 for both AM buses 1 and 2. Logic control power is provided to the command control buses 1 and 2 through four circuit breakers, TACS COMMAND CONTROL 1 PRI and SEC for AM bus 1 power and TACS COMMAND CONTROL 2 PRI and SEC for AM bus 2. Power to the manual inhibit controls is provided through the TACS MANUAL CONTROL circuit breakers (4) 1-INHBT-2, and 1 and 2.

All OWS switch selector DCS and GSE commands to the PCSA require an enable command before they can be implemented. The enable commands accomplish the connection of AM buses 1 and 2 to command control buses 1 and 2, (figure 2.3.3-5). To enable the TACS for operation, all circuit breakers, with the exception of the manual control circuit breakers, are closed before launch. TRANSFER ENABLE 1A-ON, 2A-ON, 1B-ON, 2B-ON is sent either by the OWS switch selector or by DCS command to power up command control buses 1 and 2, respectively, prior to launch. Command control buses 1 and 2 supply power to the thruster bus on/off logic and the transfer command logic.

After the command control buses are enabled, and prior to liftoff, the GSE sends BUS 1-ON and BUS 2-ON commands. These commands can also be sent by DCS prior to launch. BUS 1-ON relays connect the command control bus 1 to six thruster bus-on relays (figure 2.3.3-6). The six thruster bus-on relay contacts close, allowing power to be supplied to thruster buses 1-3A, 1-1A, 1-2A, 2-2A, 2-1A, and 2-3A from AM bus 1.

Similarly, the BUS 2-ON command connects the command control bus 2 to the six thruster bus-on relays for bus 2. This sets the thruster bus-on relays, allowing AM bus 2 power to be supplied to thruster buses 1-3B, 1-1B, 1-2B, 2-2B, 2-1B, and 2-3B (schematic not provided). With power on the 12 thruster buses, the TACS is configured to receive thruster commands from the FCC in the IU. TACS can be disabled by sending BUS 1-OFF and BUS 2-OFF by DCS command, which removes power from the 12 thruster buses.

With TACS configured in the IU mode, attitude control commands from the IU are initiated by grounding the return within the FCC. Power to the thruster command relay coils is provided by the IU (figure 2.3.3-7). A fire command is generated within the FCC by grounding the circuit. This simultaneously applies power to the thruster command relay coils. The command from the IU closes eight sets of relay contacts. Four sets of contacts provide a redundant path for supplying power from the thruster bus A, and four sets similarly provide power from the thruster bus B. Thruster bus A and B power energizes the four control valve solenoids, which open the control valves, allowing N2 to flow through the thruster (figure 2.3.3-8).

The IU thruster commands are in the form of electrical pulses of 65-millisecond duration to full on. When the pulse is applied to the thruster fire relays, the thruster control valves open. The valves close upon termination of the pulse to the solenoids.

Transfer to the ATM mode is sent approximately 4 1/2 hours after launch of SL-1 either by OWS switch selector command or by DCS command after the ATMDC is activated. The TACS TRANSFER 1-IU to ATM and TACS TRANSFER 2-IU to ATM commands remove command control bus power from the IU mode buses and apply power to the ATM mode buses (figure 2.3.3-8). Application of power to the ATM mode buses switch the transfer command relays to the ATM mode. Transfer back to the IU can be accomplished by sending both TACS TRANSFER 1-ATM and 2-ATM to the IU. In the ATM mode, the TACS augments the CMG's of the ATM. Attitude control commands from the ATM pass through the same contacts of the thruster command relays and the thruster fire relays to energize the control valve solenoids as did the IU commands. Commands from the ATMDC are issued when the Workshop Computer Interface Unit TACS driver switches close. This applies 28 vdc to the thruster command relay coils (figure 2.3.3-9). The thruster fire commands from the ATM APCS are in the form of 40-to-400 ms electrical pulses in contrast to the 65-ms IU command pulses. These pulses vary in duration to allow for the drop in thruster operating pressure with mission duration. As the N2 storage pressure drops, the thrust available at the thruster drops. Lower thrust requires that the thruster control valve stay open longer to obtain the same amount of impulse.

Upon entry into the SWS, the crew reconfigures TACS to provide manual inhibit control capability and to disable the ground command capability. The crew opens the TACS COMMAND CONTROL 1 PRI and SEC and the TACS COMMAND CONTROL 2 PRI and SEC circuit breakers, and closes the TACS MANUAL CONTROL 1 and 2 and 1-INHBT-2 circuit breakers (figure 2.3.3-10).

Power for any one of the six thruster units can be manually inhibited by placing its TACS ENABLE-INHIBIT (panel 130) switch to INHIBIT. Power is then applied to the thruster bus 1 and thruster bus 2-OFF relays to open the supply from AM bus 1 and 2 to the thruster buses A and B of the selected thruster. Inhibit power is also provided to the 500-ms timer for charging. When the inhibit command is removed, the 500-ms timer causes a 500-ms

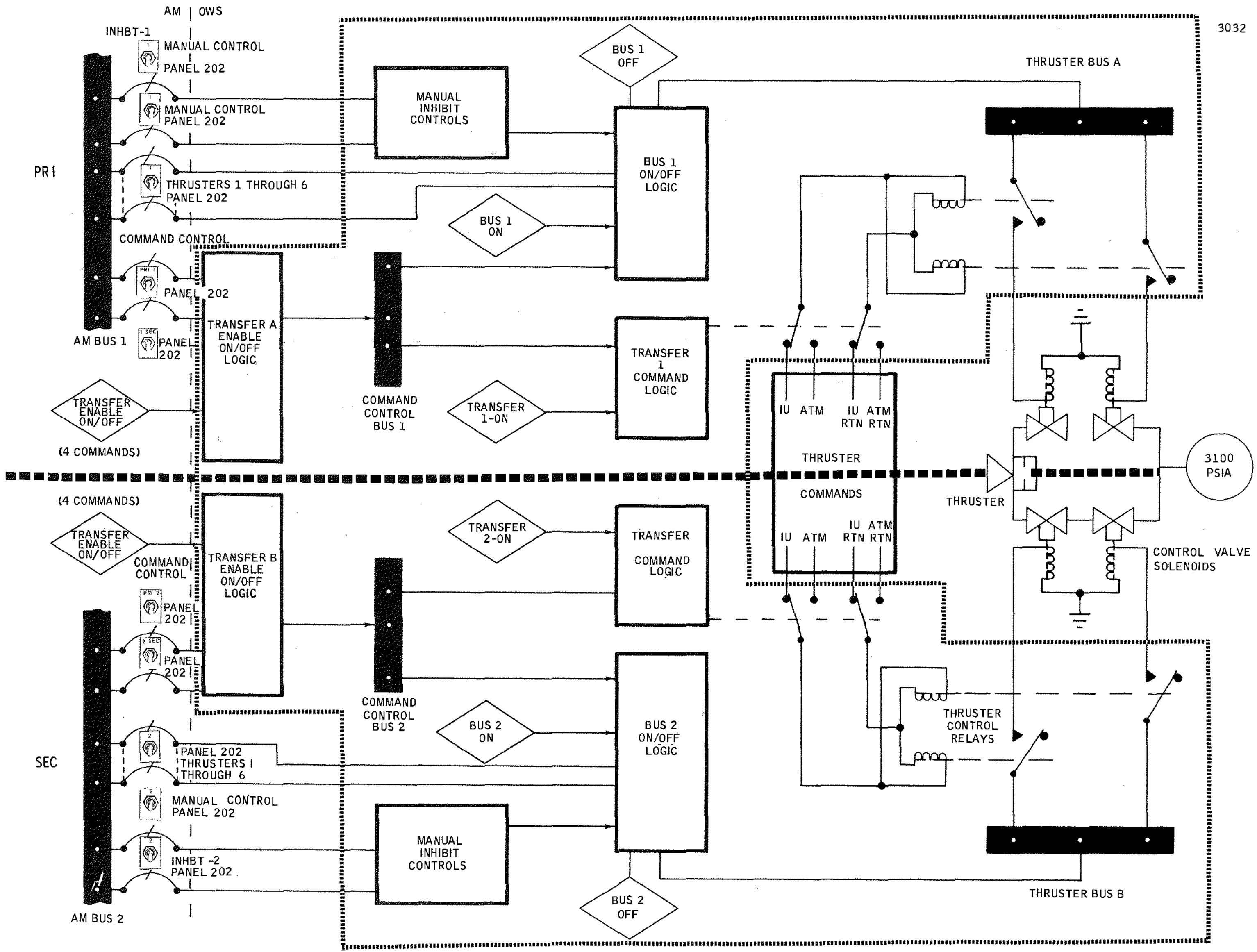



Figure 2.3.3-4 Single Thruster Control -- Schematic

3033

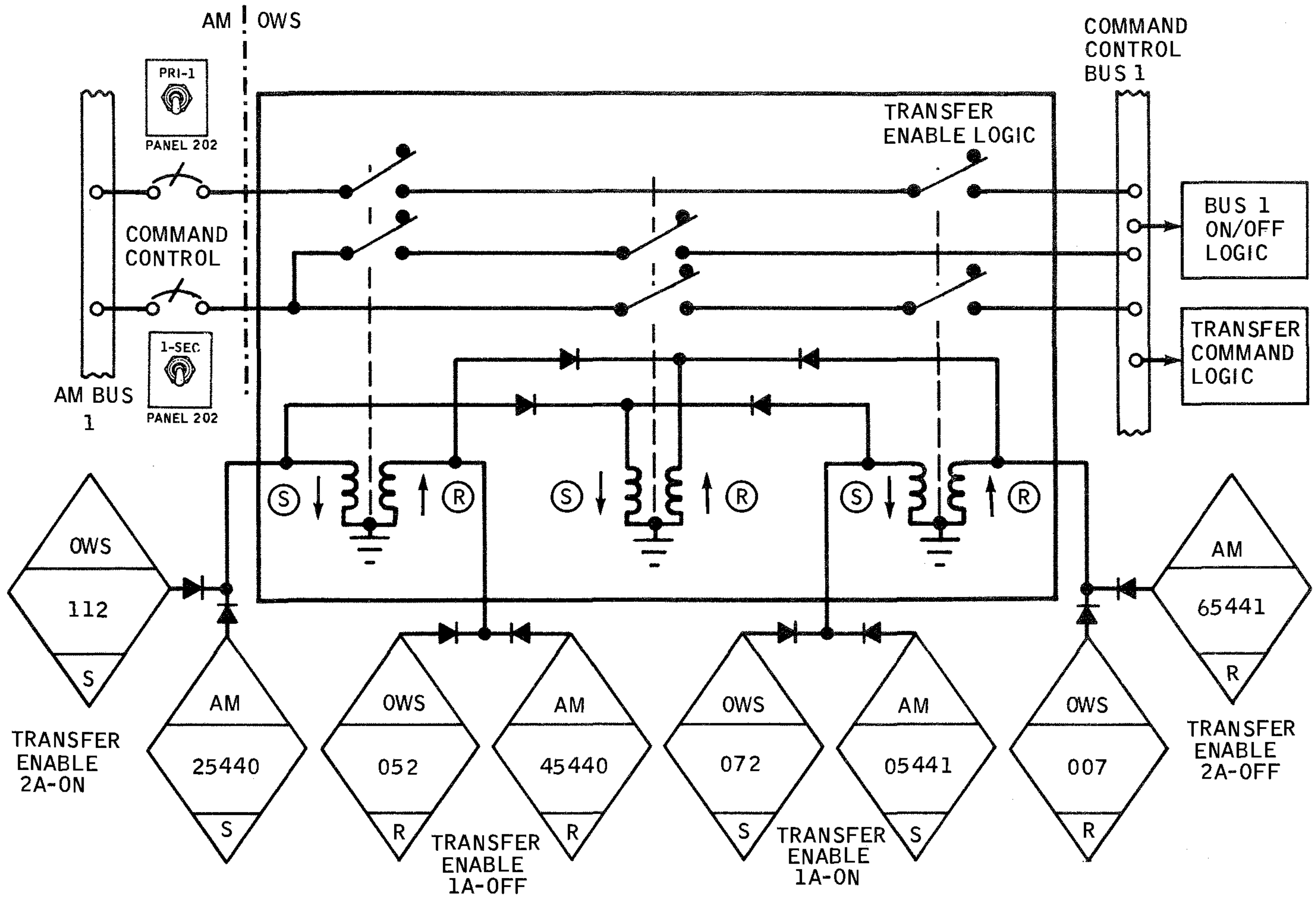



Figure 2.3.3-5 Command Transfer Enable

3034

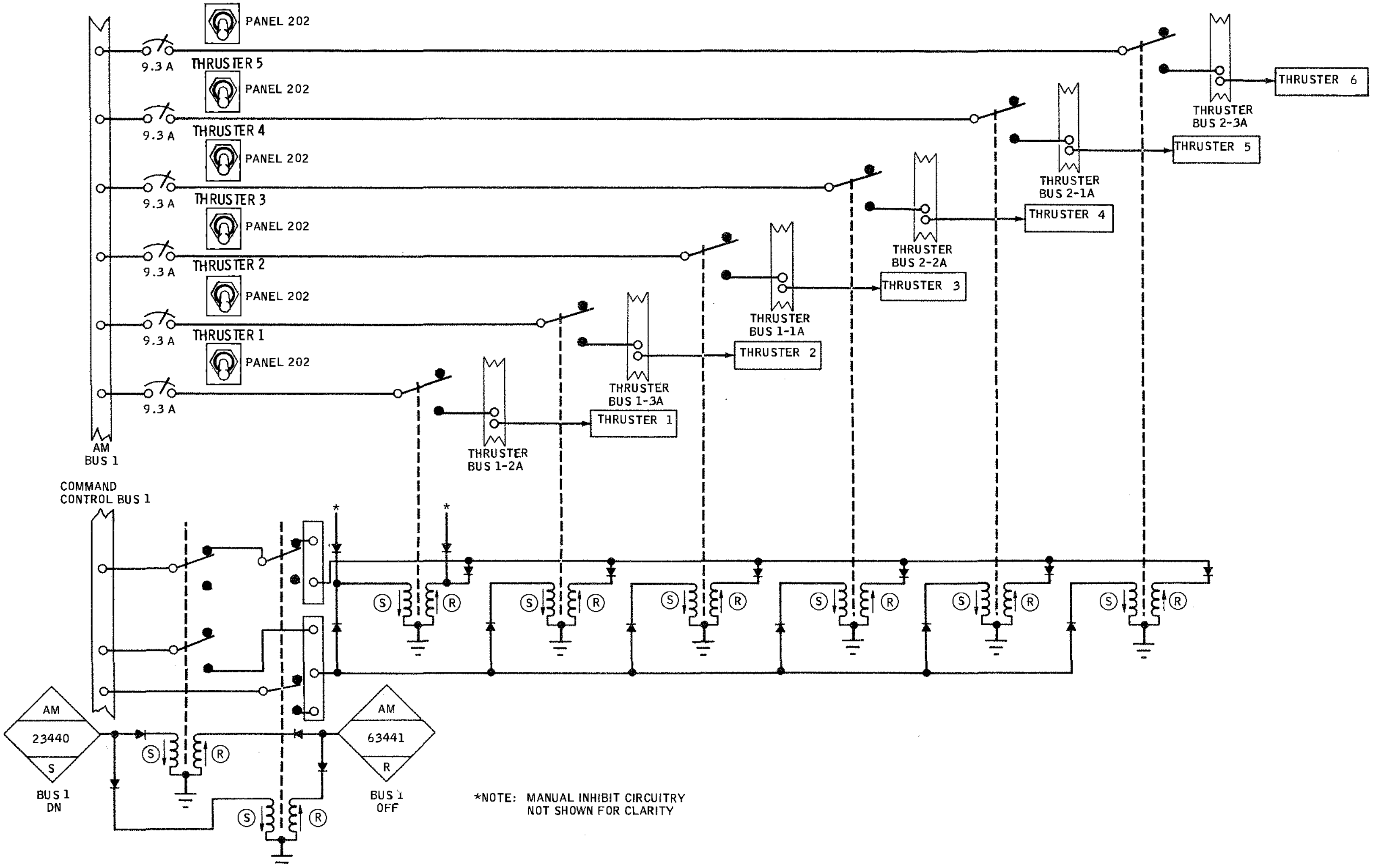



Figure 2.3.3-6 Bus 1 On/Off Command -- Schematic

3052

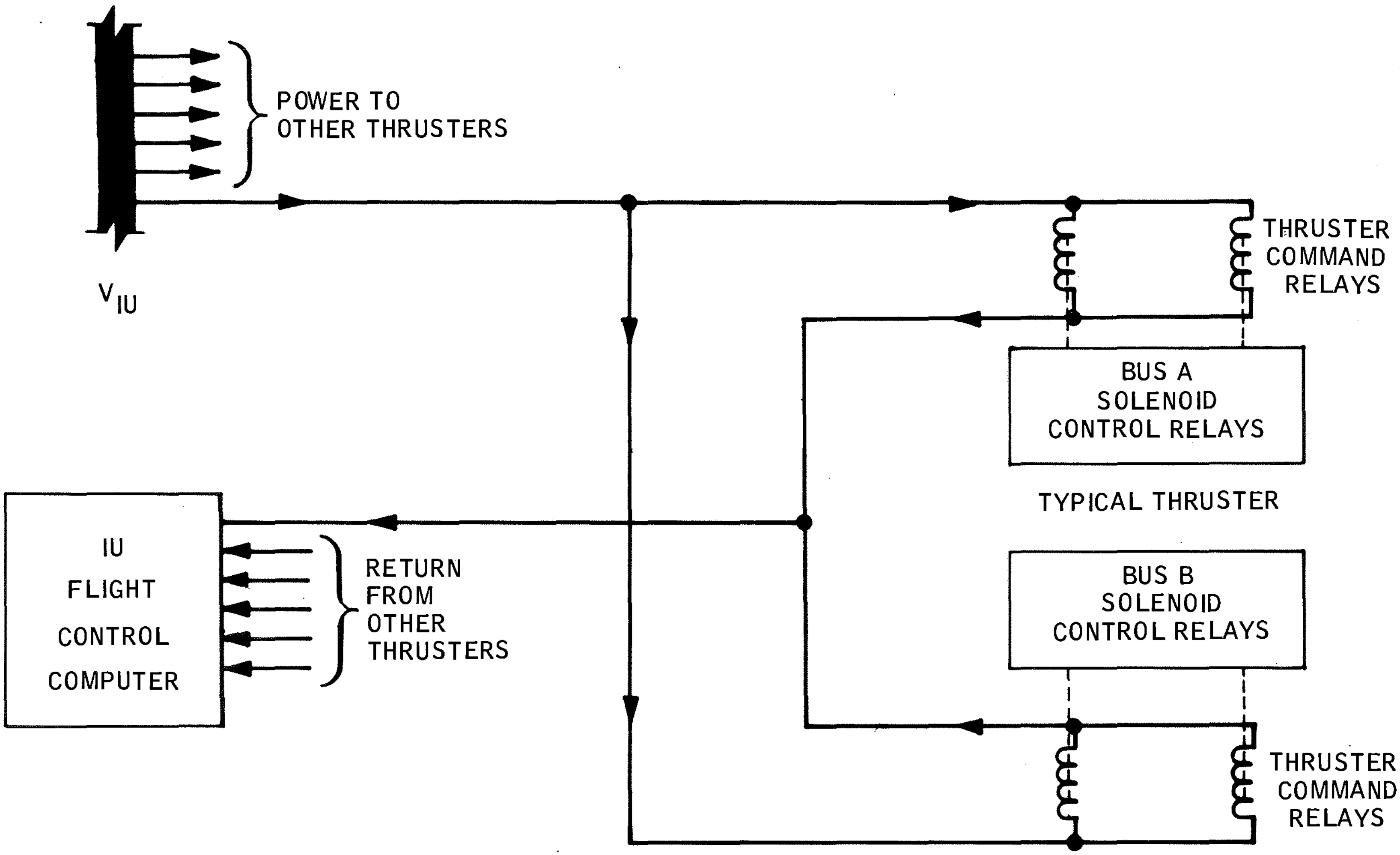



Figure 2.3.3-7 IU Command/Thruster Interface

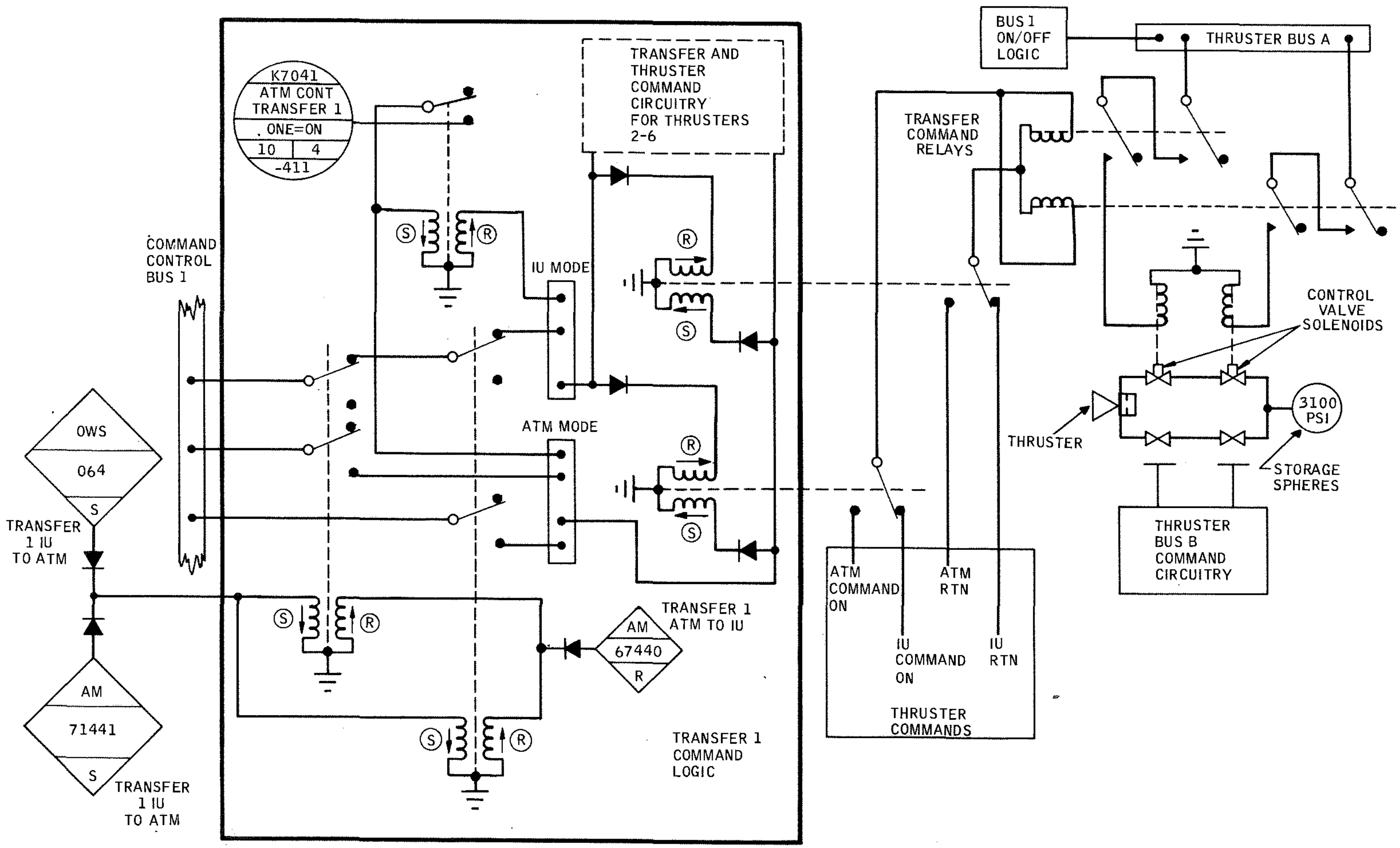



Figure 2.3.3-8 Transfer and Thruster Command -- Schematic

3053

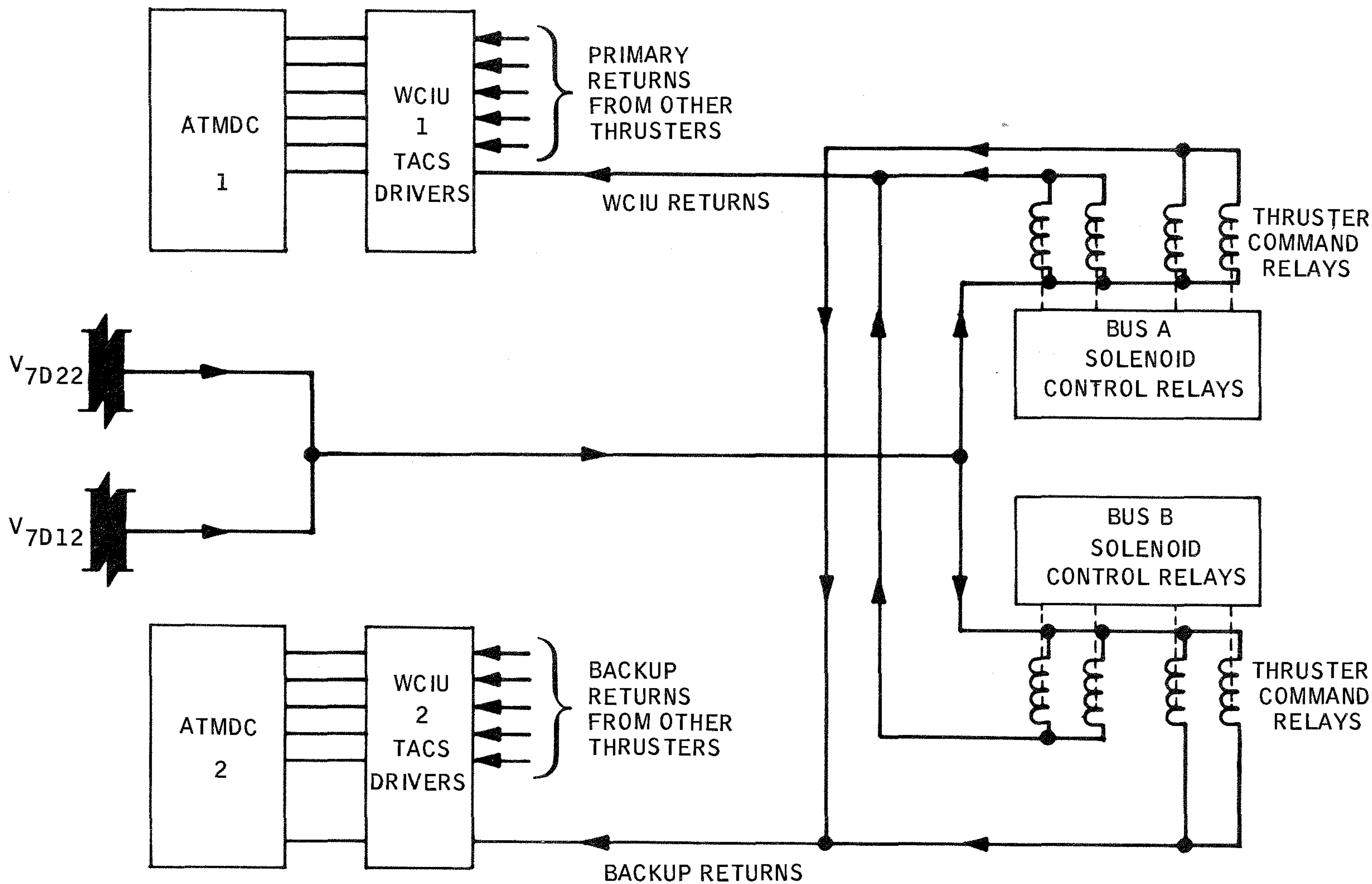



Figure 2.3.3-9 ATM DC/Thruster Interface

3028

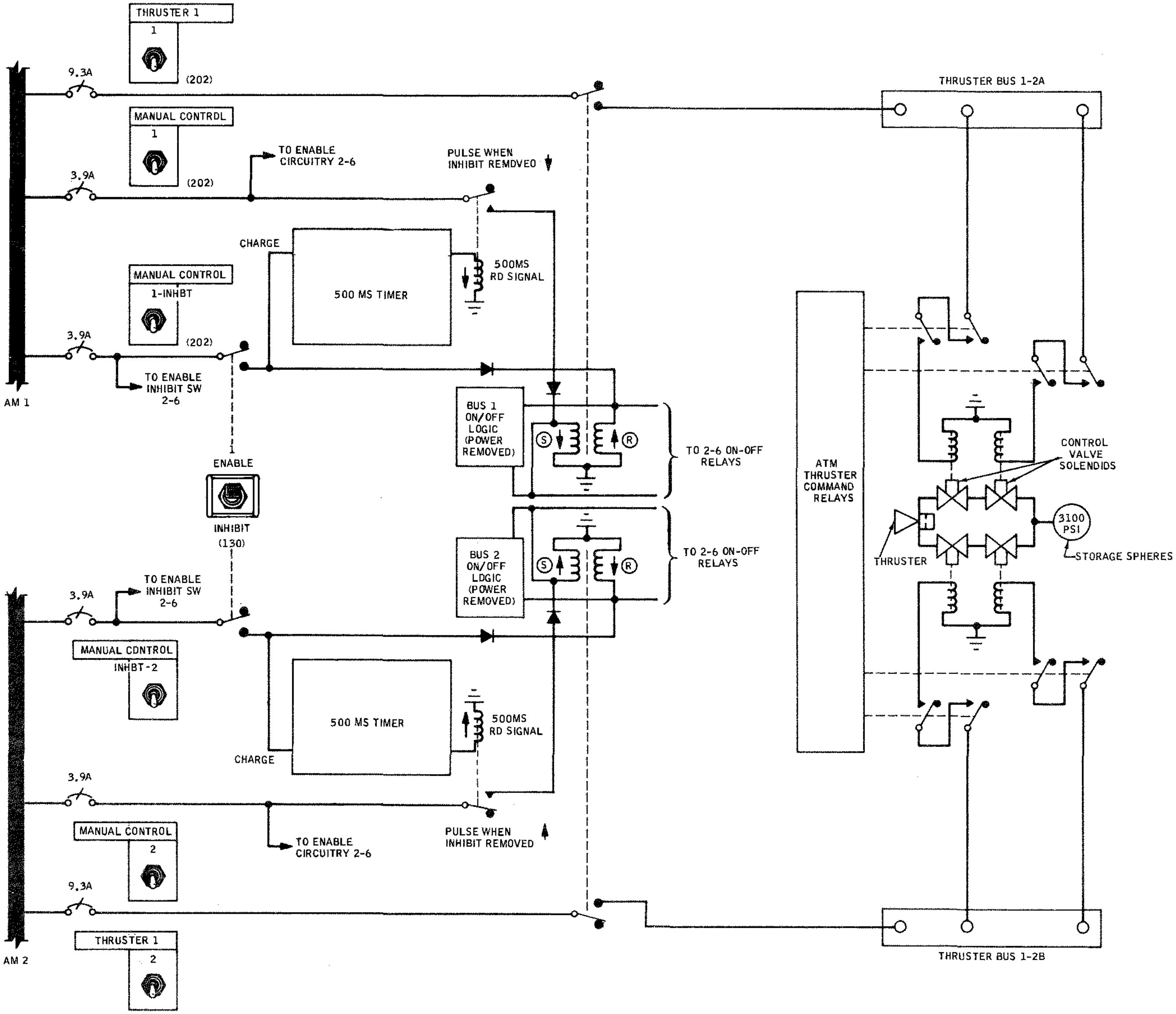



Figure 2.3.3-10 Manual Inhibit Control

3039

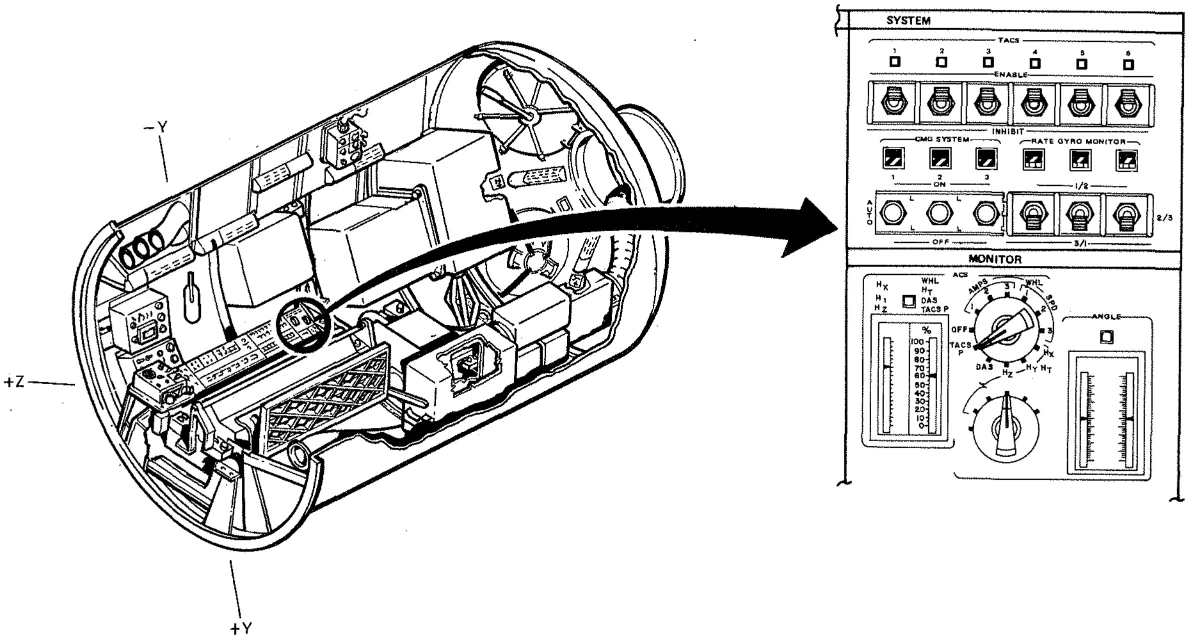



Figure 2.3.3-11 Manual Inhibit Control Panel

reset signal to be generated. AM bus 1 and bus 2 power is then supplied through the enable relays to the thruster bus 1 and 2-ON relays to close the relays, which reapply AM bus 1 and 2 power to the thruster buses A and B (figure 2.3.3-10).

Six thruster fire indications are provided on panel 130, ATM control and display, in the the MDA (figure 2.3.3-11). These indications are actuated by switch closures of the TACS thruster pressure sensors monitoring chamber pressure (Refer to section 2.3.8). A 500-ms time delay module is used to lengthen the thruster-on indication from 40-ms (minimum) to 500-ms to accommodate the display by incandescent indicators. N2 supply pressure can be monitored on the ATM control and display panel by placing the ACS monitor select switch to TACS P. The readout is in percent of full scale (i.e. 100 percent equals 3500 psia).

Caution and warning lights on panel 207 display THRUSTER STUCK and TACS ONLY malfunctions. The thruster stuck indication is the CLUSTER ATT red warning light; a HI RATE indication shares the CLUSTER ATT light. The TACS ONLY caution indication shares the ACS MALF caution light with the CMG SAT and RATE GYRO caution indications. Inhibit switches are provided for isolation of each function from initiating a caution and warning alert (figure 2.3.3-12).

The THRUSTER STUCK malfunction parameter is actually a software comparison of the propellant usage, averaged over the daylight portion of any orbit, to a preprogrammed expected usage. If the comparison results in a large difference in usage, the THRUSTER STUCK indication is initiated.

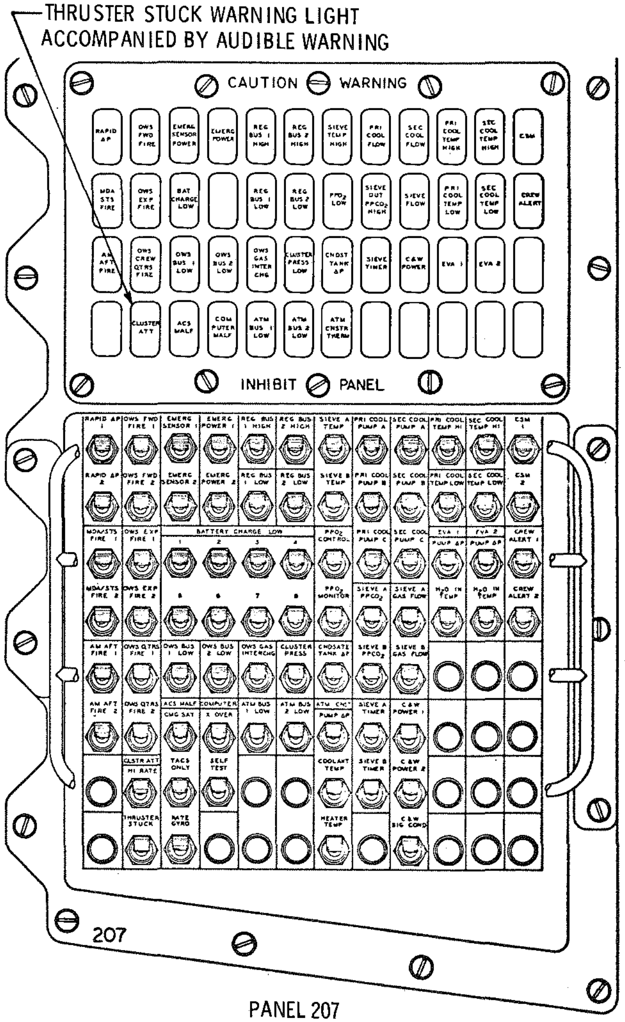
The TACS ONLY indication flags the crewman that the APCS is operating on the TACS only. This indicates a possible large usage of TACS propellant. Additional failure checks are provided through the use of the Digital Address System (DAS) as presented in figure 2.3.3-12.

## 2.3.4 SUBSYSTEM AND MAJOR COMPONENT DESCRIPTION

### 2.3.4.1 POWER AND CONTROL SWITCHING ASSEMBLY

The power and control switching assembly (PCSA) contains the circuitry and relays necessary to command and control TACS. The PCSA translates commands from the OWS switch selector and/or the DCS to enable TACS, apply power to thruster buses, and transfer the control mode between the IU and the ATM. The PCSA transfers thruster commands from either the IU or ATM to energize the quad-redundant valve opening solenoids of the thruster selected to be fired. The relays within the PCSA change state upon receiving commands of 28$\pm$TBS vdc with a minimum duration of 20 ms.

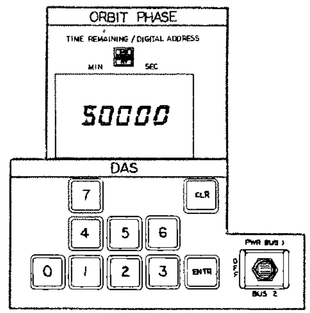
3055



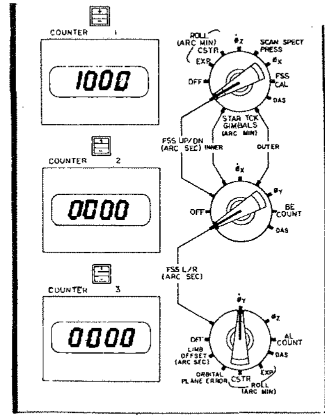

PANEL 207

## FAILURE CHECK

1. POSITION COUNTER PANEL 130 TO DAS
2. KEY THROUGH DAS OCTAL 52003 AND ENTR. THIS CALLS UP "DISPLAY ATMDC DATA".
3. KEY THROUGH DAS OCTAL 50000 AND ENTR. THIS CALLS UP "CAUTION AND WARNING CONDITION ON COUNTER.
4. MONITOR ON COUNTER SELECTED. NUMBER APPEARING ON COUNTER WINDOW IS FAILURE. IF CONDITION NUMBER "1" APPEARS, A TACS THRUSTER IS STUCK.




PANEL 130




PANEL 130

CAUTION AND WARNING CONDITION DISPLAY

| CONDITION NUMBER | C & W CONDITION |
|---|---|
| 0 | NO C & W |
| 1 | STUCK TACS THRUSTER |
| 2 | VEHICLE OVERRATE |
| 3 | COMPUTER SELF - TEST FAILURE |
| 4 | CMG SATURATION |
| 5 | SECOND RATE GYRO FAILURE IN ANY AXIS |
| 6 | AUTOMATIC SWITCH TO TACS ONLY CONTROL |

Figure 2.3.3-12 TACS Thruster Stuck

Power for the PCSA is supplied by AM buses 1 and 2, utilizing each bus to power a different half of the TACS quad-redundant thruster units. Buses are kept separate within the PCSA.

2.3.4.2 THRUSTER

Six thrusters are used in the TACS, two radial thrusters and four tangential thrusters. One radial thruster and two tangential thrusters make up a thruster module (figure 2.3.4-1). A thruster is constructed of stainless steel, having a converging-diverging nozzle to control expansion of N2 propellant. The engine operates with a chamber pressure range of approximately 300 to 3100 psia, providing 10 to 100 pounds of thrust, respectively. The engine has a throat diameter of 0.16 inch and an exit diameter of 1.16 inches (expansion ratio of 50:1), and a nozzle length, from throat to exit, of 1.45 inches. The thruster is mounted to the OWS structure with no cant angle provided.

2.3.4.3 CONTROL VALVES

Each thruster is provided with four control valves. These valves are arranged to provide two paths (redundant) for propellant to flow to the thruster. The valve is constructed of stainless steel, with integral mounting provisions provided. The valve is designed to operate in the environmental temperature range of -150° to +165°F in vacuum and is capable of flowing 1.5 lb/sec of dry nitrogen at 3000 psia. Figure 2.3.4-2 shows a cross-section of the valve. It is a positive-opening pressure based valve, which assures full valve operation at any inlet pressure from zero to the maximum operating pressure. A small pilot valve, integral and coaxial with the main poppet, is used to control pressure forces that effect opening and closing. The pilot poppet and main poppet are magnetically linked such that energizing the solenoid coil creates opening forces sufficient to effect full opening of both poppets at low pressure. In the closed condition, both poppets are pressure unbalanced closed to assure leaktight sealing.

2.3.4.4 FILL DISCONNECT

The nitrogen storage spheres are filled through a self-sealing disconnect, located at the vehicle skin, that is hardcapped prior to launch. The maximum specified leakage allowed through the internal poppet is less than 0.00002 scim. Figure 2.3.4-3 presents a cross-section of the disconnect.

2.3.4.5 N2 STORAGE SPHERES

Twenty-two titanium storage spheres contain the N2 propellant for the TACS. Each sphere has a volume of 4.5 cubic feet and is capable of containing an operating pressure up to 3100 $\pm$ 100 psia. The spheres are designed to a burst pressure of 2.5 times the maximum operating pressure or 8000 psia. The spheres are mounted to the OWS thrust structure utilizing pans and straps as shown on figure 2.3.4-4. Figure 2.3.4-5 shows the sphere mounting and manifold configuration.

2.3.4.6 STORAGE SPHERE METEOROID SHIELD

The storage sphere meteoroid shield covers the 22 spheres and the manifolding located on the thrust structure.

The shield is an annular shape, consisting of eight identical segments attached with screws. The shield is a sandwich structure (foam between aluminum face sheets). The assembled annulus is bolted to frames added around the thrust structure. Figure 2.3.4-4 shows a cutaway of the shield installation.

2.3.4.7 N2 SUPPLY LINE FILTER

A 10-micron filter is utilized in the nitrogen transfer line between the nitrogen storage/supply spheres and the thruster control valves of each thruster module. Figure 2.3.4-6 presents a cross-section of the filter. The filter is constructed of stainless steel and features a multilayer-etched disk construction to provide in-depth filtration.

2.3.4.8 PRESSURE SWITCH

Six pressure switches are utilized in the TACS. One pressure switch is mounted on each thruster to monitor the chamber pressure and provide an indication of thruster firing to the crew and telemetry. The pressure switch has a maximum actuation pressure of 135 psia and a maximum response time of 10 ms. The switch opens at a minimum of 80 psia. The pressure switch has a maximum operating pressure of 3200 psia, minimum proof pressure of 4800 psia, and a minimum burst pressure of 8000 psia. The electrical contacts are rated for 1 ampere at 28$\pm$6 vdc.

2.3.4.9 TIME DELAY MODULE

Eighteen time delay modules are utilized in the TACS. Six modules, in conjunction with the pressure switches, are used for the onboard display of thruster firing events. The time delay module extends the duration of the pressure switch pulse from 40-400 ms to 500 ms to drive the thruster indicator lights on the ATM control and display panel in the MDA.

The remaining 12 time delay modules are used for reapplication of thruster bus power after a manual inhibit command has been removed. Functionally, the time delay module is of capacitor discharge design. The application of the manual inhibit command charges the module. Removal of the inhibit command by placing the switch

9184

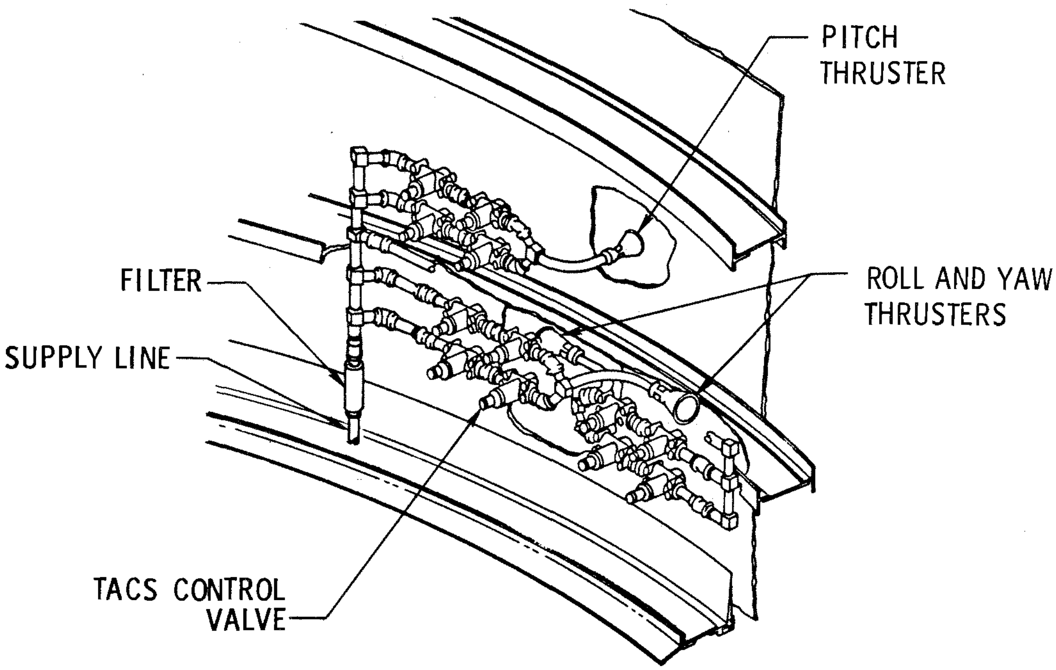



Figure 2.3.4-1 Control Valves Internal View

9185

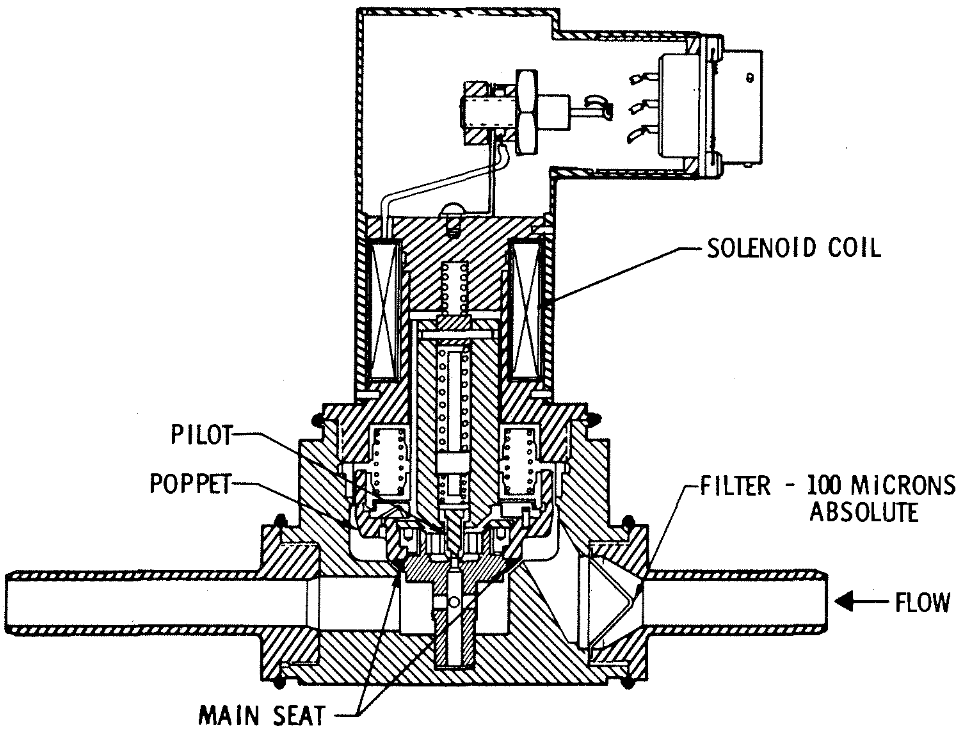



Figure 2.3.4-2 TACS Control Valve

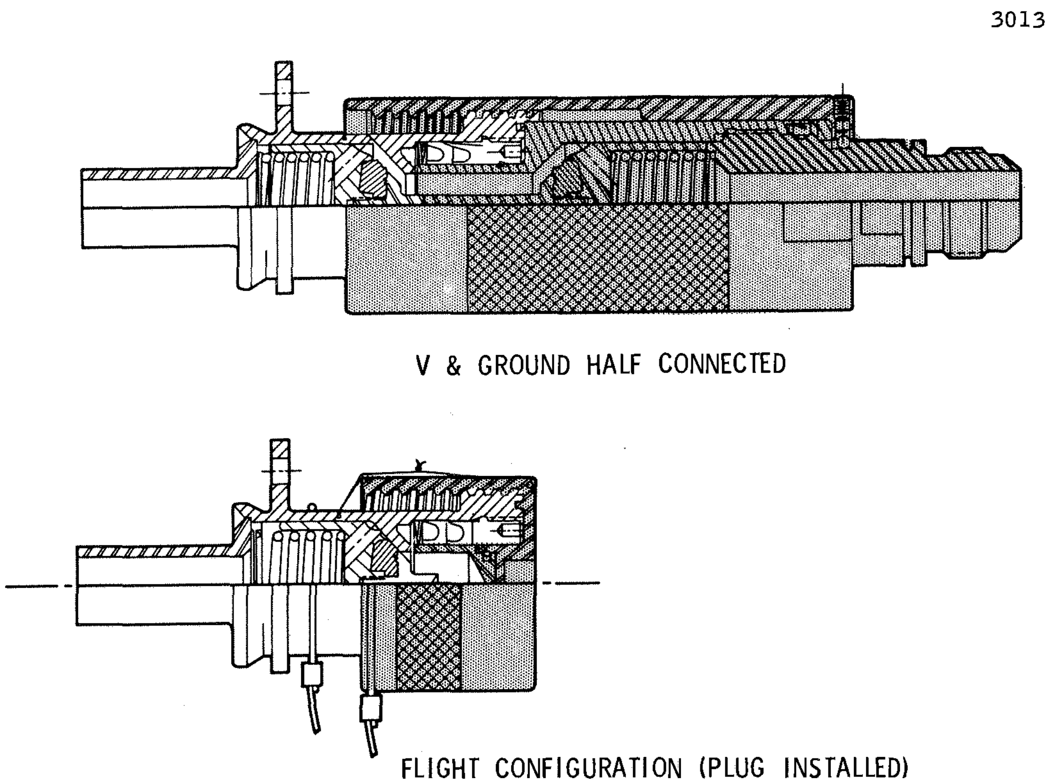



Figure 2.3.4-3 TACS Disconnect

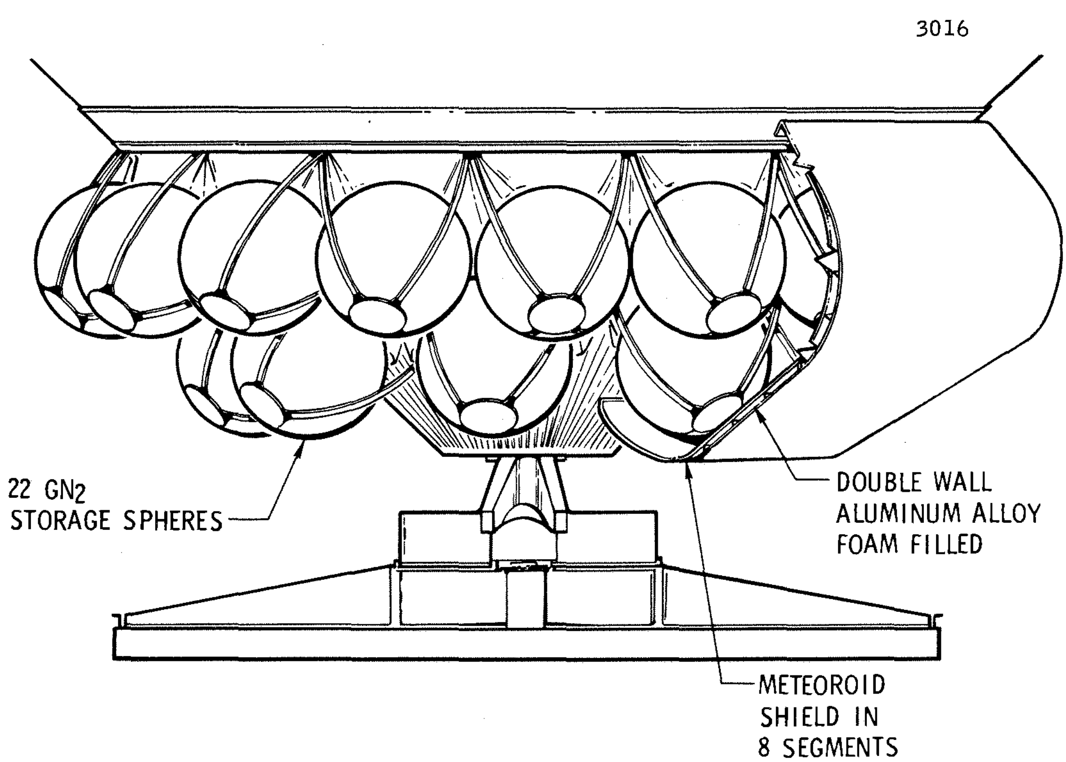



Figure 2.3.4-4 Spheres and Meteoroid Shield

9183

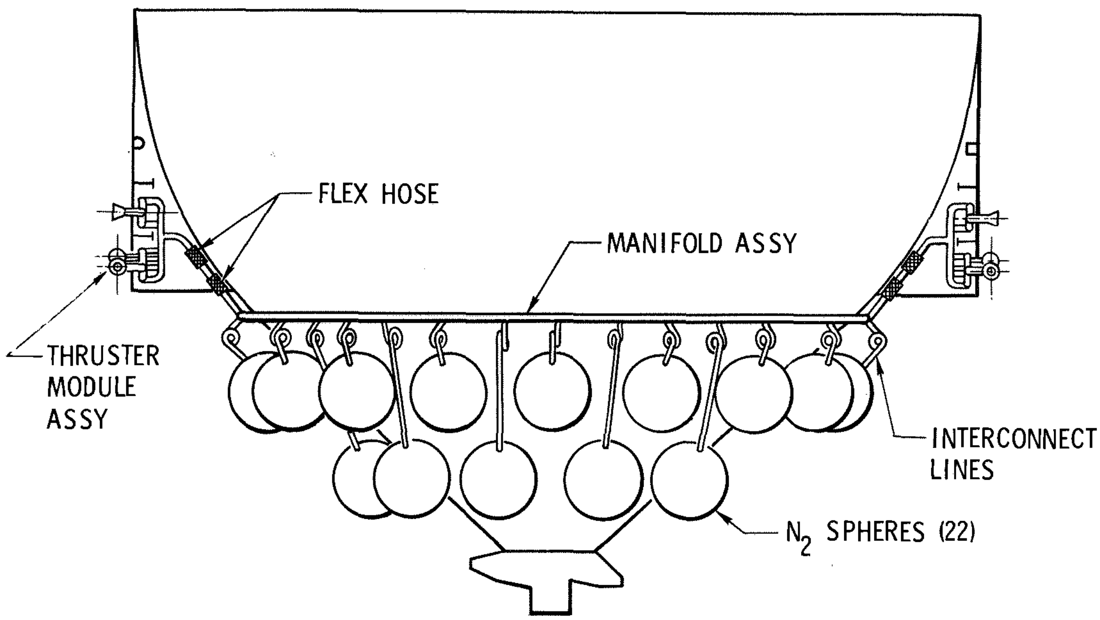



Figure 2.3.4-5 Storage Sphere Installation

3012

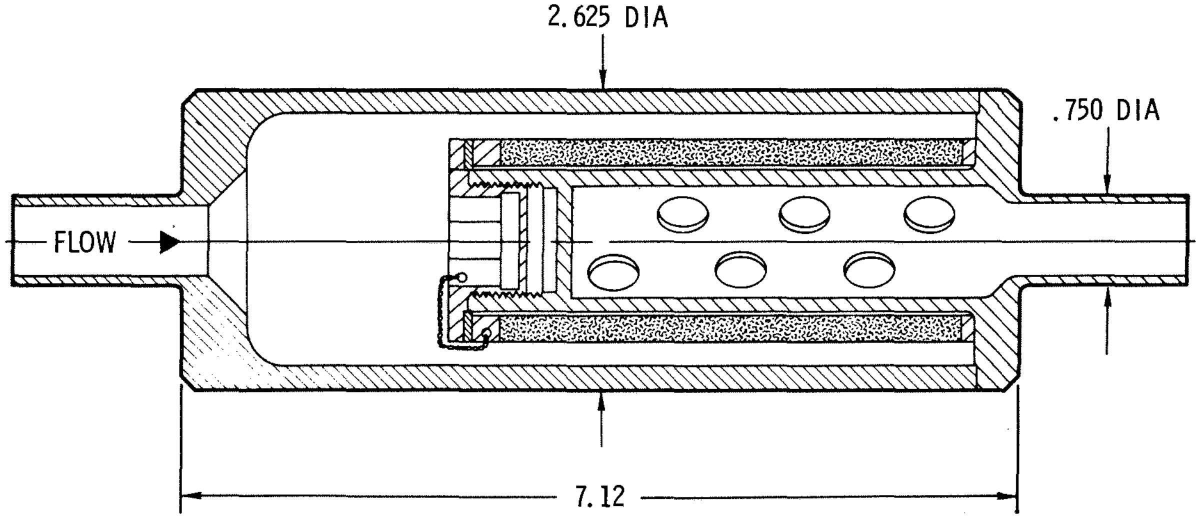



Figure 2.3.4-6 Thruster Supply Line Filter

to ENABLE allows the module to discharge. The power from the module closes the contacts of the enable relay and holds the relay closed for approximately 500 ms until the module timer runs out.

The time delay module contains three independently adjustable delay circuits, which control the power discharge to the enable relay. The delay circuits can be adjusted, prior to launch, to interrupt the discharge in the range of 100 to 1000 ms after removal of the manual inhibit command. The time delay module fully charges upon the acceptance of a command from the inhibit switch of 15 ms (minimum) and 18 to 33.5 vdc.

#### 2.3.4.10 VOLTAGE SENSOR

Two voltage sensor modules are utilized with the TACS to monitor the 12 telemetered thruster bus voltages between 0 and 35 vdc. The output of the sensors is routed to low-level multiplexers of the instrumentation system. Each voltage sensor module contains six independent voltage sensor circuits (one for each thruster bus).

### 2.3.5 FAILURE MODES

The TACS failure modes and the effect on mission capability are given in table 2.3.5-1.

TABLE 2.3.5-1 TACS - FAILURE MODES

| FAILURE | INDICATIONS | VEHICLE CAPABILITY |
|---|---|---|
| Low TACS bus power | TACS bus voltage below 24 vdc.<br><br>T/M Measurements:<br><br>M7088 24 vdc<br>M7089 24 vdc<br>M7090 24 vdc<br>M7091 24 vdc<br>M7092 24 vdc<br>M7093 24 vdc<br>M7094 24 vdc<br>M7095 24 vdc<br>M7096 24 vdc<br>M7097 24 vdc<br>M7098 24 vdc<br>M7099 24 vdc | System: With voltages below 22 vdc, the valves are slower than normal up to the point of not opening.<br><br>Normally the valves open with a minimum voltage of 16-18 vdc. Both power sources must have low voltage for a system failure to occur. The system will operate satisfactorily with one power source.<br><br>Mission: Failure of a thruster to operate will result in loss of attitude control if under IU or ATM DC (TACS "only") control.<br><br>If the SWS is under nested CMG/TACS control, attitude control will be maintained until CMG's saturate.<br><br>Pulse duration reduction will result in higher than nominal propellant usages and increased number of thruster firings. |
| Thruster fails to open on command | Telemetry thruster talkback (K7030, K7031, K7032, K7033, K7034, or K7035) fails to pick-up.<br><br>Attitude error(s) outside deadband and increasing. Onboard display thruster talkback (K7044, K7045, K7046, K7047, K7048, or K7049) fails to pick-up. | If uncorrected this failure will result in loss of attitude control and resultant loss of mission when CMG's saturate or malfunction. |
| Thruster fails open | Telemetry thruster pressure switch talkback (K7030, K7031, K7032, K7033, K7034, or K7035) fails to drop-out.<br><br>TACS bottle supply pressure (D7114, and D7116) decays noticeably.<br><br>IU Control<br>H006: ±2.5 vdc.<br>H007: ±2.5 vdc.<br>H008: ±2.5 vdc.<br><br>ATM Control<br>K382 (T/M word No. 54)<br>Bit 33<br>Bit 34<br>Bit 35<br>Bit 36<br>Bit 37<br>Bit 38<br><br>OA attitude error build-up | System: Failure of a thruster to open would trigger the opposite thruster to operate to oppose the unbalance. This stalemate will continue until the fault is corrected, or until the N2 supply is depleted (about 15 minutes with full N2 supply).<br><br>Mission:<br><br>1. IU control mode or ATM DC (TACS "only") mode.<br>a. Immediate loss of attitude control if opposing thruster has less thrust than failed thruster.<br>b. Loss of attitude control following gas depletion.<br><br>2. TACS/CMG "nested" mode.<br>a. Immediate loss of attitude control if opposing thruster has less thrust than failed thruster.<br>b. Loss of TACS back-up to CMG's after gas depletion and resultant loss of mission objectives which required TACS (such as EREP). |

TABLE 2.3.5-1 TACS - FAILURE MODES (cont'd)

| FAILURE | INDICATIONS | VEHICLE CAPABILITY |
|---|---|---|
| Low TACS supply Pressure | Telemetry measurements of TACS bottle pressure (D7115, and D7116) indicate low supply pressure.<br><br>During habitation on-board display of TACS supply pressure (D7144) indicates low supply pressure. | System: Low system pressure can result from excessive usage or leakage. Thrust will be low and performance will decrease to the point of premature depletion of available impulse.<br><br>Mission: If uncorrected, this failure could result in loss of attitude control when TACS propellent is depleted. If the SWS is under the nested CMG/TACS control, attitude control will be maintained until the CMG's saturate. |
| TACS commands not transferred from IU to ATM control when TACS command transfer No. 1 and No. 2 are issued at approximately 4 1/2 hours GET. | K7040 and K7041: Will indicate 0 vdc while in the IU mode and 28 vdc while in the ATM mode when the transfer enable commands on.<br><br>IU attitude error deadband --±2 deg pitch and yaw and ±3 deg roll.<br><br>IU angular rate deadband is ±0.2 deg/sec in all axes.<br><br>ATM angular rate deadband rate is ±0.2 deg/sec pitch and yaw, ±0.3 deg/sec roll<br><br>ATM attitude error deadbans if ±2 deg pitch and yaw, ±3 deg roll | System: TACS will receive guidance, navigation and control functions from IU only until IU batteries deplete.<br><br>Mission: Loss of attitude control when IU batteries deplete and resultant mission loss. Requires failure of both transfer commands for this to occur. |
| TACS valves powered by AM bus No. 1 (or AM bus No. 2) are not transferred from IU to ATM control when TACS command transfer No. 1 and No. 2 IU to ATM are issued. | K7041-TACS, ATM Command Mode Bus No. 1.<br><br>K7040-TACS ATM Command Mode Bus 2.<br><br>K7041-and K7040 will indicate zero vdc in the IU mode and 28 vdc while in the ATM mode but only if transfer enable commands are on. | System: Loss of TACS valve redundancy.<br><br>Thrust will be reduced 10% as a result of partial transfer of TACS firing commands.<br><br>If only one set of TACS thruster firing commands are transferred, control of the SWS will in general be commanded by the ATMDC using the transferred set of valves. The set of valves still under IU control will fire only if the IU commanded vehicle attitude varies from the ATM commanded vehicle attitude by more than 2 1/2 degrees in pitch or yaw and than 3 1/2 degrees in roll.<br><br>Mission: Possible loss of attitude control will result if the IU flight control computer(FCC) is not inhibited. |
| Inadequate TACS thrust due to obstructed supply line. | Attitude Error and Angular Rate Data will indicate that the SWS is not properly responding to attitude control/ maneuver commands.<br><br>Response to maneuvers will be slower than predicted. | System: A clogged supply line filter or other obstruction in the supply line will reduce the thrust and the minimum impulse bit for the effected module.<br><br>Inadequate thrust will result in excessively long maneuver times and loss of attitude control during disturbances which are larger than the available control thrust.<br><br>Mission: Possible loss of attitude control and resultant mission loss. |

### 2.3.6 PERFORMANCE AND DESIGN DATA

#### 2.3.6.1 DESIGN DATA

The following list contain specific data on components in the TACS.

1. N2 Supply

| Parameter | Value | |
|---|---|---|
| | Sphere | 22 Spheres |
| Volume | 4.5 cubic feet | 99 cubic feet |
| Nitrogen Capacity | | |
| @ 50°F and 3200 psia (max. load) | 71.3 lbm | 1570 lbm |
| @ 75°F and 3000 psia (min. load) | 62.8 lbm | 1380 lbm |
| Residual Nitrogen* | | |
| @ 13°F and 350 psia | 8.86 lbm | 195 lbm |
| @ 40°F and 320 psia (min.) | 7.63 lbm | 168 lbm |
| Usable Nitrogen* | | |
| With zero leakage (max.) | 62.4 lbm | 1372 lbm |
| With maximum leakage (min.) | 53.0 lbm | 1164 lbm |
| Nitrogen Leakage | | |
| TACS (max.) | NA | 21 lbm |
| Leakage Rate | NA | 24 sccm |
| Sphere Operating Temperature Range * | -15 to + 173°F | |
| Sphere Operating Pressure Range* | 300 to 3100 ± 100 psia | |
| Sphere Proof Pressure @ 210°F | 6000 psig | |
| Sphere Burst Pressure @ 210°F | 8000 psig | |

*Based on the TACS operating at thrust levels above 10 lbf.

2. Control Valves

| Parameter | Value |
|---|---|
| Operating Pressure Range | 0 to 3200 psig |
| Proof Pressure | 4800 psig |
| Burst Pressure | 8000 psig |
| Operating Life | 35,000 cycles |
| Nitrogen Temperature Range | -150° to 165°F |
| Environmental Temperature Range | -150° to 165°F |
| Valve Response (See figure 2.3.6-2) | |
| Opening Time (position 2 to 4) Maximum | 42 msec |
| Closing Time (position 6 to 8) Maximum Delay in Opening | 9 msec |
| Nitrogen flow rate with inlet conditions of 3000 psig and 70°F | 1.5 lb/sec |
| Pressure drop @ 1.5 lb/sec of nitrogen, maximum | 170 psi |
| Valve Leakage Rates (using nitrogen) | |
| External maximum @ operating temperature and pressure | 0.001 scim |
| Internal (inlet to outlet) maximum @ operating temperature and pressure | 0.12 scim (with psig downstream)<br>6.1 scim (with 10-12% of inlet pressure across valve). |
| Electrical | |
| Solenoid Voltage | 24 to 30 vdc |
| Solenoid Dropout Voltage | 2 vdc min.; 8 vdc max. |
| Solenoid Pull-in Voltage | 5 vdc min.; 22 vdc max. |
| Solenoid Current | 3 amp max. |

3. Thruster

| Parameter | Value |
|---|---|
| Throat Diameter | 0.164 inch |
| Exit Diameter | 1.16 inch |
| Throat Area, At | 0.0211 square inches |
| Exit Area, Ae | 1.055 square inches |
| Expansion Ratio, Ae/At | 50 |
| Length, Throat to Exit | 1.45 inch |
| Cant Angle | 0° |
| Operating Life | 35,000 cycles over 1 year |
| Environmental Temperature Range | -140° to 165°F |

2.3.6.2 PERFORMANCE

2.3.6.2.1 Total Impulse

The total TACS impulse available for attitude control is approximately 61,000 lb-sec. This includes both primary control requirements prior to CMG spin-up (first 6 orbits) and CMG backup requirements. The total TACS impulse budget throughout the mission is summarized on Table 2.3.6-1.

TABLE 2.3.6-1 TACS IMPULSE BUDGET

| EVENT | IMPULSE (LB-SEC) |
|---|---|
| SL-1 | |
| 1. Insertion Transients | |
| Remove 1 deg/sec each axis plus retro-rocket plume impingement disturbance | 5,800 |
| SUB-TOTAL | 5,800 |
| 2. Venting | |
| a. Waste Tank | 130 |
| b. Habitation Area Vent | 1,055 |
| SUB-TOTAL | 1,185 |
| 3. Payload Shroud and Radiator Cover Jettison | |
| a. 180 deg pitch maneuver at .3 deg/sec | 945 |
| b. Disturbance due to P.S. and Radiator Cover Jettison | 100 |
| SUB-TOTAL | 1,045 |
| 4. ATM Deployment | 115 |
| 5. Solar Inertial Attitude Acquisition | |
| a. 3-axis maneuver at .1 deg/sec | 710 |
| b. Remove orbital rate about pitch axis | 70 |
| SUB-TOTAL | 780 |

TABLE 2.3.6-1 TACS IMPULSE BUDGET (cont'd)

| EVENT | IMPULSE (LB-SEC) |
|---|---|
| 6. CMG Spin-Up | |
| a. Hold attitude for six orbits | 3,780 |
| b. Absorb momentum of CMG's 1/3 each axis | 280 |
| SUB-TOTAL | 4,060 |
| TOTAL FOR SL-1 | 12,985 |
| SL-2 | |
| 1. Rendezvous and Docking[1] | |
| a. Acquire Z-LV | |
| (1) Roll at .3 deg/sec through $\beta$ | 680 |
| (2) Achieve orbital rate in pitch | 85 |
| b. Hold Z-LV for two orbits | 920 |
| c. Acquire solar inertial | |
| (1) Remove orbital rate in pitch | 85 |
| (2) Roll at .3 deg/sec through $\beta$ | 680 |
| d. Unsuccessful docking | |
| Impact (1 ft off centerline, 10 deg misalignment, 1 ft/sec axial velocity, and 0.5 ft/sec lateral velocity), latching impulse (4,000 lb-sec) | 2,520 |
| e. Successful docking | 1,500 |
| SUB-TOTAL | 6,470 |
| 2. Z-Local Vertical (9 Passes)[2, 3] | |
| a. Two of Type A | 202 |
| b. Two of Type B | 202 |
| c. Three of Type C | 909 |
| d. One of Type D | 606 |
| SUB-TOTAL | 1,919 |
| 3. Undocking | |
| Disturbance due to separation | 350 |
| TOTAL FOR SL-2 | 8,739 |
| TOTAL THROUGH SL-2 | 21,724 |

TABLE 2.3.6-1 TACS IMPULSE BUDGET (cont'd)

| EVENT | | IMPULSE (LB-SEC) |
|---|---|---|
| SL-3 | | |
| 1. Rendezvous and Docking[1] | | 6,470 |
| | SUB-TOTAL | 6,470 |
| 2. Z-Local Vertical (18 Passes)[2, 3] | | |
| a. Five of Type A | | 506 |
| b. Five of Type B | | 506 |
| c. Six of Type C | | 1,820 |
| d. One of Type D | | 607 |
| | SUB-TOTAL | 3,439 |
| 3. Undocking | | 350 |
| | TOTAL FOR SL-3 | 10,259 |
| | TOTAL THROUGH SL-3 | 31,983 |
| SL-4 | | |
| 1. Rendezvous and Docking[1] | | 6,470 |
| | SUB-TOTAL | 6,470 |
| 2. Z-Local Vertical (18 Passes)[2, 3] | | |
| a. Five of Type A | | 506 |
| b. Five of Type B | | 506 |
| c. Six of Type C | | 1,825 |
| d. One of Type D | | 607 |
| | SUB-TOTAL | 3,444 |
| 3. Undocking | | 350 |
| | TOTAL FOR SL-4 | 10,264 |
| | TOTAL FOR MISSION | 42,247 |
| | TOTAL SYSTEM CAPACITY | 61,000 |
| | MARGIN | 18,753 |

[1] These numbers are based upon TACS-only operation, and will be updated when numbers become available for the CMG/TACS nested configuration.

[2] Reference is made to MSFC Memorandum S&E-AERO-DO-13-71, "Skylab TACS Impulse Requirements," dated 8 March 1971

[3] Z-Local Vertical Types:
a) Type A (one 60 deg pass, two consecutive orbits)
b) Type B (A's above but alternating Z-LV's for 29 hrs)
c) Type C (one 120 deg pass, anywhere in orbit)
d) Type D (two consecutive 60 deg passes in one orbit)

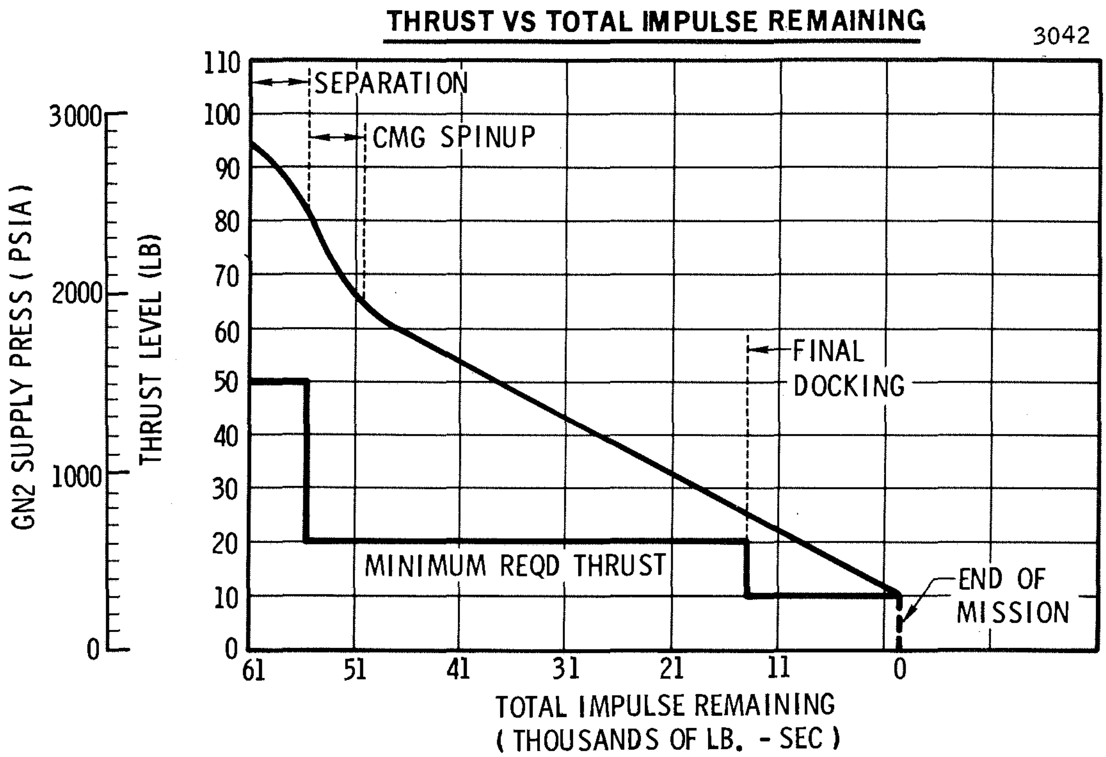



Figure 2.3.6-1 Thruster Versus Impulse Remaining

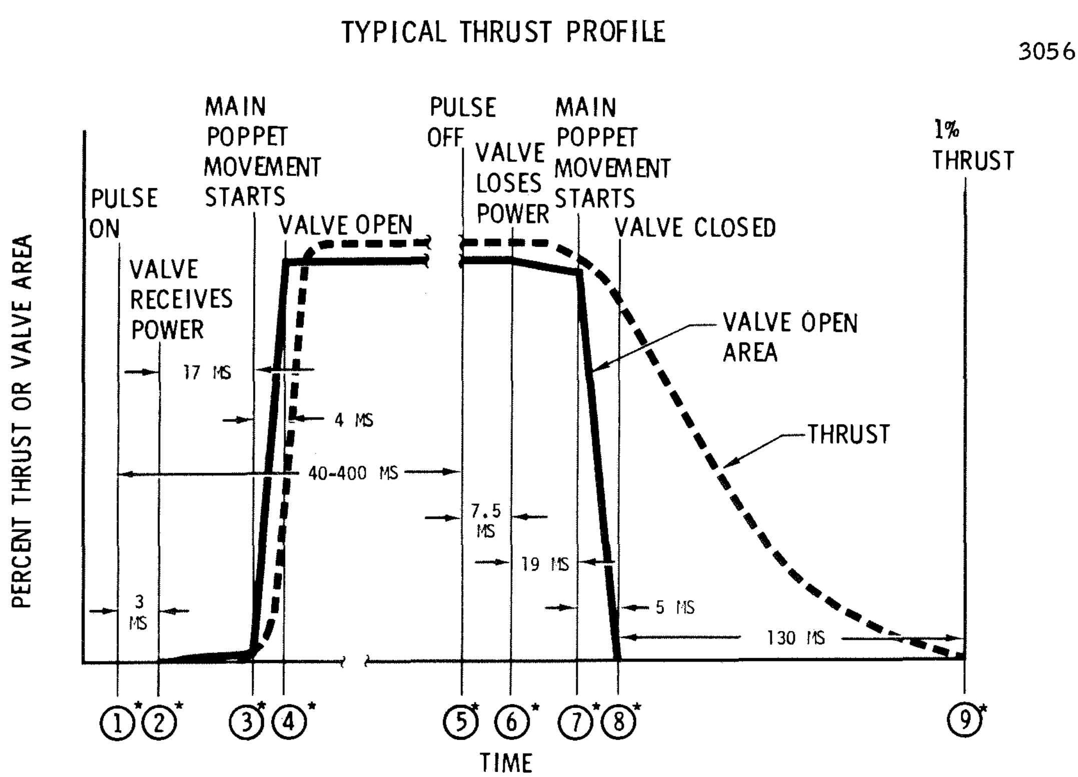



Figure 2.3.6-2 Typical Thrust Profile

2.3.6.2.2 Thrust

In order to control the potentially large disturbances and minimize the attitude excursions associated with S-II separation, it is necessary that the TACS thrust at separation be 50 lbf minimum.

Because of the TACS requirement to limit attitude disturbances induced by docking (successful or unsuccessful) of the CSM with the SWS the required minimum TACS thrust for SL-4 docking is 20 lbf. Figure 2.3.6-1 compares the predicted and required engine thrust levels versus impulse remaining. Thrust levels are shown to be above minimum levels required at all times during the mission as it assumes conservative conditions for initial propellant loading (maximum temperature and minimum pressure), valve leakage, supply system pressure drops, and maximum expected usage of propellant. Figure 2.3.6-1 indicates that a thrust level of 10 lbf will be maintained up to 61,000 lb-sec of impulse consumed.

2.3.6.2.3 Minimum Impulse Bit

During IU control, the minimum TACS electrical pulse width is 65 $\pm$ 10 ms (the output of the IU spatial amplifiers). With a thrust of 100 lbf the corresponding minimum impulse will be approximately 9.3 $\pm$ 2.3 lb-sec.

To improve the attitude control impulse usage during the majority of the mission, the ATMDC has the capability of operating in various electrical pulse width modes as determined by the APCS. The resultant electrical command is some multiple of 10 ms of from 40 to 400 ms duration. By taking into consideration the valve delay time and the available thrust (a function of the N2 pressure), the optimum electrical pulse width command from the ATMDC, hence the optimum TACS impulse, can be selected. The optimum impulse, "minimum impulse bit", is the minimum required for TACS supplement on the CMG's.

Valve response time (time to fully open or time to fully close), engine chamber volume, and throat area all influence the impulse obtained for a given command pulse width. The throat area and chamber volume are designed to satisfy impulse bit requirements. The resulting minimum impulse bit during ATM control mode ranges between 0.5 and 7.125 lb-sec. Figure 2.3.6-2 shows a typical thrust curve as a function of a given command pulse. Table 2.3.6-2 shows the valve characteristics and respective predicted impulse.

TABLE 2.3.6-2 CONTROL VALVE CHARACTERISTICS

| TIME SEGMENT | DURATION (MILLISECONDS) | ACCUMULATED TIME (MILLISECONDS) | IMPULSE (LB. SEC) | ACCUMULATED IMPULSE (LB. SEC) |
|---|---|---|---|---|
| 1-2 RELAY DELAY | 3-9 | 3-9 | 0 | 0 |
| 2-3 VALVE SOLENOID DELAY | 15-38 | 18-47 | 0 | 0 |
| 3-4 VALVE OPENING | 2-3 | 20-50 | 0-.3 | - |
| 4-5 FULL OPEN | 0-30 | 50 | 0-3.3 | - |
| 5-6 RELAY DELAY | 5-10 | 55-60 | 0.5-1.0 | - |
| 6-7 VALVE SOLENOID DELAY | 20-33 | 75-93 | 2.0-3.3 | - |
| 7-8 VALVE CLOSING | 2-3 | 77-96 | 0.2-0.3 | 4.0-6.3[2] |
| 8-9 THRUST DECAY | NA | NA | 1.5-3.8 | 5.5-10.1 |

1. Variations are due to valve voltages and coil temperatures at the maximum pressure.
2. Accumulated impulse to time 8 based on statistical combination of uncertainties in the parameters affecting impulse bit. TACS control valve and thruster characteristics for 50 ms command pulse.

2.3.7 OPERATIONAL LIMITATIONS AND RESTRICTIONS

The operational limitations and restrictions for the TACS are as follows:

o Minimum command pulse from IU or ATM that a control valve will react to is 46 milliseconds.

o Storage system must be initially loaded to 3000 to 3200 psia at 50 to 75°F.

o IU control is limited by the IU battery lifetime.

o IU Control of TACS

Maneuver Range. The maximum attitude change which may be commanded about each axis is:

| | |
|---|---|
| Roll | $\pm$180° |
| Pitch | $\mp$180° |
| Yaw | $\mp$ 60° |

Maneuver Accuracy. The accuracy to which a commanded attitude may be acquired is TBS degrees about each axis.

Maneuver Rate. The maneuver rate for attitude changes about each axis is up to 0.3 degree/second.

Attitude Hold Capability. The IU/TACS control mode is capable of maintaining the commanded attitude with the following deadbands:

a) Attitude deadbands

1) X-axis ± 3 deg
2) Y- and Z-axes ± 2 deg

b) Attitude rate deadbands

1) X-axis 0.2 deg/sec
2) Y- and Z-axes 0.2 deg/sec

Attitude Drift. The SL-1 will deviate from the commanded attitude while under IU/TACS control as a result of attitude reference drift. The specified value for IU stable platform drift is 0.5 degree per hour, maximum. Analysis of previous flights indicates that the platform drift is less than 0.25 degree per hour.

o ATM Control of TACS (TACS ONLY mode)

Maneuver Range. The maximum attitude change which may be commanded is ± 180 degrees about each axis.

Maneuver Accuracy. The accuracies to which the primary attitudes may be acquired are shown below:

| | |
|---|---|
| Solar inertial (w/o sun sensor ref.) | ± 5 deg (all axes) |
| Rendezvous (Z-LV) | ± 5 deg (all axes) |
| Earth resources experiment pointing (Z-LV) | ± 2 deg (all axes) |

The accuracy to which any other attitude may be acquired is TBS.

Maneuver Rate. The maneuver rate for attitude changes about each axis is up to 0.3 degree per second.

Attitude Hold Capability. The ATMDC/TACS control mode is capable of maintaining the Skylab attitude within the following deadbands:

| | |
|---|---|
| Attitude deadband | ± 3, 2, 2, (X, Y, Z) |
| Attitude rate deadband | ± 0.3, 0.2, 0.2 (X, Y, Z) |

o ATM Control of TACS (CMG/TACS Nested)

Maneuver Range. The maximum change which may be implemented by the CMG/TACS system is 180 degrees about each axis. Maneuvers of 180 degrees about all axes in ± 1.0 degree increments may be commanded in the attitude hold CMG and the attitude hold TACS modes.

Offset pointing capability is provided from a solar inertial attitude during the daylight portion of the orbit and is magnitude limited to ± 4.0 degrees about the X- and Y-axes. The pointing attitude commands will be entered in ± 0.1 degree increments.

Maneuver Accuracy. The CMG/TACS under ATMDC control, using the acquisition sun sensors, will achieve an attitude to the accuracy shown below:

CMG/TACS System Pointing Accuracy

| System Axis | Pointing Uncertainty (2) |
|---|---|
| X | ±6 arc min (spec)<br>±2.75 arc min (est) |
| Y | ±6 arc min (spec)<br>±2.75 arc min (est) |
| Z | ±10 arc min (spec)<br>±0.624 arc min (est) |

Maneuver Rate. The rate at which attitude changes may be performed is up to 0.3 degree per second.

Attitude Hold Capability. The CMG/TACS system is capable of maintaining the commanded attitude as shown below when the acquisition sun sensor provides the attitude reference.

Attitude Hold Capability with CMG/TACS

| Axis | Specification | Estimated |
|---|---|---|
| X | ± arc min/15 min | ±3.6 arc min/15 min |
| Y | ±9 arc min/15 min | ±5.7 arc min/15 min |
| Z | ±7.5 arc min/15 min | ±5.0 arc min/15 min |

o N2 Storage pressure above 3200 psia is unsafe for docking.

o Thruster temperatures must be maintained between -140 and +165°F for proper operation of the control valves.

o Control valves require a minimum of 16-18 vdc to activate the solenoid.

o Minimum electrical pulse capability from the IU FCC is 65 milliseconds.

o Ground control capability is inhibited if the command control circuit breakers are opened.

o N2 supply will deplete with a stuck thruster in approximately 15 minutes.

o DCS provides the capability of controling the duration of the electrical pulse from the ATMDC.

o After transfer of the IU control to the ATM control if only half of the transfer takes place, the TACS will operate under IU and ATM control. The set of valves under IU control will fire only if the IU commanded attitude varies from the ATM vehicle attitude by more than 2 1/2 degrees about the Y or Z coordinate and more than 3 1/2 degrees about the X coordinate, and if the IU is still operative.

o Only the crew has the capability to inhibit individual thrusters.

o Ground does not have the capability to inhibit individual thrusters. The ground has the capability to inhibit the electrical circuits to all six thrusters at once.

o Onboard monitor capabilities exist for firing of each thruster and manifold pressure.

2.3.8 INSTRUMENTATION AND GROUND COMMANDS

2.3.8.1 The TACS instrumentation is identified on table 2.3.8-1 and on figure 2.3.8-1.

TABLE 2.3.8-1 TACS INSTRUMENTATION

| | | | ONBOARD DISPLAY | |
|---|---|---|---|---|
| MEAS. NO. | MEASUREMENT DESCRIPTION | TM RANGE | DISPLAY RANGE | PANEL NO. |
| C7257-403 | Sphere 1 Gas Temp | -250 + 400°F | | |
| C7258-403 | Sphere 5 Gas Temp | -250 + 400°F | | |
| C7259-403 | Sphere 9 Gas Temp | -250 + 400°F | | |
| C7260-403 | Sphere 13 Gas Temp | -250 + 400°F | | |
| C7261-404 | Module 1 Inlet Gas Temp | -250 + 400°F | | |
| C7262-404 | Module 2 Inlet Gas Temp | -250 + 400°F | | |
| C7289-403 | Sphere Gas Temp | -250 + 400°F | | |
| C7290-403 | Sphere 21 Gas Temp | -250 + 400°F | | |
| D7115-403 | Supply Sensor 1 Pressure | 0-3500 PSIA | | |
| D7116-403 | Supply Sensor 2 Pressure | 0-3500 PSIA | | |
| D7144-403 | Supply Sensor 3 Pressure | 0-3500 PSIA | 0-100% | 130 |

TABLE 2.3.8-1 TACS INSTRUMENTATION (cont'd)

| MEAS. NO. | MEASUREMENT DESCRIPTION | TM RANGE | ONBOARD DISPLAY DISPLAY RANGE | ONBOARD DISPLAY PANEL NO. |
|---|---|---|---|---|
| K7030-404 | Thruster 3 Chamber Pressure On | One = press 135 PSIA<br>Zero = press 80 PSIA | Light | 130 |
| K7031-404 | Thruster 1 Chamber Pressure on | One = press 135 PSIA<br>Zero = press 80 PSIA | Light | 130 |
| K7032-404 | Thruster 2 Chamber Pressure on | One = press 135 PSIA<br>Zero = press 80 PSIA | Light | 130 |
| K7033-4-4 | Thruster 5 Chamber Pressure on | One = press 135 PSIA<br>Zero = press 80 PSIA | Light | 130 |
| K7034-404 | Thruster 4 Chamber Pressure on | One = press 135 PSIA<br>Zero = press 80 PSIA | Light | 130 |
| K7035-404 | Thruster 6 Chamber Pressure on | One = press 135 PSIA<br>Zero = press 80 PSIA | Light | 130 |
| K7040-411 | ATM Command Mode Bus No. 2 Energized | one = on<br>zero = off | | None |
| K7041-411 | ATM Command Mode Bus No. 1 Energized | one = on<br>zero = off | | None |
| M7088-411 | Voltage TACS Sub Bus 1-1A | 0-35VDC | | None |
| M7089-411 | Voltage TACS Sub Bus 1-2A | 0-35VDC | | None |
| M7090-411 | Voltage TACS Sub Bus 1-3A | 0-35VDC | | None |
| M7091-411 | Voltage TACS Sub Bus 2-1A | 0-35VDC | | None |
| M7092-411 | Voltage TACS Sub Bus 2-2A | 0-35VDC | | None |
| M7093-411 | Voltage TACS Sub Bus 2-3A | 0-35VDC | | None |
| M7094-411 | Voltage TACS Sub Bus 1-1B | 0-35VDC | | None |
| M7095-411 | Voltage TACS Sub Bus 1-2B | 0-35VDC | | None |
| M7096-411 | Voltage TACS Sub Bus 1-3B | 0-35VDC | | None |
| M7097-411 | Voltage TACS Sub Bus 2-1B | 0-35VDC | | None |
| M7098-411 | Voltage TACS Sub Bus 2-2B | 0-35VDC | | None |
| M7099-411 | Voltage TACS Sub Bus 2-3B | 0-35VDC | | None |

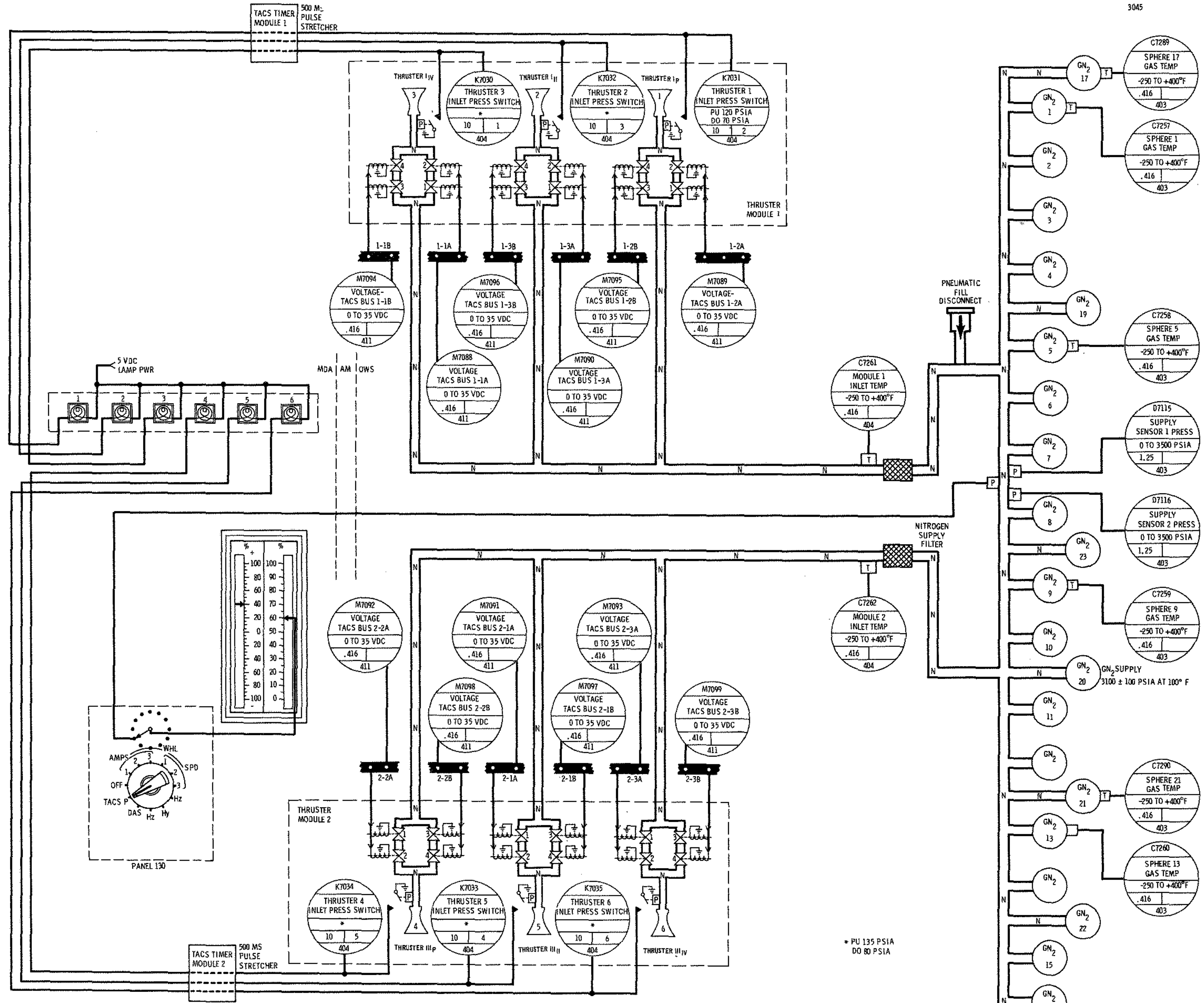



Figure 2.3.8-1 TACS Instrumentation

2.3.8.2 The TACS command lists for the OWS switch selector and the DCS are listed on tables 2.3.8-2 and 2.3.8-3, respectively.

TABLE 2.3.8-2 TACS OWS SWITCH SELECTOR COMMAND LIST

| SWITCH SELECTOR CHANNEL | FUNCTION | OCTAL CODE |
|---|---|---|
| 64 | TACS Command Transfer Enable No. 1A - ON | 072 |
| 65 | TACS Command Transfer Enable No. 1A - OFF | 052 |
| 15 | TACS Command Transfer Enable No. 1B - ON | 157 |
| 16 | TACS Command Transfer Enable No. 1B - OFF | 021 |
| 62 | TACS Command Transfer Enable No. 2A - ON | 112 |
| 63 | TACS Command Transfer Enable No. 2A - OFF | 007 |
| 13 | TACS Command Transfer Enable No. 2B - ON | 162 |
| 14 | TACS Command Transfer Enable No. 2B - OFF | 015 |
| 110 | TACS Command Transfer No. 1 IU to ATM | 064 |
| 49 | TACS Command Transfer No. 2 IU to ATM | 014 |

TABLE 2.3.8-3 TACS AM DCS COMMAND LIST

| DCS COMMAND | FUNCTION | OCTAL CODE |
|---|---|---|
| S344 | TACS Transfer Enable 1A - ON | 05441 |
| S345 | TACS Transfer Enable 1A - OFF | 45440 |
| S346 | TACS Transfer Enable 2A - ON | 25440 |
| S347 | TACS Transfer Enable 2A - OFF | 65441 |
| S312 | TACS Transfer Enable 1B - ON | 04440 |
| S313 | TACS Transfer Enable 1B - OFF | 44441 |
| S314 | TACS Transfer Enable 2B - ON | 24441 |
| S315 | TACS Transfer Enable 2B - OFF | 64440 |
| S354 | TACS BUS 1 - ON | 23440 |
| S355 | TACS BUS 1 - OFF | 63441 |
| S282 | TACS BUS 2 - ON | 25041 |
| S283 | TACS BUS 2 - OFF | 65040 |
| S343 | TACS Transfer 1 IU to ATM | 71441 |
| S311 | TACS Transfer 2 IU to ATM | 70440 |
| S363 | TACS Transfer 1 ATM to IU | 67440 |
| S289 | TACS Transfer 2 ATM to IU | 43041 |

SUBSYSTEM 2.4

ENVIRONMENTAL CONTROL SYSTEM

## 2.4.1 INTRODUCTION

The environmental control system (ECS) maintains temperature-critical equipment within operating and storage limits and provides a controlled life-supporting environment for the manned orbital assembly (OA). The ECS also provides refrigeration capabilities and supports EVA/IVA operations.

Portions of the ECS are active from prelaunch through the activation phase of the mission, with the major portions active during the manned phase of each mission. The life-support elements of the ECS are deactivated during the unmanned phase.

Five subsystems (figure 2.4.1-1) operate in conjunction to provide the required major functions of the environmental control system.

- o Pressurization and gas distribution
- o Thermal control
- o Atmosphere control
- o EVA/IVA support
- o Refrigeration

The pressurization and gas distribution system stores, distributes, and regulates the oxygen and nitrogen used during the missions, and provides prelaunch purging and pressurization, launch and in-orbit pressure equalization and venting, and in-orbit pressurization.

There are two systems maintaining thermal control, one active and one passive. The active thermal control subsystem removes heat generated by the crew and equipment, and also heats the walls and atmosphere, as required. Passive thermal control is provided by insulation, selected surface coating, and radiation shielding.

Purification and crew comfort control of the OA atmosphere is maintained by a system that circulates the atmosphere; removes moisture, carbon dioxide, and other contaminants from the atmosphere; and transfers heat from the atmosphere to the thermal control subsystem coolant loops.

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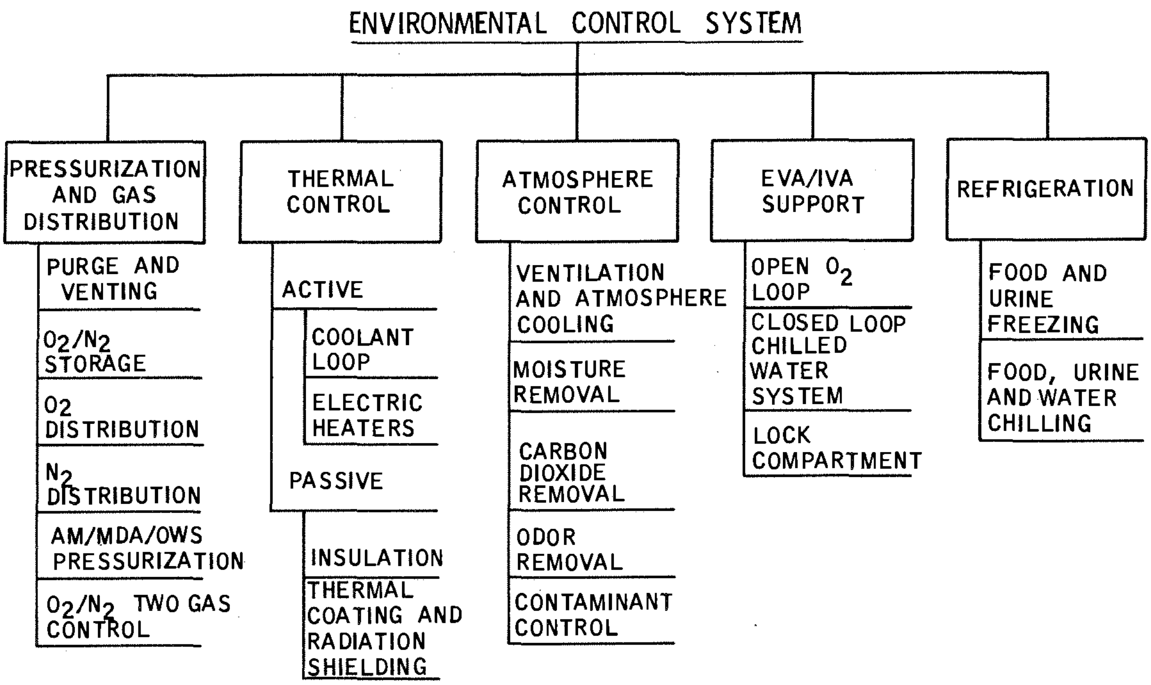


Figure 2.4.1-1 Environmental Control System

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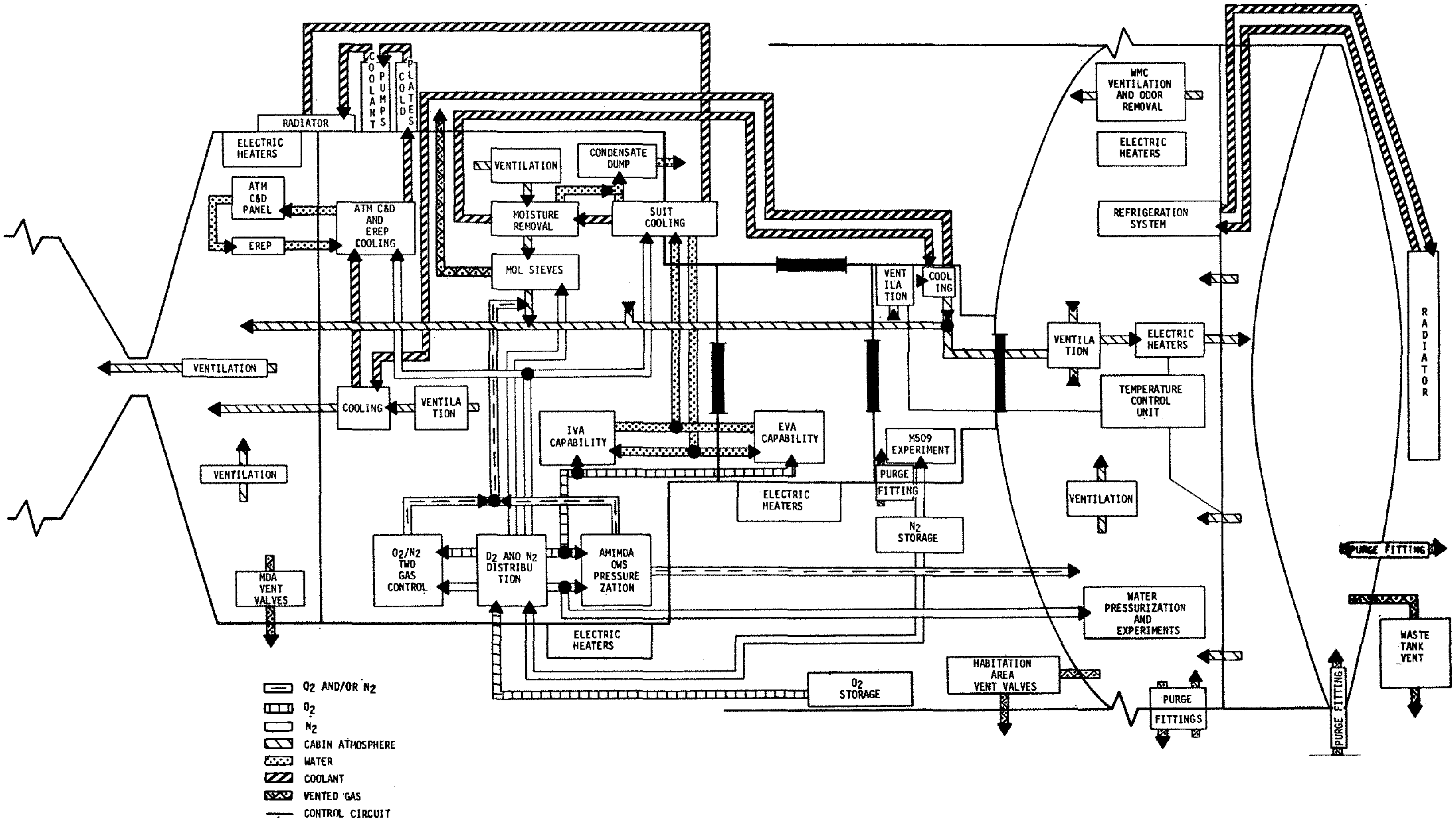


Figure 2.4.1-2 ECS Flow Diagram

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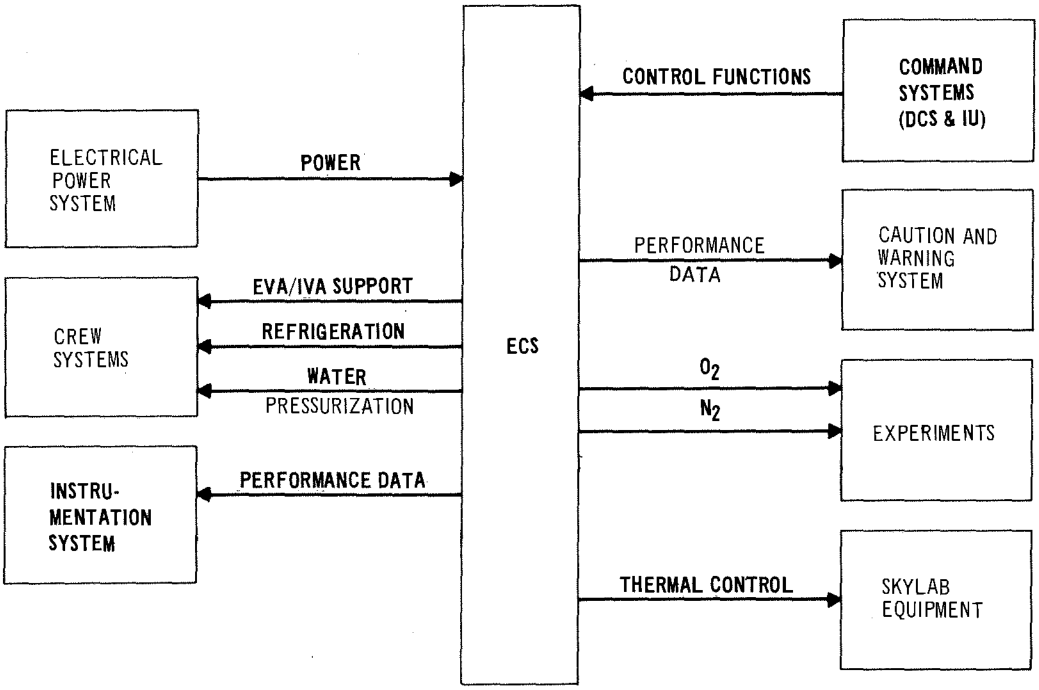


Figure 2.4.2-1 ECS Interfaces

EVA/IVA support is provided through an open-loop oxygen flow system and a closed-loop chilled water system. Provisions for depressurization and repressurization of the AM lock compartment are also provided to support EVA egress/ingress.

The refrigeration system provides for food refrigeration, food freezing, potable water cooling, urine chilling, and urine freezing.

A flow diagram of the ECS is shown in figure 2.4.1-2.

## 2.4.2 SYSTEM INTERFACES

The ECS interfaces (figure 2.4.2-1) with the electrical power system (EPS) for equipment operating power.

The instrumentation system senses ECS performance data. These data are routed to onboard ECS indicators, status lights, and to MSFN.

The ECS provides the caution and warning system (C&W) with certain parametric signals, which are monitored by the C&W for malfunction conditions.

The IU command system (during its 7.5-hour lifetime) and the AM digital command system (AM DCS) allow MSFN to control selected ECS functions with preprogrammed and real-time command capability. The command systems are used as primary control during the mission with manual control as backup during manned phases.

Coolant loops, insulation, surface coatings, and radiation shielding provide thermal stability for SWS equipment. The majority of the electrical and electronics equipment in the AM is mounted on coldplates through which coolant is routed to remove heat. A cooling water loop is used for the ATM C&D panel and EREP panel.

Two, independent, suit-cooling water systems provide astronaut cooling during EVA/IVA by furnishing a water supply life support umbilical (LSU) and a return for the water from the LSU. The ECS also supplies oxygen to the LSU for pressurizing the crewman's pressure garment assembly (PGA).

Nitrogen is provided to support experiments M509 (astronaut maneuvering equipment), T020 (foot-controlled maneuvering unit), M171 (metabolic activity), and the ESS (experiment support system).

A thermal interface between the crew systems and the refrigeration system is provided through food refrigeration, potable water chilling, urine refrigeration, urine freezing, and food freezing.

2.4.3 FUNCTIONAL DESCRIPTION

Although the five subsystems of the ECS operate in conjunction, each functional description is presented as an entity.

2.4.3.1 PRESSURIZATION AND GAS DISTRIBUTION

The pressurization and gas distribution system (figure 2.4.3-1) supports prelaunch purge, launch ascent, and orbit operations.

The AM/MDA/OWS are divided into three volumes: habitation area, waste tank, (both in the OWS), and combined MDA/AM for ground purging, launch, and initial in-orbit venting. All three are individually purged with dry N2 and maintained at a slight positive pressure.

Prior to launch, the habitation area and waste tank are independently pressurized to 24 psia. Within 5 minutes prior to launch, the MDA vent valves are opened to prevent the MDA/AM to ambient pressure from exceeding 6 psid during launch ascent. The vent valves close by automatic IU command at approximately 272 seconds after launch to entrap 0.50 psia of N2.

Approximately 30 seconds after orbit insertion, the habitation area and waste tank are simultaneously vented by automatic IU command. The waste tank vents remain open, allowing the waste tank to continuously vent to space. Habitation area venting is terminated by automatic IU command approximately 30 minutes after the start of venting to entrap 0.5 psia of N2. At the completion of venting, the temperature of the habitation area is approximately -200°F; as the atmosphere temperature increases to 70°F, the pressure increases to a minimum of 1 psia. The AM DCS is then used to pressurize the habitation area with O2 to 5 psia. At the completion of habitation area pressurization, the MDA/AM will be pressurized with O2 to 5 psia.

After CSM docking, pressures are equalized between the CSM and MDA, and the MDA is entered. The inlet port to the MDA vent valves is plugged and the two-gas control system is activated. This system will control the atmosphere total pressure at 5.0 $\pm$0.2 psia and PPO2 at 3.6 psia (nominal). After the habitation area is entered, two vent ports are plugged.

During manned mission operations, the pressurization and gas distribution system supplies the oxygen and nitrogen necessary for maintaining atmosphere pressure and O2/N2 mixture control. Oxygen is also supplied for metabolic consumption during EVA/IVA operations. Nitrogen is also supplied for pressurization of H2O reservoirs, molecular sieve operation, water system pressurization, and experiment operation. OA pressure is protected from overpressurization beyond 5.5 psid (nominal) by cabin pressure relief valves located in the CM and AM.

Reconfiguration of the pressurization and gas distribution system in preparation for the unmanned phase includes removal of the plug from the solenoid vent port in the OWS dome area. The OWS hatch remains open, allowing the combined MDA/AM/OWS to be treated as one volume. The O2/N2 control system is deactivated with the exception of the OWS and AM pressurization section, which is in the DCS control configuration. The 5 psia in the combined MDA/AM/OWS is vented to 2.0 psia after the crew departs, using the habitation area solenoid vent valves, and then allowed to decay to 0.75 psia by normal leakage. A minimum pressure of 0.75 psia is maintained by the OWS and AM pressurization section of the O2/N2 control system through the DCS.

Following each unmanned phase, the DCS is used to initiate pressurization of the MDA/AM/OWS to 5 psia with O2 and N2 to obtain a nominal PPO2 of 3.6 psia. Crew activation of the pressurization and gas distribution system for mission SL-3 differs from mission SL-1/2 in that the MDA/AM/OWS is a combined volume. Mission SL-4 deactivation and SL-4 activation are the same as mission SL-1/2 and SL-3, respectively.

2.4.3.2 THERMAL CONTROL

Active thermal control for AM-mounted equipment is provided during prelaunch activities by one of the two coolant loops (figure 2.4.3-2). The second cooling loop will be activated prior to launch. Coolant loop circulation bypasses the MDA/AM radiator and rejects heat via a ground-cooled heat exchanger. During ascent and orbital insertion, the loops (acting as a heat sink) continue to circulate coolant and provide cooling. After the payload shroud has been jettisoned, MSFN commands the radiator bypass valves to the normal position, allowing coolant to flow through the MDA/AM radiator which radiates coolant heat to space.

During the launch sequence, three groups of heaters are enabled: the MDA port, MDA wall and tunnel heaters, and AM wall heaters. These three heater groups are thermostatically controlled and, except for the tunnel heaters, remain enabled throughout the mission; however, usage is expected primarily during the unmanned phases. The OWS radiant heaters are required to maintain the OWS film vault and food storage containers at 40° to 85°F and are also used for initial warmup of the habitation area.

During the habitation phase, the coolant loops continue to provide AM equipment cooling. They also cool the atmosphere control subsystem, and the circulating water loops for EVA, the ATM C&D panel, and the EREP. Coolant temperature control during all mission phases is maintained by a suit battery cooling module. Three pumps are installed in each of the coolant loops for redundancy and operational flexibility. Normal operation has one pump operating in each of the two coolant loops. The equipment coldplates are plumbed to both loops.

The three cabin heat exchangers, operating in conjunction with the four heat exchangers located in the AM aft compartment, and the condensing heat exchangers used with the molecular sieves provide the means for atmosphere heat to be transferred from the atmosphere to the coolant loop fluid.

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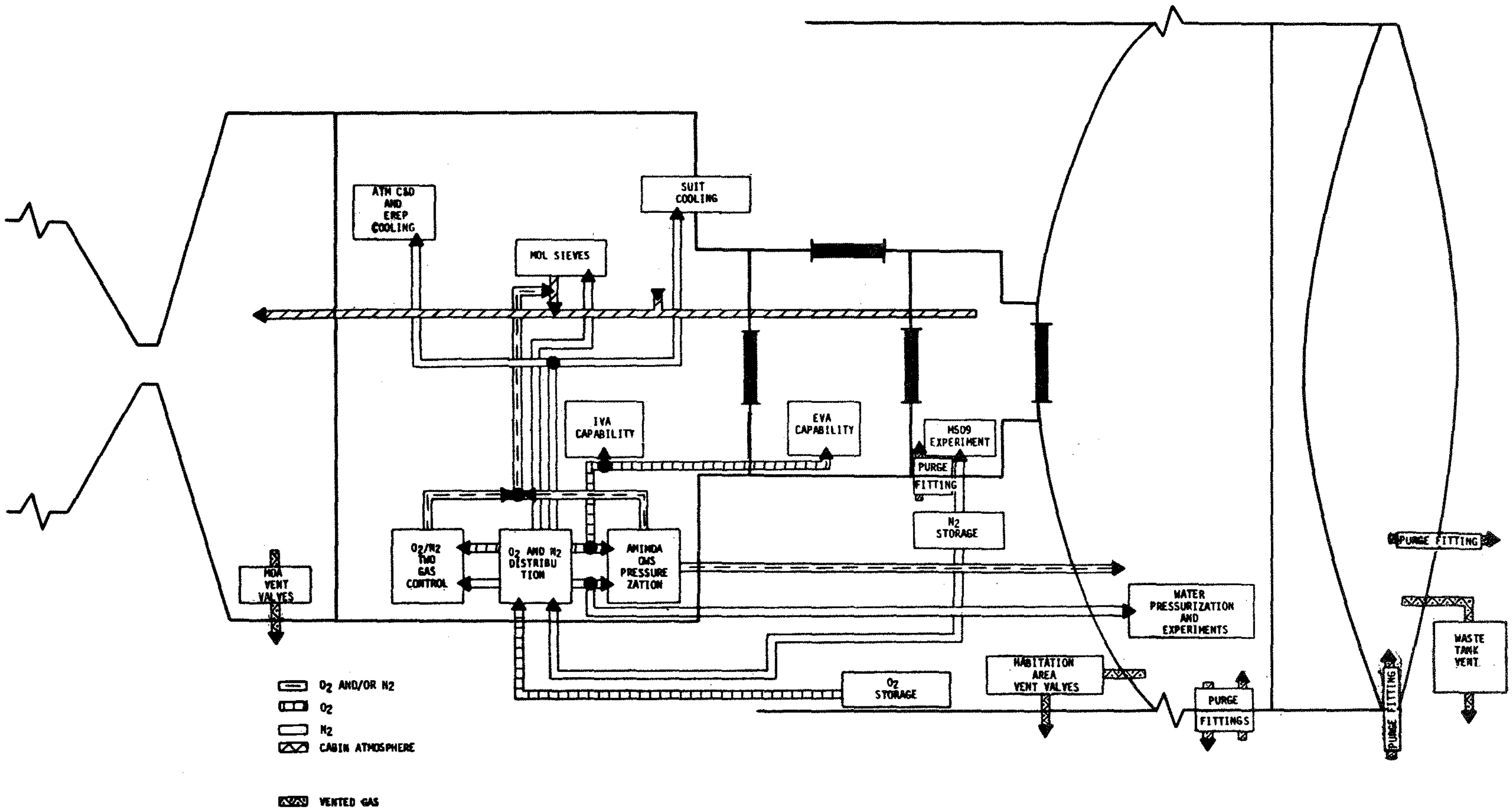


Figure 2.4.3-1 Pressurization and Gas Distribution

4042A

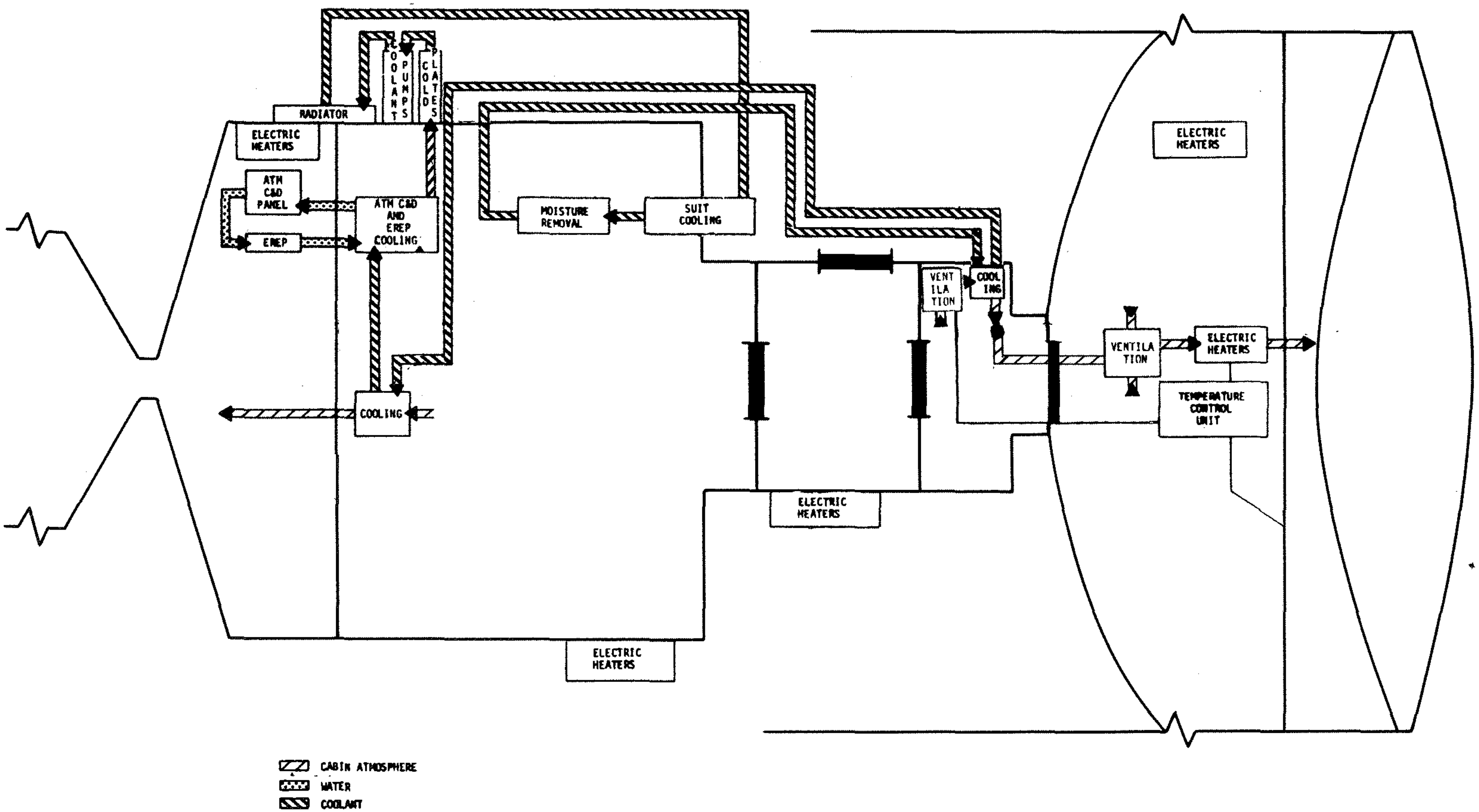


Figure 2.4.3-2 Thermal Control

Active temperature control of the habitation area during manned phases of the mission is maintained by a thermal control system, which provides manual or automatic control of heaters for heating or heat exchanger fans for cooling. Four 125-watt heaters are located in each of the three habitation area ventilation ducts. The heat exchanger fans are located in the AM aft compartment OWS cooling module and are part of the atmosphere control subsystem (paragraph 2.4.4.3.1).

During preparation for the unmanned phase, the habitation area thermal control system, the heat exchanger fans, and one coolant loop are deactivated. One coolant loop remains active during the unmanned phase to provide temperature stabilization and cooling for coldplate-mounted equipment. Automatic switchover is provided if the operative loop fails.

Heaters other than the OWS convective heaters are positioned to the command mode and controlled from the ground during storage and activation phases.

The passive thermal control system, consisting of insulation, thermal coating, and radiation shielding, requires no activation or deactivation. The passive system assists in maintaining thermal control through all phases of the mission.

2.4.3.3 ATMOSPHERE CONTROL

The atmosphere control system (figure 2.4.3-3) is inactive until crew entry of the SWS, at which time CSM/MDA circulation is provided by installation of the CSM/MDA interchange duct and activation of the CSM docking port fan. The two MDA area fans and the three AM circulation fans are activated to provide circulation and cooling through the MDA/AM. The CSM docking port fan and the AM fans function throughout the habitation phases, while the MDA area fans are normally operated only when crewmen are in the MDA. A fan upstream of each molecular sieve is activated to provide gas flow through a condensing heat exchanger and molecular sieve. Each molecular sieve provides odor removal and molecular sieve A is activated for carbon dioxide removal. The moisture removed in the condensing heat exchanger is stored in the condensate module and expelled to space when the module is full.

Gas flow from the molecular sieves is directed to the MDA until habitation area activation; then flow is directed to the habitation area. The AM duct fan is energized to supply a mixture of conditioned gas and ambient STS gas to the habitation area. Habitation area circulation is provided by 12 duct fans installed in the three habitation area ducts.

The habitation area thermal control system maintains the temperature of the habitation area atmosphere by controlling the AM aft compartment heat exchanger fans or habitation area duct heaters.

The waste management compartment (WMC) ventilation unit provides odor and contaminant removal and atmosphere circulation for the WMC. This system is normally used only during periods of WMC occupancy.

Three portable fans in the habitation area are available to provide extra ventilation if required.

During deactivation for the unmanned phase, the molecular sieve beds are baked out. Carbon dioxide ($CO_2$) removal continues by activation of the CM lithium hydroxide system. The solids traps and charcoal canisters are removed and stowed and new units are installed. Water in the condensate tank is dumped, and the condensing heat exchanger plates are dried. At crew egress, all fans are deactivated; the system is reactivated upon ingress for revisits.

2.4.3.4 EVA/IVA SUPPORT

EVA/IVA support (figure 2.4.3-4) is provided in the AM by a regulated oxygen supply, the suit cooling system, EVA and IVA panels, and life support umbilicals (LSU).

The EVA and IVA panels provide the interface between the LSU and the oxygen supply and liquid cooling garment (LCG) cooling water supply. Each panel can support two EVA/IVA crewmen through independent oxygen shutoff valves, oxygen supply quick disconnects (QD's) and cooling water inlet and outlet QD's.

Oxygen is provided to the pressure control unit (PCU) of the astronaut life support assembly (ALSA) through the LSU. The PCU (section 2.5.7) supplies oxygen to the crewman's pressure suit and exhausts gases from the suit to ambient through a non-propulsive vent.

Each of two independent suit-cooling systems consists of a water reservoir, redundant pumps, heat exchangers, and QD's for interfacing with the LSU's. QD's located on EVA and IVA panels 217, 317, and 323 provide an INLET for delivery of cooling water to the LSU and an OUTLET for return of cooling water from the LSU. The water loop is not normally utilized for IVA.

An EVA hatch is provided in the AM lock compartment for EVA. An equalization valve, which vents to ambient, is used to depressurize the AM lock compartment. The compartment is repressurized through two equalization valves, one in the AM lock compartment forward hatch and one in the aft hatch.

2.4.3.5 REFRIGERATION

The refrigeration system (RS) (figure 2.4.3-5) is a low-temperature thermal control system that uses a refrigerant fluid in a closed-loop circuit, dissipating heat through an externally mounted radiator. The RS provides for freezing of food and urine, and for chilling of food, urine, and potable water. The RS controls temperature through a range of +42° to -20°F; the particular temperature varies according to the function (freezing, chilling, etc.).

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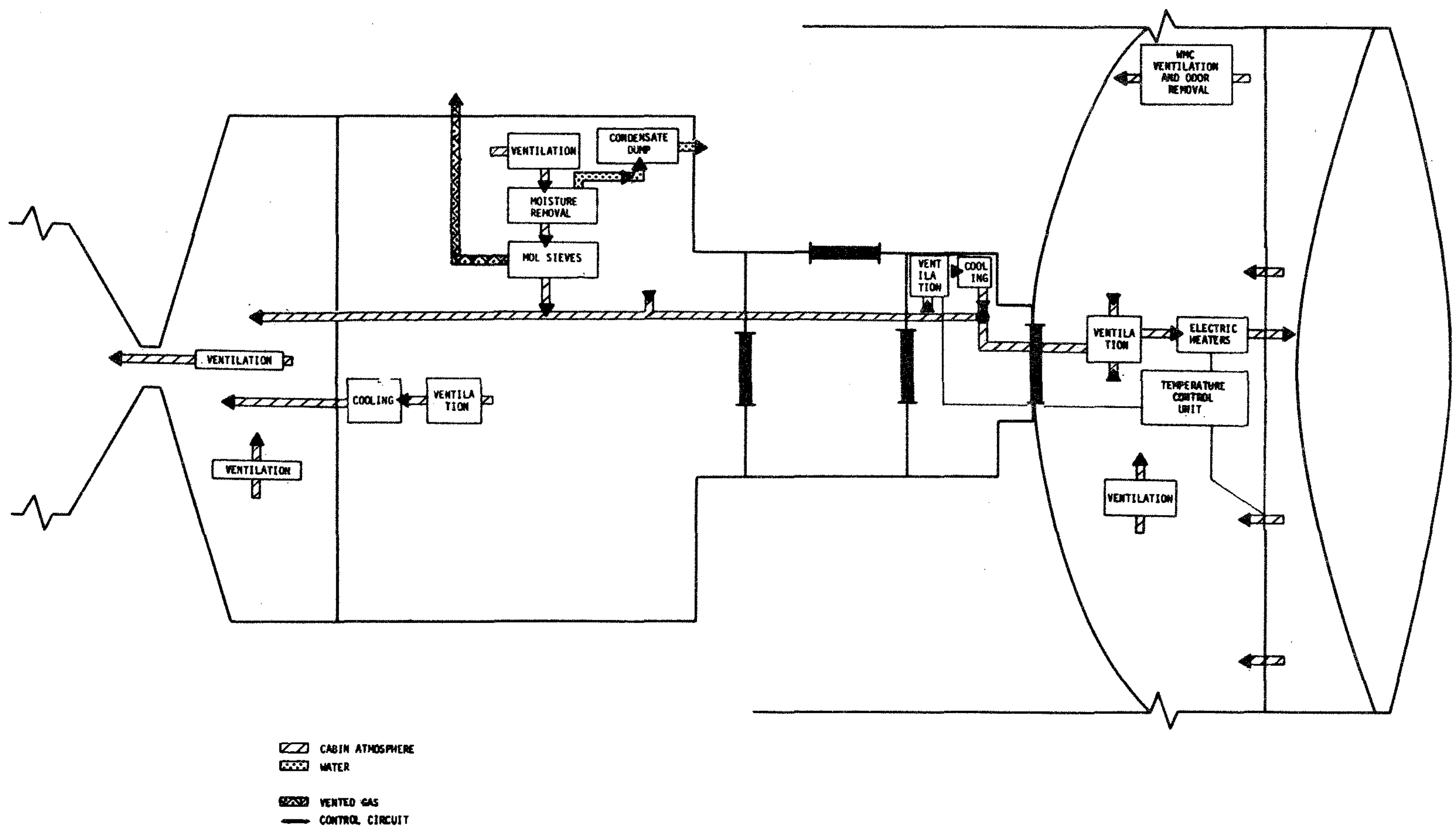


Figure 2.4.3-3 Atmosphere Control

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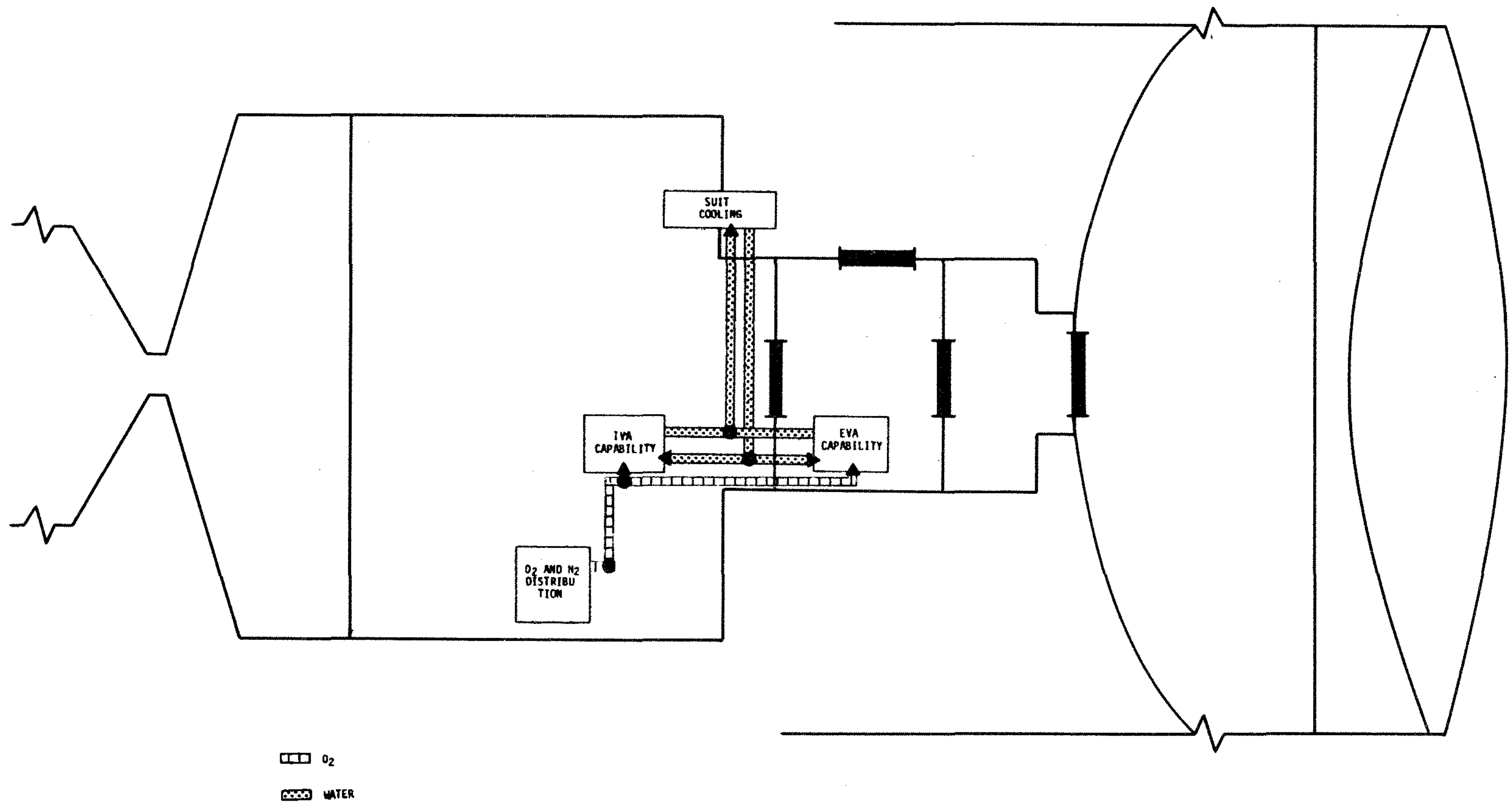


Figure 2.4.3-4 EVA/IVA Support

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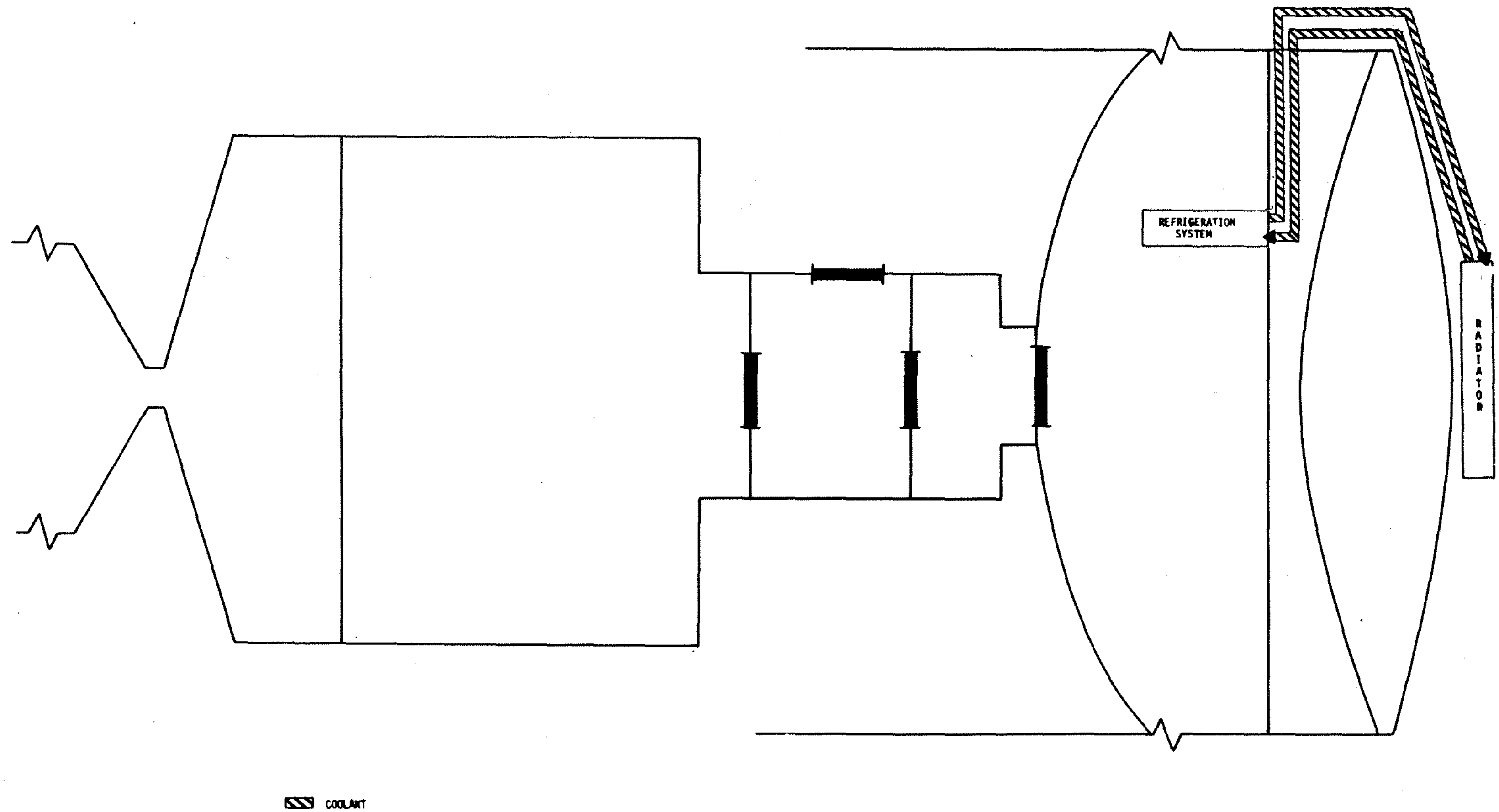


Figure 2.4.3-5 Refrigeration

Temperature control of the RS is initiated a short time before the mission food supply is placed in the OWS. A refrigerant pump is activated, and the radiator bypass valve is actuated to the bypass position. The heat from the RS is transferred through the ground cooling heat exchanger to a ground cooling cart via umbilicals. Prior to liftoff, the umbilicals are disconnected from the ground cooling heat exchanger, and power to the RS primary and secondary logic systems is disabled, causing the operating pump to be deactivated.

Following S-II stage separation, the RS radiator shield is jettisoned and the RS primary and secondary logic systems are enabled, causing pump No. 1 in the primary loop to be turned on. These functions are accomplished by automatic IU command. System heat loads are absorbed by a thermal capacitor until the RS radiator temperature drops to 0 ±2°F, activating the bypass valve to flow refrigerant through the radiator.

Normal operation and control of the RS during habitation is accomplished automatically by the RS controllers logic, which has the capability to select loops/pumps in the event of anomalies. Visual displays along with refrigeration system pumps switches on panel 616 provide crew monitoring and backup control capabilities.

The RS remains operational during unmanned phases.

2.4.4 SUBSYSTEM AND MAJOR COMPONENT DESCRIPTION

2.4.4.1 PRESSURIZATION AND GAS DISTRIBUTION

The pressurization and gas distribution system is separated into seven functions for detailed description:

1. Purge and venting
2. O2/N2 storage
3. Oxygen distribution
4. Nitrogen distribution
5. AM/MDA/OWS pressurization
6. O2/N2 two-gas control system
7. Major component operation

2.4.4.1.1 Purge and Venting

The AM/MDA/OWS are divided into three separate volumes for SL-1 ground purging, launch, and initial in-flight venting (figure 2.4.4-1). These three volumes (the waste tank, habitation area, and combined MDA/AM) are purged and vented independent of one another. Purging of the three volumes is accomplished by using a ground support equipment (GSE) N2 source.

Prelaunch purging of the waste tank is through the waste tank pressure disconnect and out the 5-inch diameter vent port. This vent port is capped at the completion of the purge.

The habitation area is purged through the secondary outlet of the habitation area vent valve and out an opening in a port formerly used for hydrogen fill on the S-IV B. Both openings are capped after the purge.

The MDA/AM is purged (at a maximum rate of 10 lb/min) at the completion of the waste tank and habitation area purge, through a purge fitting in the AM aft compartment. Two redundant check valves located in the OWS hatch prevent the AM aft compartment pressure from exceeding the habitation area pressure by more than 0.5 psid. The check valves crack at 0.1 psid and are full flow, into the OWS, at 0.3 psid. Purge flow from the aft compartment is through the OWS gas interchange duct to the STS, and through open equalization valves in the forward and aft lock hatches to the STS. The purge gas flows from the STS to the MDA vent. The MDA vent system consists of two, motor-operated, 4-inch diameter valves. These valves are installed in series such that venting will be terminated even if only one valve closes. Each valve is independently controlled through the OWS switch selector with DCS backup capability. The inlet port to these valves is plugged during activation of SL 1/2 and remains in this condition throughout the remainder of the mission. At the completion of the purge, the fitting in the aft compartment is capped and the two MDA vent valves are closed.

There are three equalization valves in the AM lock compartment, each with a minimum effective flow area of 1.6 square inches. One, located in the internal hatch between the AM lock compartment and AM aft compartment, is used to equalize the pressure in these compartments. A second valve, located in the AM lock compartment forward hatch, is used to equalize the pressure between the AM forward compartment and the AM lock compartments. The third equalization valve, located in the AM lock compartment wall adjacent to the EVA hatch, is used to depressurize the compartment for EVA. These equalization valves have an operating handle located on each side of the valve and can, therefore, be opened and closed from either side of the mounting structure. To fully open the valve from the fully closed position, the handle is rotated 75 degrees, which, through bevel gears, causes the butterfly disc to rotate, opening the valve. To close the valve, reverse the direction. Each valve has a screen at the valve inlet on each side that catches debris. The inlet on the lock compartment side of each valve also has a removable pressure cap.

The waste tank pressure disconnect is used for prelaunch pressurization of the waste tank to a nominal 24 psia. The waste tank is vented through two, diametrically-opposed, 1.5-inch diameter ducts, approximately 11 inches long, installed in the sides of the waste tank (figure 2.4.4-2). The vent ducts have blanket heaters around the exterior to prevent water from freezing in the duct. Each duct has a primary and secondary heater element, 11.3 watts each. The primary element has an operating thermostat that opens at 97° ±5°F and closes at 47°±5°F. The secondary element has an operating thermostat that opens at 52°±5°F and closes at 37°±5°F. A pressure cap, retained by two redundant pneumatic actuators, is provided on each duct to retain tank pressure until venting is required. Pressure to the pneumatic actuators is provided through an actuation control module from a pneumatic sphere. Each actuation control

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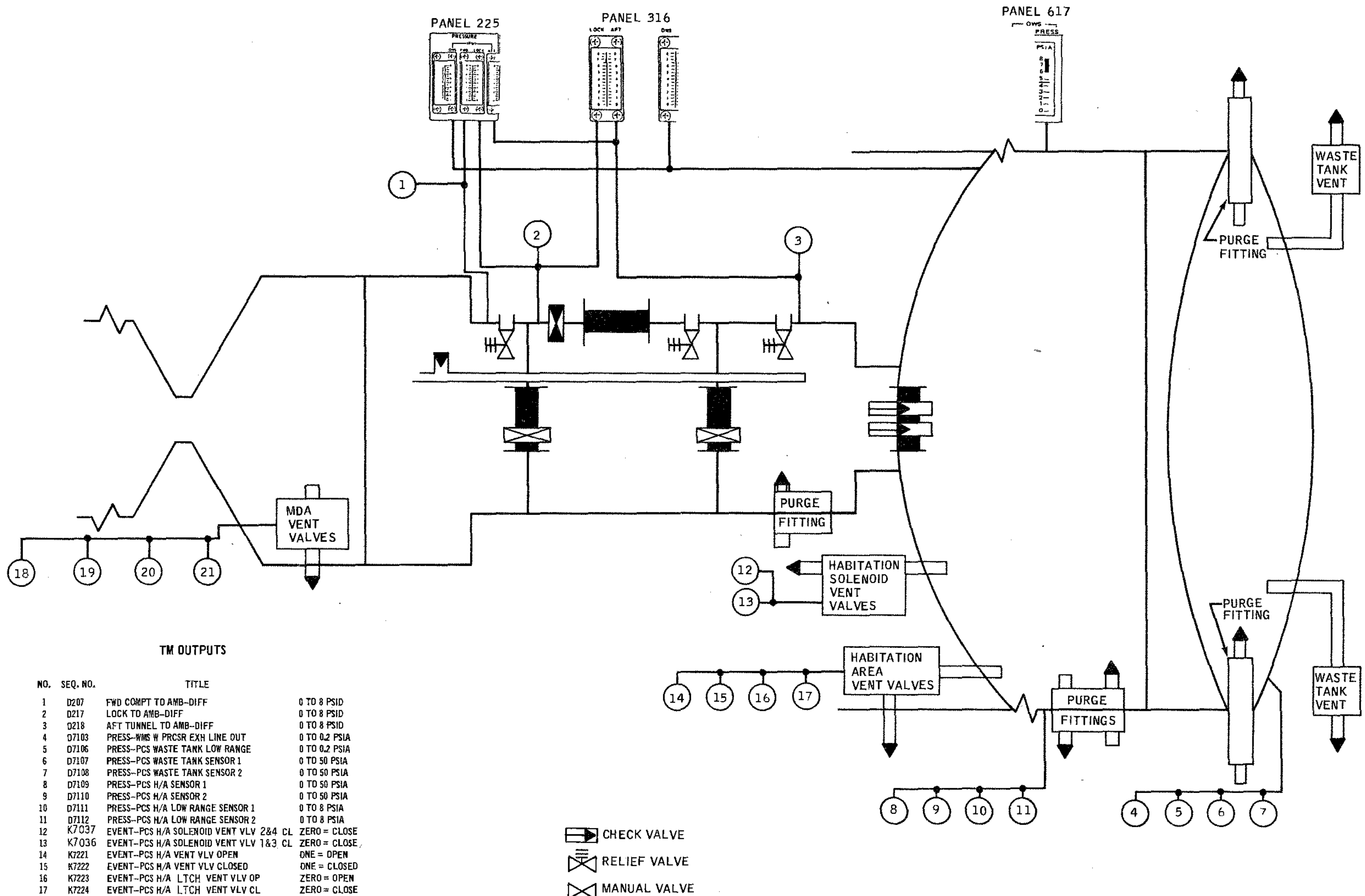



### TM OUTPUTS

| NO. | SEQ. NO. | TITLE | |
|---|---|---|---|
| 1 | D207 | FWD COMPT TO AMB-DIFF | 0 TO 8 PSID |
| 2 | D217 | LOCK TO AMB-DIFF | 0 TO 8 PSID |
| 3 | D218 | AFT TUNNEL TO AMB-DIFF | 0 TO 8 PSID |
| 4 | D7103 | PRESS-WMS W PRCSR EXH LINE OUT | 0 TO 0.2 PSIA |
| 5 | D7106 | PRESS-PCS WASTE TANK LOW RANGE | 0 TO 0.2 PSIA |
| 6 | D7107 | PRESS-PCS WASTE TANK SENSOR 1 | 0 TO 50 PSIA |
| 7 | D7108 | PRESS-PCS WASTE TANK SENSOR 2 | 0 TO 50 PSIA |
| 8 | D7109 | PRESS-PCS H/A SENSOR 1 | 0 TO 50 PSIA |
| 9 | D7110 | PRESS-PCS H/A SENSOR 2 | 0 TO 50 PSIA |
| 10 | D7111 | PRESS-PCS H/A LOW RANGE SENSOR 1 | 0 TO 8 PSIA |
| 11 | D7112 | PRESS-PCS H/A LOW RANGE SENSOR 2 | 0 TO 8 PSIA |
| 12 | K7037 | EVENT-PCS H/A SOLENOID VENT VLV 2&4 CL | ZERO = CLOSE |
| 13 | K7036 | EVENT-PCS H/A SOLENOID VENT VLV 1&3 CL | ZERO = CLOSE |
| 14 | K7221 | EVENT-PCS H/A VENT VLV OPEN | ONE = OPEN |
| 15 | K7222 | EVENT-PCS H/A VENT VLV CLOSED | ONE = CLOSED |
| 16 | K7223 | EVENT-PCS H/A LTCH VENT VLV OP | ZERO = OPEN |
| 17 | K7224 | EVENT-PCS H/A LTCH VENT VLV CL | ZERO = CLOSE |
| 18 | K0001 | EVENT-VENT VLV 1 OPEN | ONE = OPEN |
| 19 | K0002 | EVENT-VENT VLV 1 CLOSED | ZERO = CLOSED |
| 20 | K0003 | EVENT-VENT VLV 2 OPEN | ONE = OPEN |
| 21 | K0004 | EVENT-VENT VLV 2 CLOSED | ZERO = CLOSED |

Figure 2.4.4-1 Purge and Venting

4049

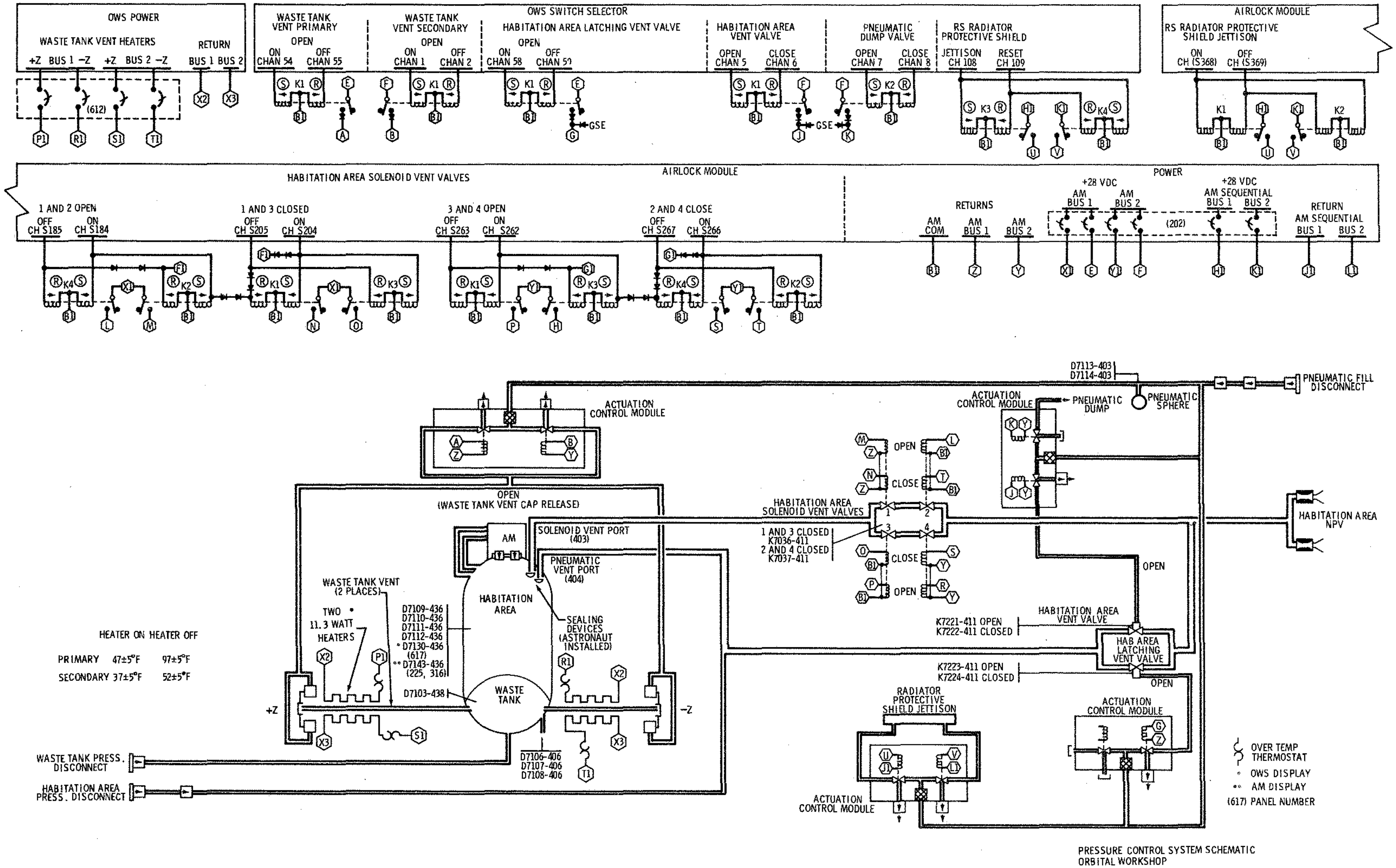



Figure 2.4.4-2 Habitation Area and Waste Tank Venting

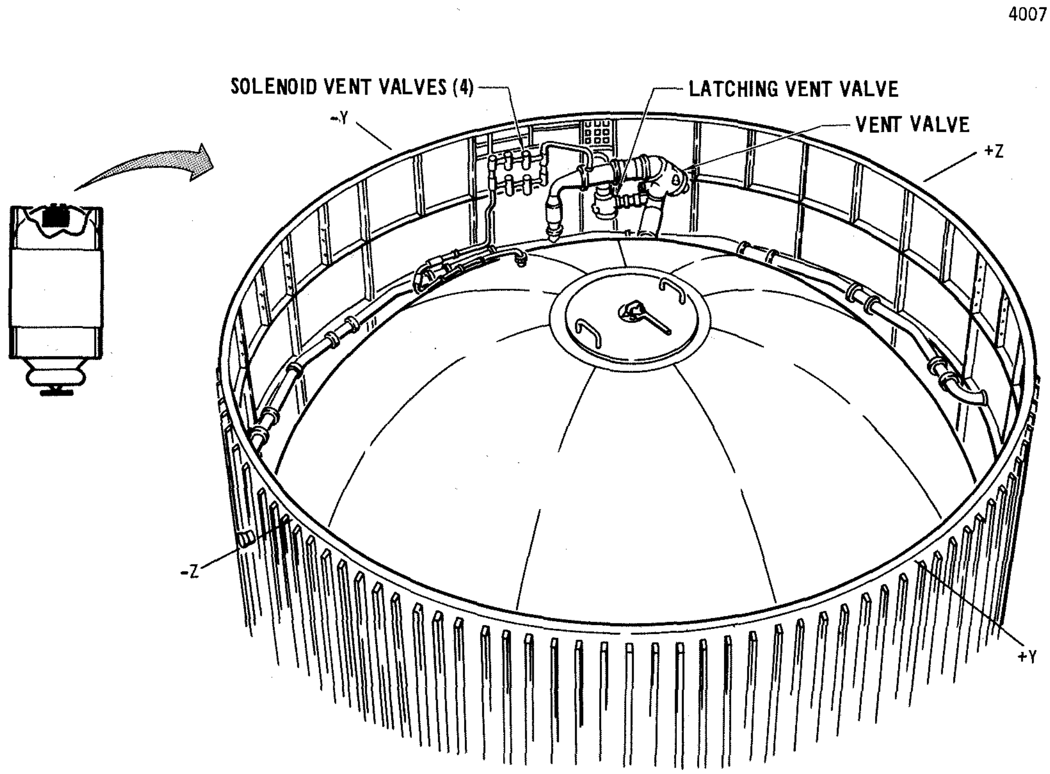



Figure 2.4.4-3 Habitation Area Non-Propulsive Vent

module consists of two 3-way solenoid valves. Energizing of the solenoids by IU command through the OWS switch selector allows pressure to be applied to the pneumatic actuators, which will rotate the cap away from the vent ducts. Tank pressure will also assist in releasing the cap. The cap will be retained after ejection. The actuation control module solenoids are then deactivated, which vents the line from the pneumatic actuators to the solenoid. The waste tank will remain vented throughout the remainder of the mission.

Pre-launch pressurization of the habitation area to a nominal 24 psia with GSE N2 is through the habitation area pressurization disconnect during the prelaunch sequence. The habitation area vent system utilizes two sets of valves: 1) a pair of parallel-redundant, normally closed, pneumatically actuated valves used for initial blowdown and 2) a set of quad-redundant latching solenoid valves used for venting during preparation for the unmanned phase (figure 2.4.4-3). The two sets of valves exhaust into a common manifold that divides into two equal-length wrap-around ducts. Each duct terminates in an orifice plate that is in a plane perpendicular to the OWS centerline and are directed 180 degrees apart so venting is non-propulsive. The habitation area vent valve and latching vent valve are each controlled by one solenoid valve of an actuation control module. Energizing the solenoid valve provides pneumatic pressure to open the vent valve. De-energizing the solenoid valve vents the pressure from the vent valve, allowing it to close. The habitation area vent valve and latching vent valve also act as relief valves, with a maximum cracking pressure of 26 psia and a minimum reseat pressure of 23 psia.

Control of the actuation control module solenoid valves is from the IU through the OWS switch selector.

Pneumatic pressure to the actuation control module solenoid valves is supplied from a 4.5 cubic foot pneumatic sphere. The sphere is pressurized prior to liftoff to 495 psia with N2. The minimum pressure required for habitation area vent valve actuation is 70 psia with the habitation area at 5 psia. The remaining solenoid valve in the actuation control module used for the habitation area vent valve is utilized to vent the pneumatic sphere, both during ground operations and at the completion of its orbit use.

To provide for habitation area venting during the unmanned phase four latching-type solenoid vent valves are provided. These valves are series/parallel connected in a habitation area vent line separate from the line used with the latching vent valve and the vent valve. Open/close control of these solenoid vent valves is through the DCS. The valves are controlled in series pairs for open and in parallel pairs for close.

Both vent ports in the habitation area are sealed with sealing devices by the crew when they first enter the area. The sealing device in the vent port leading to the habitation area solenoid vent valves is removed prior to the unmanned phase to permit DCS-controlled depressurization of the SWS.

Three cabin pressure relief valves located in the AM forward, lock, and aft compartments limit pressure in these compartments, the MDA and the OWS, (when open to the AM) to a maximum of 6.0 psia.

2.4.4.1.2 O2/N2 Storage

Sufficient oxygen (O2) and nitrogen (N2) is launched with SL-1 to satisfy requirements for missions SL-1/2, 3, and 4 (table 2.4.4-1). The O2 is stored in six tanks mounted to the fixed airlock shroud (figure 2.4.4-4). The tanks are 45-inch diameter cylinders, 90 inches long. They have elliptical ends and are constructed of fiberglass over a welded thin metallic liner. The six oxygen tanks are manifolded together through check valves to provide 5611 pounds of oxygen (initially at 3000 psia) of which 4930 pounds are usable at normal flow rates. The N2 is stored in six 40-inch-diameter titanium spheres mounted on the AM trusses. The six tanks provide 1511 pounds of nitrogen at 3000 psia of which 1320 pounds are usable at normal flow rates.

Each nitrogen and oxygen tank (figure 2.4.4-5) has an outlet assembly consisting of a fill valve, a check valve, and two pressure transducers. The pressure transducers provide two inputs to telemetry and one input to an onboard display. Two temperature sensors (one for telemetry, the other for display) are provided for each oxygen and nitrogen tank. The O2 and N2 tank displays are located on the O2/N2 control panel 225. The pressure transducer and temperature sensor outputs for any one of the six oxygen tanks are selected by the O2 BOTTLES indicator selector and displayed on the O2 BOTTLES (PSI x 10) and O2 BOTTLES (°F) indicators. The pressure transducer and temperature sensor outputs for any one of the six nitrogen tanks are selected by the N2 BOTTLES indicator selector and displayed on the N2 BOTTLES (PSI x 10) and N2 BOTTLES (°F) indicators.

2.4.4.1.3 Oxygen Distribution

Oxygen from the oxygen storage tanks (figure 2.4.4-5) is directed through a 10 micron filter. The filter has an integral relief valve (crack to full flow 40 to 50 psid, reseat by 30 psid minimum) installed across the inlet and outlet. The outlet of the filter is routed to parallel latching type solenoid valves and a bleed orifice. The bleed orifice allows 0.01 lb/hr flow to bypass closed solenoid valves. The bleed flow keeps the line from the latching solenoid valves to the 120 psig regulator assembly pressurized when there is no demand on the O2 system. Keeping this line pressurized prevents compressive heating in the line when a solenoid valve is opened. The solenoid valves are controlled through the O2 BOTTLES - PRI and SEC switches on panel 225; these switches provide manual open, close, or command capability. The CMD position allows the solenoid valve to be opened or closed via DCS command. The flow from the solenoid valves is routed through an orifice that limits the flow rate to 5 lb/min maximum and on to the 120-psig regulator assembly.

The 120 psig regulator assembly has a 10-micron inlet filter and two parallel paths, each path containing a toggle valve, a 120±10 psig-regulator, a relief valve (maximum cracking pressure of 170 psig and minimum reseat pressure of 150 psig) and a check valve. Use of either regulator provides a minimum of 22.7 lb/hour total flow. The outlets of the check valves are connected, and routed past two 0-200 psia transducers. One has an output to telemetry and display O2/N2 CONTROL SYSTEM O2 indicator panel 225 and the other has an output to display PRESSURE (PSI) O2 indicator panel 316. The gas flow proceeds through the coolant heat exchanger and is warmed by the coolant. The O2 then divides into three paths, with one path going through an oxygen flow controlling orifice (22.65 lb/hr) to the MDA/AM/OWS pressurization system (paragraph 2.4.4.1.5). The second path directs O2 flow through two series-mounted check valves to the O2/N2 two-gas control system (paragraph 2.4.4.1.6). The third path delivers O2 to the STS IVA panel 217 and the two AM lock compartment EVA panels 317 and 323. Each panel is divided into two O2 sections, each consisting of a shutoff valve, orifice, quick disconnect, and pressure cap.

2.4.4.1.4 Nitrogen Distribution

N2 from No. 1 and 2 nitrogen storage tanks (figure 2.4.4-5) is routed through check valves (manifolded together) and routed to the M509 bottle recharge station (panel 390).

N2 from No. 3, 4, 5, and 6 nitrogen storage tanks is routed through check valves (manifolded together) and routed to the M509 recharge station and to the O2/N2 control system panel 225. Each supply to the M509 recharge station passes through an orifice (5 lb/min) and a shutoff valve to a bleed shutoff valve and the M509 recharge qd. The nitrogen routed to the O2/N2 control system panel 225 passes through a 10 micron filter. The filter has an integral relief valve (crack to full flow 40 to 50 psid, reseat by 30 psid minimum) across the inlet and outlet. The flow from the filter is routed to two, parallel, latching-type solenoid valves. The solenoid valves are controlled through the N2 BOTTLES - PRI and SEC switches on panel 225 provide manual open, close or command capability. The CMD position allows a solenoid valve to be opened or closed via DCS command. The outlets from the solenoid valves are joined and routed through an orifice (5.0 lb/min) to the 150-psig regulator assembly. This assembly contains a 10-micron inlet filter and two parallel paths. Each path contains a toggle valve, a 150±10 psig-regulator, a relief valve (open, meet full flow, and reseat 180 to 210 psig) with relief port routed overboard, and a check valve. Use of either regulator provides a minimum of 22.7 lb/hr. The outlets of the check valves are connected and routed past a 0 to 225 psia transducer, with an output to telemetry and to display O2/N2 CONTROL SYSTEM N2 indicator on panel 225. The N2 flow then divides into five paths, with one path going through an orifice (6.95 lb/hr) to the MDA/AM/OWS pressurization system (paragraph 2.4.1.5). A second path directs N2 through parallel manual shutoff valves to the two molecular sieves where the N2 is used for pneumatic control of the gas selector valves. A third path provides N2 to a 5-psia regulator assembly.

The 5-psia regulator assembly has a 25-micron inlet filter and two parallel paths. Each path flows up to 0.05 lb/hr and contains a toggle valve, a pressure regulator (5.0±0.2 psia), a relief valve (open at 6.2 psid max., close at 5.8 psid max.), and a 25-micron filter. The outlets of the filter are connected and routed past a 0 to 8 psia pressure transducer (output to telemetry to the gas side of the two EVA/IVA cooling reservoirs and the ATM cooling reservoir). The fourth path directs N2 to a three-position selector valve, which is part of the O2/N2 two-gas control system (paragraph 2.4.4.1.6). The remaining flow path provides N2 through a manual shutoff valve and orifice (13.5 lb/hr) to the water system pressurization panel 500 located in the OWS.

TABLE 2.4.4-1 02 AND N2 SUMMARY

4066

| CONSUMABLES | SL 1/2 (28 DAYS) | | SL 1/3 (56 DAYS) | | SL 1/4 (56 DAYS) | |
|---|---|---|---|---|---|---|
| | $O_2$ (LB) | $N_2$ (LB) | $O_2$ (LB) | $N_2$ (LB) | $O_2$ (LB) | $N_2$ (LB) |
| METABOLIC $O_2$ (2.0 LB/MAN-DAY) | 168 | | 336 | | 336 | |
| LEAKAGE △1 (14 LB/DAY TOTAL, 10.712 LB/DAY $O_2$, 3.288 LB/DAY $N_2$) | 300 | 92 | 600 | 184 | 600 | 184 |
| CSM 2.4 LB/DAY TOTAL | | | | | | |
| CSM/MDA INTERFACE 1.2 LB/DAY TOTAL | | | | | | |
| ONE MDA DOCKING PORT 0.2 LB/DAY TOTAL | | | | | | |
| MDA 1.8 LB/DAY TOTAL | | | | | | |
| AM/MDA INTERFACE 0.6 LB/DAY TOTAL | | | | | | |
| AM 2.8 LB/DAY TOTAL | | | | | | |
| OWS 5.0 LB/DAY TOTAL | | | | | | |
| MOLECULAR SIEVE △4 (3.48 LB/DAY TOTAL, 2.62 LB/DAY $O_2$, 0.86 LB/DAY $N_2$) | 73 | 24 | 147 | 48 | 147 | 48 |
| AM AND MDA PRESSURIZATION △1 (1764 CU FT AT 40°F) | 39 | 12 | 39 | 12 | 39 | 12 |
| OWS PRESSURIZATION △1 (9550 CU FT AT 40°F) | 212 | 65 | 212 | 65 | 212 | 65 |
| EVA LOCK REPRESSURIZATION △1 (154 CU FT AT 50°F WITH 4 REPRESS CYCLES FOR SL 1/2 AND 7 EACH FOR SL 1/3 AND SL 1/4) | 12.8 | 4 | 22.4 | 7 | 22.4 | 7 |
| EVA $O_2$ (9.0 LB/MAN HOUR WITH 10 MAN HOURS FOR SL 1/2 AND 18 MAN HOURS FOR SL 1/3 AND 12 MAN HOURS FOR SL 1/4 | 90 | | 162 | | 108 | |
| EXPERIMENTS △2 △3 | 41 | 12 | 84 | 26 | 84 | 26 |
| OWS DRINKING WATER TANK PRESSURIZATION | | 5 | | 9 | | 9 |
| LEAKAGE FROM $O_2$ AND $N_2$ SUPPLY TANKS AND SYSTEM (INCLUDES SUBSEQUENT ORBIT STORAGE PERIOD) | 7 | 3 | 7 | 3 | 4 | 2 |
| MISSION TOTALS | 943 | 217 | 1609 | 354 | 1552 | 353 |
| THREE MISSION $O_2$ TOTAL | 4104 | | | | | |
| THREE MISSION $N_2$ TOTAL | 924 | | | | | |

△1 BASED ON 5.0 PSIA TOTAL PRESSURE WITH $PPO_2$ – 3.7 PSIA AND $PPN_2$ – 1.3 PSIA AND LEAKAGE DATA

△2 REQUIREMENTS SHOWN BASED ON GAS LOSS OVERBOARD FROM M092 EXPERIMENT. ALL OTHER EXPERIMENT $O_2$ AND $N_2$ USAGE CREDITED TO LEAKAGE

△3 DATA OBTAINED FROM MSFC

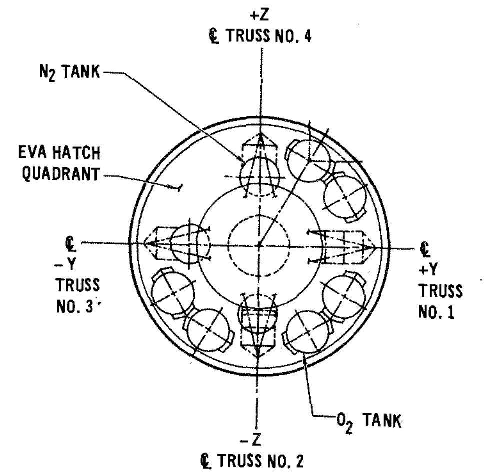
△4 BASED ON OPERATION OF ONE MOLECULAR SIEVE SYSTEM AND MAXIMUM GAS LOSS RATES MEASURED DURING DEVELOPMENT TESTS WITH 1.25 FACTOR APPLIED

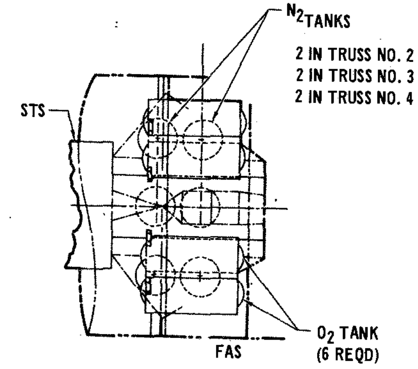
## STORED QUANTITIES

| | $O_2$ – LB | | $N_2$ – LB | |
|---|---|---|---|---|
| | EACH TANK | 6 TANK TOTAL | EACH TANK | 6 TANK TOTAL |
| CAPACITY AT 3000 PSIA AND 100°F | 936 | 5611 | 251 | 1511 |
| RESIDUAL AT 300 PSIA AND 0°F | 114 | 681 | 31 | 191 |
| USABLE AT NORMAL FLOW RATES | 822 | 4930 | 220 | 1320 |
| CONSUMABLES REQUIRED | | 4104 | | 924 |
| MARGIN | | 826 | | 396 |

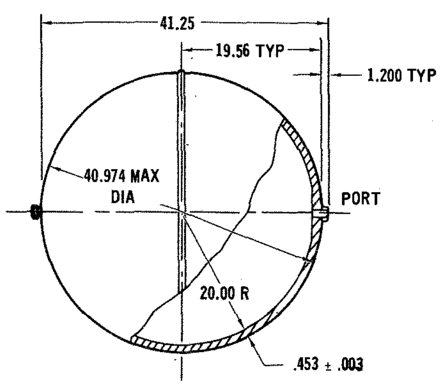
EACH $O_2$ TANK VOLUME 57 CU FT
EACH $N_2$ TANK VOLUME 19.3 CU FT

4339




## NITROGEN TANK (SPHERICAL)




| | |
|---|---|
| VOLUME | 19.3 CU FT |
| WEIGHT (DRY) | 393 LB |
| OPERATING PRESSURE | 3000 PSIG |
| MATERIAL | TITANIUM |
| 251 LB $N_2$ AT 3000 PSIG, 100°F | (TOTAL) |
| 220 LB $N_2$ | (USABLE) |

## OXYGEN TANK

| | | | |
|---|---|---|---|
| VOLUME | – 57 CU FT | 936 LB $O_2$ AT 3000 PSIG, 100°F | (TOTAL) |
| WEIGHT (DRY) | – 2100 LB | 822 LB $O_2$ | (USEABLE) |
| OPERATING PRESSURE | – 3000 PSIG | | |
| RATED PRESSURE | – 4500 PSIG | | |
| MATERIALS | – 321 ST. STL. LINER WITH FIBERGLAS WRAP | | |

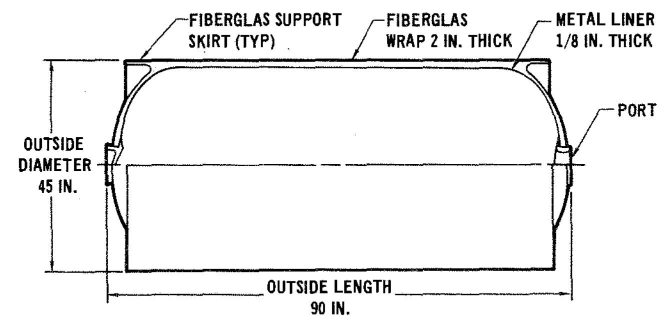
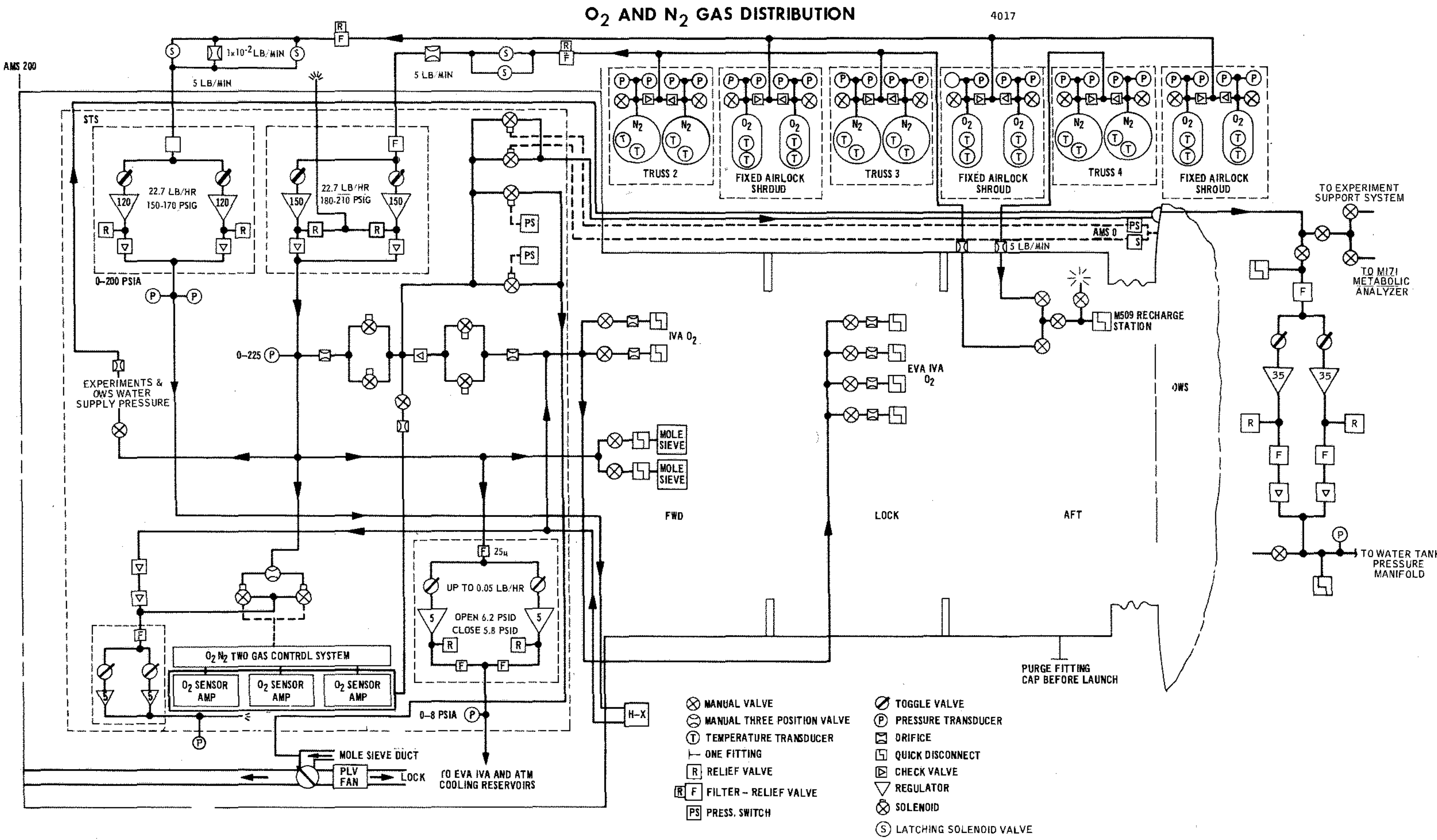



Figure 2.4.4-4 02/N2 Tank Arrangement




29

Figure 2.4.4-5 02 and N2 Gas Distribution

The flow in panel 500 divides, with each path directed through a manual shutoff valve. One shutoff valve supplies the M171 metabolic analyzer and ESS. The outlet from the remaining shutoff valve divides, one path to a quick disconnect and one path to the 35-psi regulator assembly. The 35-psi regulator assembly, panel 500, consists of a 10-micron inlet filter and two parallel paths, each path containing a toggle valve, a 35±2-psig regulator, a relief valve (crack 45±2 psig, reseat 43 psig minimum), a 10-micron filter, and a check valve. The outlets of the check valves are connected, and the flow again divides. One path goes through a manual PRESSURE BLEED valve to the cabin and the other path to the 35 PSI N2 PORTABLE WATER TANK PRESSURIZATION quick disconnect and the water tank pressure manifold. This manifold supplies the 10 water containers and has a 0 to 75 psia transducer with output to telemetry.

2.4.4.1.5 MDA/AM/OWS Pressurization System

The MDA/AM/OWS pressurization system (figure 2.4.4-6) is used for on-orbit pressurization of the OWS and/or the MDA and AM. The system can be controlled via DCS command or manually by using switches on the O2/N2 control system, panel 225. The O2 used for MDA/AM/OWS pressurization is supplied from the 120-psig regulator, through an orifice to two parallel O2 fill solenoid valves and a check valve, which then connects with the outlet from the two parallel N2 fill solenoid valves. Individual control of the two O2 and two N2 fill solenoids is provided by DCS or O2 FILL PRI, O2 FILL SEC, N2 FILL PRI, and N2 FILL SEC switches located on the O2/N2 control system panel 225. The combined oxygen and nitrogen line divides, one line to the MDA/AM/OWS pressurization manifold and one line through a shutoff valve and orifice (1x10-3 lb/hr) to the partial pressure oxygen (PPO2) sensor assembly.

The MDA/AM/OWS pressurization manifold has four outlets. Each outlet is routed through a solenoid operated valve. Two of the outlets from OWS fill solenoids are then connected and routed to the OWS forward dome for habitation area pressurization. The two remaining solenoid outlets from AM fill solenoids are connected and routed to the molecular sieve outlet duct for AM/MDA pressurization. Each of the four normally closed solenoids is controlled by its open/close/command switch on panel 225. When a switch is in the CMD position, the "open" ground command is sent through a pressure switch to the valve. Each pressure switch de-energizes one of the valves when the internal pressure reaches 5.0±0.2 psia.

For DCS-controlled pressurization all shutoff valves on the O2/N2 control system panel, which control nitrogen and oxygen flow from the storage tanks to the pressurization solenoid valves, must be open. With both oxygen and nitrogen supplied to the pressurization manifold the system provides pressurization of the AM/MDA and OWS to 5.0 psia with an O2/N2 gas mixture of approximately 74 percent oxygen and 26 percent nitrogen. The flow of oxygen and of nitrogen are controlled by the respective orifices. Calculations indicate the MDA and AM will be pressurized from 0.5 to 5 psia in 1.7 hours and the OWS within 9.3 hours in a sequential operation (11 hours for total duration). Individual pressurization of the OWS or AM with oxygen only or nitrogen only is accomplished through proper selection of the O2 fill, N2 fill, OWS fill, or AM fill solenoids.

2.4.4.1.6 O2/N2 Two-Gas Control System

The two-gas control system maintains oxygen partial pressure at 3.6±0.3 psia and controls the total pressure to 5.0±0.2 psia. The 120-psig oxygen supply entering the control system from the two series-mounted check valves (figure 2.4.4-7) connects to a nitrogen line. The 150-psig nitrogen supply entering the control system is controlled by the three-position [PRI-OFF-SEC] selector valve, panel 225. This valve allows the nitrogen to be shut off or directs the nitrogen to either of two nitrogen solenoid valves.

A switch operating in conjunction with the three-position valve provides an electrical path for controller power to operate the selected nitrogen solenoid valve. The solenoid valve outlets are connected together and routed to the oxygen line. The combined oxygen/nitrogen line routes the gas through a 10-micron filter to the 5-psia cabin pressure regulator assembly. The regulator assembly contains parallel manual shutoff valves and cabin pressure regulators. The two regulator outputs are manifolded together and exit behind panel 225.

Three PPO2 controller circuits are provided for redundancy. Each circuit consists of a PPO2 sensor, an amplifier, and a controller. The O2/N2 CONTROLLER selector on panel 225 is used to select one of the controller circuits to operate the selected nitrogen solenoid valve. The selected controller circuit also provides outputs to an O2/N2 CONTROLLER PPO2 (PSI) indicator (1, 2, or 3), telemetry, and the caution & warning system. The O2/N2 CONTROLLER MONITOR selector selects a controller circuit to provide outputs to an O2/N2 CONTROLLER PPO2 (PSI) indicator (1, 2, or 3), telemetry, and the caution & warning system. The caution & warning system PPO2 warning indication is triggered when the PPO2 drops below 155 mmHg (3 psia). The PPO2 sensed by the selected PPO2 sensor (O2/N2 CONTROLLER selector) is controlled between 3.3 and 3.9 psia. When the PPO2 drops near 3.3 psia, the selected nitrogen solenoid valve supplying N2 to the cabin pressure regulators is de-energized and closes. As the 150-psig N2 supply to the cabin pressure regulator bleeds below 120 psig through the regulators, the 120-psig O2 supply flows through the two check valves and supplies the cabin pressure regulators. The parallel redundant regulators exit into a common plenum, the outlet of which is orificed to limit flow to 1.15±0.15 lb/hr at 5 psia. Either or both of the regulators is capable of providing 1.0 to 1.3 lb/hr flow to maintain 5.0±0.2 psia. As the PPO2 increases toward 3.9 psia, the selected nitrogen solenoid is energized allowing the 150-psig N2 to be supplied to the cabin pressure regulators. The 150-psig N2 acting against the O2 check valves prevents 120-psig oxygen flow to the cabin pressure regulators.

Oxygen will be supplied to the cabin pressure regulators in case of electrical power failure, most types of solenoid valve failures, and loss of PPO2 sensor output. The cabin total pressure can exceed 5.2 psia and may be as high as 6.0 psia during extensive IVA and experiment operation. The increase in total pressure is accompanied by a corresponding increase in either PPO2 or PPN2. Total pressure is limited to 5.5 to 6.0 psia by the cabin pressure relief valves (figure 2.4.4-1).

4019

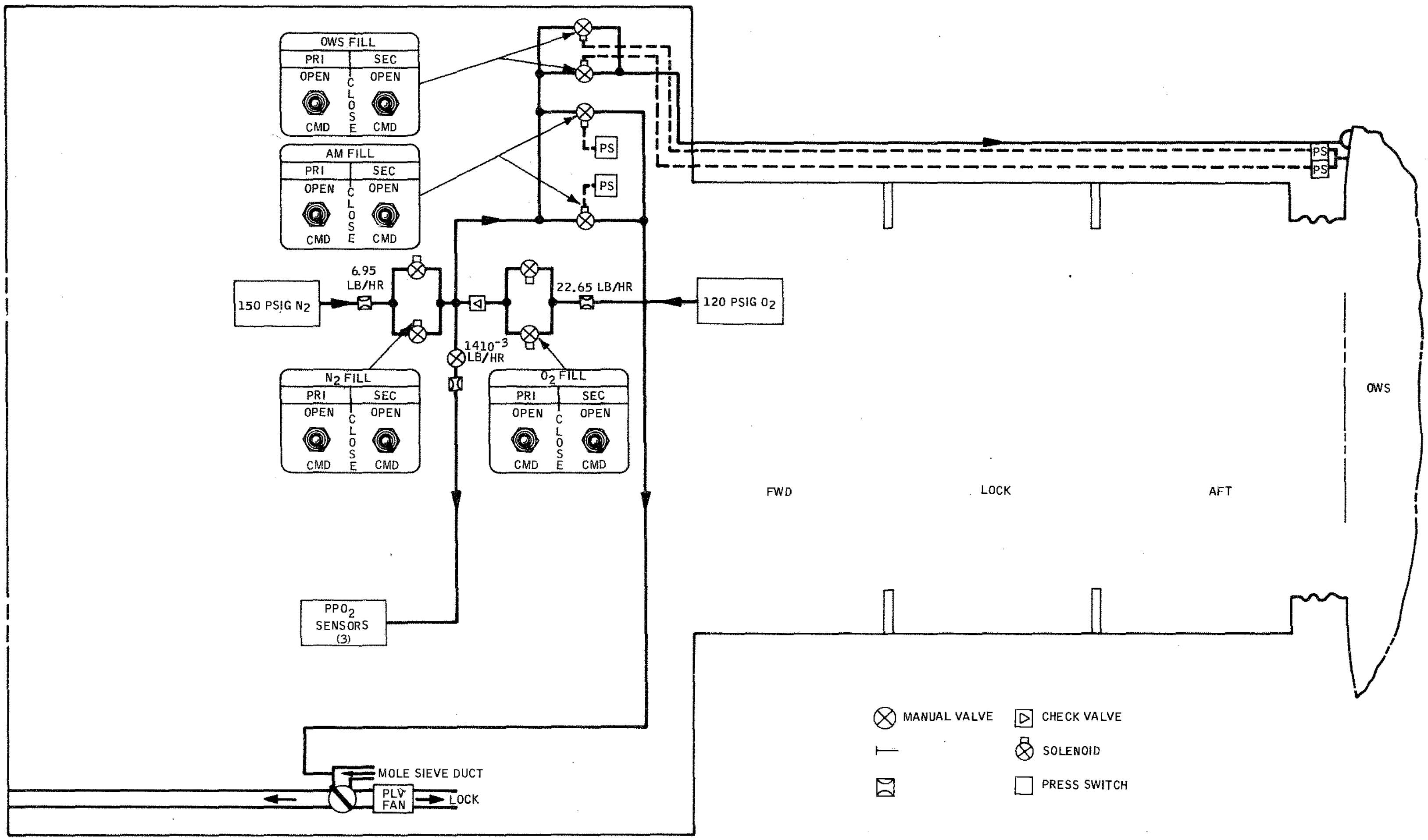



Figure 2.4.4-6 AM/MDA and OWS Pressurization

4001

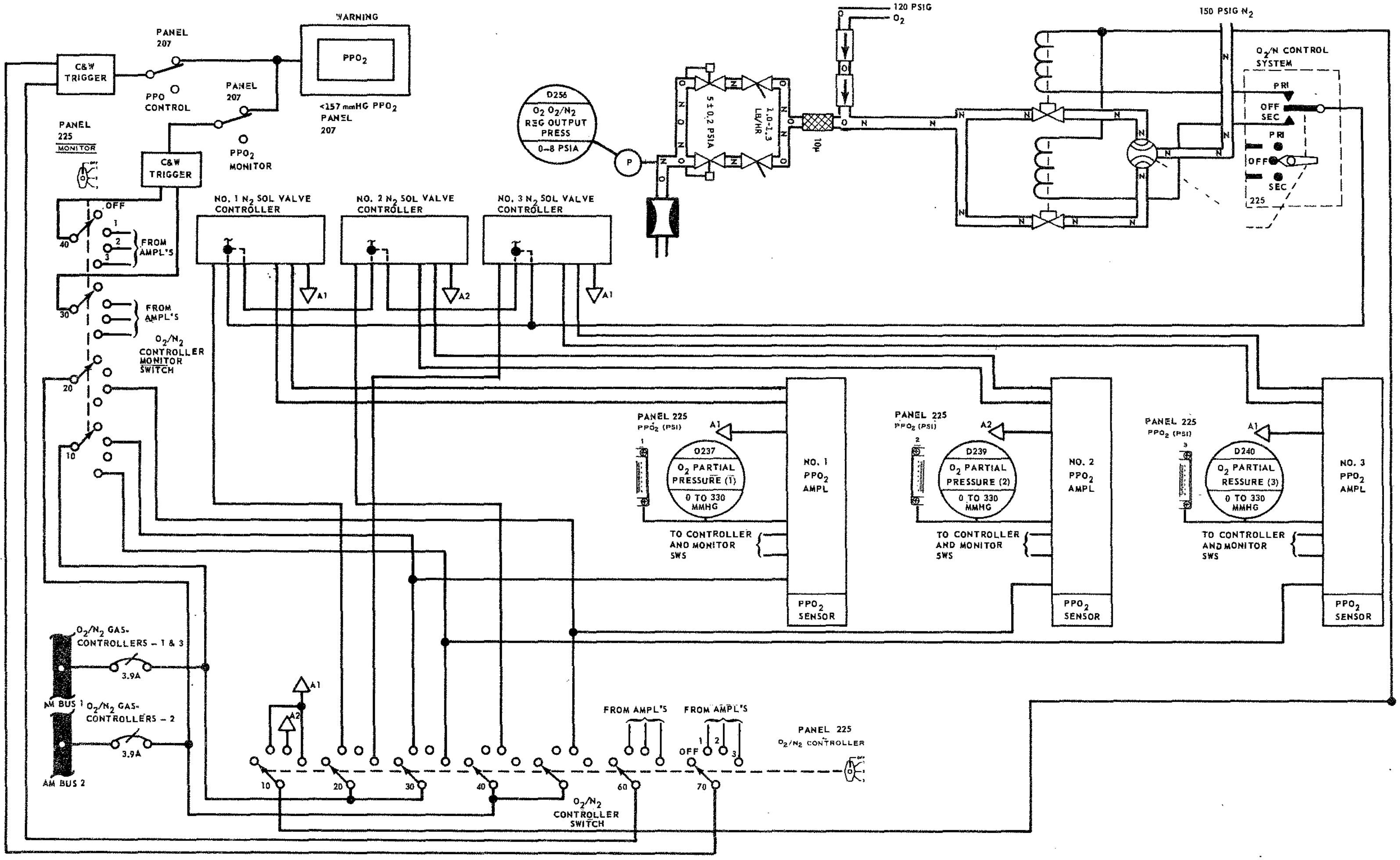



Figure 2.4.4-7 02/N2 Gas Control

Verification capability of the PPO2 sensors is provided by the manually operated CALIBRATE valve on the O2/N2 control panel 225. During verification, a vented cover is closed over the sensors, either the O2 fill or the N2 fill solenoid is energized open, and the CALIBRATE valve is opened. The oxygen or nitrogen is routed to the PPO2 sensors from the CALIBRATE valve.

Oxygen is used for total pressure verification and nitrogen is used for zero scale verification. Normally PPO2 sensor verification is performed after sensor replacement or on a periodic basis.

2.4.4.1.7 Major Component Operation

ACTUATION CONTROL MODULE

Four actuation control modules (figure 2.4.4-2) are provided to control N2 pressure from the pneumatic sphere to: (1) Habitation area vent valve, (2) Habitation area latching vent valve, (3) Waste tank pneumatic actuators, and (4) Radiator plume impingement shield actuator.

The actuation control module (figure 2.4.4-8) consists of an inlet filter and two, parallel-mounted, two-position, latching solenoid valves. Each valve has an inlet, an outlet, and a vent port. In the open position the inlet and outlet ports are connected; in the closed position, the outlet and vent ports are connected. All four actuation control modules are identical although their functions are different.

The actuation control module for the habitation area vent valve has one solenoid valve, with its outlet port routed to the vent valve pneumatic actuator and vent port vented, allowing the vent valve to close. The other solenoid has its vent port capped, and the outlet port is utilized as a pneumatic dump to depressurize the pneumatic sphere after all operations are complete.

The actuation control module for the habitation area latching vent valve uses one of its two solenoids to open and close the vent valve. The outlet and vent ports of the non-operating solenoid valve are capped.

The actuation control module for the waste tank pneumatic actuators has the outlet ports on both solenoids routed to the redundant pneumatic actuators on each vent duct. The vent ports are orificed so that if one solenoid valve fails to open the pneumatic pressure from the open solenoid valve will still position the pneumatic actuators and not bleed out through the failed solenoid.

The actuation control module for the radiator shield actuator has both outlet ports routed to the radiator shield actuator and both vent ports are vented.

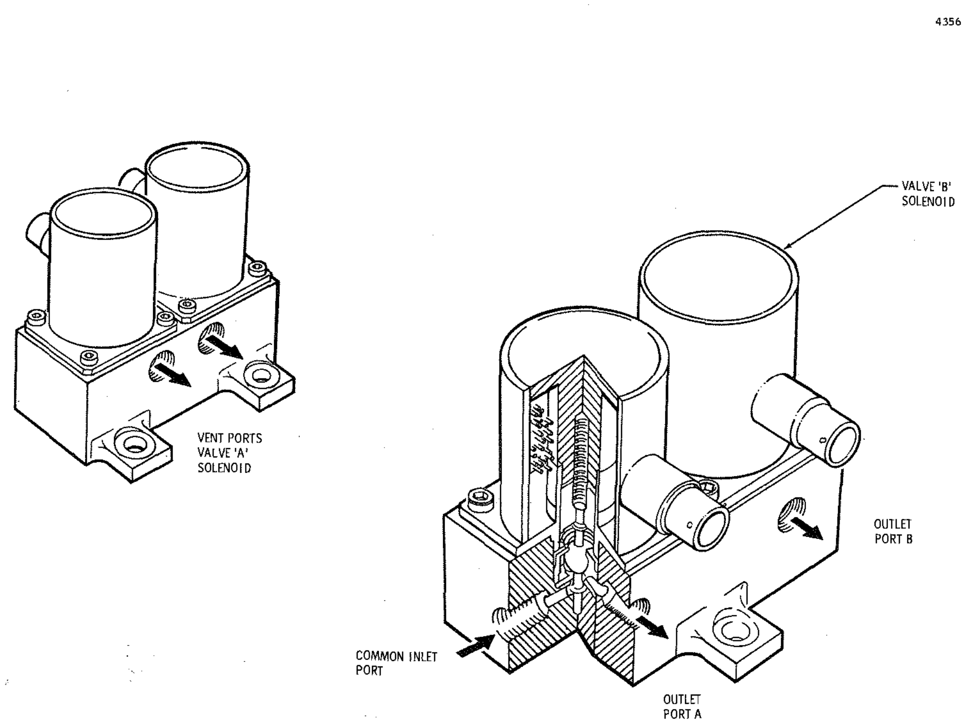



Figure 2.4.4-8 Actuation Control Module

HABITATION AREA VENT VALVE

The vent valve is opened by applying pneumatic pressure to the pneumatic actuation port (figure 2.4.4-9). The pressure required to open the valve is 200 psia with the habitation area pressure at 26 psia, and 70 psia with the habitation area at 5 psia. The pressure moves the vent piston, which is connected to the main poppet, opening the valve. The valve remains open until the pneumatic pressure at the pneumatic actuation port is vented. Venting the pressure acting on the vent piston allows the main poppet return spring to move the main poppet to the close position. The valve also acts as a relief valve. As the pressure on the inlet side of the main poppet increases to the pilot valve setting, the pilot valve is forced open, allowing gas pressure to act on the main piston. The main piston is moved, opening the main poppet. When the inlet pressure decreases below the pilot valve setting, the pilot valve closes. The pressure acting on the main piston bleeds off through the controlled bleed orifice, allowing the main poppet return spring to move the main poppet to the closed position. Open and closed position indicating switches actuated by the main piston, provide inputs for telemetry. The secondary outlet of the valve is used for ground purging of the habitation area, and then capped.

HABITATION AREA LATCHING VENT VALVE

The operation of the habitation area latching vent valve is the same as the habitation area vent valve. The latching capability of this valve is no longer utilized.

WASTE TANK VENT PNEUMATIC ACTUATORS

Pneumatic actuators (figure 2.4.4-10) are provided on both waste tank vents to unlatch the end caps that seal the non-propulsive vent (NPV). Pneumatic pressure to the actuators is provided by an N2 sphere and controlled by an actuation control module (figure 2.4.4-2). N2 is routed to the actuation control module, where it passes through a filter and to redundant, parallel mounted solenoid valves. When the open command is sent to the solenoids, N2 flows to the pneumatic actuators on both vents. N2 entering an actuator acts against the redundant pistons, moving the actuator rods outward. As these rods move outward, they rotate the mechanism that releases the cap yoke. After the vent caps are deployed, the solenoid valves in the actuation control module are de-energized and the N2 pressure from the pneumatic actuators is vented. Torsion springs at the cap yoke hinge points maintain the cap in the open position.

HABITATION AREA SOLENOID VENT VALVE

The quad-redundant solenoid valves (figure 2.4.4-11) are used for venting the habitation area in preparation for the unmanned phase. The valves are installed, two series-mounted valves in parallel with two other series-mounted valves for redundancy in opening or closing. Each valve is a latching-type solenoid valve controlled by a DCS command. A position "talk-back" switch on the solenoid valve allows the ground to determine whether the valve is open or closed.

CABIN PRESSURE RELIEF VALVE

Three cabin pressure relief valves (figure 2.4.4-12) are installed in AM compartment walls to protect against overpressurization of the MDA/AM/OWS. Each valve consists of two sets of pilot-operated, pneumatic, main poppet valves and a manually operated shutoff valve. Cabin pressure is sensed in the pilot valve through the cabin air port filter. When the pressure in the pilot valve increases to 5.5 to 6.0 psid, cabin to ambient, the pilot valve poppet will move, allowing the chamber behind the main poppet valves to be exposed to ambient. Cabin pressure acting on the other side of the chamber against the diaphragm will unseat the main poppet valve and allow cabin atmosphere to escape to ambient. As cabin pressure decreases as sensed in the pilot valve, the pilot valve poppet will move such that the chamber behind the main poppet valves will no longer be exposed to ambient. Cabin pressure will bleed into the chamber through a small orifice and the main poppet spring will close and seat the main poppet valve. The valve material is aluminum and contains teflon, silicone rubber and stainless steel parts.

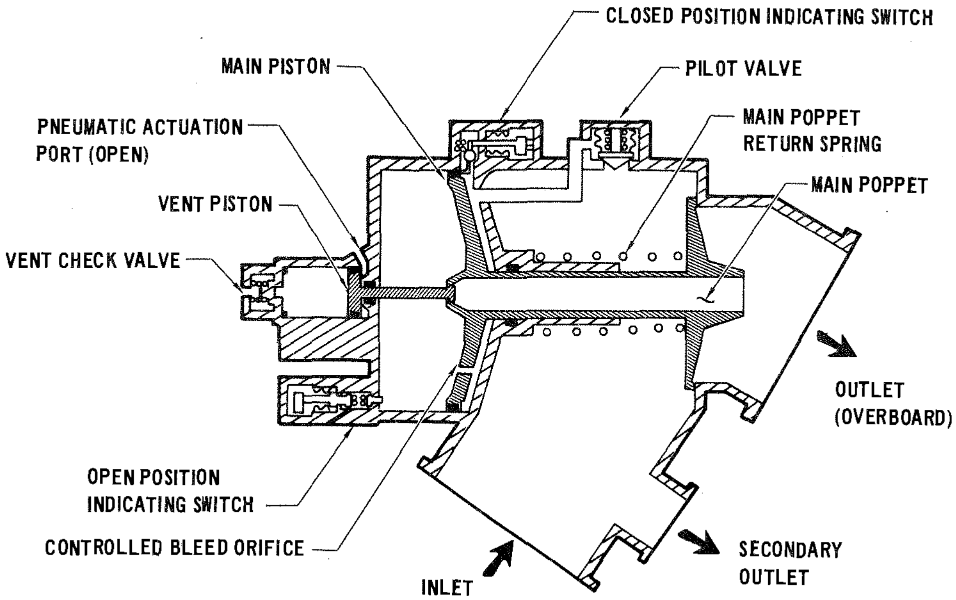
PRESSURE EQUALIZATION VALVE

The pressure equalization valve (figure 2.4.4-13) is a manually operated valve used to equalize pressure across lock compartment bulkheads and across the external (EVA) hatch. The valve is a butterfly type in which the disc (which makes the closure) is offset from the shaft around which it rotates. The valve is designed to mount in a bulkhead and to be operated by a handle on either side of the bulkhead. The shaft turned by the handles is coupled to the valve stem by bevel gears. The valve is held is the full-open or full-closed position by ball-type detents. The detents are unlocked by pressing a button on either handle. Principal parts of the valve are aluminum alloy.

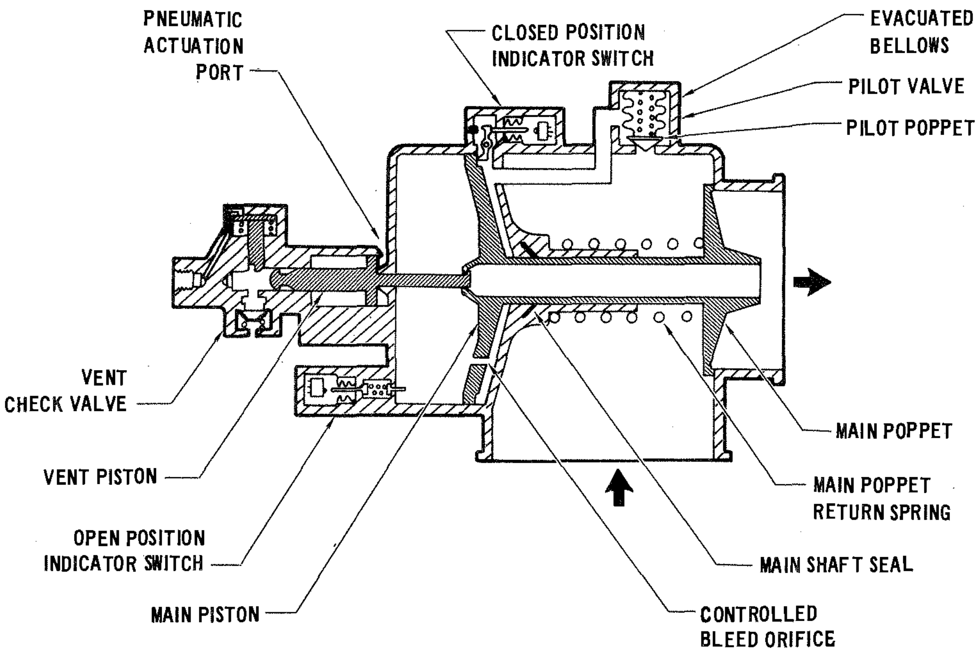
PRESSURE REGULATOR ASSEMBLY (120 PSIG)

The pressure regulator assembly (figure 2.4.4-14) regulates oxygen supplied at 300 to 3000 psia to a nominal 120 psig. The assembly package provides a single inlet port with a 10-micron filter and a single outlet port. Between these ports are two parallel circuits, each consisting of redundant regulators and relief valves isolated by downstream check valves and upstream shutoff valves. A test port is provided in each circuit to verify relief and check valve operation. Oxygen entering one of the parallel circuits is directed through a toggle shutoff valve to a pressure regulator. As the pressure in the reference chamber decreases below the set point (120 psig), the spring acting against the diaphragm will unseat the poppet and allow gas flow through the regulator. The relief valve downstream of the regulator is constructed such that when the pressure at the diaphragm reaches its set point (150 to 170 psig), the spring will compress and the poppet will open, allowing the gas to be vented into the cabin.

4006




HABITATION AREA VENT VALVE




HABITATION AREA LATCHING VENT VALVE

Figure 2.4.4-9 Habitation Area Vent Valve

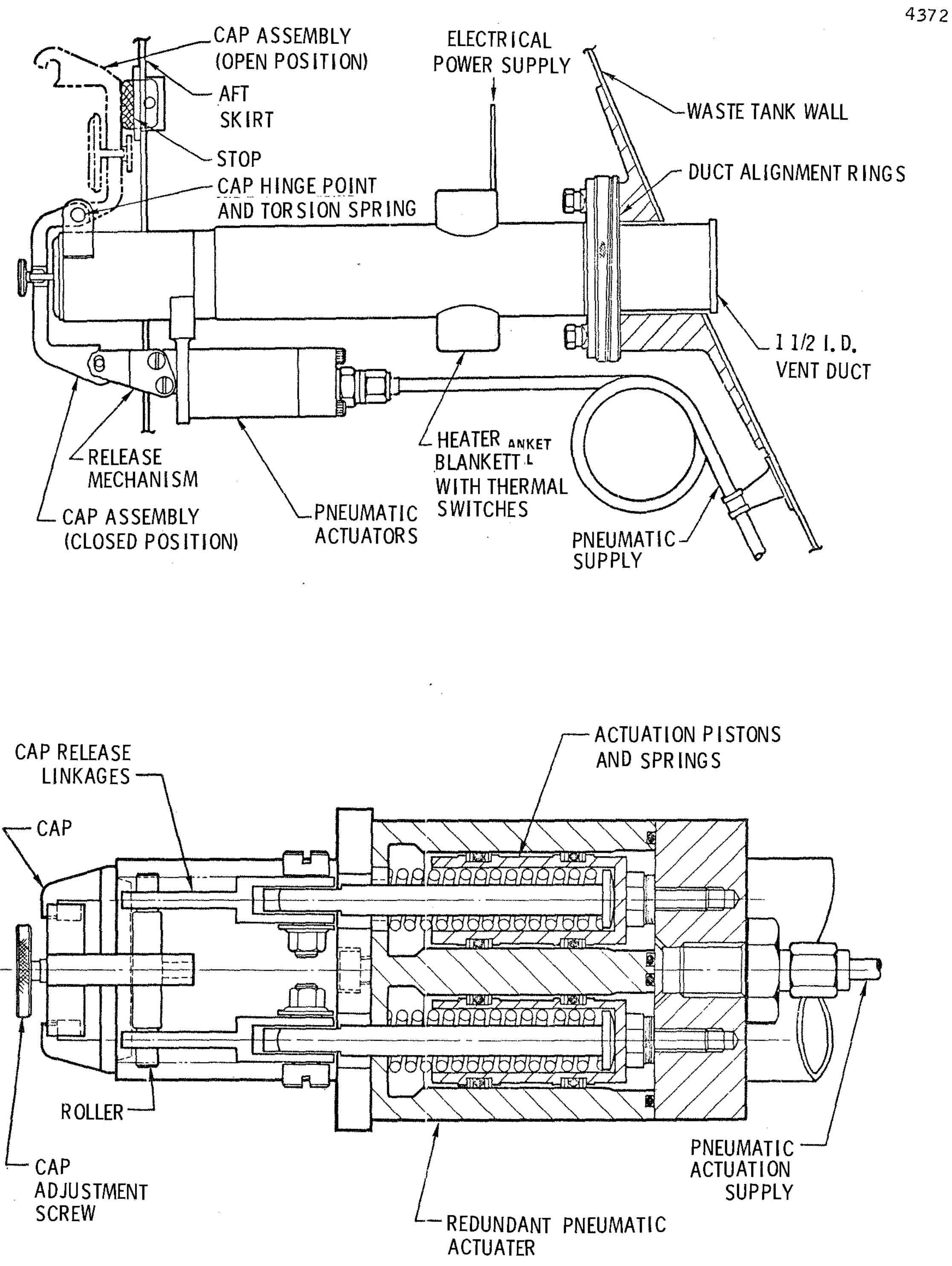



Figure 2.4.4-10 Waste Tank NPV and Cap Release

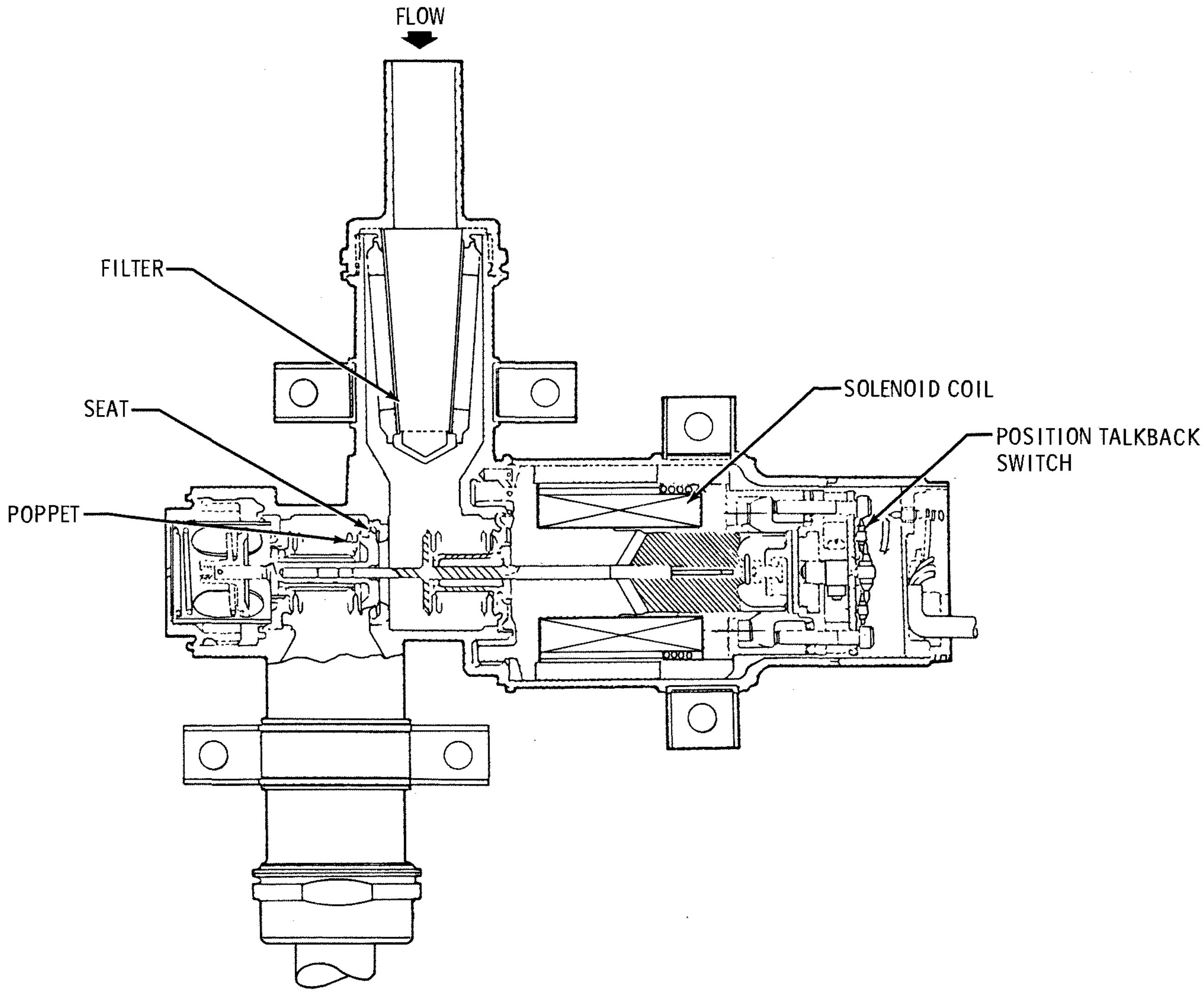



Figure 2.4.4-11 Habitation Area Solenoid Vent Valve

4029

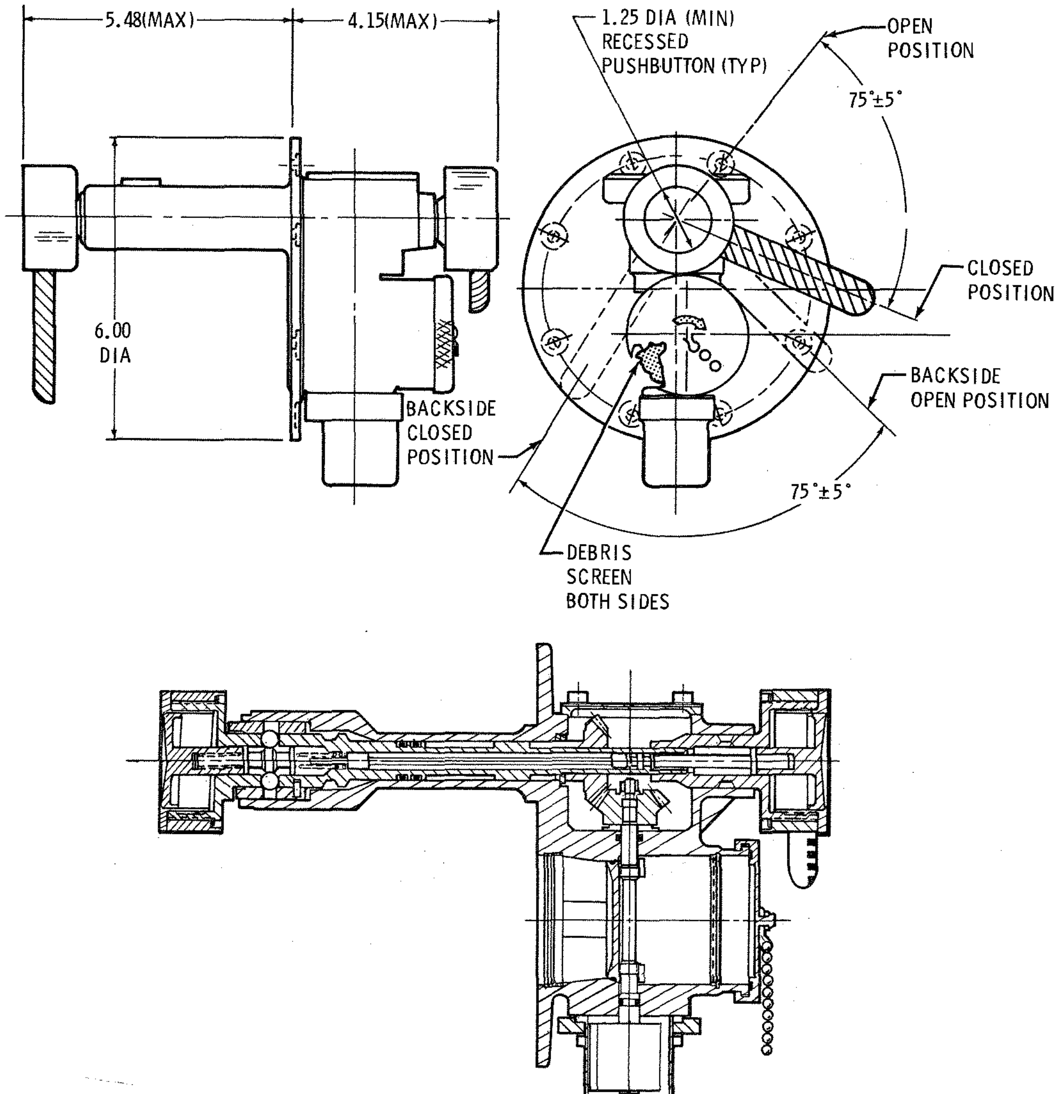



Figure 2.4.4-13 Pressure Equalization Valve

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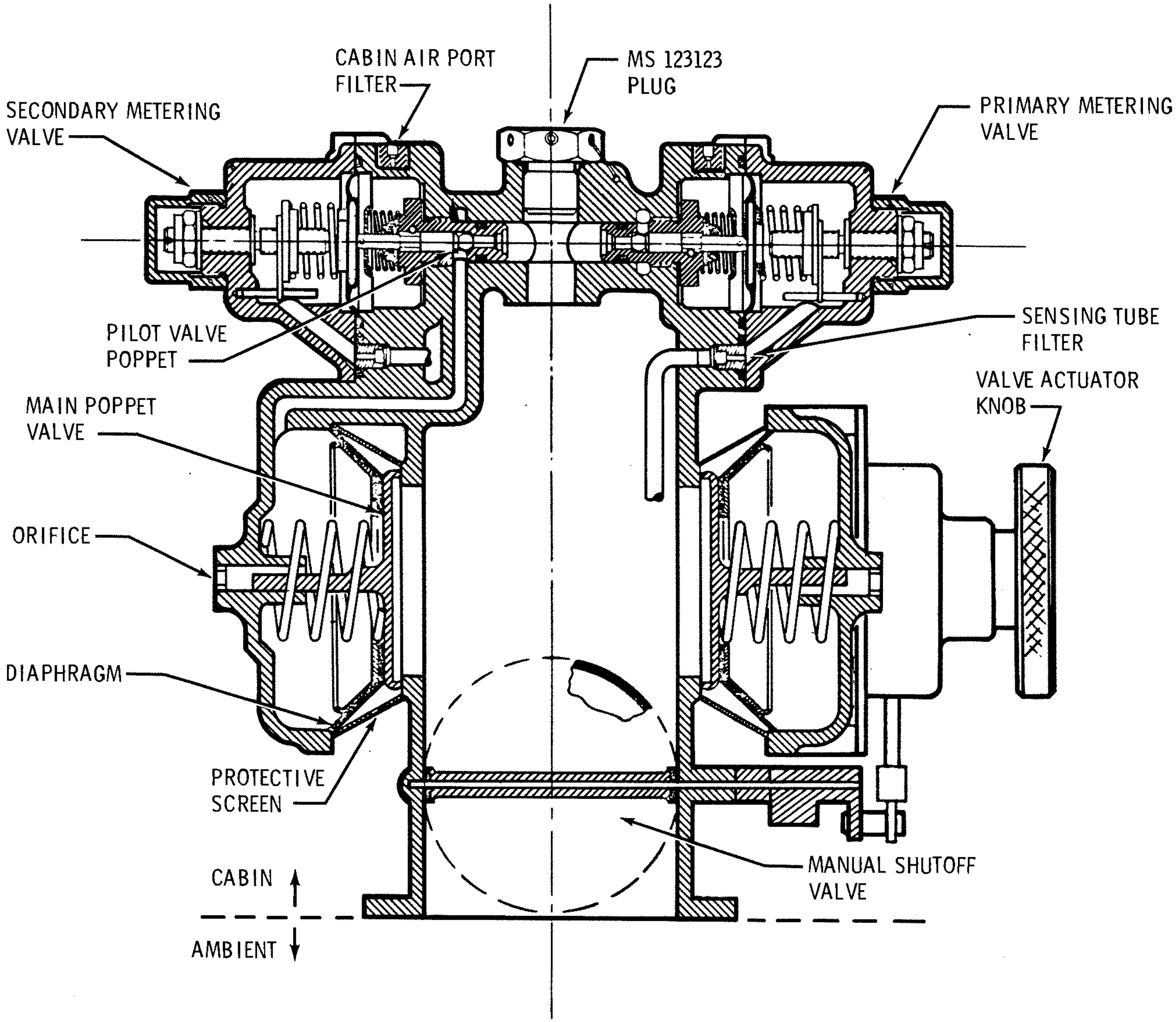


Figure 2.4.4-12 Cabin Pressure Relief Valve

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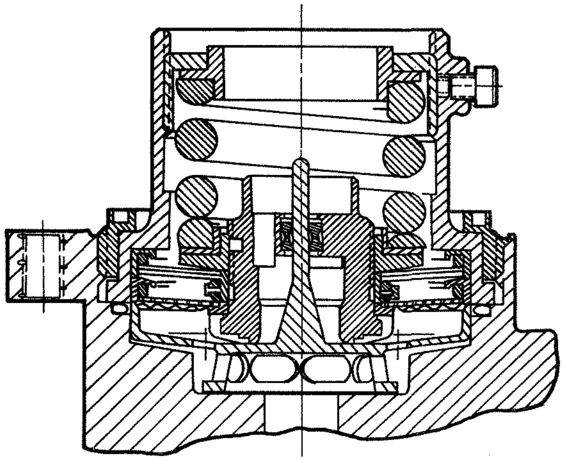
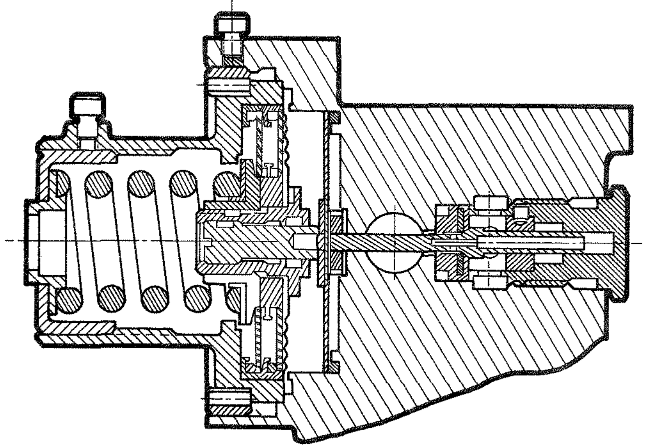
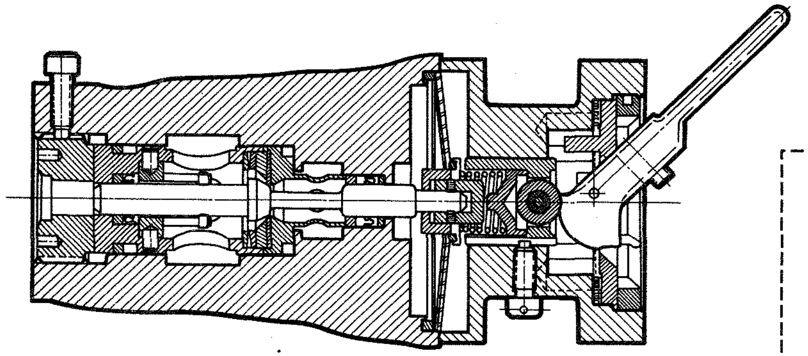


RELIEF VALVE



PRESSURE REGULATOR



SHUT-OFF VALVE, $O_2$ $N_2$ REGULATOR

PANEL 225

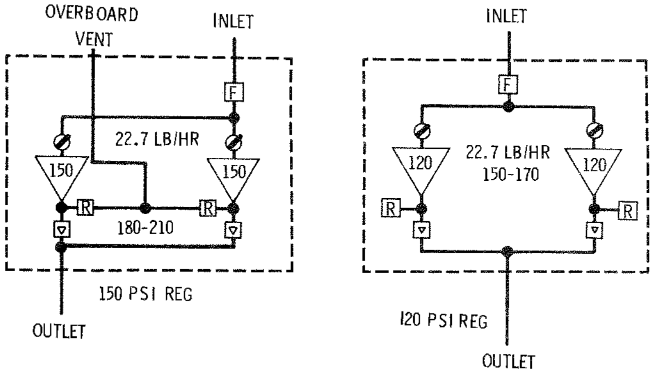



Figure 2.4.4-14 Pressure Regulator Assembly

4359

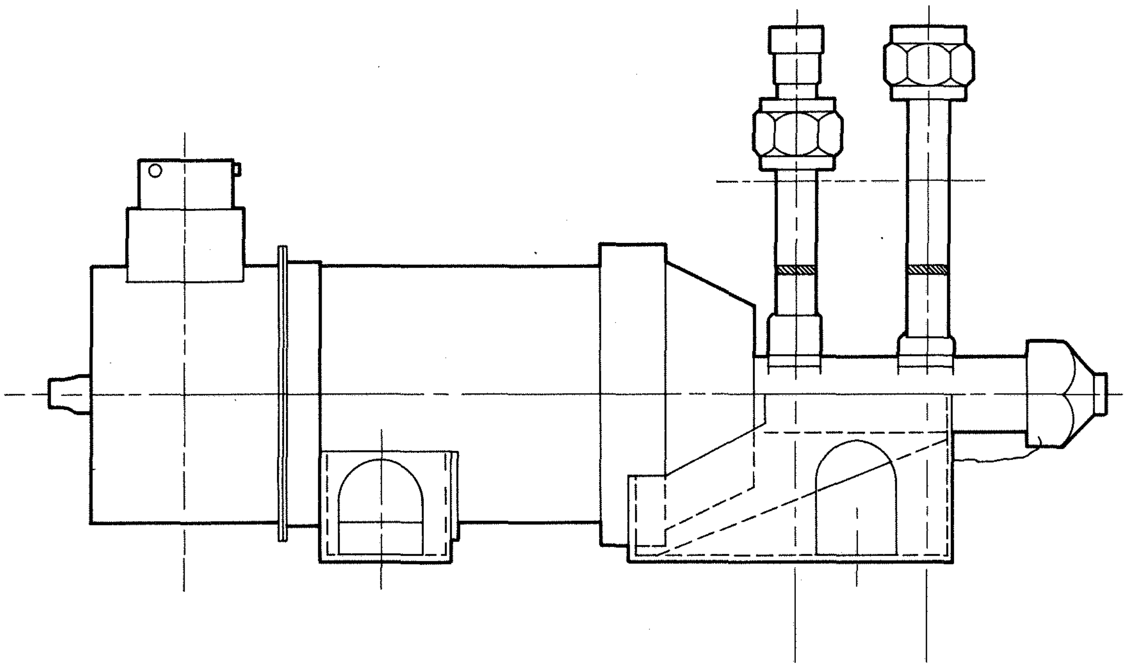


Figure 2.4.4-15 Latching Solenoid Valve

PRESSURE REGULATOR ASSEMBLY (150 PSIG)

The pressure regulator assembly regulates nitrogen supplied at 300 to 3000 psia to a nominal 150 psig. The assembly package is identical to the 120-psig pressure regulator assembly except the regulator set point is 150±10 psig, the relief valve setting is 180 to 210 psig, and the relief valve is vented overboard.

LATCHING SOLENOID VALVE

The latching solenoid valve (figure 2.4.4-15), installed in the high-pressure oxygen and nitrogen lines, isolates storage tanks from the internal cabin when gas flow is not required. The valve is a quick-acting, two-port, two-way valve that opens or closes upon application of an appropriate signal. The valve has a latching feature that locks the valve into position. Internal switching removes power from the coil circuit upon completion of poppet translation. Electrical signals are provided to telemetry to indicate valve position.

CABIN PRESSURE REGULATOR ASSEMBLY

The cabin pressure regulator assembly (figure 2.4.4-16) is used to maintain pressure of the internal atmosphere at 4.8 to 5.2 psia during normal operation. The regulator assembly consists of two independently operating parallel circuits, with each circuit containing a toggle shutoff valve, a test port, and a pressure regulating valve. Both circuits are contained in one stainless steel housing and employ a common inlet port with a 10-micron filter, a common orifice, and a common outlet port. The valve uses teflon seals and standard fittings. The aneroid within the regulator section contains entrapped gas at 0.5 psia and an actuator spring. The aneroid housing is referenced to cabin pressure. As cabin pressure decreases below 5.0±2 psia, the aneroid, assisted by its internal spring, expands. A compression spring and the expanding aneroid moves the bellows assembly, causing the upper valve stem to unseat a 1.0 mm sapphire ball. $O_2$ or $N_2$ will flow from the toggle valve through the regulator and downstream orifice (1.0 to 3 lb/hr) to the outlet port. As cabin pressure increases the aneroid compresses and the lower valve stem reseats the sapphire ball. Flowrate is roughly proportional to cabin pressure.

WATER RESERVOIR PRESSURE REGULATOR ASSEMBLY

The water reservoir pressure regulator assembly (figure 2.4.4-17) controls pressure in water cooling reservoirs at 4.8 to 5.2 psia. The assembly includes redundant inlet toggle valves, pressure regulators, pressure relief valves, flow limiters, and filters, all mounted in one housing. Movement of the manual toggle valve levers is 90 degrees between open and closed positions. The aneroid within the regulator section contains

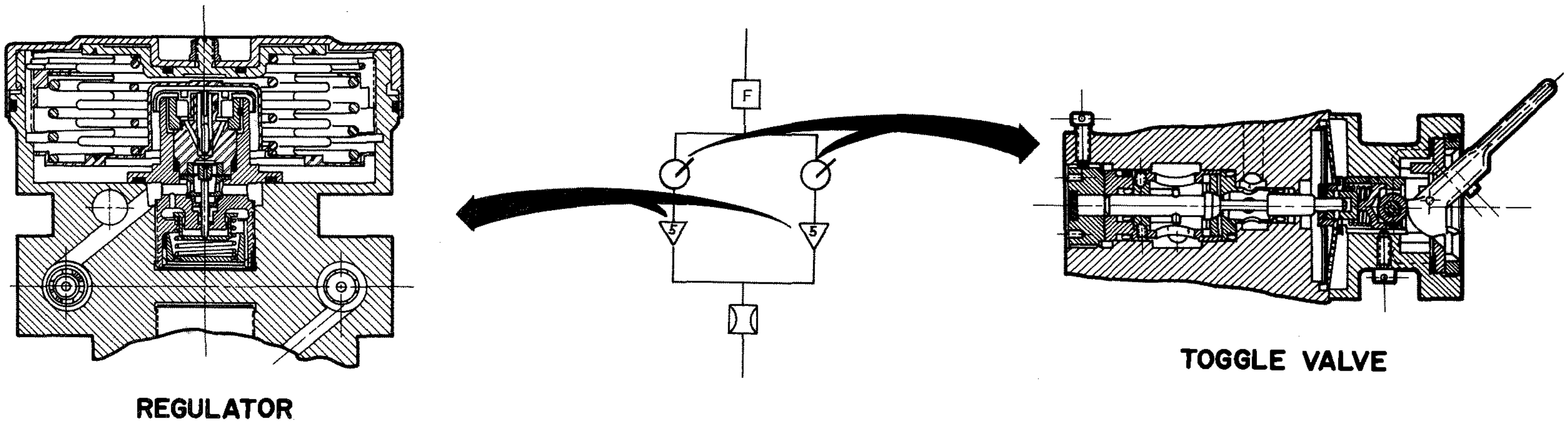



Figure 2.4.4-16 Cabin Pressure Regulator Assembly

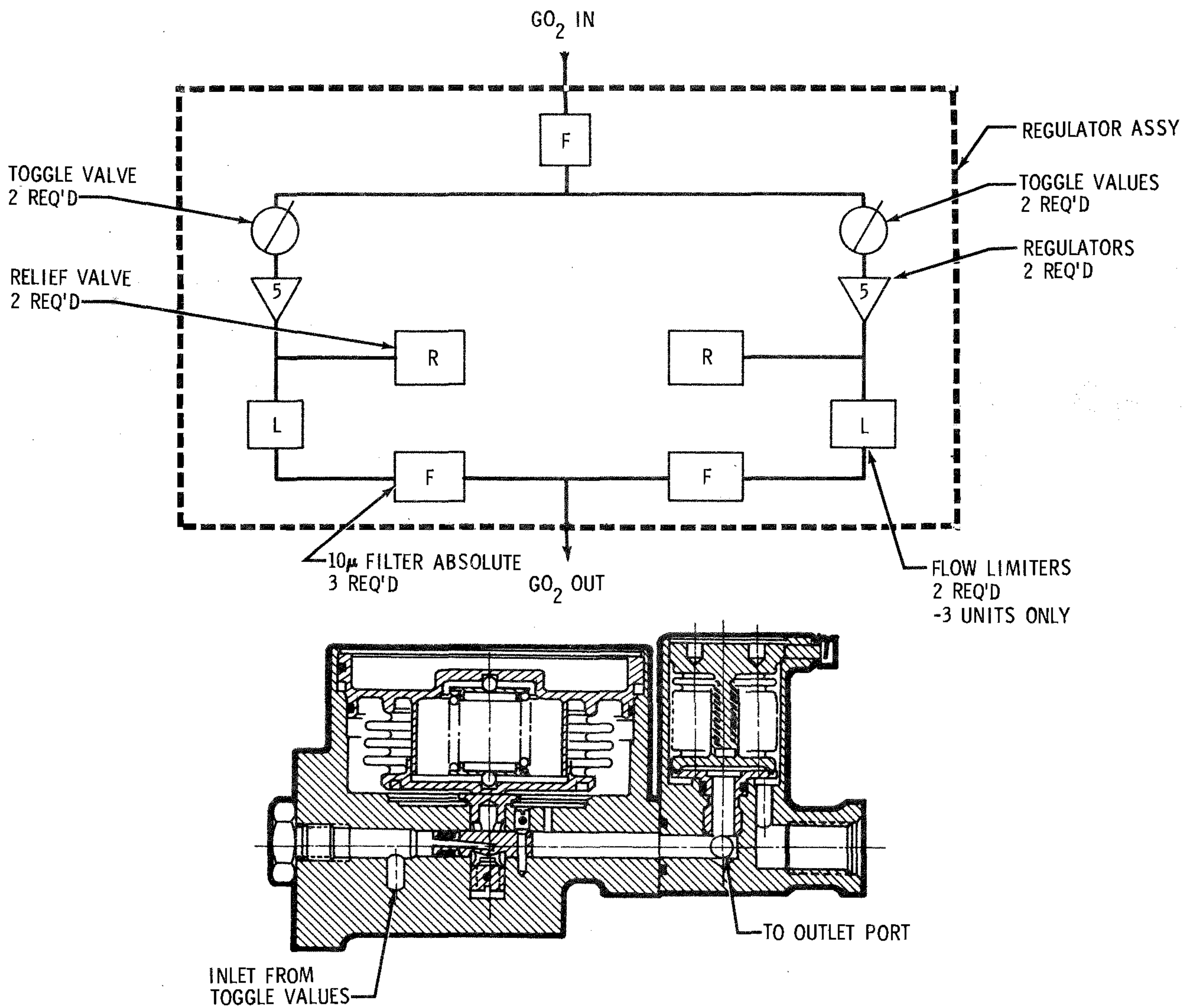



Figure 2.4.4-17 Water Reservoir Pressure Regulator

4360

PANEL 390

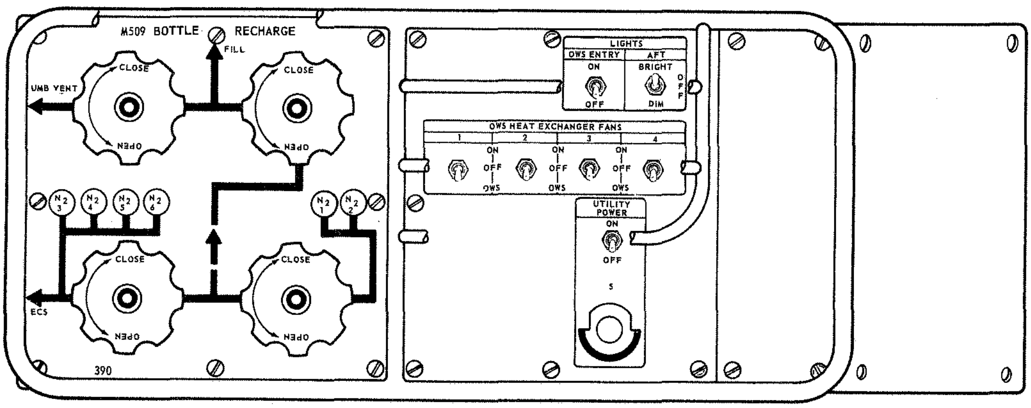



Figure 2.4.4-18 M509 Recharge Station (Panel 390)

entrapped gas at 0.5 psia and an actuator spring with the aneroid chamber being referenced to reservoir inlet pressure. As the reservoir inlet pressure decreases below 4.8 to 5.2 psia, the aneroid, assisted by its internal spring, will expand, pushing the poppet away from its seat. The N2 is then allowed to flow from the toggle valve through the poppet seat to the outlet port, maintaining reservoir inlet pressure at 4.8 to 5.2 psia. The relief valve on the outlet port will crack open, meet full flow, and reseat within the range of 5.8 to 6.2 psia. During the boost phase, the relief valve is full open until the cabin pressure decreases to this range. The flow limiters restrict N2 flow to .005 to .05 lb/hr.

M509 RECHARGE STATION

An M509 recharge station (figure 2.4.4-18) provides a source of high-pressure nitrogen for experiment support. The recharge station includes manual shutoff valves for selecting the N2 pressure source and a quick-disconnect fitting for attachment to an umbilical, which interfaces with experiment N2 tanks. A bleed capability is also provided through a manual shutoff valve. This UMB VENT valve is opened prior to recharge operation to depressurize the line between the FILL valve and quick-disconnect. Once the line is depressurized, the UMB VENT valve is closed and the M509 bottle can be connected to the FILL QD. The FILL valve and shutoff valve from N2 bottles 3, 4, 5 and 6 are opened to fill the M509 bottle. The shutoff valve from N2 bottles 3, 4, 5 and 6 is then closed, and the shutoff valve from N2 bottles 1 and 2 is opened to perform a topping-off operation. The shutoff valve from N2 bottles 1 and 2 is then closed, the FILL valve is closed, and the SUPPLY valve on the M509 bottle is closed. The UMB VENT valve is then opened to depressurize lines so the quick disconnects can be demated.

OXYGEN PARTIAL PRESSURE SENSOR, AMPLIFIER, CONTROLLER ASSEMBLY

The PPO2 sensor, amplifier, controller assembly (figure 2.4.4-19) provides the capability for sensing and controlling of oxygen partial pressure. The sensor consists of a diffusion barrier, catalytic electrode, basic electrolyte, and metal counter-electrode. These are physically joined together in a housing and electrically connected externally through a load resister. The diffusion barrier provides an oxygen flow directly proportional to the oxygen partial pressure, resulting in a current flow through the external load resister. The voltage drop across the load resister is amplified and conditioned by the amplifier to provide a continuous 0 to 5 volt output proportional to 0 to 6.4 psi PPO2 for caution and warning, telemetry, and O2/N2 control and a 0 to 400 mv output proportional to 0 to 6 psi PPO2 for onboard indication. As the sensor voltage increases to 2.90 volts (maximum), the controller opens the N2 supply solenoid valve to permit use of N2 for cabin total pressure control. When the sensor voltage decreases to 2.73 volts (minimum), the controller closes the N2 supply solenoid valve, allowing use of O2 for cabin total pressure control.

# $O_2/N_2$ GAS CONTROL

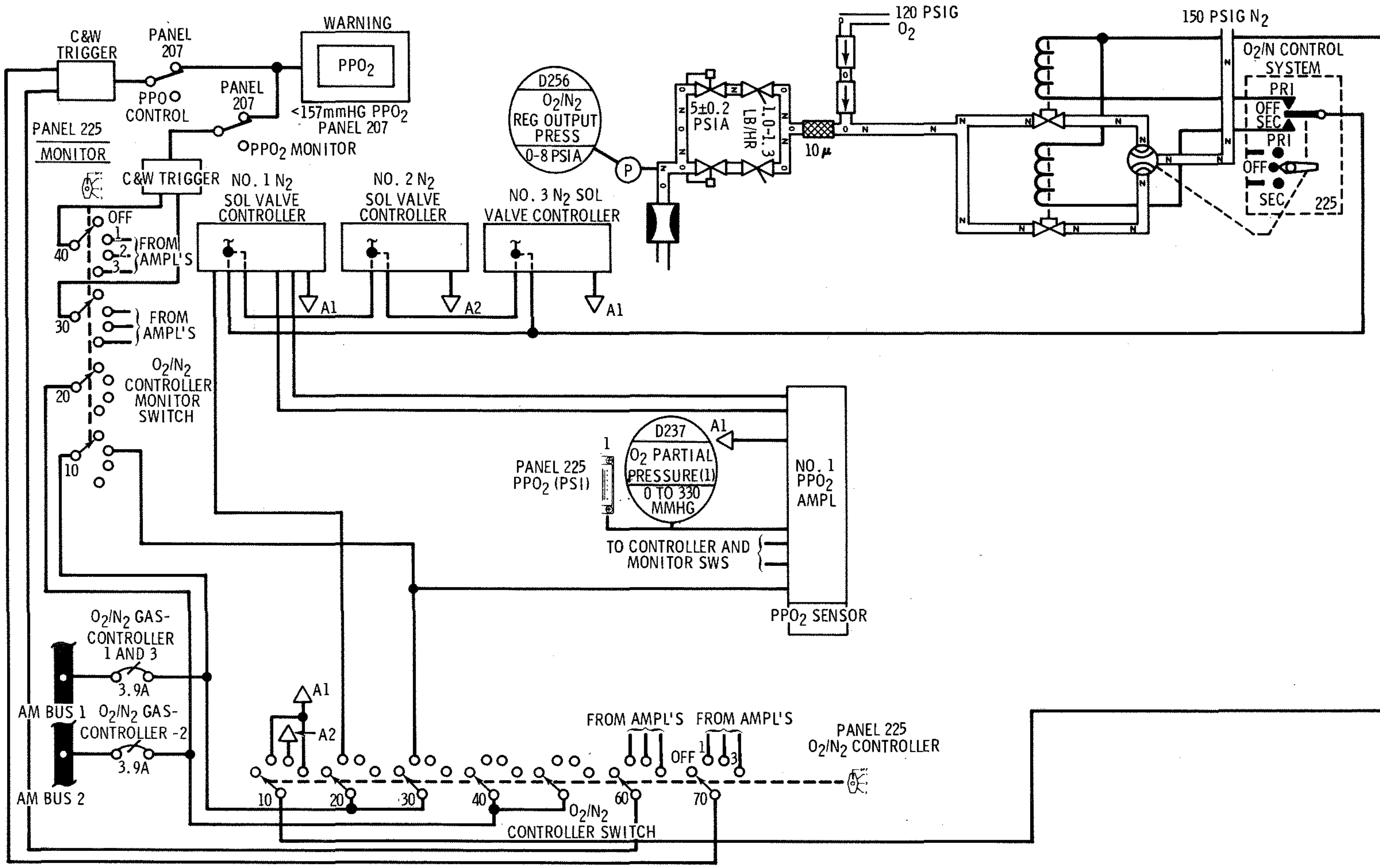



Figure 2.4.4-19 PPO2 Sensor, Amplifier, Controller

2.4.4.2 THERMAL CONTROL

Thermal control is divided into four groups:

- o Coolant loops
- o Electric heaters
- o Insulation
- o Thermal coatings and radiation shielding

The following paragraphs describe each group and the components used in each group.

2.4.4.2.1 Coolant Loop

Active thermal control is provided by a primary and secondary coolant loop (figure 2.4.4-21). Both loops are normally operated with one pump throughout habitation, but only one loop is normally used during unmanned phases. The coolant loops provide active cooling to ECS equipment, and coldplated electrical and electronics equipment. The ECS equipment consists of suit cooling heat exchangers, condensing heat exchangers, cabin heat exchangers for the OWS and AM/MDA, an ATM C&D panel and EREP panel heat exchangers, and an oxygen heat exchanger. The coldplated equipment consists of three tape recorders, two battery modules, six electronics modules, and two coolant pump inverter coldplates. Flow through the tape recorder, battery, and electronics modules is paralleled to reduce system pressure drop. All coldplates except the pump inverter coldplates contain two coolant passages. With the exception of the suit cooling circuits, the primary and secondary loops, although isolated from each other, flow in parallel paths.

The coolant used in the loops is a low viscosity fluid with a silicate ester base referred to as MMS-602 (coolanol 15). It has a functional temperature range of -100 degrees to +300°F, a flash point of 170°F, an auto ignition point of 490°F, and a pour point of -140°F.

The coolant is circulated through each loop by two parallel pump assemblies. One pump assembly incorporates one inlet reservoir, two parallel, constant displacement electrical pumps, and a check valve in each pump outlet. The second pump assembly incorporates one inlet reservoir and one constant displacement electrical pump with a check valve in the pump outlet. The inlet reservoirs maintain a positive pressure at the pump inlet and each incorporates a low-level limit switch that actuates a RES LO light on the STS control panel 203 when the reservoir bellows is in the empty position. Three inverters for each coolant loop provide power to the coolant pumps. Each inverter can supply power to only two coolant pumps either individually or simultaneously. Inverter 1 will supply power to pumps A and B, inverter 2 supplies pumps B and C and inverter 3 supplies pumps C and A. The coolant pump and the inverters are controlled from the PRIMARY COOLANT LOOP and SECONDARY COOLANT LOOP switches on panel 203. Each pump has an on/off switch and the inverters have a selector switch. The CMD position allows for both pumps and inverters to be controlled from the ground through the DCS. Only the two pumps supplied by an inverter may operate when that inverter is selected. This prevents three-coolant-pump simultaneous operations per coolant loop but does allow simultaneous operation of any two of three coolant pumps per coolant loop. A pump inverter package consists of three pump inverters mounted on a common single pass coldplate. Coolant flow rate with one-pump operation is 240 lb/hr; the rate with two-pump operation is 460 lb/hr. Flow-sensing reed switches are located in the check valves to indicate the flow status of each pump. If a coolant pump is activated and the flow-sensing reed switch for that pump is not actuated, then the appropriate caution and warning indication (PRI COOL FLOW or SEC COOL FLOW) is triggered.

The output from the assemblies (figure 2.4.4-22) flows past two temperature transducers that actuate the caution and warning system caution indication PRI COOL TEMP HI if the coolant temperature is 120°F. A third temperature transducer provides output to telemetry. The coolant then flows through a 100-micron filter assembly which has a relief valve to permit bypassing a clogged filter. A differential pressure range of 3 to 7 psi across the filter actuates the relief valve. The coolant flow from the filter divides with one fluid path routed to the suit/battery cooling module. The remaining fluid path from the filter flows to the radiator bypass and relief valve. The radiator bypass and relief valve is a solenoid-actuated, hydraulic-operated valve that directs coolant flow through the radiators or allows the coolant flow to bypass the radiators and flow through a ground cooling heat exchanger. The valve is controlled from the STS control panel 203 RAD FLOW three-position toggle switch. The position BYPASS is for bypass flow, NORM is for radiator flow, and CMD is for ground DCS control of the valve. Prior to launch, the coolant flow bypasses the radiator and rejects waste heat through the ground cooling heat exchanger to a GSE ground cooling cart. In orbit, the coolant flow is directed to the radiator for heat rejection.

The radiator consists of 11 panels: four panels are mounted on the STS, four panels are mounted on the lower MDA, and three panels are mounted on the upper MDA. Each STS panel consists of 0.050 inch thick magnesium skin seam-welded to magnesium extrusions. The MDA panel configurations are similar except that they have 0.032 inch thick skins. The extrusions are "T" shaped with a single coolant passage in the bottom of the "T". The crossbar top of the "T" is attached to the inner surface of the skin to form a file of either the primary or secondary coolant loop. Two of the files form the primary coolant passage and the other two form the secondary coolant passage. The panel skins are bolted to fiberglass stringers riveted to the pressure wall. Spiral turbulators (42 total) are installed in both files of the primary and secondary crossover lines between all STS and MDA radiator panels except for STS panel crossovers between -Z and -Y and +Z and +Y where turbulators are installed in only one of the two files. The 11 radiator panels have a total surface area of 432 square feet with 102 square feet to STS and 330 square feet to MDA. The radiator outlet and bypass

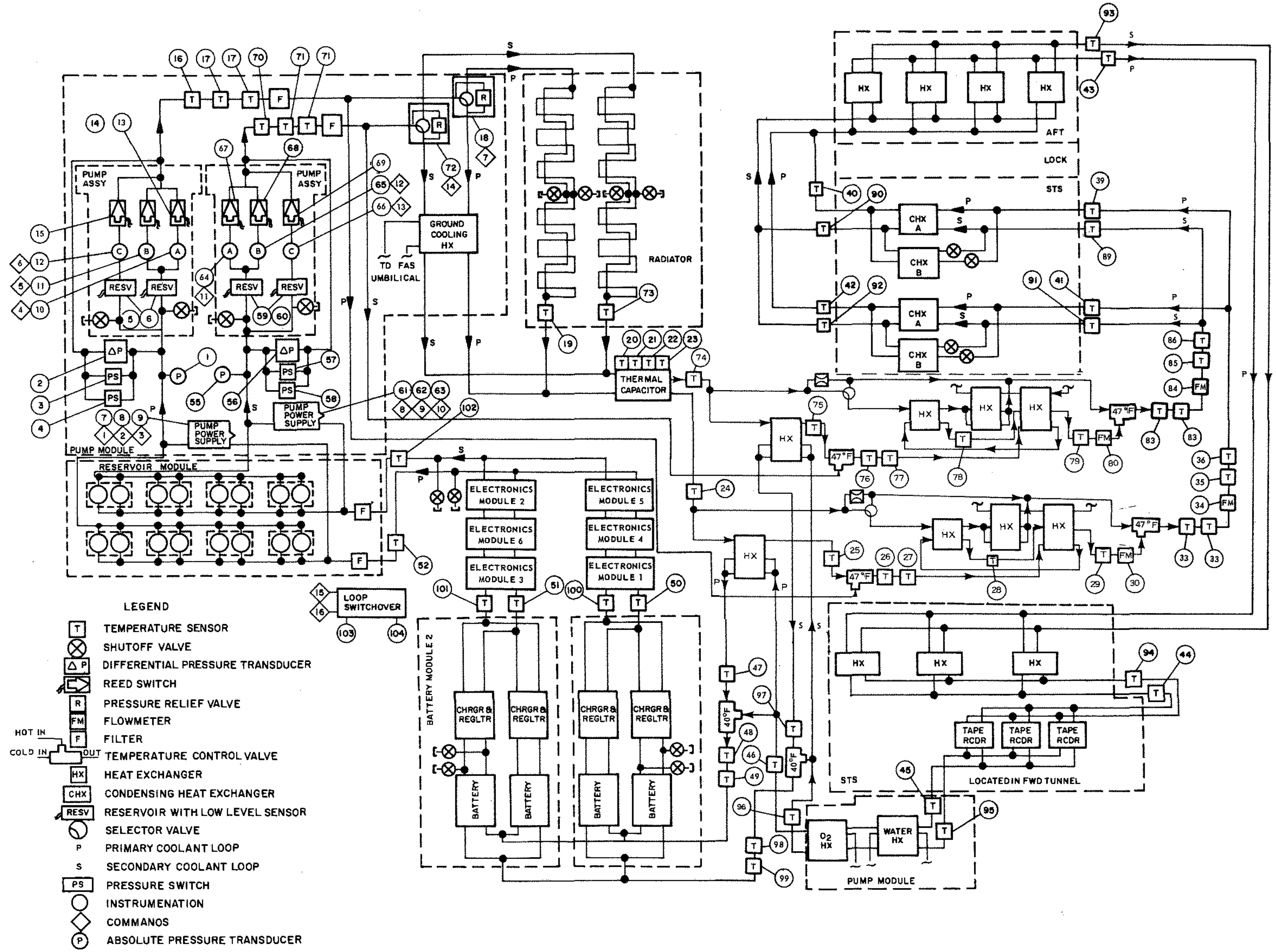



Figure 2.4.4-21 Coolant System

lines are connected and routed to a thermal capacitor. The capacitor stores heat while the vehicle is on the hot side of the orbit and rejects the heat on the cold side. The capacitor utilizes 20 pounds of tridecane wax (melting point 22.2°F and heat of fusion 66.5 Btu/lb), placed in aluminum honeycomb and brazed to coldplates. During night-side (shaded) operations, the excess radiator capacity (outlet temperature less than 22.2°F) is used to freeze the wax. During the day-side (in sunlight), the radiator heat rejection capability is supplemented by melting the wax with warm coolant discharging from the radiator and reducing the coolant temperature at the capacitor outlet. One common capacitor is used for both coolant loops.

The capacitor outlet goes to the suit/battery cooling module. This module controls the distribution of the available radiator cooling capability.

First in priority is the EVA heat load, followed by the ECS heat loads with any remaining capacity being utilized for supplemental equipment cooling. The module basically consists of a two-passage regenerative-type heat exchanger, three 3-passage heat exchangers of the ground cooling type, three temperature control valves, and a heat exchanger coolant flow bypass valve.

The regenerative-type heat exchanger is used to equalize the temperature between two parallel flow paths. The ground cooling type heat exchangers are used to equalize the temperature between two parallel flow paths and to either cool or receive cooling from the third counter-flow path.

The temperature control valves provide for the mixing of relatively cold coolant with relatively warm coolant to obtain a desired mixed coolant outlet temperature. The 40°F temperature control valve will control the coolant outlet temperature to 40 +2, -4°F and the two 47°F valves will control their outlet temperature to 47 ±2°F.

The heat exchanger coolant flow bypass valve is a latching-type solenoid valve operated from a two-position (EVA/BYPASS) switch on the IVA panel. For periods other than EVA, the valve is in a bypass position, which prevents water in the three-path ground cooling type heat exchanger from freezing.

The flow entering the Suit/Battery Cooling module from the thermal capacitor divides, going to the supplemental battery cooling heat exchanger and/or the heat exchanger coolant flow bypass valve. The bypass valve has an orificed bleed path around the valve to provide 30 lb/hr flow when the bypass valve is in the EVA position. This bleed flow provides a cold bias to the cold inlet of the 47°F temperature control valve (TCV) "B", ensuring the cold inlet will be colder than the warm inlet to TCV "B". During periods other than EVA the bypass valve will be in the BYPASS position which allows coolant flow directly to the cold inlet of 47° TCV "B". As this cold inlet to TCV "B" drops below 47°F, TCV "B" will allow coolant to flow through the warm inlet, mixing warm and cold to maintain TCV "B" outlet at 47±2°F. The warm coolant is supplied from the outlet of TCV "A". The coolant from TCV "A" flows through the first EVA water heat exchanger, the two-path regenerative-type heat exchanger, and back through the first EVA water heat exchanger to the warm inlet of TCV "B". Coolant will therefore flow from TCV "A" only when there is a demand for warm coolant at TCV "B". When the demand for coolant flow from TCV "A" is initiated, the coolant to the cold inlet is relatively warm since it flows through the supplemental battery cooling heat exchanger. This heat exchanger is a three-path ground-cooling type, with the coolant path to the cold inlet of TCV "A" in counter flow with parallel paths of very warm coolant from the EVA and ECS heat loads. Since TCV "A" is attempting to maintain its outlet to 47±2°F, the cold inlet port will be full open. As the temperature out of the thermal capacitor reaches its nominal 22.35°F the demand for coolant to the cold inlet of TCV "B" will diminish and the demand to the warm inlet will increase. Since the coolant to the warm inlet of TCV "B" is supplied by TCV "A", the increase in flow through TCV "A" will cause the temperature of the coolant at the cold inlet of the TCV "A" to decrease until it reaches 47±2°F. When this occurs all coolant flow to the cold inlet of TCV "B" is stopped and the warm inlet to TCV "A" begins to open to maintain TCV "A" outlet at 47°F. The coolant to the warm inlet on TCV "A" is supplied by a line upstream of the AM/MDA radiators. This is the nominal operating configuration.

If the system is operating under nominal conditions and an EVA is initiated, the temperature of the coolant to the warm inlet of TCV "B" will increase above 47±2°F. The temperature will increase since it is circulated through a ground cooling type heat exchanger which interfaces with the suit cooling loop. TCV "B" will begin mixing coolant from its cold inlet to maintain the 47±2°F output. The coolant to the warm inlet and cold inlet interface through a regenerative heat exchanger before entering TCV "B" so that the temperatures and flows will tend to equalize before reaching TCV "B".

A 40±2°F TCV in the suit/battery cooling module has the coolant supply to the cold inlet coming through the supplement battery cooling heat exchanger and coolant supply to the warm inlet directly from the EVA and ECS heat loads.

A decrease in ECS heat loads (normally during unmanned phases) causes the temperature of coolant to the supplemental battery cooling heat exchanger to decrease. This decrease in coolant temperature in counterflow with coolant going to the cold inlet of TCV "A" will cause the temperature of the coolant from the EVA and ECS heat loads through the supplemental battery cooling heat exchanger to approach 40±2°F. At this value, the 40±2°F TCV will begin to cycle its warm inlet open to maintain its outlet at 40±2°F. The 40°F TCV limits the minimum coolant temperature delivered to the battery coldplates.

The output from TCV "B" flows through two temperature transducers that initiate the C&W caution light PRI COOL TEMP LOW if the coolant temperature < 40°F. The coolant then flows through a telemetry flow meter and two temperature transducers, which provide an input to the loop switchover logic network when the coolant temperature < 38°F. The coolant leaves the suit battery cooling module and divides into two paths.

The coolant in each path flows past a telemetry temperature transducer, then divides into two paths through condensing heat exchangers A and B. A manual shutoff valve, PRI COOLANT HT EXCH B, is provided upstream of condensing heat exchanger B. The parallel paths join before flowing past a telemetry temperature transducer. The coolant flow from heat exchangers A and B associated with molecular sieve A and coolant flow from heat exchangers A and B associated with molecular sieve B unite and flow to the four heat exchangers located in the AM aft compartment. The four heat exchangers are plumbed together in parallel, allowing an equally divided coolant flow to each. The heat exchanger output flows again recombine and flow through a telemetry temperature transducer to the three STS cabin heat exchangers.

The flow divides into three parallel paths before reaching the STS cabin heat exchangers. Each of the three heat exchangers is constructed to provide primary and secondary coolant flow paths and a crossflow path for cabin gases.

Coolant from the three heat exchangers recombines, flows past a telemetry temperature transducer, then through the three parallel connected tape recorder coldplates located in the AM forward compartment. The parallel paths unite and the coolant flows to the ATM cooling module. The flow passes a telemetry temperature transducer through a three-path ground-cooling type heat exchanger, flowing in parallel with the ATM C&D panel water cooling system (paragraph 2.4.4.2.1.1). Coolant flow is then routed to the pressurization and gas distribution system oxygen heat exchanger. The coolant flow leaves the ATM cooling module, passes a telemetry temperature transducer, and enters the suit battery cooling module. The coolant path divides, with one path going to the warm inlet of the 40°F TCV, and the other path going to the supplemental battery cooling heat exchanger, then to the cold inlet of the 40°F TCV. The coolant flows from the 40°F TCV through two telemetry temperature transducers and divides into parallel paths to flow through the two battery modules. The flow through each battery module divides again, with each path going through two battery and two charger regulator coldplates before recombining. The parallel coolant paths from both battery module each flow through a telemetry temperature transducer and three series-mounted electronic module coldplates. The coolant paths join and flow through a telemetry temperature transducer to a filter and the coolant reservoir module. The line entering the reservoir module divides. One path bypasses the reservoirs going to the coolant pump module and the other path divides into eight parallel paths to flow through the eight 53-cubic-inch reservoirs, then unite. Each reservoir utilizes a mechanically loaded bellows to compensate for coolant expansion and contraction. A pressure of 47.5 psia maximum is exerted on the coolant when the bellows is filled to a 53-cubic-inch capacity. The reservoir bypass line flows through a coolant pump power supply coldplate and combines with the coolant line from the reservoirs. The coolant line separates into three paths, one goes to the inlet reservoir upstream of pumps A and B, one goes to the inlet reservoir upstream of pump C, and the third makes a bypass loop around the pumps and contains a telemetry differential pressure transducer and two pressure switches, all mounted in parallel.

2.4.4.2.1.1 ATM Control and Display Panel and EREP Cooling Assembly

The ATM C&D panel and associated accessories located in the MDA and the EREP are cooled by a prelaunch-serviced water cooling loop originating in the AM. The cooling system (figure 2.4.4-23) consists of an ATM tank module located in the STS and an ATM water pump module located exterior to the STS. The ATM tank module contains a water tank, filter, and filter bypass relief valve identical to those in the suit cooling $H_2O$ tank module. The ATM water pump module contains three parallel plumbed positive displacement rotary vane water pumps and a ground cooling type heat exchanger interfacing with the MMS-602 coolant loops. Each pump has an integral bypass relief valve, a differential pressure transducer for telemetry and an outlet check valve. The single water loop is capable of removing 1335 Btu/hr from the MDA load and 102 Btu/hr from the operating pump. The system delivers water to the MDA at a temperature between 40°F and 75°F at a flow rate of 220 lb/hr minimum. The maximum water delivery pressure is limited to 37.2 psia by the relief valve. The water line is connected by flex hose to the ATM C&D panel. Location of the heat exchanger in the AM coolant loop is downstream of the tape recorder coldplates to avoid impacting atmosphere conditioning and suit cooling module performance.

Pressure transducer and temperature sensor outputs are telemetered by the AM telemetry system. The three circuit breakers for the $H_2O$ pumps (ATM COOLANT PUMPS A, B, and C) are located on panel 200 in the AM, and the three operating switches for the $H_2O$ pumps (ATM COOLANT PUMPS A, B, and C) are located on panel 203. The ATM coolant pumps LO$\Delta$ P light will come on if a pumps switch is placed to ON and the differential pressure across the pumps is below 4 psid.

2.4.4.2.1.2 OWS Thermal Conductors (Heat Pipes)

Condensation control is provided in the OWS by utilizing thermal conductors or heat pipes. Since the orbital attitude of the OWS is normally maintained in solar inertial, there will be a temperature differential between the +Z side (hot side) and the -Z side (cold side). It is expected that temperatures on the hot side could reach 90 to 100°F while the cold side temperatures drop to 35 to 40°F. Since the ECS maintains the humidity level in the OWS at a dewpoint temperature of 47°F, condensation would form on the walls of the OWS. To eliminate this problem, a system of heat pipes are installed at various locations around the OWS walls (figure 2.4.4-24) to equalize the hot and cold side temperatures thereby increasing the temperature on the cold side above the dewpoint temperature. With heat pipes installed, the expected hot side and cold side temperatures will be 65° and 55°F, respectively.

One set of heat pipes are attached to the balsa wood insert (figure 2.4.4-25) at the dome to cylinder intersection (station 53.1). The heat pipes are attached to aluminum plugs, inset and bonded into holes through the balsa wood to contact the hot side of the OWS tank wall. The aluminum plugs decrease the thermal resistance between the heat pipes and the hot exterior of the OWS and enable more heat to be transferred to the cold side of the OWS.

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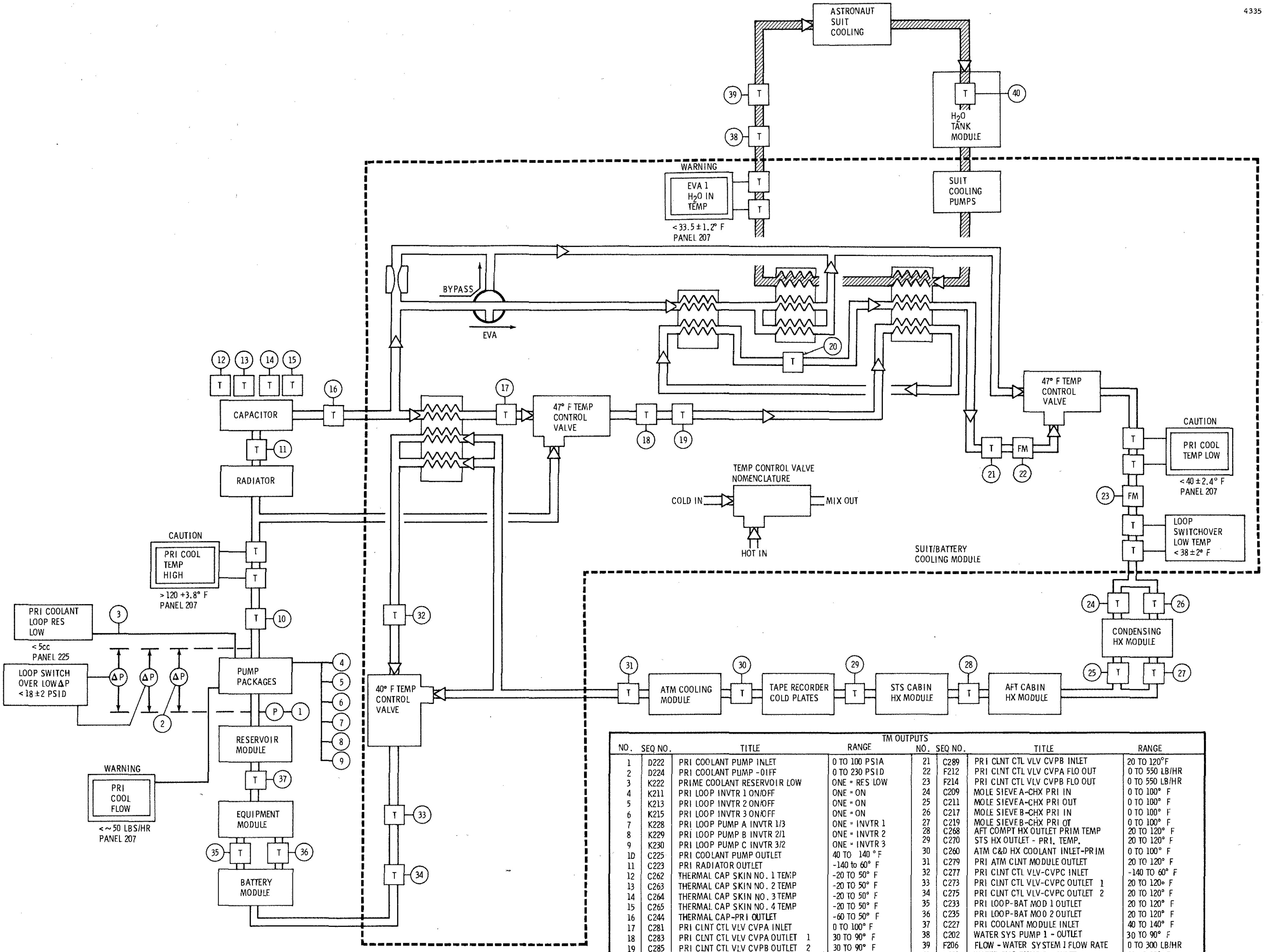


TM OUTPUTS

| NO. | SEQ NO. | TITLE | RANGE | NO. | SEQ NO. | TITLE | RANGE |
|---|---|---|---|---|---|---|---|
| 1 | D222 | PRI COOLANT PUMP INLET | 0 TO 100 PSIA | 21 | C289 | PRI CLNT CTL VLV CVPB INLET | 20 TO 120°F |
| 2 | D224 | PRI COOLANT PUMP - DIFF | 0 TO 230 PSID | 22 | F212 | PRI CLNT CTL VLV CVPA FLO OUT | 0 TO 550 LB/HR |
| 3 | K222 | PRIME COOLANT RESERVOIR LOW | ONE = RES LOW | 23 | F214 | PRI CLNT CTL VLV CVPB FLO OUT | 0 TO 550 LB/HR |
| 4 | K211 | PRI LOOP INVTR 1 ON/OFF | ONE = ON | 24 | C209 | MOLE SIEVE A-CHX PRI IN | 0 TO 100° F |
| 5 | K213 | PRI LOOP INVTR 2 ON/OFF | ONE = ON | 25 | C211 | MOLE SIEVE A-CHX PRI OUT | 0 TO 100° F |
| 6 | K215 | PRI LOOP INVTR 3 ON/OFF | ONE = ON | 26 | C217 | MOLE SIEVE B-CHX PRI IN | 0 TO 100° F |
| 7 | K228 | PRI LOOP PUMP A INVTR 1/3 | ONE = INVTR 1 | 27 | C219 | MOLE SIEVE B-CHX PRI OT | 0 TO 100° F |
| 8 | K229 | PRI LOOP PUMP B INVTR 2/1 | ONE = INVTR 2 | 28 | C268 | AFT COMPT HX OUTLET PRIM TEMP | 20 TO 120° F |
| 9 | K230 | PRI LOOP PUMP C INVTR 3/2 | ONE = INVTR 3 | 29 | C270 | STS HX OUTLET - PRI. TEMP. | 20 TO 120° F |
| 10 | C225 | PRI COOLANT PUMP OUTLET | 40 TO 140 °F | 30 | C260 | ATM C&D HX COOLANT INLET-PRIM | 0 TO 100° F |
| 11 | C223 | PRI RADIATOR OUTLET | -140 to 60° F | 31 | C279 | PRI ATM CLNT MODULE OUTLET | 20 TO 120° F |
| 12 | C262 | THERMAL CAP SKIN NO. 1 TEMP | -20 TO 50° F | 32 | C277 | PRI CLNT CTL VLV-CVPC INLET | -140 TO 60° F |
| 13 | C263 | THERMAL CAP SKIN NO. 2 TEMP | -20 TO 50° F | 33 | C273 | PRI CLNT CTL VLV-CVPC OUTLET 1 | 20 TO 120° F |
| 14 | C264 | THERMAL CAP SKIN NO. 3 TEMP | -20 TO 50° F | 34 | C275 | PRI CLNT CTL VLV-CVPC OUTLET 2 | 20 TO 120° F |
| 15 | C265 | THERMAL CAP SKIN NO. 4 TEMP | -20 TO 50° F | 35 | C233 | PRI LOOP-BAT MOD 1 OUTLET | 20 TO 120° F |
| 16 | C244 | THERMAL CAP-PRI OUTLET | -60 TO 50° F | 36 | C235 | PRI LOOP-BAT MOD 2 OUTLET | 20 TO 120° F |
| 17 | C281 | PRI CLNT CTL VLV CVPA INLET | 0 TO 100° F | 37 | C227 | PRI COOLANT MODULE INLET | 40 TO 140° F |
| 18 | C283 | PRI CLNT CTL VLV CVPA OUTLET 1 | 30 TO 90° F | 38 | C202 | WATER SYS PUMP 1 - OUTLET | 30 TO 90° F |
| 19 | C285 | PRI CLNT CTL VLV CVPB OUTLET 2 | 30 TO 90° F | 39 | F206 | FLOW - WATER SYSTEM I FLOW RATE | 0 TO 300 LB/HR |
| 20 | C287 | PRI HX OUT-SUIT/BAT CLNT MOD | 0 TO 100°F | 40 | C201 | WATER SYS PUMP 1 - INLET | 30 TO 90° F |

Figure 2.4.4-22 Primary Coolant Loop

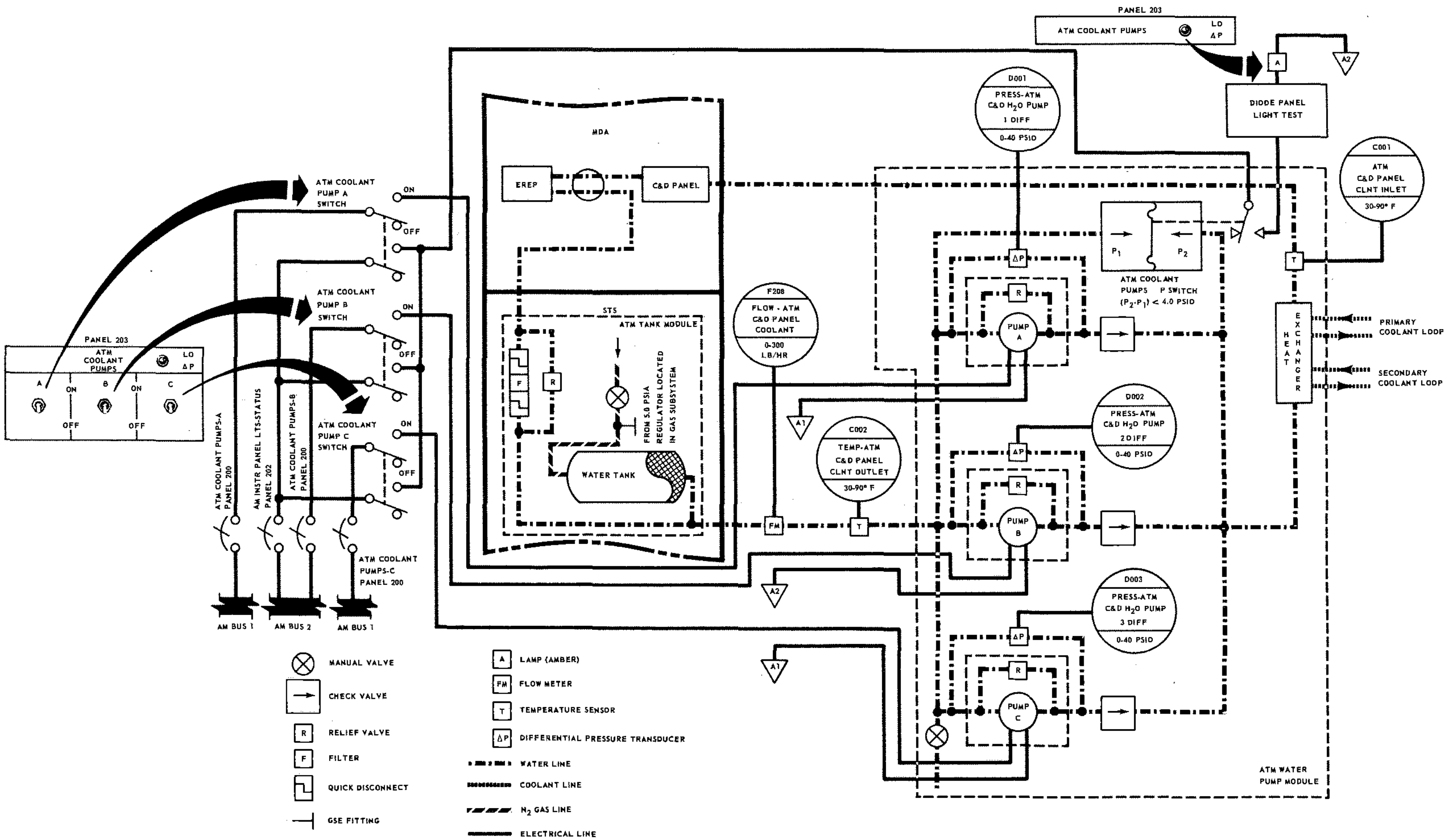


Figure 2.4.4-23 ATM C&D Panel Cooling System

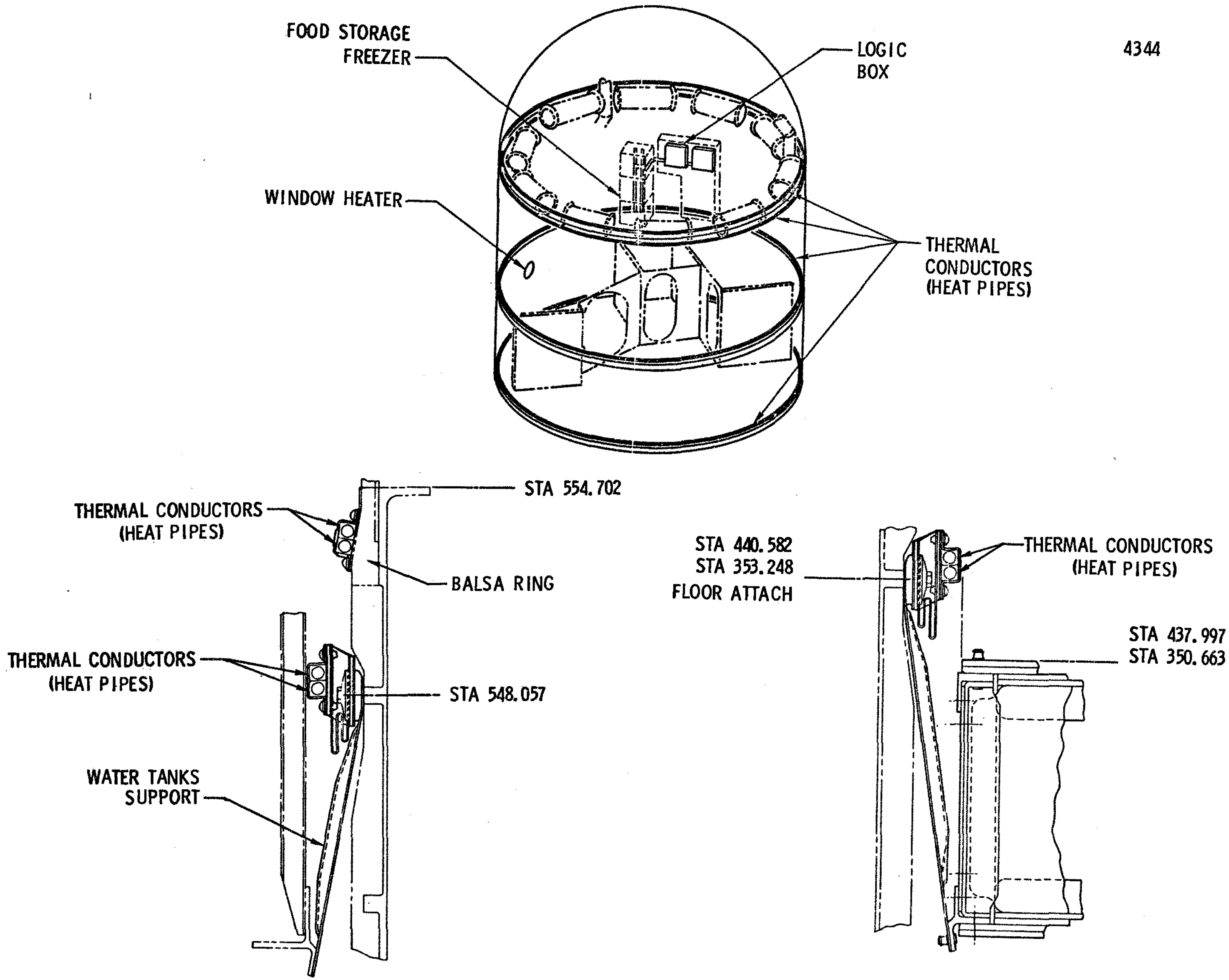


Figure 2.4.4-24 Heat Pipe Locations

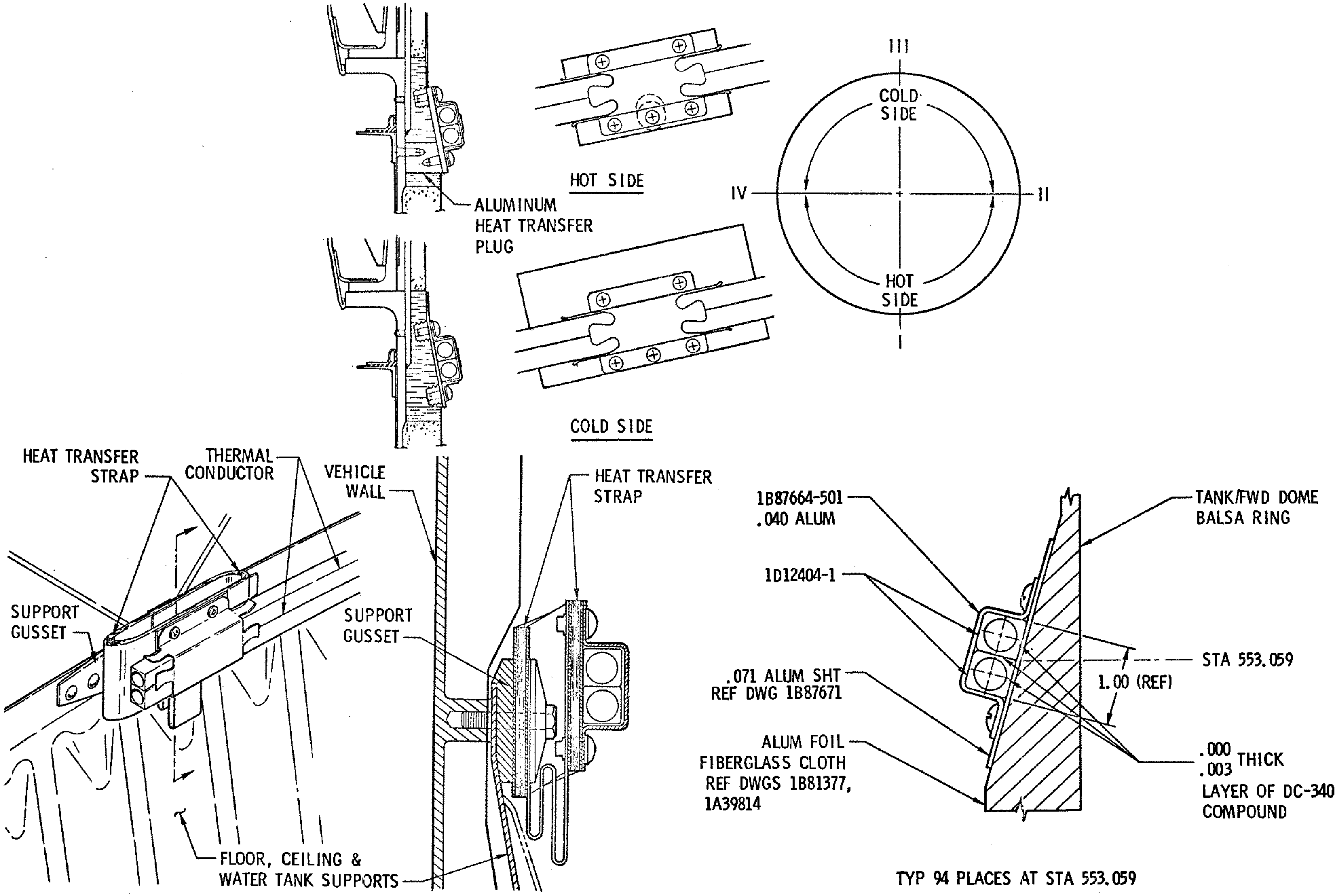


Figure 2.4.4-25 Heat Pipe Installation -- OWS Wall

A second set of heat pipes are attached to the water bottle support cone attach bolts at the tank wall (station 548.1). The attach points on the cold side of the OWS require phenolic spacers between the support cones and the tank wall to maintain the interior temperatures above 55°F.

A third and fourth set of heat pipes are installed at the floor/ceiling attach points (station 440.6 and 353.25). The installation is essentially identical to that at the water bottle support.

Two more sets of heat pipes are installed from the refrigeration system logic unit to an aluminum plate located between the food freezer and tank wall to maintain this area above 55°F (figure 2.4.4-26). Transferring heat away from the logic unit will also maintain the ambient food boxes below their upper limit temperature of 85°F.

Each set of heat pipes (figure 2.4.4-27) consists of parallel sealed aluminum extrusions, filled with Freon 22 (liquid) and containing a stainless steel wire cloth wick. On the hot side of the OWS, the outer Freon layer will vaporize, increasing the pressure and causing the Freon vapor to flow along the outer passage to the lower pressure or cold side of the OWS. As the vapor reaches the cold side it will condense flow to the inner passage and eventually flow back to the hotside through the center of the heat pipe via the wick.

2.4.4.2.2 Electrical Heaters

The electrical heaters are divided into three groups, depending on location; MDA, AM and OWS (figure 2.4.4-28).

The MDA heater group consists of four heater systems; wall, tunnel, port, and window heaters.

There are 16 wall heaters, numbered 1 through 16 each with a primary and a secondary element. Heaters 1 through 8 (each element 20 watts) are located on the MDA wall between the radial and axial docking ports. These heaters are also referred to as the upper heaters. Heaters 9 through 16 (each element 40 watts) are located on the MDA wall between the radial port and the STS. These heaters are also referred to as the lower heaters. The 32 heater elements are divided into four groups, further divided into two groups of four heaters each.

| | |
|---|---|
| Primary 1 | (heaters 1 through 4 primary upper 20 watts each) |
| | (heaters 13 through 16 primary lower 40 watts each) |
| Secondary 2 | (heaters 1 through 4 secondary upper 20 watts each) |
| | (heaters 13 through 16 secondary lower 40 watts each) |
| Primary 2 | (heaters 5 through 8 primary upper 20 watts each) |
| | (heaters 9 through 12 primary lower 40 watts each) |
| Secondary 1 | (heaters 5 through 8 secondary upper 20 watts each) |
| | (heaters 9 through 12 secondary lower 40 watts each) |

Each group of four heaters has one 70°F thermostat and one 45°F thermostat. Each of the four elements has its own overtemp thermostat, which will open at 97±3°F and close at 93°F. In MANUAL control, the heaters will be controlled in two groups (either PRI or SEC) through the 70°F thermostats. In CMD, a redundant capability, via DCS to turn power on/off to the heaters and select primary or secondary heaters is provided. The DCS also has the capability of selecting either the 45°F or the 70°F thermostats to control the heaters. The design of the system is such that the primary and secondary elements of a heater will not be on at the same time. The heaters are nominally activated through the 45°F thermostat for storage periods and through the 70°F thermostat for periods of habitation.

There are two tunnel heaters located in the CSM port tunnel; each heater has a primary and a secondary 80-watt element. Each element has an operating thermostat that opens at 74°F maximum and closes at 60°F minimum and an overtemp thermostat that opens at 105°F maximum and closes at 91°F minimum. Manual control provides primary or secondary select capability. Command control provides redundant on/off control, utilizing the same commands used for wall heaters on/off. A separate command is used to select primary or secondary tunnel heaters. The heaters are activated during both storage and habitation periods.

Both docking ports have a heater with a primary and secondary 15-watt element. Each element has an inline thermostat (close 60°F minimum, open 70°F maximum) for control and an overtemp thermostat (open 82°F maximum and close by 72°F minimum). The DCS provides for combined CSM and SPARE on/off select and individual CSM, SPARE primary or secondary select. The heaters are activated during habitation and storage. The MDA experiment window heater system consists of two frame heaters (each 80 watts) and a conductive film heater (40 watts between) window panes. The window frame is made up of two U-shaped sides. Each side of the frame has a heater. The heating system is manually activated only and is controlled through panel 117, located in the MDA dome section. There are four temperature sensors mounted on the center area of the window, one for window overtemp (open 105°F, close 91°F), one referenced with one side of the frame, another referenced with the other half of the frame, and the fourth sensor is referenced with cabin ambient. Once activated, the control logic will energize the heaters independently to maintain the difference in frame to glass temperature at ±4°F and the difference in glass to ambient temperature at ±17°F. If these limits are exceeded, the TEMP light, panel 117, will come on. The frame heaters are also equipped with overtemp sensors (open 105°F, close 91°F), and if the frame or window overtemp is reached all heaters are turned off and the overtemp light comes on. The RESET switch must be initiated to reactivate the heaters after an overtemp. During habitation, the heater system will be in an automatic mode; during storage, it will be off.

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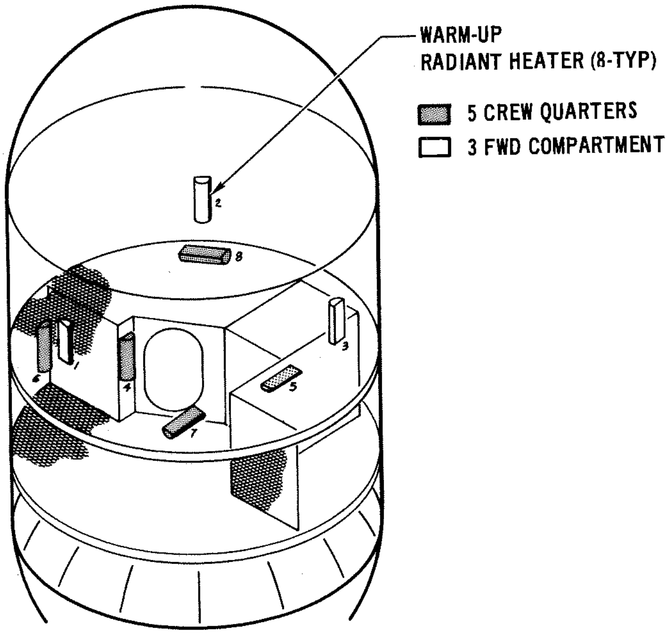


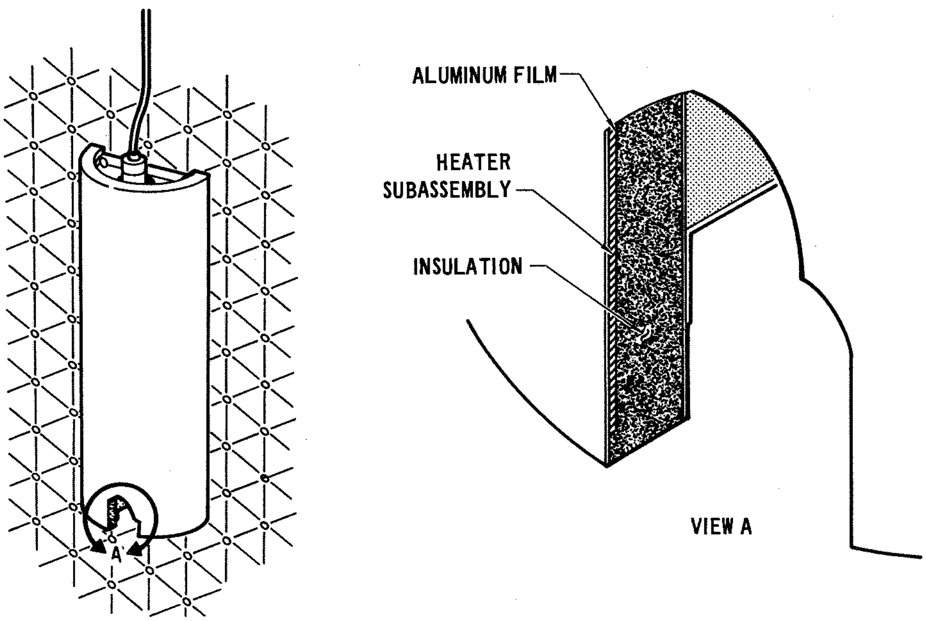


Figure 2.4.4-29 Radiant Heaters

The AM has seven 15-watt heaters located on the exterior surface of the STS aft bulkhead, seven 15-watt heaters located on the exterior wall of the lock compartment, and one 15-watt heater located on the exterior wall of the forward compartment. These heaters are provided to maintain the wall temperatures at a tolerable level during cold mode operation and to prevent freezing of water in the suit cooling system and ATM cooling module during orbit storage. Control of the heaters is provided through a manual ON/OFF/CMD switch, a HI/LO switch both on panel 203 and the DCS. Each heater is activated through a 42°F and 62°F parallel-connected thermostats and an 85°F series connected thermostat. When either the 42°F or the 62°F thermostat is used, the 85°F thermostat acts as an overtemperature control. With the select switch in the CMD position, the DCS provides the capability to direct power to the 42°F thermostat or to the 62°F thermostat. With the select switch in the ON position, the HI/LO switch directs power to either the 85°F thermostat or the 62°F thermostat. The 42°F and 62°F thermostats are located approximately mid-span between heater elements and the 85°F thermostat is located immediately adjacent to heater elements.

The 42°F and 62°F thermostats are used for all unmanned mission phases with the 85°F capability being used during any cold manned phases that may occur.

The OWS uses two types of heaters for thermal control, a radiant type and a convective-element type. A third type, consisting of an electrically conductive coating applied to the outboard surface of the inner unit glass is used for defogging the wardroom window. Of the eight radiant type heaters (figure 2.4.4-29) five are installed in the OWS crew quarters and three in the OWS forward compartment. The heaters operate at 210°F, with each heater using 125 watts of power. These heaters are used for heating in preparation for habitation and to maintain the OWS film vault and food storage containers above 40°F during storage. The heaters can be used during periods of habitation, but their high touch temperature of 210°F will normally preclude this. A deactivated heater will cool to 105°F in approximately 50 minutes, but the heated area around the heater will require 1 hour.

Control for the radiant heaters in two groups of four heaters each (group No. 1 includes heaters 1, 3, 5 and 7; group No. 2 heaters 2, 4, 6, and 8) is provided through two manual ON/OFF/CMD switches located on panel 203. The DCS provides independent on/off control for each group when the switches are in the CMD position.

A four-element convective heater assembly (figure 2.4.4-30) is installed downstream of the fan assembly in each of the three habitation area gas distribution ducts. When activated, the heaters provide heating of the gas passing through the gas distribution ducts. The total convective heater capability is 1500 watts, 125 watts per each element. The elements in each duct are numbered 1 through 4 and controlled in groups of two, numbers 1 and 3 together and 2 and 4 together. The system can be operated automatically or manually. In manual operation, 1500 watts are controllable through the DUCT 1 and DUCT 2 AUTO/ON/OFF switches and the DUCT 3 BUS 1/OFF/BUS 2 switches, panel 617. These switches may be turned on or off at any time, overriding the action of the automatic system. Power for duct 1 is derived from OWS bus 1, and power for duct 2 is derived from OWS bus 2. A capability is provided for selecting either bus 1 or bus 2 as a source of power, and normally the load would be split between bus 1 and bus 2. In automatic, only the heaters in ducts 1 and 2 are controllable and are actuated through the OWS thermal control logic (paragraph 2.4.4.2.5) in four increments of 250 watts. Two inline series-connected temperature thermostats are provided to interrupt power to each element should an overtemperature occur. Thermostat actuation will deactivate the heaters at 260±7°F and reactivate the heaters at 240±7°F.

The WINDOW HEATER BUS 1/OFF/BUS 2 switch on the wardroom control and display panel 702 provides for manual control of the conductive film wardroom window heater. The power dissipation for the total surface area is 32 watts. The heater is energized during the habitation phase to defog the wardroom window and deenergized during the unmanned phase.

#### 2.4.4.2.3 Insulation

Thermal control on the MDA, AM, and OWS is accomplished in part by an insulation system. This insulation system helps to control the inner wall and non-coldplated equipment temperatures within the allowable limits by controlling the transfer of heat between the inner walls and the surroundings. It also minimizes the electrical heater power required to make up heat loss during cold mode and orbit operations.

The MDA utilizes a high-performance multilayer insulation blanket (HPI) placed between the MDA pressure skin and the radiator/meteoroid shield and extending into the docking ports. The HPI consists of 91 layers of perforated double aluminized Mylar with Dacron net spacers.

The STS does not use insulation, but relies on exterior thermal coatings and goldcoated tape on the inside of the radiator and outside of the pressure vessel.

Thermal isolation of the AM tunnel section is accomplished by meteoroid and thermal curtains designed as radiation shields. The thermal curtains are fabricated from a single layer of fiberglass cloth with Viton rubber impregnated on one side and gold coated on the other side. The meteoroid curtain is of a similar construction except it is thicker with an off-white fiberglass cloth exterior coating against the Viton rubber side. Fiberglass standoffs are installed to minimize curtain contact with structure or equipment in all areas except at attach points. Both the meteoroid and thermal curtains are installed with the gold side internal, except for the thermal curtain covering the suit/battery cooling module.

The thermal curtain is installed on the tunnel section as follows: (figure 2.4.4-31)

1. Over the sides of the outermost truss members (except in the EVA bay), attaching to the STS bulkhead on the forward end and to the octagon ring on the aft end.
2. Between trusses from the STS bulkhead to the octagon ring (except in the EVA bay).
3. From the octagon ring to the OWS dome encircling the flexible tunnel extension.

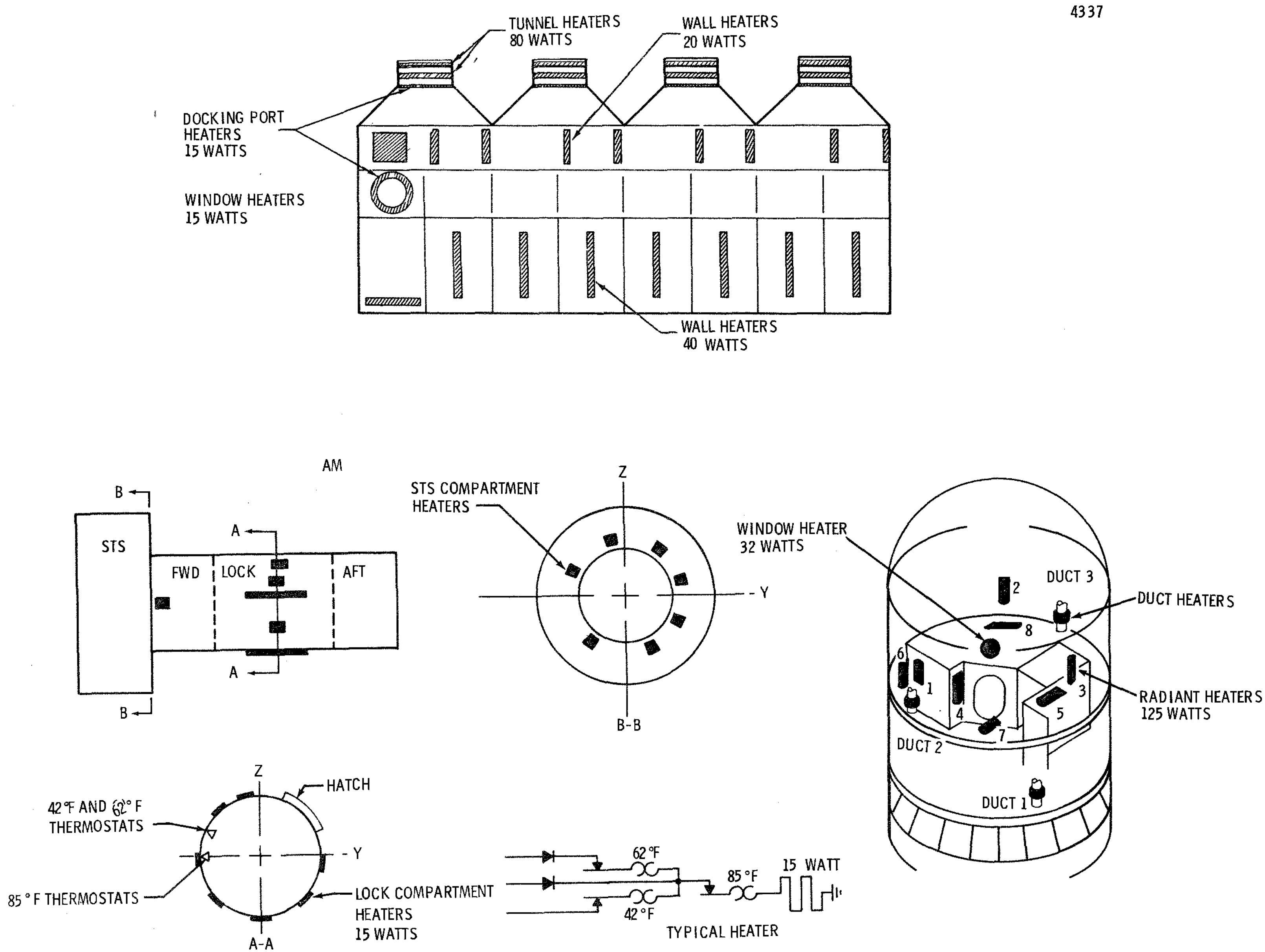


Figure 2.4.4-28 Electrical Heater Locations

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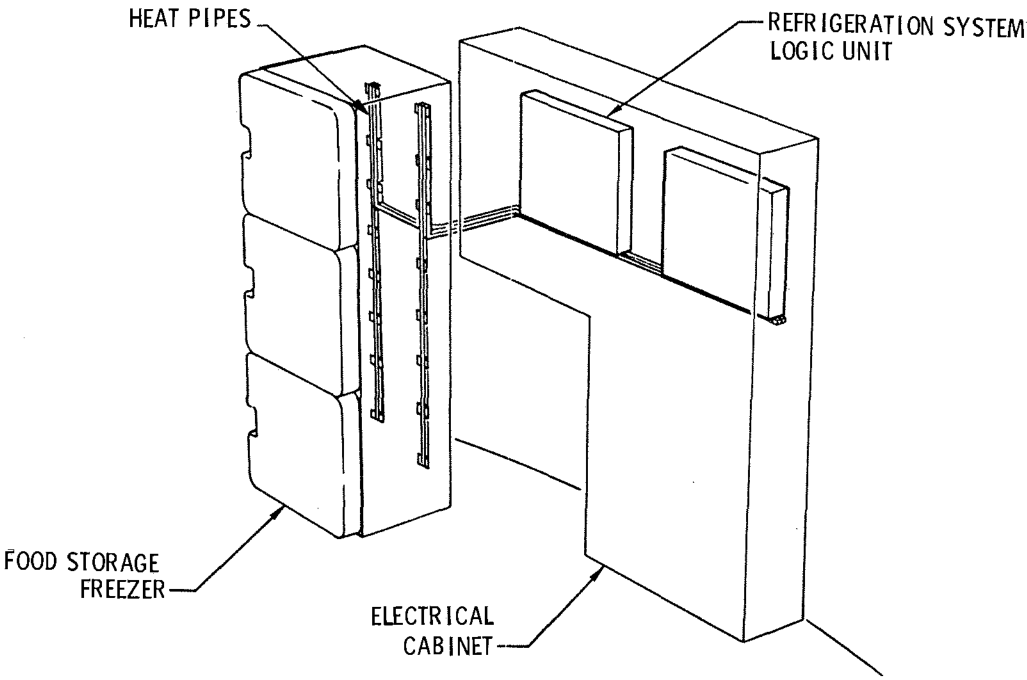


Figure 2.4.4-26 Heat Pipe Installation -- Food Freezer

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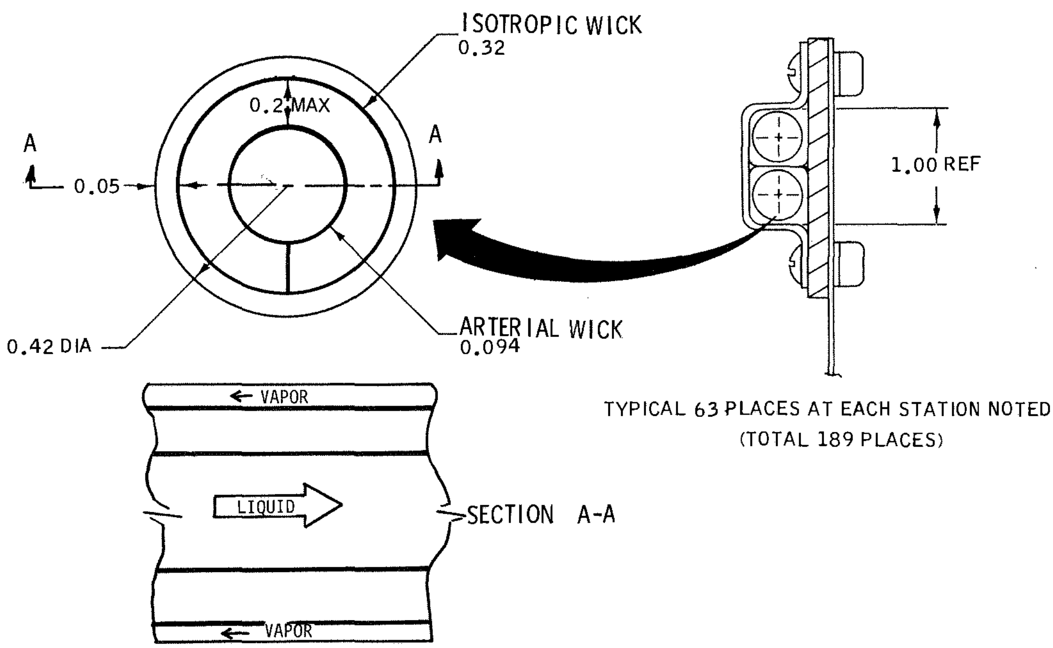


Figure 2.4.4-27 Heat Pipe Section

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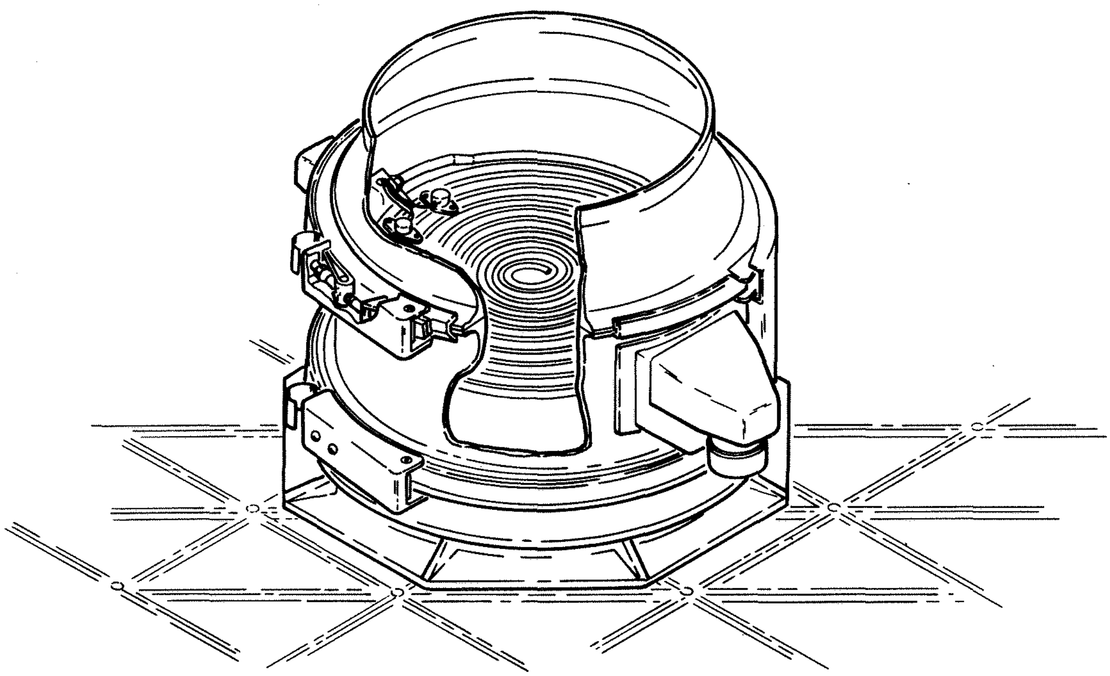

Figure 2.4.4-30 Convective Heater

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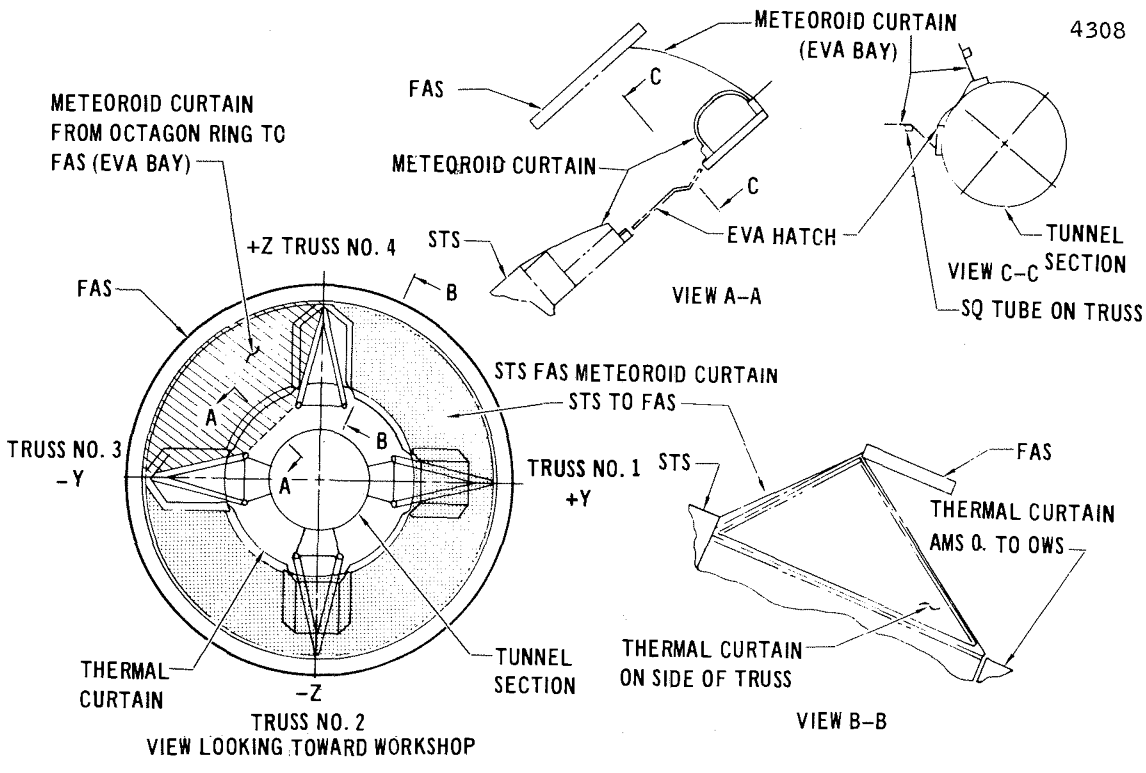


Figure 2.4.4-31 AM Thermal Installation

The meteoroid curtain covers from the aft end of the STS to the FAS, except that in the EVA bay the curtain covers from the octagon ring to the FAS, from the STS to the octagon ring, and along the truss sides from the AM to the FAS.

The OWS forward dome exterior insulation is High-Performance Insulation (HPI). The insulation system covers the dome forward of the debris shield. The HPI consists of 48 alternate layers of double aluminized Mylar and 47 layers of Dacron net spacer material. The layers are held together with intermittently spaced nylon fasteners (buttons), which penetrate the multilayer insulation and retain the layer at a constant thickness of 0.5 inch with a density of 0.16 lb/ft2.

There are 18 panels (20-degree gore sections) covering the forward dome area (figure 2.4.4-32). The panels are approximately 160 inches long and by 48 inches wide at the aft end, and 12 inches wide at the forward end. An outer and inner structural protective cover made up of Dacron or nylon provides protection to the insulation during handling. The 18 panels are identical except for the cutouts required at the three electrical feed-through fittings. Special, skullcap-shaped HPI is used to cover the three electrical fittings and tie to the panel insulation. The forward end of the HPI has a structural attachment to the electrical support panels. The aft end of the HPI connects to the debris shield with velcro. The habitation area sidewall is insulated with 1.0 inch of foam, the forward dome with 0.5 inch. The common bulkhead, aft dome, and sidewall to aft dome joint are insulated with 3 inches of foam(figure 2.4.4-33). A fiberglass liner is bonded to the surface of the foam. The fiberglass liner covering the 1.0 inch and 0.5 inch foam has 0.003 inch aluminum foil bonded to the exterior surface. The aluminum foil is coated with light yellow teflon. The fiberglass liner covering the 3.0 inch foam has 0.005 inch aluminum foil bonded to the exterior surface of the fiberglass.

2.4.4.2.4 Thermal Coatings and Radiation Shielding

Selected thermal coatings (figure 2.4.4-34) assist in SWS temperature control. The AM trusses are coated with an aluminized paint to give an emissivity of 0.5. The emissivity is 0.5 on the internal surface of the FAS (except in the EVA quadrant). The IU and OWS forward skirt and dome have a 0.8 emissivity. The battery module components, exterior of the cylindrical section of the STS under the radiator, and the backsides of the radiator will have low emissivity surfaces.

The external surface thermal coating employed consists of aluminum, black, and white paints. The radiator uses a white paint (zinc oxide) with a low ratio of solar absorptivity ($\alpha$) to emissivity ($\epsilon$) in order to provide low effective sink temperatures and resultant higher heat rejection rates. The design value used for the radiator surface is slightly higher than values measured for a clean surface to account for degradation during the mission caused by exposure to UV, meteoroids, exhaust plume impingement, etc. Both black and white paints are used on the forward skirt, and black paint is used on the IU, FAS, and MDA. An aluminum paint ($\alpha$=.25, $\epsilon$=.30) is used on the DA and on squares provided around the top of the FAS to improve visibility during docking.

The meteoroid shield exterior is painted black, except for a region about the +Z where white paint is used. The white paint controls the rate of absorption of direct solar energy during high beta angle periods of flight.

The OWS meteoroid shield boot (figure 2.4.4-35) minimizes the radiative heat loss from the forward and aft annulus formed by the deployed meteoroid shield and the S-IV B tank. The boot installation accomplishes this by: (1) blocking the annulus view to space and (2) coating the interior surface on the boot with teflon and the exterior with a black epoxy paint. The tank external surface optical coating of gold-coated kapton provides the proper thermal radiation interchange between the meteoroid shield, the boot, and the tank.

The meteoroid shield extension (thermal shield) covers portions of the forward and aft skirts (figure 2.4.4-36), providing a low emissivity surface. It extends from the tank joints to the first frame of the forward or aft skirt. This is about 32 inches in both cases. The primary function of the shield is to prevent excessive heat losses from the tank because of radiation. The heat loss results from conduction through the tank joint and into the skirt and radiation interchange between the dome and skirts. A coating pattern, using gold-coated kapton film on the inner and outer surfaces of the forward and aft skirt sections covered by the thermal shield and the inner surface of the thermal shield, minimizes the thermal radiation interchange between the dome, the skirts, and the thermal shield. A secondary function of the shield is to reduce heat input from solar radiation. The shield tends to stabilize the overall interior temperature of the OWS.

The habitation area surfaces have optical (emittance) property control to promote radiation interchange and to equalize internal temperatures. The coatings being utilized are:

1. The aluminum foil fire retardant liner is coated with colored teflon on the areas from the lower floor forward.
2. The area below the floor is anodized.
3. The crew quarters walls and lower and upper floors are color anodized.

These coatings will give emittances greater than 0.7.

OWS electronic components currently requiring thermal control are mounted on panels in the forward skirt. These components and their thermal control schemes are as follows:

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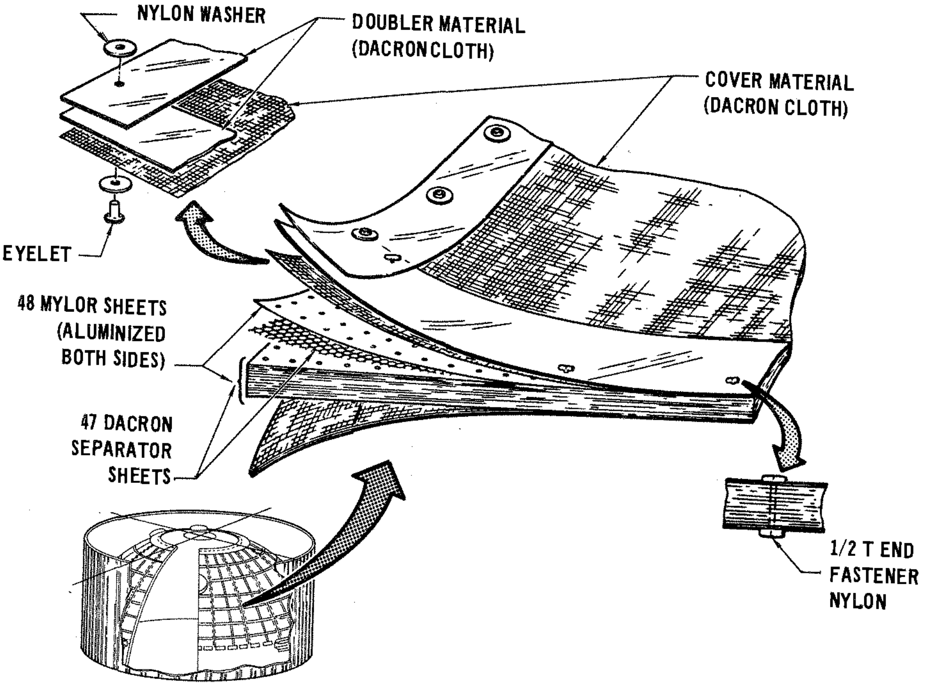


Figure 2.4.4-32 High-Performance Insulation

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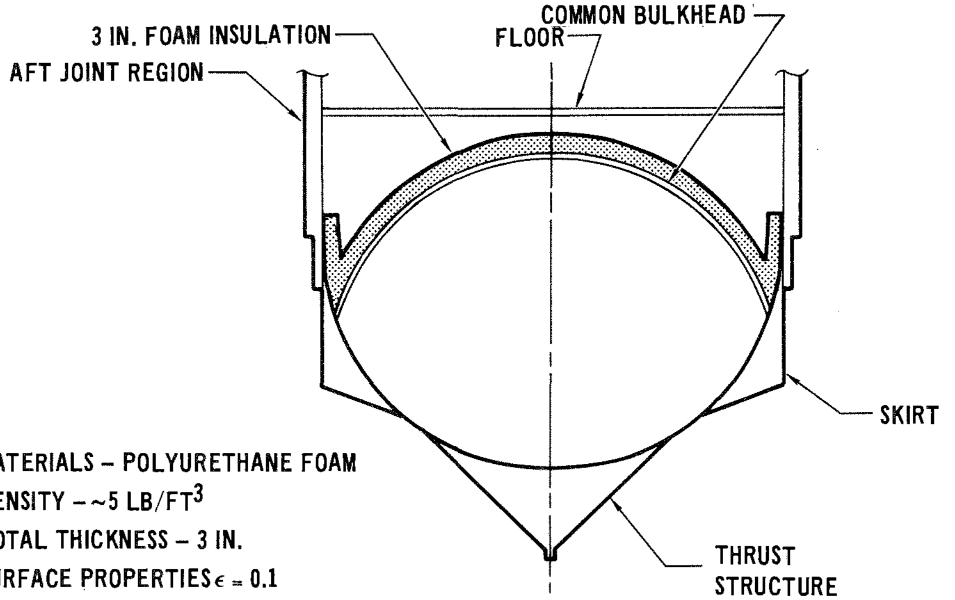



- MATERIALS – POLYURETHANE FOAM
- DENSITY – ~5 LB/FT$^3$
- TOTAL THICKNESS – 3 IN.
- SURFACE PROPERTIES $\epsilon = 0.1$

Figure 2.4.4-33 Foam Insulation Below Crew Quarters

4103

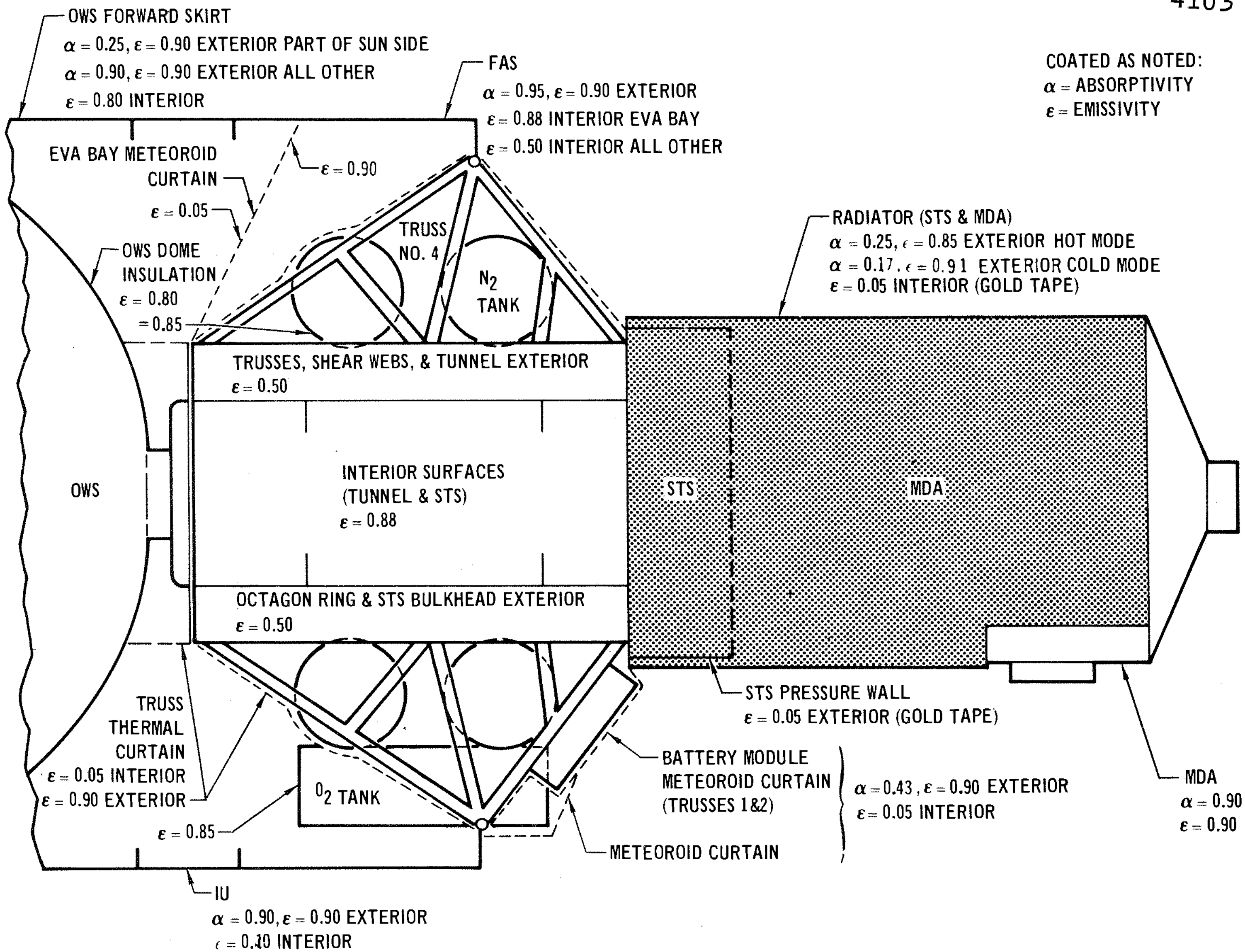



Figure 2.4.4-34 AM/MDA Thermal Coatings

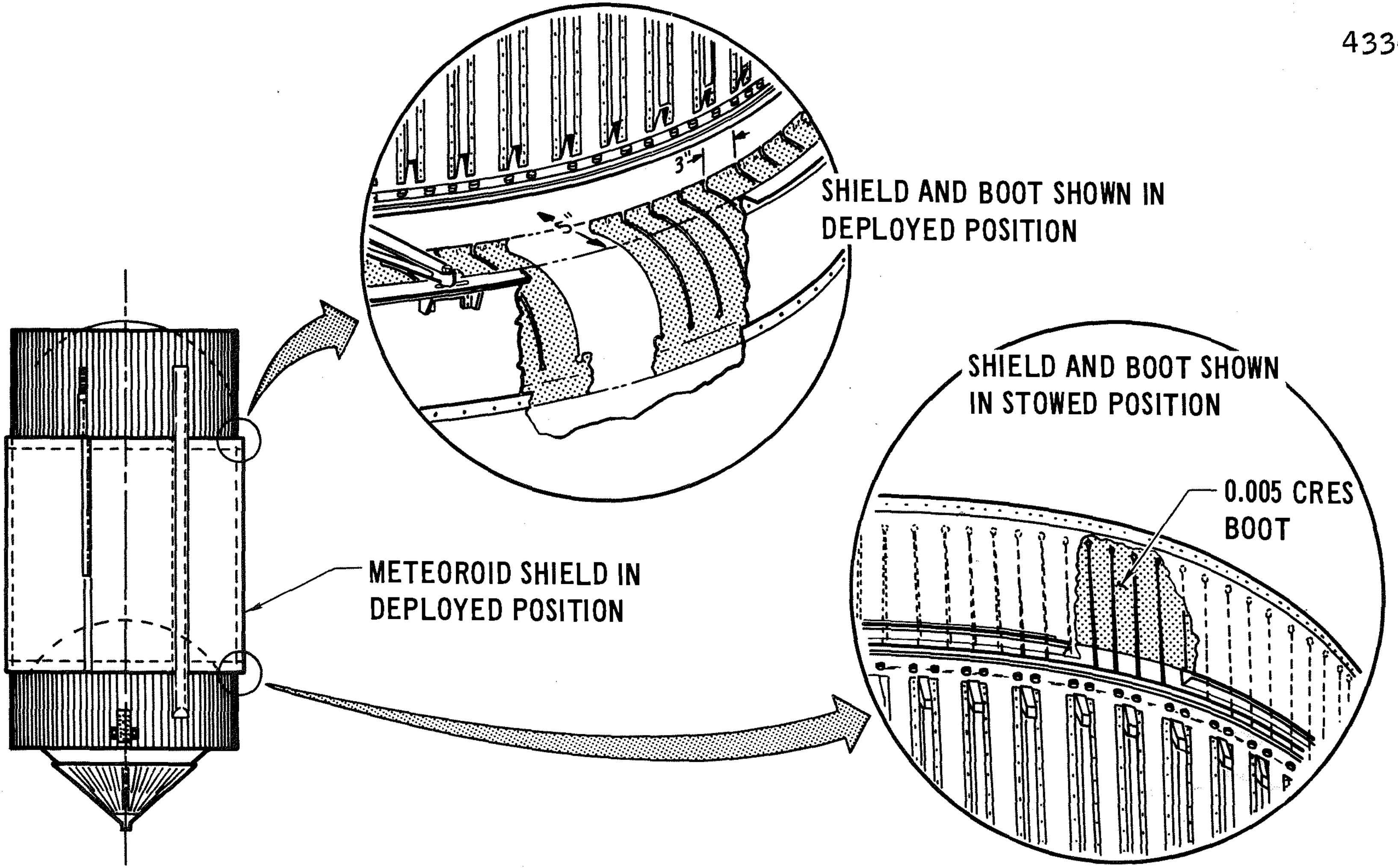



Figure 2.4.4-35 Meteoroid Shield Boot

4104

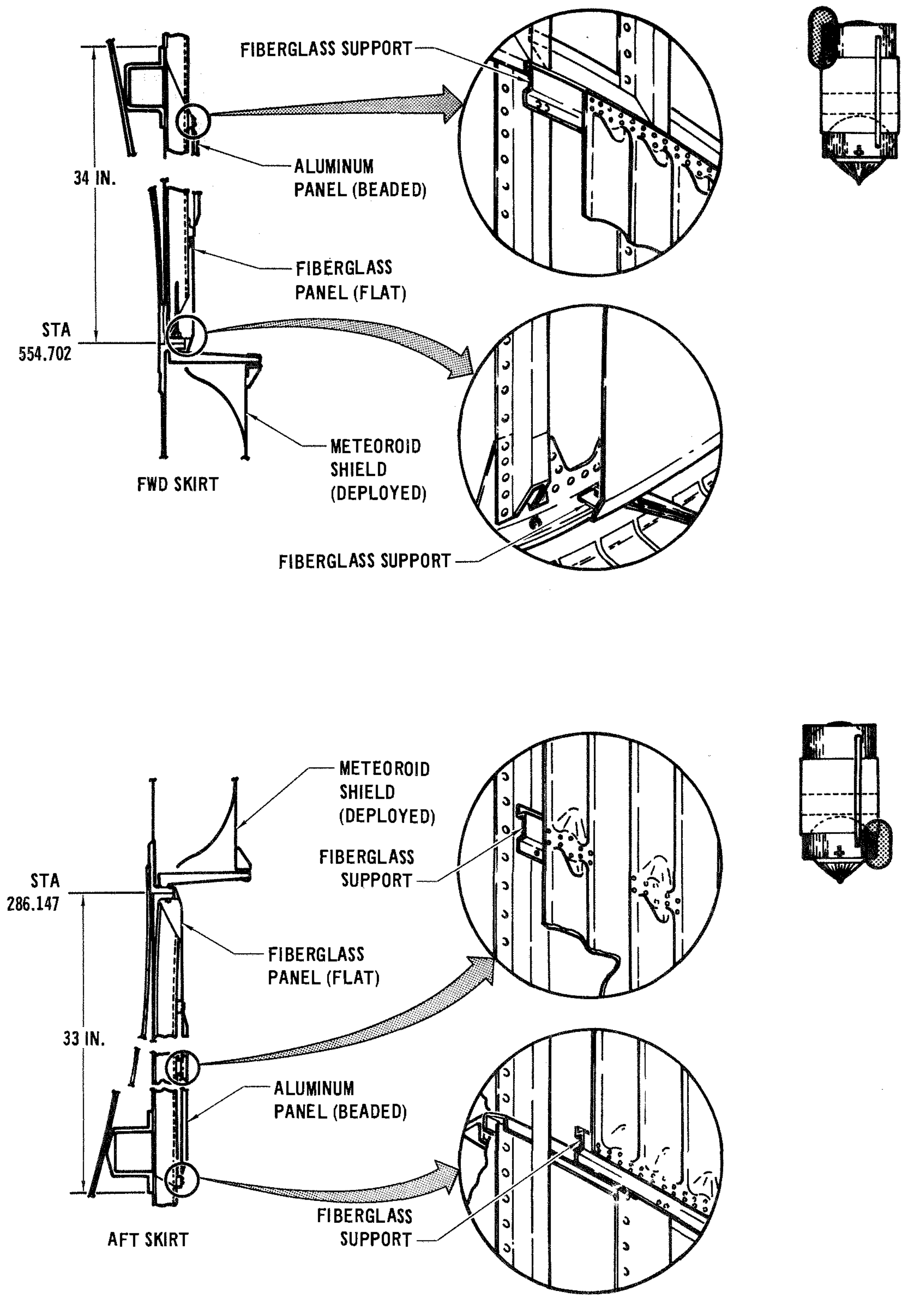



Figure 2.4.4-36 Forward and Aft Thermal Shield

Switch Selector

All surfaces of the unit except the mounting surface are covered with a low emissivity ($\epsilon$) coating - $\leq$ 0.1. The coating is required to retard component cooling during its operational lifetime (the first 7.5 hours of flight).

Multiplexers

A low emissivity surface, $\leq$ 0.1, in conjunction with thermostatically controlled heaters is required to maintain the component temperatures above 35°F. Further, the outboard side of the panels must have an $\leq$ 0.9 and the external surface of the forward skirt in the regions of signal conditioning panels must be painted white to prevent high temperature problems.

OWS DC-DC Converters

A high emissivity surface, $\leq$ 0.9, is required in conjunction with the passive schemes shown for the multiplexers to prevent high component temperature problems.

2.4.4.2.5 Major Component Operation

COOLANT PUMP ASSEMBLY

The difference between the one-pump assembly and the two-pump assembly (figure 2.4.4-37) is the removal of one pump motor, one pump cartridge, and the plugging of the pump cartridge opening.

The two-pump assembly consists of a fill valve, two poppet check valves, a coolant reservoir with a low-level switch, two gear pumps, two electrical motors, and three ports (fill, an inlet, and an outlet port), all installed in a common housing. A manually operated plunger used to open or close a flow passage between the fill port and the fluid reservoir, serves as the fill valve. After completion of the ground filling operation, the plunger is locked in the closed position. The spring-load, poppet-type check valve prevents any backflow through the standby pump and also contains a reed switch, which initiates the C&W PRI COOL FLOW and SEC COOL FLOW warning alert for a "low flow" condition when the flow through the check valve is less than 50 lb/hr. The contacts on the reed switch are made by an internal magnet for no flow and broken when the poppet moves the magnet away. The fluid reservoir is a compression bellows-type assembly charged with freon. The pressure exerted on the fluid when the bellows is in the empty position is a minimum of 19.0 psia when operating at 72°F. The pressure exerted on the fluid when the bellows is filled to 53-cubic-inches is a maximum of 47.5 psia at a temperature of 150°F. When the bellows is in the empty position (5-cubic-inches or less), an electrical switch is closed and a RES LO light, panel 203, comes on.

Each motor drives a gear pump by a direct coupling. The motors require three phase 12-vac, 60 cps. The motor is cooled by the passage of coolant fluid through the housing. The pump inverters vary the input current while maintaining nearly constant frequency to maintain an approximately constant flowrate.

OWS THERMAL CONTROL SYSTEM

The thermal control system consists of a thermal control assembly (TCA), temperature sensors, and OWS control and display panel No. 617. The TCA controls the OWS atmosphere temperature by cycling the OWS cooling module cabin heat exchangers fans (paragraph 2.4.4.3.1) or OWS convective heater elements (paragraph 2.4.4.2.2) on and off as necessary to maintain the selected temperature. The TEMP SELECT (°F) selector, panel 617, provides the means for selecting an OWS atmosphere temperature of 60° to 90°F. The selected OWS atmosphere temperature is compared with the actual atmosphere temperature as sensed by three temperature sensors located in experiment compartment diffuser No. 1 and initiates TCA action in the heating or cooling mode.

The allowable temperature deviation is $\pm$4°F from the temperature set point (figure 2.4.4-38). Should the temperature increase by 4°F above the set point, the thermal control system enters a cooling cycle and all four heat exchanger fans are turned on. When the temperature decreases 2°F below the temperature set point, all four heat exchanger fans are turned off. Then if the temperature increases to 1°F above the set point, one heat exchanger fan is turned on; 2°F, second fan; 3°F, third fan; 4°F, all four heat exchanger fans on.

When the temperature goes below the set point by 2°F, the heat exchanger fan(s) is turned off, and the thermal control system remains in the cooling cycle until the cabin gas temperature goes 4°F below the temperature set point. Then the system enters the heating cycle and the converse of the cooling cycle is performed, utilizing four 250-watt increments of convective heaters.

Panel 617 provides onboard monitoring and control of the temperature control system. A two-temperature transducer installed in wardroom diffuser No. 2 provides inputs to the OWS TEMP indicators used to monitor the performance of the TCA. The DUCT AIR FLOW 1, 2, and 3 indicators verify adequate gas flow for heater operation. The HEAT EXCHANGER FANS 1, 2, 3, and 4 switches provide for AUTO or manual ON/OFF control of the fans and heat exchanger. Heater switches are covered in paragraph 2.4.4.2.2. Four current sensors are provided with an output to telemetry only. Each sensor measures the combined current flow to three 125-watt heater elements.

Sequence of controller operation while in the automatic mode is shown in figure 2.4.4-38.

4143

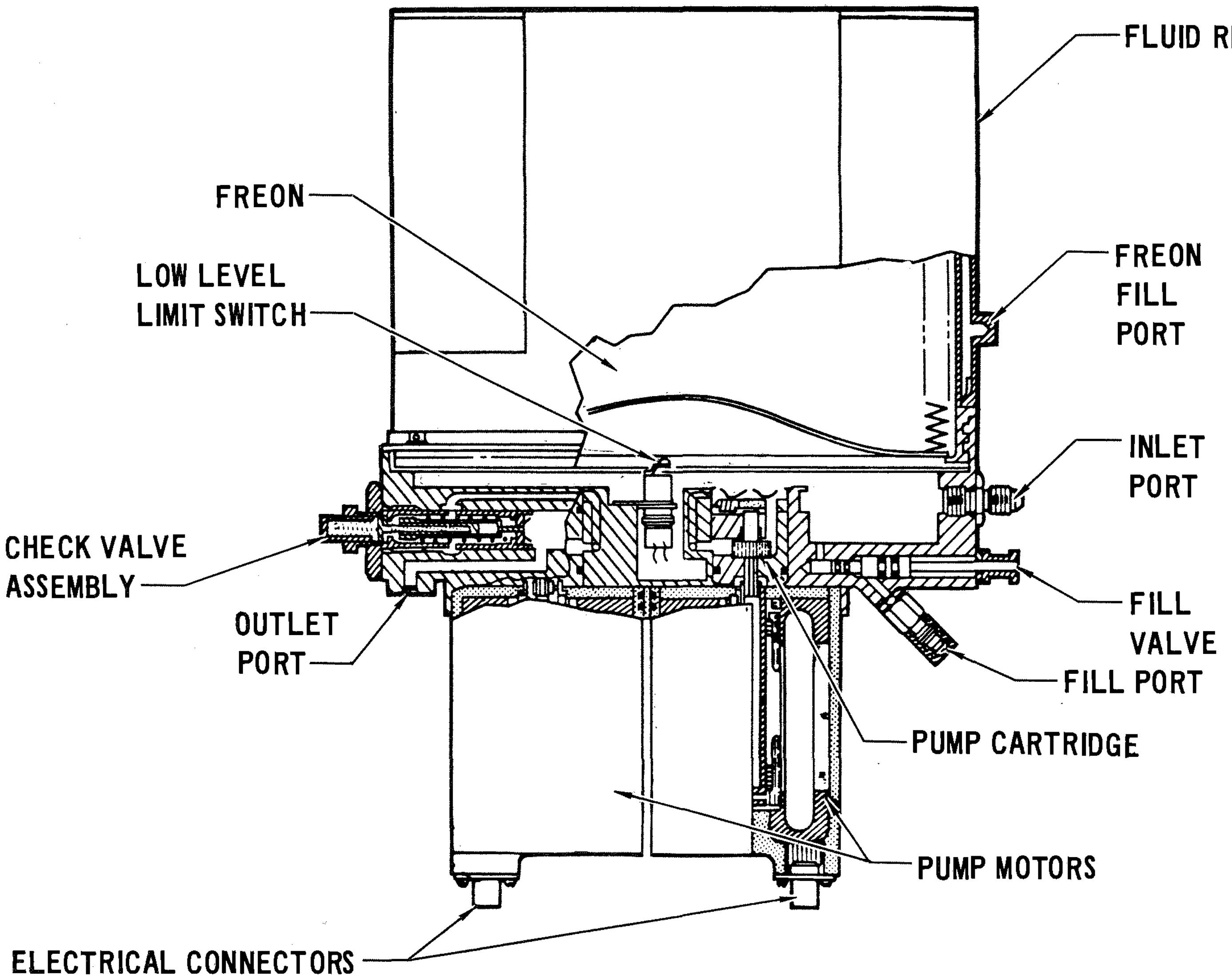



Figure 2.4.4-37 Coolant Pump Assembly

4092

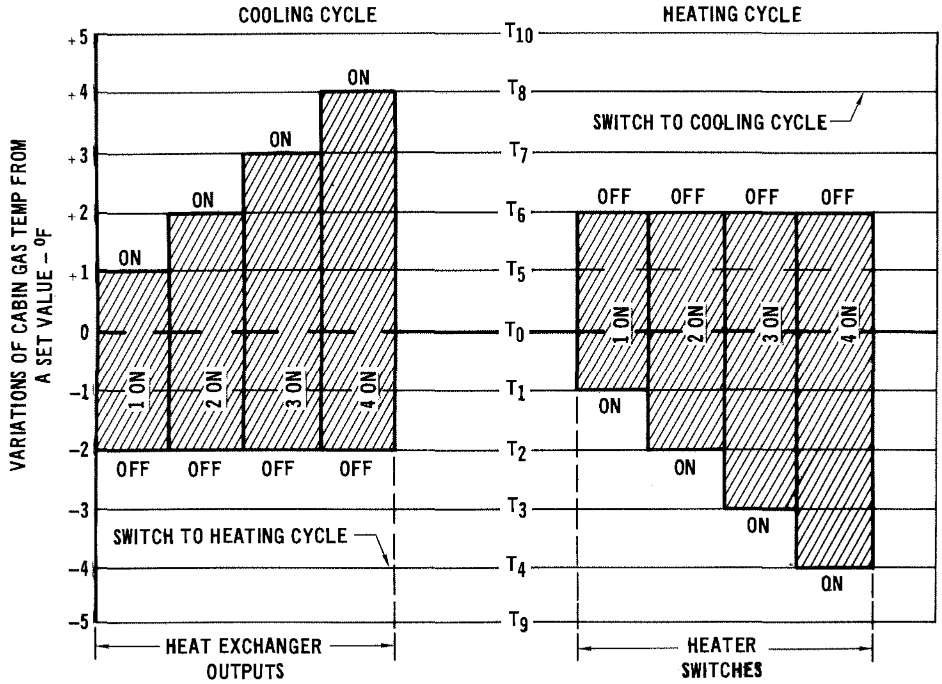


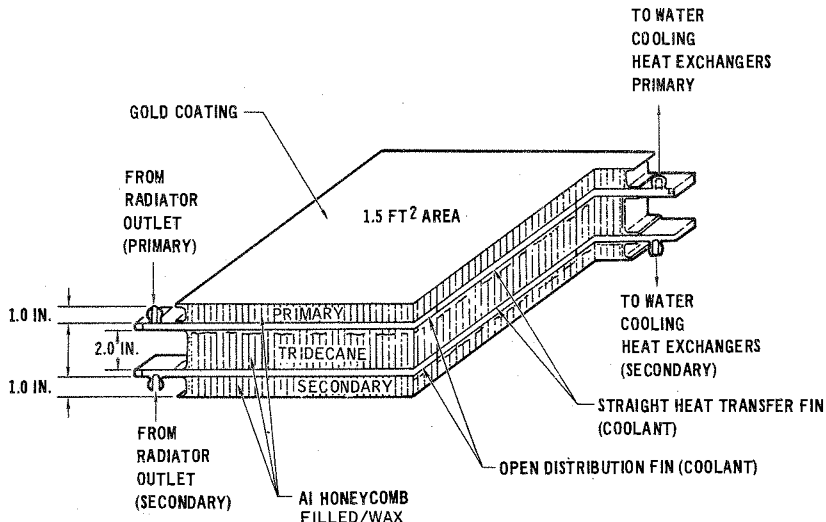

Figure 2.4.4-38 Automatic Temperature Control Logic

The term "heater" used in this sequence description means a group of two 125-watt elements.

Initially, both the heat exchanger fans and the OWS duct heater will be de-energized:

a. If the controller is in the heating cycle and TA is initially equal to, or subsequently drops to, a temperature of T1 or lower, cut on one heater. Remain in this mode until TA is equal to T6 or T2.
b. If the controller is in the heating cycle and TA is initially equal to, or subsequently drops to, a temperature of T2 or lower, cut on one more heater. Remain in this mode until TA is equal to T6 or T3.
c. If the controller is in the heating cycle and TA is initially equal to, or subsequent drops to a temperature of T3 or lower, cut on one more heater. Remain in this mode until TA is equal to T6 or T4.
d. If the controller is in the heating cycle and TA is initially equal to, or subsequently drops to a temperature of T4 or lower, cut on one more heater. Remain in this mode until TA is equal to T6.
e. If the controller is in the heating cycle, and TA subsequently rises to a temperature of T6 or greater, cut off all heaters. Remain in this mode until TA is equal to T8.
f. If the controller is in the heating cycle and TA rises to a temperature greater than T8, the controller will switch to the cooling cycle and energize four heat exchanger fans.
g. If the controller is in the cooling cycle, and TA is initially equal to, or subsequently rises to, a temperature of T5 or greater, cut on one heat exchanger fan. Remain in this mode until TA is equal to T2 or T6.
h. If the controller is in the cooling cycle, and TA is initially equal to, or subsequently rises to a temperature of T6 or greater, cut on one more heat exchanger fan. Remain in this mode until TA is equal to T2 or T7.
i. If the controller is in the cooling cycle, and TA is initially equal to, or subsequently rises to, a temperature of T7 or greater, cut on one more heat exchanger fan. Remain in this mode until TA is equal to T2 or T8.
j. If the controller is in the cooling cycle, and TA is initially equal to, or subsequently rises to, a temperature of T8 or greater, cut on one more heat exchanger fan. Remain in this mode until TA is equal to T2.
k. If the controller is in the cooling cycle, and TA is equal to, or subsequently drops to, a temperature of T2 or lower, cut off all heat exchanger fans. Remain in this mode until TA is equal to T4.
l. If the controller is in the cooling cycle, and TA drops to a temperature less than T4, the controller will switch to the heating cycle and cut on four heaters.

4301




CAPACITOR COMPOUND

| | |
|---|---|
| MATERIAL | TRIDECANE |
| WEIGHT | ~20 LB |
| SPECIFIC HEAT | 0.4 |
| MELTING POINT | 22.2° F |
| HEAT OF FUSION | 66.5 Btu/LB |
| STRUCTURAL TRANSITION AT -6° F REQUIRES | 18.6 Btu/LB |

Figure 2.4.4-39 Thermal Capacitor

THERMAL CAPACITOR

The thermal capacitor (figure 2.4.4-39) is a phase-change heat sink installed downstream of the radiator to supplement radiator performance. The unit consists of primary and secondary coolant loop coldplates sandwiched between honeycomb-type chambers containing 19.6 pounds of paraffin (tridecane). Melting of the tridecane occurs at 22.35°F with a heat of fusion of 66.5 Btu/lb. A structural transition occurs at -0.7°F with an associated heat absorption of 17.9 Btu/lb. The capacitor stores heat (melts) while the vehicle is on the hot side of the orbit and rejects heat (freezes) on the cold side.

GROUND COOLING TYPE HEAT EXCHANGER

The ground cooling heat exchanger (figure 2.4.4-40) is a cross-counterflow, plate-fin heat exchanger having three channels. One fluid channel makes three passes while the other two channels each make a single pass. The unit is constructed of stainless steel with nickel fins. This type of heat exchanger is utilized to provide the interface between AM coolant loops and (1) the ground cooling loop, (2) the ATM C&D Panel/EREP water loop, and (3) the suit cooling water loops. A ground cooling type heat exchanger is also installed to provide heat transfer between cold fluid from the radiator/capacitor and warm fluid being routed to battery module coldplates. In the refrigeration system, a ground cooling type heat exchanger is used to provide an interface between the refrigeration cooling loop and a ground cooling loop.

RADIATOR BYPASS VALVE

The radiator bypass valve (figure 2.4.4-41) is a solenoid-controlled, hydraulically actuated selector valve with a spring-loaded relief valve in parallel with one branch of the valve. When the solenoid is energized, the solenoid valve poppet unseats, allowing the top of the actuator piston to be exposed to the lower, pump inlet pressure. The lower pressure causes the actuator piston and slide valve to move. As the slide valve moves up, the outlet port to the radiator is closed and the outlet port to "bypass" is opened.

When the solenoid valve is de-energized, the solenoid valve poppet seals off the port to pump inlet (sump) and the inlet pressure moves the actuator piston and slide valve down, closing the "bypass" outlet and opening the outlet to the radiator. The relief valve will unseat and allow flow from the inlet port to the bypass port if the differential pressure across the radiator reaches 215 to 230 psid.

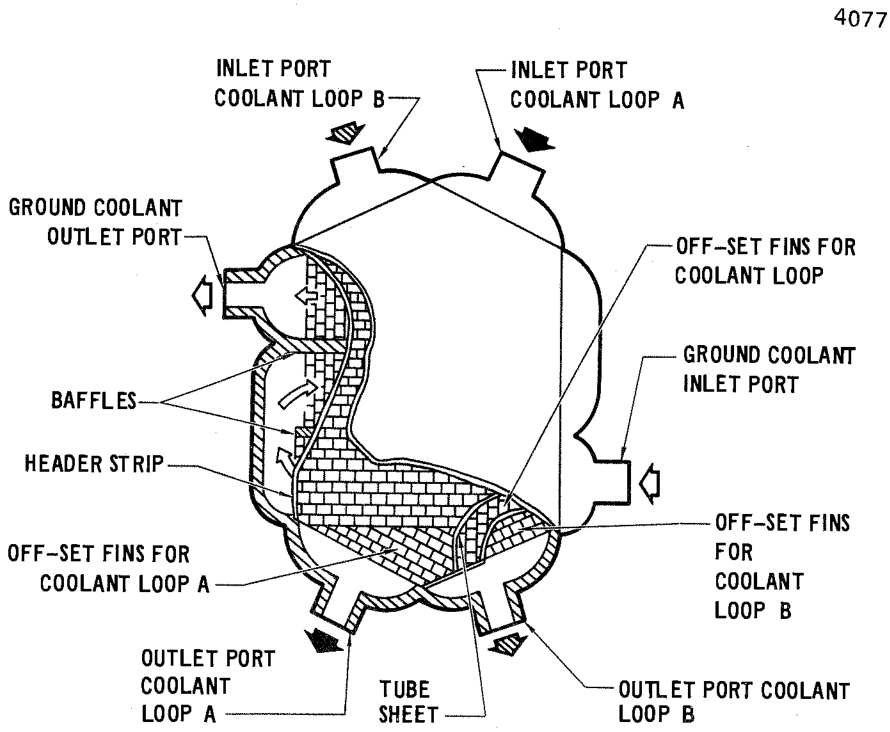



Figure 2.4.4-40 Ground Cooling Heat Exchanger

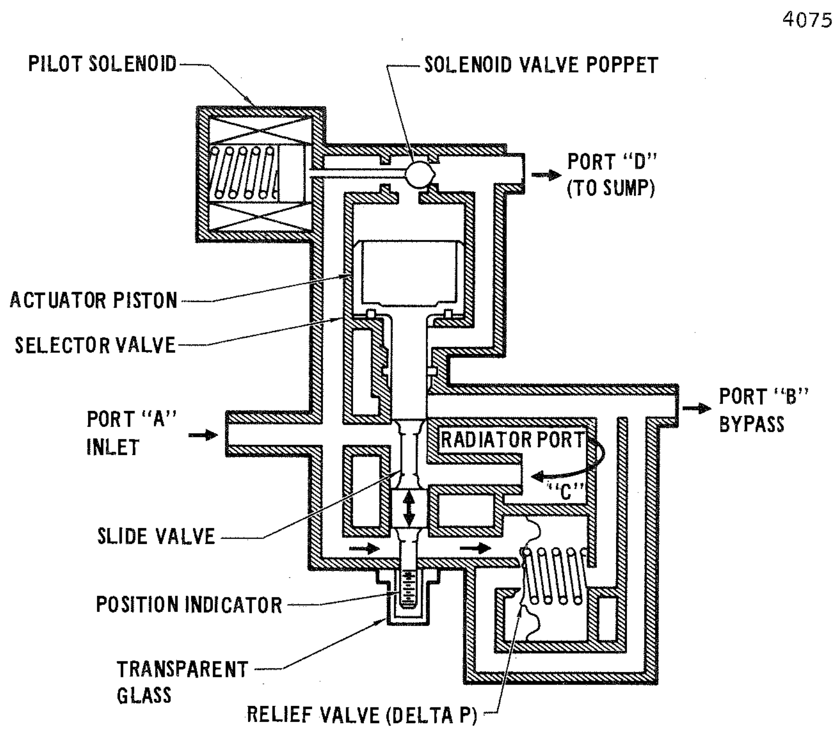



Figure 2.4.4-41 Radiator Bypass and Relief Valve

RADIATOR

The radiator (figure 2.4.4-42) is composed of 11 panels mounted on cylindrical surfaces of the STS and MDA. Approximately 432 square feet of surface area are available for rejection of heat from the coolant system to space. Coolant is circulated through T-bulb extrusions with a 0.25 inch I.D. Each magnesium extrusion is seam welded to the inner surface of the skin to form one of two files contained in a single passage of either the primary or secondary coolant loop. The magnesium panels have a thickness of 0.05 inch on the STS and 0.032 inch on the MDA. Panel skins are bolted to fiberglass stringers attached to the pressure wall. Spiral turbulators are installed in a major portion of crossover lines between panels.

TEMPERATURE CONTROL VALVE (47°F)

The 47°F temperature control valve (figure 2.4.4-43) has two inlet ports (one for hot fluid and one for cold) and one outlet port. It uses a spring opposed thermal actuator to position a flow-regulating spool, which varies the relative size of the hot and cold inlet ports to provide the desired effluent temperature. The thermal actuator is filled with Dow Corning DC 200 working fluid and is a sealed unit with a stainless steel bellows.

TEMPERATURE CONTROL VALVE (40°F)

The 40°F temperature control valve (figure 2.4.4-44) has two inlet ports (one for hot fluid and one for cold) and one discharge port. It uses a spring-opposed thermal control element (wax mixture with a high coefficient of expansion) to position a flow-regulating sleeve, which proportionately opens and closes the hot and cold inlet ports to provide a fluid mix of the desired temperature. Uniform temperature is obtained by passing the mix through flow turbulators before it reaches the thermal control element. The housing is aluminum with an epoxy amine coating, and seals are Buna N and Viton A.

REGENERATIVE TYPE HEAT EXCHANGER

The regenerative heat exchanger (figure 2.4.4-45) is a cross-counterflow, liquid-to-liquid plate-fin type heat exchanger having two flow channels. One channel makes four passes through the unit while the other channel makes a single pass. The unit is constructed of stainless steel with nickel fins. One of the heat exchangers is used in each coolant loop to warm cold radiator/capacitor coolant prior to entering heat exchangers interfacing with the suit cooling water loop. Three more heat exchangers are used in each refrigeration loop to warm coolant from the freezers prior to entering the warm inlet of the chiller temperature control valve.

COLDPLATE

Coldplates (figure 2.4.4-46) are installed to provide direct heat transfer paths from high heat dissipation components to the coolant system. A typical coldplate consists of a sandwich formed by the brazing of three aluminum sheets separated by corrugated fin material enclosed within aluminum frames to form two independent flow passages. Fin configuration and orientation provide satisfactory flow distribution and minimize pressure drop. Inlet and outlets ports are welded to the assembly and are provided for both the primary and secondary flow circuits. Mounting holes are drilled in the frames. Overall thickness of the coldplate (excluding fittings) is approximately 0.25 inch.

COOLANT FILTER

Filters (figure 2.4.4-47) installed in the coolant system filter all solid contaminants larger than 100 microns out of the fluid. Each filter assembly contains two independent filter systems located side-by-side within one housing. Each filter system consists of a removable, irreversible filter element, a mechanical shutoff to allow ground replacement of filters, a nonadjustable relief valve to permit fluid to bypass the filter in the event of filter clogging, and a bleed valve to facilitate purging of the filter system of air. The housing assembly is made of aluminum alloy, the filters are stainless steel, and the seals are neoprene. Dissimilar metals are protected against electrolytic corrosion.

OXYGEN HEAT EXCHANGER

The O2 heat exchanger (figure 2.4.4-48) is a cylindrical tubular heat exchanger. The O2 makes a single pass through the tubes prior to being routed to the two-gas control system, O2 Fill system, or LSU's. The coolant makes four passes per circuit across the tubes for a cross-counter flow configuration of heat exchanger. Two coolant circuits are provided to accommodate the primary and secondary coolant loops.

WATER PUMP AND WATER FILTER

The water pump (figure 2.4.4-49) is a positive-displacement, rotary vane, electrically powered pump assembly consisting of five subassemblies: (1) pump, (2) relief valve, (3) AC electric motor, (4) DC to AC inverter, and (5) outer housing which encloses the entire assembly. Pumps can continue to operate with the outlet line blocked because the internal relief valve allows flow from the outlet back to the inlet side of the pump when the outlet pressure builds up to the relief valve cracking pressure. Most structural parts are made of corrosion-resisting steel and the bearings are carbon journals. The entire unit is hermetically sealed by welding. The motor stator and inverter are separated from the motor and pump and are sealed in an inert atmosphere.

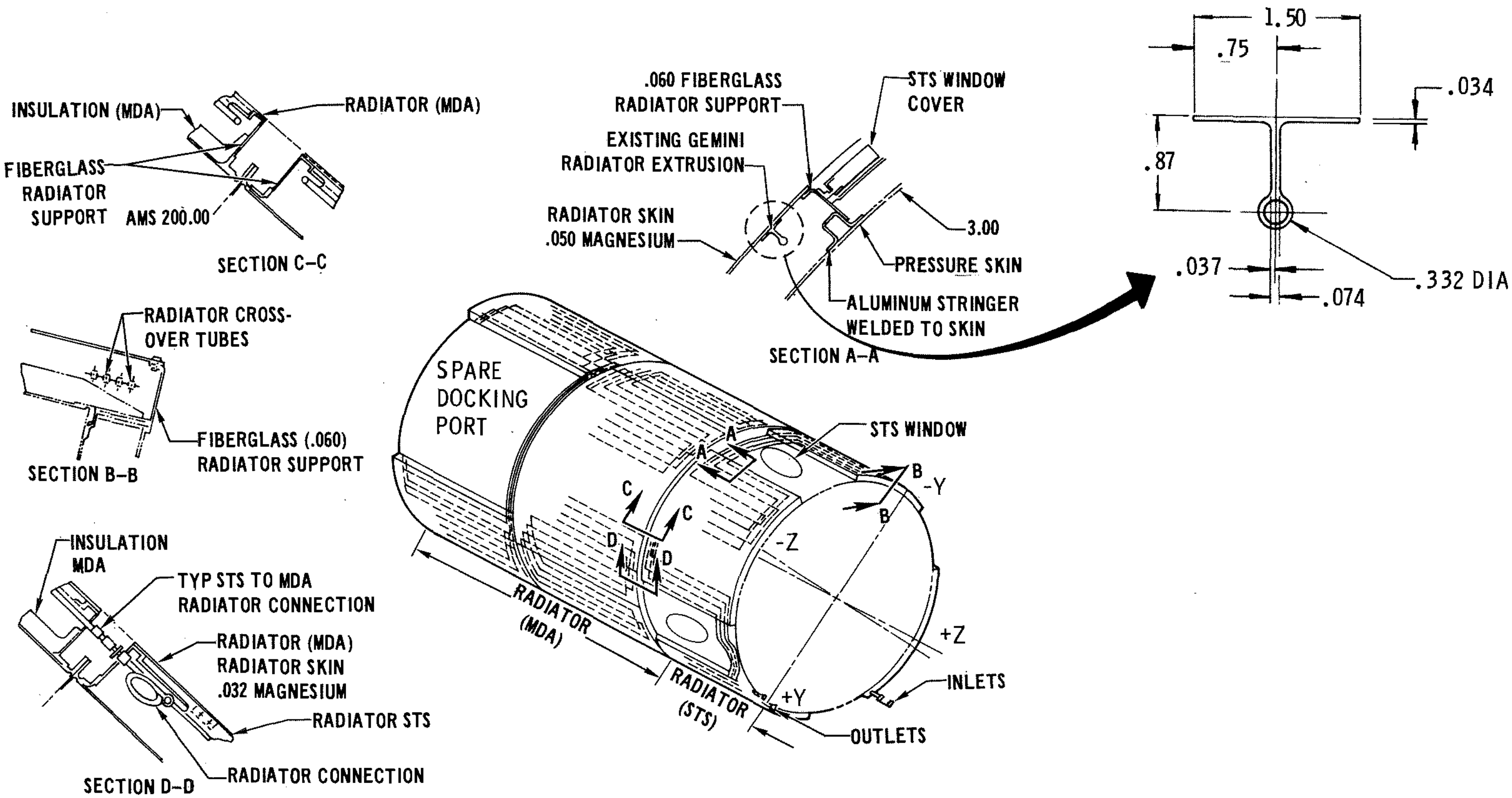



Figure 2.4.4-42 Radiator Configuration

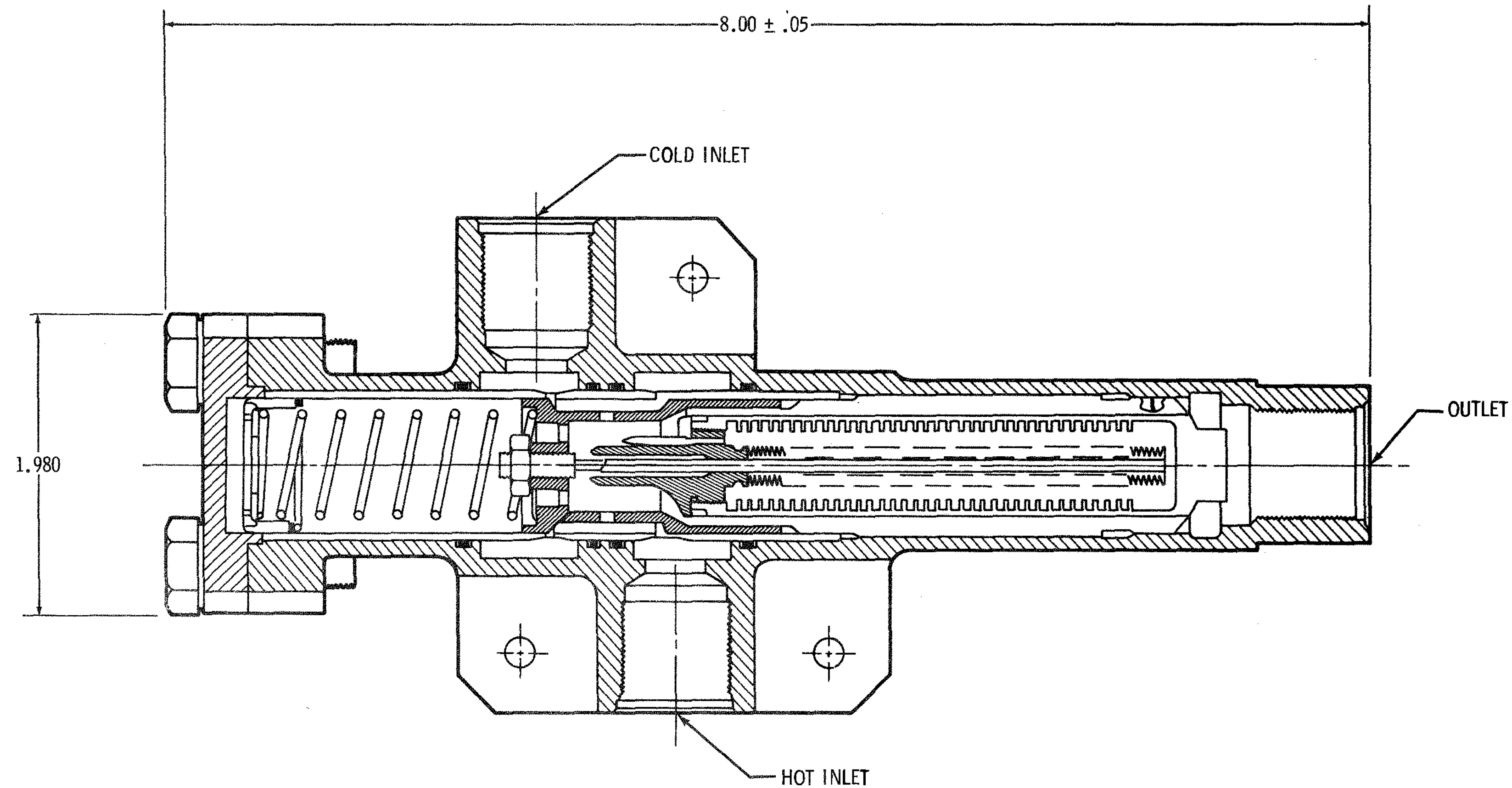



Figure 2.4.4-43 Temperature Control Valve -- 47°F

4333

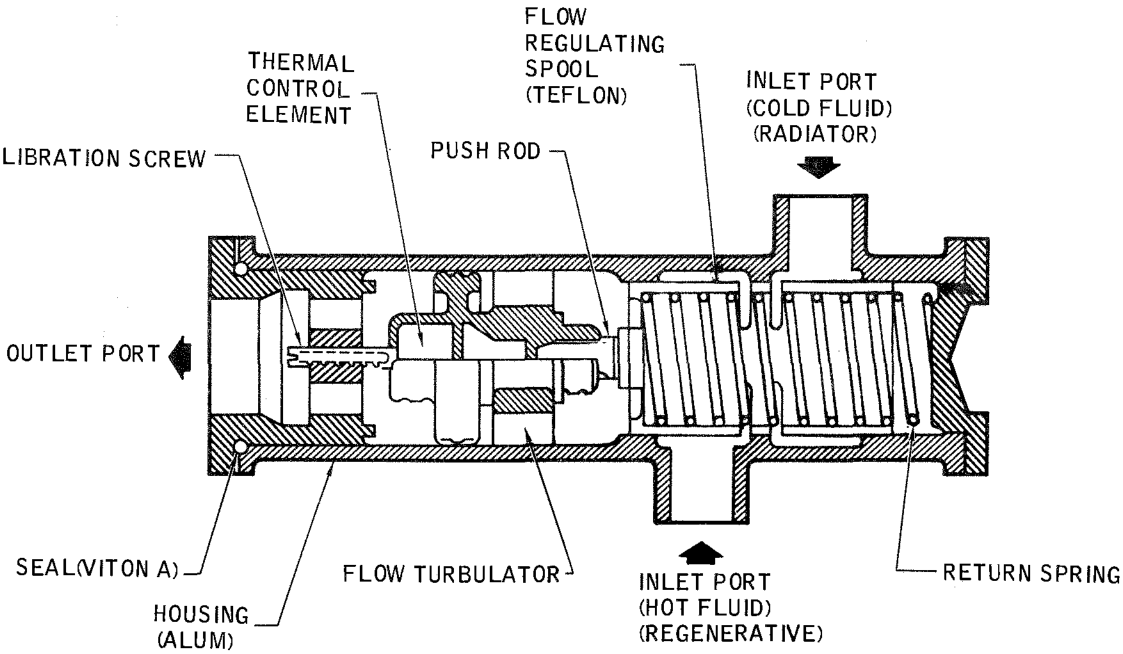



Figure 2.4.4-44 Temperature Control Valve -- 40°F

4079

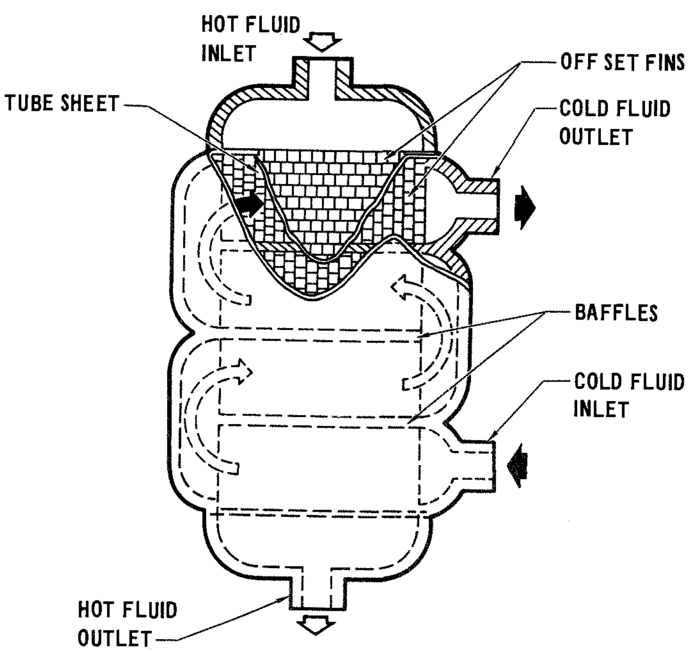



Figure 2.4.4-45 Regenerative-Type Heat Exchanger

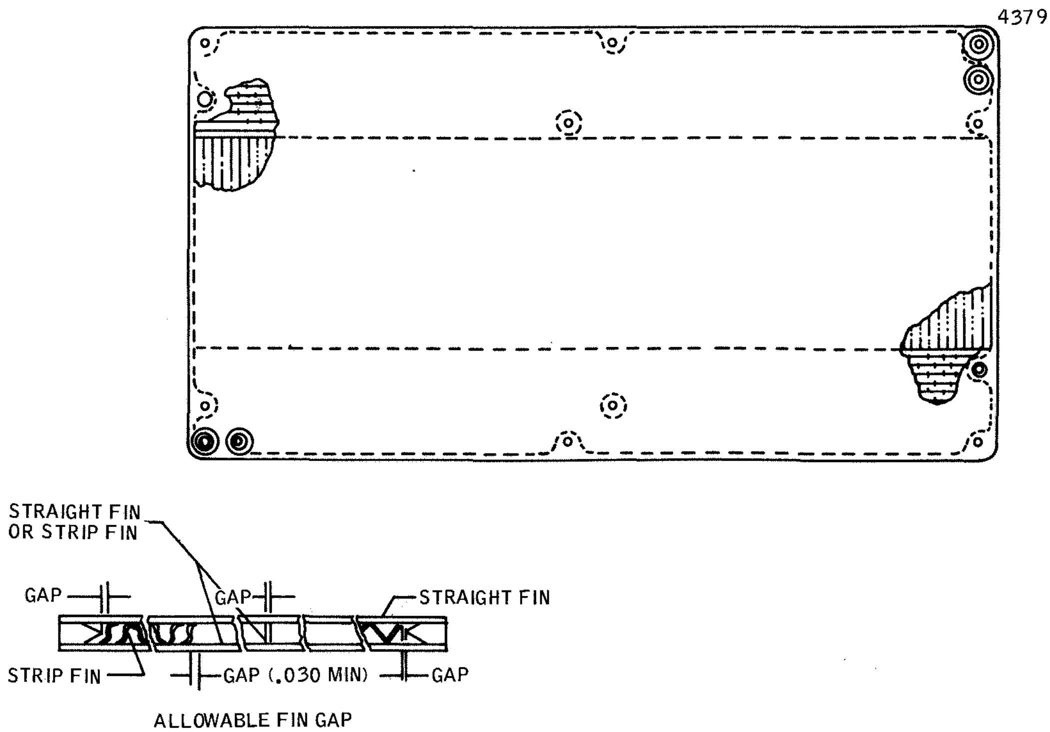



Figure 2.4.4-46 Coldplate (Typical)

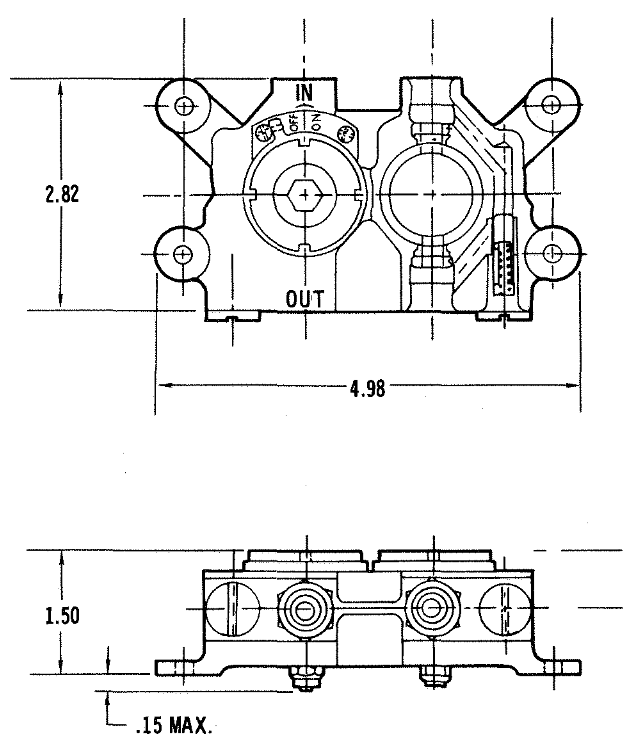



Figure 2.4.4-47 Coolant Filter

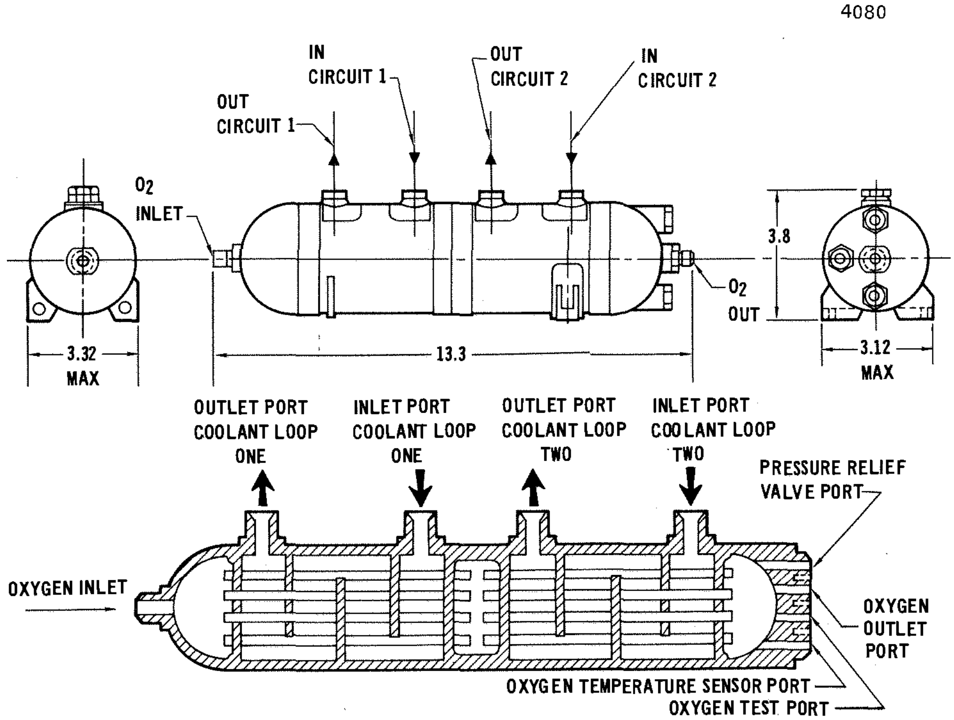



Figure 2.4.4-48 Oxygen Heat Exchanger

The filter installed upstream of water pumps in the ATM C&D Panel/EREP cooling system, removes most particles of 10 microns or larger. The filter assembly consists of a head, bowl and filter element. The head provides inlet and outlet ports in straight-through alignment, three non-symmetrical mounting bosses, and a threaded opening for attaching the cylindrical bowl. The bowl holds the filter element in place in the head. Water enters the inlet port on the head and flows into the bowl. The water passes from the periphery of the bowl through the filter element and center support core to the outlet port. The filter element is made up of a sintered stainless steel mesh. All other parts are stainless steel except for a Viton O-ring between the bowl and the head.

HEAT EXCHANGER COOLANT FLOW BYPASS VALVE

The heat exchanger coolant flow bypass valve (figure 2.4.4-50) is provided for contingency use in the coolant loop. Although not anticipated, the thermal balance in the suit/battery cooling module may require that the regenerative and ground cooling type heat exchangers be bypassed.

The bypass valve is a three-way, two-position, latching solenoid valve, operated from the IVA panel, with limit switches for position indication. The two valve positions provide for either routing coolant flow through the regenerative and ground cooling type heat exchanger (EVA position) or bypassing coolant flow around these heat exchangers (BYPASS position).

2.4.4.3 ATMOSPHERE CONTROL

The atmospheric control system provides ventilation and atmospheric cooling, moisture removal, carbon dioxide (CO2) removal, odor removal, and contaminant control. For descriptive purposes, the atmospheric control system is divided into a combination of subsystems, each with a specific function, but integrated for overall control and efficiency. Briefly, these subsystems are as follows:

1. Ventilation and atmosphere cooling - provided by post landing ventilation (PLV) fans, compressors, and heat exchangers located in the MDA/AM/OWS ducting system.
2. Moisture removal - accomplished by the circulation of the cabin gas through condensing heat exchangers and the molecular sieve system.
3. Carbon dioxide removal - by the sorbent beds of the molecular sieve system.
4. Odor removal - accomplished through use of activated charcoal located in each molecular sieve system and in the WMC ventilation subsystem.
5. Contaminant control - covers those contaminants other than moisture, carbon dioxide, and odor. This control is accomplished in two ways, through the use of filters, screens, and traps for particulate contaminants and through normal vehicle atmosphere overboard leakage.

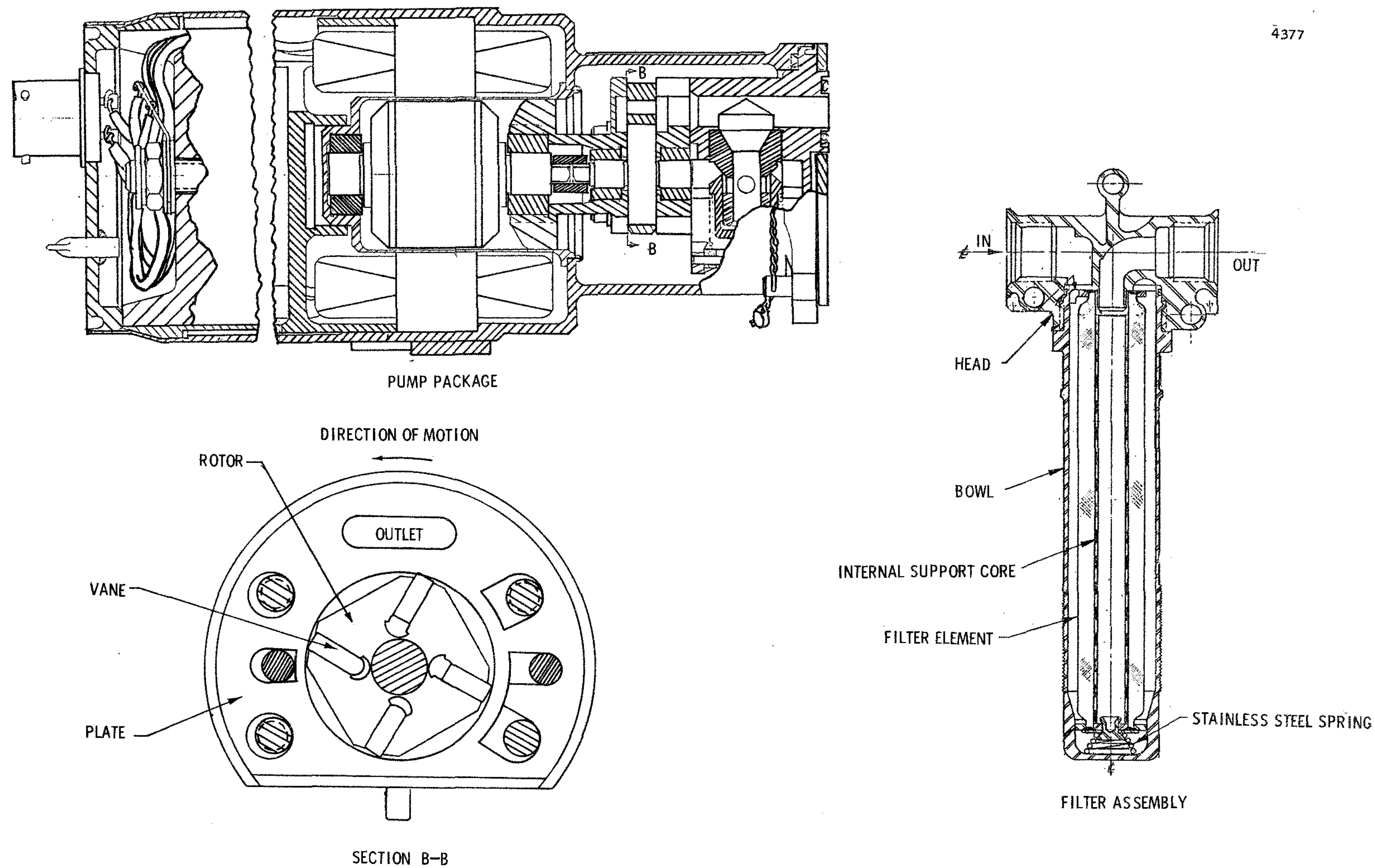



Figure 2.4.4-49 Water Pump and Filter

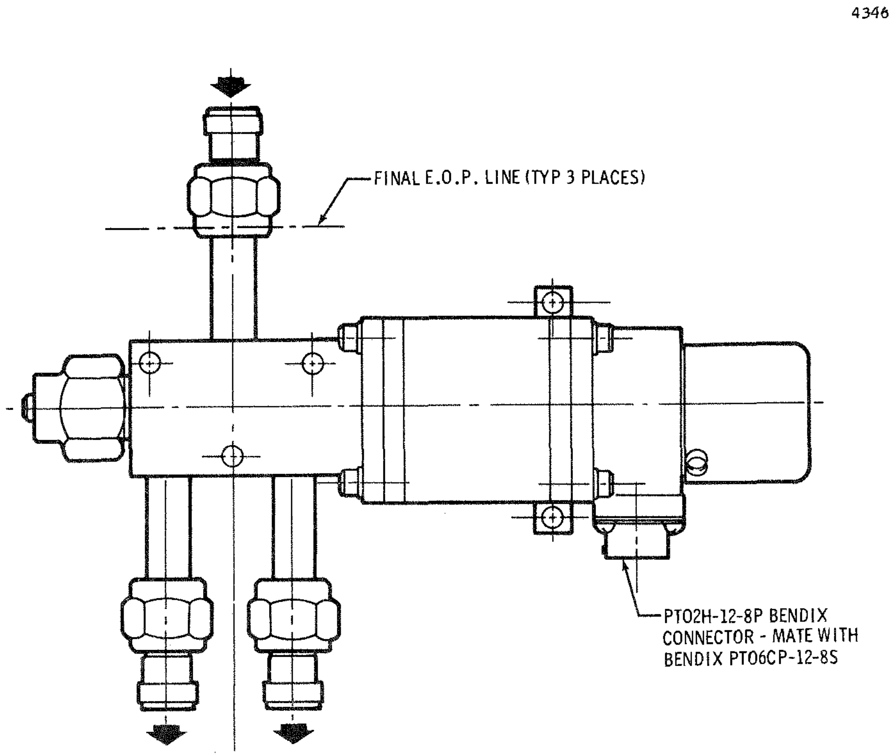



Figure 2.4.4-50 Heat Exchanger Coolant Flow Bypass Valve

2.4.4.3.1 Ventilation and Atmosphere Cooling

The ventilation system circulates atmosphere gas conditioned by heat exchangers and molecular sieve systems through the MDA, AM, and the OWS (figure 2.4.4-51). Ducting and fans are utilized to gather and distribute the atmospheric gas.

Two types of fans are used to provide circulation: the PLV fan, which is basically the post landing ventilation fan used in the Apollo program, and the sieve fans, which are basically the suit compressors used in the Apollo CSM. The PLV fan is a two-speed, single-stage, vane-axial design with three 5-inch diameter blades and a relatively high flow output with a low delta P. The sieve fan is a single-stage centrifugal design with a single speed and a relatively low flow with a high delta P. All PLV and sieve fans are inflight replaceable and spares are provided (nine PLV and one molecular sieve fan).

The fan locations and approximate flow rates are as follows:

MDA - Two PLV fans arranged to circulate the atmosphere within the MDA (170 cfm each)
One PLV duct fan located in the 6-inch CSM/MDA interchange duct to provide circulation to the docked command module. (170 cfm)
AM - Four sieve fans which direct cabin gas through the molecular sieve systems. (34.2 cfm each)
Three PLV fans used with heat exchangers to provide gas flow to the MDA. (55.7 cfm each)
One PLV duct fan to provide molecular sieve system conditioned gas to the OWS. (119 cfm)
Four PLV fans and heat exchangers to provide cool gas to the OWS. (39.25 cfm each)
OWS - Twelve PLV fans, four installed in each of three ducts to provide OWS circulation. (150 cfm each)
One PLV fan installed in the gas outlet of the WMC. (108 cfm)
Three locally controlled portable fans. (150 cfm each)

The docked CSM receives ventilation through a PLV fan and duct assembly from the MDA. The fan may be connected to either one of two redundant power disconnects, energized from panel 203. The fan is energized through all phases of habitation.

MDA ventilation is provided by two PLV fans installed in the MDA and three PLV fans installed in the STS. The fans are individually controlled from panel 203 and used for local MDA area ventilation as the crew requires.

The three STS fans and three cabin heat exchangers, (connected in parallel) in the coolant loop are installed in a cabin heat exchanger module (figure 2.4.4-52). The module acts as a fan noise muffler. Each fan circulates STS atmosphere through a heat exchanger and a 4 inch diameter duct at approximately 55 cfm to the MDA.

4012

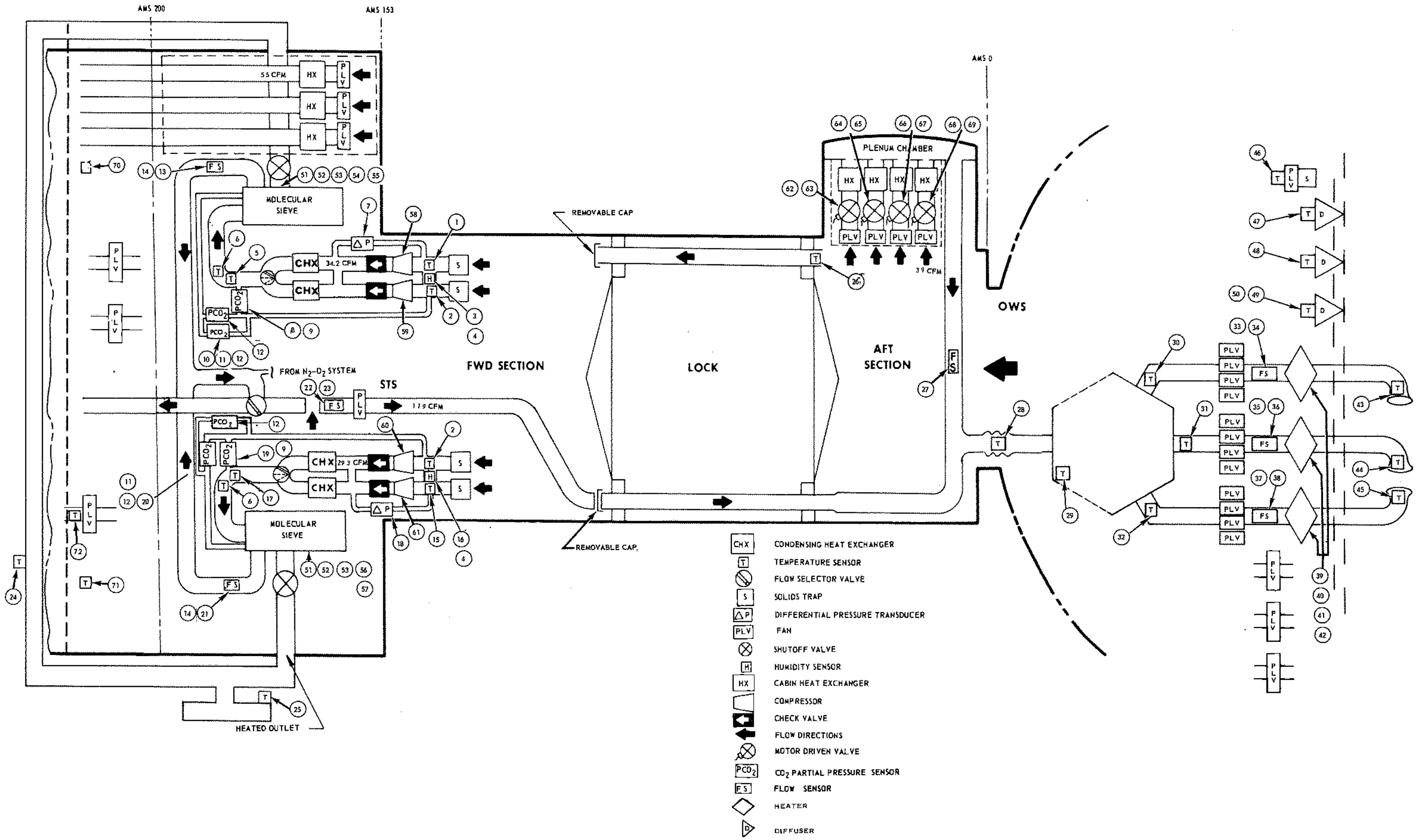
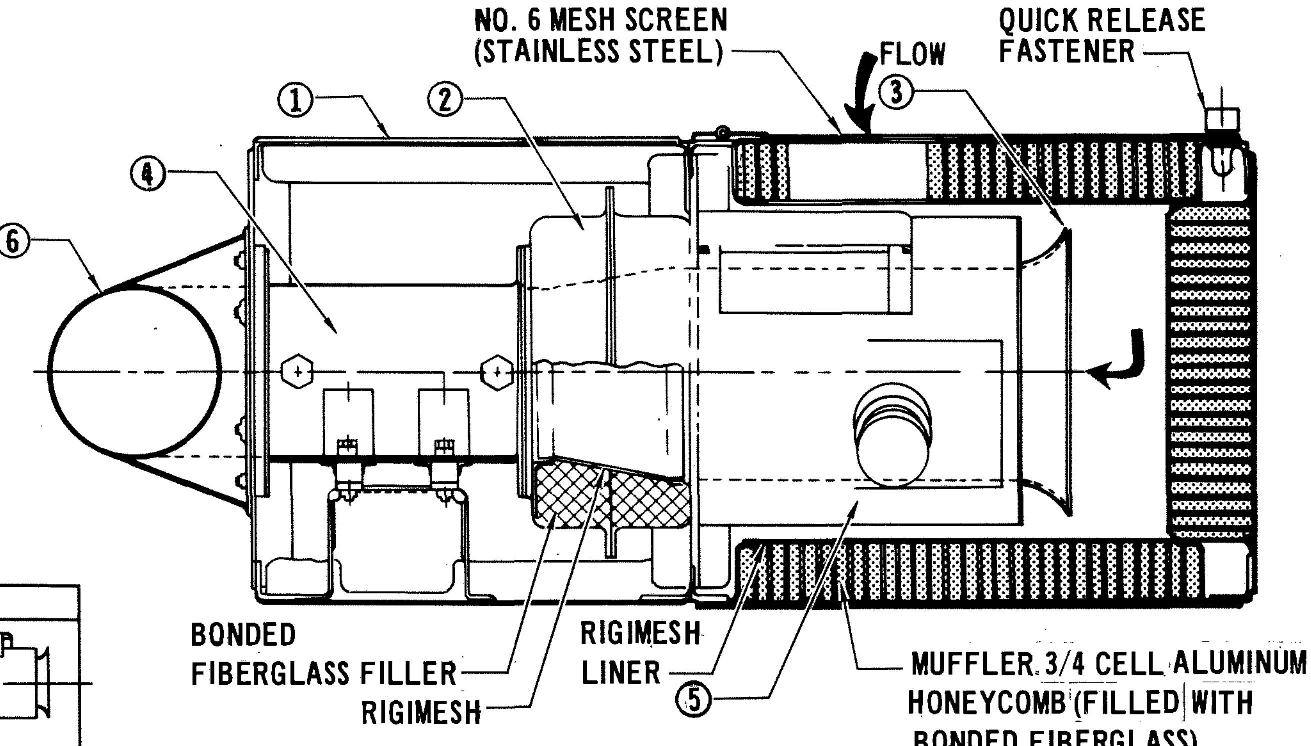
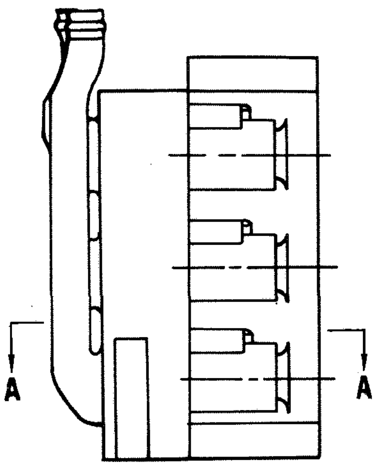



Figure 2.4.4-51 Atmosphere Control System

4117




A-A

EQUIPMENT LIST

| KEY | QTY | PART NOMENCLATURE | KEY | QTY | PART NOMENCLATURE |
|---|---|---|---|---|---|
| 1 | 1 | CONTAINER ASSY. | 4 | 3 | HEAT EXCHANGER |
| 2 | 3 | TRANSITION DUCT | 5 | 3 | PORTABLE FAN ASSY |
| 3 | 3 | BELLMOUTH ASSY | 6 | 3 | DUCT ASSY |

Figure 2.4.4-52 Cabin Heat Exchanger Module

Fan operation is controlled by individual switches on panel 203. Coolant flow rate through the heat exchangers is equally divided.

Gas flow through each of the molecular sieve systems is provided by redundant sieve fans. Either the primary or the secondary fan is selected for operation by use of the MOLECULAR SIEVE, SIEVE A or B FANS POWER switch, panel 203. The operating fan draws STS atmosphere through the solids traps and delivers it to the molecular sieve system through the check valves and condensing heat exchangers. Normal mode will be one fan of each molecular sieve system in operation. The fan providing gas flow to the operating mol sieve will flow at 34.2 cfm and the fan supplying gas flow to the non-operating mol sieve will flow at 29.3 cfm. The difference in flow is due to the difference in flow resistance between an operating and nonoperating molecular sieve.

Flow sensors are provided in the gas outlet of each molecular sieve system. The sensors provide an output to telemetry and to the C&W system. A caution alarm, SIEVE FLOW, will be initiated if the flow decreases to $< 21.1 \pm 3.8$ cfm.

The gas leaving the molecular sieve systems is manifolded together and routed to the MDA/OWS gas selector valve. The selector valve has three positions, MDA, BOTH, and OWS. The MDA position directs the molecular sieve systems outlet flow through the MDA interchange duct to the MDA. The BOTH Position divides the flow between the MDA and OWS interchange ducts. The OWS position directs the flow to the OWS interchange duct.

The OWS interchange duct has a screened wall section through which STS atmosphere is drawn and mixed with the molecular sieve flow. This mixed flow then passes a flow sensor and through the AM duct fan, which operates continuously during habitation, and is delivered to the AM aft compartment. The approximate flow rate is 119 cfm. The flow sensor provides an output to telemetry and the C&W system. If the flow drops to $78 \pm 10.4$ cfm, a caution alarm, OWS GAS INTERCHG, is initiated. In the AM aft compartment, the OWS interchange duct interfaces with the OWS cooling module outlet.

The OWS cooling module (figure 2.4.4-53) contains four cabin heat exchangers to provide cooling for the OWS atmosphere. A rotary solenoid operated shutoff valve and PLV fan is provided upstream of each cabin heat exchanger. Operation of the heat exchangers is normally controlled by a thermal control assembly located in the OWS, which simultaneously activates or deactivates the respective gas shutoff valves and PLV fans in sequence to maintain a selected OWS atmosphere temperature. The OWS HEAT EXCHANGER 1, 2, 3, and 4 switches on panel 390 override OWS control of the shutoff valves and fans. OWS panel 617 switches provide for AUTO/ON/OFF control of the shutoff valves and fans. The gas circulated through the OWS cooling module cabin heat exchangers mixes with the OWS interchange duct flow in the OWS supply duct. Gas flow rate through each heat exchanger by each PLV fan is approximately 39 cfm. The total coolant loop flow rate is divided equally among all four heat exchangers.

The AM/OWS VCS duct, 8 inches in diameter, carries the revitalized gas to the OWS mixing chamber (figure 2.4.4-54). The revitalized gas from the AM and the recirculated gas from the OWS are combined in the mixing chamber and drawn into the three OWS ducts. Flow through each duct is provided by a fan cluster. A fan cluster consists of a porous-wall baffled resonant chamber, an inlet and outlet muffler, and four PLV fans. During habitation, the fans operate continuously, each cluster providing 600 cfm gas flow. Each duct carries the flow to a fan cluster, past two flow sensors, through a convective duct heater (paragraph 2.4.4.2.2), and into the plenum area below the crew quarters floor. The fan cluster inlet duct is a wire-reinforced, dual-ply armalon cloth construction. The discharge duct is of single-ply armalon construction. One of the flow sensors in each duct provides an output to TM, and the other sensor provides an output to display on panel 617. The duct outlet turns, diffuses, and directs the air into the plenum area between the floor and common bulkhead. The plenum provides a flow path to the diffusers. Two types of adjustable, velocity-profile, diffusers are used (figure 2.4.4-55). The WMC, wardroom, and experiment area use circular vane diffusers, while the sleep compartment has rectangular diffusers. The circular diffusers give limited local velocities from 100 ft/min at the diffuser outlet to approximately 15 ft/min at the crew quarters ceiling.

WMC ventilation consists of a PLV fan, a vent filter, and a muffler located in the ceiling of the WMC (figure 2.4.4-56). The filter/ odor removal canister consists of two, 1-inch deep, annular, concentric, activated charcoal deodorizer beds with inlet filtration. Circulation is provided from the plenum through the diffusers, through the fan filter assembly, and then into the OWS forward compartment. With the fan operating, the flow is 108 cfm. Normal circulation without the fan operating is 10 cfm, which provides some odor control continuously. The FAN BUS 1/OFF/BUS 2 switch on panel 800 provides for manual control of the system. The system is normally operated from BUS 1 when the WMC is in use.

The muffler is a porous-wall baffled, resonant-chamber device and reduces the exit noise level by 15 to 20 db.

Three portable fans are provided for spot ventilation (figure 2.4.4-57). The portable fan assembly utilizes the PLV fan in a support that can be attached to the OWS structural grids and electrically connected to any UTIL PWR outlet. Each fan assembly is equipped with an inlet screen, a sound suppressor, an adjustable diffuser, and a HIGH/LO/OFF control switch.

2.4.4.3.2 Moisture Removal

The moisture removal system (figure 2.4.4-58) provides the capability of condensing atmosphere moisture in the condensing heat exchangers, removing condensate from the heat exchangers, storing the condensate, and expelling the condensate to space. It provides the capability of removing gas from the suit cooling loop liquid/gas separator, storing the gas and expelling the gas to space. In addition, the system provides a means of evacuating and reservicing the life support umbilicals.

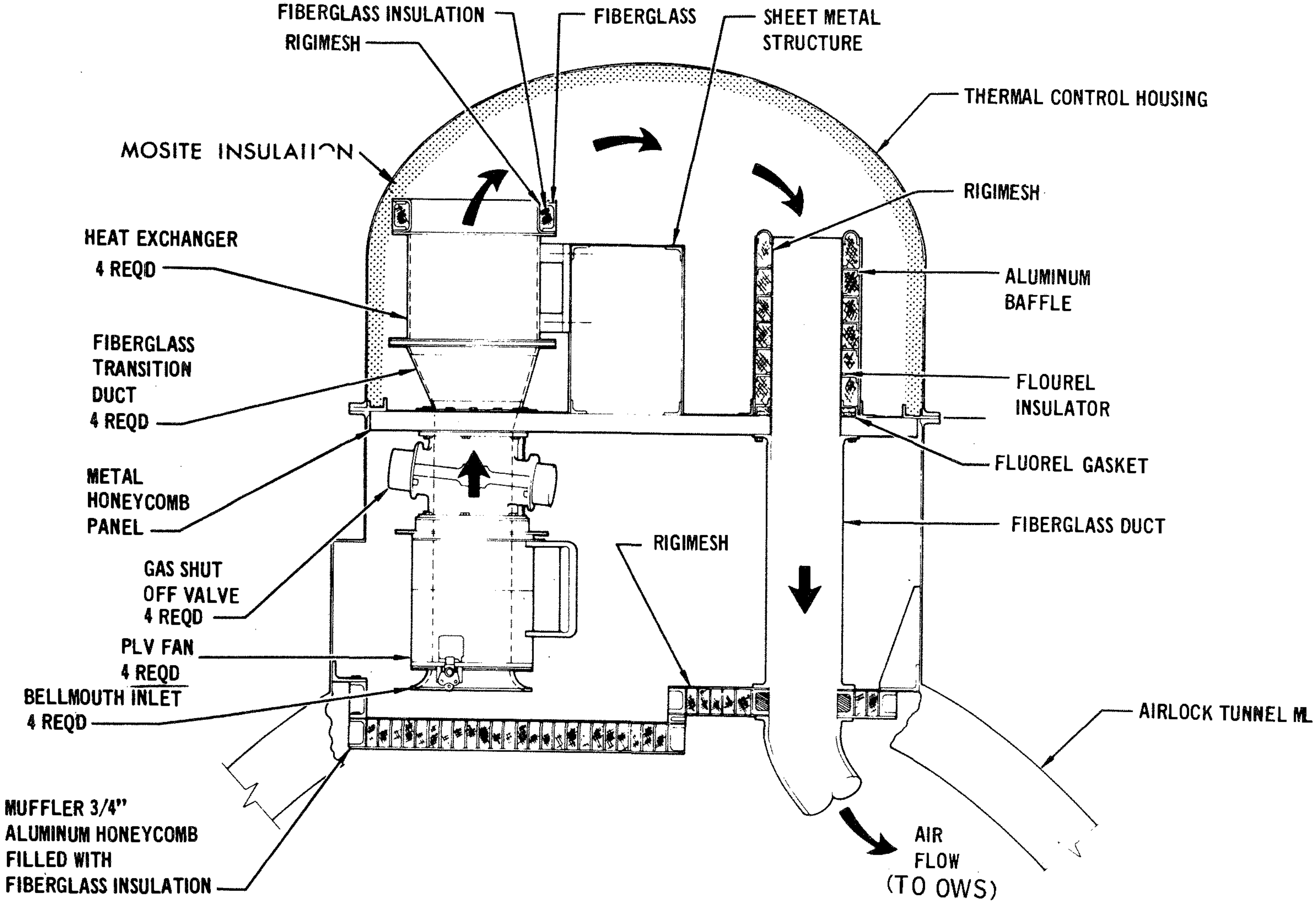



Figure 2.4.4-53 OWS Cooling Module

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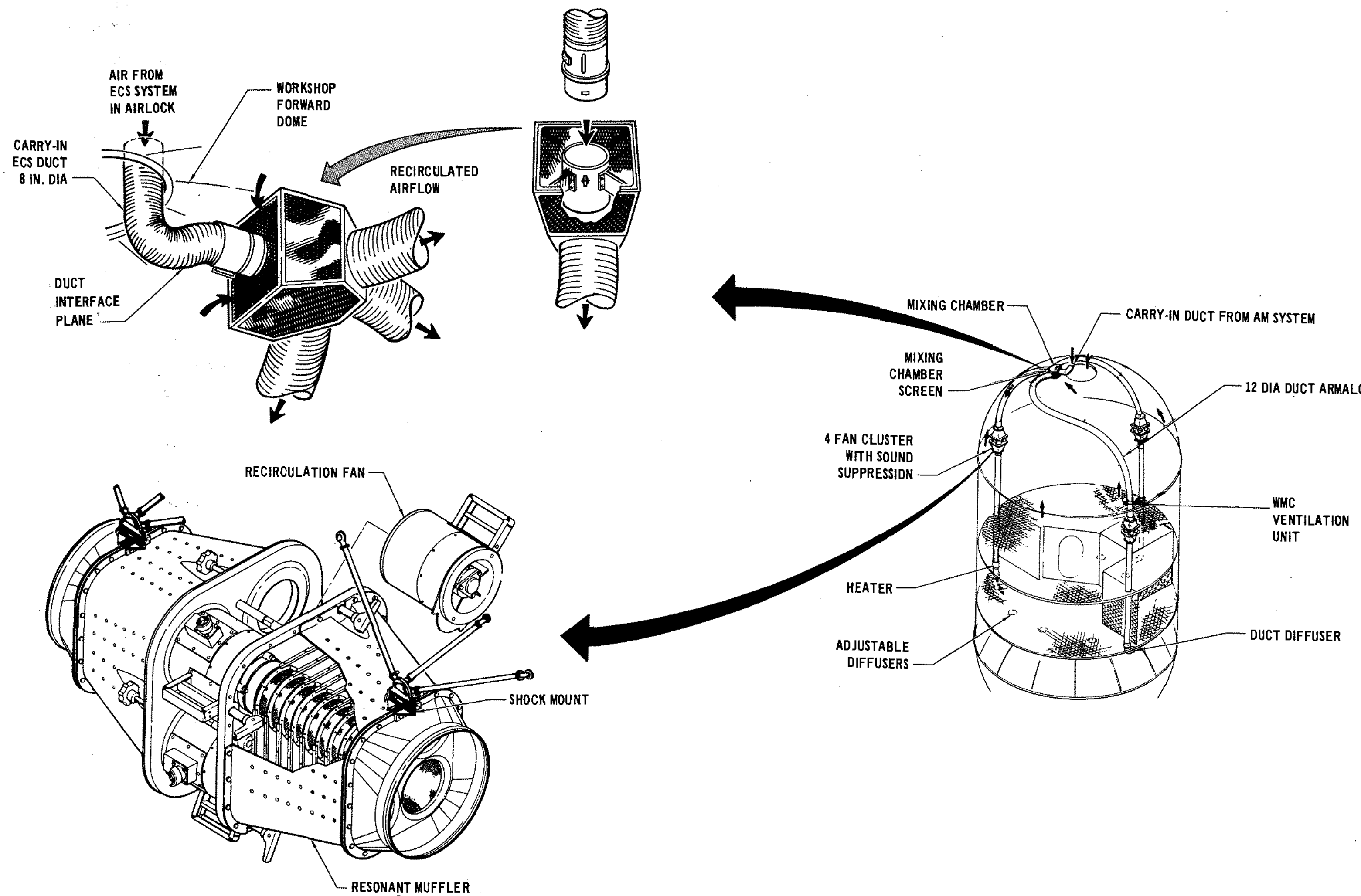


Figure 2.4.4-54 OWS Ventilation

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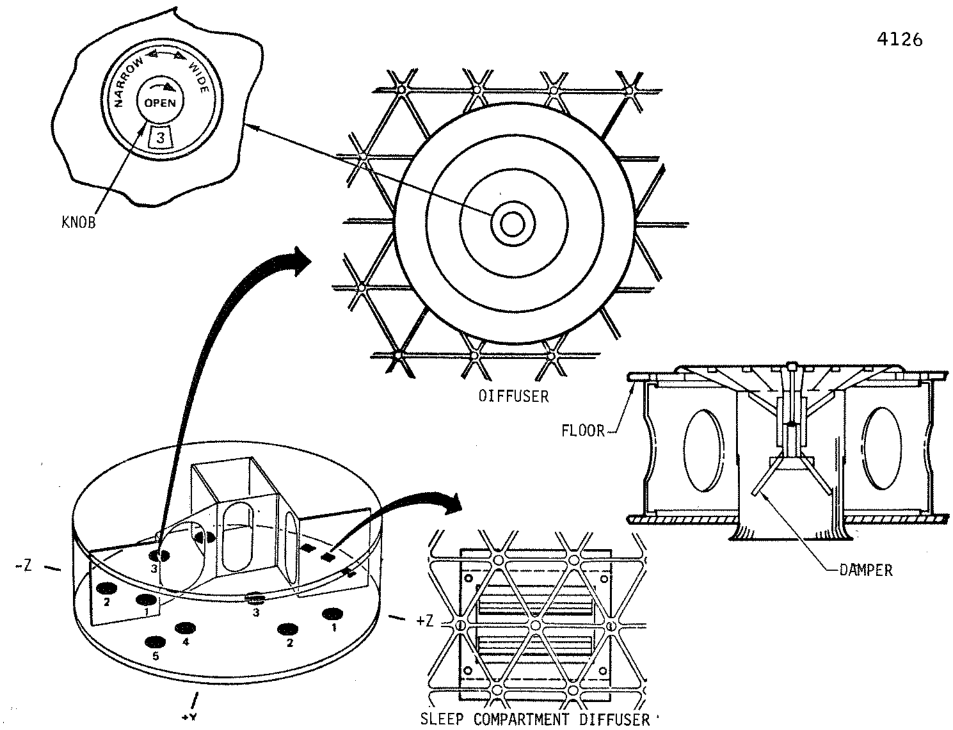


Figure 2.4.4-55 OWS Air Diffusers

Water will be removed from the atmosphere being circulated through the condensing heat exchanger when the dew point temperature of the atmosphere is above the temperature of the coolant entering the condensing heat exchanger. Four condensing heat exchangers are provided, two located upstream of each of the two molecular sieve systems. The normal mode of operation is one active condensing heat exchanger upstream of each molecular sieve system. The two remaining heat exchangers are redundant and are provided with valving for isolation from the condensate system and also for precluding coolant flow and gas flow through them. The contingency mode consists of putting one or both of the redundant heat exchangers into operation (i.e., providing gas and coolant flow and condensate system hookup and servicing). In this mode the coolant flow is split equally between the two condensing heat exchangers associated with any one molecular sieve.

Moisture that has condensed within the heat exchanger is absorbed by internal wicking and routed to inflight replaceable, porous water separator plate assemblies, two of which are installed in each heat exchanger. The downstream side of the water separator plates is connected to the line from the gas separator, and this common line is routed to the condensate tank. The condensate storage tank contains an internal flexible bladder and has a capacity of approximately 15 to 16 pounds of water.

The condensate system, exclusive of the two gas separators in the suit cooling system, has 17 components whose total gas leakage can be 0.0005 pounds of $O_2$/hr or 195 scc/hr tested to 5 psid and 70°F. During normal operation, the pressure within the storage tank is sufficiently low to allow moisture condensed in the heat exchangers to be drawn through the heat exchanger water separator plates and transferred into the storage tank by cabin ambient pressure. Gas leakage plus water collection will cause the tank to be pressurized to 4.3 psia (0.5 psia below cabin pressure) within 12 hours, minimum. When the tank pressure increases to approximately 0.5 psi below cabin pressure, the collected condensate and gas is manually dumped into the waste tank. A caution signal is initiated when the cabin to tank pressure differential decreases to less than 0.8 to 0.3 psid.

The condensate dump line from the CONDENSATE TANK H2O valve end is routed through two parallel-mounted check valves to a quick-disconnect on panel 393 in the AM aft compartment. A hard line with a flex hose on either end is installed in the OWS from the dome area to the waste management compartment. The flex line in the dome area has a quick-disconnect on its free end that will be mated to panel 393 during SWS activation. The flex line routed to the waste management compartment has a quick-disconnect on its free end that will be mated to the WMC water system dump quick disconnects after the water distribution network has been serviced.

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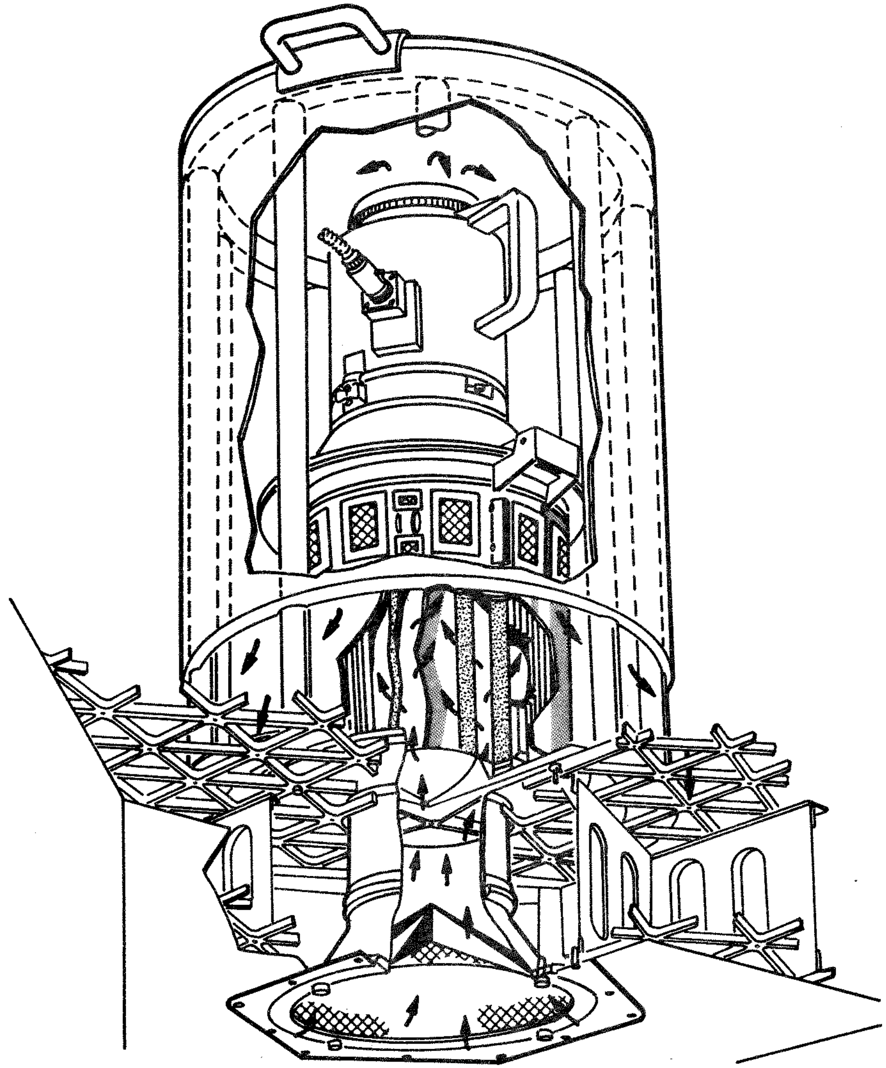

Figure 2.4.4-56 WMC Fan Assembly

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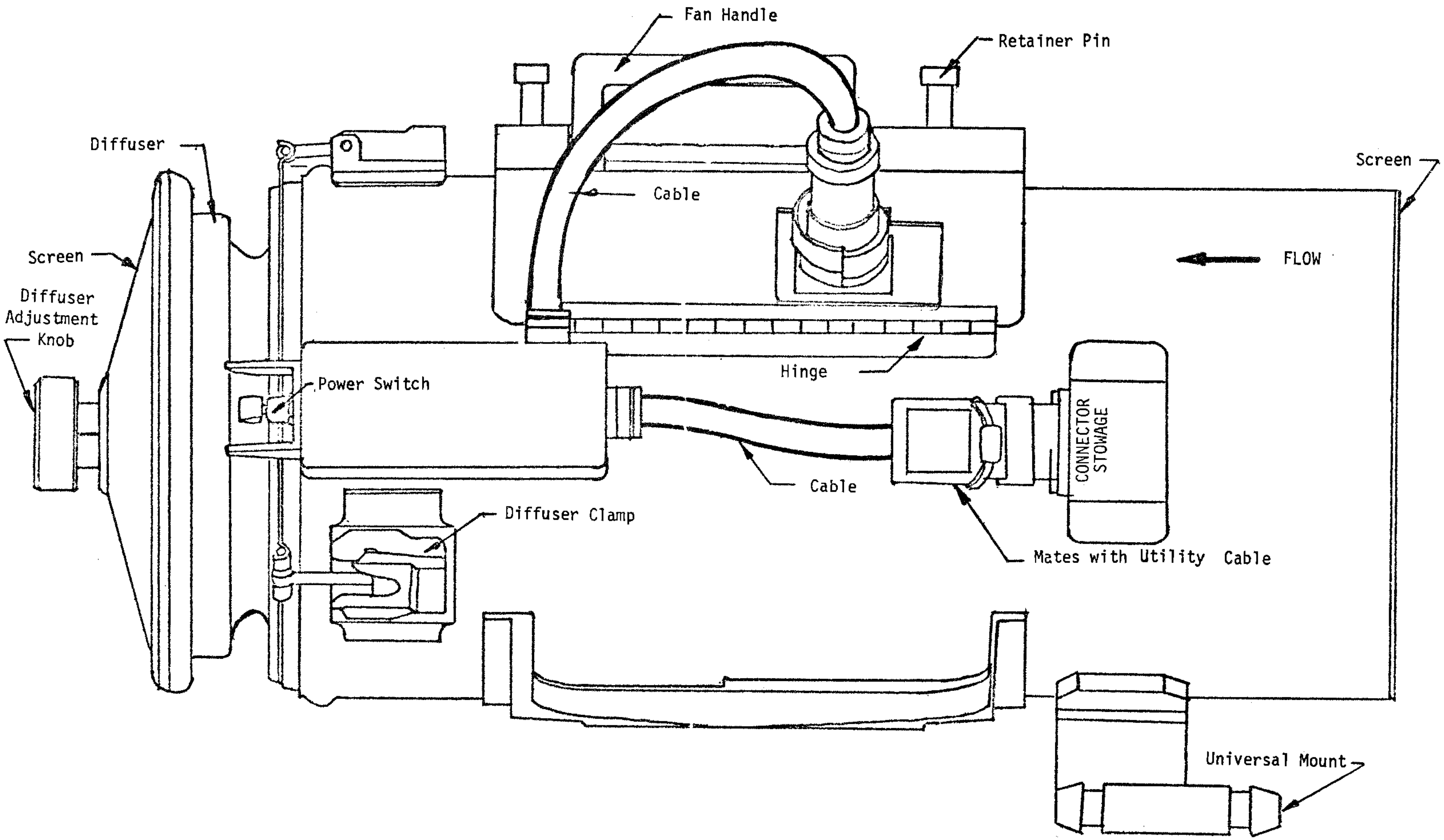


Figure 2.4.4-57 Portable Fan Assembly

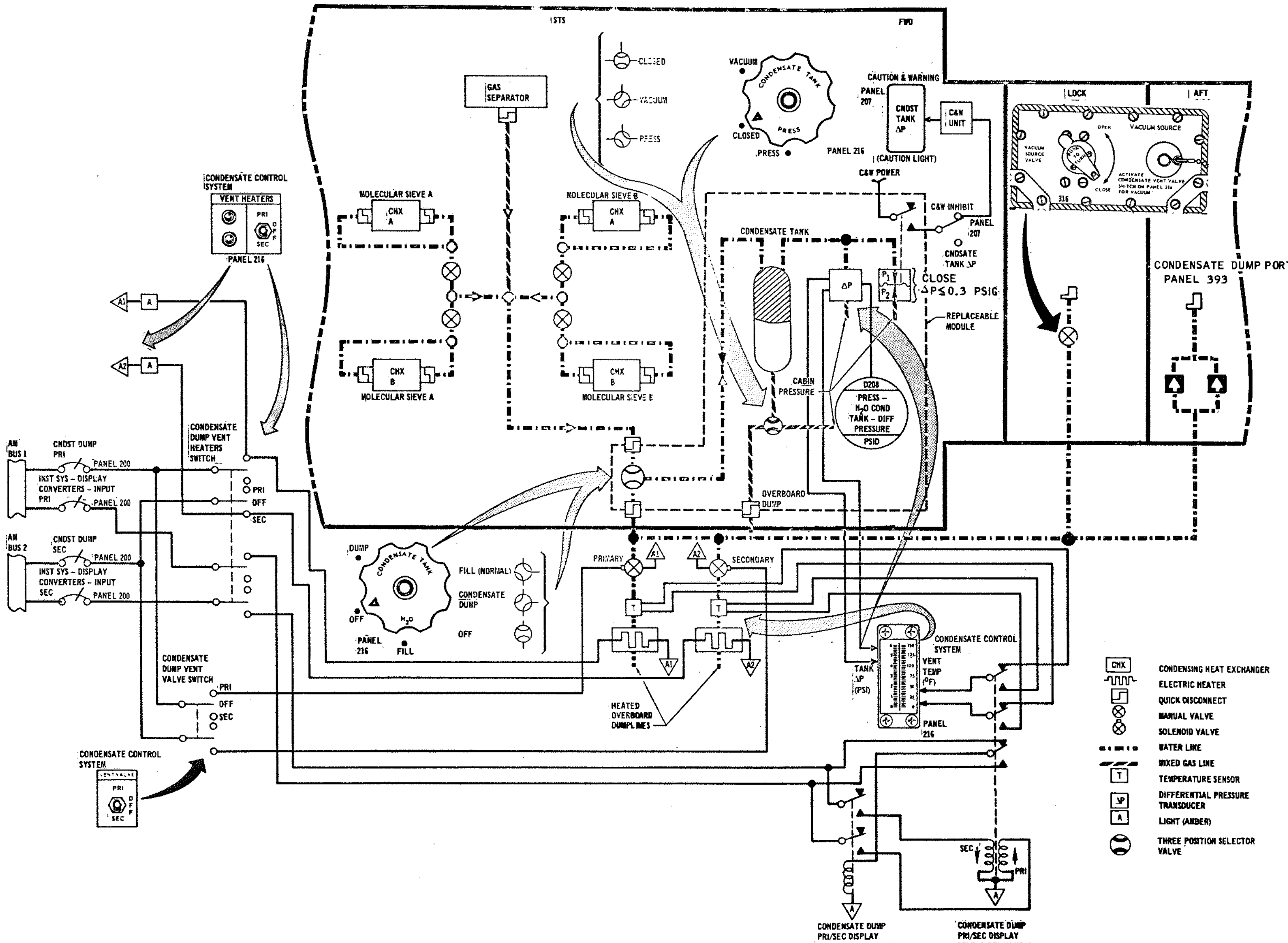


Figure 2.4.4-58 Condensate Collection and Removal

Dumping is accomplished by positioning the WMC H20 DUMP HTR switch, panel 800, to ON, the CONDENSATE TANK H20 valve, panel 216, to the DUMP position, placing the CONDENSATE TANK PRESS valve to PRESS, and opening the WATER DUMP valve, panel 831. When the position of the condensate tank bladder indicates the water is dumped, (10 to 15 minutes) the WATER DUMP valve is closed, the heaters turned off, the CONDENSATE TANK PRESS valve positioned to VACUUM momentarily to evacuate the gas side of the bladder, then moved to CLOSED, and the CONDENSATE TANK H20 valve is positioned to FILL.

A vacuum source is provided at the lock compartment instrument panel (quick disconnect and shutoff valve) by teeing a hardline into the condensate dump line upstream of the parallel check valves. It is primarily used for evacuating the LSUs.

Two parallel redundant dump lines which tee off the condensate dump line provide the hard vacuum required for evacuating and servicing the LSUs. It can also be used for contingency condensate dumping. Each line contains a solenoid operated shutoff valve, a temperature sensor for onboard display, and a 40-watt vent heater.

A spare inflight replaceable condensate tank assembly is provided. Those items within the dotted line (figure 2.4.4-58) are included in the assembly.

Moisture is also removed by the operating molecular sieve system (paragraph 2.4.4.3.3). The moisture is trapped in the sorbent canisters and vented to space. The rate of moisture removal of an operating molecular sieve system is 8.16 lb/day with a 52°F inlet dew point temperature. Essentially all water is removed from that portion of the gas flow passing through the molecular sieve system sorbent canisters.

2,4.4.3.3 Carbon Dioxide Removal

The carbon dioxide (CO2) removal system is located in the STS and consists of two molecular sieve systems. Each molecular sieve system (figure 2.4.4-59) contains two identical sorbent canister assemblies and charcoal canister mounted in a common structural framework. Both systems are utilized during habitation, one mol sieve for CO2, water, and odor removal; and the other for odor removal only. The CO2 and water removal capability of the system used for odor removal only is redundant and will be used only if the operating system fails. The gas flow through the molecular sieve systems is nominally 34.2 cfm (53.4 lb/hr) through the operating system and 29.3 cfm (45.9 lb/hr) through the system used for odor removal only. In the operating system, the gas flow is split, such that 15.0 to 15.5 lb/hr flows through one of the two sorbent canisters for CO2 and water removal and 17 to 18 lb/hr through the charcoal canister for odor removal. The remaining 20 to 21 lb/hr flows through a bypass duct, where it joins the other two streams at the gas outlet. The molecular sieve assembly is capable of removing 8.6 lb/day of water and 6.75 lb/day of carbon dioxide at inlet conditions of a 52°F dew point temperature and a CO2 partial pressure of 5.5 mmHg. Each sorbent canister assembly (figure 2.4.4-60) consists of a pneumatically actuated gas selector valve and a two-section sorbent bed. The pre-dryer section of the bed contains Linde type 13X synthetic zeolite (sorbent) while the carbon dioxide absorbent section contains type 5A synthetic zeolite with an integral plate-fin electrical heater for bakeout purposes.

Each molecular sieve system has an electro-pneumatic switching unit, which provides automatic sequencing control of the gas selector valves at 15-minute intervals. A switching unit consists of redundant automatic cycle timers, manual interconnect valves, and solenoid switching valves. During normal automatic operation, the selected cycle timer provides a 15-second duration, 28 vdc signal every 15 minutes. This signal energizes a solenoid switching valve. The energized valve supplies a 15-second 150-psig nitrogen (paragraph 2.4.4.1.4) pulse to both gas selector valve actuators, through the manual interconnect valves, positioning one actuator to adsorb and one to desorb. The gas on the back side of the actuator is vented overboard through a non-energized solenoid switching valve. A gas selector valve remains in position until again actuated by the gas selector valve actuator. The gas selector valve may also be manually positioned, panel 226 or 227.

Sequencing of the gas selector valves diverts the CO2 and moisture-laden gas alternately between the sorbent canisters. Each sorbent canister adsorbs for 15 minutes, then desorbs for 15 minutes. Atmosphere gas passes through the gas selector valve into the pre-dryer section where the water vapor is adsorbed, then through the CO2 sorbent section where the CO2 is adsorbed. The gas then proceeds to the outlet section of the gas selector valve. The alternate canister is vacuum desorbing the CO2 and water vapor adsorbed during the previous half-cycle.

This operational sequence is continued until the water vapor reaching the CO2 sorbent section prevents efficient CO2 removal (a minimum of 28 days). The system is then subjected to a heated regeneration bakeout at 400+15, - 19°F, using integral 390 watt heaters. An overtemp cutoff and C&W alarm is provided if the canister bed temp reaches 425° to 450°F. The bakeout of molecular sieve system canisters is done sequentially, with the canister being heated, manually placed in a desorb mode, and isolated from the automatic sequencing for the 5 hour heating cycle. The canister not undergoing heating remains in the automatic mode. At the completion of the heating cycle, the heated canister is returned to the automatic mode while the remaining canister is positioned to the desorb mode and isolated from automatic sequencing for 5 hours of heating. Each canister requires 5 hours of heating and 10 to 12 hours of cool-down until it returns to maximum operating efficiency. Because of the temperature of the sorbent, the canister is unable to remove any CO2 during the first 8 hours (5 hours heating and 3 hours cool-down) of the bakeout operation.

A position indicating switch associated with each gas selector valve provides an output to telemetry when the valve is in an adsorb position and provides for molecular sieve fan shutdown in the event both selector valves are in the adsorb position. This automatic shutdown capability may be overridden by positioning the MOL SV FAN DISCONNECT switch panel 203, to OFF. Shutting the MOL SV FAN off when both beds are in the adsorb

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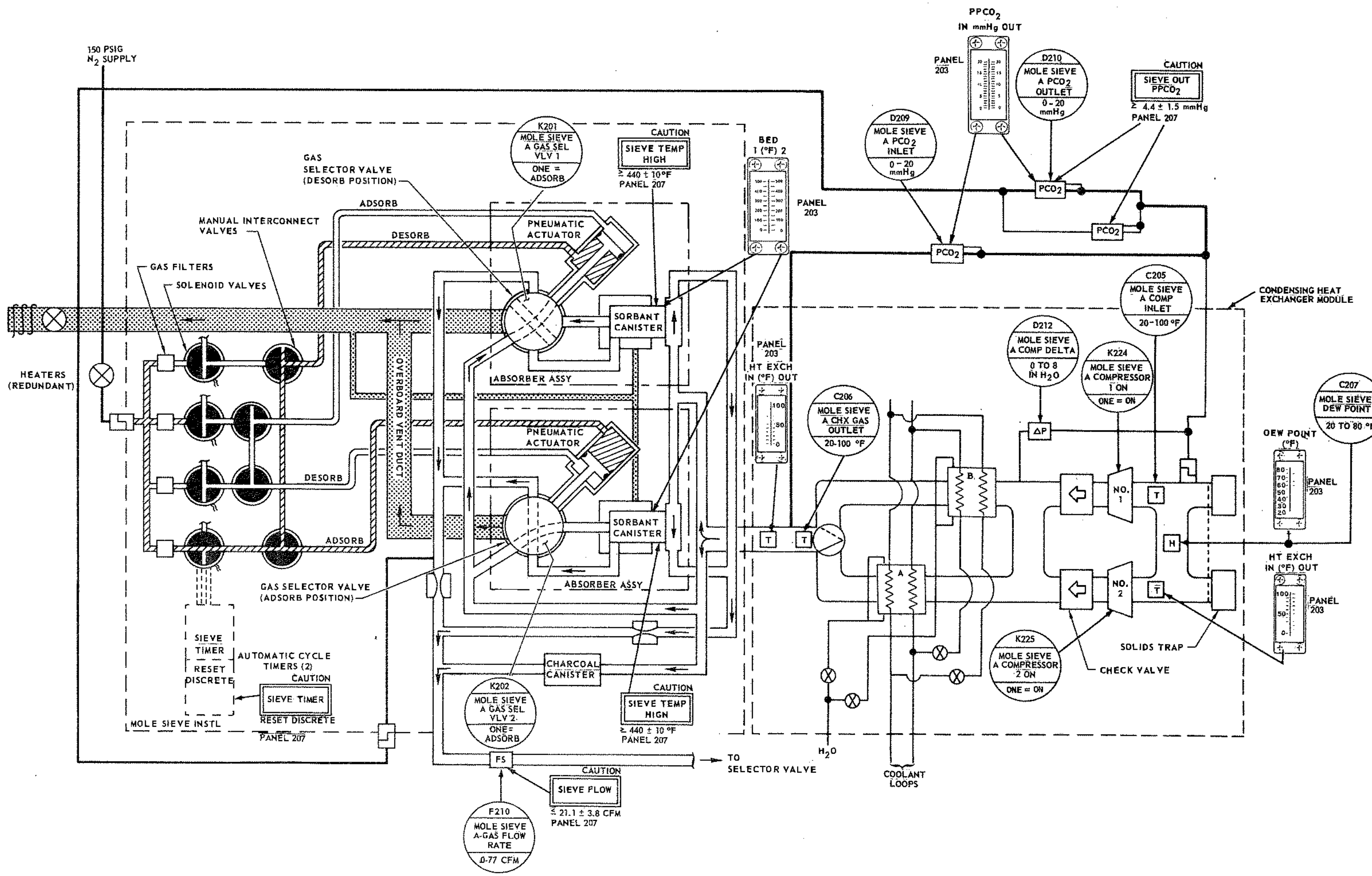


Figure 2.4.4-59 Molecular Sieve System

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MOLECULAR SIEVE ADSORB MODE

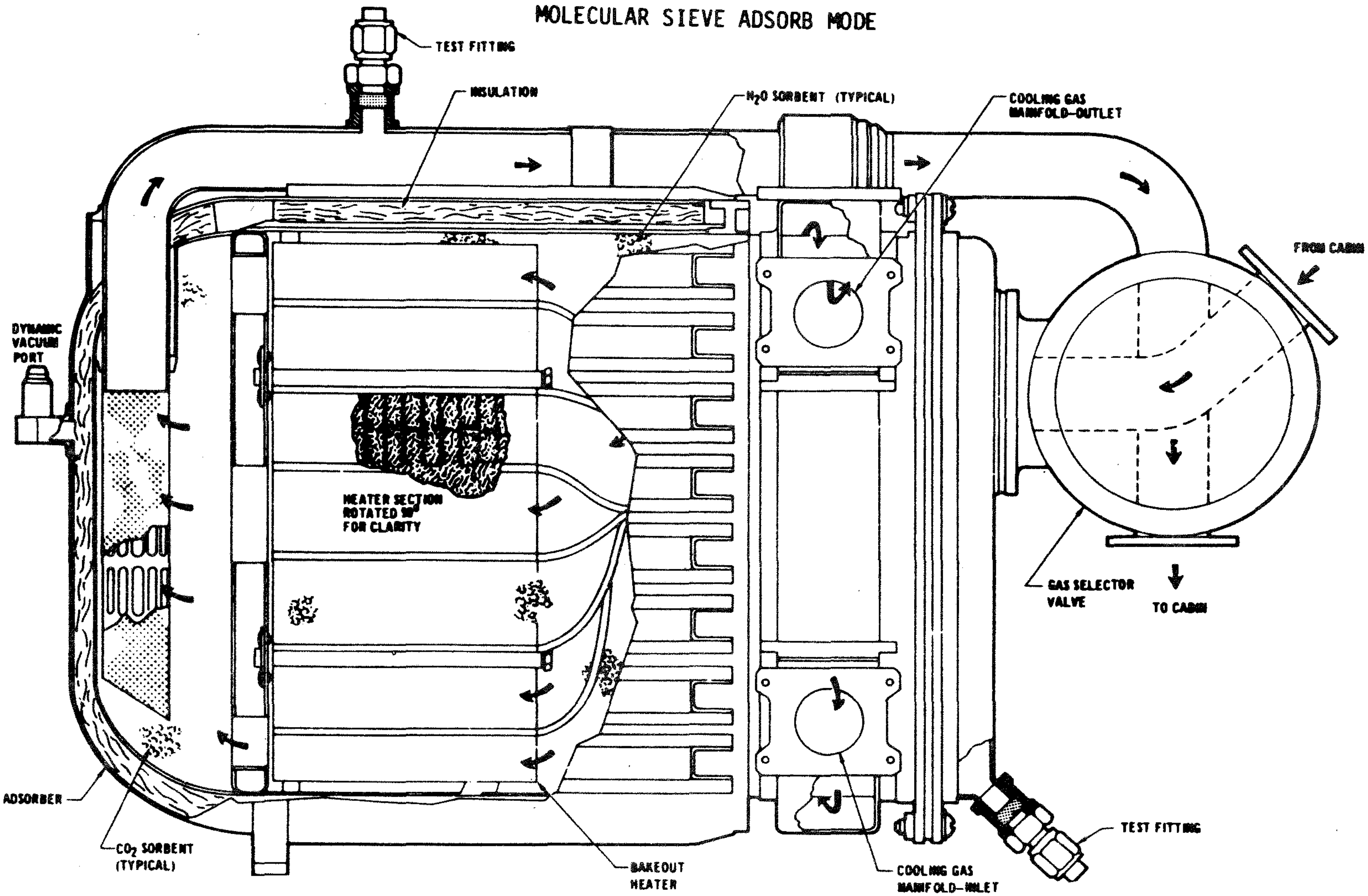


Figure 2.4.4-60 Molecular Sieve Bed

position prevents a sorbent canister from being in an active adsorb cycle over 15 minutes. If a sorbent canister is in an active adsorb cycle over 15 minutes, excess water vapor reaches the CO2 sorbent section and prevents efficient CO2 removal. As the efficiency decreases, the PPCO2 level out of the molecular sieve increases, causing the C&W SIEVE OUT PPCO2 alarm to be activated at 4.4±1.5 mmHg PPCO2. Actuation of the C&W SIEVE OUT PPCO2 because of excessive water in the sorbent canisters necessitates canister bakeout.

Vacuum desorbing of a canister takes place through a molecular sieve system overboard exhaust duct. The ducts from each system are joined and routed to a non-propulsive tube, which exhausts the effluents to vacuum. The entire exhaust duct system is divided into seven sections and each section is equipped with a primary and a secondary heater to prevent exhaust vapor from freezing in the duct. Primary heater thermostats activate at 50°F nominal, the secondary heaters activate at 42°F nominal. Primary and secondary heaters each have a total capacity of 62.4 watts at 28 volts. Microfoil insulation tape and a low emittance tape are wrapped around the duct to minimize heater power. The heaters are activated during molecular sieve operation. Heater thermostats for heaters 7 through 18 are activated by the SIEVE A VENT HEATERS switch, panel 203 and all the heater thermostats 1 through 18 are activated by the SIEVE B VENT HEATERS switch, panel 203.

2.4.4.3.4 Odor Removal

Odor removal is provided in each molecular sieve system by flowing cabin gas through a charcoal canister. The gas flow rate through the charcoal canister in the molecular sieve system with the CO2 sorbent canisters operating is 17 to 18 lb/hr. The gas flow rate through the molecular sieve system with the CO2 sorbent canisters isolated from the atmosphere is 20 to 21 lb/hr. The canister contains 9 pounds of activated coconut shell charcoal for adsorption of the odor producing molecules. The activated charcoal is a form of charcoal containing millions of tiny holes that form an internal structure of interconnected capillary passages slightly larger in size than the molecules to be removed. Adsorption takes place on this internal surface area. The canisters are replaced after approximately 28 days of use.

Odor removal is also provided for odors generated from waste management and personal hygiene activities within the WMC. The cabin gas leaving the WMC passes through an odor removal canister. The canister consists of two, 1-inch-deep, annular, concentric, activated charcoal deodorizer beds with inlet screening. This gas attains an odor-free level of 80 percent or better. The odor removal canisters are replaceable.

2.4.4.3.5 Contaminant Control

A solids trap assembly consisting of two filter elements is located upstream of the molecular sieve fans in each molecular sieve system. These filters remove contaminating particles from the gas flow entering the molecular sieve systems. Each filter element incorporates a filter bypass valve, which assures a continuous gas flow if the filter element is clogged. Spare solids trap assemblies are provided for routine replacement.

Screens to restrict particulate migration through the circulation system are provided on the following inlets:

1. Cabin heat exchanger module inlet (STS)
2. OWS cooling module inlet (AM aft compartment)
3. STS gas inlet to the OWS interchange duct fan (STS)
4. OWS mixing chamber recirculated gas inlet (OWS dome)
5. Portable fan inlets
6. WMC vent filter (WMC ceiling)

These screens are periodically cleaned in place to prevent restriction to the gas flow.

The gaseous contaminants not removed by the molecular sieve systems or the OWS WMC ventilation subsystem are maintained at an acceptable level through "normal" vehicle atmosphere overboard leakage. If the overboard leakage is less than that calculated as "normal", a manual bleed can be initiated.

2.4.4.3.6 Major Component Operation

PLV FAN

A modified Apollo Post Landing Ventilation (PLV) Fan (figure 2.4.4-61) is used for gas circulation within the MDA/AM/OWS. The fan is a single stage, axial-flow unit, driven by a brushless dc motor. The impeller has three airfoil-shaped blades and rotates at approximately 5000 rpm. Deswirl vanes are provided in the fan stator. The fan impeller is constructed of glass-reinforced polymide and the motor housing and deswirl vanes are aluminum.

MOLECULAR SIEVE FAN

The molecular sieve fan (figure 2.4.4-62) is used to circulate cabin gas through the molecular sieve system. The unit consists of a single-stage centrifugal impeller attached directly to an induction-type electric motor inside the aluminum housing. An electrical receptacle and a pressure sensing port mounts on the housing. The fan has concentric inlet and outlet duct quick disconnect flanges. Two grease-packed ball bearings support the squirrel cage induction motor rotor and the extended centrifugal aluminum impellers. A vaneless diffuser is formed between the cast aluminum alloy inlet cover and the motor stator-housing. Flow through the unit turns axially downstream after passing outward through a diffuser into a conically converging annular passage over the motor housing. The flow is then straightened by integrally cast deswirl vanes, which also support the motor. An aluminum alloy conduit carries the electrical lead across the flow path into a hermetically sealed receptacle outside the unit. Four mounting pads are cast as integral parts of the housing.

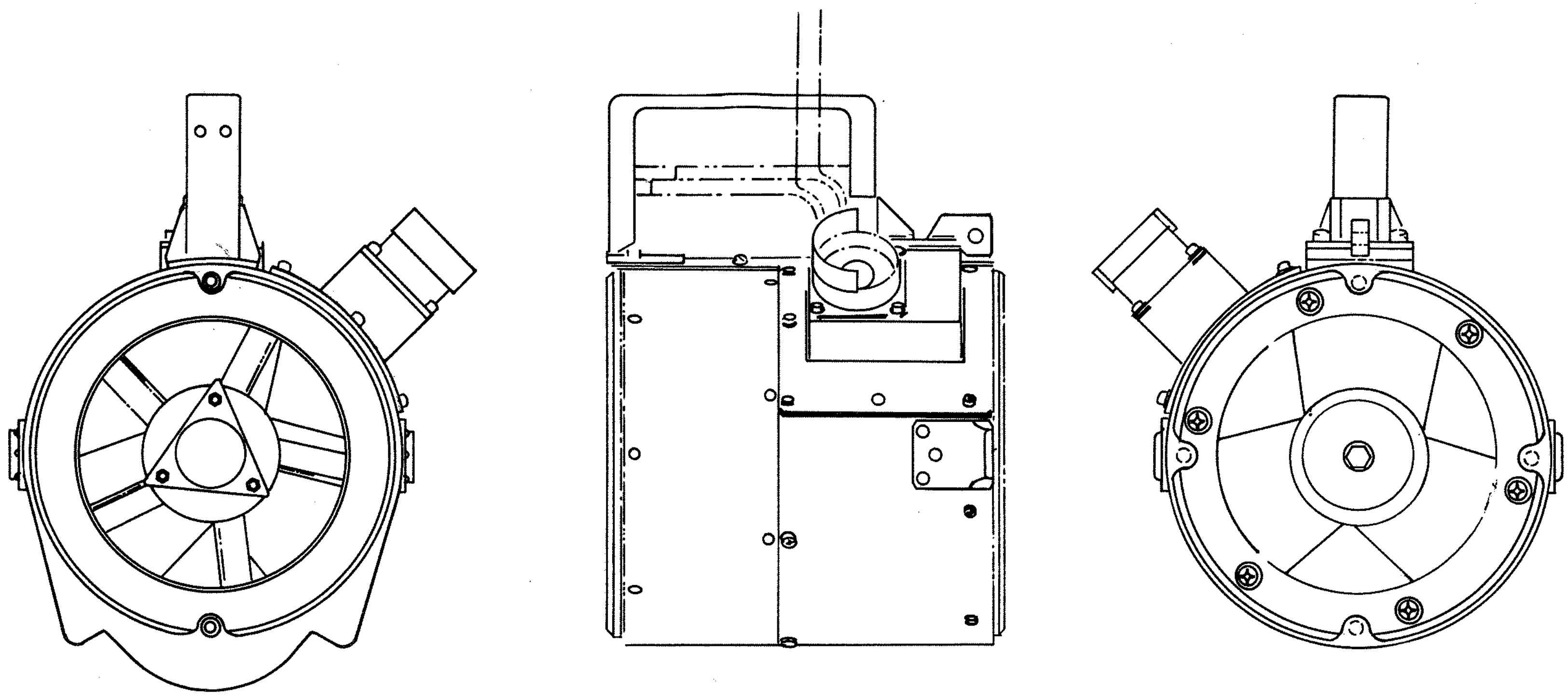

Figure 2.4.4-61 PLV Fan

GAS CIRCULATION SHUTOFF VALVE

Gas circulation shutoff valves (figure 2.4.4-63) are installed downstream of each heat exchanger fan in the OWS cooling module to prevent gas backflow through non-operating fans from operating ones. They operate in conjunction with the fan and are controlled by the OWS thermal control unit. The butterfly valve is operated by two rotary solenoids. A dc signal applied to the proper solenoid will result in the valve flapper being rotated 90 degrees to a closed/open position. The output torque of the solenoid is transmitted to the flapper shaft via a pin and clevis coupling. The valve flapper is held in position at both extremities of travel by a roller-detent mechanism. An externally accessible lever permits manual operation of the valve. An aluminum ring seal is installed around the flapper.

CABIN HEAT EXCHANGER

The cabin heat exchangers (figure 2.4.4-64) are used to cool the cabin atmosphere. There are three heat exchangers in the STS and four in the OWS cooling module (AM aft compartment). The heat exchanger is a welded assembly of corrosion-resistant steel. It is a cross-counterflow, gas-to-liquid, plate-fin heat exchanger, containing redundant liquid cooling passages. The unit is rectangular in shape and is provided with a rectangular nut plate flange on each end for attachment to ducts. There are two coolant inlet ports and two output ports, providing for two separate coolant loops.

CONDENSING HEAT EXCHANGER AND WATER SEPARATOR

The condensing heat exchanger and water separator (figure 2.4.4-65) cools cabin gas and removes excess water from the gas prior to entry into the molecular sieve. The unit is stainless steel and is designed as a cross-counterflow plate-fin unit. The single-pass gas passages contain wicking material to absorb condensed moisture. Water is drawn off by capillary action and removed from the heat exchanger by the pressure differential maintained across the water separator plates. The unit contains a gas inlet and outlet, four coolant ports, and two water outlet ports. The four coolant ports are required for the two, redundant, six-pass coolant circuits. Both coolant circuits are used during normal operations.

WATER SEPARATOR PLATE ASSEMBLY

Two water separator plate assemblies (figure 2.4.4-66) are attached to each condensing heat exchanger and remove water that has been condensed from cabin gas circulated through the heat exchanger. The unit consists of two water separator elements attached to a stainless steel cover plate and is inflight replaceable. The cover plate has six bolt holes to mate with studs mounted on the heat exchanger, a molded-in-place seal, and six captive nuts for attachment to the heat exchanger. Each of the water separator elements is made up of a stainless steel grid, sandwiched between two sheets of sintered glass filter material. Open cell polyurethane sheet (1/16 inch thick) is wrapped around the separator element to serve as wicking material. The foam wicking material picks up water from the fiberglass wick in the heat exchanger and, by capillary action, carries it to the surfaces of the separator plates. Water is drawn through the plates into the stainless steel grids by the pressure differential (8 inches H2O minimum) between cabin atmosphere and the condensate storage tank.

CONDENSATE TANK ASSEMBLY

The condensate tank assembly (figure 2.4.4-67) is composed of a water tank, quick-disconnects, selector valves, and sensors. The cylindrical tank is made of transparent epoxy-polyurenthane copolymer material. A flexible Viton diaphragm divides the vessel into a water chamber and a gas chamber. A selector valve provides the capability for exposing the gas chamber to vacuum or to cabin pressure. Another selector valve permits connection of the water chamber to condensing heat exchangers and the gas separator or to the overboard dump line. The assembly is inflight replaceable, using quick-disconnects. Water connections and other fittings on the tank are stainless steel. A sensor is installed to indicate pressure differential between the water chamber and the cabin. A pressure switch provides a signal to the C&W system when the water tank requires dumping. The basic water tank is also used in the ATM tank module and in both suit cooling H20 tank modules as reservoirs, the gas chamber being pressurized to 5 psi GN2.

CONDENSATE DUMP SOLENOID VALVE

Condensate dump solenoid valves (figure 2.4.4-20) are installed at the discharge end of the condensate tank line for use as dump valves. The valves are identical to the O2/N2 fill solenoid valves (paragraph 2.4.4.1.7), except that the position switch is deleted and the length is decreased accordingly.

CONDENSATE DUMP HEATERS

Electrical heaters are installed on each of the 0.25-inch condensate dump lines and exit ports to prevent the freezing of water during a contingency overboard dump operation. A heater rod is spiraled around the dump line and on the flat surface of the dump exit port plate. The heaters are controlled by a switch in the cabin and have no automatic temperature control capability.

MOLECULAR SIEVE GAS SELECTOR VALVE

The gas selector valve assembly (figure 2.4.4-68) alternately directs process gas through the absorbing molecular sieve cannister and then connects the cannister to vacuum for desorption. The gas valve assembly is a five-port, two-positioned, pneumatically actuated, plug valve. The valve is positioned by introduction of high-pressure gas (150 psi N2) into supply ports on the pneumatic actuator as controlled by the cycle timer in conjunction with solenoid

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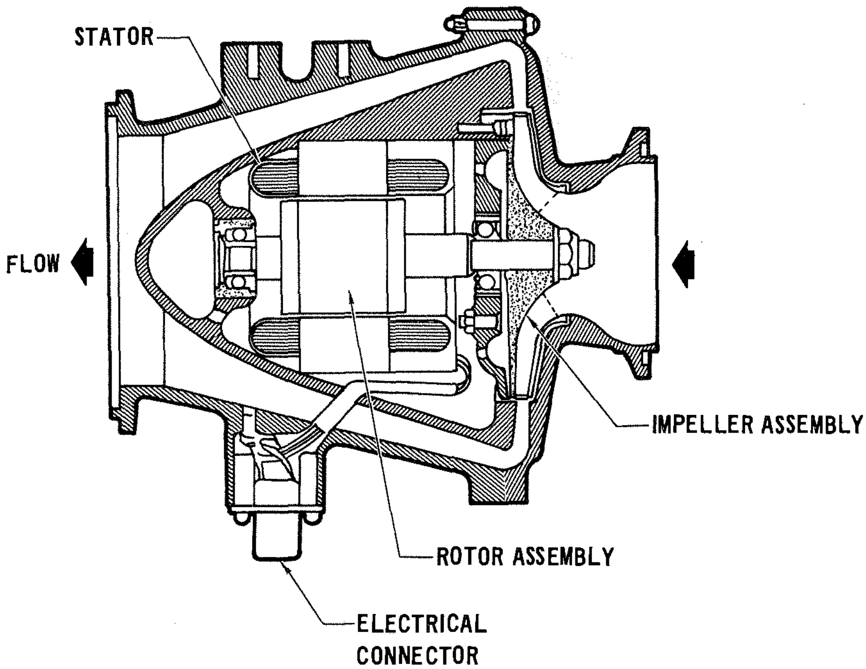


Figure 2.4.4-62 Molecular Sieve Fan

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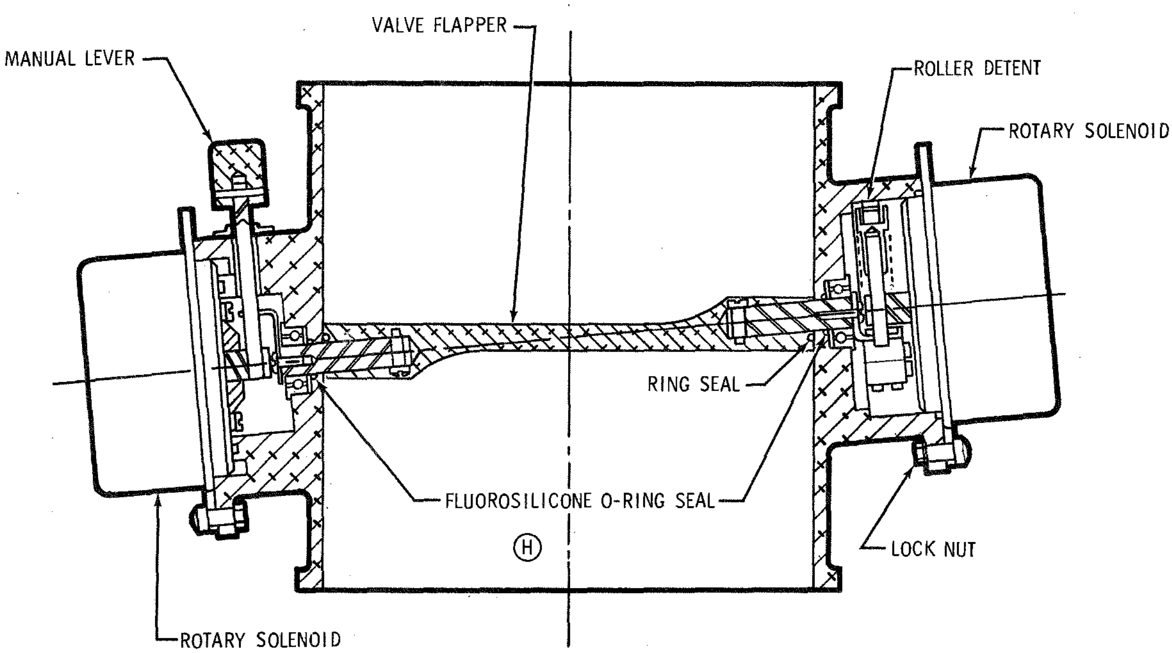


Figure 2.4.4-63 Gas Circulation Shutoff Valve

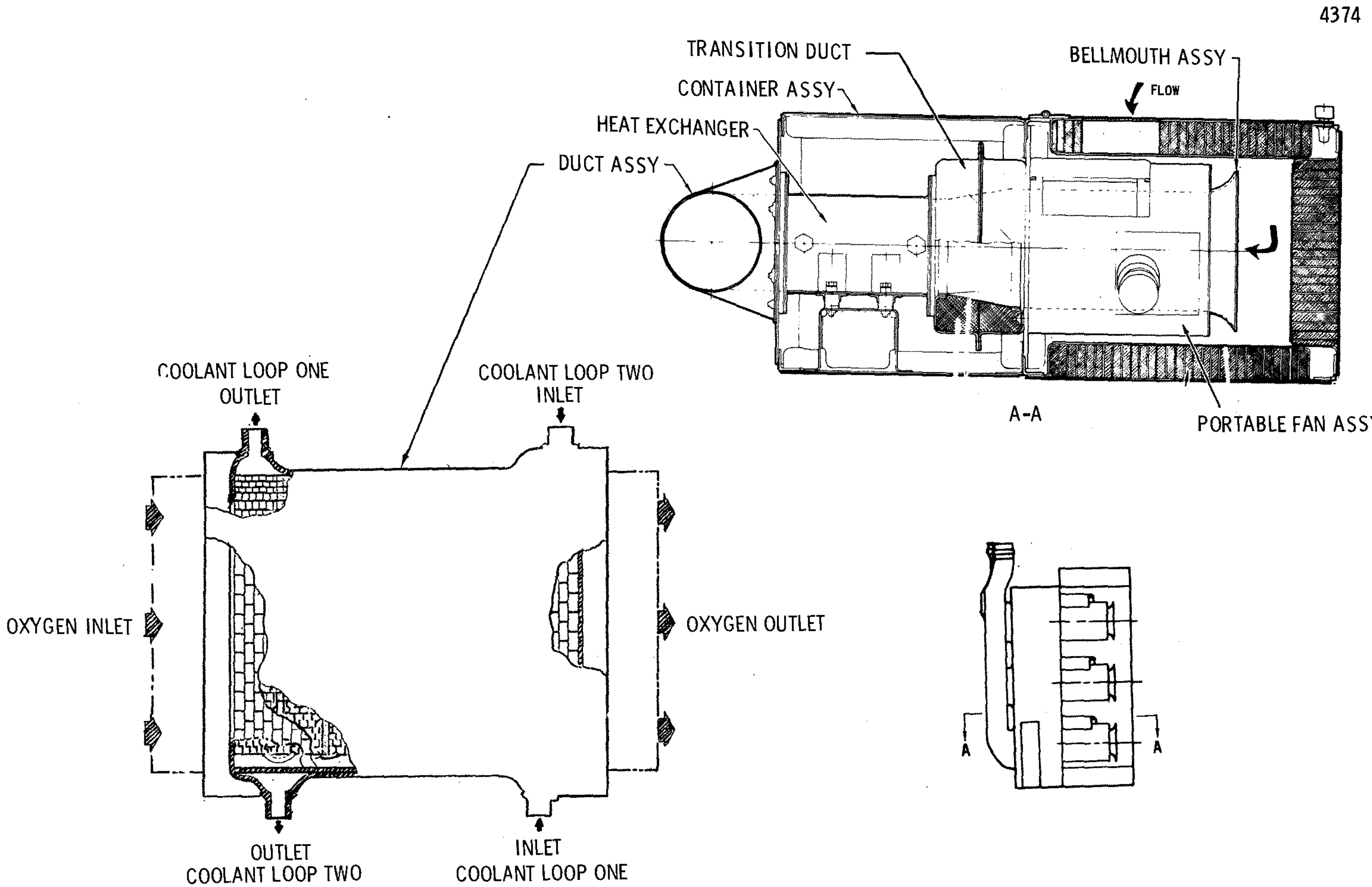


Figure 2.4.4-64 Cabin Heat Exchanger

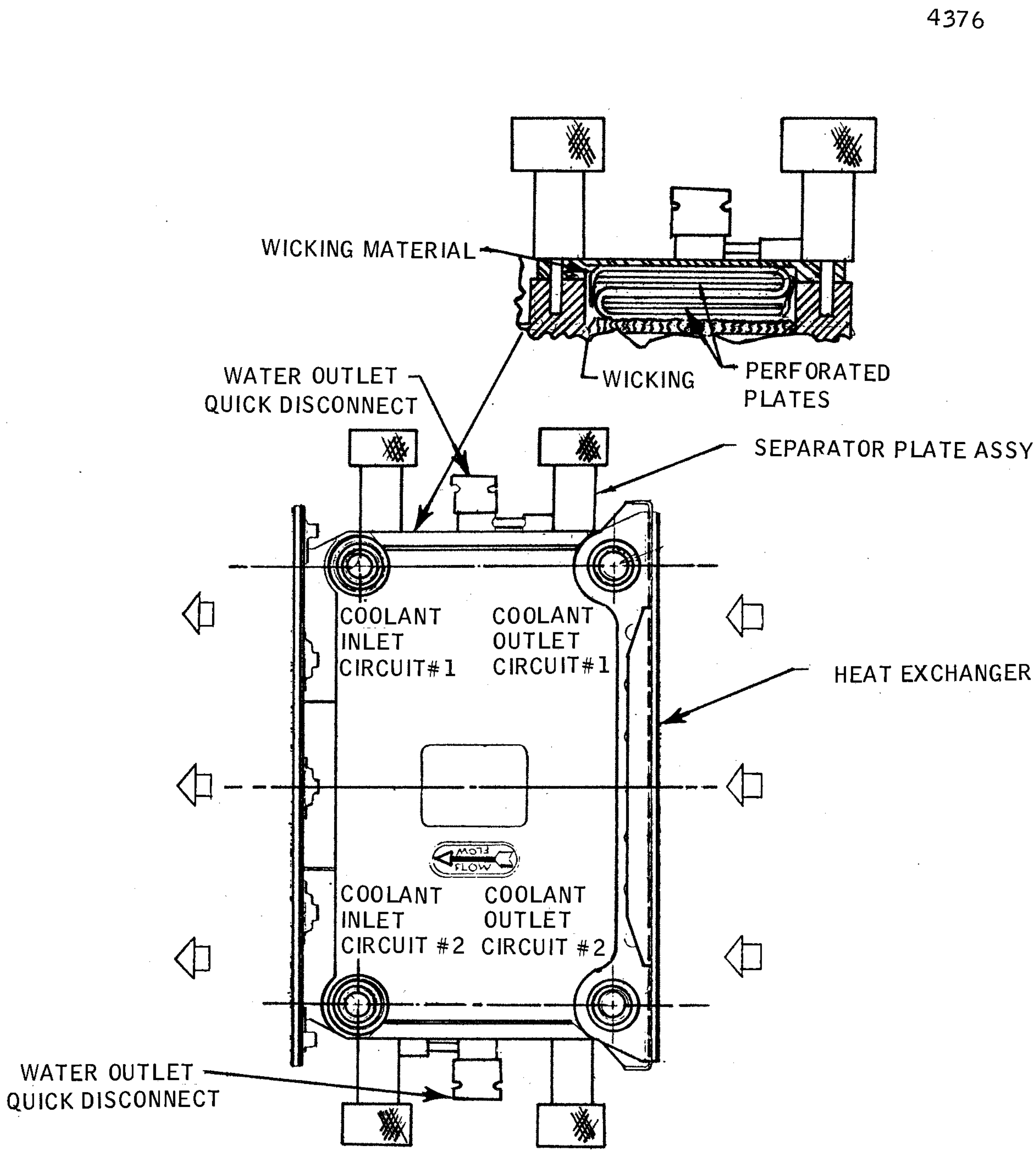


Figure 2.4.4-65 Condensing Heat Exchanger and Water Separator

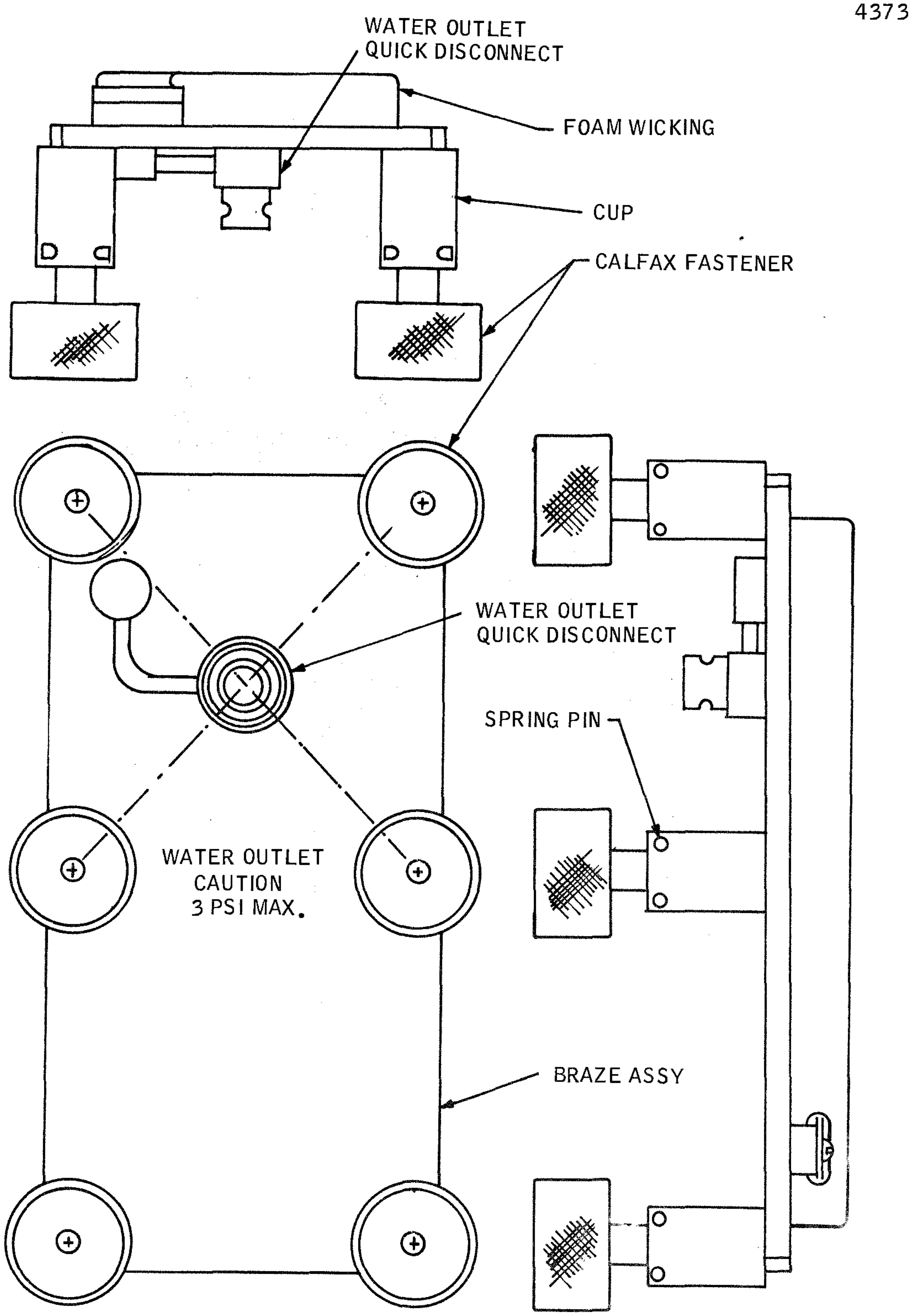


Figure 2.4.4-66 Water Separator Plate Assembly

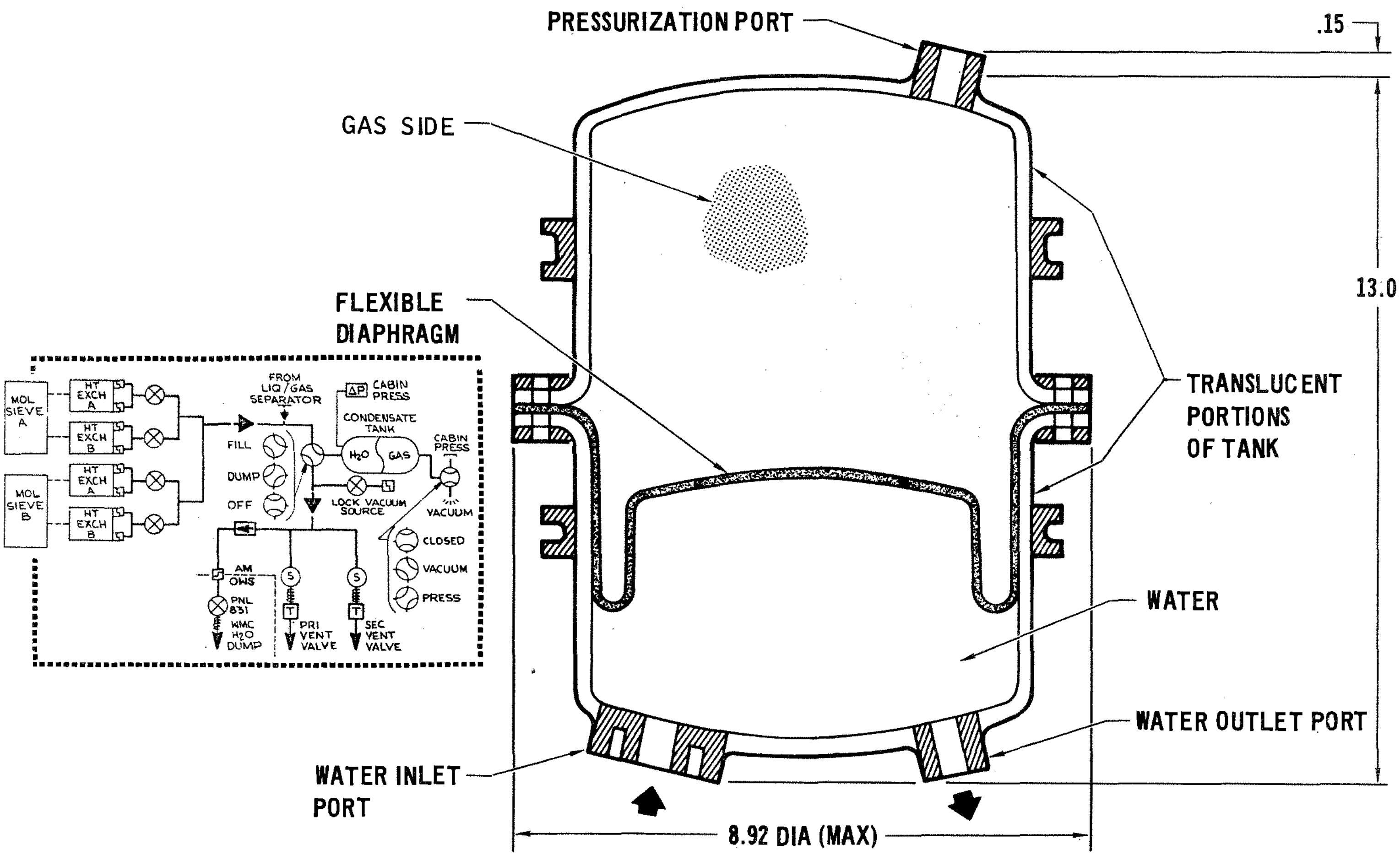


Figure 2.4.4-67 Condensate Tank Assembly

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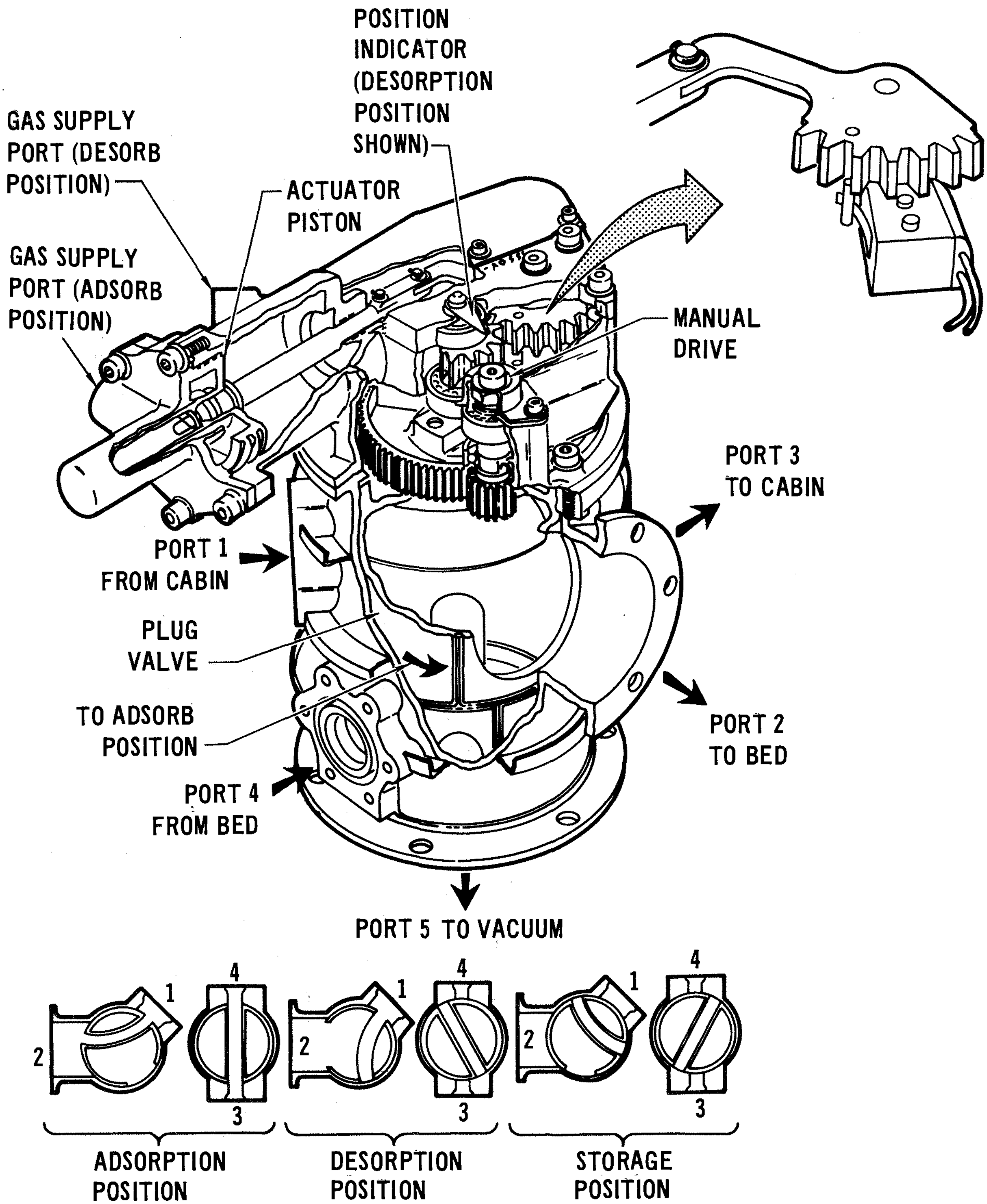



Figure 2.4.4-68 Gas Selector Valve

switching valves. When the selector valve is in the adsorb position, process gas passes through the inlet port into the sorbent canister for processing. The gas then passes through the valve outlet port and into the cabin. When the valve is in the desorb position, the inlet and outlet process gas ports and the canister outlet port are sealed off and the canister inlet is opened to the vacuum duct. While the valve is being switched, all process gas ports are simultaneously shut off before the valve moves to the desorb position. A manual override control is provided for positioning the valve in case of an actuator failure. To provide canister isolation during storage, an intermediate canister isolation position is provided that may be set with the manual override. Open and closed limit switches are used for position indication on telemetry.

MOLECULAR SIEVE SORBENT CANISTER

The molecular sieve sorbent canister (figure 2.4.4-69) contains the sorbents for drying of the process gas stream and removal of carbon dioxide. An integral electrical heater provides 375°F bakeout capability for regeneration of the molecular sieve. The canister or housing is fabricated in two sections. The predryer section consists of a housing packed with 10.35 pounds of Linde Type 13X synthetic zeolite in 1/16 inch diameter pellets. The carbon dioxide removal section consists of a vacuum-insulated housing containing 7.0 pounds of Linde Type 5A synthetic zeolite in 1/16 inch diameter pellets. The canister is fabricated of stainless steel, reinforced for both internal and external loadings. A low-thermal-conductivity glass fiber and multilayer insulation is used in the vacuum annulus, which is vented to the system overboard vacuum duct. A plate-fin heater is imbedded in the Type 5A section for removal of water vapor from the carbon dioxide sorbent during regeneration. The electric heater consists of Kapon heating elements sandwiched between aluminum plate-fin elements. Six heating elements are arranged in parallel. Each of the six contains an integral Balco resistance sensor for control and indication of heater operation. The canisters have cooling manifolds that provide cooling to reduce case touch temperatures during bakeout.

MOLECULAR SIEVE SOLENOID VALVE

The molecular sieve solenoid switching valve (figure 2.4.4-70) controls the pressure supply to the pneumatic actuator on each gas selector valve. The valve is a three-way, two-position solenoid valve, featuring an inlet port, a cylinder port connected to the pneumatic actuator, and an exhaust port. In the normal or nonenergized condition, the cylinder port is connected to the exhaust port. In the energized position, the inlet or pressure port is connected to the cylinder port, allowing flow through the manual interconnect valves to the pneumatic actuator of the gas selector valve. There are four solenoid valves associated with each molecular sieve. Each valve is controlled by an AUTO/OFF/MANUAL switch, panels 226 and 227. In the AUTO position, the solenoid valve is controlled by the molecular sieve cycle timer.

MANUAL INTERCONNECT VALVE

There are four manual interconnect valves (figure 2.4.4-70) provided in each of the two molecular sieve systems to direct N2 pneumatic pressure from the solenoid valves to the gas selector valve actuators. The valves provide cross-over capability so that when the cycle timer opens one solenoid valve, the pneumatic pressure through the interconnect valve will simultaneously position the gas selector valve actuator for one sorbent bed to adsorb and the other to desorb. The valve is also used to isolate an actuator during molecular sieve bakeout or in case of a failure. The valve has three ports and three positions, each 90 degrees apart, and consists of a rotating plug in an aluminum housing.

MOLECULAR SIEVE CYCLE TIMER

Automatic cycle timers (figure 2.4.4-71) are utilized to electrically actuate solenoid switching valves that pneumatically position gas selector valves on the molecular sieve sorbent canisters. The cycle timer is a hermetically sealed, solid-state programmer. The programmer has an oscillator that provides a preset output consisting of 14.67 second pulses. Pulses are counted and decoded to actuate power switches at the proper time intervals. Reset capability is provided in case of power interruption. Solid-state power switches, which supply power to the solenoid switching valves, are current limited to prevent malfunction in the event of a short circuit. A voltage regulator reduces and regulates supply voltage to a fixed value so that stable operation of the oscillator and integrated circuits is attained. In addition, protection is provided for continuous application of reverse polarity and for supply voltage transients.

SOLIDS TRAP

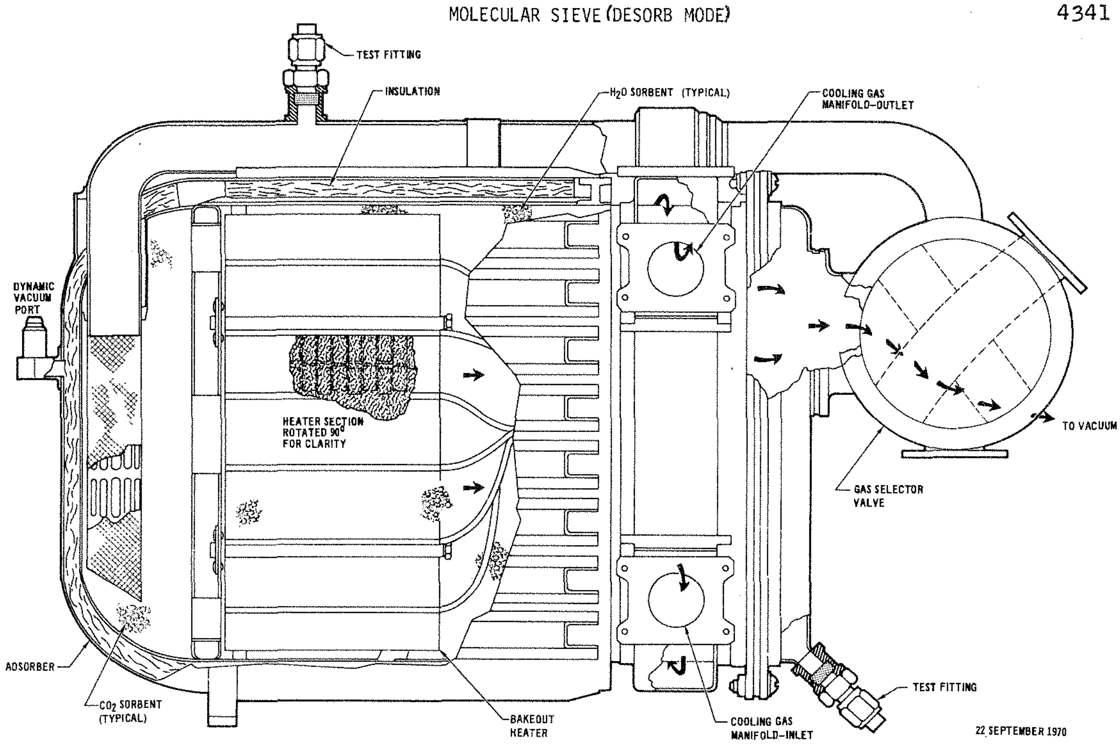
A solids trap (figure 2.4.4-72) is installed upstream of each molecular sieve fan to prevent particles generated in the cabin from entering the molecular sieve system. The unit consists of a cylindrical, 40 micron stainless-steel screen, an aluminum housing, and a silicone rubber, center-supported, disc-shaped relief valve. If the screen becomes blocked, the relief valve opens to allow straight-through flow without filtering. The unit is replaced inflight every 10 days.

CHARCOAL CANISTER

The charcoal canister (figure 2.4.4-73) removes odors from cabin gas circulated through the atmosphere purification circuit. The unit is installed in a circuit parallel to the molecular sieve sorbent canisters with a discharge venting to the subsystem outlet duct. The canister is a self-contained removable unit and contains 9 pounds of activated cocoanut shell charcoal. It consists of a housing assembly that contains filter cloth screens, back plates, and springs to ensure that the canister remains securely packed. The canister incorporates a flexible handle for ease in handling during replacement and index markings on the quick-disconnect fittings to indicate locked and released positions. The canister is replaced every 28 days.

MOLECULAR SIEVE (DESORB MODE)

4341




MOLECULAR SIEVE (ADSORB MODE)

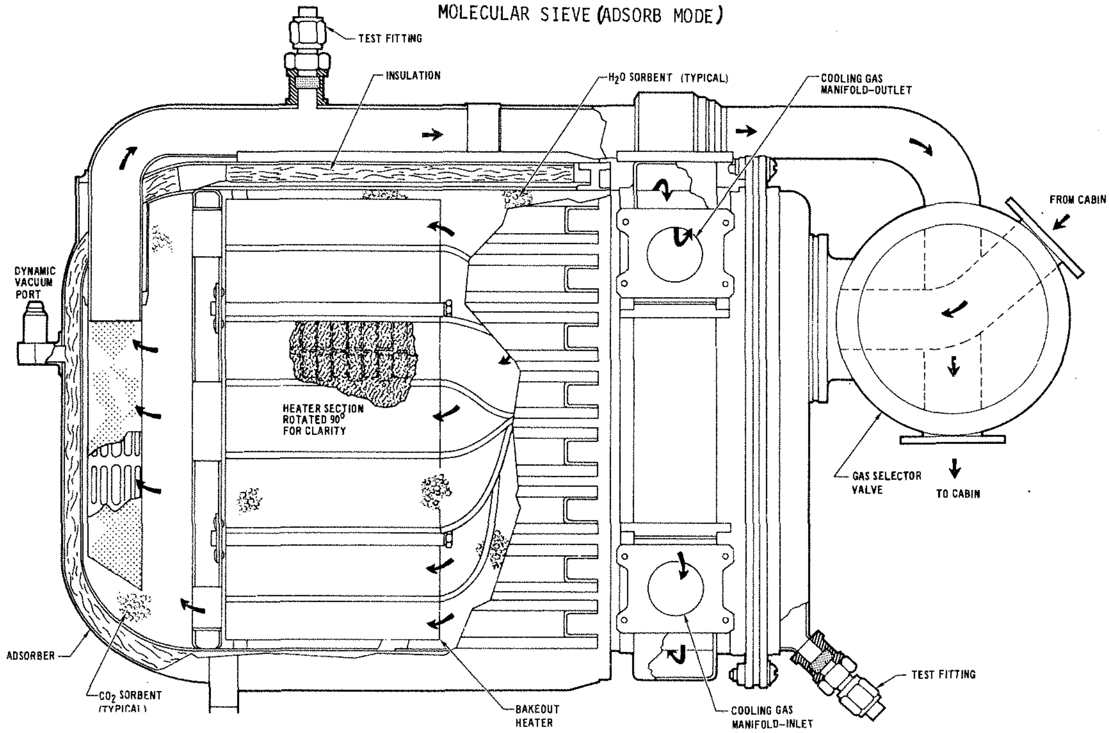



Figure 2.4.4-69 Molecular Sieve Sorbent Canister

4350

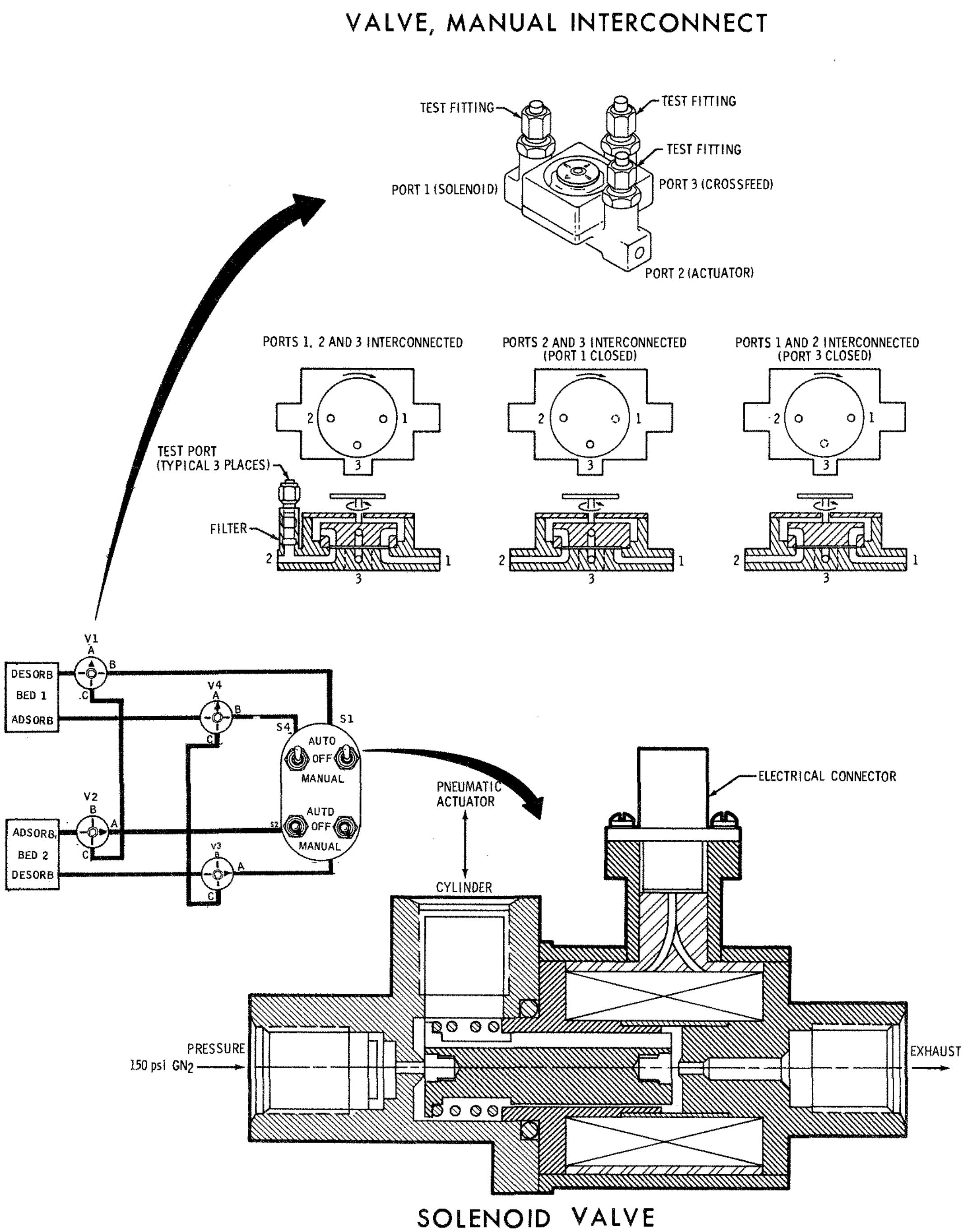
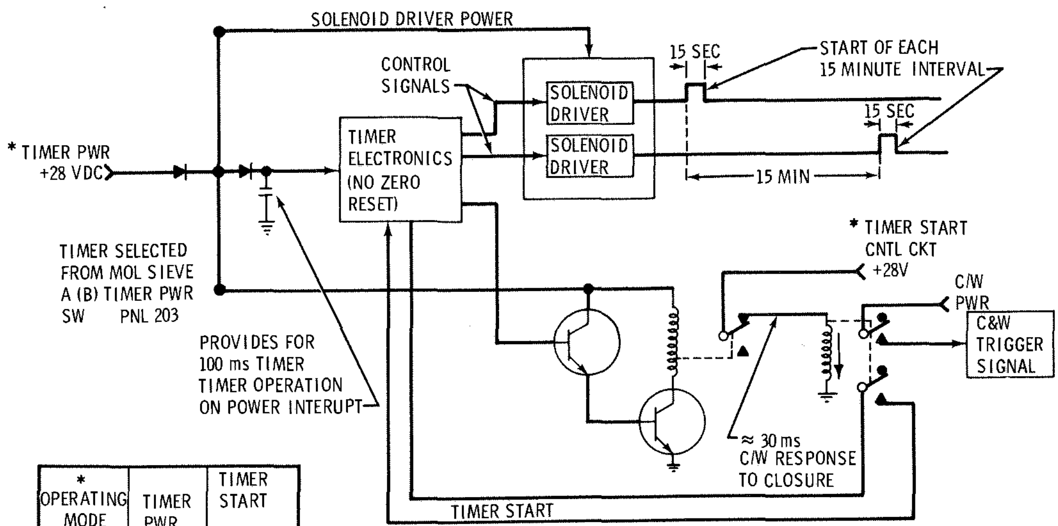



Figure 2.4.4-70 Molecular Sieve Solenoid & Manual Interconnect Valves

8220

## MOL SIEVE CYCLE TIMER
(4 - 2 PER MOL SIEVE PRI AND SEC)




| * OPERATING MODE | TIMER PWR | TIMER START |
|---|---|---|
| S, A, PRI | AM 1 | AM 2 |
| S, A, SEC | AM 2 | AM 1 |
| S, B, PRI | AM 1 | AM 2 |
| S, B, SEC | AM 2 | AM 1 |

NOTE: TIMER START POINT IS RANDOM FOR POWER INT > 100 ms AND FOR INITIAL START
TIMER START SIGNAL HAS NO EFFECT IF TIMER IS RUNNING

Figure 2.4.4-71 Molecular Sieve Cycle Timer

4129

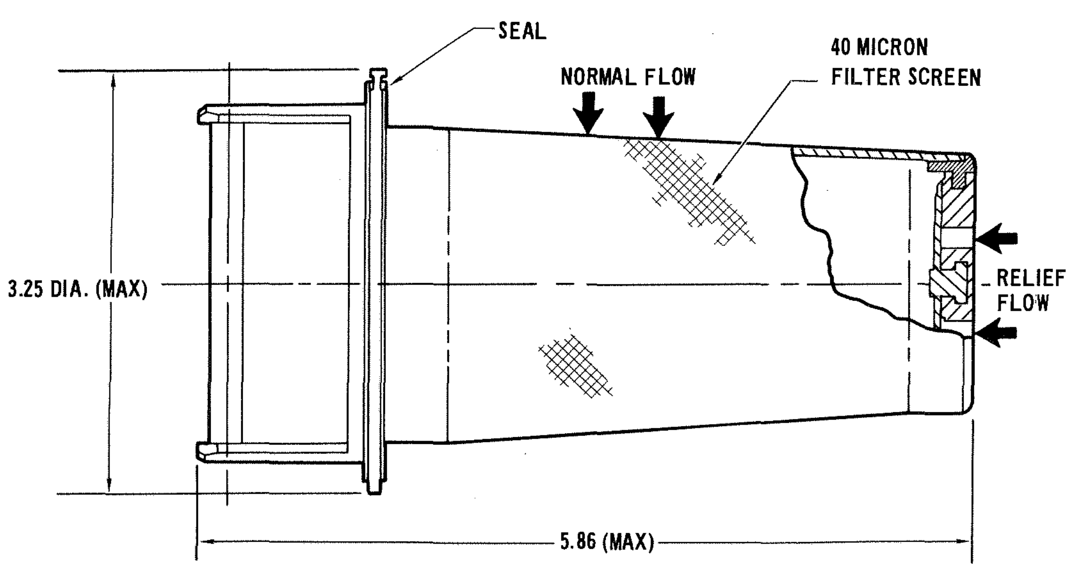



Figure 2.4.4-72 Solids Trap

4130

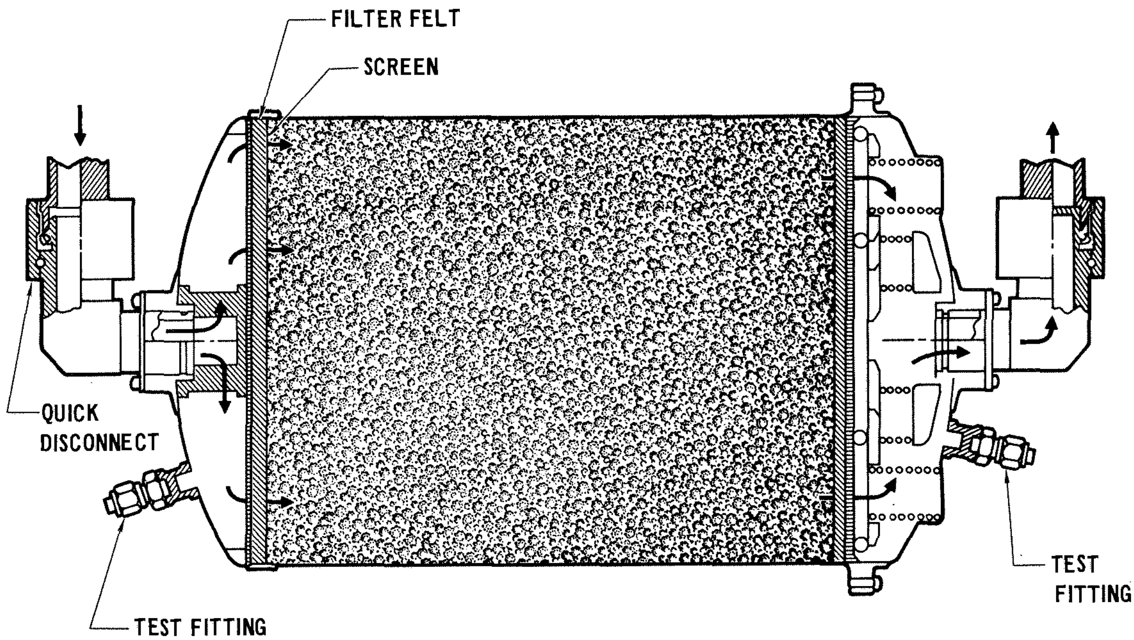



Figure 2.4.4-73 Charcoal Canister

2.4.4.4 EVA/IVA SUPPORT

The EVA/IVA support system (figure 2.4.4-74) provides the crewmen with a regulated oxygen supply, a suit cooling system, and a means of depressurizing and repressurizing the lock compartment. The primary reason for EVA activity is ATM experiment camera and film placement and retrieval.

2.4.4.4.1 EVA/IVA System

The suit cooling system (figure 2.4.4-75) provides astronaut cooling during EVA by circulating water through the life support umbilical (LSU), pressure control unit (PCU), and liquid cooling garment (LCG). The system consists of two identical subsystems, one subsystem per MMS 602 coolant loop. Each subsystem uses a suit cooling module, one-half of the H20 tank module, EVA/IVA panel quick-disconnects and interconnecting lines. The two suit cooling modules are located exterior to the STS. Each module consists of two pumps in parallel for redundancy, two ground cooling type three-path heat exchangers as well as pump check valves and pump relief valves. The pump relief valves limit pressure in the LCG to 37.2 psia in the event of a blocked line. The H20 tank module is located in the STS and consists of a water tank, liquid/gas separator and separator bypass relief valve for each of the two subsystems.

Water is circulated at 200 lb/hr minimum by the selected pump to the two ground-cooling type heat exchangers in series (figure 2.4.4-76). The heat exchangers are a three-path type, operated in counterflow with the MMS 602 coolant loop. The water transfers heat to the coolant fluid. The water enters the first heat exchanger, which has two parallel coolant paths of relatively warm coolant. After flowing through this heat exchanger, the coolant enters the warm inlet of the 47°F temperature control valve. The water then passes through the second heat exchanger, which has two parallel coolant paths of relatively cold coolant coming through a two path regenerative heat exchanger from the radiator. The two parallel paths of coolant from the second heat exchanger are plumbed together to enter the cold inlet of the 47°F temperature control valve. The water is then delivered to the IVA or EVA panels for interface with the umbilical. For periods other than EVA, the HX COOLANT FLOW switch on the IVA panel 217 is positioned to BYPASS, causing the coolant flow to bypass these heat exchangers, preventing possible freezing of the water.

The primary and secondary MMS 602 coolant loops dissipate a total heat load of approximately 12,000 Btu/hr during EVA activities and deliver coolant at an average temperature of approximately 28°F to each water module. Each suit cooling subsystem can reject up to 2000 Btu/hr to the coolant loop with a maximum water delivery temperature to the umbilical of 43°F. Although one suit cooling subsystem is supplied for each of two astronauts, two quick-disconnects per subsystem are provided in the AM lock compartment so if a coolant loop fails, both astronauts could be serviced from one water loop. If this occurs, two coolant pumps will be operated in the one remaining

4321

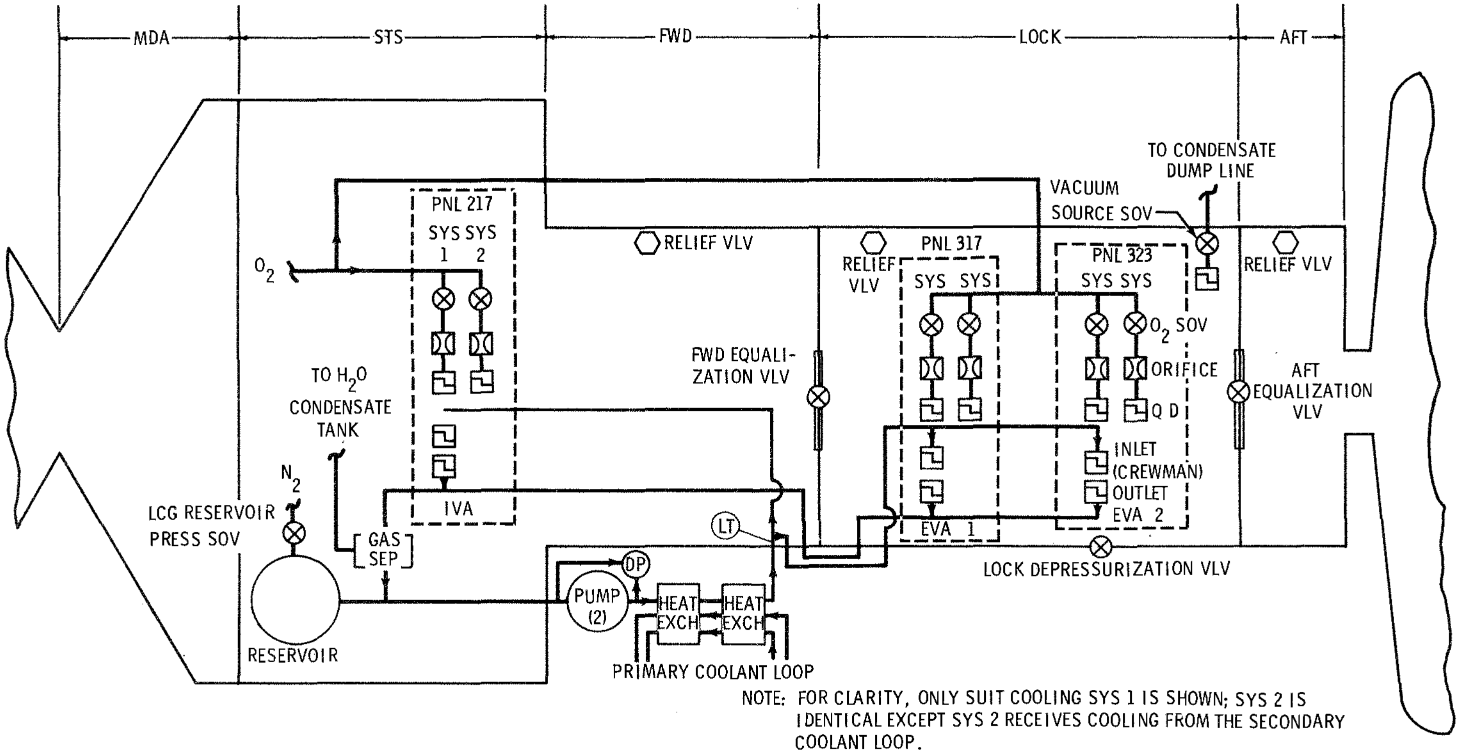



Figure 2.4.4-74 EVA/IVA Support System

4024

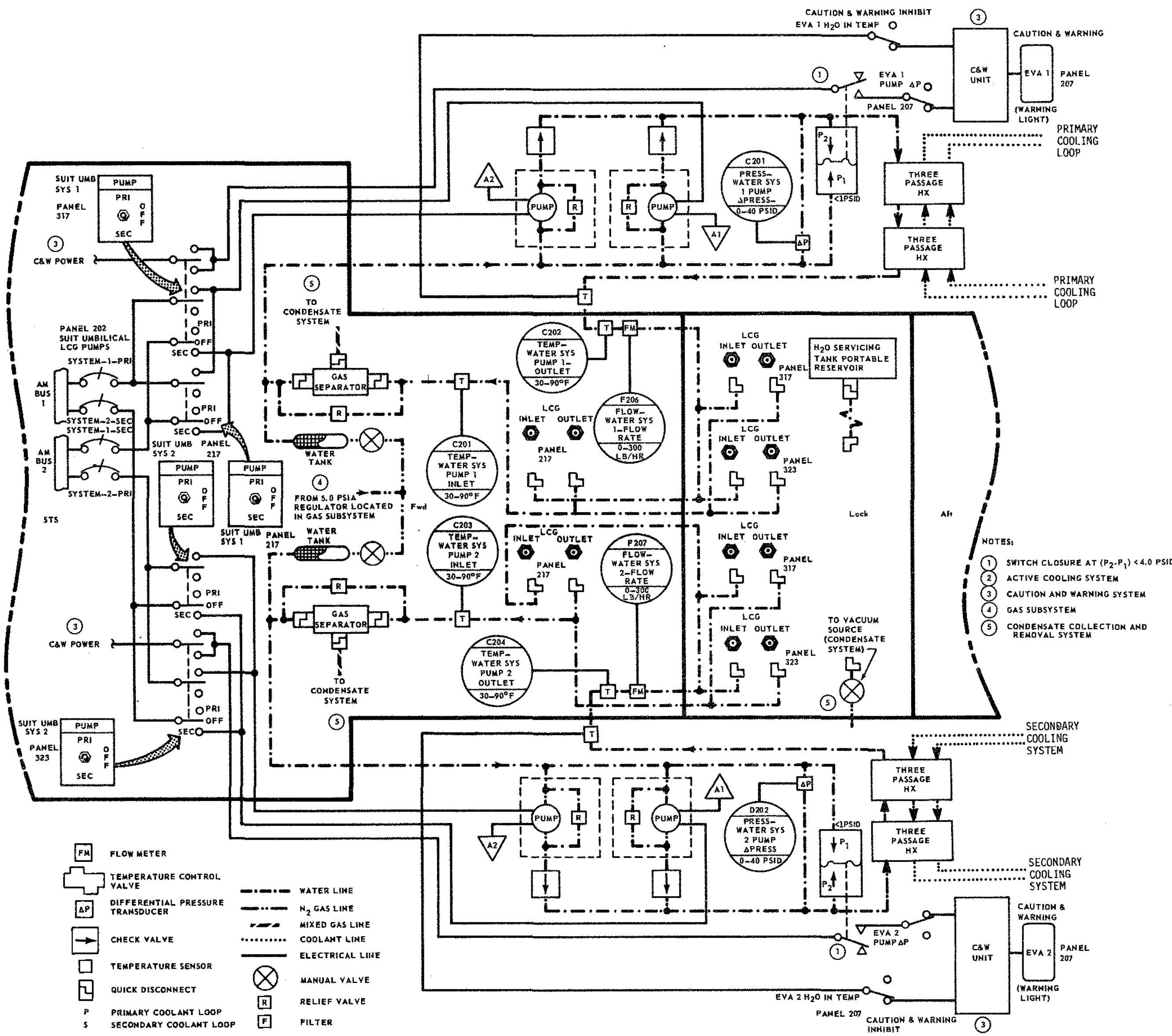



Figure 2.4.4-75 Suit Cooling System

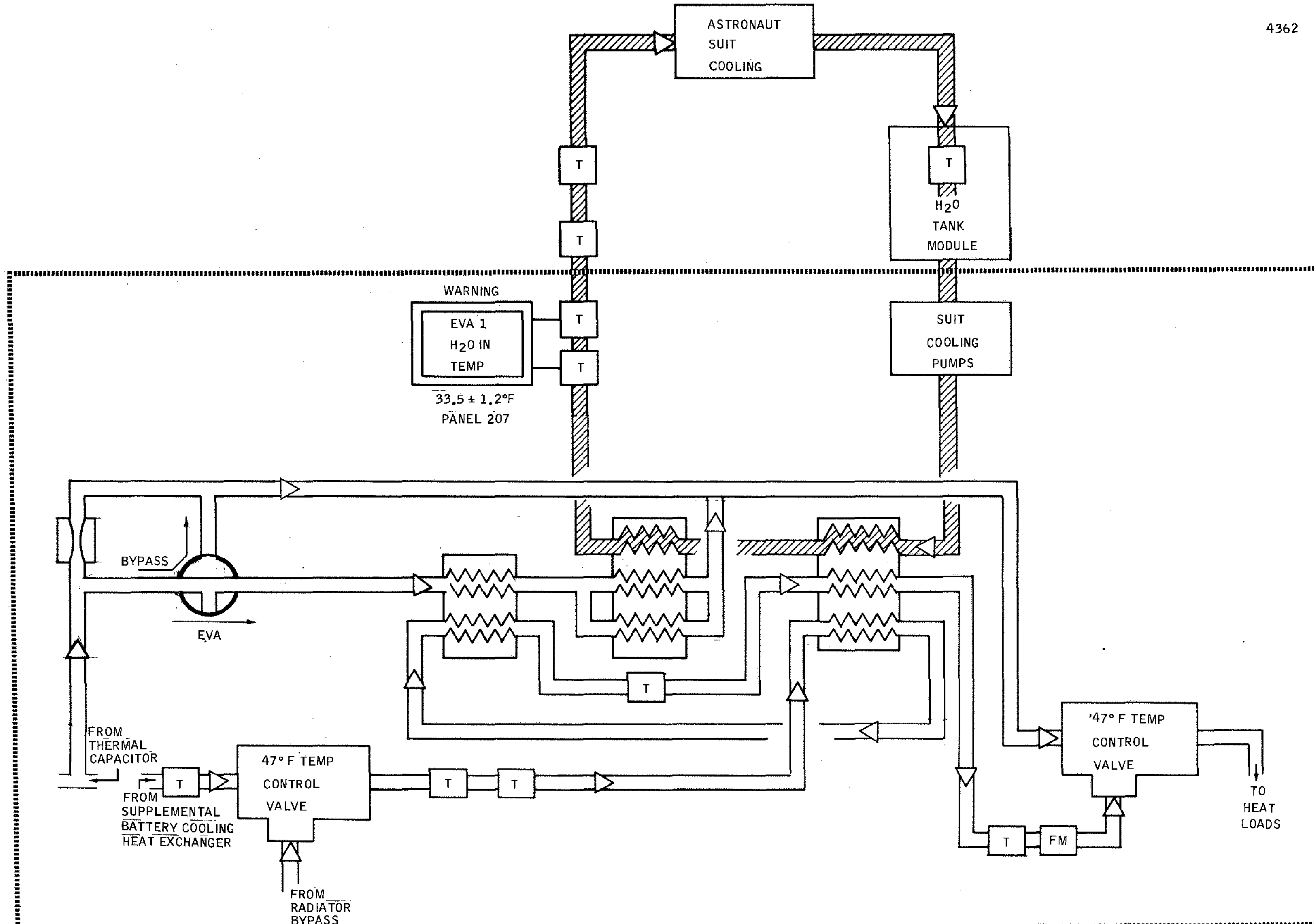



Figure 2.4.4-76 Suit Cooling System -- Coolant Loop Interface

coolant loop, increasing the coolant flow to 460 lb/hr. With two men serviced from one water loop, water flow rate is 125 lb/hr per man. A single coolant loop operating at a flow of 460 lb/hr is capable of dissipating the EVA heat load of approximately 12,000 Btu/hr and delivering coolant at an average temperature of 28°F to the water module.

Nominal pump performance is based on a pump inlet pressure of 5.0 psia or greater. Performance degradation results from operating at lower inlet pressures because of the possibility of cavitation. Pump inlet pressure is referenced to, and maintained at, the same level as the reservoir. Reservoir pressure is maintained by the 5 psia reservoir pressure regulator assembly.

Oxygen is supplied to the IVA and EVA stations from the 120-psi regulator assembly. The 120-psi regulator assembly is capable of providing a minimum total system flow of 22.7 lb/hr. An orifice located in each supply line upstream of the interface restricts oxygen flow rate through any one suit. If one umbilical breaks or a suit is torn, the orifice restricts flow to that suit to 13.7 lb/hr and allows approximately 9 lb/hr to be provided to the second crewman while maintaining a minimum pressure of approximately 65 psia at the AM/umbilical interface.

Egress for EVA is provided in the AM lock compartment. The lock compartment is depressurized by sealing it off from surrounding compartments and then by opening the equalization valve adjacent to the EVA hatch. The minimum time required to depressurize the AM lock compartment from 5.0 to 0.15 psia is 120 seconds. The EVA hatch is then opened and the crewmen may egress. When the crewmen have completed EVA, they return to the AM lock compartment and close the EVA hatch. Repressurization is accomplished by using the equalization valve located in the lock compartment forward hatch. The minimum time required to pressurize the AM lock compartment from 0 to 4.95 psia is 24 seconds.

2.4.4.4.2 EVA/IVA Panels

Control panels are provided for the IVA and EVA stations located in the AM (figure 2.4.4-77). The STS IVA panel 217 provides complete services for two crewmen, one on SUIT UMB SYS 1 and the other on SUIT UMB SYS 2. Each system has the following provisions:

- LSU POWER switch - supplies electrical power to the life support umbilical (LSU)
- PUMP switch - provides capability to turn on primary or secondary pump in a suit cooling system
- HX COOLANT FLOW switch - (located on IVA panel only) provides capability to either bypass or flow coolant from the radiator through the heat exchangers in the suit/battery cooling module
- EVA CCU connector - provides interface with LSU wiring for electrical power, communications and bio-medical data
- $O_2$ SUPPLY quick disconnect - provides interface with LSU for oxygen supply
- $O_2$ SUPPLY valve - manual shut off valve for oxygen supply
- LCG INLET and OUTLET - provides interface with LSU for suit cooling water supply and return

A jumper hose is installed between the inlet and outlet quick disconnects of both suit umb systems on the IVA panel. The hose allows for thermal expansion of the water loops between the inlet port and the pump package when the systems are inactive. Connecting the inlet and outlet ports allows the reservoirs to compensate for thermal expansion. An orifice is provided in the hose to prevent bypassing the suited crewman when the loops are active, yet allows for pressure equalization when the loops are inactive.

The AM lock compartment EVA panels 317 and 323 provide identical capabilities as the STS IVA panel, except that the suit cooling system 1 pumps can only be controlled from EVA panel 1 and suit cooling system 2 pumps can only be controlled from EVA panel 2. Under normal EVA conditions, one crewman utilizes EVA panel 1 while the other crewman utilizes EVA panel 2.

2.4.4.4.3 Major Component Operation

WATER TANK MODULE

The water tank module contains two water tanks, two shutoff valves, two gas separators, two relief valves, and two temperature transducers; one each for suit cooling system 1 and one for suit cooling system 2. The two systems are separate and completely independent. The water tanks (figure 2.4.4-67) are made of an epoxy-polyurethane copolymer material molded into cylindrical halves. A flexible Viton diaphragm located between the two halves separates the water side and the gas side. The tank is transparent, allowing the quantity of water in the tank to be visually monitored. The water tanks have a capacity of 16 pounds of water at 5.5 psia and 115°F. The gas side of the tank is pressurized with nitrogen from the 5 psia regulator assembly. The tanks provide make-up water to the loop and a positive inlet pressure to the pumps.

WATER PUMP

Water pumps installed in the suit cooling loops are identical to those used in the ATM C&D Panel/EREP cooling loop, paragraph 2.4.4.2.5 (figure 2.4.4-49).

GAS SEPARATOR

The gas separator assembly (figure 2.4.4-78) is installed in the suit cooling systems to remove free gas from the water prior to entering the pump. The unit consists of parallel hydrophobic and hydrophillic surfaces. The porous hydrophobic surface allows gas to pass through into the gas collecting manifold and out of the assembly when subjected to a differential pressure. The hydrophillic stainless steel screen allows water flow but acts as

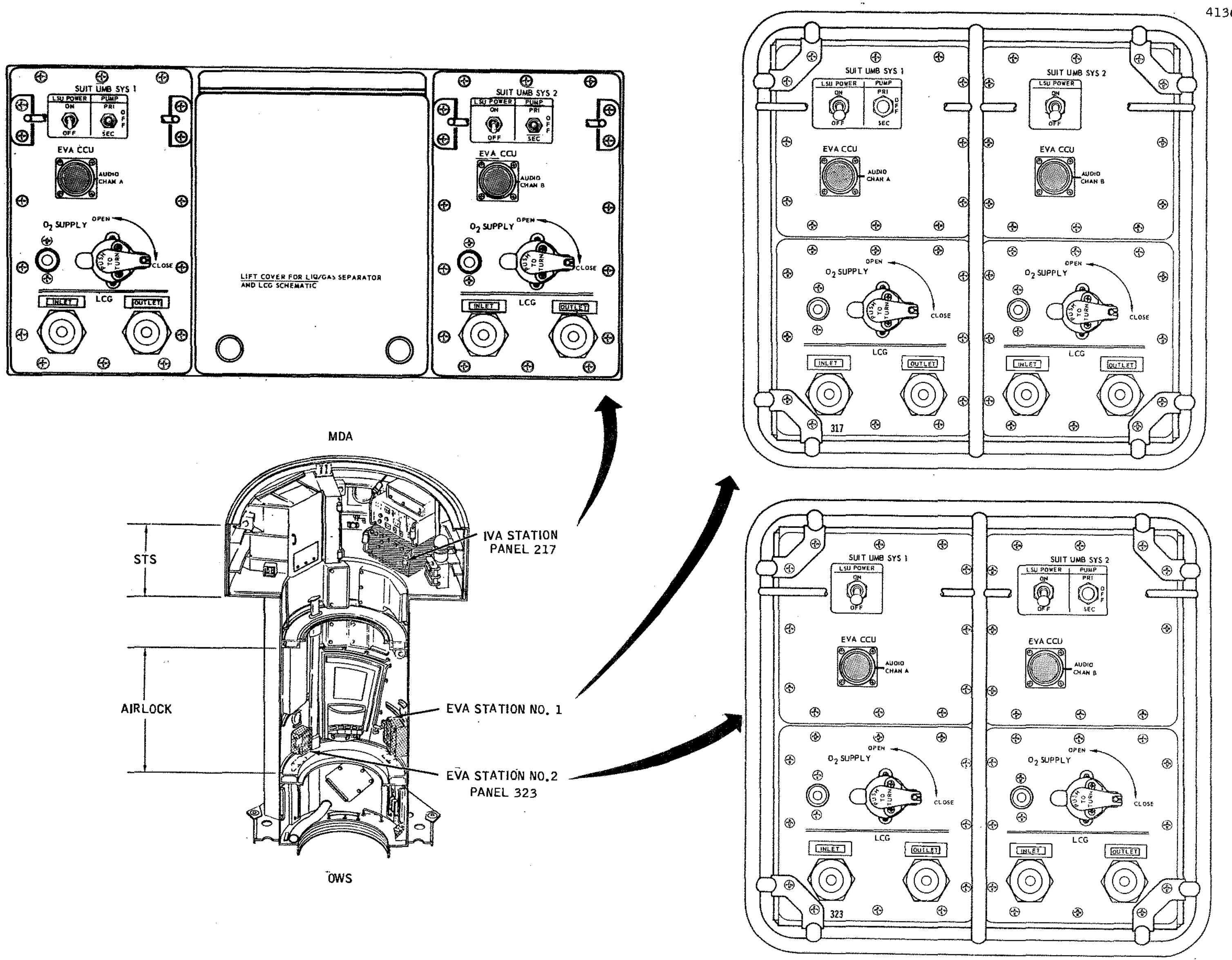



Figure 2.4.4-77 EVA/IVA Station

4375

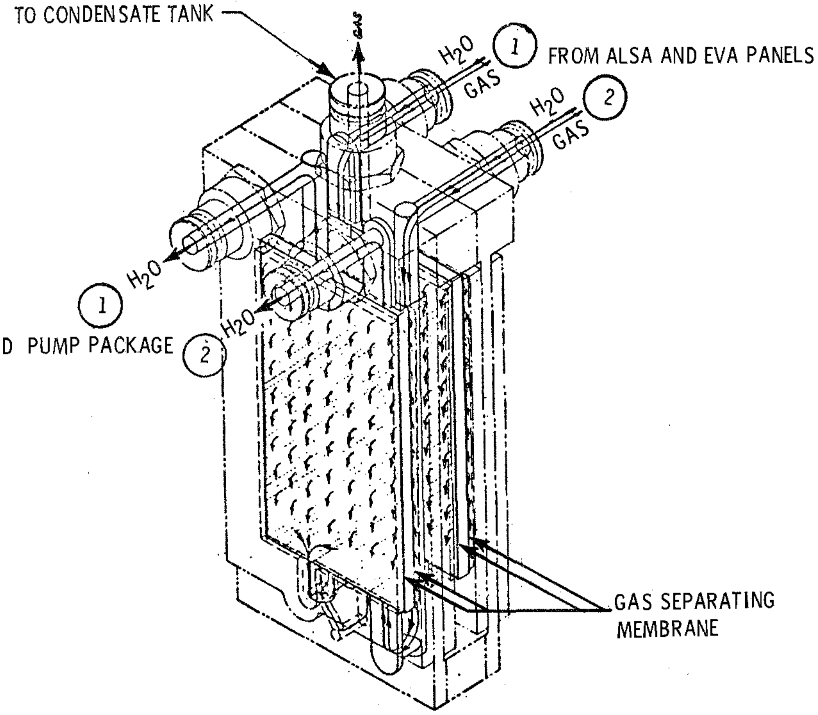



Figure 2.4.4-78 Gas Separator

a gas barrier when surface tension forces hold water in interstices of the screen. The screen also acts as a particulate filter for the influent water. Independent gas separation functions are provided for two water loops. Redundant check valves in each gas discharge line prevent backflow into gas collection manifolds. Quick disconnects are provided to permit inflight replacement of the unit.

2.4.4.5 REFRIGERATION

The RS consists of dual redundant refrigerant circuits (figure 2.4.4-79). Each of the circuits contains four pumps with any pump capable of supplying normal flow requirements. The circuits are essentially identical and independent of each other except for common utilization of the radiator, ground cooling heat exchanger, and thermal capacitor. These components have separate coolant paths.

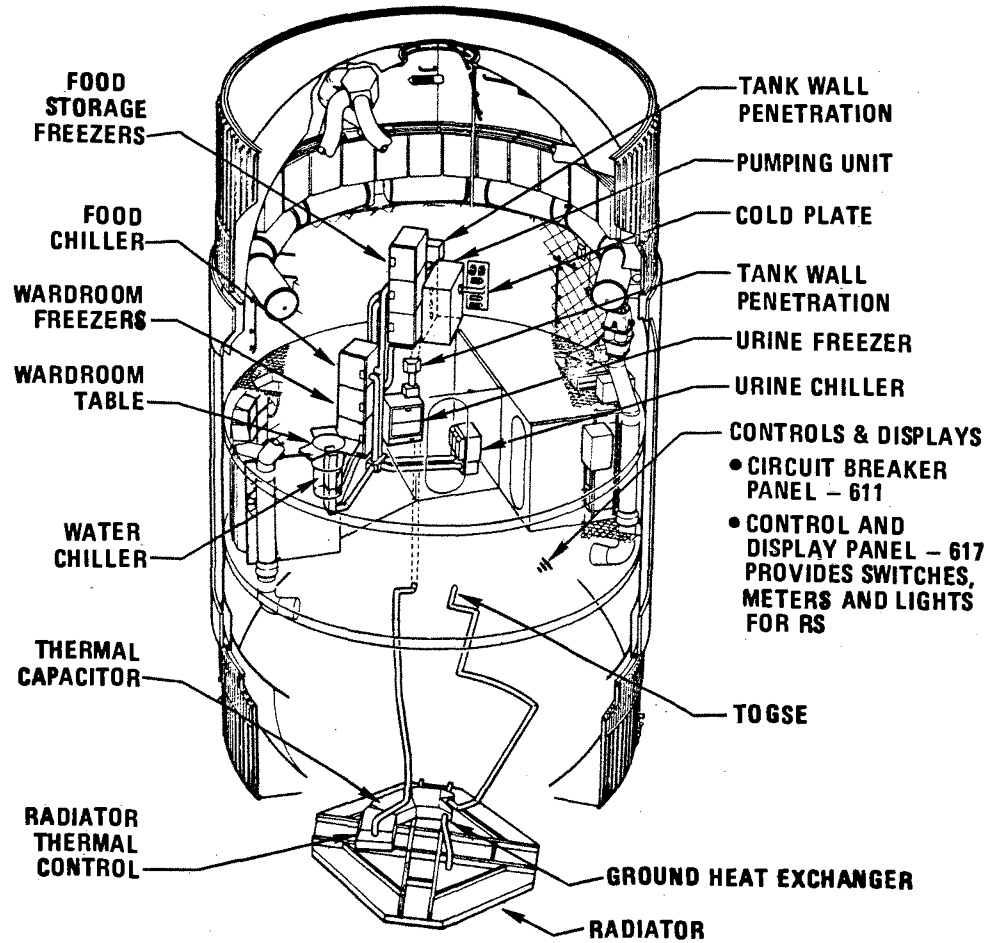
2.4.4.5.1 Coolant Loop Operation

The RS (figure 2.4.4-80) utilizes a single-phase liquid refrigerant, Coolanol-15. This refrigerant is circulated through the freezers and chillers to absorb heat; the heat is rejected to either an external space radiator or a thermal capacitor. Temperature control for refrigeration is maintained by a freezer temperature control valve, which controls refrigerant temperature to $-17\pm3$°F, and a regenerative loop, which limits the temperature of the refrigerant supplied to the chillers to $39\pm3$°F. A thermal capacitor, which consists of a phase-changing wax compound heatsink (UNDECANE, C11H24), absorbs RS heat when the surface temperature of the space radiator exceeds system operating temperatures and cannot be used for heat rejection. This condition occurs initially during ascent, and subsequently for a portion of a Z-LV orbit when heat influx resulting from solar effects is maximum. If the radiator surface temperature reaches $15\pm2$°F, a control circuit driven by a temperature transducer on the radiator assembly actuates the radiator bypass valve to the radiator bypass position. The refrigerant flow is directed past the radiator directly to the thermal capacitor where heat transfer from the refrigerant to the thermal capacitor occurs at essentially a constant temperature of -14°F (phase-change temperature of UNDECANE).

When the radiator surface temperature drops to $0\pm2$°F, the radiator temperature transducer causes the radiator bypass to open, allowing full flow of refrigerant through the radiator. The refrigerant from the radiator outlet passes through the thermal capacitor, which regenerates the phase-change wax in preparation for the next warm cycle. During this period, a constant temperature of -14°F, (phase-change temperature of UNDECANE) is maintained at the thermal capacitor.

As the radiator outlet temperature continues to drop and the stored heat is absorbed from the thermal capacitor, the exit temperature of the refrigerant from the thermal capacitor drops until the thermal capacitor has passed through a second phase change point at -34°F. If the thermal capacitor outlet temperature reaches $-41\pm2$°F,

4027




REQUIREMENTS

| | |
|---|---|
| FROZEN FOOD | -20° TO + 0°F |
| FOOD CHILLER | +33° TO + 45°F |
| CHILLED WATER | +33° TO + 45°F |
| FROZEN URINE | -2.5°F MAX |
| CHILLED URINE | +59° F MAX |

SYSTEM OPERATION

TWO REDUNDANT LOOPS. 4 PUMPS PER LOOP OPERATING MODE, ONE PUMP ON IN ONE LOOP.

PUMPS

| | |
|---|---|
| FLOW | 125±11 lbs/hr (.0365 CFM) |
| PRESSURE DROP | 55 PSID |
| PUMP POWER | 40 WATTS |
| PUMP OPERATING LIFE | ±2250 HRS EA |
| RADIATOR CAPACITY | 1680 BTU/HR |

EARTH RESOURCES CAPABILITY
2 PASSES PER 6 ORBITS
4 PASSES PER 16 ORBITS
MAX OPERATING PRESSURE 140 PSIA (DESIGN)
COOLANT VOLUME PER LOOP 1016 $IN.^3$

Figure 2.4.4-79 Refrigeration System

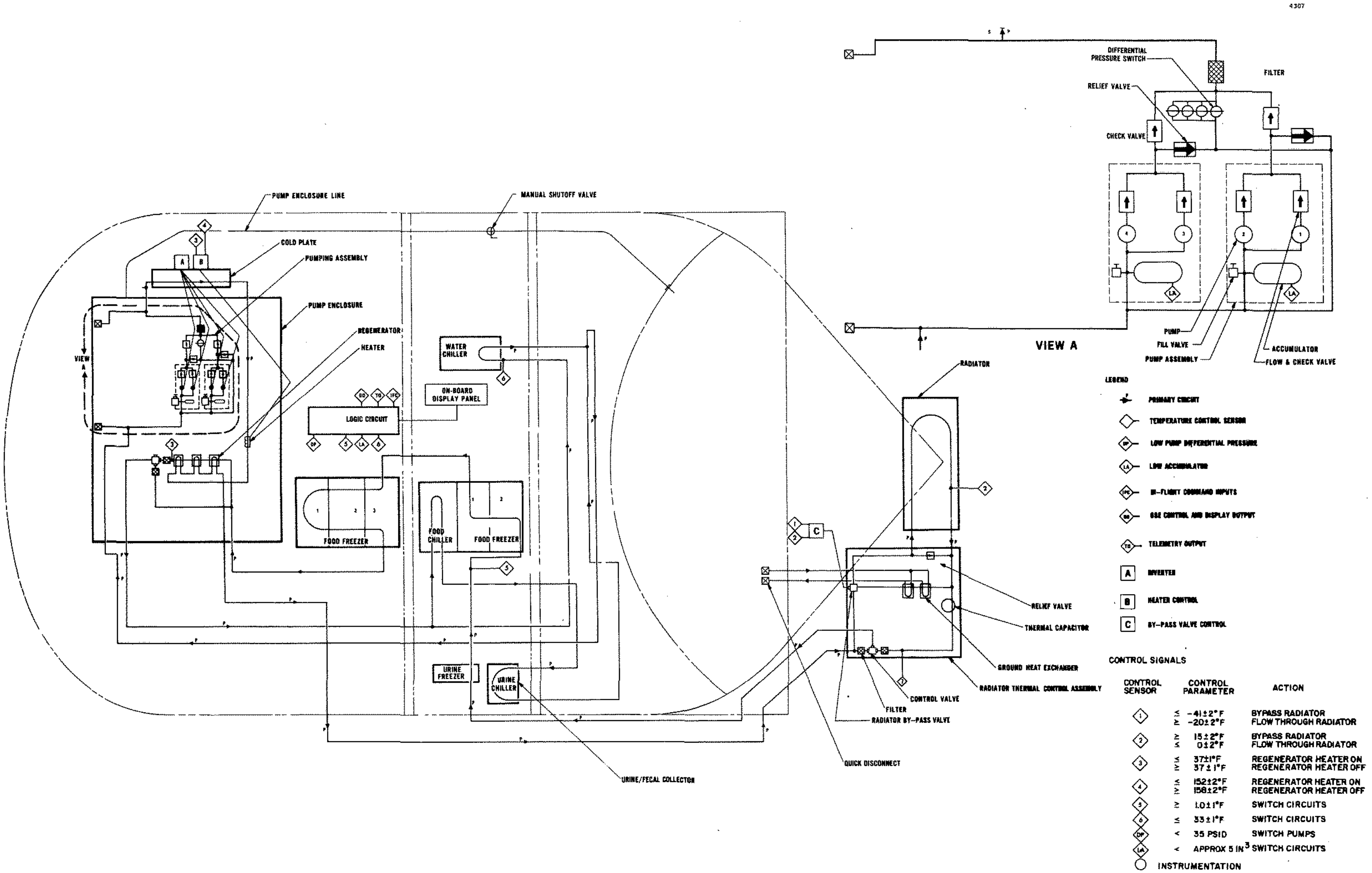



Figure 2.4.4-80 Refrigeration System Coolant Loop

the temperature transducer actuates the radiator bypass valve to the radiator bypass position; the thermal capacitor now has the capacity to absorb two orbits of RS heat before requiring the radiator. The control circuit actuates the radiator bypass to open when the outlet temperature sensor reaches -20±2°F At this temperature, the thermal capacitor has enough storage capacity to last for one orbit. This cold condition will generally only occur during the unmanned phase.

A 30-psid relief valve is installed across the radiator to maintain a pressure differential in getting the flow started through the radiator. The relief valve also provides pressure relief to keep from blocking circuit flow.

The freezer temperature control valve (TCV) downstream of the thermal capacitor responds to inlet temperatures below -17°F by mixing warmer refrigerant from the radiator/thermal capacitor bypass to achieve the desired control valve outlet temperature of -17±3°F. From this point the coolant flows in series through the urine freezer, the wardroom food freezer No. 1, the wardroom food freezer No. 2, food storage freezer No. 3, food storage freezer No. 2 and food storage freezer No. 1.

The refrigerant is then controlled to 39±3°F by means of a 75-watt heater, three regenerator heat exchangers, and the chiller temperature control valve (TCV). The 39±3°F fluid temperature control at the outlet of the chiller TCV is achieved by proportional flow mixing of the regenerator outlet and the freezers outlet. The flow through the three regenerator heat exchangers is warmed by a counter-flowing refrigerant path from the regenerator heater. The refrigerant is routed in parallel paths, one through the water chiller and one through the chilled food compartment and urine chiller. The paths unite and a single path is routed to a pump assembly.

The pump assembly is essentially two two-pump packages tied together in parallel. A two-pump package consists of two parallel pumps with discharge check valves and pump differential pressure transducers, a 53-cubic-inch-accumulator and a 100-psid bypass relief valve. The pump assembly outlet is routed through a 10-micron filter, through the inverter and heat or controls coldplate, and to the 75-watt regenerator heater. The regenerator heater is provided to ensure the regenerator capability of the regenerator heat exchangers. From the regenerator heater, the flow passes through the three regenerator heat exchangers, and to either the radiator or thermal capacitor for heat rejection, or to the warm inlet on the freezer TCV for mixing. A thermostat, located between the chiller TCV inlet and the regenerator heat exchanger cold side outlet, causes the regenerator heater to energize and de-energize as the temperature reaches 37±1°F.

The RS contains a control logic unit that continuously monitors and automatically provides system switching to rectify the following malfunctions:

a. A low differential pressure across the pump package. If the pump differential pressure should drop below 35 psid, the logic unit automatically switches off the active pump and activates the next pump. The sequence is primary pump numbers 1, 2, 3, and 4 and then secondary pump numbers 1, 2, 3, and 4. When secondary pump No. 4 is operating and a low $\Delta$ P signal is received, the logic unit recycles back through pumps 1, 2, 3, and 4 of the primary loop. A 30-second delay in $\Delta$ P logic is provided to allow for pressure buildup after a pump has been switched on.

b. A low pump package accumulator liquid level. When any one of the primary pumps is operating and a primary loop accumulator liquid level drops below 5 cubic inches, the logic unit automatically switches from the primary loop to the secondary loop (pump 1). When any one of the secondary pumps is operating and a low secondary accumulator is sensed, the logic unit automatically cycles back to the primary loop (pump 1). Loop switching occurs 2 minutes after the accumulator liquid level low of 5 cubic inches is reached.

c. A high freezer inlet temperature. The logic unit switches to the secondary loop (pump 1) when a primary pump is operating and a temperature equal to or greater than -4±1°F is sensed at the freezer inlet. When a secondary pump is operating and a high freezer inlet temperature is sensed, the logic switches back to the primary loop (pump 1). A 30-minute delay in high freezer inlet temperature logic after loop switching is provided to allow the new loop time to stabilize the freezer inlet temperature.

d. A low chiller inlet temperature. The logic unit switches to the secondary loop (pump 1) when a primary pump is operating and a temperature equal to or less than 33.5±1°F is sensed at the chiller inlet. When a secondary pump is operating and a low chiller temperature is sensed, the logic unit switches back to the primary loop (pump 1). A 30-minute delay in low chiller temp inlet temperature logic after loop switching is provided to allow the new loop time to stabilize the chiller inlet temperature.

The RS logic unit allows only a single pump to be operating. Therefore, if a pump other than the active pump is switched on, the logic switches off the previously active pump.

The RS logic unit also provides signals to the following panel 616 malfunction indicator lights for both the primary and secondary loops:

a. PUMP LOW $\Delta$ P
b. ACCUM LOW
c. INLET TEMP FREEZER HIGH
d. INLET TEMP CHILLER LOW

These indicator lights are latched on by the logic unit until the STATUS RESET switch is actuated.

2.4.4.5.2 Major Component Operation

RADIATOR

The radiator (figure 2.4.4-81) is an irregular-shaped octagon located on the aft thrust structure below the J-2 engine thrust casting. Approximately 84 square feet of area is available for heat rejection. Refrigerant is circulated through T-bulb extrusions with a 0.193 inch I.D. The extrusions are stitch welded to the 0.025 inch thick aluminum radiator surface. The radiator is redundantly plumbed, with each loop tracing a separate path across the effective radiator area. The back face of the radiator is insulated from the OWS thrust structure by utilizing series resistance barriers of polyurethane foam and high performance insulation to minimize heat leak from the OWS.

THERMAL CAPACITOR

The thermal capacitor (figure 2.4.4-82) provides heat removal capability during periods of radiator bypass. The unit is an aluminum brazed tank with internally finned aluminum passages containing 20 pounds of UNDECANE Wax ($C_{11}H_{24}$) with a controlled phase change at -14°F and -34°F. The heat of fusion at -14°F is 66 Btu/lb and the heat required for the phase change at -34°F is 18 Btu/lb. This part is similar in design and operation to the thermal capacitor used in the AM thermal control system (figure 2.4.4-39).

TEMPERATURE CONTROL VALVE

The freezer and chiller temperature control valves (figure 2.4.4-83) function to provide regulated fluid temperatures to the freezers and to the chillers. Both of the valves operate on the same principle. A change in the regulated temperature acts on a thermostatically operated flow diverter to restore the preset temperature. The thermal control element is a direct acting device which responds to temperature changes by converting the corresponding volumetric change of a liquid to essentially linear motion to position a refrigerant flow regulating spool. The thermal control element for the freezer TCV is filled with Dow Corning silicone and with wax for the chiller TCV. Movement of the spool causes a proportional adjustment in the mixing of the two streams of inlet flow (warm and cold) to achieve the desired mixed outlet flow temperature.

RADIATOR BYPASS VALVE

The radiator bypass valve (figure 2.4.4-84) provides a means of bypassing coolant flow around the radiator under certain conditions. It is a two-position, latching-type solenoid valve which is controlled by a control circuit driven by temperature transducers. The radiator bypass valve is positioned to bypass when the radiator surface temperature transducer senses a temperature of 15±2°F or when the thermal capacitor out temperature transducer reaches -41±2°F. The bypass valve is positioned to flow when the radiator surface temperature transducer senses a temperature of 0±2°F or when the thermal capacitor out temperature transducer reaches -20±2°F.

REGENERATIVE HEAT EXCHANGER

The three series-mounted regenerative heat exchangers operate in conjunction with a control valve to provide a refrigerant temperature of +39±3°F to the inlet of the chilled food compartment chiller. The design is a high efficiency counterflow exchanger, similar in design to the unit used in the AM thermal control system (figure 2.4.4-45).

PUMP PACKAGE

The pump package is similar to the coolant system pump package (paragraph 2.4.4.2.5)(figure 2.4.4-37).

WARDROOM FOOD FREEZER

The floor-mounted freezer assembly (figure 2.4.4-85) is divided into three food compartments, each with a foam-filled door. The annulus between the food compartments and the outer freezer shell is insulated with polyurethane foam. The food compartments incorporate the refrigeration subsystem fluid circuit.

Two compartments of the food freezer provide low temperature storage (+10°F max) for 100 pounds (56 day supply) of frozen food. The third compartment provides 33°F to 50°F storage for up to 50 pounds of perishable food and chills beverages and desserts. Instrumentation is provided for temperature readout.

FOOD STOWAGE FREEZER

The food stowage freezer (figure 2.4.4-85) provides low temperature storage (+10°F max) for 150 lbs (84-day supply) of frozen food. The floor-mounted freezer assembly is divided into three 28-day food supply compartments. The annulus between the outer shell and the food compartments is filled with foam insulation. Three foam-filled doors are provided. Heat is rejected from the food compartments to refrigeration subsystem fluid circuit. Transducers are provided for temperature readout.

WATER CHILLER

A water chiller (figure 2.4.4-86) provides chilled drinking water at 35°F to 50°F. The unit is constructed of stainless steel, with an outer layer of foam insulation. The cooling refrigerant and the drinking water pass through adjacent annular helical passages. The refrigerant is controlled to an inlet temperature of 36 to 39°F. The unit holds 4 pounds of chilled drinking water. Approximately 1 hour is required to rechill 4 pounds of incoming water.

4146

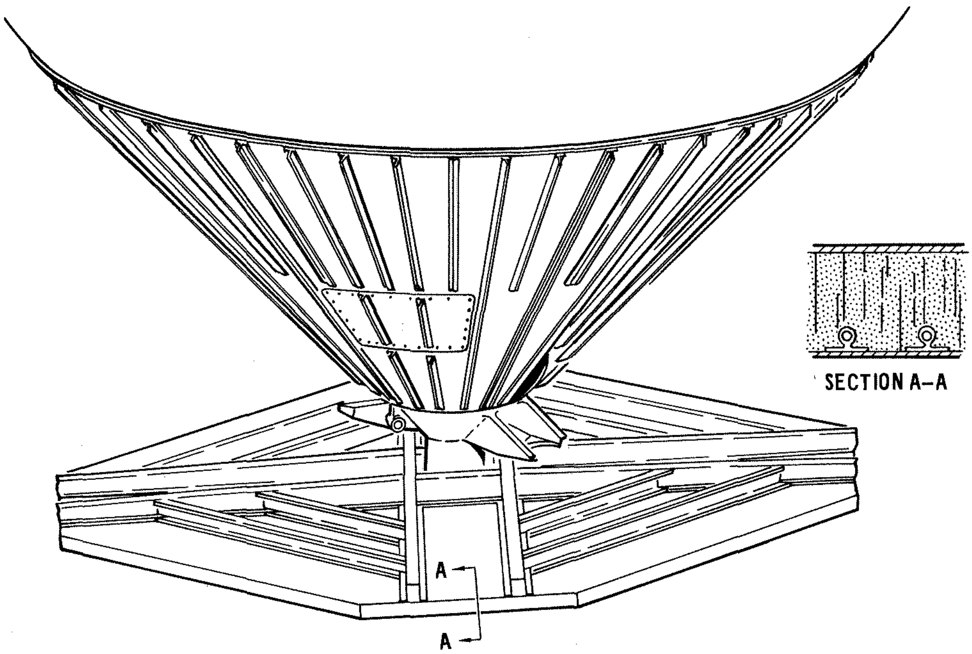



Figure 2.4.4-81 Refrigeration System Radiator

4149

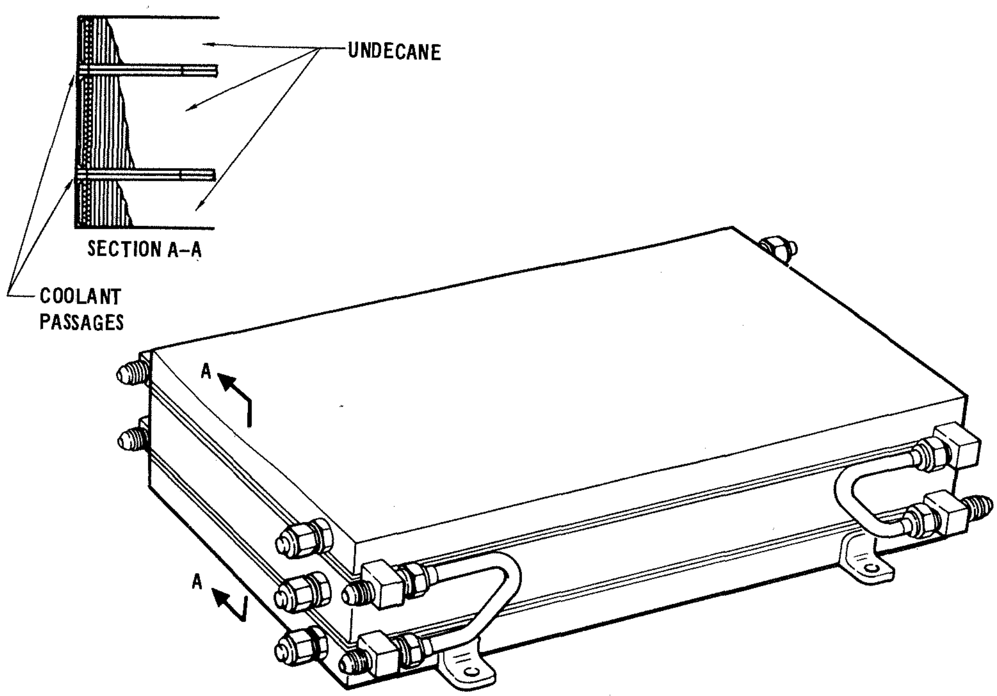



Figure 2.4.4-82 Thermal Capacitor - Refrigeration System

4380

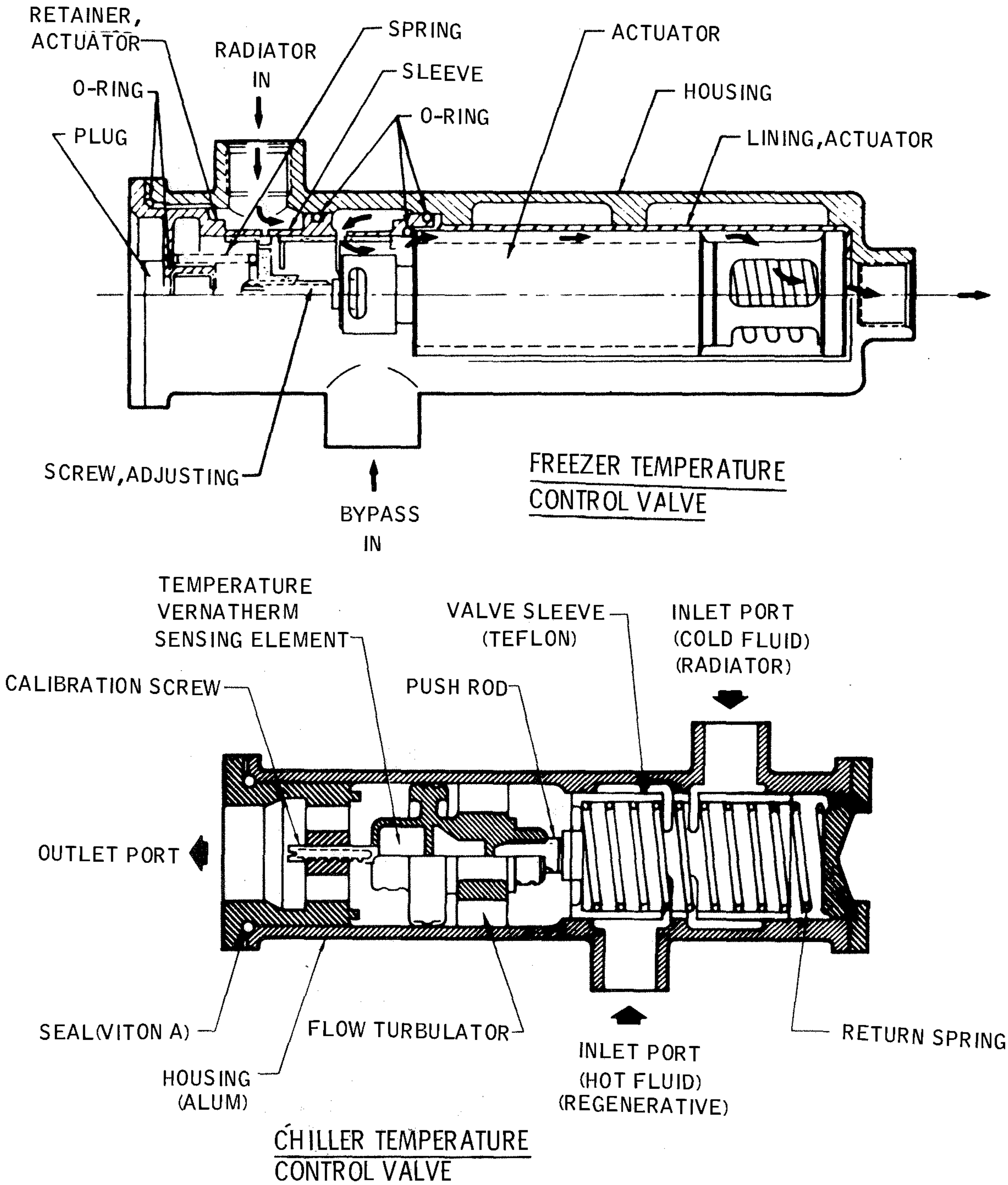



Figure 2.4.4-83 Temperature Control Valves

4351

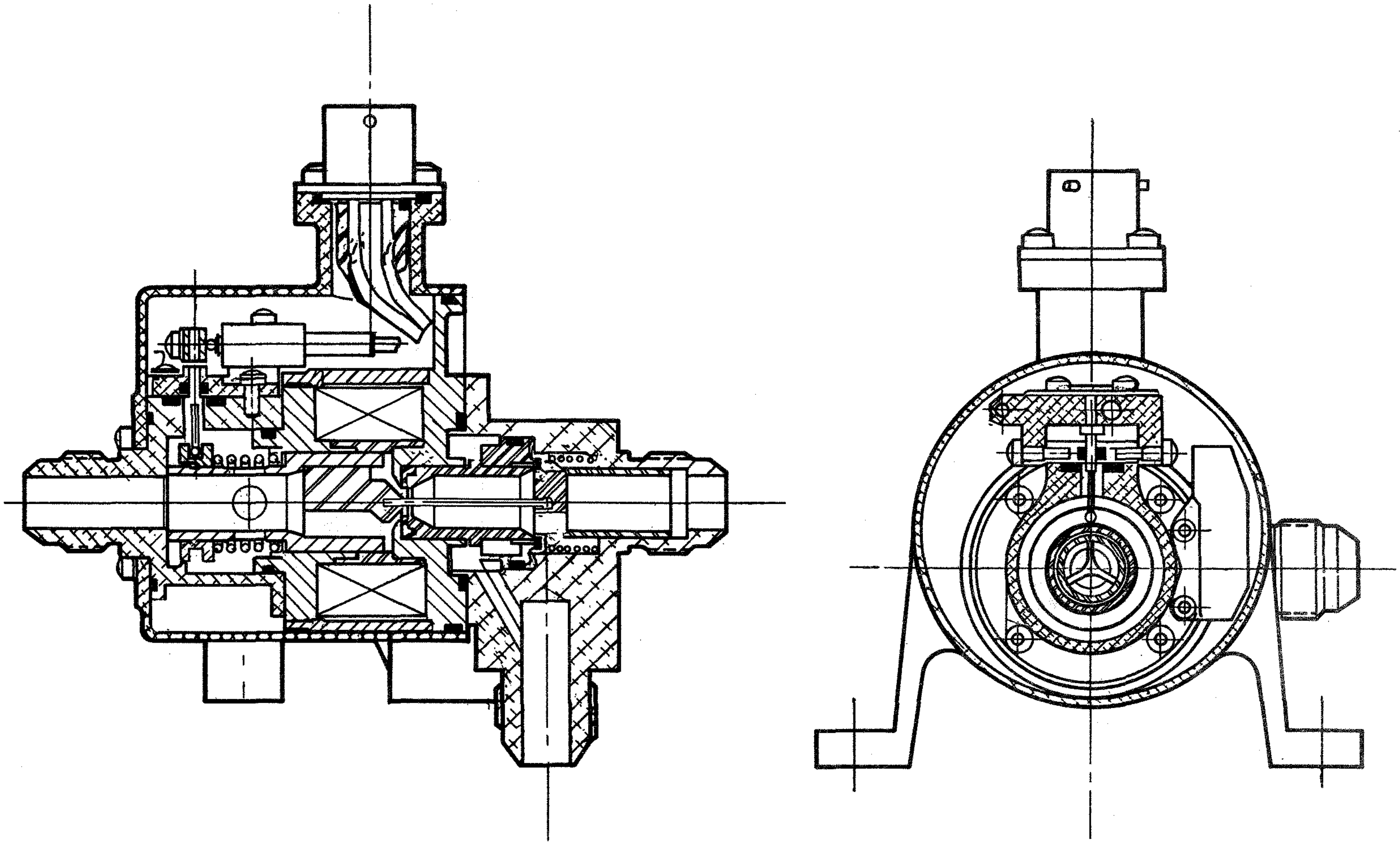
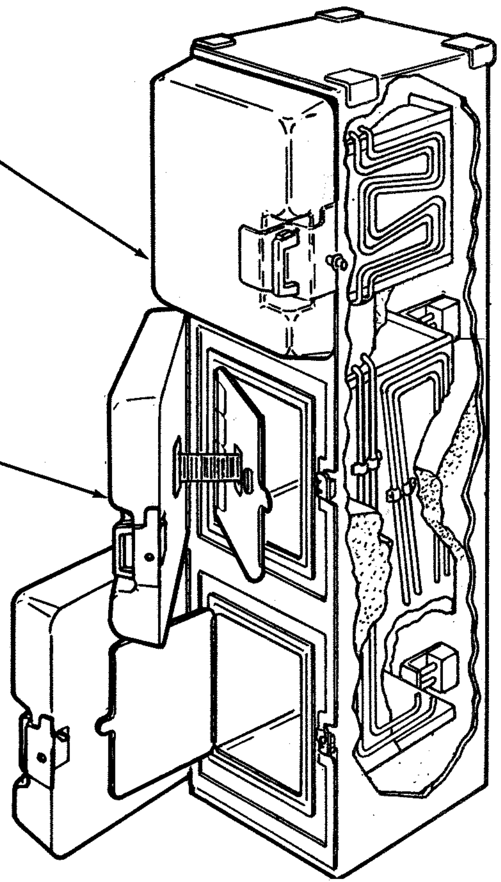
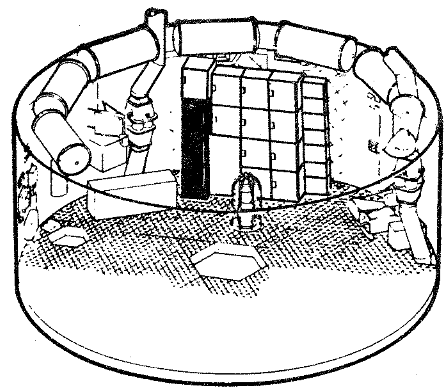
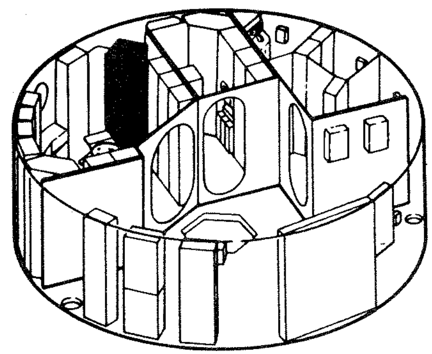


Figure 2.4.4-84 Radiator Bypass Valve



FOOD STORAGE FREEZER LOCATION



WARDROOM FOOD FREEZER LOCATION

Figure 2.4.4-85 Food Freezers

4155

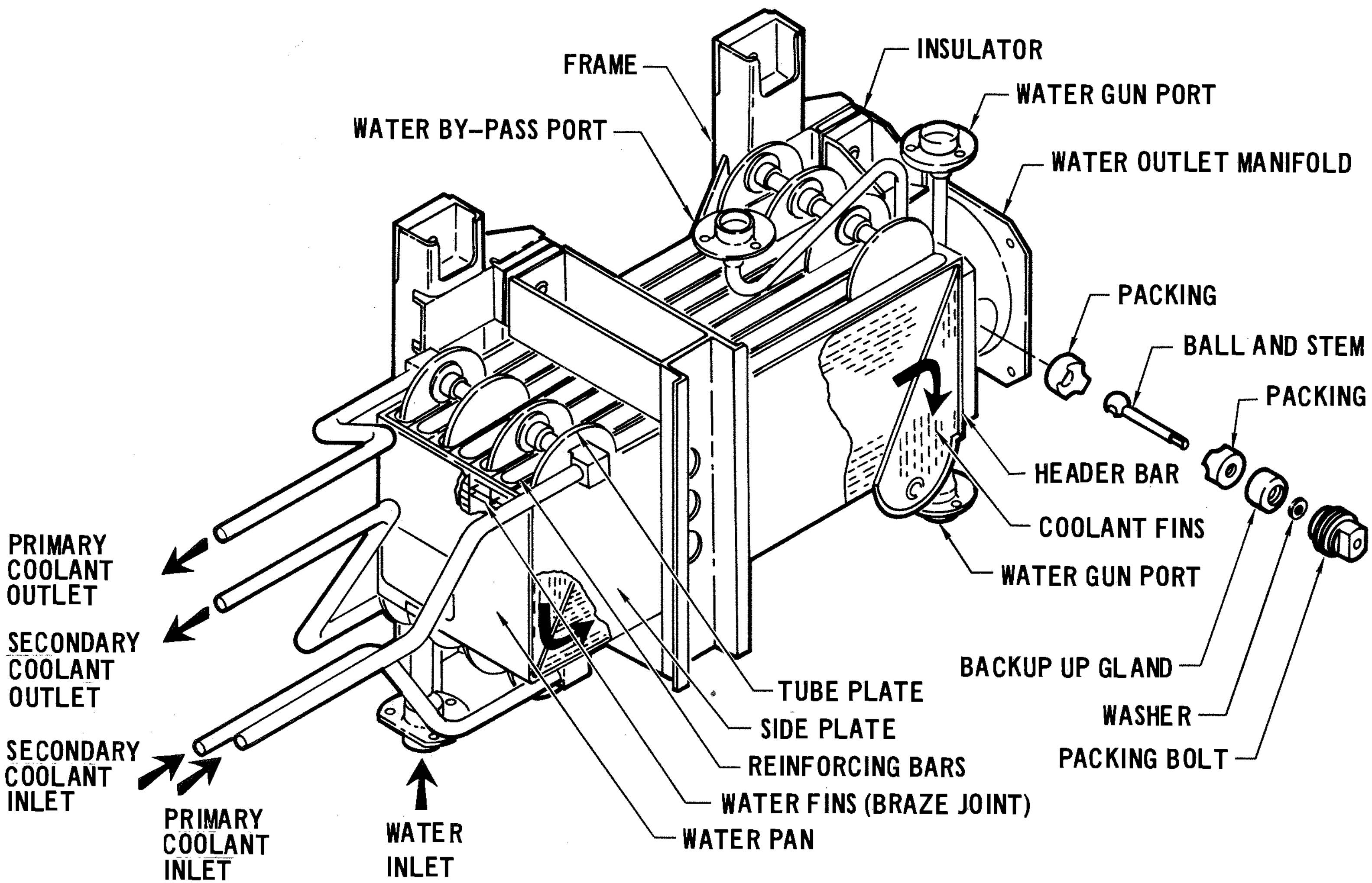



Figure 2.4.4-86 Water Chiller

4152

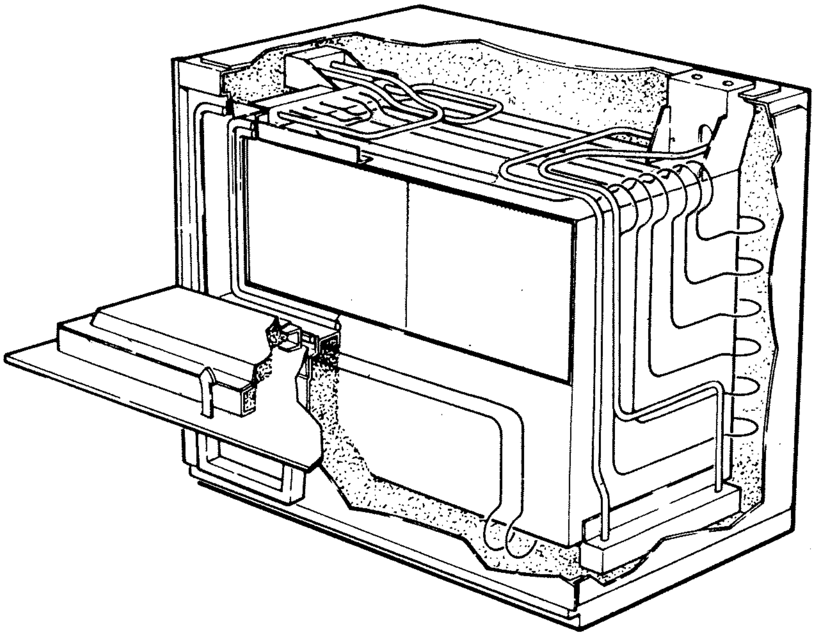


Figure 2.4.4-87 Urine Freezer

URINE FREEZER

The urine freezer (figure 2.4.4-87) provides low-temperature storage (+2°F max) for up to 168 urine samples in four trays. (Each urine sample is 120ml.). The floor-mounted freezer is a double shelled aluminum box. The annulus between the shells contains cooling coils from both RS loops and foam insulation.

2.4.5 FAILURE MODES

The ECS failure modes and the effect on mission capability are given in the following table.

2.4.5.1 PRESSURIZATION AND GAS DISTRIBUTION

| FAILURE | INDICATION | VEHICLE CAPABILITY |
|---|---|---|
| H/A vent vlv fails to open or remain open | Valve talk-backs indicate valve position. Habitation area pressure stops decreasing at TB4 + 900 seconds | Habitation area pressure will vent through the latching vent valve until it is command closed at TB4 + 900 seconds. At this time, H/A pressure should be 2.8 -3.2 psia and solenoid vent valves can be used to bring pressure down to desired level |
| H/A latching vent vlv fails to open or remain open | Valve talk-backs indicates valve position | Habitation area pressure will vent normally, through H/A vent valve since depressurization rate is controlled by orifices on NPV's |
| Either or both H/A vent valves fails to close | Habitation area pressure continues to decrease after TB4 + 1800 sec. Valve talk-backs indicate valve position | If failure is not corrected, habitation area pressure could go to 0 psia, MDA/AM could go to 0.1 psia, and SWS could not be pressurized prior to crew arrival. Pressure below 0.5 psia may cause damage to certain equipment |
| H/A solenoid vent valve fails to open | Valve talk-backs indicate valve position | Valves are quad-redundant. Parallel mounted valves provide redundancy in opening |

2.4.5.1 PRESSURIZATION AND GAS DISTRIBUTION (cont'd)

| FAILURE | INDICATION | VEHICLE CAPABILITY |
|---|---|---|
| H/A solenoid vent valve fails to close | Valve talk-backs indicate valve position | Valves are quad-redundant. Series-mounted valve provides redundancy in closing |
| Waste tank vent cap fails to open | Waste tank pressure decay rate is about 1/2 normal. ATM APCS measurements shows abnormal disturbances | Propulsive venting will impose severe requirements on TACS usage during blowdown. During other phases of the mission, venting will produce some propulsive effects which will affect vehicle attitude rates and probably lead to premature depletion of the TACS |
| Actuation Control Module (ACM) fails to energize (four total) | | |
| 1. To H/A latching vent valve | Latching vent valve talk-back indicates valve position | Latching vent valve will not open. See "H/A latching vent valve fails to open" |
| 2a. To H/A vent valve | Vent valve talk-back indicates valves position | Vent valve will not open. See "H/A valve fails to open" |
| 2b. From pneumatic supply | Pneumatic sphere pressure does not decrease | Unable to dump pneumatic sphere |
| 3. To waste tank pneumatic actuators | Waste tank pressure does not decrease | Requires a double failure since ACM has redundant solenoid valves |
| 4. To radiator shield jett actuator | Radiator surface temperature does not decrease | Would require a double failure since ACM has redundant solenoid valves |
| Cabin pressure relief valves fails close | No indication under normal conditions unless all three valves fail | |
| Cabin pressure relief valve fails open | Cabin pressure decreases | Crew can close manual shutoff valve |
| Equalization valve fails to open | Visual indication plus inability to equalize pressures | Equalization valve in forward lock compartment hatch and valve in aft hatch can in most cases be used as backups for each other. Valve in MDA hatch and valve adjacent to EVA hatch have no backup |
| Equalization valve fails to close | Visual indication | Each valve has screw-on cap to manually close opening |
| 120-psi regulator assembly | None unless both regulators fail or if periodic functional checks are made | There are two parallel-mounted redundant regulators |
| 150-psi regulator assembly | None unless both regulators fail or if periodic functional checks are made | There are two parallel-mounted redundant regulators |
| 5-psia cabin pressure regulator assembly | None unless both regulators fail or if periodic functional checks are made | There are two parallel-mounted redundant regulators |
| 5-psi reservoirs pressure regulator assembly | None unless both regulators fail or if periodic functional checks are made | There are two parallel-mounted redundant regulators |
| O2 sensor, amp-loss of signal to O2/N2 controller | Telemetry and on-board display of PPO2 indicates PPO2 increasing | Loss of N2 makeup capability until standby unit is switched on |

2.4.5.1 PRESSURIZATION AND GAS DISTRIBUTION (cont'd)

| FAILURE | INDICATION | VEHICLE CAPABILITY |
|---|---|---|
| O2 sensor | Telemetry and on-board display of PPO2 from that sensor is 0 psia. If sensor was selected by controller switch, telemetry and on-board display of PPO2 from other sensors will indicate PPO2 increasing | Loss of N2 makeup capability until sensor is replaced |

2.4.5.2 THERMAL CONTROL

| FAILURE | INDICATION | VEHICLE CAPABILITY |
|---|---|---|
| Coolant pump assembly | C&W alarm is actuated (low $\Delta$P). Telemetry readout on low flow and delta pressure across the pump | Three pumps in each loop provide redundancy. During unmanned phase, automatic loop switching occurs in event of pump failure |
| Radiator bypass valve fails in bypass | Radiator out temp telemetry does not show temperature decrease. Crew feels warm gas coming from heat exchangers | Loss of heat rejection capability via radiator when using affected coolant loop.<br>Redundant coolant loop available |
| 40°F and 47°F temperature control valves (TCV) | Coolant outlet temperature readouts on telemetry are abnormal | Incorrect coolant temperatures to heat heat- loads<br><br>Redundant coolant loop available |
| ATM H2O pump assembly | C&W alarm is actuated (low $\Delta$ P). Telemetry readout on temperature levels and low $\Delta$ P | Loss of H2O flow in ATM C&D PANEL cooling loop<br><br>Two remaining H2O pumps provide redundancy |

2.4.5.3 ATMOSPHERE CONTROL

| FAILURE | INDICATION | VEHICLE CAPABILITY |
|---|---|---|
| PLV fans (27 total) | Crewman touches fan and determines it is not operating.<br>Telemetry flow sensor for: AM XFER DUCT fan, 4 OWS H-X fans, OWS VCS DUCT 1, 2, and 3 fans | Decrease or total loss of gas flow, depending on location of fan<br>Fans are in-flight replaceable as spares are carried on-board |
| Molecular sieve fan | C&W and telemetry indication of low mol sieve gas flow and $\Delta$ P | Activate redundant molecular sieve fan or redundant molecular sieve assembly |
| Gas circulation shutoff valve (1 of 4) | Crew notes reduction in circulation to OWS due to backflow if valve fails open or to no-flow if valve fails closed. Telemetry indicates valve position | Valve can be opened or closed manually |
| Condensate tank assembly | Water visible on gas side of bladder | Loss or reduction of ability to collect, store, or dump condensate. Tank assemblies are in-flight replaceable |
| Molecular sieve gas selector valves fails in adsorb or desorb | Telemetry indicates drop in compressor $\Delta$ P when fans stop, also an increase in PPCO2 level.<br>If gas selector valve is in "adsorb" position and the other gas selector valve changes to "adsorb" the fan will stop operating<br>or | Isolate gas selector valve using manual interconnect valves. If valve binds in "adsorb" position, activate molecular sieve fan interlock switch to "OFF"<br>or<br>Activate redundant molecular sieve |

2.4.5.3 ATMOSPHERE CONTROL (cont'd)

| FAILURE | INDICATION | VEHICLE CAPABILITY |
|---|---|---|
| | If gas selector valve is in "desorb" position, an increased PCO2 level will be indicated on PCO2 meter because only one sorbent canister is functioning | |
| Molecular sieve sorbent canister fails to remove CO2 | C&W PCO2 signal to crew. Telemetry shows abnormal PCO2 | Cabin gas becomes contaminated with CO2. Activate redundant sieve and bakeout poisoned canister |
| Solenoid valve fails open or closed | C&W PCO2 signal to crew. Telemetry indicates abnormal PCO2 level | One of four solenoid valves would be inoperative. Associated gas selector valve cannot be properly cycled, causing loss of one sorbent canister |
| | If gas selector valve is in "adsorb" position and other gas selector valve changes to "adsorb", fan will stop operating. If gas selector valve is in "desorb" position, PCO2 level will increase because only one sorbent canister is functioning | Actuate redundant solenoid valve and continue operation of molecular sieve, using the manual interconnect valve to bypass affected solenoid valve |
| Manual interconnect valve | Crew cannot actuate valve | Valves are repositioned only in case of solenoid valve failure or during molecular sieve bakeout |
| Molecular sieve timer | Telemetry indicates increase in PCO2 level<br>Gas selector valve position does not change every 15 minutes. PCO2 level increases | Prevent automatic operation of molecular sieve. Possible poisoning of one sorbent canister. Actuate molecular sieve timer power switch to select alternate timer |

2.4.5.4 EVA/IVA

| FAILURE | INDICATION | VEHICLE CAPABILITY |
|---|---|---|
| Suit cooling pump | C&W signal is activated. Increase in suit temperature. Telemetry indicates zero pump $\Delta$ P | Loss of H2O cooling loop until redundant pump is activated |
| Suit cooling system gas separator | Telemetry indicates abnormal pump $\Delta$ P. None unless associated pump cavitates. At such time, C&W will be activated | H2O flows through separator bypass relief valve possibly injecting gas into H2O system, which may cavitate associate pump, or cause gas blockage of the LCG.<br>Deactivate affected system, and activate redundant system or replace defective separator with onboard spare |
| Radiator bypass valve fails in bypass | FREEZER HIGH light comes on. Telemetry and on-board readout of urine freezer temps above +1°F | Loss of cooling capacity. Loop switching will occur |
| Radiator bypass valve fails in radiator mode | Telemetry indicates valve does not bypass when radiator surface temp reaches +15 $\pm$2°F or when thermal capacitor out temp drops to -41$\pm$2°F | Crew or ground can switch coolant loops |

2.4.5.5 REFRIGERATION

| FAILURE | INDICATION | VEHICLE CAPABILITY |
|---|---|---|
| Refrigeration pump | Pump LOW $\Delta$ P light comes on. Telemetry indicates low pump $\Delta$ P | Coolant circulation stops. Pump switching will occur at 35 psid. Loop switching will occur if pump 4 was selected |
| Freezer control valve fails high | FREEZER HIGH light comes on. Telemetry and on-board readout of urine freezer temp above +1°F | Loss of one of the two coolant loops. Loop switching will occur |
| Freezer control valve fails low | Telemetry and on-board readout of freezer temps reads less than -17$\pm$3°F | Crew or ground can switch coolant loops |
| Chiller control valve fails high | Urine chiller and water chiller temperatures read high | Loss of one of the two coolant loops. Crew or ground can switch coolant loops |
| Chiller control valve fails low | CHILLER LOW light comes on. Telemetry and on-board readout of water chiller temps below 33.5$\pm$1°F | Loss of one of two coolant loops. Loop switching will occur |
| Severe coolant leak | ACCUM LOW light comes on. PUMP LOW $\Delta$ P light comes on. Telemetry readout of less than 5-cubic-inches in accumulator | Loss of coolant loop. Loop switching will occur |

2.4.6 PERFORMANCE AND DESIGN DATA

2.4.6.1 PRESSURIZATION AND GAS DISTRIBUTION COMPONENTS

Actuation Control Module
- Operating Pressure . . . . . . . . . . . . . . . . . . . . . . . . 50-800 psig
- Flow Rate. . . . . . . . . . . . . . . . . . . . . . . . . . . 2.0 lb/min, He at inlet pressure of 500 psig, 60°F and P = 300 psi, min
- Response Time. . . . . . . . . . . . . . . . . . . . . . . . . 0.15 seconds
- Voltage Range. . . . . . . . . . . . . . . . . . . . . . . . . 24 to 30 vdc
- Pull-in Voltage. . . . . . . . . . . . . . . . . . . . . . . . 22 vdc max., 5 vdc min
- Drop-out Voltage . . . . . . . . . . . . . . . . . . . . . . . 8 vdc max., 1 vdc min
- Current. . . . . . . . . . . . . . . . . . . . . . . . . . . . 2 amps

Habitation Area Vent Valve
- Operating Pressure . . . . . . . . . . . . . . . . . . . . . . . 220 - 500 psig
- Flow Rate. . . . . . . . . . . . . . . . . . . . . . . . . . . 1 lb/sec, N2 at inlet pressure of 26 psia, with 475$\pm$25 psig at actuator open port
- Relief Valve . . . . . . . . . . . . . . . . . . . . . . . . . Cracks at 26 psia with max. flow closes and reseats at 23 psia

Habitation Area Latching Vent Valve
- Operating Pressure . . . . . . . . . . . . . . . . . . . . . . . 120 - 500 psig
- Flow Rate. . . . . . . . . . . . . . . . . . . . . . . . . . . 1 lb/sec, N2 at inlet pressure of 26 psia, with 475$\pm$25 psig at actuator open port
- Relief Valve . . . . . . . . . . . . . . . . . . . . . . . . . Cracks at 26 psia with max. flow, closes and reseats at 23 psia

Waste Tank Pneumatic Actuators
- Operating Pressure . . . . . . . . . . . . . . . . . . . . . . . 80 - 500 psig
- Response Time. . . . . . . . . . . . . . . . . . . . . . . . . 1340 ms max, 230 ms min

Habitation Area Solenoid Vent Valve
- Operating Pressure . . . . . . . . . . . . . . . . . . . . . . . 0-26 psig
- Flow Rate. . . . . . . . . . . . . . . . . . . . . . . . . . . 0.006 lb/sec at P = 0.25 psi
  (at 70°F, with exit pressure = 14.7 psia) 0.023 lb/sec at P = 2.5 psi
- Voltage Range. . . . . . . . . . . . . . . . . . . . . . . . . .24 - 30 vdc
- Pull-in Voltage . . . . . . . . . . . . . . . . . . . . . . . . .24 vdc max, 5 vdc min
- Current. . . . . . . . . . . . . . . . . . . . . . . . . . . . .3 amps

| | |
|---|---|
| **Cabin Pressure Relief Valve** | |
| Operating Pressure | 5.5 psig max, full flow at 6.0 psig |
| Cracking Pressure | 5.5 - 6.0 psid cabin to ambient |
| Flow Rate (for each of two ports) | 12 lb/min $N_2$ at 70°F with inlet at 20.7 psia and outlet at 14.7 psia |
| (effective area - 0.472 sq. in.) | 3.89 lb/min $N_2$ at 70°F with inlet at 6.0 psia and outlet at 0 psia |
| **Equalization Valves** | |
| Operating pressure | 6.2 psid max. |
| Flow Rate | 10.0 lb/min, air at $70\pm20$°F |
| (effective flow area - 1.44 sq.in.) | with 5.0 psia at inlet and 2.6 psia outlet |
| Actuation Torque | 40 in-lb max with P = 6.2 psi |
| **120-Psig Regulator Assembly** | |
| Inlet Pressure Range | 300 - 3000 psia |
| Regulated Pressure | $120\pm10$ psig |
| Lock-up Pressure | 145 psig max at $70\pm10$°F |
| Flow Rate (per regulator) | 0.38 lb/min at 70°F and 300 psia inlet |
| Relief Pressure Range | 150-170 psig |
| Inlet Filter | 10 microns nominal |
| **150-Psig Regulator Assembly** | |
| Inlet Pressure Range | 300 - 3000 psia |
| Regulated Pressure | $150\pm10$ psig |
| Lock-up Pressure | 175 psig max, at $70\pm10$°F |
| Flow Rate (per regulator) | 0.38 lb/min at 70°F and 300 psia inlet |
| Relief Pressure Range | 180 - 210 psig |
| Inlet Filter | 10 microns nominal |
| **35-Psig Regulator Assembly** | |
| Inlet Pressure Range | 140 - 180 psig |
| Regulated Pressure | $35\pm2$ psig |
| Lock-up Pressure | 39 psig |
| Relief Pressure Range | Crack at 47 psig, reseat at 43 psig |
| Filter (3) | 10 microns nominal, 25 microns absolute |
| **Latching Solenoid Valve** | |
| Operating Pressure | 3000 psig |
| Pressure Drop | 45 psid with $O_2/N_2$ flow at 2.5 lb/min |
| Actuation Time | 60 ms with 22 - 30 vdc |
| Power Consumption | 82.5 watts max any solenoid element at 30 vdc and 0-120°F |
| **Cabin Pressure Regulator Assembly** | |
| Operating Pressure | 100 - 215 psig |
| Regulated Pressure | 4.8 - 5.2 psia |
| Lock-up Pressure | 5.3 psia max |
| Flow Rate | 1.0 lb/hr min $O_2$ or $N_2$ at 70°F |
| Inlet Filter | 10 microns nominal |
| **Reservoir Pressure Regulator Assembly** | |
| Operating Pressure | 80 - 210 psia |
| Regulated Pressure | 4.8 - 5.2 psia |
| Lock-up Pressure | 5.5 psia max at $60\pm10$°F |
| Flow Rate | 0.005 - 0.05 lb/hr $N_2$ |
| Relief Valve | 5.8 - 6.2 psia |
| Inlet and Outlet Filters | 10 microns nominal |
| **M509 Recharge Station** | |
| Operating Pressure | 300 - 3000 psia |
| Flow Rate | 5.0 lb/min $N_2$ |
| **$PPO_2$ Sensor, Amplifier, Controller** | |
| Sensor Range | 0 - 6.4 psi |
| Control Range | 3.3 - 3.9 psi |
| **Solenoid Valve** | |
| Operating Pressure | 210 psig max |
| Flow Rate | 0.5 lb/min min $GO_2$ at 70°F inlet of 60 psia |
| Voltage Range | Open at 18 vdc max, clost at 2 vdc min |
| Power Consumption | 1.35 amp max at 30 vdc |

Three-Position Selector Valve
- Operating Pressure . . . . . . . . . . 0 - 210 psig
- Flow Rate. . . . . . . . . . 0.38 lb/min, N2 at $70 \pm 20$°F with 145 psig inlet

2.4.6.2 THERMAL CONTROL COMPONENTS

Coolant Pump Assembly
- Flow Rate (1 Pump) . . . . . . . . . . 230 lb/hr at 120°F and P = 50 psi
- Flow Rate (2 Pumps). . . . . . . . . . 460 lb/hr
- Operating Pressure . . . . . . . . . . 100 psig

Radiant Heater
- Heat Dissipation . . . . . . . . . . 125 watts at 24 vdc
- Voltage Range. . . . . . . . . . 22 to 28 vdc
- Surface Temperature. . . . . . . . . . 210°F

Convective Heater
- Heat Dissipation . . . . . . . . . . 500 watts (125 watts per element at 24 vdc)
- Voltage Range. . . . . . . . . . 22 to 28 vdc
- Surface Temperature. . . . . . . . . . 100 - 113°F

Thermal Capacitor
- Operation Pressure
  - Coolant side . . . . . . . . . . 140 psig max
  - Wax side . . . . . . . . . . 40 psig max
- Pressure Drop. . . . . . . . . . 2.1 psig at design flow
- Flow Rate. . . . . . . . . . 220 lb/hr at 75°F
- Wax Type . . . . . . . . . . Tridecane 22.35°F melting point, 66.5 Btu/lb -0.7°F structural transition point, 18.6 Btu/lb

Ground Cooling Type Heat Exchanger
- Operating Pressure . . . . . . . . . . 230 psig max
- Pressure Drop
  - (3 pass channel) . . . . . . . . . . 0.62 psig with 425 lb/hr flow at 40°F
  - (1 pass channel) . . . . . . . . . . 0.31 psig with 336 lb/hr flow at 40°F
- Heat Transfer. . . . . . . . . . 17,700 Btu/hr with flow of 183 lb/hr in each single pass or 336 lb/hr in one single pass at 40°F and flow 425 lb/hr in 3-pass at -65°F

Radiator Bypass Valve
- Operating Pressure . . . . . . . . . . 230 psig max
- Pressure Drop. . . . . . . . . . 2.5 psid with 366 lb/hr flow at 120°F
- Relief Valve Range . . . . . . . . . . 215 - 230 psid
- Power Consumption. . . . . . . . . . 0.81 amps at 28 vdc and 70°F

Radiator
- Surface Area . . . . . . . . . . 432 sq.ft., = 0.25 max, $\alpha$ = 0.85 min
- Pressure Drop. . . . . . . . . . 21 psid with 230 lb/hr flow at 50°F; 71 psid with 500 lb/hr flow at 50°F

47°F Temperature Control Valve
- Control Range. . . . . . . . . . 45 - 49°F with 240 lb/hr flow at 50 psia; 44 - 50°F with 460 lb/hr flow at 110 psia
- Operating Pressure . . . . . . . . . . 230 psig
- Pressure Drop. . . . . . . . . . 2.5 psid at 460 lb/hr flow

40°F Temperature Control Valve
- Control Range. . . . . . . . . . 36 - 42°F
- Operating Pressure . . . . . . . . . . 100 psig
- Pressure Drop. . . . . . . . . . 0.7 psid with 366 lb/hr flow

Regenerative Heat Exchanger
- Operating Pressure . . . . . . . . . . 230 psig
- Pressure Drop
  - (Single-pass). . . . . . . . . . 0.6 inches H20 with 81 lb/hr at 120°F
  - (4-pass) . . . . . . . . . . 3.8 inches H20 with 81 lb/hr at 40°F
- Heat Transfer. . . . . . . . . . 4720 Btu hr with 81 lb/hr flow and single-pass temp decrease from 115.5 to - 20°F with 4-pass temp increase from -85 to 60°F

Cold Plate (typical)
- Operating Pressure . . . . . . . . . . 100 psig
- Pressure Drop. . . . . . . . . . 1-2 psi with 220 lb/hr flow at 75°F
- Thermal Conductance. . . . . . . . . . 50 Btu/hr ft2 min

| | | |
|---|---|---|
| **Coolant Filter (100 microns)** | | |
| Operating Pressure | 230 psig | |
| Pressure Drop | 1.0 psi with 366 lb/hr at 80°F | |
| Relief Pressure Range | 3 to 8 psid | |

| O2 Heat Exchanger | Oxygen Side | Coolant Side |
|---|---|---|
| Operating Pressure | 1000 psig max | 230 psig |
| Pressure Drop (at flow capacity) | 2 inches H20 | 2.1 psi |
| Flow Rate | 0.35 lb/hr at 800 psia inlet and 50°F outlet | 366 lb/hr max at 130°F inlet |

| | |
|---|---|
| **ATM Cooling Pump** | |
| Flow Rate | 220 lb/hr at 22 vdc |
| Pressure Drop | 10 psid |
| Relief Valve Range | 26 - 31 psid |
| Power Consumption | 30 watts at 28 vdc |
| **ATM Water Filter** | |
| Operating Pressure | 60 psig max |
| Pressure Drop | 0.65 psid max at 70°F |
| Flow Rate | 0.5 gpm min |
| Filtration | 10 microns nominal, 25 microns absolute |
| **H-X Bypass Valve** | |
| Operating Pressure | 250 psig |
| Pressure Drop | 5 psid |
| Flow Rate | 450 lb/hr at 120 psia inlet and 70±10°F |
| Power Consumption | 90 watts max at 30 vdc |

2.4.6.3 ATMOSPHERE CONTROL COMPONENTS

PLV Fan

Operating Pressure . . . . . 4.8 - 5.2 psia (in orbit)
14.7 psia (on ground)

Flow Rate:

| Flow Rate (cfm) | Δ P (in. H20) |
|---|---|
| 40 | .31 |
| 50 | .30 |
| 75 | .28 |
| 100 | .26 |
| 150 | .15 |
| 180 | .08 |

Power Consumption . . . . . 13 watts at 30 vdc

| | |
|---|---|
| **Molecular Sieve Fan** | |
| Operating Pressure | 5.5 psi max |
| Flow Rate | (Operating Molecular Sieve) 34.2 cfm (53.5 lb/hr)<br>(Non-Operating Molecular Sieve) 29.3 cfm (45.9 lb/hr) |
| **Gas Circulation Shutoff Valve** | |
| Pressure Drop | 0.028 inches H20 max at 5 lb/min flow and 14.7 psia inlet |
| Power Consumption | 2 amps at 30 vdc and 76°F |

| Cabin Heat Exchanger | Gas Side | Coolant Side |
|---|---|---|
| Operating Pressure | 5.5 psig | 120 psig |
| Pressure Drop | 0.5 inches H20 | 0.45 psi |
| Flow Rate | 88 cfm 02 with 90°F 5 psia inlet | 40 lb/hr 40°F |
| Heat Transfer | 680 Btu/hr, 40 lb/hr at 40°F, 88 cfm 02 at 82°F and 5 psia | |

| Condensing Heat Exchanger | Gas Side | Coolant Side |
|---|---|---|
| Operating Pressure | 5.5 psig | 100 psig |
| Pressure Drop | 3.5 inches H20 | 0.4 psi |
| Flow Rate | 37.56 lb/hr at 135°F and 5 psia | 80 lb/hr at 40°F |
| Heat Transfer | 1500 Btu/hr min | |

| | |
|---|---|
| **Condensate Tank Assembly** | |
| Operating Pressure | 5.5 psig |
| Capacity | 16 lbs of H20 at 115°F and 5.5 psia |

Condensate Dump Solenoid Valve
- Pressure Drop. . . . . . . . . . 6.5 psid with 0.5 lb/min $O_2$ at 70°F and 60 psia
- Operating Voltage. . . . . . . . . . Open at 18 vdc max, Close at 2 vdc min
- Power Consumption. . . . . . . . . . 1.35 amps at 30 vdc

Molecular Sieve Gas Selector Valve
- Operating Pressure (actuator). . . . . . . . . . 100 - 250 psia
- Pressure Drop (process gas). . . . . . . . . . 0.062 inches $H_2O$ (two passes) with 15.5±0.5 lb/hr at 5 psia
- Operating Time . . . . . . . . . . 15 sec max

Molecular Sieve Sorbent Canister
- Flow Rate. . . . . . . . . . 15 - 16 lb/hr
- Pressure Drop. . . . . . . . . . 3.3 inches $H_2O$
- $CO_2$ Removal Rate . . . . . . . . . . 0.281 lb/hr at 5.5 mmHg $PCO_2$ and 46°F dewpoint inlet
- Bakeout Heater . . . . . . . . . . 360 watts at 22 vdc

Molecular Sieve Solenoid Valve
- Operating Pressure . . . . . . . . . . 250 psig $N_2$
- Pressure Drop. . . . . . . . . . 5.0 psid
- Flow Rate. . . . . . . . . . 0.093 lb/min at 70°F and 100 psig
- Power Consumption. . . . . . . . . . 10 watts

Manual Interconnect Valves
- Operating Pressure . . . . . . . . . . 250 psig max
- Pressure Drop. . . . . . . . . . 5.0 psi max
- Flow Rate. . . . . . . . . . 1.39 lb/min, $N_2$ at 70°F and 100 psig

Molecular Sieve Timer
- Power Consumption. . . . . . . . . . 2.06 watts at 24 vdc

| Time (sec) | nominal solenoid operating program S1 | S2 | S3 | S4 |
|---|---|---|---|---|
| 0-15 | Off | Off | On | On |
| 15-880 | Off | Off | Off | Off |
| 880-895 | On | On | Off | Off |
| 895-1760 | Off | Off | Off | Off |
| 1760-1775 | Off | Off | On | On |
| Reset | Off | Off | Off | Off |

Solids Traps
- Operating Pressure . . . . . . . . . . 5.5 psig
- Pressure Drop. . . . . . . . . . 0.55 inches $H_2O$ at 70°F and 5 psia
- Flow Rate. . . . . . . . . . 17.1 cfm nominal
- Relief Valve . . . . . . . . . . $\Delta$ P = 0.8±0.3 inches $H_2O$ at flow of 200 sccm

Charcoal Canister
- Flow Rate. . . . . . . . . . 18.2 lb/hr at 5 psia (operating sieve) 21.8 lb/hr (non-operating sieve)
- Pressure Drop. . . . . . . . . . 2.2 inches $H_2O$

### 2.4.6.4 EVA/IVA SUPPORT COMPONENTS

Suit Cooling Pump
- Flow Rate. . . . . . . . . . 200 - 350 lb/hr
- Pressure Drop. . . . . . . . . . 19 psi at 300 lb/hr, 22 vdc
- Relief Valve . . . . . . . . . . 26 - 31 psid
- Power Consumption. . . . . . . . . . 30 watts at 28 vdc

Gas Separator
- Flow Rate. . . . . . . . . . 200 - 350 lb/hr
- Pressure Drop. . . . . . . . . . 0.55 - 0.60 psid max
- Gas Removal Efficiency . . . . . . . . . . 95% of 20±2 sccm influent gas at normal coolant flow

### 2.4.6.5 REFRIGERATION COMPONENTS

Radiator
- Operating Pressure . . . . . . . . . . 140 psia max
- Pressure Drop. . . . . . . . . . 36 psi max, 10 psi min
- Flow Rate. . . . . . . . . . 125±11 lb/hr
- Surface Area . . . . . . . . . . 84 sq. ft.
- Heat Transfer. . . . . . . . . . 1680 Btu/hr

| | |
|---|---|
| Thermal Capacitor | |
| Operating Pressure | |
| (Coolant Side) | 140 psia max |
| (Wax Side) | 40 psia max |
| Pressure Drop | 1.75 psi at 225 lb/hr, 75±3°F |
| Flow Rate | 125 lb/hr |
| Wax Type | Undecane, -14.07°F melting point 66.47 Btu/lb; -34°F structural transition point 18.6 Btu/lb |

| Temperature Control | Chiller TCV | Freezer TCV |
|---|---|---|
| Control Temperature | 39±3°F | -17±3°F |
| Operating Pressure | TBS | TBS |
| Pressure Drop | TBS | TBS |
| Flow Rate | TBS | TBS |

| | |
|---|---|
| Radiator Bypass Valve | |
| Operating Pressure | 140 psia max |
| Pressure Drop | (Inlet to rad. out) 2.5 psid<br>(Inlet to rad. bypass) 4.0 psid |
| Flow Rate | 125±11 lb/hr |
| Pump Package | |
| Operating Pressure | 100 psig max |
| Pressure Rise | 55 psid |
| Flow Rate | 125±11 lb/hr |
| Power Consumption | 70 watts max |
| Freezers | |
| Flow Rate | 125 lb/hr |
| Operating Pressure | 100 psig |

| | Wardroom Freezer | Storage Freezer | Urine Freezer |
|---|---|---|---|
| Pressure drop | 2.7±0.2 psi | 4.4±3 psi | 2.5 psi |

2.4.7 OPERATIONAL LIMITATIONS AND RESTRICTIONS

The operational limitations and restrictions for the five ECS subsystems are as follows:

2.4.7.1 PRESSURIZATION AND GAS DISTRIBUTION

o MDA/AM ground purge rate must be limited to 10 lb/min to prevent pressurization of the aft compartment and damage to habitation area dome. (Max $\Delta$ P allowed across habitation area dome hatch is 0.5 psi)

o The habitation area and waste tank must be pressurized to a minimum internal pressure of 22 psia during boost to provide structural integrity under boost loads.

o The maximum pressure differential to be imposed across the OWS common bulkhead during ground operations is ±7.5 psid to prevent possible structural weakening to the bulkhead attach points. Weakening of the attach structure would reduce failure limits (habitation area 36 psia waste tank 0 psia and waste tank 41 psia habitation area 0) for permanent structural damage.

o Planned orbital activities should not result in cabin pressures in excess of 5.5 psia. At pressures above 5.5 psia, the cabin relief valves may open. An open relief valve may not reseat properly, resulting in a gas leak.

o The MDA vent valves must be open a minimum of 5 minutes prior to launch. Internal AM/MDA pressure must be ambient at liftoff to prevent MDA/AM pressures above 6 psid during ascent. Excess MDA/AM pressure could cause structural damage and the resultant loss of seals.

o Pressure equalization valves must be open and compartment pressures equalized prior to opening internal hatches, to prevent possible injury to crew.

o The manual valve on the cabin pressure relief valves must be open at all times to prevent overpressurization of individual compartments or the entire cluster.

o Two N2 tanks shall remain isolated from the primary N2 system until pressure within the primary tanks has decreased to 300 psia. Isolation is required to prolong availability of high-pressure N2 for recharging experiment gas bottles.

o Operation of M509 and T020 experiments must be limited in duration and frequency to prevent a total pressure increase above 5.5 psia or an oxygen partial pressure decrease below 3.3 psia.

o Internal pressure within the cluster shall be decreased to approximately 2.0 psia prior to the unmanned phase. Such action is required to reduce atmospheric dewpoint and avoid possible condensation of moisture on walls and equipment.

2.4.7.2 THERMAL CONTROL SYSTEM

- o Coolant system operation is required at all times during the mission and during prelaunch checkout when equipment cooled by the coolant system is operating.
  - o Prelaunch - One or two loops, one pump/loop, depending on total heat load of operating equipment.
  - o Launch through initial orbit - One loop, one pump.
  - o After initial orbit and subsequent active missions - Two loops, one pump/loop normally; one loop, two pumps contingency.
  - o Unmanned Phase - One loop, one pump with automatic pump switchover capability.
- o The dewpoint of ambient air during prelaunch must be 40°F or lower to prevent condensation on coolant lines.
- o Ground coolant must be supplied to the ground cooling heat exchanger until 5 to 10 minutes before lift-off to provide a charged thermal capacitor (tridecane wax temperature -7°F) for equipment cooling prior to radiator activation.
- o Fluid must be purged from the ground coolant line prior to umbilical disconnect to avoid excessive pressures in the ground cooling heat exchanger, possible rupture of the unit, and loss of both primary and secondary flight coolant loops.
- o After liftoff, coolant must bypass the radiator until the radiator cools down to a serviceable temperature (47°F) at approximately 15 minutes after PS jettison.
- o Impingement of CSM RCS exhaust plumes on AM radiator surfaces must be minimized to avoid excessive degradation of thermal coatings and heat rejection capability.
- o Maximum allowable coolant temperatures required for compatibility with equipment qualification limits are in general 120°F with the following exceptions:
  - o Maximum coolant inlet temperature to tape recorders and battery module components (batteries, chargers, and regulators) shall be 100°F or less. Normally, coolant inlet temperature to battery coldplates must be maintained at a level that will limit maximum battery cell temperatures to approximately 80°F to prevent degradation of battery life.
  - o Maximum coolant temperature at the ATM C&D panel heat exchanger shall be limited to 78°F by restricting internal atmospheric temperature to 83°F maximum to prevent excessive water delivery temperatures to the ATM C&D panel.
- o Minimum coolant temperatures at the inlet to inactive water heat exchangers shall be maintained at 33°F or above to prevent freezing of the water.
- o The four aft compartment and three STS cabin heat exchanger fans shall be deactivated during EVA to prevent possible condensation in the heat exchangers.
- o With a water supply temperature of 78°F in the ATM C&D panel and EREP cooling system, maximum heat addition to the loop shall be limited to 1335 Btu/hr from the C&D panel and EREP components and 102 Btu/hr for the water pump. The water loop will be deactivated during EVA/IVA to minimize radiator heat loading.
- o Condensing heat exchanger cooling gas flow shall be directed to the occupied module (MDA or OWS) under cold case conditions to prevent unnecessary use of electrical heater power in the unoccupied module.
- o Coolant flow should be switched from EVA to BYPASS before shutting off the EVA loop water flow, to prevent exposure of stagnant water in the heat exchanger to cold coolant. The water could possibly freeze and cause damage to the heat exchanger.
- o To assist in preventing gas and wall temperatures from exceeding the maximum limits required for crew comfort during mission phases where the beta angle is greater than 60 degrees or less than -60 degrees, the following constraints are imposed on the waste heat sources:
  - o A maximum of four lights will be on during the 8-hour sleep period.
  - o Lights will be turned off in unoccupied compartments during the working day.
  - o The portable lights will not be operated.
- o To maintain food temperature requirements (40 ° to 85°F) and to avoid condensation during tank blowdown at the beginning of the unmanned phase, the OWS radiant heaters shall be energized within 1 hour after insertion and immediately upon crew closeout. The radiant heaters will be de-energized if the OWS food containers or film vault temperatures exceed 75°F.
- o The electric power for the MDA window heaters and the wardroom heater must be on during manned operations to prevent condensation or ice forming on the window when the window cover is opened.
- o The meteoroid shield must be deployed following orbit insertion to maintain food containers and film temperatures above 40°F.

o Activation of the first pump in an inactive coolant loop during periods of low heat loads on the coolant system,such as unmanned phase and activation prior to crew habitation, is constrained to occur at an orbital position between 75 degrees prior to orbital noon and 158 degrees after orbital noon. The maximum design operating pressure can be exceeded at the filter immediately dowstream of the pump, the radiator bypass selector valve, and the radiator inlet and at the 47°F temperature control valve (A) when an inactive loop is started up between the orbital positions of 158 and 285 degrees past orbital noon during the low heat load conditions of orbital storage. Loop activation at these conditions results in initial full flow being commanded through the cold radiator, resulting in excess pressures between the pump and radiator for approximately 15 seconds. Loop activation occurs for the following operations:

  o Startup of one pump in the secondary loop by DCS command during activation prior to crew habitation.
  o Automatic Restart System (ARS) startup of one pump in the secondary coolant loop during orbit storage due to a failure in the primary loop.

  Since the ARS startup is the result of a loop failure that has a probability of 0.35 of occurring during the critical portion of the orbit and is a condition that would not be repeated, the resulting overpressure that does not exceed 65 percent of proof pressure is acceptable. However, loop startup during activation prior to each crew visitation represents an unnecessary risk that must be avoided by observing the above limitation.

o Switching of the heat exchanger coolant flow from the "BYPASS" to the "EVA" position when operating two pumps in a single AM coolant loop (two pumps in one loop is a backup mode to the normal configuration of one pump in each of the two loops) is constrained to occur at an orbital position between 75 degrees prior to orbital noon and 158 degrees after orbital noon. Excessive coolant loop pressures may occur between the pumps and the radiator when "EVA" flow is initiated with two pumps in one loop operating. At orbital positions between 158 and 285 degrees past orbital noon, coolant flow demanded of the cold radiator results in increased loop pressures, which may be sustained for up to 2 minutes. To avoid these excessive loop pressure transients in what would be a backup mode of operation and avoid any risks on the then remaining loop, the above limitation shall be observed.

2.4.7.3 ATMOSPHERE CONTROL SYSTEM

o Two condensing heat exchangers will be operated at all times during manned phases of the mission to prevent excessive dewpoint levels and possible condensation in cabin heat exchangers.

o Only one compressor upstream of a molecular sieve system can be operated at a time to avoid excessive molecular sieve gas flow and more rapid degradation of sorbent canister performance.

o Redundant condensing heat exchangers will remain isolated from the active system (no coolant or gas flow) to prevent condensation of moisture in the unit and possible degradation of wicking material.

o Condensing heat exchangers with wetted water separator plates must not be exposed to vacuum conditions. Freezing of water in the porous plate will result in damage to the plate.

o The condensate tank must be dumped when the cabin to tank differential pressure has decreased to 0.3 psi to prevent excessive dewpoint levels and possible condensation on walls and equipment.

o The metabolic moisture generation rate for the three-man crew must equal or exceed the rate of water loss from the atmosphere via overboard leakage, molecular sieve venting, and usage of HSS refrigerators and freezers to avoid dewpoint levels below 46°F.

o Active molecular sieve canisters must be baked out when cabin PCO2 increases to 5.5 mmHg to restore maximum performance.

o Following molecular sieve bakeout, gas flow from the hot molecular sieve shall be directed to the OWS such that it can be mixed with cool gas from AM aft compartment heat exchangers before entering the cabin.

o MDA and AM wall heaters shall be activated during all mission phases to maintain required temperature levels for the crew and/or equipment.

o Following molecular sieve bakeout, the initiation of gas flow through the hot sieve bed must be delayed until 15 minutes after turning the heater off to prevent a possible fire hazard.

2.4.7.4 EVA/IVA SYSTEM

o The maximum heat load on each suit cooling system (excluding pumps) shall not exceed 2000 Btu/hr. Negative heat loads are limited to 800 Btu/hr per system to prevent excessively low coolant temperatures into condensing heat exchangers.

o The gas outlet of the gas separator assembly shall not be exposed to pressures lower than 0.09 psia to prevent damage to the unit.

o Inflight servicing of the LSU/PCU shall not be attempted when OWS water supply pressures exceed 37 psig to avoid possible damage to the PCU.

- o Following inflight servicing of the LSU/PCU, the LSU shall be connected to the EVA/IVA Panel prior to making additional connections to the PCU. This sequence is required to prevent seal damage in the multiple connectors.
- o The jumper assembly with relief valve installed must be connected to the suit cooling system prior to inflight servicing to eliminate the possibility of overpressurization of the water reservoir.
- o Cooling system reservoirs must not be filled to a level greater than three-fourths full during inflight servicing. Remaining volume is required for pressure control.

The operational limitations and restrictions for the EVA/IVA system are as follows:

- o Jumper hoses must be installed on panel 217 across SUIT UMB SYS 1 INLET and OUTLET SUIT UMB SYS 2 INLET and OUTLET when the suit cooling systems are not in use to prevent pressure buildup between pump check valves and the INLET QD's.

2.4.7.5 REFRIGERATION SYSTEM

- o The thermal capacitor must be in a charged condition (Undercane wax temperature $>$ -17°F) at liftoff to provide food cooling prior to radiator activation.
- o The refrigeration system must be placed in manual control when installing warm urine containers in the urine freezer to prevent automatic loop switchover (food freezer inlet temp $< 1\pm1$°F).

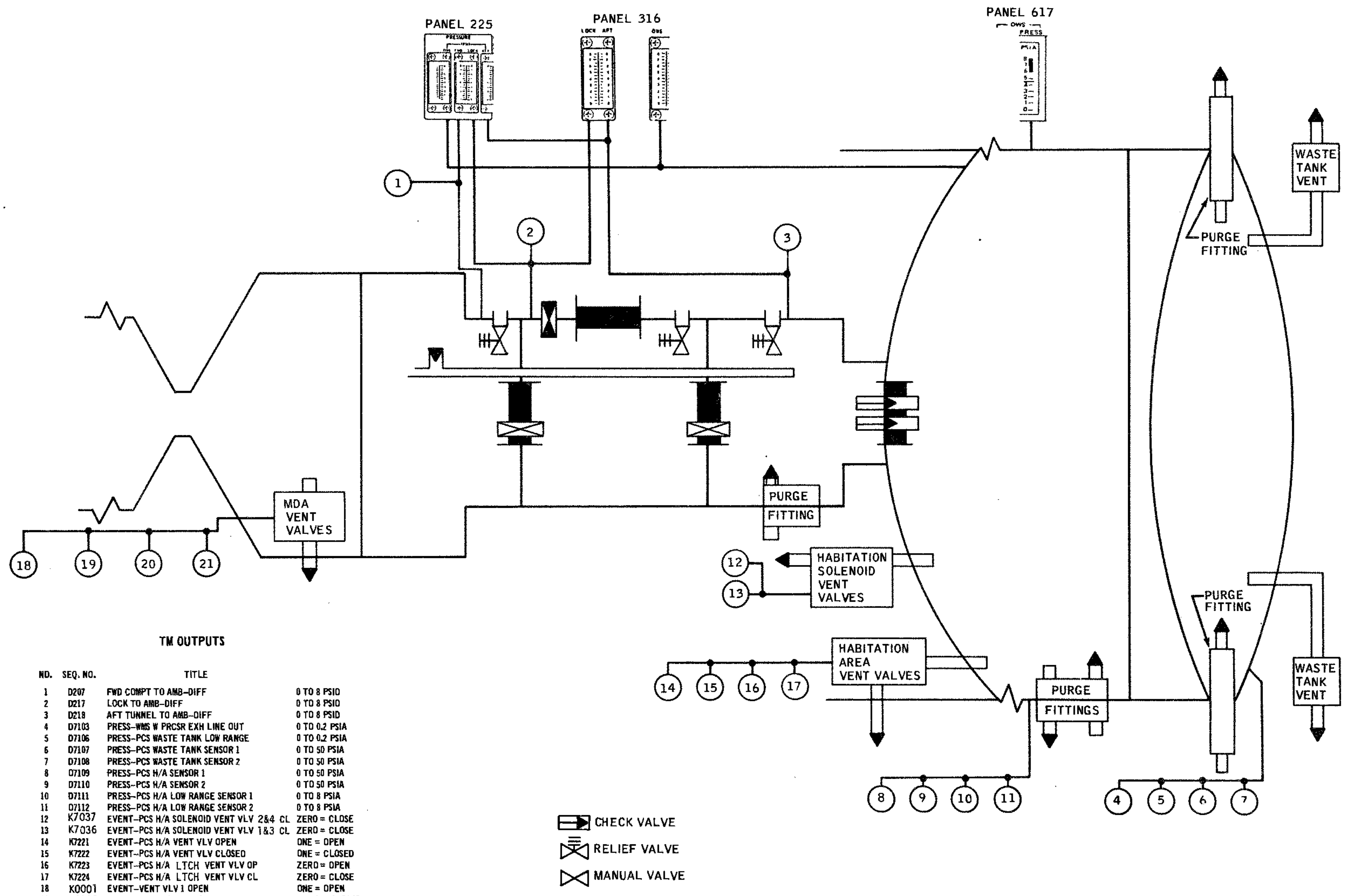
2.4.8 INSTRUMENTATION AND GROUND COMMANDS

Tables 2.4.8-1 through 2.4.8-12 provide a complete list of instrumentation measurements and ground commands for the environmental control system. Figures 2.4.8-1 through 2.4.8-7 show the location of the various transducers and command relays.

TABLE 2.4.8-1 PURGE AND VENTING

| NO. | MEASUREMENT NUMBER | DESCRIPTION | TELEMETRY RANGE | ONBOARD DISPLAY RANGE | ONBOARD DISPLAY PANEL |
|---|---|---|---|---|---|
| 1 | D207-540 | FWD COMPT TO AMB-DIFF | 0 TO 8 PSID | 0 TO 8 PSI | 225 |
| 2 | D217-540 | LOCK TO AMB-DIFF | 0 TO 8 PSID | 0 TO 8 PSI | 225, 316 |
| 3 | D218-540 | AFT TUNNEL TO AMB-DIFF | 0 TO 8 PSID | 0 TO 8 PSI | 225, 316 |
| 4 | D7103-438 | PRESS-WMS W PRCSR EXH LINE OUT | 0 TO 0.2 PSIA | 0 TO 0.2 | 800 |
| 5 | D7106-406 | PRESS-PCS WASTE TANK LOW RANGE | 0 TO 0.2 PSIA | | |
| 6 | D7107-406 | PRESS-PCS WASTE TANK SENSOR 1 | 0 TO 50 PSIA | | |
| 7 | D7108-406 | PRESS-PCS WASTE TANK SENSOR 2 | 0 TO 50 PSIA | | |
| 8 | D7109-436 | PRESS-PCS H/A SENSOR 1 | 0 TO 50 PSIA | | |
| 9 | D7110-436 | PRESS-PCS H/A SENSOR 2 | 0 TO 50 PSIA | | |
| 10 | D7111-436 | PRESS-PCS H/A LOW RANGE SENSOR 1 | 0 TO 8 PSIA | | |
| 11 | D7112-436 | PRESS-PCS H/A LOW RANGE SENSOR 2 | 0 TO 8 PSIA | | |
| 12 | K7037-411 | EVENT-PCS H/A SOLENOID VENT VLV 2&4 CL | ZERO = CLOSE | | |
| 13 | K7036-411 | EVENT-PCS H/A SOLENOID VENT VLV 1&3 CL | ZERO = CLOSE | | |
| 14 | K7221-411 | EVENT-PCS H/A VENT VLV OPEN | ONE = OPEN | | |
| 15 | K7222-411 | EVENT-PCS H/A VENT VLV CLOSED | ONE = CLOSED | | |
| 16 | K7223-411 | EVENT-PCS H/A LTCH VENT VLV OP | ZERO = OPEN | | |
| 17 | K7224-411 | EVENT-PCS H/A LTCH VENT VLV CL | ZERO = CLOSE | | |
| 18 | K0001 | EVENT-VENT VLV 1 OPEN | ONE = OPEN | | |
| 19 | K0002 | EVENT-VENT VLV 1 CLOSED | ZERO = CLOSED | | |
| 20 | K0003 | EVENT-VENT VLV 2 OPEN | ONE = OPEN | | |
| 21 | K0004 | EVENT-VENT VLV 2 CLOSED | ZERO = CLOSED | | |

See figure 2.4.8-1.




**TM OUTPUTS**

| NO. | SEQ. NO. | TITLE | |
|---|---|---|---|
| 1 | D207 | FWD COMPT TO AMB-DIFF | 0 TO 8 PSID |
| 2 | D217 | LOCK TO AMB-DIFF | 0 TO 8 PSID |
| 3 | D218 | AFT TUNNEL TO AMB-DIFF | 0 TO 8 PSID |
| 4 | D7103 | PRESS-WMS W PRCSR EXH LINE OUT | 0 TO 0.2 PSIA |
| 5 | D7106 | PRESS-PCS WASTE TANK LOW RANGE | 0 TO 0.2 PSIA |
| 6 | D7107 | PRESS-PCS WASTE TANK SENSOR 1 | 0 TO 50 PSIA |
| 7 | D7108 | PRESS-PCS WASTE TANK SENSOR 2 | 0 TO 50 PSIA |
| 8 | D7109 | PRESS-PCS H/A SENSOR 1 | 0 TO 50 PSIA |
| 9 | D7110 | PRESS-PCS H/A SENSOR 2 | 0 TO 50 PSIA |
| 10 | D7111 | PRESS-PCS H/A LOW RANGE SENSOR 1 | 0 TO 8 PSIA |
| 11 | D7112 | PRESS-PCS H/A LOW RANGE SENSOR 2 | 0 TO 8 PSIA |
| 12 | K7037 | EVENT-PCS H/A SOLENOID VENT VLV 2&4 CL | ZERO = CLOSE |
| 13 | K7036 | EVENT-PCS H/A SOLENOID VENT VLV 1&3 CL | ZERO = CLOSE |
| 14 | K7221 | EVENT-PCS H/A VENT VLV OPEN | ONE = OPEN |
| 15 | K7222 | EVENT-PCS H/A VENT VLV CLOSED | ONE = CLOSED |
| 16 | K7223 | EVENT-PCS H/A LTCH VENT VLV OP | ZERO = OPEN |
| 17 | K7224 | EVENT-PCS H/A LTCH VENT VLV CL | ZERO = CLOSE |
| 18 | K0001 | EVENT-VENT VLV 1 OPEN | ONE = OPEN |
| 19 | K0002 | EVENT-VENT VLV 1 CLOSED | ZERO = CLOSED |
| 20 | K0003 | EVENT-VENT VLV 2 OPEN | ONE = OPEN |
| 21 | K0004 | EVENT-VENT VLV 2 CLOSED | ZERO = CLOSED |

Figure 2.4.8-1 Purge and Venting

TABLE 2.4.8-2 HABITATION AREA AND WASTE TANK INSTRUMENTATION

| NO. | MEASUREMENT NUMBER | DESCRIPTION | TELEMETRY RANGE | ONBOARD DISPLAY RANGE | ONBOARD DISPLAY PANEL |
|---|---|---|---|---|---|
| 1 | D7103-438 | PRESS-WMS W PRCSR EXH LINE OUT | 0 to 0.2 PSIA | | |
| 2 | D7106-406 | PRESS-PCS WASTE TANK LOW RANGE | 0 to 0.2 PSIA | | |
| 3 | D7107-406 | PRESS-PCS WASTE TANK SENSOR 1 | 0 to 50 PSIA | | |
| 4 | D7108-406 | PRESS-PCS WASTE TANK SENSOR 2 | 0 to 50 PSIA | | |
| 5 | D7109-436 | PRESS-PCS H/A SENSOR | 0 to 50 PSIA | | |
| 6 | D7110-436 | PRESS-PCS H/A SENSOR 2 | 0 to 50 PSIA | | |
| 7 | D7111-436 | PRESS-PCS H/A LOW RANGE SENS 1 | 0 to 8 PSIA | | |
| 8 | D7112-436 | PRESS-PCS H/A LOW RANGE SENS 2 | 0 to 8 PSIA | | |
| 9 | D7113-403 | PRESS-PCS PNEU SPHERE SENSOR 1 | 0 to 1000 PSIA | | |
| 10 | D7114-403 | PRESS-PCS PNEU SPHERE SENSOR 2 | 0 to 1000 PSIA | | |
| 11 | D7130-436 | PRESS-PCS H/A LOW RANGE | | 0 to 8 PSIA | 617 |
| 12 | D7143-436 | PRESS-PCS H/A LOW RANGE | | 0 to 8 PSIA | 225 & 316 |
| 13 | K7036-411 | EVENT-PCS H/A SOL VT VLV 2 & 4 CL | ZERO = CLOSE | | |
| 14 | K7037-411 | EVENT-PCS H/A SOL VT VLV 1 & 3 CL | ZERO = CLOSE | | |
| 15 | K7221-411 | EVENT-PCS H/A VENT VLV OPEN | ONE = OPEN | | |
| 16 | K7222-411 | EVENT-PCS H/A VENT VLV CLOSED | ONE = CLOSED | | |
| 17 | K7223-411 | EVENT-PCS H/A LCHG VENT VLV OP | ZERO = OPEN | | |
| 18 | K7224-411 | EVENT-PCS H/A LCHG VENT VLV CL | ZERO = CLOSE | | |

See figure 2.4.8-2

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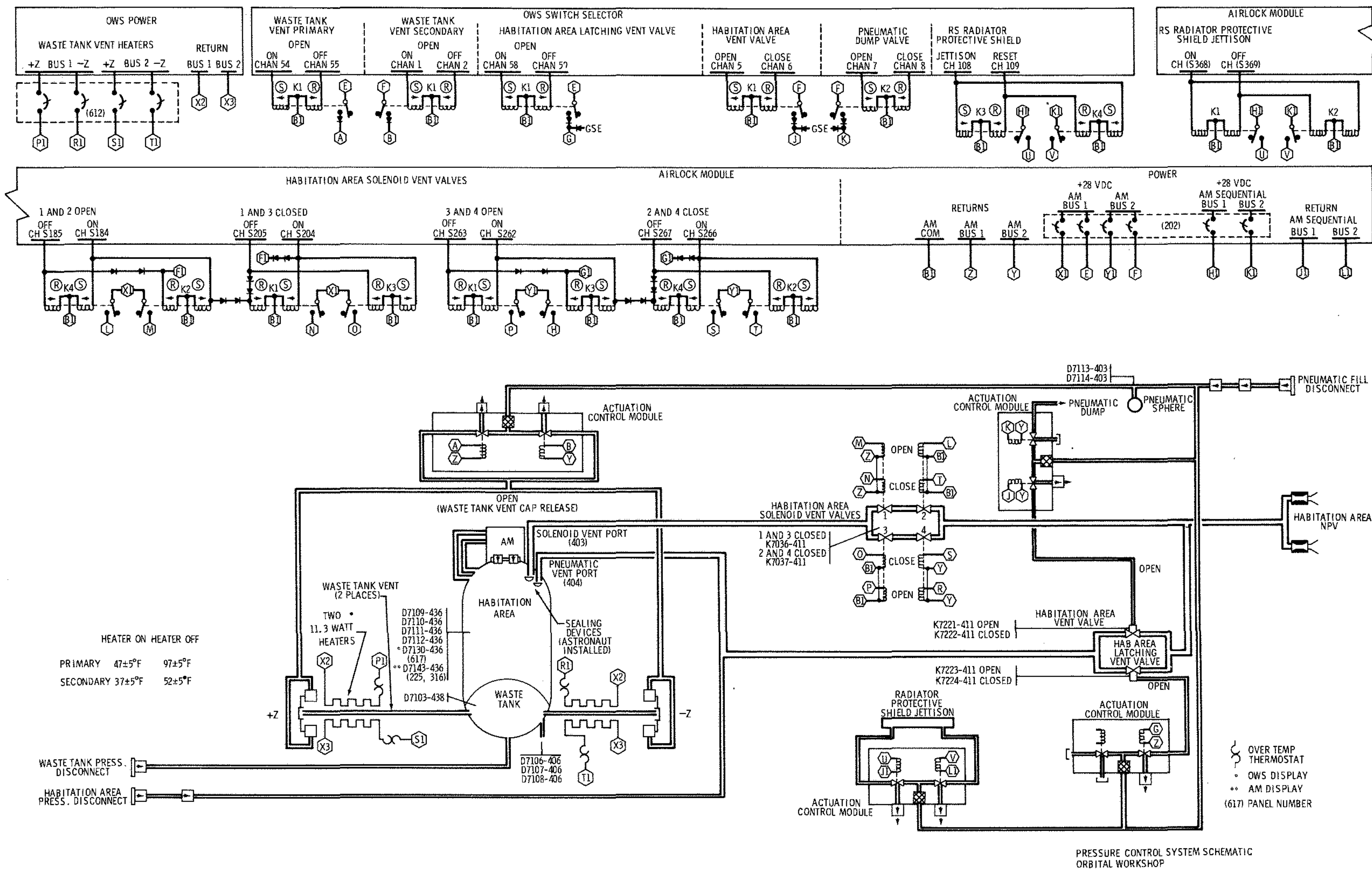


Figure 2.4.8-2 OWS Vent System Control

TABLE 2.4.8-3 SWS VENTING

| DCS COMMAND | COMMAND TITLE | FUNCTION | OCTAL CODE |
|---|---|---|---|
| S185<br>S184 | OWS H/A SOL VT VLV 1 & 2 OPEN | OFF<br>ON | 44720<br>40720 |
| S205<br>S204 | OWS H/A SOL VT VLV 1 & 3 CLOSE | OFF<br>ON | 45460<br>41460 |
| S263<br>S262 | OWS H/A SOL VT VLV 3 & 4 OPEN | OFF<br>ON | 47204<br>43204 |
| S267<br>S266 | OWS H/A SOL VT VLV 2 & 4 CLOSE | OFF<br>ON | 46604<br>42604 |
| 54 | PCS WASTE TANK VENT PRIMARY OPEN | ON | 164 |
| 55 | PCS WASTE TANK VENT PRIMARY OPEN | OFF | 144 |
| 1 | PCS WASTE TANK VENT SECONDARY OPEN | ON | 177 |
| 2 | PCS WASTE TANK VENT SECONDARY OPEN | OFF | 137 |
| 5 | PCS HABITATION AREA VENT VALVE | OPEN | 002 |
| 6 | PCS HABITATION AREA VENT VALVE | CLOSE | 055 |
| 58 | PCS HABITATION AREA LATCHING VENT VALVE OPEN | ON | 071 |
| 59 | PCS HABITATION AREA LATCHING VENT VALVE OPEN | OFF | 153 |
| 7 | PCS PNEUMATIC DUMP VALVE | OPEN | 035 |
| 8 | PCS PNEUMATIC DUMP VALVE | CLOSE | 077 |
| 20 | MDA VENT VALVE 2 | OFF | 156 |
| 21 | MDA VENT VALVE 2 - CLOSE | ENABLE | 101 |
| 22 | MDA VENT VALVE 2 - OPEN or CLOSE | EXECUTE | 121 |
| 66 | MDA VENT VALVE 1 - CLOSE | ENABLE | 111 |
| 67 | MDA VENT VALVE 1 - OPEN or CLOSE | EXECUTE | 067 |
| 111 | MDA VENT VALVE 1 | OFF | 012 |
| 47 | MDA VENT VALVE 2 OPEN | ENABLE | 115 |
| 112 | MDA VENT VALVE 1 OPEN | ENABLE | 113 |

TABLE 2.4.8-4 O2 AND N2 GAS DISTRIBUTION INSTRUMENTATION

| NO. | MEASUREMENT NUMBER | DESCRIPTION | TELEMETRY RANGE | ONBOARD DISPLAY RANGE | ONBOARD DISPLAY PANEL |
|---|---|---|---|---|---|
| 1 | C247-530 | O2 SUPPLY BOTTLE 1 - TEMP | -50 to 160°F | | |
| 2 | C248-530 | O2 SUPPLY BOTTLE 2 - TEMP | -50 to 160°F | | |
| 3 | C249-530 | O2 SUPPLY BOTTLE 3 - TEMP | -50 to 160°F | | |
| 4 | C250-530 | O2 SUPPLY BOTTLE 4 - TEMP | -50 to 160°F | | |
| 5 | C251-530 | O2 SUPPLY BOTTLE 5 - TEMP | -50 to 160°F | | |
| 6 | C252-530 | O2 SUPPLY BOTTLE 6 - TEMP | -50 to 160°F | | |
| 7 | C916-530 | STS - O2 TANK 1 thru 6 | | -25 to 125°F | 225 |
| 8 | C253-504 | N2 SUPPLY BOTTLE 1 - TEMP | -25 to 160°F | | |
| 9 | C254-504 | N2 SUPPLY BOTTLE 2 - TEMP | -25 to 160°F | | |
| 10 | C255-503 | N2 SUPPLY BOTTLE 3 - TEMP | -25 to 160°F | | |
| 11 | C256-503 | N2 SUPPLY BOTTLE 4 - TEMP | -25 to 160°F | | |
| 12 | C257-502 | N2 SUPPLY BOTTLE 5 - TEMP | -25 to 160°F | | |
| 13 | C272-502 | N2 SUPPLY BOTTLE 6 - TEMP | -25 to 160°F | | |
| 14 | C917-504 | STS-N2 TANK 1 thru 6 | | -25 to 125°F | 225 |
| 15 | D226-530 | O2 SUPPLY BOTTLE 1 - PRESS | 0 to 4K PSIA | | |
| 16 | D227-530 | O2 SUPPLY BOTTLE 2 - PRESS | 0 to 4K PSIA | | |
| 17 | D228-530 | O2 SUPPLY BOTTLE 3 - PRESS | 0 to 4K PSIA | | |
| 18 | D229-530 | O2 SUPPLY BOTTLE 4 - PRESS | 0 to 4K PSIA | | |
| 19 | D230-530 | O2 SUPPLY BOTTLE 5 - PRESS | 0 to 4K PSIA | | |
| 20 | D231-530 | O2 SUPPLY BOTTLE 6 - PRESS | 0 to 4K PSIA | | |
| 21 | D232-504 | N2 SUPPLY BOTTLE 1 - PRESS | 0 to 4K PSIA | | |
| 22 | D233-504 | N2 SUPPLY BOTTLE 2 - PRESS | 0 to 4K PSIA | | |
| 23 | D234-503 | N2 SUPPLY BOTTLE 3 - PRESS | 0 to 4K PSIA | | |
| 24 | D235-503 | N2 SUPPLY BOTTLE 4 - PRESS | 0 to 4K PSIA | | |
| 25 | D236-502 | N2 SUPPLY BOTTLE 5 - PRESS | 0 to 4K PSIA | | |
| 26 | D257-502 | N2 SUPPLY BOTTLE 6 - PRESS | 0 to 4K PSIA | | |
| 27 | D241-530 | ALT O2 SUPPLY BOTTLE 1 - PRESS | 0 to 4K PSIA | | |
| 28 | D242-530 | ALT O2 SUPPLY BOTTLE 2 - PRESS | 0 to 4K PSIA | | |
| 29 | D243-530 | ALT O2 SUPPLY BOTTLE 3 - PRESS | 0 to 4K PSIA | | |
| 30 | D244-530 | ALT O2 SUPPLY BOTTLE 4 - PRESS | 0 to 4K PSIA | | |
| 31 | D245-530 | ALT O2 SUPPLY BOTTLE 5 - PRESS | 0 to 4K PSIA | | |
| 32 | D246-530 | ALT O2 SUPPLY BOTTLE 6 - PRESS | 0 to 4K PSIA | | |
| 33 | D247-504 | ALT N2 SUPPLY BOTTLE 1 - PRESS | 0 to 4K PSIA | | |
| 34 | D248-504 | ALT N2 SUPPLY BOTTLE 2 - PRESS | 0 to 4K PSIA | | |
| 35 | D249-503 | ALT N2 SUPPLY BOTTLE 3 - PRESS | 0 to 4K PSIA | | |
| 36 | D250-503 | ALT N2 SUPPLY BOTTLE 4 - PRESS | 0 to 4K PSIA | | |
| 37 | D251-502 | ALT N2 SUPPLY BOTTLE 5 - PRESS | 0 to 4K PSIA | | |
| 38 | D258-502 | ALT N2 SUPPLY BOTTLE 6 - PRESS | 0 to 4K PSIA | | |
| 39 | D918-530 | STS O2 TANK 1 thru 6 | | 0 to 4K PSIA | 225 |
| 40 | D919-504 | STS N2 TANK 1 thru 6 | | 0 to 4K PSIA | 225 |
| 41 | D204-505 | O2 REG OUTPUT (N2-O2 CNTL) | 0 to 200 PSIA | | |
| 42 | D920-505 | STS REGULATED O2 PRESSURE | | 0 to 200 PSIA | 225 |
| 43 | D915-505 | LOK REGULATED O2 PRESSURE | | 0 to 200 PSIA | 316 |
| 44 | D205-505 | N2 REG OUTPUT (N2-O2 CNTL) | 0 to 225 PSIA | | |
| 45 | D921-505 | STS REGULATED N2 PRESSURE | | 0 to 225 PSIA | 225 |
| 46 | D256-537 | O2/N2 REG OUTPUT PRESS | 0 to 8 PSIA | | |
| 47 | D238-534 | EVA SUIT CLNT RES PRESS | 0 to 8 PSIA | | |
| 48 | D237-520 | O2 PARTIAL PRESSURE (1) | 0 to 330 mmHg | | |
| 49 | D239-520 | O2 PARTIAL PRESSURE (2) | 0 to 330 mmHg | | |
| 50 | D240-520 | O2 PARTIAL PRESSURE (3) | 0 to 300 mmHg | | |
| 51 | D922-520 | STS O2 PARTIAL PRESSURE (1) | | 0 to 6 PSIA | 225 |
| 52 | D923-520 | STS O2 PARTIAL PRESSURE (2) | | 0 to 6 PSIA | 225 |
| 53 | D924-520 | STS O2 PARTIAL PRESSURE (3) | | 0 to 6 PSIA | 225 |
| 54 | K944-537 | STS PPO2 LOW (LIGHT) | | 157 mmHg | 207 |
| 55 | D7133-436 | PRESS-WS PRESS MANF INLET GAS | 0 to 75 PSIA | | |
| 56 | K238-537 | PRI O2 SUPPLY VALVE OPEN | ONE = OPEN | | |
| 57 | K240-537 | PRI O2 SUPPLY VALVE CLOSED | ONE = CLOSED | | |
| 58 | K239-537 | PRI N2 SUPPLY VALVE OPEN | ONE = OPEN | | |
| 59 | K241-537 | PRI N2 SUPPLY VALVE CLOSED | ONE = CLOSED | | |
| 60 | K242-537 | SEC O2 SUPPLY VALVE OPEN | ZERO = OPEN | | |
| 61 | K244-537 | SEC O2 SUPPLY VALVE CLOSED | ZERO = CLOSED | | |
| 62 | K243-537 | SEC N2 SUPPLY VALVE OPEN | ZERO = OPEN | | |
| 63 | K245-537 | SEC N2 SUPPLY VALVE CLOSED | ZERO = CLOSED | | |

See figure 2.4.8-3.

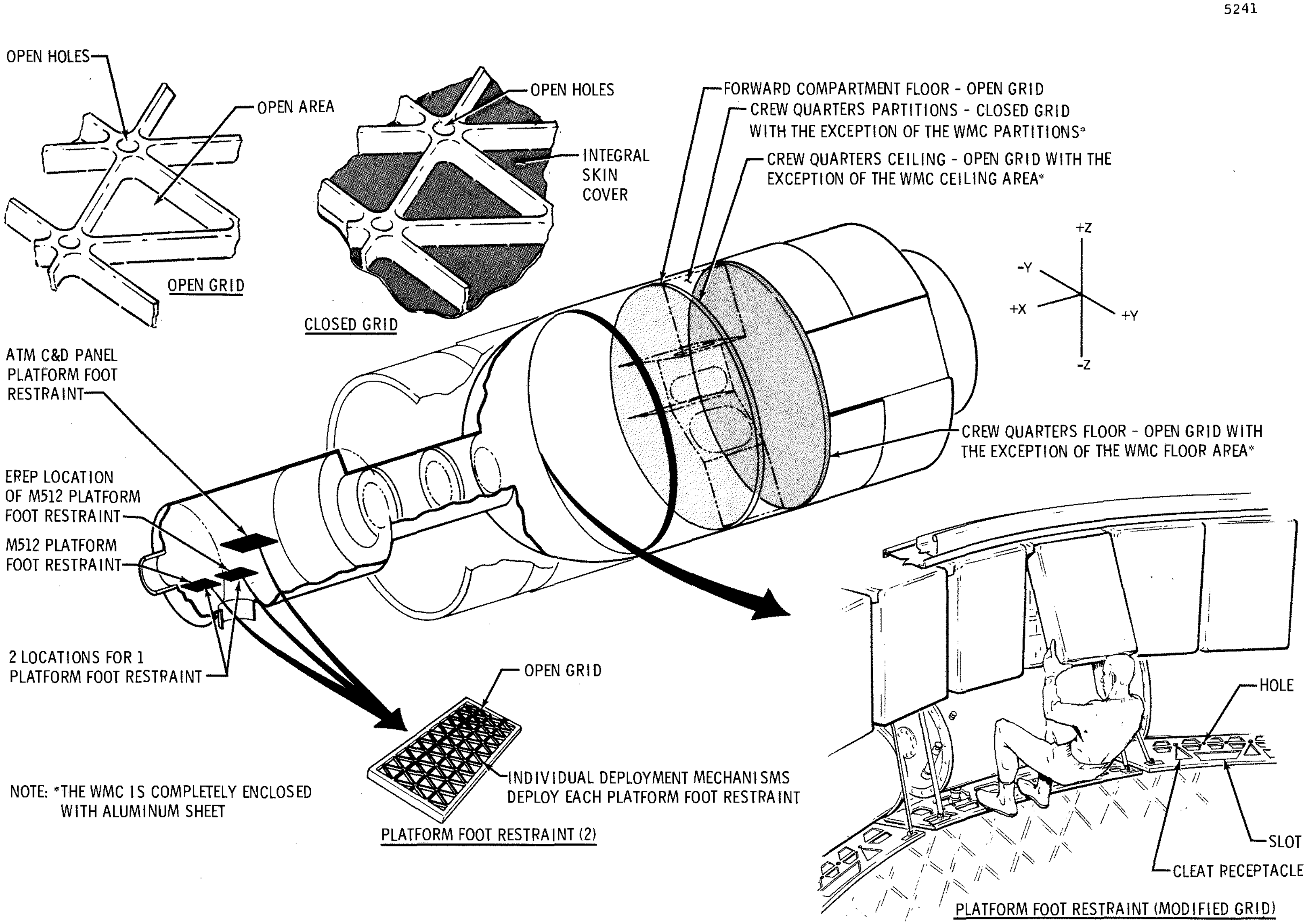


Figure 2.5.3-1 Grid Locations

2.5.3.3 FOOT RESTRAINTS

Foot restraints are provided internally and externally on the SWS to permit restraint of the crewman's feet. Restraint at the foot-level provides body restraint in a desired orientation to free the crewman's hands to perform two-handed work activities in the zero-G environment. Internal foot restraints are provided in fixed and portable forms to permit operational flexibility for habitation activities, whereas all external foot restraints are fixed to structure. Platform foot restraints, light-duty foot restraints, food table foot restraints, a footwell, and PGA foot restraints compose the fixed restraints. The PGA foot restraint is also provided in a portable form together with triangle shoes.

2.5.3.3.1 Platform Foot Restraints

Platform foot restraints are provided in the MDA and in the forward dome of the OWS to restrain the crewman in these heavy work load areas.

Two platforms in the MDA contain open grid and are deployable to facilitate efficient stowage and multi-use locations (figure 2.5.3-1). The open grid permits use of all portable restraints for the desired type of restraint. The MDA platform foot restraints are used mainly during the performance of experiments conducted in the MDA, during use of the ATM C&D panel and the STS instrument panel.

The OWS platform foot restraints, located under the water tanks in the OWS forward area, are composed of sections of modified grid platforms, rigidly mounted on the periphery of the tank wall (figure 2.5.3-1). Each platform section contains: (1) the hole pattern found in grid to facilitate the use of any of the portable restraints; (2) cleat receptacles, which accept the insertion of the triangle shoe for foot restraint; and (3) open slots to permit the insertion of the bare foot for convenient foot restraint or to serve as a hand restraint. The OWS platform foot restraints are used mainly to gain access to the D400 stowage compartments and while conducting procedures and maintenance on the water tanks.

2.5.3.3.2 Light-Duty Foot Restraints

Two pairs of light-duty foot restraints are permanently located on the WMC floor, one in front of the fecal/urine collector and one in front of the handwasher (figure 2.5.3-2). The foot restraints permit waste management activities, personal hygiene functions, and equipment servicing to be accomplished in an efficient manner. Each of the light-duty foot restraints contains a cushioned sole surface for comfort and is fitted with two velcro-lined straps to provide an adjustment to the individual crewman's foot envelope.

2.5.3.3.3 Food Table Foot Restraints

The base of the food table is allocated to restraining the crewmen's feet while the crewmen utilize the food table. Each of the three food table's eating stations is provided a set of permanently located foot restraints, which are composed of two adjustable foot restraint straps for bare foot restraint and two cleat receptacles to accept and retain the cleats of the triangle shoes (figure 2.5.3-2). The foot restraint straps are lined with velcro to permit adjustment to the individual crewman's foot envelope. In addition, at the toe-end of each foot restraint strap, a toe slot is provided on the floor-mounted base plate to permit the crewman to insert the forward section of his foot for additional stability.

2.5.3.3.4 Footwell

The stowage compartment door directly beneath the handwasher in the WMC contains a horizontal slot that serves as a footwell to accept and retain bare feet inserted into the slot (figure 2.5.3-2). The crewman occupies this position when hairbrushing and nail clipping functions are to be conducted directly beneath the ceiling-mounted intake of the WMC fan. In addition, this positions the crewman in front of the mirror on stowage compartment H830 door to facilitate the accomplishment of these personal hygiene functions.

2.5.3.3.5 PGA Foot Restraints

Four PGA foot restraints are permanently located on the exterior of the SWS to restrain the suited crewmen during EVA while performing two-handed tasks at the EVA workstations. A PGA foot restraint is located at the FAS workstation, center workstation, transfer workstation and sun end workstation. The PGA foot restraint accepts and retains the PGA boots through use of a toe-bar and a heel fitting. Heel clips, which are an integral part of the PGA boots, engage under the foot restraint heel fittings to provide rigid PGA boot restraint.

2.5.3.3.6 Portable PGA Foot Restraints

Two portable PGA foot restraints are provided for use on the OWS forward compartment floor grid as a restraining mechanism for the crewman while he is donning and doffing his spacesuit or for spacesuit restraint during suit drying operations. The foot restraint is as described in paragraph 2.5.3.3.5, with additional provisions to facilitate its portability. A quick-release fastener is located at the rear of the base plate to permit easy installation and removal of the restraint from the grid surface (figure 2.5.3-2). Two grid clips fitted to the underside of the base plate positively capture the grid surface upon installation to provide rigid engagement of the foot restraint to the grid. The two portable foot restraints are launch secured to the OWS forward compartment floor grid. For use during contingency modes, the foot restraints may be carried about the SWS to aid in accomplishing repair/corrective action tasks while the crewman is suited.

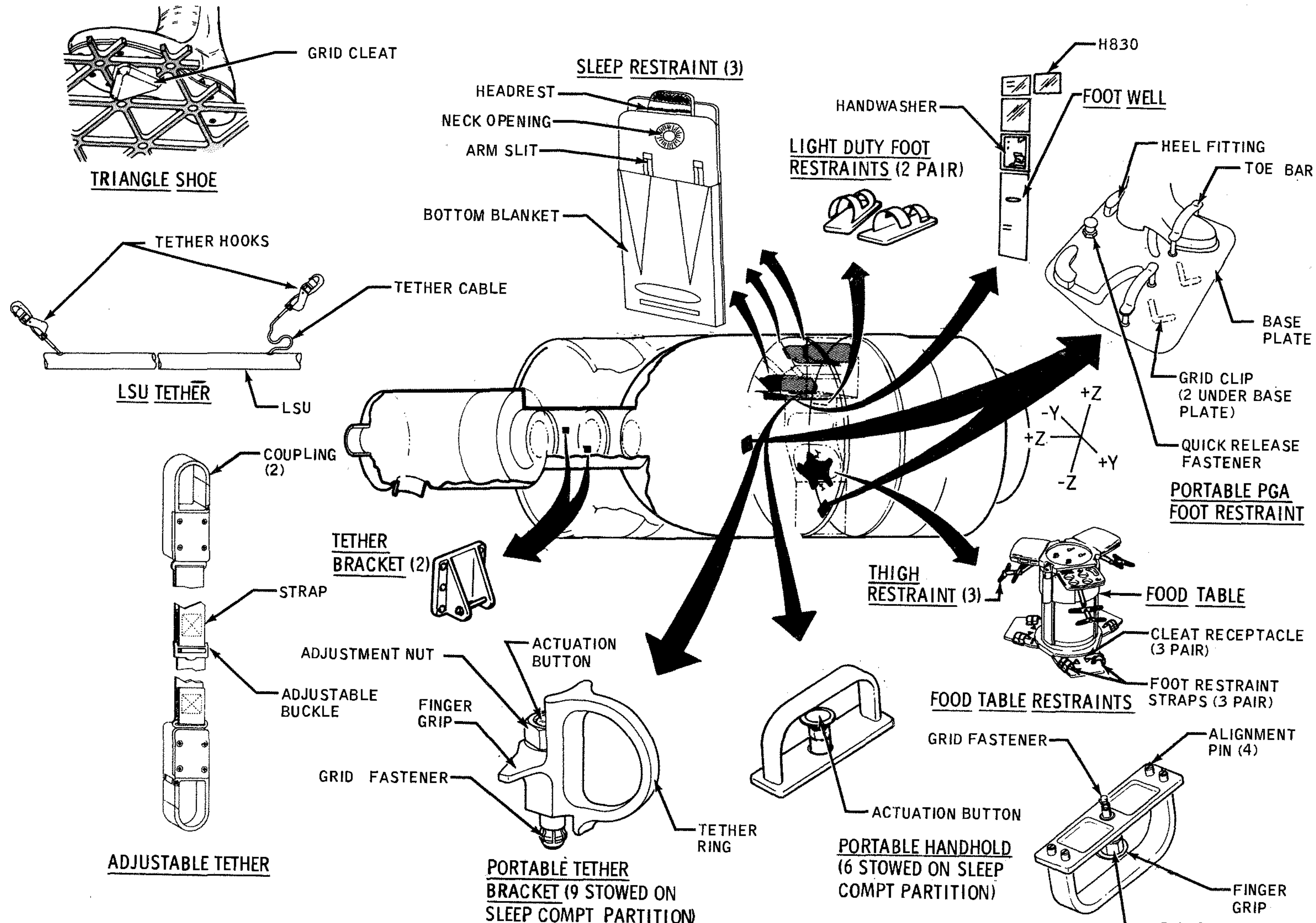


Figure 2.5.3-2 Crewman Restraints - Internal

2.5.3.3.7 Triangle Shoes

One pair of custom-fitted, low-quarter, triangle shoes are provided to each crewman for use as a foot restraint on grid-type surfaces (figure 2.5.3-2). A triangular grid cleat with an integral engage/disengage mechanism is fitted to the sole of each shoe. The grid cleat can be inserted into the triangular cutouts in open grid or into the cleat receptacles located on platform foot restraints and food table foot restraints. Once the cleat is inserted, the shoe is rotated slightly to engage the cleat onto the underside of the attaching surface. The cleat is disengaged using the reverse action. Should the cleat fail, it is removable from the shoe through use of three screws accessed from inside the shoe. Replacement grid cleats are available from triangle shoes assigned to previous/subsequent mission crewmen. When replacing the grid cleat, care must be taken to insure that the interchange is performed with the same type shoe (right hand or left hand). If such precautions are not followed, the shoe will be fitted with a reverse-acting grid cleat. The triangle shoes for the SL-2 crew are launched in a stowage compartment in the crewman's sleep area. The remaining triangle shoe provisions are stowed in stowage compartments in the OWS forward dome. The triangle shoes are easily donned and doffed for daily wearing with the shirtsleeve clothing.

2.5.3.4 HANDRAILS

Internal handrails are provided throughout the interior of the SWS while external handrails are located on the AM, DA, and ATM. The handrail aids the crewman in translating across a surface and also provides a means of body stabilization while performing tasks in the immediate vicinity of the handrail. Handrail capability exists to translate to the internal extremes of the habitable modules. They are permanently located in those areas, internally and externally, where heavy traffic or task loading occurs. Handrails are flattened tubing with a typical cross-section of approximately 5/8 by 1 3/8 inches, are mounted approximately 2 1/4 inches above the surface, and provide a grasping surface for the bare hand or the spacesuit glove. All handrails are colored blue.

2.5.3.4.1 Internal Handrails

Internal handrails are mounted throughout the MDA, AM and OWS to permit the crewmen to translate through the SWS and to provide restraint while operating controls on the panels, performing maintenance, gaining access to stowed items, relocating equipment, and utilizing components of operational equipment (figure 2.5.3-3).

A firemans pole is provided for installation between the OWS hatch and the experiment compartment egress opening in the OWS forward compartment. The pole permits rapid translation through the forward compartment and is especially useful during an emergency egress from the crew quarters. Because of its rigidity, the pole permits torsional stability in free space while the crewman traverses its length with equipment in hand or when trying to maintain a desired orientation. The firemans pole is removable and can be rapidly broken down into four sections through use of its pin-lock joints. A stowage location against a stowage compartment in the OWS forward compartment is provided for the sections of the firemans pole. The pole is launched in this location and is deployed during SL-2 activation for immediate use to facilitate equipment transfer and relocation.

2.5.3.4.2 External Handrails

External handrails are mounted on the AM in the bay area outside the EVA hatch (EVA bay), the FAS area enclosing the EVA bay, the DA route leading to the ATM workstations (EVA "trail"), and the ATM workstations (figure 2.5.3-4). The crewmen utilize the handrails to facilitate transfer through the EVA hatch, to restrain themselves at a particular workstation, and to provide translation ability between the workstations. The external handrails are assigned alphanumeric designators as depicted in figure 2.5.3-4. These designators appear on the blue-colored handrails in aluminized paint and are used for reference purposes when coordinating and communicating EVA procedures between crewmen or with the ground.

The external handrail F-5, adjacent to the EVA hatch, doubles as a foot restraint for the crewman. The crewman inserts his spacesuit boot under the F-5 handrail for foot restraint to perform contingency EVA tasks.

2.5.3.5 HANDHOLDS

Handholds in the SWS consist of fixed and portable handholds that permit body restraint and orientation while the crewmen are performing tasks. Fixed handholds are permanently installed aids located in heavily utilized areas in the habitable modules and permit astronaut stabilization while performing specific mission tasks and one-handed work activities. Portable handholds provide restraint anywhere on a grid surface, as required by the crew, and are intended for use in those areas where light task loading occurs or where the use rate is insufficient to justify permanent installation. Both types of handholds are colored blue.

2.5.3.5.1 Fixed Handholds

Handholds are permanently fixed to structure throughout the SWS. They are located in the vicinity of operational equipment in areas where handrails are not required either because of restricted space or where there is no concern for mobility provisions (figure 2.5.3-3). The fixed handholds are shorter than handrails and readily adapt to direct mounting on pieces of operational equipment. Fixed handholds are used to facilitate hatch movement and for restraint while accessing stowed items or while operating controls.

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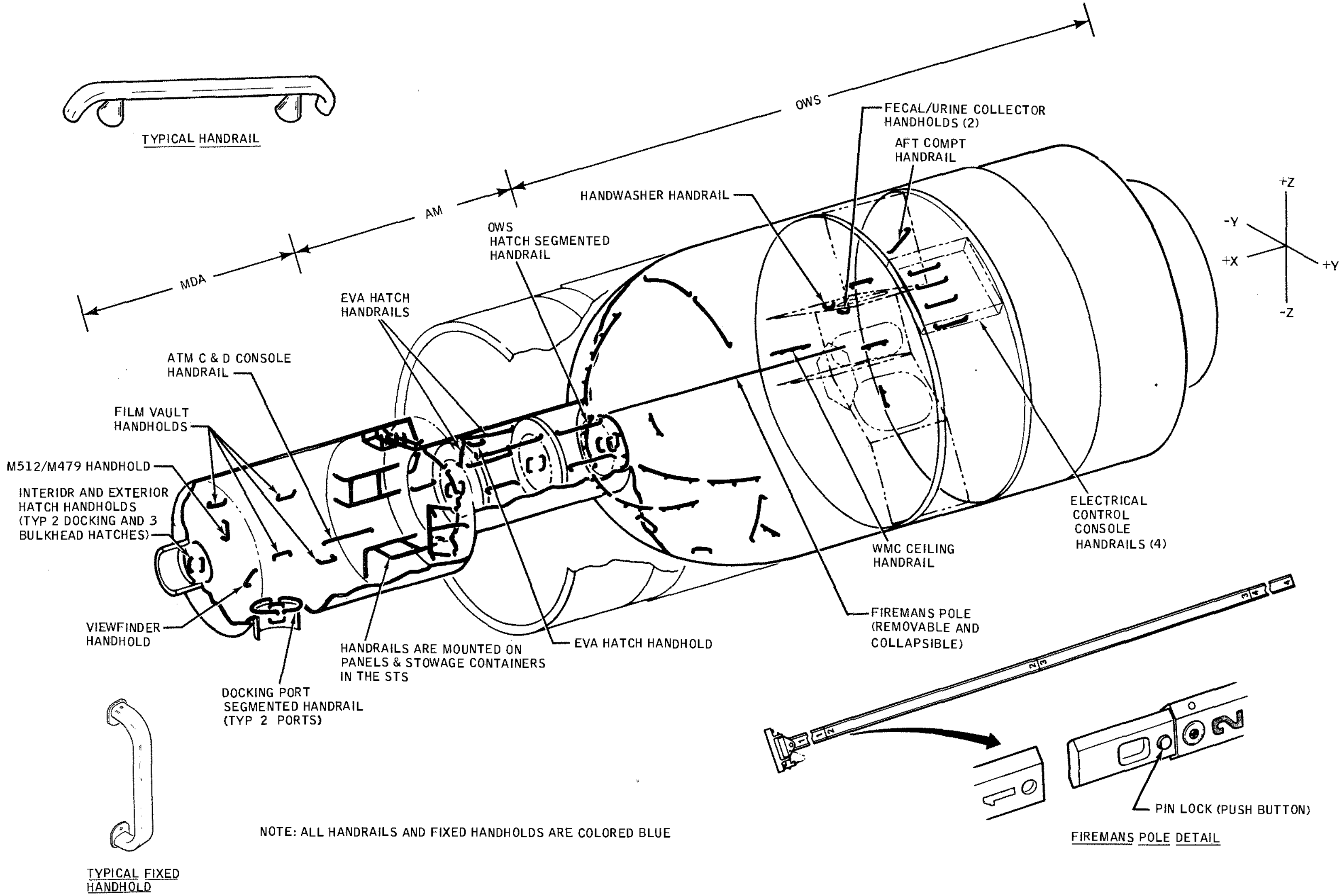


Figure 2.5.3-3 Fixed Crewman Hand Restraints - Internal

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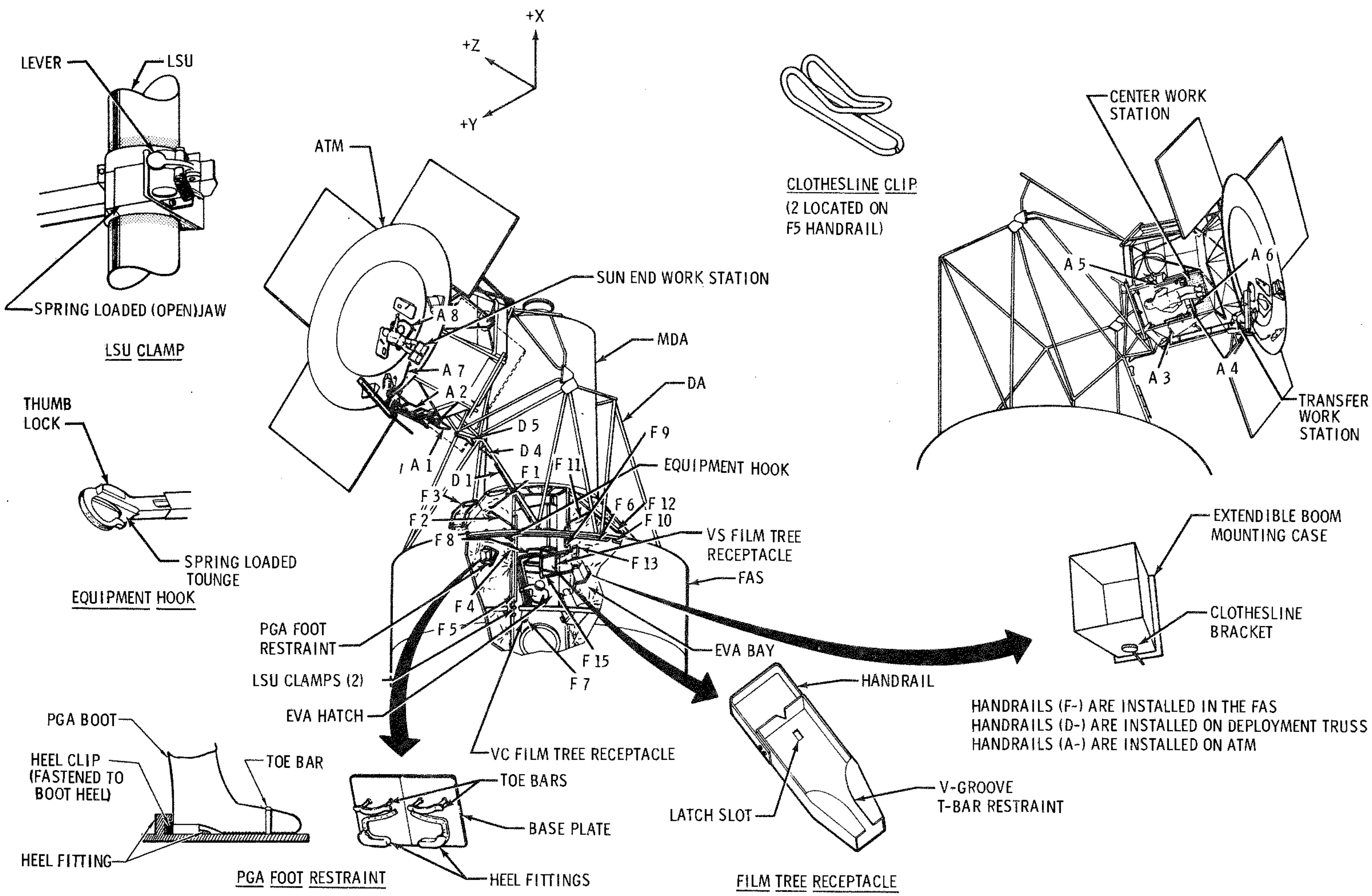


Figure 2.5.3-4 External Restraints and Mobility Aids

2.5.3.5.2 Portable Handholds

Six portable handholds are supplied that attach to grid provisions in the SWS, and provide a hand restraint for the crewman. The portable handholds can be used and operated with the gloved or bare hand. An actuation button is utilized to operate a quick-release grid fastener to attach or detach the unit from the circular hole pattern in the grid (figure 2.5.3-2). A visual indication of positive engagement of the unit in the grid hole is provided on the handhold by viewing the position of the button in its housing. The actuation button is depressed to engage the handhold into the grid. Positive engagement is attained when the actuation button is flush with the finger grip. Four alignment pins (two at each handhold underside extremity) grasp the grid pattern and provide handhold rotational restraint and even load distribution on the grid. A hexagonal adjustment nut is located under the finger grip and may be rotated by hand to tighten the handhold against the mounting surface for additional rigidity. The portable handholds are temporarily stowed in the grid surface on the sleep compartment entrance partition until required for use.

2.5.3.6 TETHERING DEVICES

Tethering devices are provided to facilitate a means of return to the SWS structure while moving about in large open areas. For these purposes, a tether is provided on the life support umbilical (LSU) and tether brackets are supplied in both fixed and portable forms to secure the tether to the SWS structure. In addition, an adjustable tether is provided for use mainly in the OWS as a mobility aid in the forward area.

2.5.3.6.1 LSU Tether

When each crewman wears an LSU either during EVA or during suited IVA operations, he is tethered through use of an LSU tether, which is an integral part of the LSU (figure 2.5.3-2). The LSU tether is 60-feet long and is composed of a steel cable fitted with two quick-release tether hooks, one that attaches to the crewman and one that attaches to a tether bracket. The LSU tether not only restricts the crewman to a maximum operating distance from the SWS structure but also assures that undue stresses are not transmitted to the the electrical, oxygen, and water lines contained within the LSU.

2.5.3.6.2 Tether Bracket

Two tether brackets are permanently located in the lock compartment, one immediately adjacent to each EVA control panel (figure 2.5.3-2). The tether brackets are utilized by the crewmen during EVA or during suited IVA to attach the LSU tether hook.

2.5.3.6.3 Portable Tether Bracket

Portable tether brackets attach to the grid provisions in the SWS and provide a convenient attach point for the LSU tether during suited IVA operations. The bracket can be operated with the gloved or bare hand. An actuation button is utilized to operate a quick-release grid fastener to attach or detach the unit from the circular hole pattern in the grid (figure 2.5.3-2). Operation of the grid fastener and its adjustment nut is as described for the portable handhold.

Nine portable tether brackets are supplied and are temporarily stowed in the grid surface on the sleep compartment entrance partition until required for use.

2.5.3.6.4 Adjustable Tether

Two adjustable tethers are provided for location mainly in the OWS forward area for use as a mobility aid to supplement the firemans pole. The adjustable tether is a 20-foot (maximum length) strap, which can be adjusted to a desired length through use of a buckle (figure 2.5.3-5). Each end of the strap is fitted with a quick-release coupling that will connect to open grid, handrails, handholds, or convenient structure. Each coupling is spring loaded closed to permit positive capture of the attaching structure. Both adjustable tethers are launched deployed between a handrail on the OWS forward dome and the OWS forward compartment floor grid to assist the crewmen in translating through the OWS forward area during SWS activation. The adjustable tethers may be removed when not in use and stowed in an OWS stowage compartment.

2.5.3.7 THIGH RESTRAINTS

Three thigh restraints are located at the food table, one at each eating station. The thigh restraint is used to provide a comfortable and efficient means of stabilizing the crewman in a semi-seated position while he is occupying the eating station (figure 2.5.3-2). The thigh restraint is frictioned hinged in two places: (1) at the table to permit the selection of the desired elevation for out-of-the-way stowage and to permit opening of the food table pedestal access doors, and (2) at the mid-point of the thigh restraint to provide the selection of the desired seating position. The thigh restraint is fitted with a slide-adjustment to permit its conformation to the size of the crewman's thighs. The thigh restraints are used in conjunction with the food table foot restraints for use during food management and off-duty activities. The thigh restraints are launched, secured against the food table pedestal with a strap-type launch restraint, which is removed during SL-2 activation.

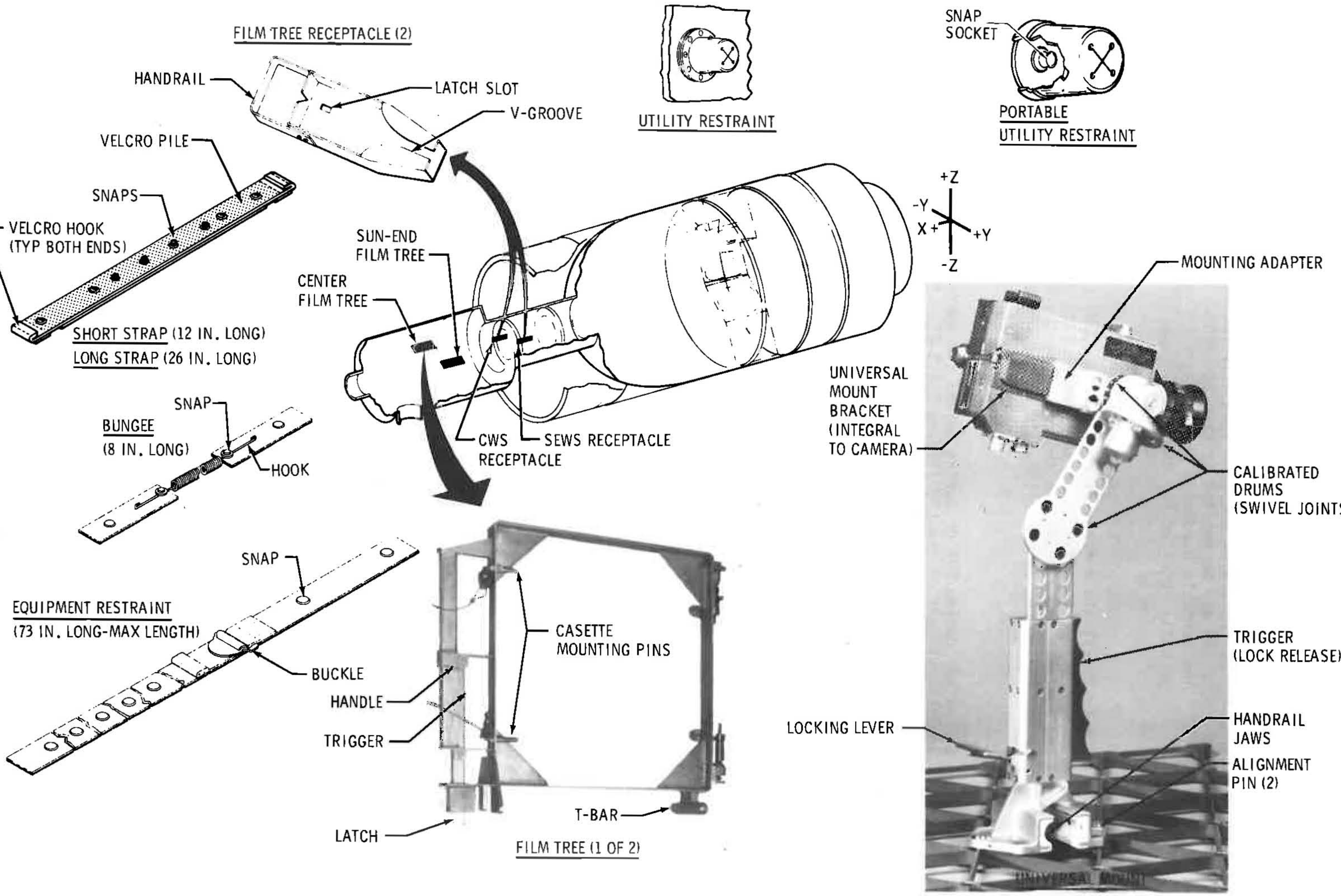


Figure 2.5.3-5 Equipment Restraints - Internal

2.5.3.8 SLEEP RESTRAINTS

The sleep restraints are provided for thermal comfort and body restraint while the crewman is sleeping. Each of the three sleep areas within the sleep compartment contain a sleep restraint, vertically mounted on one of the sleep area's partitions (figure 2.5.3-2). The sleep restraints are replaced every 14 days and are disposed of through the trash disposal airlock. Replacement sleep restraints are stowed in sleep area stowage compartments.

Each sleep restraint is easily removed from a sleep restraint frame. The frame is strapped to the floor and ceiling grid to provide rigidity for the sleep restraint. The sleep restraint contains a replaceable headrest and blankets with two expandable arm slits and neck opening. The neck opening is used for ingress/egress and for emergency egress from the sleep restraint. The sleep restraints for the first 14 days of the SL-2 mission are launched installed in the sleep areas.

2.5.3.9 WASTE MANAGEMENT RESTRAINTS

The fecal/urine collector in the WMC is fitted with an adjustable lap restraint, to provide whole body restraint while the crewman is seated on the fecal collector. The strap-type lap restraint is adjustable to any desired length for comfortable restraint through use of a velcro lining. One end of the lap restraint is attached to a ring adjacent to the fecal collector and is fitted with a spring. When the lap belt is in the using position on the crewman, the spring permits the crewman to perform the wiping function while being securely restrained. A quick-release spring clip is attached to the other end of the lap restraint and may be positioned in one of two locations: (1) to a ring adjacent to the fecal collector for use; or (2) snapped in a ring at the top of the fecal/urine collector cabinet for convenient stowage when not in use. However, the lap restraint in the stowage position interferes with the opening of the fecal/urine collector access door when blower or filter access is required. Hence, the restraint must be temporarily connected into the using position when utilizing the access door. For activities associated with waste collection, the crewman will utilize the lap restraint in conjunction with the two handholds located on the fecal/urine collector.

2.5.3.10 STRAPS

Three types of straps are used to restrain small and large articles to the SWS structure: short straps, long straps and equipment restraints. These straps are portable and permit the crewmen to temporarily restrain and/or stow equipment for convenient access while performing work tasks.

2.5.3.10.1 Short Straps

Sixty-four short straps are launched in OWS stowage compartments. Some of these short straps are wrapped around the long power cables and communication cables stowed in the OWS, as the crewmen will require the use of the short strap to restrain the cable when it is in use. The short straps are constructed of a beta fabric webbing which is 12 inches long and one inch wide (figure 2.5.3-5). The webbing is faced on one side with velcro pile while each end contains velcro hook. Both sides of the strap are fitted with four snap studs and four snap sockets. These provisions allow the strap to be secured about a structure or to structure-mounted snaps and velcro to conform to the envelope of the restrained item. The short straps will be used to temporarily restrain small articles such as cables, tools, books, and replacement parts.

2.5.3.10.2 Long Straps

Twenty long straps are launched in an experiment compartment for ready accessibility. The long strap is 26 inches long and 1 inch wide and is constructed similar to the short strap but contains four additional snap studs (figure 2.5.3-5). The long straps will be used to temporarily restrain moderately sized equipment such as the vacuum cleaner, food trays, and replacement parts.

2.5.3.10.3 Equipment Restraints

Eighteen equipment restraints are launched in an experiment compartment stowage compartment for ready accessibility. The equipment restraint is a webbed, beta fabric strap, 73 inches long and 1 inch wide (figure 2.5.3-5). The end of the restraint is fitted with a snap stud and a snap socket to permit the end of the restraint to be securely looped and fastened about a handrail, handhold, or open grid. The length of the webbed strap is adjustable to a length of 73 inches through use of a buckle to permit adjustment to the envelope of the restrained item. The equipment restraint will be used to temporarily restrain large pieces of equipment such as urine return containers and replacement parts.

2.5.3.11 BUNGEE

Twenty portable bungees are launched in an experiment compartment stowage compartment and are used to restrain reference material such as books or papers. The bungee is 8 inches long and is constructed of a coil spring fitted on both ends with a hook (figure 2.5.3-5). The hook may be attached to holes or joints on SWS stowage compartment doors to permit retention of the reference material or small items against a surface for convenient temporary stowage while performing work tasks. Maximum extension of the bungee is 12 inches. Bungees are also installed in the flight data files and in the galley.

2.5.3.12 UTILITY RESTRAINTS

The utility restraint is a fluorocarbon rubber cup, supplied in two forms: fixed to structure and portable (figure 2.5.3-5). The cup contains a cruciform slit into which small flexible items may be inserted for temporary restraint. The interior of the cup is rounded to facilitate cleaning to prevent microbiological growth.

2.5.3.12.1 Fixed Utility Restraints

Utility restraints are provided throughout the OWS permanently fixed to structure near food preparation areas, in the WMC, in the sleep areas, and near articles of operational equipment. The utility restraints are used to retain towels, washcloths, tissues, and clothing while they are being temporarily stowed for drying or for ready access.

2.5.3.12.2 Portable Utility Restraints

Six portable utility restraints are stowed in an experiment compartment stowage compartment. The portable utility restraint is backed with an aluminum disc, fitted with a snap socket (figure 2.5.3-5). The snap socket will mate with the snap studs located throughout the SWS for retention of the portable utility restraint in a convenient location. The restraints will be used to temporarily retain tissues, towels, and washcloths near the using area for ready access.

2.5.3.13 UNIVERSAL MOUNT

Twelve universal mounts are stowed in OWS forward compartment and experiment compartment stowage compartments. The universal mount is used as an attachable/detachable portable equipment mount for readily securing equipment to convenient structure. The base of the universal mount contains two alignment pins to permit its installation in the grid hole pattern or in specially located hole patterns such as on the platform foot restraint in the OWS (figure 2.5.3-5). In addition, handrail jaws are provided at its base to permit the installation of the mount on a convenient handrail or handhold. The alignment pins and handrail jaws are movable to assure ease of installation and to permit a firm capture of the mounting structure. A trigger, when compressed, separates the alignment pins and handrail jaws for rapid installation and removal of the mount. A locking lever, when depressed, provides a firm grasp of the structure until released by trigger action. A mounting adapter on the universal mount provides an easy installation/removal mechanism for the articles of portable equipment. Each article contains a permanently installed universal mount bracket, which accepts the mounting adapter through a sliding action and serves as the point of restraint. The universal mount can swivel the equipment through two axes: pitch and yaw. Three calibrated drums with markings in degrees provide the swivel joints with a reference for desired pointing of the equipment. The three calibrated scales provide coarse pitch pointing, fine pitch pointing, and yaw pointing. The universal mount will be used with the portable lights, high intensity lights, food trays, hand-held cameras, tool boxes and their drawers, repair kit and its drawers, and IMSS work table.

2.5.3.14 LSU CLAMPS

Two LSU clamps are located in the EVA bay, adjacent to the EVA hatch and facilitate life support umbilical management during EVA (figure 2.5.3-4). The clamp is made up of two jaws: one fixed, the other movable. The movable jaw is spring-loaded open and contains a lever to override the spring when LSU retention is desired. When not in use, the spring maintains the movable jaw in the open position for easy insertion of the umbilical. When the LSU is placed in the clamp, the crewman closes the spring-loaded jaw with the lever. In the event that the LSU experiences side loads due to a crewman's activity, the spring-loaded jaw will open, which frees the LSU and prevents possible LSU damage due to its restraint in the clamp. The crewman may also operate the lever to release the LSU from the clamp. In addition, one LSU clamp is located at each ATM workstation (refer to SLOH/ATM for details).

2.5.3.15 CLOTHESLINE RESTRAINTS

Clothesline brackets and clothesline clips are mounted on the exterior of the SWS to restrain the clothesline when it is deployed to permit the operation of the clothesline and to provide temporary out-of-the-way restraint (paragraph 2.5.7).

2.5.3.15.1 Clothesline Brackets

The clothesline bracket is an eye-type restraint which provides for the installation of one end of the clothesline to permit contingency film transfer during EVA (figure 2.5.3-4). One clothesline bracket is permanently located adjacent to each of the two operational extendible booms in the EVA bay. Normally, one end of the clothesline is installed in each clothesline bracket in the EVA bay to simplify deployment procedures when the clothesline is required for use. Two clothesline brackets are also located on the ATM to permit restraint of the loose end of the deployed clothesline (refer to SLOH/ATM for details). To use the clothesline during contingency film transfer, one end must be installed in its clothesline bracket in the EVA bay and the other end must be connected to the clothesline bracket at the film receiving point on the ATM.

2.5.3.15.2 Clothesline Clips

Two clothesline clips are permanently located in the EVA bay, adjacent to the EVA hatch, and provide the crewman with a temporary out-of-the-way stowage of the clothesline when it is deployed for use (figure 2.5.3-4). One clip (for the sun end clothesline) and another (for the center clothesline) provide restraints for each clothesline to prevent its entanglement, by restraining the clothesline outside the operating envelope of the crewman in the EVA bay. The clothesline is easily inserted and removed from the clothesline clip.

2.5.3.16 EQUIPMENT HOOKS

An equipment hook is located adjacent to the EVA hatch in the EVA bay to provide a temporary out-of-the-way restraint for EVA equipment. A section of the equipment hook eye is spring-loaded to facilitate easy loading of the equipment into the hook. Once the equipment is placed in the hook, the eye is maintained closed through use of a thumb lock (figure 2.5.3-4). The thumb lock is used when equipment is inserted into the hook and when equipment removal is desired. Additional equipment hooks are also located at the ATM workstations (refer to SLOH/ATM for details).

2.5.3.17 FILM TREES

The film provisions for the ATM camera resupply are divided into center workstation film provisions and sun-end workstation film provisions. All of the film provisions destined for a particular workstation are grouped together and restrained in a single, portable device called a film tree (figure 2.5.3-5). The film tree contains mounting provisions for film cassettes and cameras for convenient restraint and access during the EVA transfer from the film vaults to the ATM. These mounting provisions are fitted with retractable pins for camera and film cassette restraint. The base of the film tree contains a T-bar to facilitate mounting in a film tree receptacle and contains a latch that permits positive engagement of the film tree in the film tree receptacle. The latch is operated through use of a trigger, located on the film tree handle. Two film trees are provided and are stowed on the wall structure in the MDA near the film vaults until required for use. The film trees are not interchangeable, since each is specially outfitted to accept only the film provisions for its particular workstation.

2.5.3.18 FILM TREE RECEPTACLES

To temporarily restrain the film trees both inside and outside the SWS, two film tree receptacles are permanently located in the lock compartment and two film tree receptacles are permanently located in the EVA bay (figures 2.5.3.-2 and -5). Each receptacle contains a V-groove for restraint of the film tree's T-bar and also contains a slot that engages the film tree latching mechanism. Each film tree receptacle, except the center workstation (CWS) film tree receptacle in the lock compartment, contains a handrail. The handrail is used by the crewman to aid in installing and removing the film tree from its receptacle. To install the film tree in the receptacle, the T-bar of the tree is fitted into the V-groove of the receptacle and pushed as far forward as possible. This action also forces the latching mechanism to engage into the latch slot on the receptacle. To remove the tree, the film tree trigger is actuated, which releases the latch and frees the tree to permit its removal. Additional film tree receptacles are located at the ATM workstations (refer to SLOH/ATM for details).

2.5.3.19 LCG HANGERS

Liquid cooling garment hangers are supplied for use in air drying the LCG's at the suit drying stations in the OWS (paragraph 2.5.7). The LCG hanger is a rigid, open triangular section that fits into the back and shoulder area of the LCG. A flexible strap fitted with snaps is connected to the triangular section to permit the LCG to be stretched while being air dried. The snaps are provided to secure the LCG hanger to convenient structure. Three LCG hangers are stowed in OWS forward dome stowage compartments until required for use. Each crewman will utilize one LCG hanger to dry his LCG in the OWS.

2.5.3.20 PGA HANGER STRAP

Pressure garment assembly hanger straps are supplied for use while the spacesuits are occupying the suit drying stations in the OWS (paragraph 2.5.7). The PGA hanger strap is a flexible webbed strap, fitted on one end with a coupling and on the other end with snaps. The coupling permits the strap to be secured to the PGA-mounted D-ring while the snaps permit the strap to be attached to convenient structure. The strap also contains a buckle to allow adjustment of its length to stretch the PGA for suit drying operations. Three PGA hanger straps are stowed with the LCG hanger in OWS forward dome stowage compartment until ready for use. Each crewman will utilize one PGA hanger strap to restrain his PGA at the suit drying stations.

2.5.3.21 VELCRO

Velcro pile is provided in "patch" form and is permanently installed on handrails, stowage compartments, structure, etc. throughout the SWS where work tasks will be conducted. They provide a restraining surface to which velcro-hook lined disposal bags, restraint straps, books, tools, etc. may be conveniently restrained for temporary stowage and/or use. In addition, a supply of velcro hook and pile in "patch" form with adhesive backing is provided in tool kit 2 for installation in those light-workload work areas where velcro capability does not exist.

2.5.3.22 SNAPS

Snap studs are located throughout the SWS on stowage compartment doors, partitions, structure, handrails, etc. and are configured in a standard snap pattern which accomodates all SWS and CSM provisions that contain snap sockets (figure 2.5.3-6). In addition, snap sockets and studs are provided in tool kit 2 for use while restraining snap-fitted items in the grid pattern.

2.5.4 <u>LIGHTING SYSTEM</u>

2.5.4.1 SWS ILLUMINATION

The SWS lighting system is used for orbital operations conducted external to the SWS and to support daily habitational activities.

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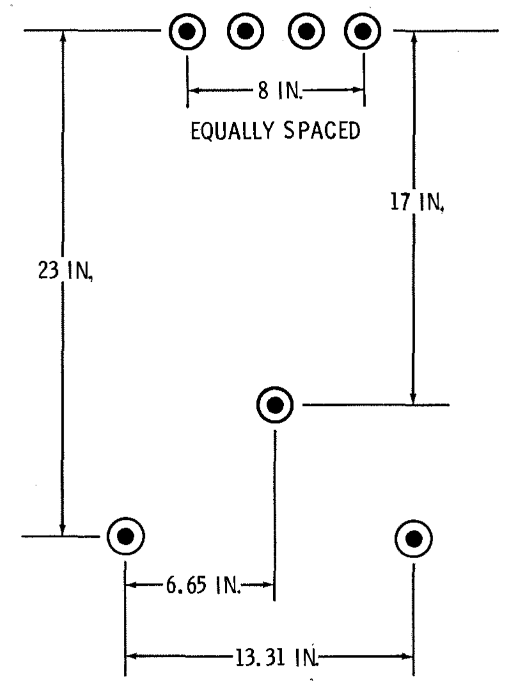


Figure 2.5.3-6 SWS Snap Pattern

2.5.4.2 SWS EXTERNAL LIGHTING

External lighting on the SWS aids the crewmembers: (1) during visual acquisition of the SWS from the CSM using a system of SWS mounted tracking lights (2) during CSM/SWS rendezvous docking through use of the SWS docking lights and (3) during EVA to provide EVA "trail" illumination using EVA lights.

2.5.4.2.1 Tracking Lights

The SWS has two, high-intensity, flashing tracking light systems to permit CSM crews to visually acquire, track, and if necessary, navigate to the SWS. With the tracking lights operating, the SWS is visible from the CSM, through the sextant, as a navigable star (third magnitude) at a trailing distance of 629 NM.

Four tracking lights, located on the ATM truss on the "Y" axis, form a cone of strobing illumination about the "X" axis with the beam directed in the +X direction (figure 2.5.4-1). Two of the four tracking lights form a primary tracking light system, one on the +Y axis and one of the -Y axis. The remaining two tracking lights form a secondary tracking light system with its lights located below the primary tracking lights on the ATM truss. The tracking light systems are independent, with the secondary tracking lights used only if a primary system fails.

A LIGHTING, TRACKING [ON-OFF-CMD] switch is provided on panel 207 to provide control of the tracking lights (figure 2.5.4-2). During SWS uninhabited periods, the switch will be in the CMD position, which permits the ground to select either the primary or the secondary tracking light system to initiate or to terminate tracking light operation, using DCS commands. Direct onboard control of both systems simultaneously, is provided by the ON and OFF switch positions; this mode is for rescue purposes only. In addition, the time reference system may be used through DCS commands to turn off the tracking lights at a predetermined time when the CSM is predicted to be within 1 NM of the SWS. At this point it will be necessary for the crew to begin aligning the CSM with the SWS, using the docking lights without interference from the high-intensity tracking lights.

An automatic switchover logic senses the flashing of the selected tracking light system (figure 2.5.4-2). If a tracking light or the entire system fails during its operation, the remaining system will be automatically activated. The ground enables the operation of the automatic switchover logic through selection of the primary tracking light system. If the primary system fails, the automatic switchover logic will activate the secondary tracking lights and turn off the primary tracking lights. If the secondary system also fails, the automatic switchover logic activates the primary system, allowing both systems to operate simultaneously. The automatic switchover logic may be disabled by DCS command.

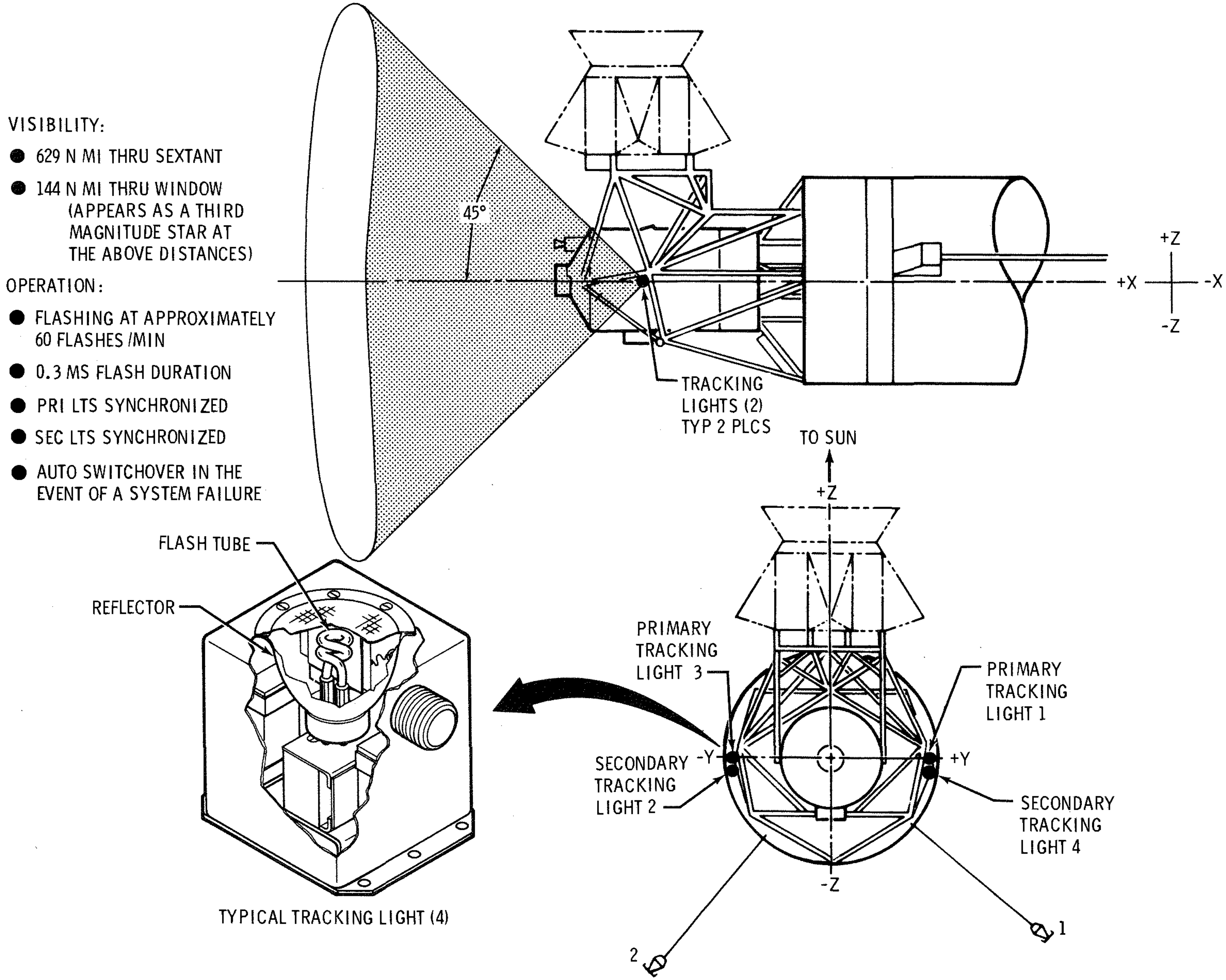


Figure 2.5.4-1 Tracking Lights

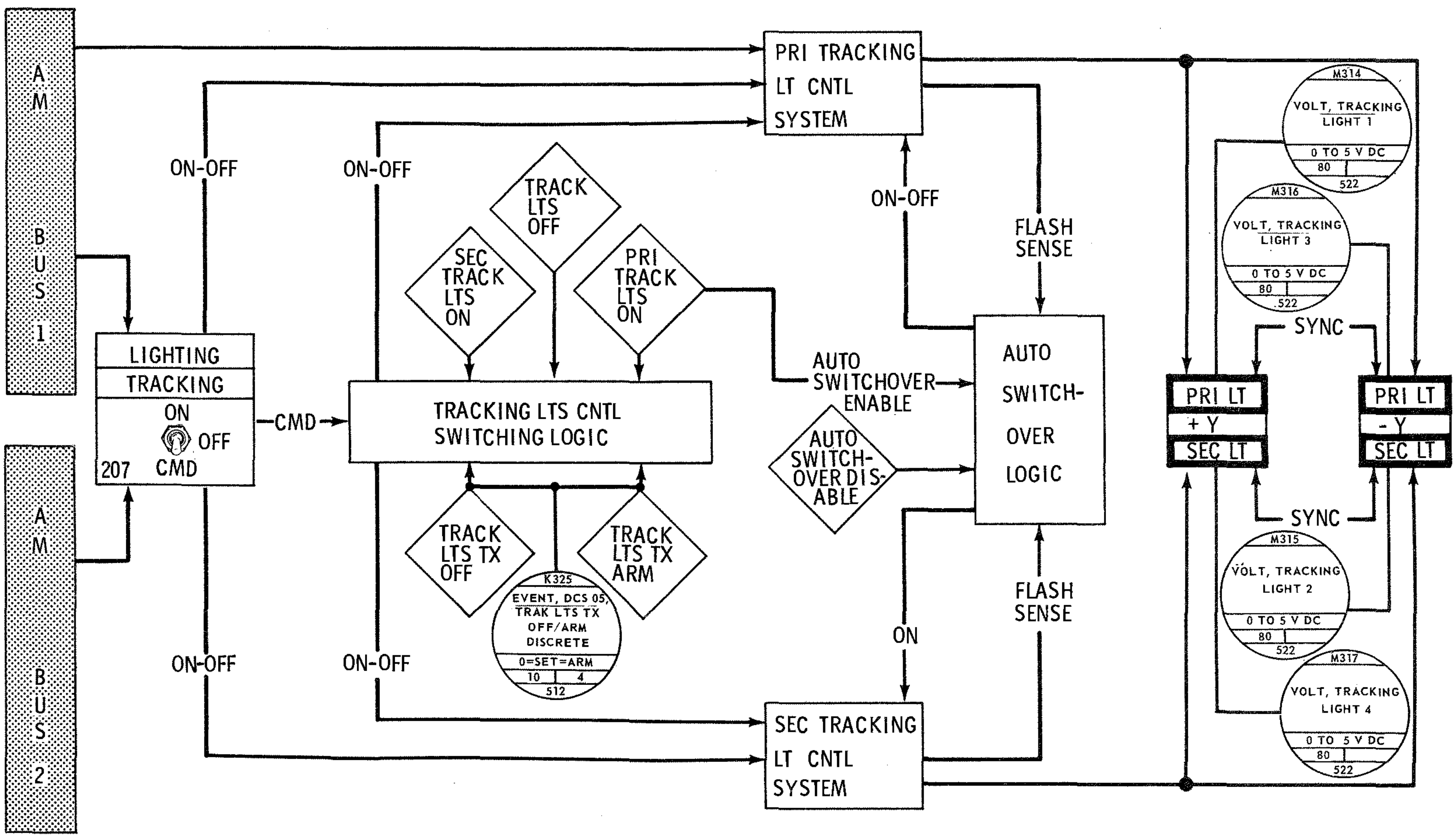


Figure 2.5.4-2 Tracking Lights -- Functional Diagram

The primary tracking lights are synchronized during their operation as are the secondary tracking lights; however, the primary and secondary systems are not synchronized to each other. Each tracking light contains a telemetered measurement that indicates the strobing action of the light.

2.5.4.2.2 Docking Lights

The SWS has a system of colored, low-intensity docking lights, placed so as to provide gross range and attitude information to the CSM crew during CSM/SWS rendezvous and predocking maneuvers.

The docking lights are located on the MDA, on the AM, and discone antennae as follows (figure 2.5.4-3):

a) Two 20-watt, incandescent, red lights, one on the MDA conical section and one on the ATM deployment assembly truss on the +Y axis.

b) Two 20-watt, incandescent, green lights, one on the MDA conical section and one on the ATM deployment assembly truss on the -Y axis.

c) Two 20-watt, incandescent, white lights, one on the MDA conical section and one on the AM D024 sample panel handrail on the +Z axis.

d) Two 20-watt, incandescent, amber lights, one on the MDA conical section and one on the ATM deployment assembly truss on the -Z axis.

e) Two lights, each with four, 0.7-watt, incandescent, white lights, are on each discone antenna tip.

The colored docking lights on the MDA and AM are located with each color for one particular axis (figure 2.5.4-3). This arrangement permits alignment of the MDA-mounted colored docking light with the corresponding colored docking light on the AM during rendezvous and docking. The crew will orient the CSM and align it with the SWS "X" axis by "matching up" the colored docking lights. The docking lights will be used from a trailing distance of 1 NM to a trailing distance of 200 feet. The docking lights on each discone antenna, mark the location of the discone antenna tip to prevent collision.

The docking lights are divided into two operational groups, group 1 and group 2 (figure 2.5.4-4). The colors are grouped so that if a given group fails, the remaining group will still permit CSM orientation and alignment with the SWS. A LIGHTING, DOCKING [ON-OFF-CMD] switch is provided on panel 207 to control the docking lights. The switch will be in the CMD position during uninhabited periods to permit ground control of the docking lights. Direct onboard control of both docking light groups simultaneously is provided by the ON and OFF switch positions; this mode is for rescue purposes only. Direct DCS control (on and off) of the docking lights is provided by groups 1 and 2 on-and-off DCS commands. Both groups are used during CSM/SWS rendezvous and docking. Event indicators are telemetered to indicate the on or off state of each docking light group.

The white docking light mounted on the D024 sample panel handrail on the AM is also used as an AM EVA light. Control of this light for EVA is supplied by the LIGHTING, EVA, AM [ON-OFF] switch on panel 316.

2.5.4.2.3 EVA Lights

EVA lighting, on the FAS, DA, and ATM, assists the crewmen in tasks at the various EVA workstations and illuminates the EVA "trail" (figure 2.5.4-5). The EVA lights will be used during each of the six EVA's.

The EVA lights, located on the SWS exterior, provide the necessary illumination as follows (figure 2.5.4-5):

a) Five AM EVA lights are located around the FAS workstation: four are mounted adjacent to the EVA hatch and the remaining light is mounted on the D024 sample panel handrail. AM EVA lights provide nondirectional lighting of the FAS workstation.

b) Eight DA EVA lights are located around the FAS workstation and along the EVA "trail": four are mounted on the FAS and four on the DA. DA EVA lights serve to illuminate the EVA "trail" with directional lighting.

c) Twelve ATM EVA lights are dispersed at the three workstations on the ATM: five surround the center workstation, one at the transfer workstation, four flank the sun end workstation, and one is inside each camera door at the sun end workstation. With the exception of the camera door lights, ATM EVA lights provide nondirectional lighting of the ATM workstations. The camera door lights provide internal lighting of the area behind the camera door for camera retrieval and reloading.

The EVA lights are controlled by (figure 2.5.4-6) three switches in the lock compartment on panel 316: the LIGHTING, EVA, AM [ON-OFF] switch controls the five AM EVA lights; the LIGHTING, EVA, DA [ON-OFF] switch controls the DA EVA lights; and the LIGHTING, EVA, ATM [ON-OFF] switch controls the ATM EVA lights (figure 2.5.5-6). However, backup "off" control of the ATM EVA lights is provided by ground commands to assure that the ATM EVA lights are turned off inside the sun end workstation camera doors.

With the exception of the ATM EVA lights, the loss of a single bus will not seriously affect the illumination of a given area. In the case of the ATM EVA lights, DCS commands, coupled with onboard switch control, serves to turn the ATM EVA lights on or off using a single bus.

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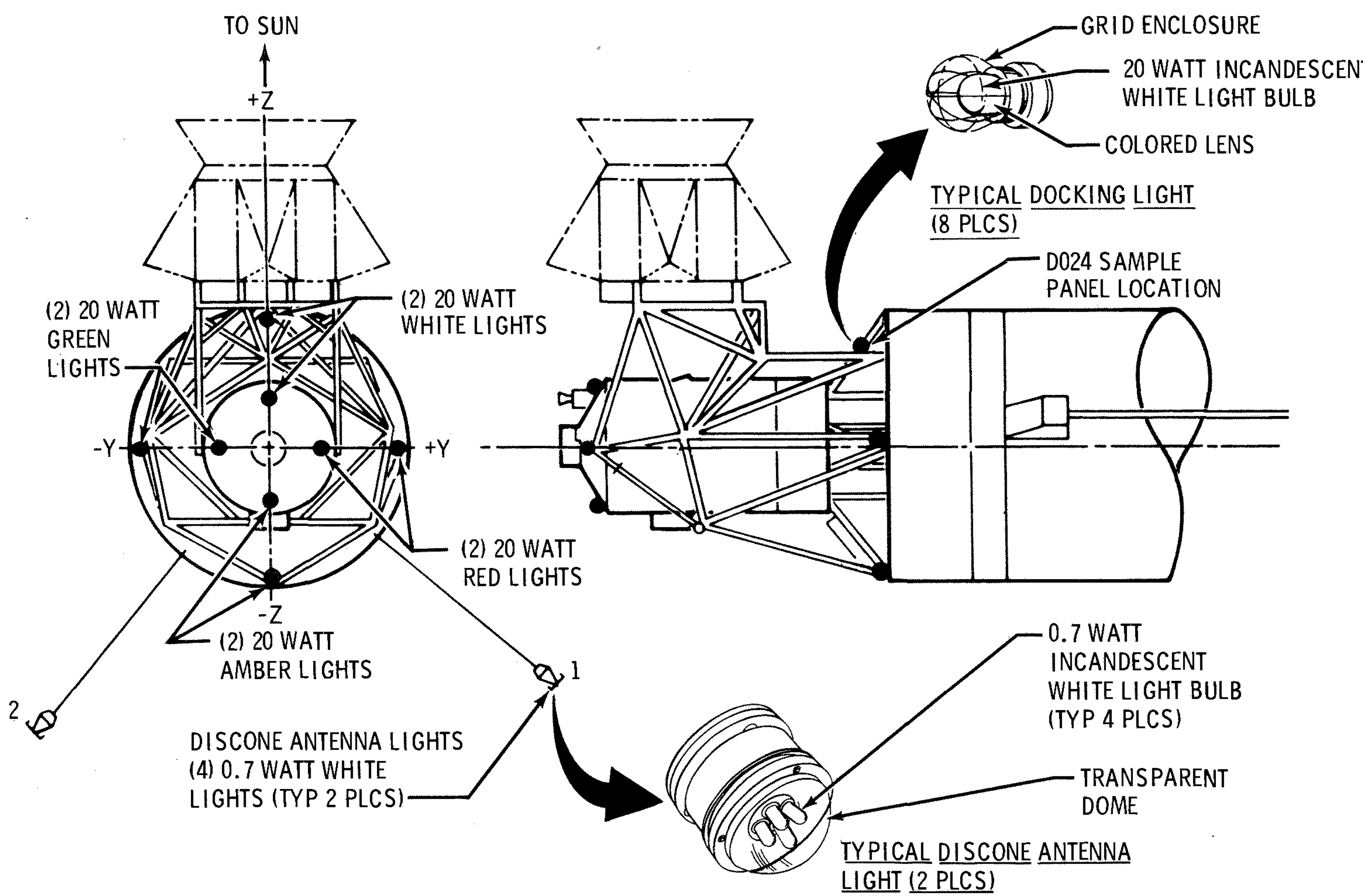


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Figure 2.5.4-3 Docking Lights

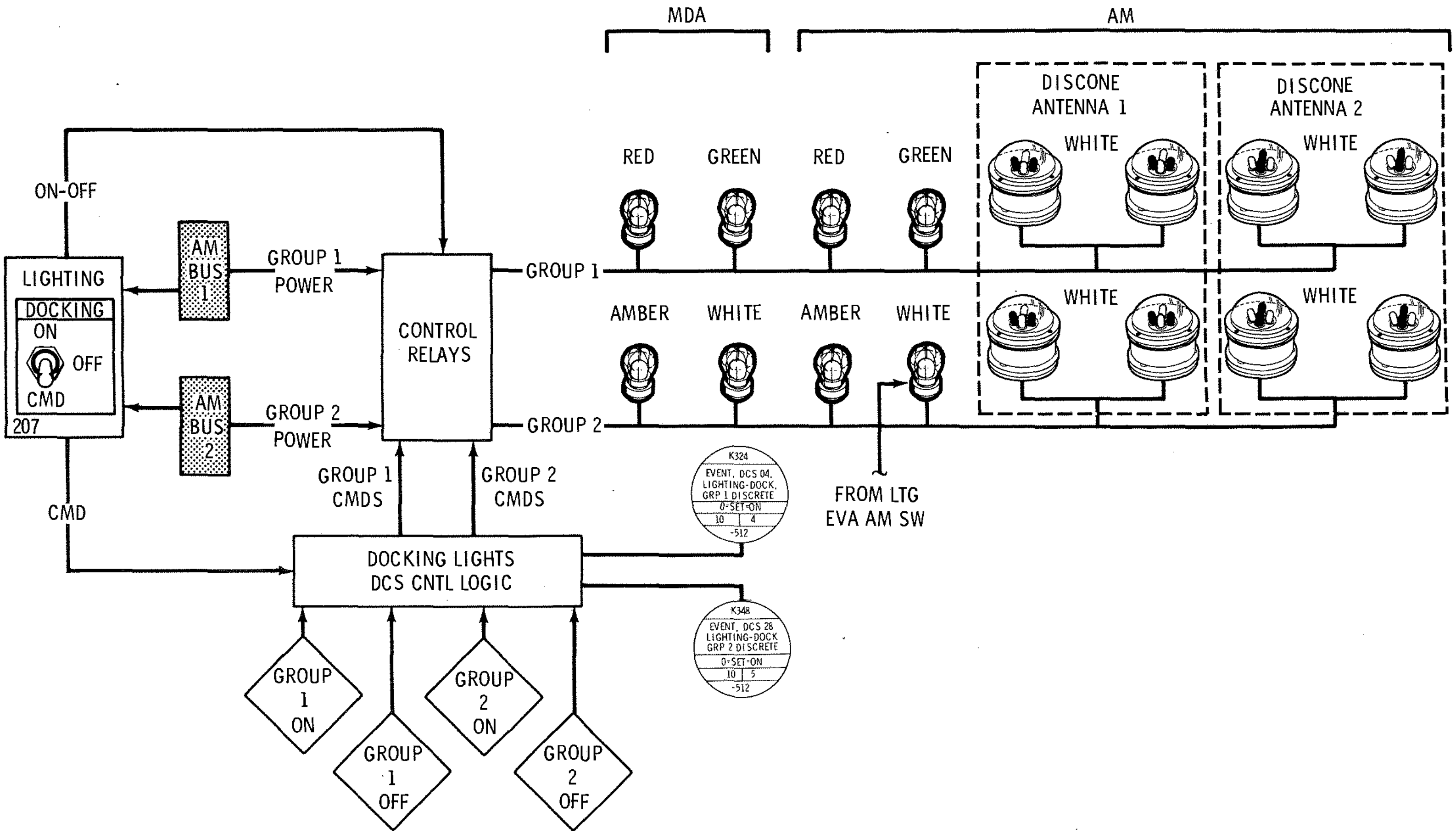


Figure 2.5.4-4 Docking Lights -- Functional Diagram

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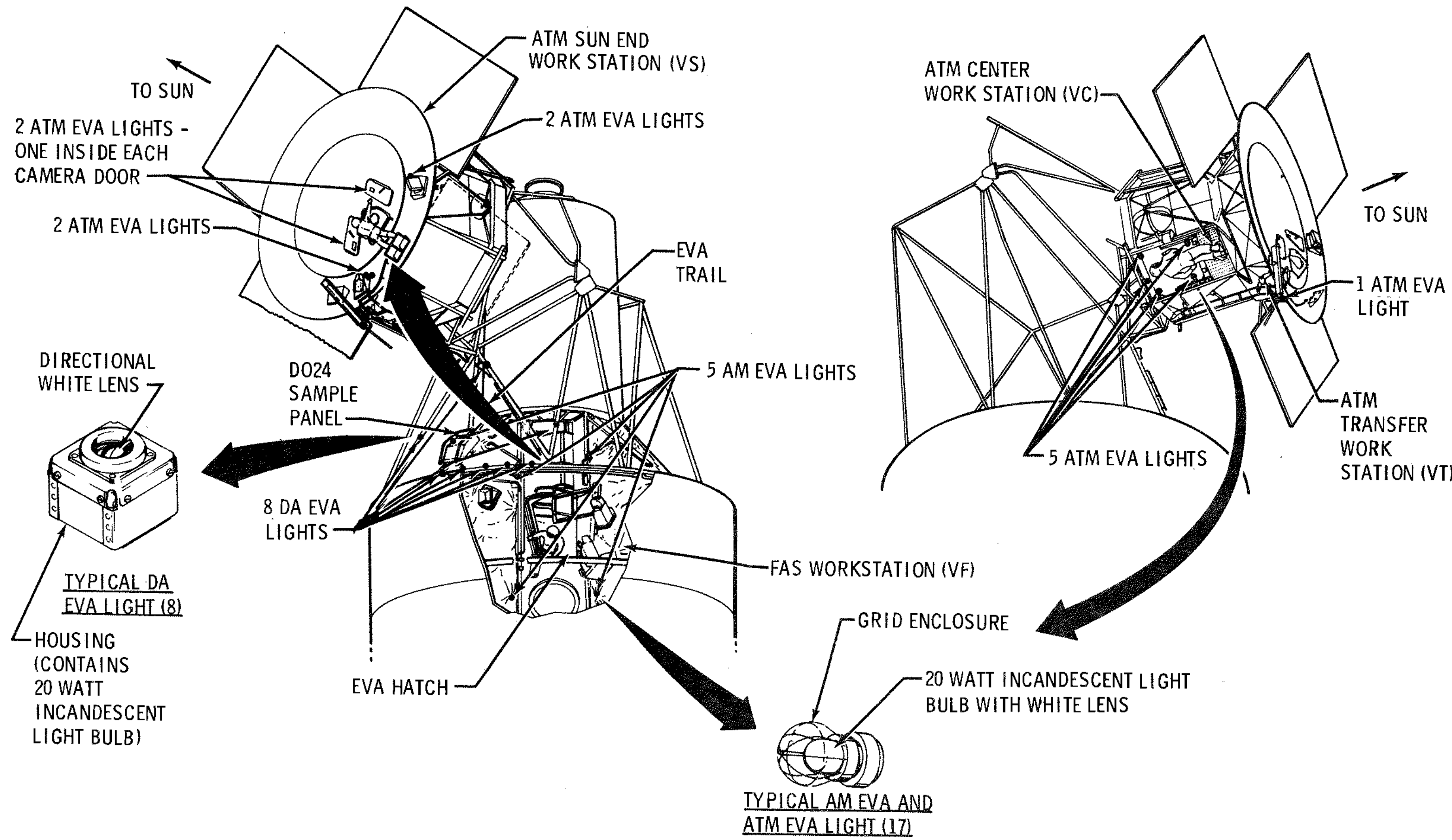



Figure 2.5.4-5 EVA Lighting

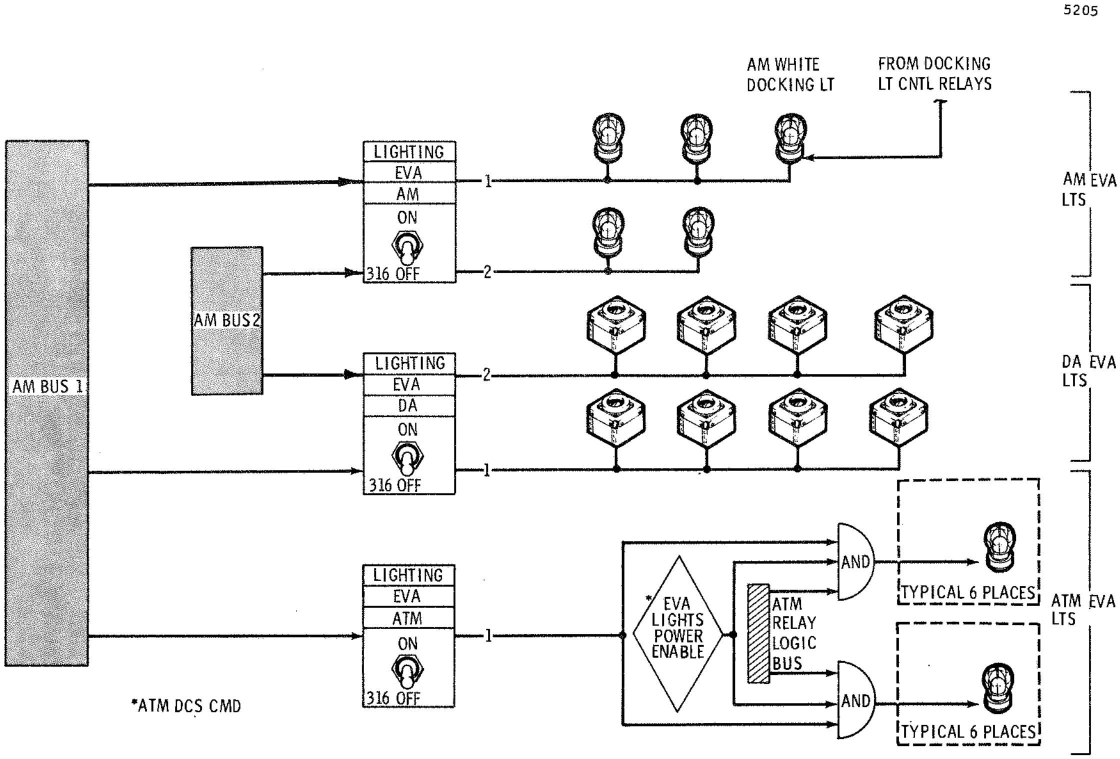



Figure 2.5.4-6 EVA Lighting -- Functional Diagram

The AM EVA light on the D024 sample panel handrail is also the AM white docking light. Control of this light for docking purposes is supplied by the docking light control relays which route either a DCS command or the LIGHTING, DOCKING switch command to the light (paragraph 2.5.4.2.2).

2.5.4.3 SWS INTERNAL LIGHTING

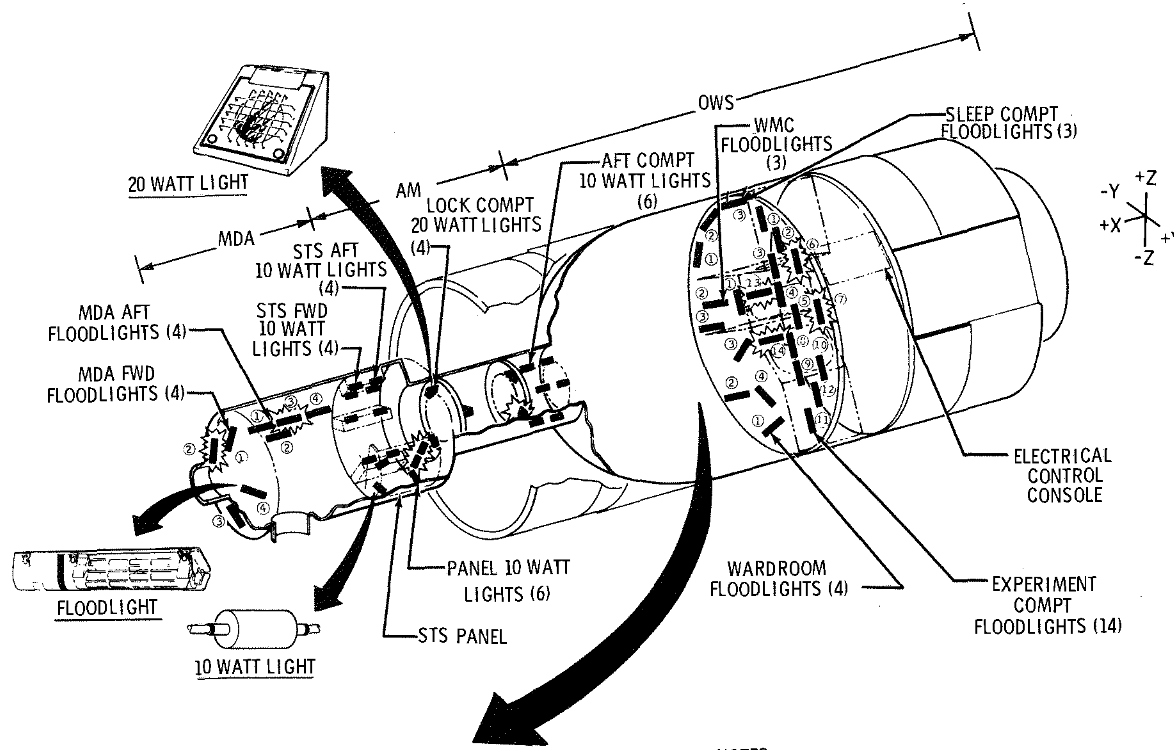
Interior lighting in the SWS (figure 2.5.4-7) illuminates the interior of the MDA, AM and OWS for habitation and experimentation tasks, (2) illuminates areas of the SWS used during initial entry, provides contingency illumination (emergency lighting network), and provides portable lights for additional illumination. In addition, light baffles in the sleep compartment can be used during sleep periods.

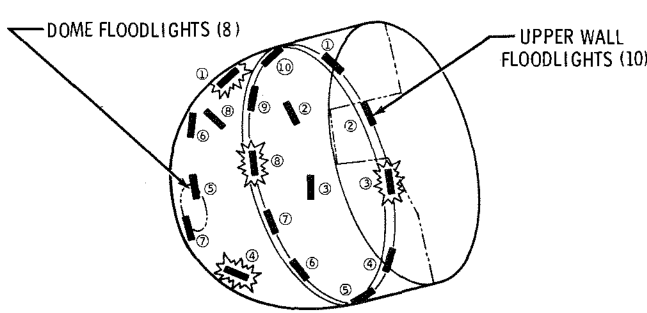
2.5.4.3.1 MDA Internal Lighting

The MDA contains eight floodlights for internal illumination: four in the forward section (one on each axis) and four in the aft section (figure 2.5.4-7). Each floodlight houses a replaceable floodlight bulb, which contains an integral HI-LO-OFF switch. The bulb is a fluorescent lamp enclosed by a tempered glass tube, coated with translucent teflon to prevent fragmentation and migration of the glass in the event of breakage. The floodlight contains a hinged cover to permit access for bulb replacement (figure 2.5.4-8). Spare floodlight bulbs are stowed in the OWS. The hinged cover bears the floodlight number to identify the light location. These floodlight numbers correspond to the remote light switch placards on panel 207.

The MDA floodlights may be remotely turned on or off from one of two separate locations: the INTERIOR LIGHTS switch on panel 101 adjacent to the axial docking port tunnel in the MDA or the four MDA light switches located on panel 207 in the STS (figure 2.5.4-9). All of these switches provide parallel control of the MDA floodlights, but will do so only if the integral light switch on the floodlight bulb is set on the LO or HI position. Placing the floodlight bulb integral light switch to the OFF position disables that particular floodlight from being controlled by any remote switch (figure 2.5.4-10). The integral light switch (LO) provides for continued low-intensity illumination of the MDA during critical power management periods. The panel 101 INTERIOR LIGHTS switch turns on all the MDA floodlights simultaneously and is primarily used during SWS activation and deactivation. The panel 207 MDA light switches control the MDA floodlights in pairs, a control method used mainly during habitation.

Bus assignments for the MDA floodlights are divided among the floodlights so that loss of a single bus will disable only half of the floodlights in any given area (figure 2.5.4-9). If emergency lighting is required, the emergency lighting network will automatically supply power to the No. 2 (forward) and No. 3 (aft) floodlights, illuminating them to a high intensity regardless of the position of the floodlights' remote or integral light switch (figure 2.5.4-10). The fwd 2 and aft 3 floodlight covers are marked with a red stripe to identify the emergency function of the floodlight (figure 2.5.4-8).




NOTES:

LIGHT LOCATION

EMERGENCY LIGHT (MDA & AM)
INITIAL ENTRY/EMERGENCY LIGHT (OWS)

① LIGHT LOCATION NUMBER

- MDA & OWS EVEN & ODD NUMBERED LIGHTS ARE POWERED BY EVEN & ODD NUMBERED BUSSES RESPECTIVELY
- THE EMERGENCY LIGHTS ON THE STS INSTRUMENT PANEL ARE POWERED DURING AN EMERGENCY FROM EPS CNTL BUS 1 (RIGHT SIDE) & EPS CNTL BUS 2 (LEFT SIDE) (VIEWED FACING PANEL & FEET IN THE MDA)

Figure 2.5.4-7 SWS Internal Lighting

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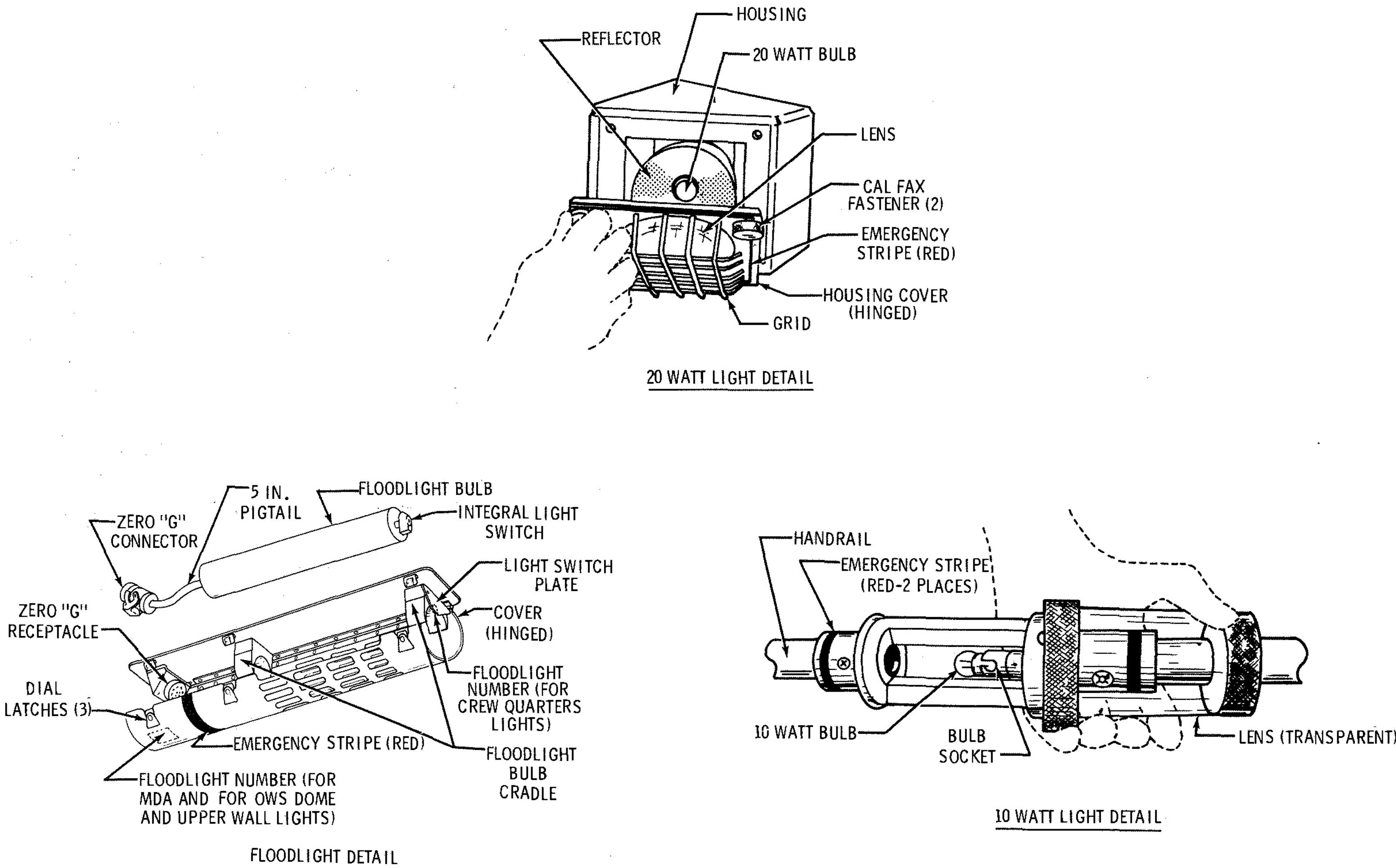


Figure 2.5.4-8 Internal Lights

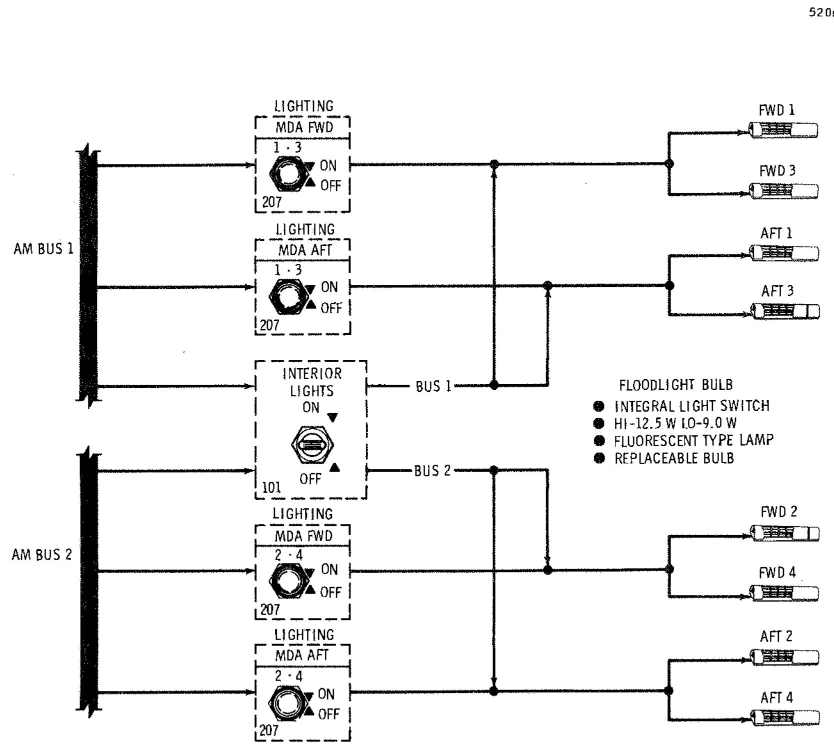


Figure 2.5.4-9 MDA Internal Lighting -- Functional Diagram

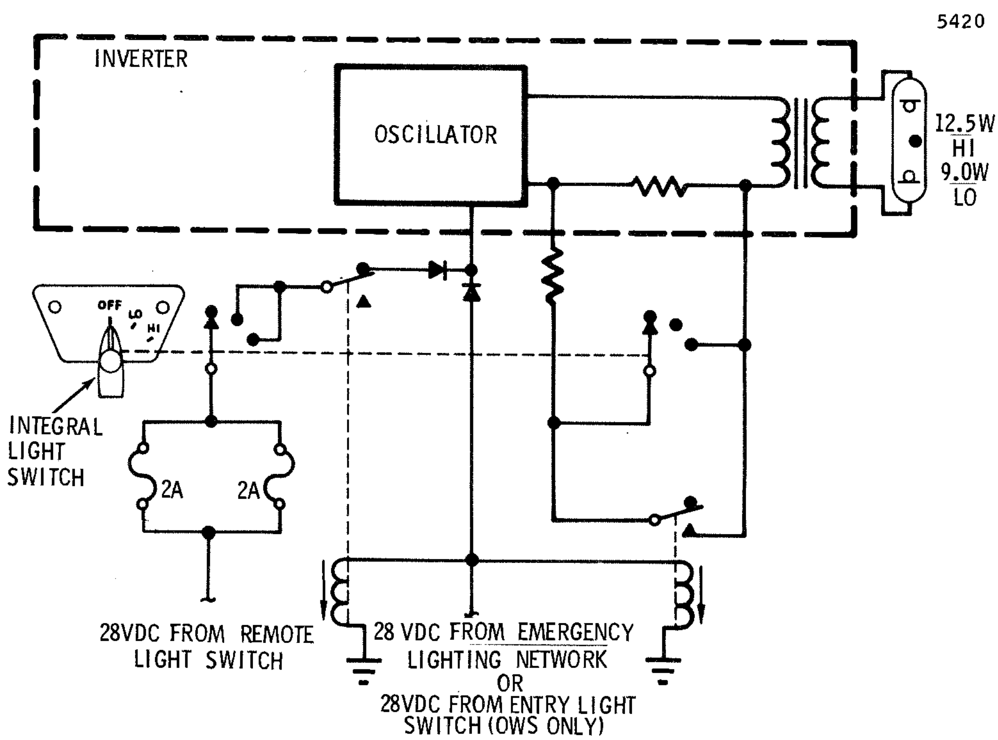


Figure 2.5.4-10 Floodlight Bulb -- Schematic

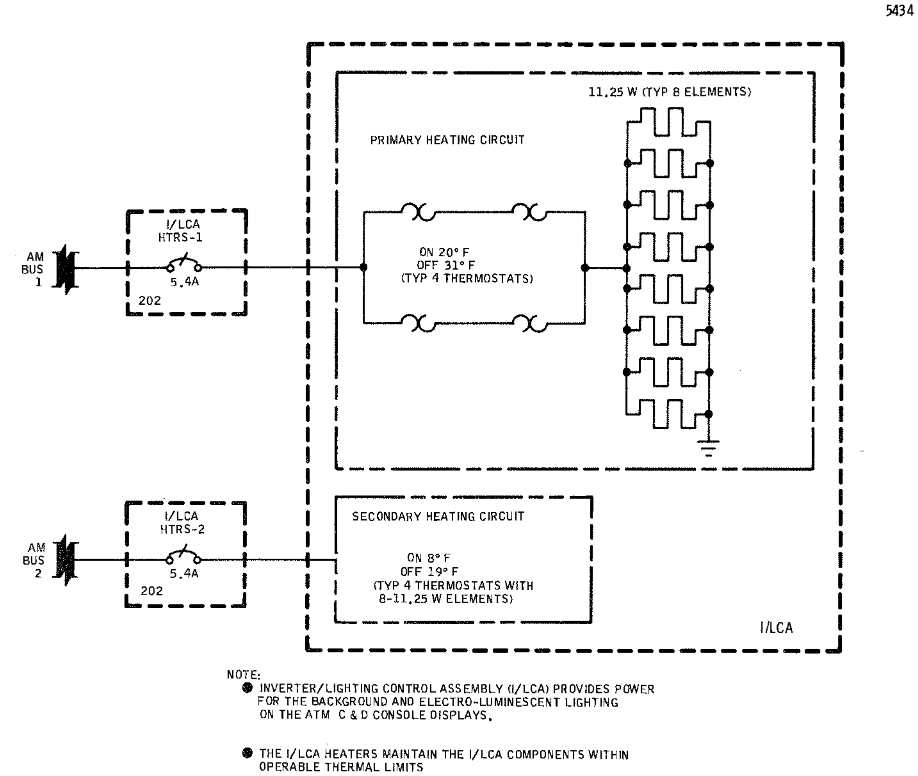


Figure 2.5.4-11 I/LCA Heater -- Schematic

2.5.4.3.2 I/LCA Thermal Control

The inverter/lighting control assembly (I/LCA) is an electronics unit mounted externally on the MDA at the base of the L-band antenna truss. The I/LCA provides the power for the backround and electro-luminescent lighting of the ATM C&D console displays. In order to sustain its operations, the I/LCA components must be maintained within certain temperature limits; to accomplish this, the I/LCA is fitted with primary and secondary heating circuits (figure 2.5.4-11). The heating circuits are powered during all mission phases. The primary heating circuit, because of its higher thermostat settings, is the normally active circuit. The secondary heating circuit serves as a backup. Each heating circuit features quad-redundant thermostat control to eliminate the possibility of total heating circuit failure resulting from a failure of any one of its thermostats. Eight heater elements per heating circuit are dispersed about the I/LCA.

2.5.4.3.3 AM Internal Lighting

The AM has twenty 10-watt lights and four 20-watt lights for internal illumination (figure 2.5.4-7). In addition, 33 meters in the AM have meter lights to enhance readability.

2.5.4.3.3.1 STS and AM Aft Compartment Lighting

The 10-watt lights are dispersed for total area illumination by the placement of four in the STS forward area, four in the STS aft area, six surrounding the STS panel, and six in the AM aft compartment (figure 2.5.4-7). Each 10-watt light, is handrail mounted, and contains a 10-watt, replaceable, incandescent bulb (figure 2.5.4-8). The bulb, mounted in a bulb socket, is protected by a transparent, nonbreakable lens, which is removable for bulb replacement. Replacement bulbs are stowed in the AM.

Both AM buses are supplied among the STS forward lights, STS aft lights, and the AM aft compartment lights to assure that the loss of a single bus will only disable half the lights (figure 2.5.4-12). However, loss of AM bus 2 will disable all the lights surrounding the STS panel. The STS forward lights, STS aft lights, and STS panel lights are controlled by a LIGHTING, STS FWD dimmer; a LIGHTING, STS AFT dimmer; and a LIGHTING, PANEL dimmer, respectively on panel 207. The dimmers have three basic lighting modes: lights off (OFF), lights full brilliance (FIXED), and varying light intensity (1 to 9). In the FIXED position, 28 vdc is directly supplied to the lights; whereas, for a varying light intensity selection, position 1 controls the light intensity to barely visible while position 9 controls the light intensity to almost full brilliance. The dimmer, when manipulated from 9 to 1, simultaneously reduces the light intensity and the power consumption. This feature allows for continued illumination of the STS during critical power management periods. Control of the AM aft compartment lights is provided by a LIGHTS, AFT [BRIGHT-OFF-DIM] switch on panel 390. The BRIGHT position supplies 28 vdc to all six AM aft compartment lights, while the DIM position supplies 28 vdc to only three of the AM aft compartment lights.

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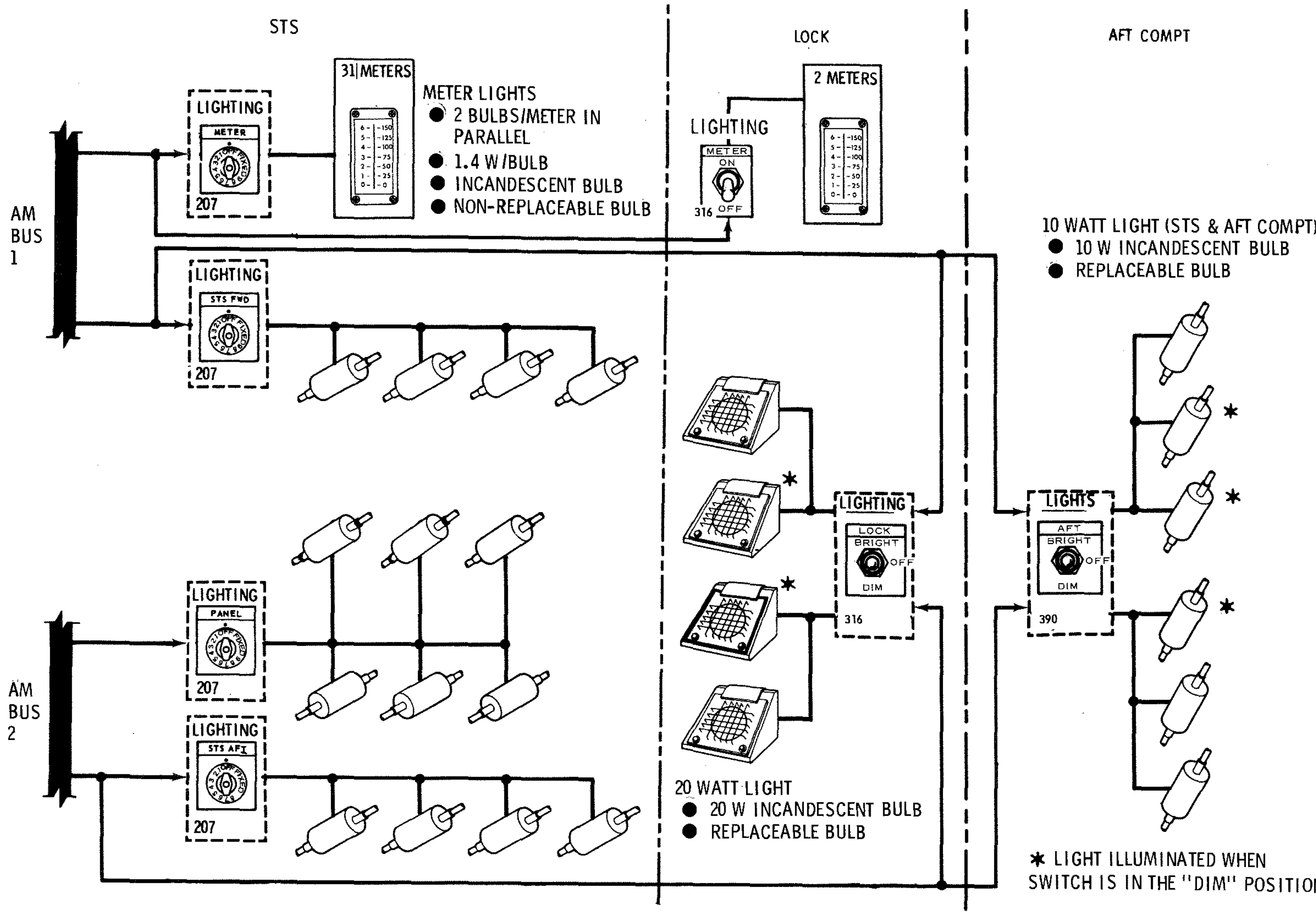



Figure 2.5.4-12 AM Internal Lighting -- Functional Diagram

If emergency lighting is required, the emergency lighting network will automatically supply power to the two 10-watt lights adjacent to the circuit breaker panels. These lights will illuminate to full brilliance regardless of the position of the LIGHTING, PANEL dimmer. These emergency lights are marked with a red stripe on each end of the light (figure 2.5.4-8).

2.5.4.3.3.2 AM Lock Compartment Lighting

Four 20-watt lights, located in the lock compartment at the bulkheads, provide internal lighting of the lock compartment. One 20-watt, replaceable, incandescent bulb is mounted in each light housing in a bulb socket recessed in the reflector (figure 2.5.4-8). A housing cover contains a translucent lens and a grid to protect the lens from damage. The housing cover is hinged to permit access to the bulb. Spare bulbs are stowed in the AM.

Both AM buses are supplied to the lock compartment lights so that only half of the lighting in the lock compartment is disabled if a bus fails (figure 2.5.4-12). A LIGHTING, LOCK [BRIGHT-OFF-DIM] switch on panel 316 permits selection of desired illumination levels and facilitates power management. The BRIGHT position supplies 28 vdc to all four lock compartment lights, whereas the DIM position supplies 28 vdc to only two lights. The BRIGHT position is used for EVA; for habitation, the crew will configure the lock compartment lighting as they desire.

If emergency lighting is required, the emergency lighting network will supply power to one of the four lock compartment lights, controlling that light regardless of the position of the LIGHTING, LOCK switch. The lock compartment 20-watt light that doubles as an emergency light is marked with a red stripe on the housing cover (figure 2.5.4-8).

2.5.4.3.3.3 AM Meter Lighting

Thirty-four meters located in the AM are illuminated internally to enhance readability. The meters are mounted on STS panels 203, 206, 216, and 215 and on lock compartment panel 316 (figure 2.5.4-13). Each meter contains two 1.4-watt, incandescent light bulbs, wired in parallel for redundancy. The meter lights located in the STS panel meters are controlled by the LIGHTING, METER dimmer on panel 207 (figure 2.5.4-12); the dimmer is identical in operation to the dimmers described in paragraph 2.5.4.3.3.1. The meter lights located in the lock compartment panel meters are controlled by the LIGHTING, METER [ON-OFF] switch on panel 316.

2.5.4.3.4 OWS Internal Lighting

The OWS contains 42 floodlights for internal illumination: 8 in the forward dome (dome lights); 10 in the forward compartment (upper wall lights); 4 in the wardroom; 3 in the WMC; 3 in the sleep compartment; and 14 in the experiment compartment (figure 2.5.4-7). Each floodlight houses a replaceable fluorescent floodlight bulb that contains an integral HI-LO-OFF switch. The floodlight bulb is described in paragraph 2.5.4.3.1 and depicted in figure 2.5.4-8. The hinged cover bears the floodlight number to identify the light's location in the forward dome and in the forward compartment. For crew quarters installations, the floodlight number is marked on the light switch plate. These floodlight numbers correspond to remote light switch placards on panels 616 and 630 (figures 2.5.4-14 and -15).

The OWS dome lights, upper wall lights, and experiment compartment lights may be turned on in assigned combinations for each area through the remotely located LIGHTING, DOME switches; LIGHTING, UPPER WALL switches; and LIGHTING, EXPERIMENT COMPARTMENT switches on panel 616 (figures 2.5.4-14 and -15). In addition, panel 616 provides simultaneous remote switch control of all sleep compartment lights through a single LIGHTING, SLEEP COMPARTMENT switch. Panel 630, located on the experiment compartment partition between the wardroom and the WMC, provides remote control of the wardroom and WMC lights. The wardroom lights may be turned on in pairs through the LIGHTS, WARDROOM switches on panel 630; all WMC lights may be turned on simultaneously by a single LIGHTS, WMC switch on panel 630. The remote switches for the OWS lights will control their respective floodlights providing the appropriate floodlight bulb integral light switch is set on HI or LO. Placing the integral light switch to OFF, disables that floodlight from being controlled by any remote switch (figure 2.5.4-10). The integral light switch provides for continued low-intensity illumination of the OWS during critical power management periods.

Lighting redundancy is provided to the OWS floodlights by powering approximately half of a given area's lights from OWS bus 1 and half from OWS bus 2. If emergency lighting is required, the emergency lighting network will automatically supply power to the dome 1, dome 4, upper wall 3, upper wall 8, and experiment compartment 6, 7, 13, and 14 floodlights. These floodlights will illuminate to their high intensity regardless of the position of the floodlights' remote or integral light switch (figure 2.5.4-10). The floodlight covers of these lights are marked with a red stripe (figure 2.5.4-8).

Lighting in the OWS during SWS activation and deactivation is controlled by a single LIGHTS, OWS ENTRY [ON-OFF] switch on AM aft compartment panel 390, which controls the eight OWS emergency lights mentioned previously. When the LIGHTS, OWS ENTRY switch is positioned ON, EPS control bus power is applied to the eight emergency lights, which double as entry lights.

2.5.4.3.5 Entry Lighting

During SWS manned activation and deactivation, an easily controlled lighting system illuminates certain operational SWS areas. The entry lighting system makes use of existing MDA and OWS floodlights to accomplish this specialized lighting condition.

5201

– STS CONTROL PANEL 207 DIMMER CONTROL OF THE FOLLOWING METER LIGHTS

- ECS CONTROL PANEL 203
  - MOL SIEVE $PPCO_2$
  - MOL SIEVE HEAT EXCH
  - MOL SIEVE DEW POINT
  - MOL SIEVE BED 1/2
- EPS CONTROL/CAUTION & WARNING CONTROL PANEL 206
  - BATTERY CHARGE (%) PRI/SEC
  - DIGITAL CLOCK
  - TRANSFER BUS 1 & 2 VOLTAGE
  - REG BUS 1 & 2 VOLTAGE
  - BATTERY AMPS 7 & 8
  - BATTERY AMPS 5 & 6
  - BATTERY AMPS 3 & 4
  - BATTERY AMPS 1 & 2
  - BATTERY VOLTS 7 & 8
  - BATTERY VOLTS 5 & 6
  - BATTERY VOLTS 3 & 4
  - BATTERY VOLTS 1 & 2
  - ARRAY AMPS 7 & 8
  - ARRAY AMPS 5 & 6
  - ARRAY AMPS 3 & 4
  - ARRAY AMPS 1 & 2
  - PCG TOTAL BUS 1 & 2
  - OWS BUS 1 & 2
  - TRANSFER TO CSM BUS A & B
  - ATM TO TRANSFER BUS 1 & 2
- CONDENSATE CONTROL PANEL 216
  - CNDS TANK ΔP/VT TEMP
- $O_2/N_2$ CONTROL PANEL 225
  - $O_2$ BOTTLE PSI/°F
  - $N_2$ BOTTLE PSI/°F
  - $O_2/N_2$ PSI
  - OWS °F/PSI
  - AM PRESS PSI FWD/LOCK
  - AM AFT PRESS/$PPO_2$ - 1
  - $PPO_2$ - 2/3

– LOCK COMPARTMENT CONTROL PANEL 316 SWITCH CONTROL OF THE FOLLOWING METER LIGHTS

- LOCK COMPT CONTROL PANEL 316
  - PRESS LOCK/AFT
  - PRESS OWS/$O_2$

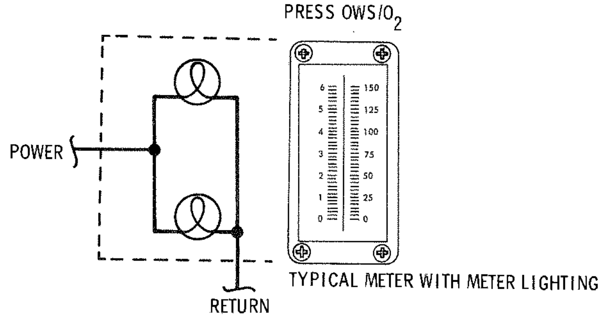



Figure 2.5.4-13 AM Meter Lights

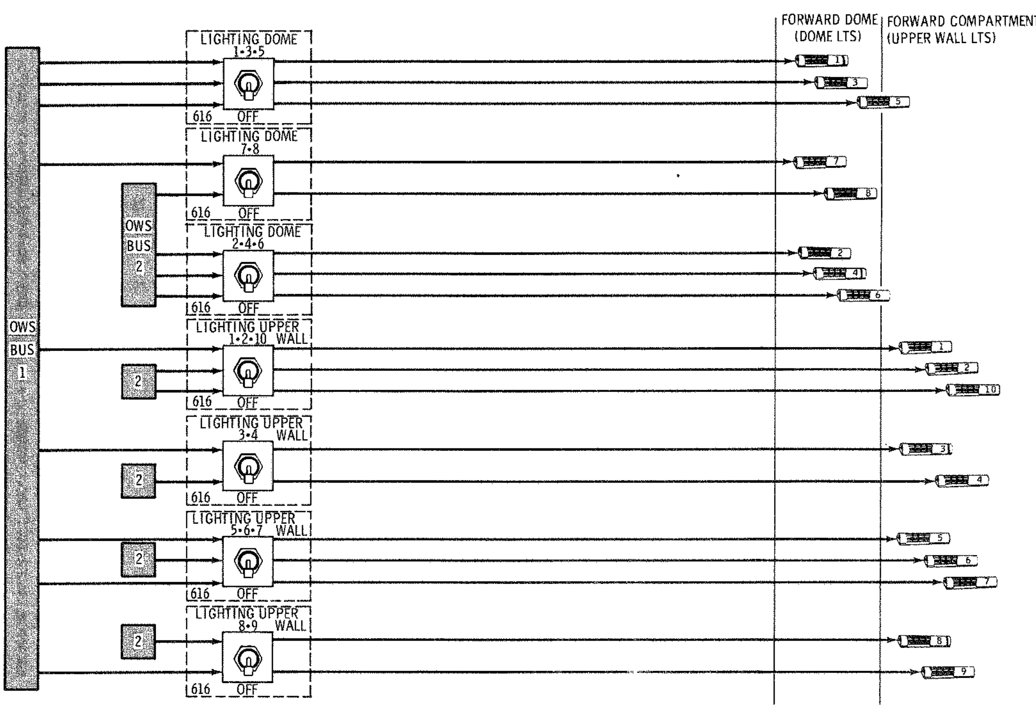



Figure 2.5.4-14 OWS Forward Area Lighting -- Functional Diagram

5209

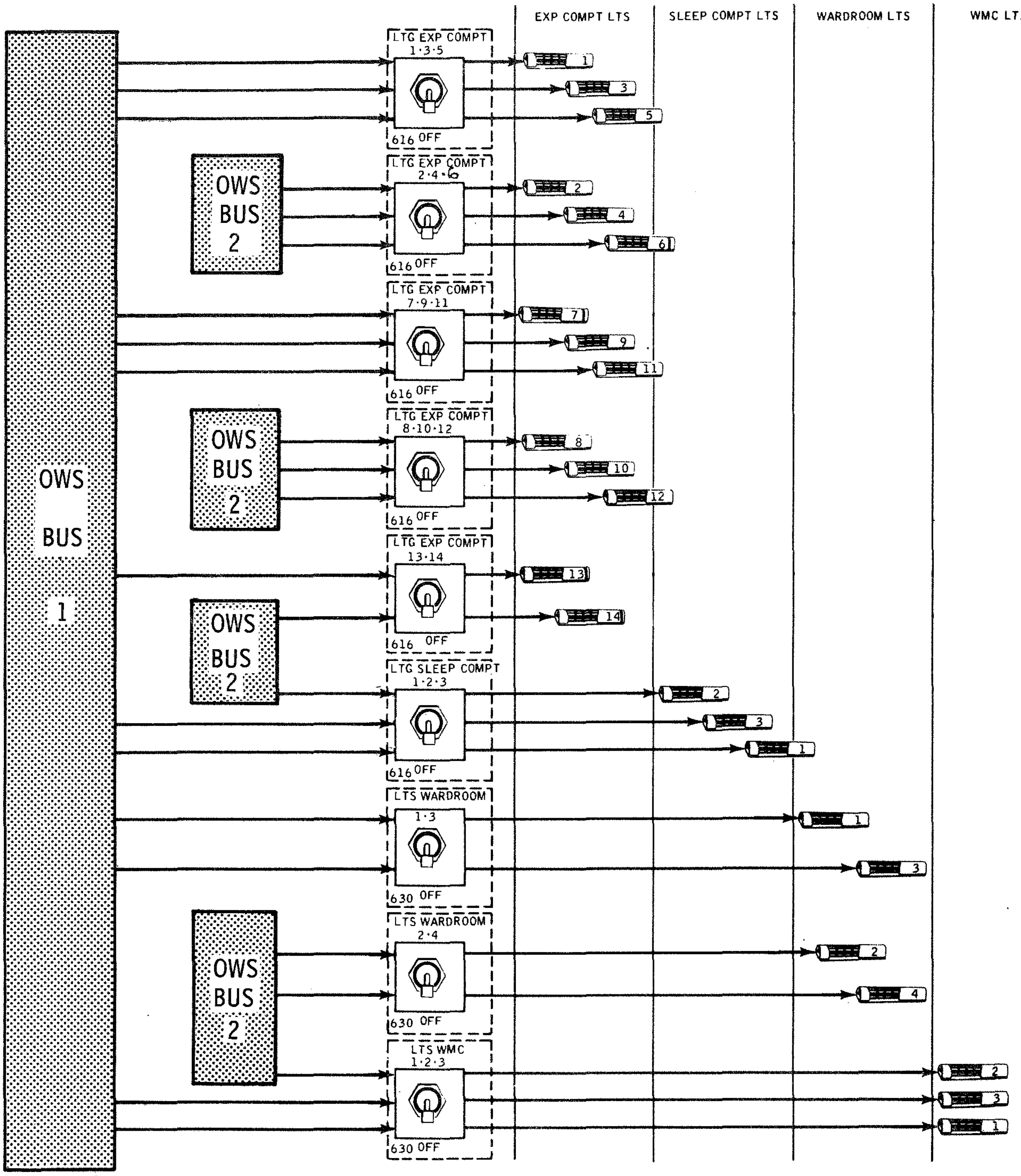



Figure 2.5.4-15 OWS Crew Quarters Lighting -- Functional Diagram

5422

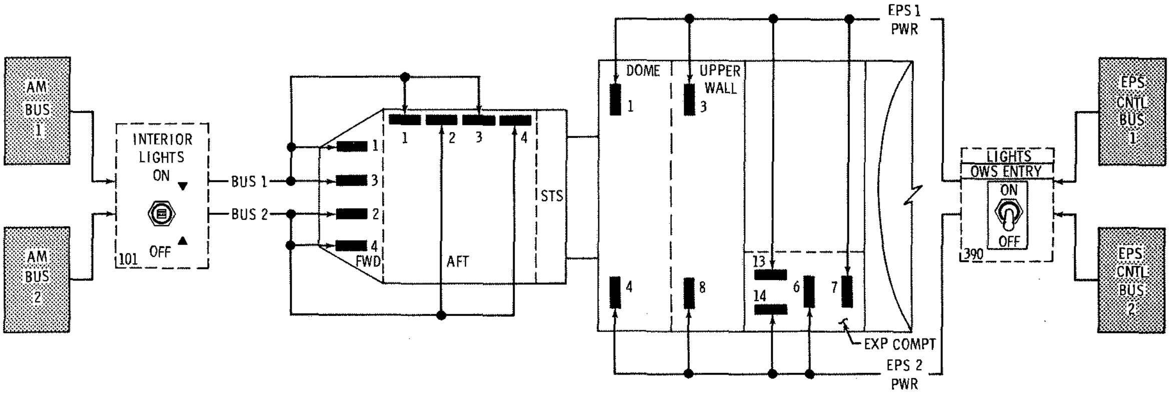



Figure 2.5.4-16 Entry Lighting -- Functional Diagram

To illuminate the interior of the MDA and the STS panels, single-switch control of all eight MDA floodlights is provided by the INTERIOR LIGHTS [ON-OFF] switch on panel 101 (figure 2.5.4-16). Panel 101 is located immediately adjacent to the axial docking port in the MDA. The INTERIOR LIGHTS switch supplies AM bus power to the MDA floodlights so that only half of the floodlights in any given area are disabled if a single bus fails. When power is supplied to the MDA floodlights from this remote switch, the floodlights will come on if the floodlight bulb integral light switch is in the LO or HI position (figure 2.5.4-10). All of the MDA floodlights are launched with their integral light switches in the HI position. Prior to deactivation, the crewmen will configure the floodlight integral light switches on the HI position to permit maximum illumination during MDA entry or exit.

To illuminate the OWS for entry and exit tasks, single-switch control of the eight emergency lights in the OWS (they double as entry lights) is provided by the LIGHTS, OWS ENTRY [ON-OFF] switch on panel 390 in the AM aft compartment (figure 2.5.4-16). DOME lights 1 and 4 and UPPER WALL lights 3 and 8 serve to illuminate the forward area in the OWS. EXPERIMENT COMPARTMENT lights 13 and 14 flank, and provide illumination, of the egress opening in the experiment compartment. EXPERIMENT COMPARTMENT lights 6 and 7, located over the electrical control console, illuminate the control console to conduct activation and deactivation procedures. The LIGHTS, OWS ENTRY switch supplies EPS control bus power to the OWS entry lights and turns on these floodlights to their maximum intensity regardless of the position of the floodlights' integral light switch or remote light switch (figure 2.5.4-10). The crew uses the OWS entry lights during activation upon opening of the OWS hatch, and during deactivation, after the reconfiguration of the OWS internal lights.

2.5.4.3.6 Emergency Lighting

During normal operation the lights in the SWS are assigned to buses so that a loss of a single distribution bus will not disable any more than half the lights in any given area. Illumination in this case is degraded, but crew operations can continue at a satisfactory level. If both buses that supply power to lights within the MDA/AM or in the OWS fail, an emergency lighting network will automatically activate and supply illumination.

The buses that normally power the lights in a module (AM buses 1 and 2 for the MDA/AM lights, and OWS buses 1 and 2 for the OWS lights) are continuously monitored for proper voltage level by two emergency lighting network low voltage sensors. One low voltage sensor monitors AM bus 1 and 2 and the other low voltage sensor monitors OWS bus 1 and 2 (figure 2.5.4-17). If the voltage level for both AM buses 1 and 2 or both OWS buses 1 and 2 decays to 23 vdc, the appropriate low voltage sensor will activate and provide power from EPS control buses 1 and 2 to the emergency lights in the MDA/AM or in the OWS (figure 2.5.4-17). Power is applied directly to the lights, turning them on to

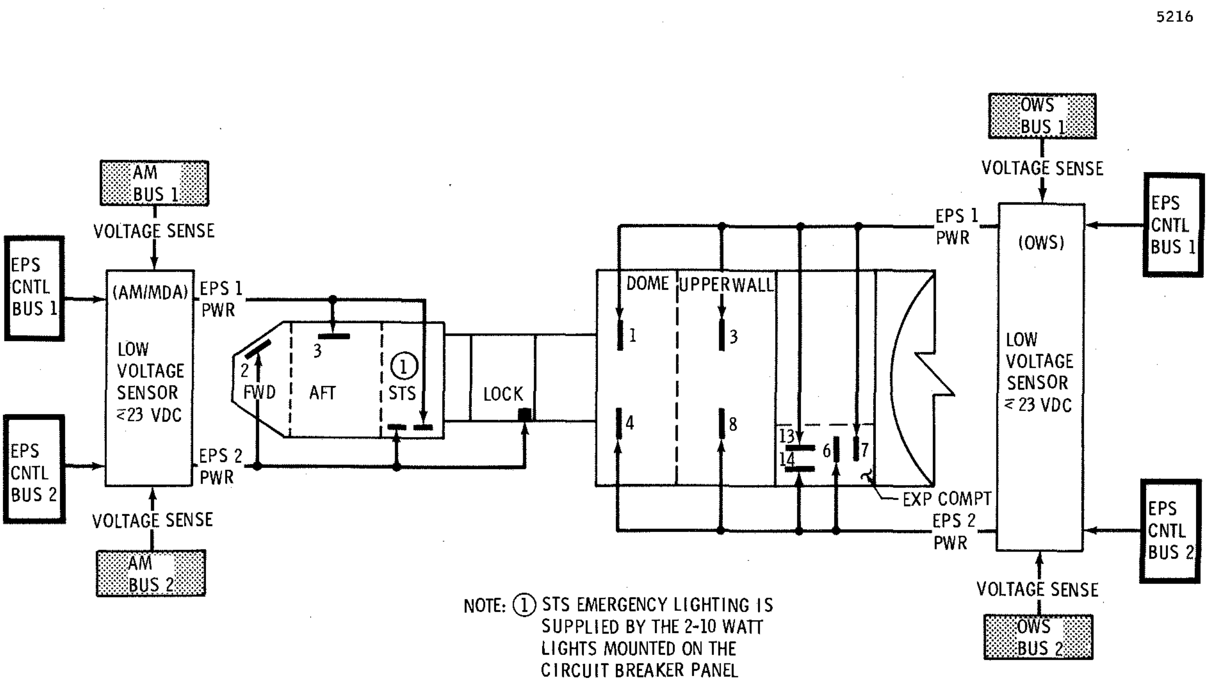



Figure 2.5.4-17 Emergency Lighting -- Functional Diagram

their highest intensity regardless of the position of their integral light switch and/or remote light switch. Simultaneously, the normal bus power supply is automatically switched off of the emergency lights (figure 2.5.4-10 for MDA and OWS emergency power provisions). When either failed bus increases to 23 vdc, the low voltage sensor deactivates and removes EPS control bus power from the emergency lights while automatically switching the emergency lights back to their normal bus.

The emergency lights in each module are the normal usage lights selected because of proximity to critical operational areas. These emergency lights are marked with a red stripe (figure 2.5.4-8) to identify their emergency function. The crew must immediately replace the light bulb if it malfunctions.

The emergency lights in the MDA provide contingency illumination of the MDA, particularly the translation route between the CSM and the STS. The emergency lights in the STS supply illumination of the STS panels, particularly the circuit breaker panels. The emergency light in the lock compartment provides illumination of the translation route between the OWS and the STS and provides contingency illumination of the lock compartment if a failure occurs during EVA. The emergency lights in the OWS dome and on the upper wall provide illumination of the OWS forward area and also serve to illuminate the translation route between the crew quarters and the AM aft compartment. The emergency lights in the experiment compartment provide not only general contingency illumination of the crew quarters but serve to illuminate the egress opening in the experiment compartment ceiling and the electrical control console.

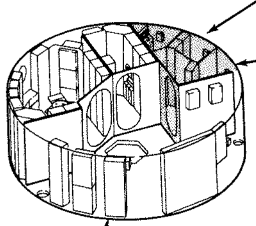
2.5.4.3.7 Sleep Compartment Light Baffling

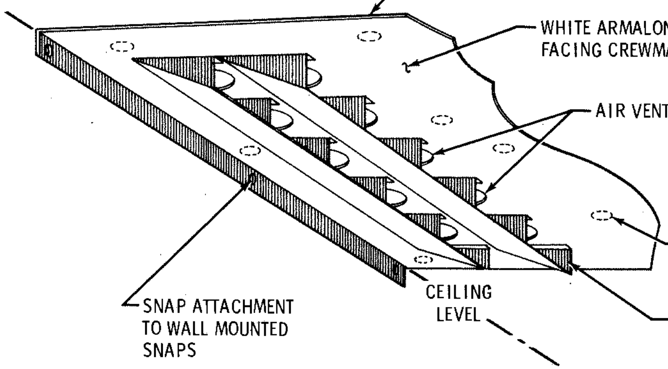
The crewmen place four light baffles on the ceiling grid of the sleep areas for light abatement during sleep periods (figure 2.5.4-18). Each of the four light baffles is sized for a particular sleep area location and is constructed of an opaque, fireproof fabric. The baffles contain air vent openings for sleep area ventilation and louvers that direct the light filtering through the air vent openings, away from the crewman's eyes while he is sleeping. Three of the baffles have snaps for installation on the ceiling grid and on wall surfaces. The hatch light baffle has velcro to mate with velcro located on light baffle 2. This permits the hatch baffle's installation on the ceiling if the hatch cover is in place or is removed.

The light baffle(s) for each sleep area is stowed in a stowage compartment in its appropriate sleep area when not in use.

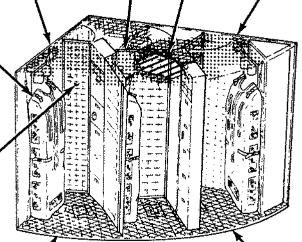
2.5.4.3.8 Portable Lighting

Portable lighting is provided for use in the SWS to: (1) supply additional illumination, using the portable light; and (2) provide illumination for photography, utilizing the high-intensity light.




TYPICAL LIGHT BAFFLE SECTION




SLEEP COMPARTMENT VIEW LOOKING INBOARD

LIGHT BAFFLE FEATURES-

- BLOCK DIRECT LIGHT TRANSMISSION INTO THE EYES OF THE CREWMAN WHILE HE IS OCCUPYING THE SLEEP RESTRAINT
- AIR VENT OPENINGS ASSURE ADEQUATE SLEEP VENTILATION
- LIGHT BAFFLES ARE LAUNCHED IN A STOWAGE COMPARTMENT AND ARE INSTALLED AS REQUIRED ON THE CEILING GRID USING SNAPS
- THE HATCH LIGHT BAFFLE IS FITTED WITH VELCRO ON ITS PERIPHRY WHICH MATES WITH A VELCRO LINER ON LIGHT BAFFLE 2. SNAPS ARE NOT PROVIDED ON THE HATCH LIGHT BAFFLE

Figure 2.5.4-18 Sleep Compartment Light Baffles

2.5.4.3.8.1 Portable Light

Three portable lights are stowed together in a stowage compartment in the OWS forward dome. The portable light has a housing with a carrying handle and a floodlight bulb (figure 2.5.4-19). The housing is hinged and secured with dial-latches to permit access to the floodlight bulb. Spare floodlight bulbs are stowed in a nearby stowage compartment. The housing also is fitted with a universal mount bracket for use with the universal mount to permit restraint on a convenient structure (paragraph 2.5.3).

The portable light may be connected to any convenient UTILITY OUTLET in the SWS for floodlight bulb power. The 15-foot utility cables may be used as extensions to allow the portable light to be used in remote locations of the SWS. The floodlight bulb integral light switch provides selection (HI-LO-OFF) of desired illumination levels (figure 2.5.4-20).

2.5.4.3.8.2 High-Intensity Light

Two, portable, high-intensity lights for use during photographic tasks are stowed together in a stowage compartment in the OWS forward compartment. Each high-intensity light contains four, permanently installed fluorescent lamps, protected by a grid housing (figure 2.5.4-19). The grid housing is fitted with a collapsible carrying handle and a universal mount bracket for use with the universal mount to permit restraint on a convenient structure (paragraph 2.5.3).

The four fluorescent lamps are separated for dual system control, with two lamps assigned to SYS 1 and the remaining two lamps assigned to SYS 2 (figure 2.5.4-21). Each system may be operated in one of two illumination modes, HIGH or LOW, through system switch controls mounted on the high-intensity light. Either mode utilizes both lamps, but each system's circuitry is designed such that the LOW mode emits a two-lamp output of only 40 watts while the HIGH mode will emit a two-lamp output of 75 watts. A single POWER switch, mounted adjacent to the system control switches, provides power to operate SYS 1 and/or SYS 2. Overtemperature protection of temperature critical components of the high-intensity light is provided through a thermal protect thermostat, which is internally mounted in the high-intensity light and connected to SYS 2 (figure 2.5.4-21). If an overtemperature condition occurs, the thermostat will close and interrupt the power supply to the SYS 2 lamps, extinguishing the lamps. After the thermostat is allowed to cool to its open setting, the crewman may reapply power to the SYS 2 lamps by momentarily positioning the THERMAL PROTECT switch to RESET.

Each high-intensity light contains a 12-inch pigtail for use at any HI POWER ACCESSORY OUTLET. A high-power accessory adapter cable may be used as a short extension cord.

The high-intensity light will be used for photographic purposes in the OWS forward dome and OWS forward compartment only. For performance of some photographic tasks, both of the high-intensity lights will be required.

## 2.5.5 STOWAGE

### 2.5.5.1 STOWAGE PROVISIONS

Certain equipment is stowed in SWS stowage devices which are sequentially numbered and labeled from the MDA through the OWS. Equipment is stowed in the MDA, AM and OWS for the launch and on-orbit stowage. This paragraph does not discuss experiment stowage provisions, which are detailed in the SLOH/EXP.

### 2.5.5.2 STOWAGE NUMBERING SYSTEM

The stowage areas in the SWS are assigned 100 through 900 series numbers, which aid in rapidly identifying the general area within which an item is stowed (figure 2.5.5-1). The individual stowage locations are assigned sub-numbers based on the 100-900 number series assigned to a given area. The stowage numbers appear in a conspicuous location on the stowage equipment. The letter prefixing the stowage number reference, is used for training purposes only and does not appear with the stowage number on flight hardware.

### 2.5.5.3 STOWAGE LABELING

Each stowage provision is fitted with a stowage label that contains the assigned stowage number, the items stowed, and their quantities. A label kit supplies additional labels for use in reidentifying stowage equipment (paragraph 2.5.15). Marking pens, in the flight data files, permit the crewmen to write on a stowage label or on the stowage equipment surface to track the status of the contents.

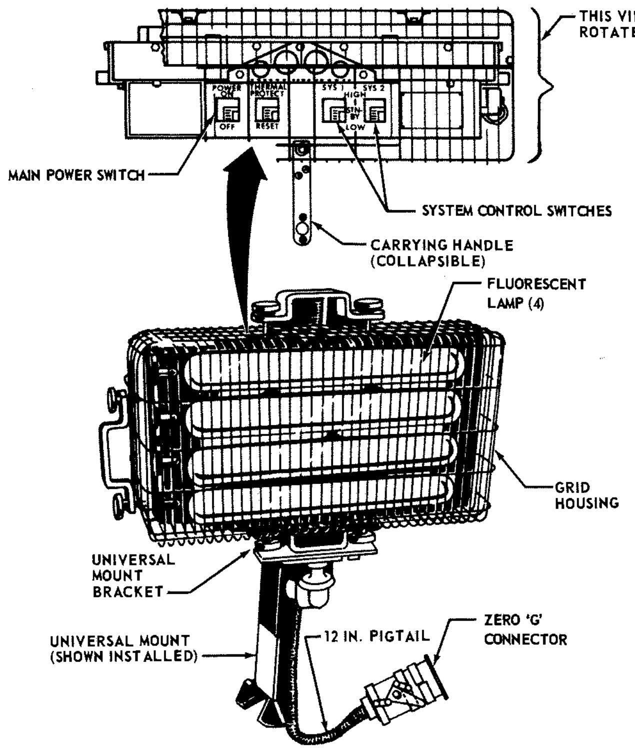
### 2.5.5.4 MDA STOWAGE

In the MDA, four stowage compartments and four film vaults are assigned (M) 100 series stowage numbers (figure 2.5.5-2). These stowage provisions are vented to cabin atmosphere by the stowage equipment door joint.

#### 2.5.5.4.1 MDA Stowage Compartments

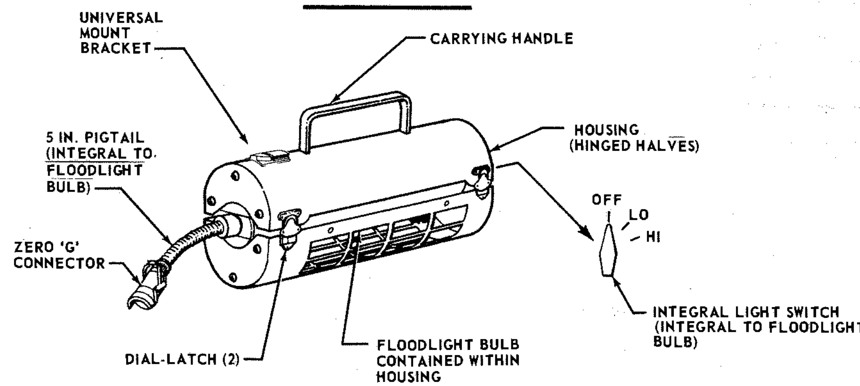
The MDA has four stowage compartments (M125, M126, M157, and M168) to store replacement CSM LiOH cartridges, crewman communications equipment, SWS activation equipment, flight data documents, and mol sieve solids trap spare parts (figure 2.5.5-3). Stowage compartment M168 is launched in the AM and is transferred to the MDA during SL-2 activation. With the exception of M168, MDA stowage compartments are permanently located on structure and are constructed of sheet metal. Each stowage compartment contains a friction-hinged door to maintain the door in the desired position. The door is fitted with a dog-ear-latch to allow one-handed opening of the door and to positively latch the door in the closed position during the launch phase.

HIGH INTENSITY LIGHT




- 2 SEPARATE LIGHTING SYSTEMS
- 4 PERMANENTLY INSTALLED FLUORESCENT LAMPS WITH 2 LAMPS/SYSTEM
- INTEGRAL SWITCH CONTROL HIGH-MODE 75 W AND LOW-MODE 40 W PER SYSTEM
- OVERTEMPERATURE PROTECTION PROVIDED
- 2 STOWED
- POWERED FROM ANY HI-PWR ACCESSORY OUTLET

PORTABLE LIGHT




- 1 REPLACEABLE FLOODLIGHT BULB
- INTEGRAL LIGHT SWITCH CONTROL HI-12.5 W AND LO-9.0 W
- 3 STOWED
- POWERED FROM ANY UTILITY OUTLET
- LAUNCHED WITH A FLOODLIGHT BULB INSTALLED

Figure 2.5.4-19 Portable Lighting

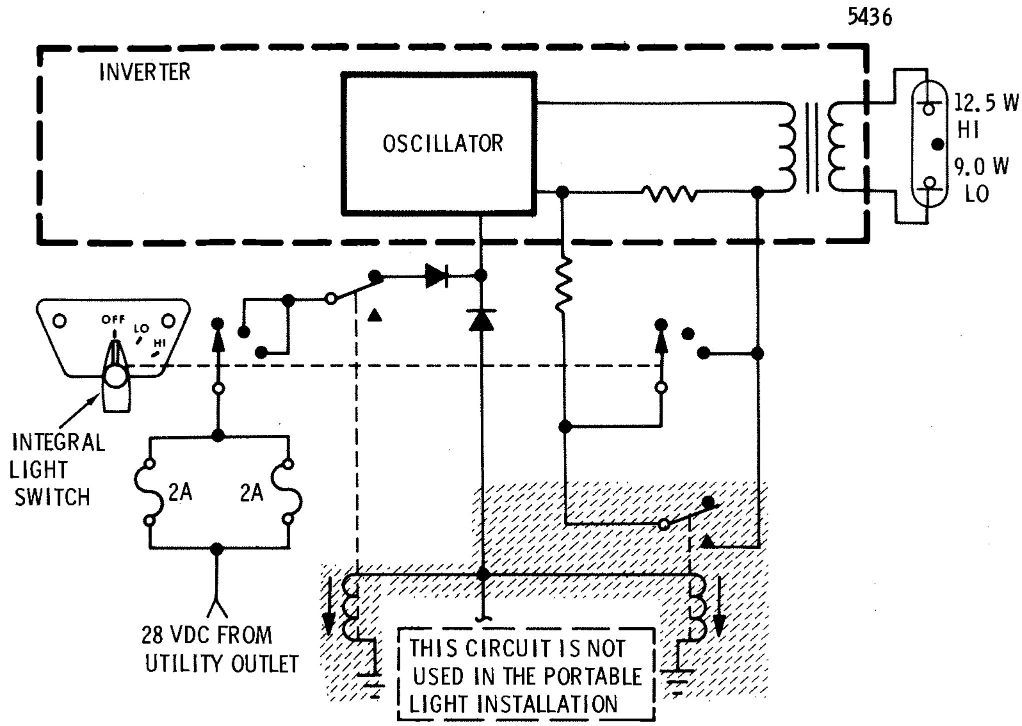



Figure 2.5.4-20 Floodlight Bulb -- Schematic (Portable Light Usage)

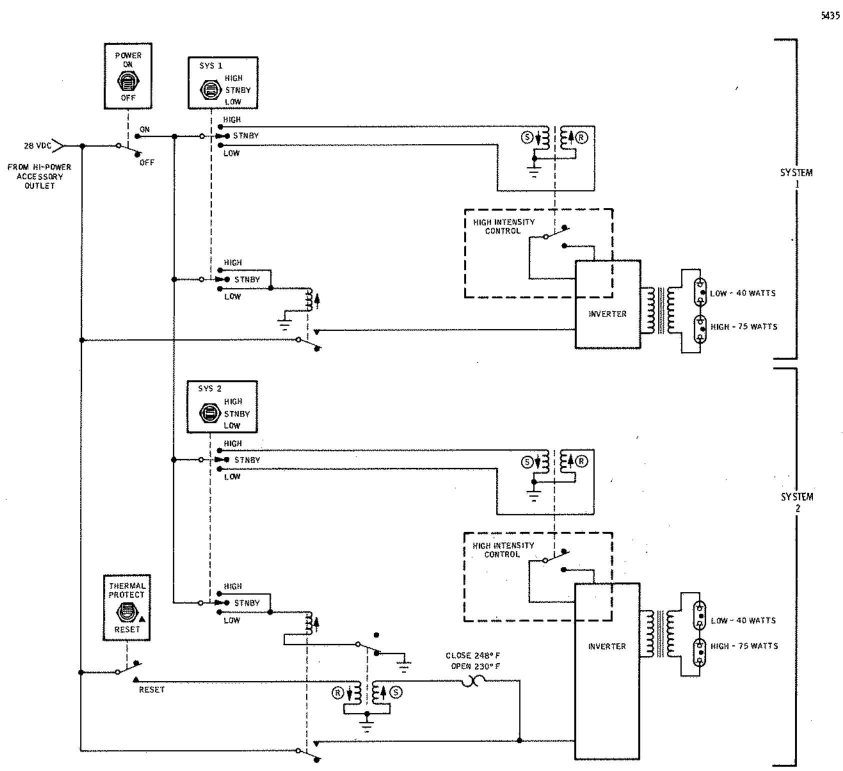



Figure 2.5.4-21 High-Intensity Light -- Schematic

OAM STOWAGE NUMBERING SYSTEM

5182

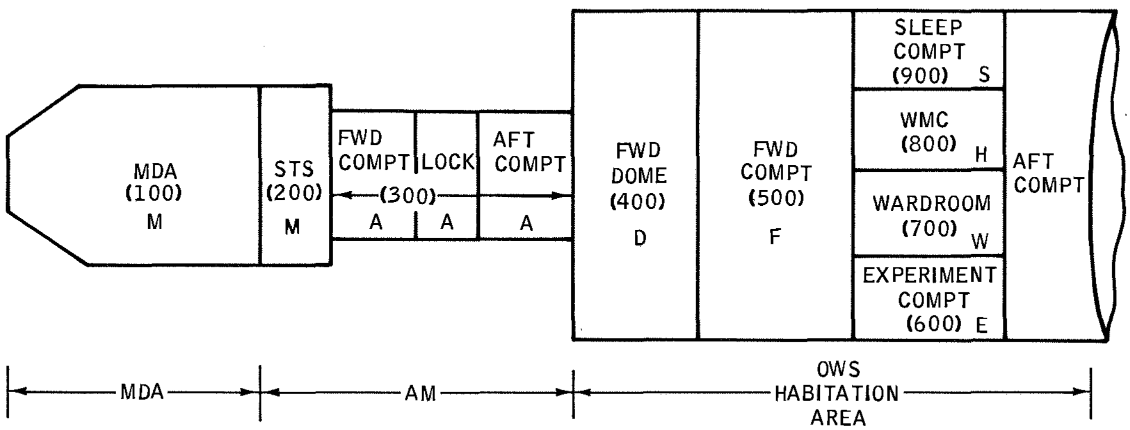



Figure 2.5.5-1 SWS Stowage Numbering System

2.5.5.4.2 MDA Film Vaults

Film vaults M124, M141, M143, and M152 provide stowage locations for ATM film magazines and cameras (figure 2.5.5-3). Each vault features aluminum shielding to supply radiation protection to stored film. A hinged vault door is secured in the closed position with door expando-grip pins. The interior surface of three of the vault doors is partitioned for cameras and film magazines which are retained with expando-grip pins. The interior of the vault has racks to retain film magazines for resupplying ATM photographic equipment during EVA's. Exposed ATM film is temporarily stowed in these film vaults for eventual return to earth.

2.5.5.5 AM STOWAGE

There are five stowage compartments in the AM, three in the STS and two in the AM forward compartment. In addition, there are two LSU containers in the lock compartment (figure 2.5.5-2). These stowage provisions vent to cabin atmosphere at the stowage equipment lid joint. Stowage in the STS is assigned (M) 200 series numbers, while the AM forward compartment and lock compartment stowage is assigned (M) 300 series numbers.

2.5.5.5.1 AM Stowage Compartments

The five AM stowage compartments (M201, M202, M208, M301, and M302) store spare parts and flight data documents (figure 2.5.5-4). All of the stowage compartments except M208 (AM flight data file) are removable through use of Calfax mounting fasteners. The only stowage compartment that is removed is M168, which is permanently relocated in the MDA upon SL-2 activation. The stowage compartment lids are secured closed, using lid-mounted Calfax fasteners, and contain friction hinges to maintain the lid in the desired position. The stowed items are either mounted in place using Calfax fasteners or restrained with foam-type packing.

2.5.5.5.2 LSU Containers

Two LSU containers (M310, M311) are mounted on the exterior of the lock compartment and stow one 60-foot LSU in each spherical enclosure (figure 2.5.5-4). Each LSU container has a lid, which is removable from the lock compartment through use of lid-mounted Calfax fasteners. The stowed LSU is coiled in its container, with the LSU connectors mated to dummy receptacles on the LSU container lid. A temporary LSU CONTAINER LID stowage area is located in the AM aft compartment for temporary stowage of each LSU container lid when the LSU is serviced or in use during EVA.

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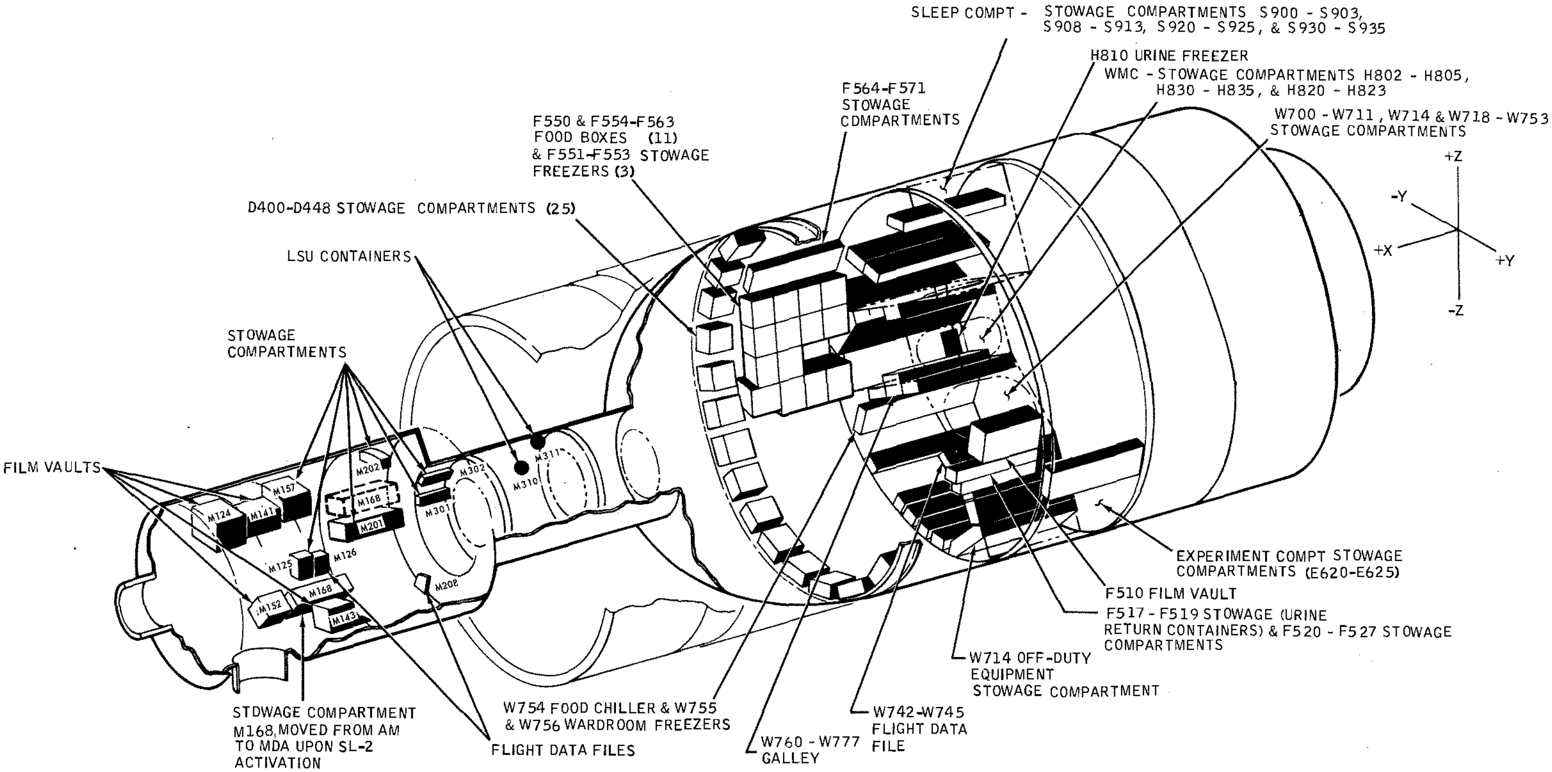


Figure 2.5.5-2 SWS Equipment Stowage

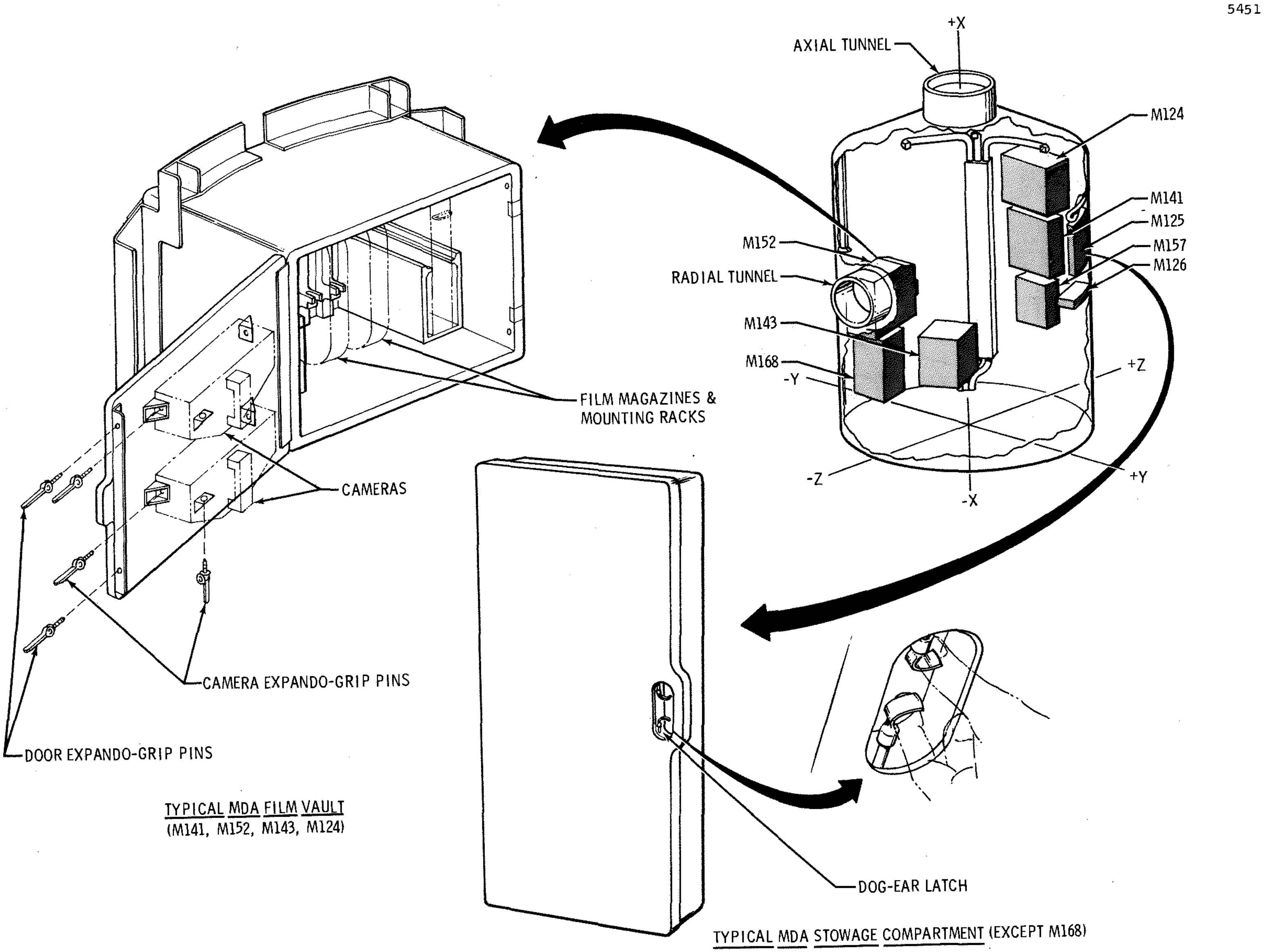


Figure 2.5.5-3 MDA Stowage

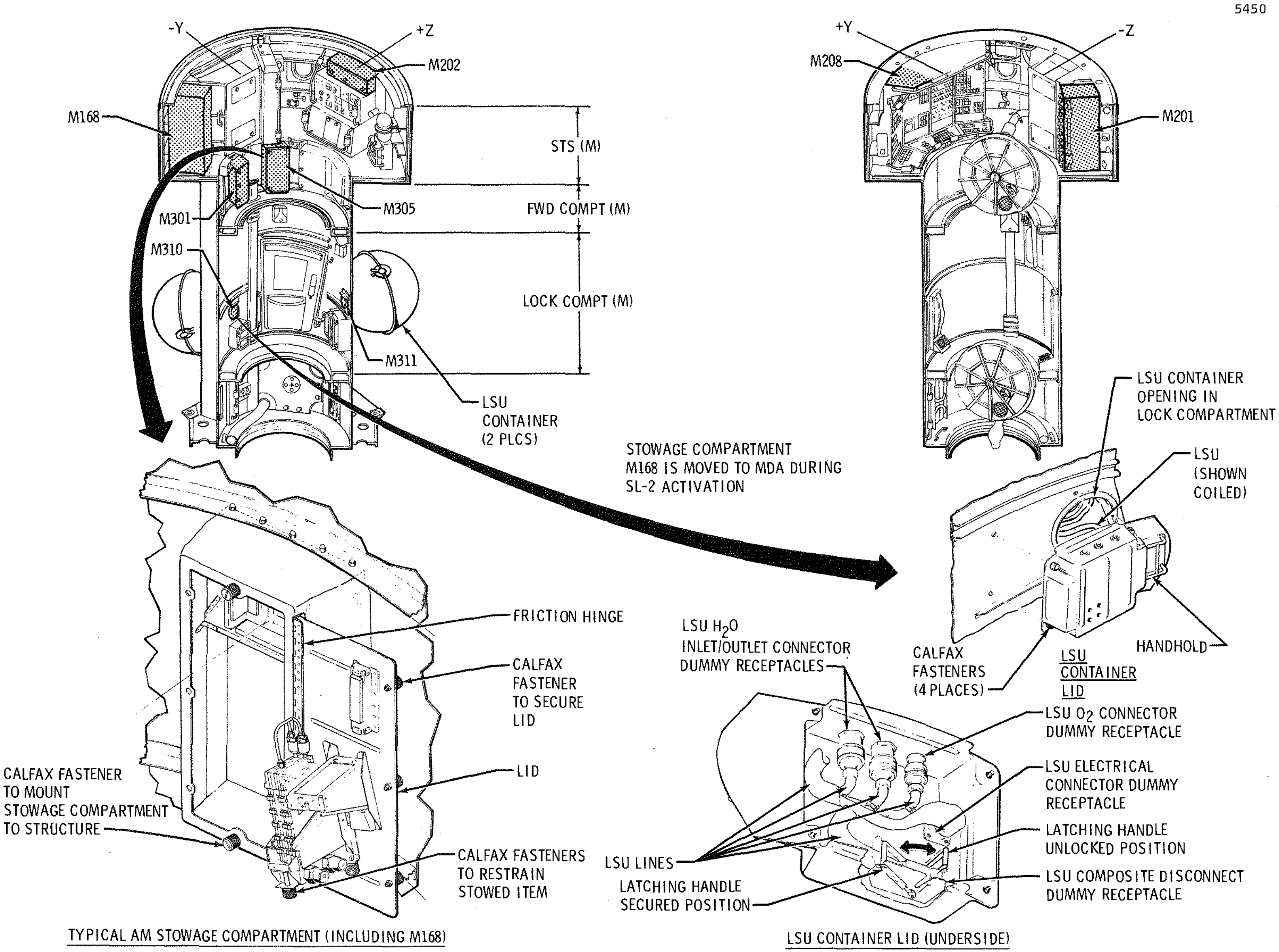


Figure 2.5.5-4 AM Stowage

2.5.5.6 OWS STOWAGE

OWS stowage is provided in the forward dome, forward compartment and crew quarters through the use of various sized stowage compartments, dispensers, refrigerated and ambient temperature food storage facilities, refrigerated urine storage, and a film vault (figure 2.5.5-2). All stowage in the OWS is vented to cabin atmosphere by the stowage equipment door or lid joint. Stowage in the forward dome is assigned (D)400 series numbers, in the forward compartment is (F)500 series, in the experiment compartment is (E)600, in the wardroom is (W)700, in the WMC is (H)800 and, in the sleep compartment is (S)900.

2.5.5.6.1 OWS Stowage Compartments

Stowage compartments in the OWS are of five basic sizes: (1) 6 $ft^3$ (stowage compartments of the D400 series); (2) 1.5 $ft^3$ (stowage compartments of F523-F527); (3) 3 $ft^3$ (stowage compartments of S900-S903); (4) 5 $ft^3$ through 6.5 $ft^3$ (stowage compartments W714, and H820-H823); and (5) 1 $ft^3$ (the remaining stowage compartments in the forward compartment and throughout the crew quarters) (figures 2.5.5-5 and -6). These stowage compartment interiors (with the exception of the D400 series stowage compartments) have holes on the top and bottom of the compartment into which adjustable straps are inserted for launch and or-orbit restraint of the stowed items. The D400 series stowage compartments stowed items are restrained with permanent straps or bolts, since each stowed item is custom mounted. All stowage compartment doors and lids are friction hinged to maintain the door or lid in the desired position.

The latches on the stowage compartments (except D400 series) are the lift handle type. The latches on the D400 stowage compartments are dial latches. The lift handle latches may be forced with a latch release tool (stowed in tool kit) if required. All stowage compartments are constructed of sheet metal. The D400 series stowage compartments are individually removable on-orbit, if required, with the aid of tools. The remainder of the stowage compartments are removable in their vertical assemblies as one floor-to-ceiling unit, with the aid of tools. There is no scheduled removal of any OWS stowage compartment during the Skylab missions.

2.5.5.6.2 Tissue Dispensers

Certain stowage compartments in the OWS crew quarters have tissue dispensers for tissues, wipes and disinfectant moistened pads (paragraph 2.5.13) (figure 2.5.5-7). Each dispenser accomodates three cartridges, which are individually dispensed in their own segment of the dispenser. Four dispensers are located in the wardroom, one in the WMC and one in each of the sleep areas. Normally, one dispenser segment contains a cartridge of tissue while the remaining two segments each contain a cartridge of wipes. (paragraph 2.5.13). However, in one of the wardroom installations, three cartridges of disinfectant moistened pads are used instead of the dry tissue and wipes. Each dispenser contains three spring-feed devices, a cartridge retainer with cartridge retention cams, a compartment door with three tissue access openings, and three hinged dispension lids. The spring-feed mechanisms advance the tissue in the cartridge from the rear as each tissue is removed. The hinged compartment door provides access to the cartridges to facilitate removal and loading operations while also providing access openings on its face through which tissues may be obtained. A spring-loaded dispension lid covers each access opening on the compartment door to provide flammability control of the combustible tissue. The cartridge retainer and cartridge retention cams restrain each cartridge within the dispenser. The cams permit easy removal and replacement of a cartridge.

When the dispensers are in use, the cartridges occupy only about one-third of the stowage compartment interior, permitting additional stowage of other items. Additional stowage in this area does not hinder removal and replacement of a cartridge.

2.5.5.6.3 Fecal Bag Dispenser

Fecal bags are readily available to the crew in the WMC through a dispenser. The fecal bag dispenser occupies the H833 stowage compartment adjacent to the handwasher (figure 2.5.5-8). The permanently mounted dispenser contains a spring-feed device, a resupply lid, and a dispension lid. As each fecal bag is removed from the dispenser, the spring-feed mechanism at the rear of the dispenser advances the remaining fecal bags into an accessible position, replacing the withdrawn item. The resupply lid serves to restrain the stored contents while providing an opening through which fecal bags may be obtained. This lid is friction hinged and maintained in the closed position through a latch. The resupply lid is used to replenish the dispenser with a resupply of fecal bags. The dispension lid is spring loaded closed and must be opened to obtain individual fecal bags.

2.5.5.6.4 Towel Dispenser

New towels are readily available to the crew through five removable towel dispensers. One towel dispenser is launched in a WMC stowage compartment for immediate use; the remaining dispensers are located in wardroom stowage compartments. The outside surface of the towel dispenser is lined with velcro to mate with velcro located in the stowage compartments (figure 2.5.5-9). Each towel dispenser is launched with a supply of 18 towels. Each towel dispenser is partitioned into three equally sized tiers; the tiers are open at the front and will accomodate six rolled towels per tier (paragraph 2.5.13). The towels are restrained in place through friction fit. The stowage compartment door provides flammability control of the combustible towels.

2.5.5.6.5 Trash Containers

Certain stowage compartments in the OWS are allocated for use as trash containers for the stowage of trash (figure 2.5.5-10). The trash container is a stowage compartment with a modified door that accepts the installation of a trash bag onto an opening on the backside of the door. Trash is inserted directly into the bag through

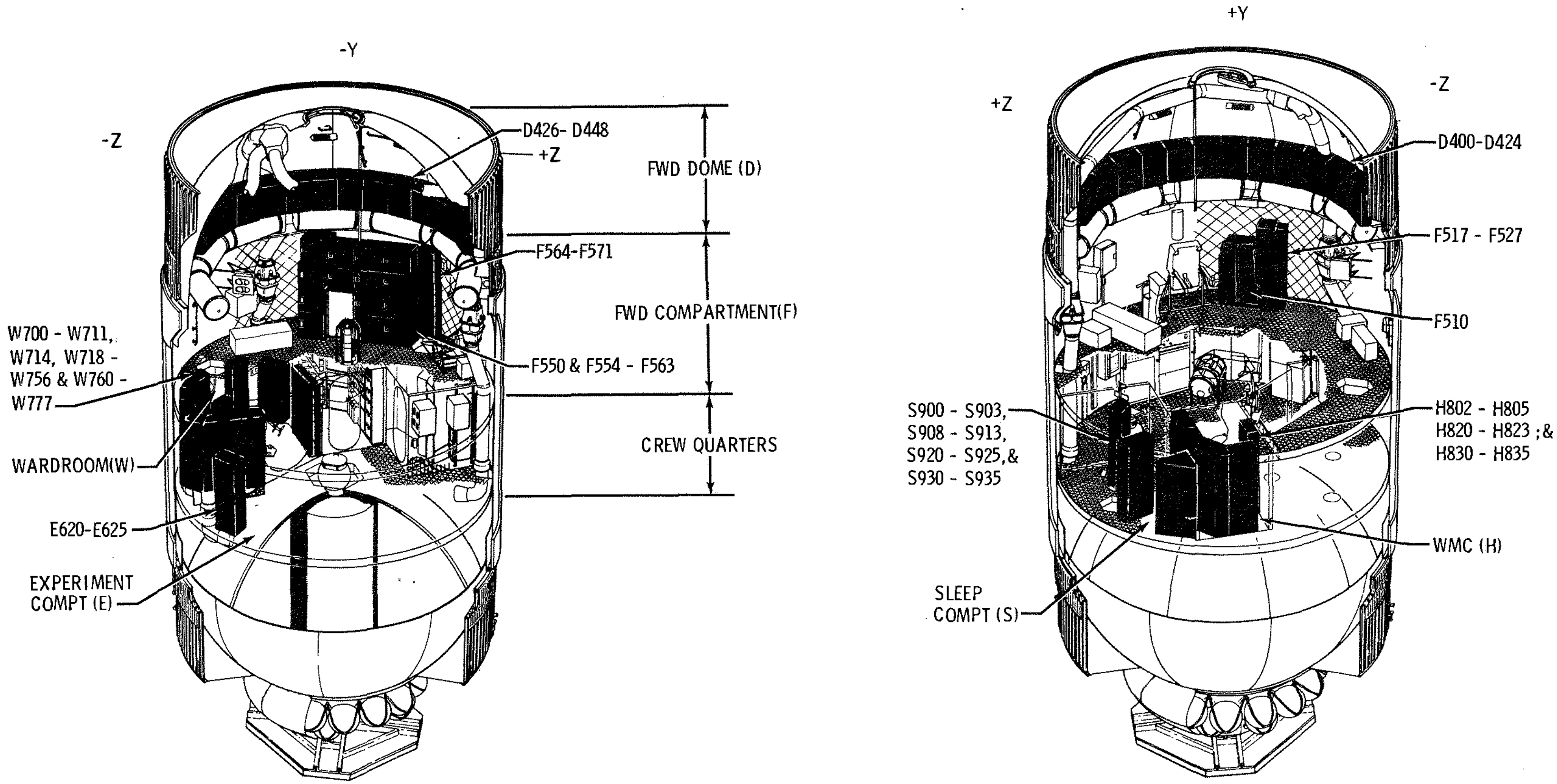


Figure 2.5.5-5 OWS Stowage

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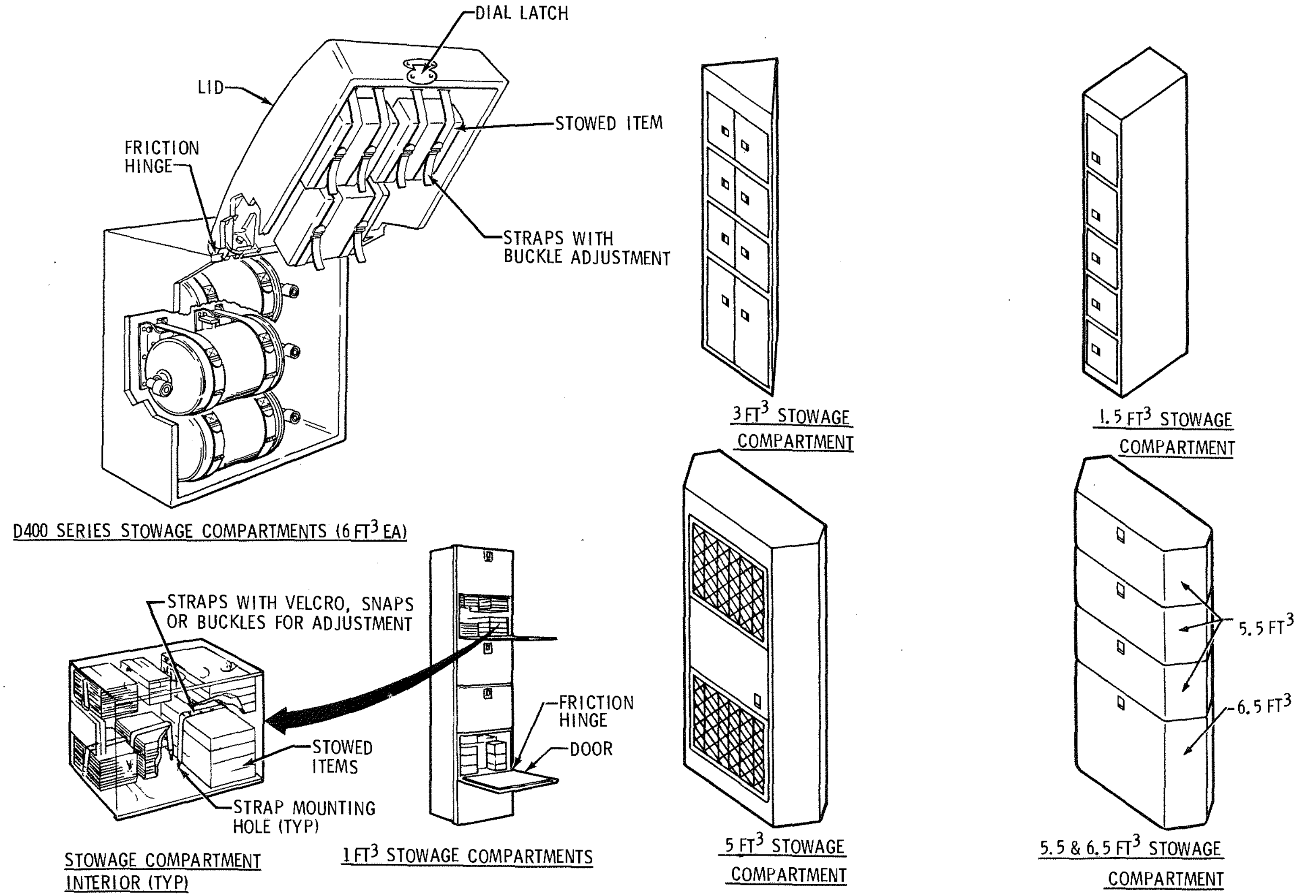


Figure 2.5.5-6 OWS Stowage Compartments

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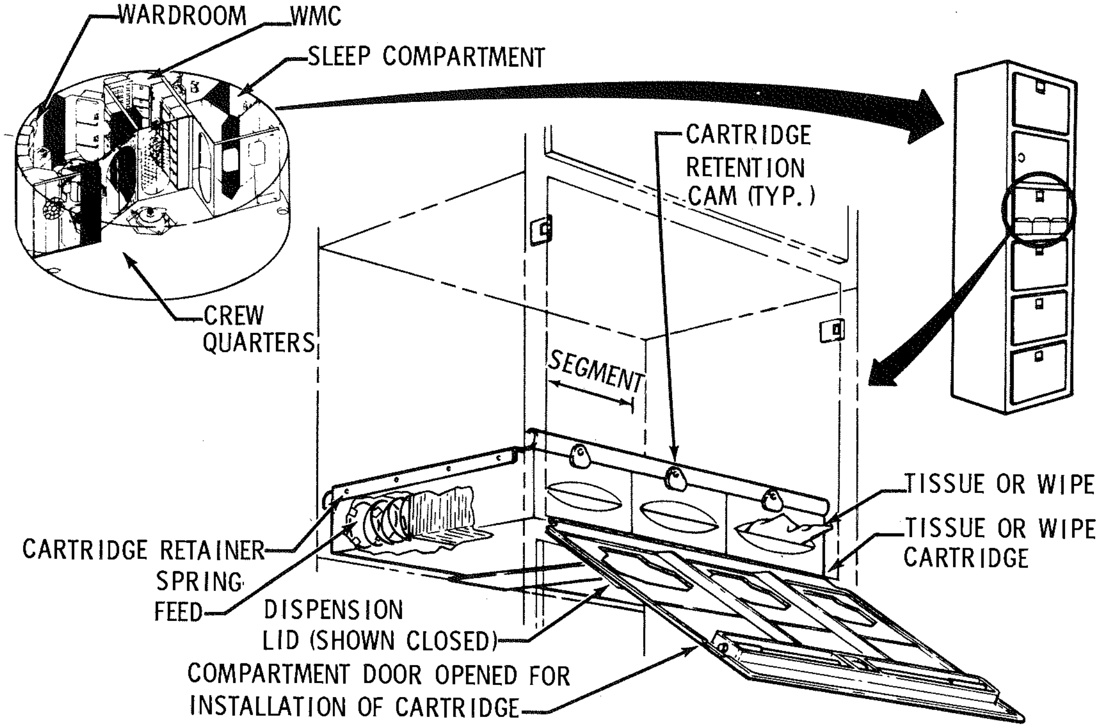


Figure 2.5.5-7 Tissue Dispenser -- Installation

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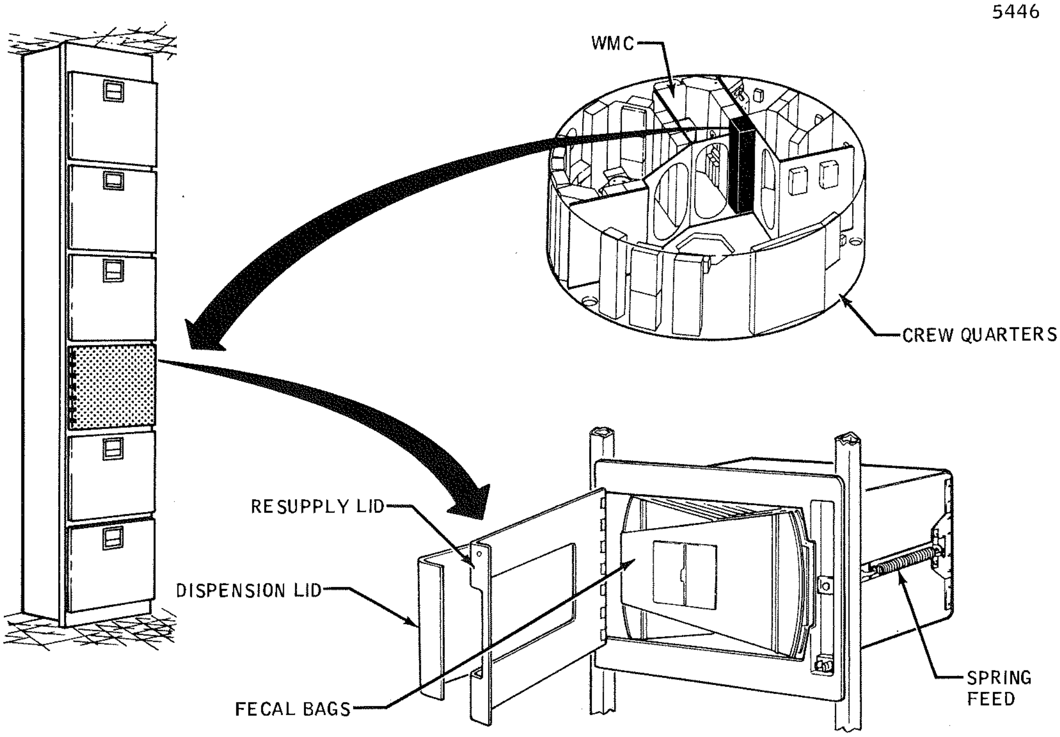



Figure 2.5.5-8 Fecal Bag Dispenser

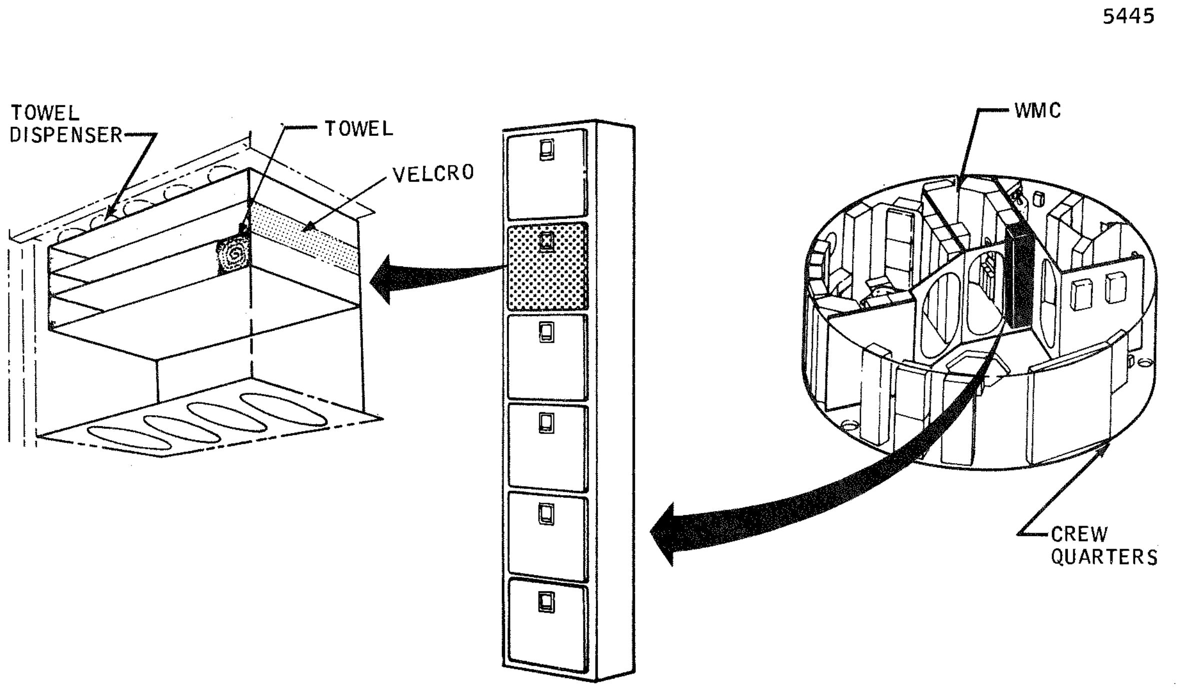



Figure 2.5.5-9 Towel Dispenser

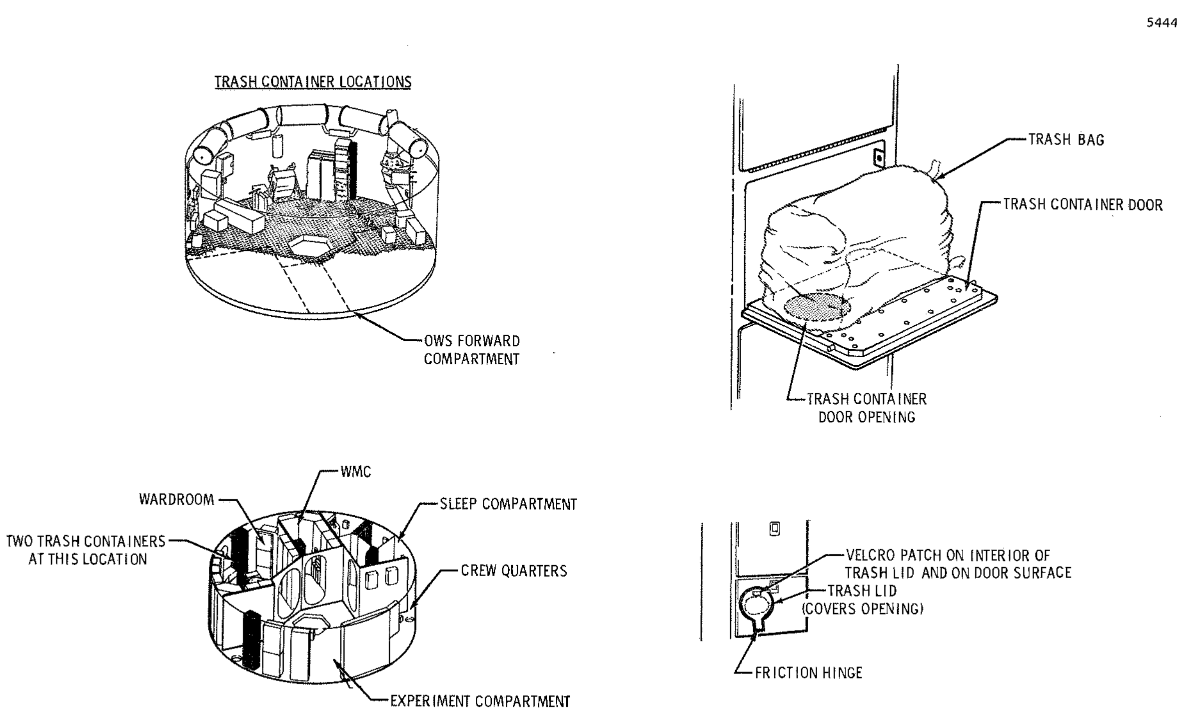



Figure 2.5.5-10 Trash Container

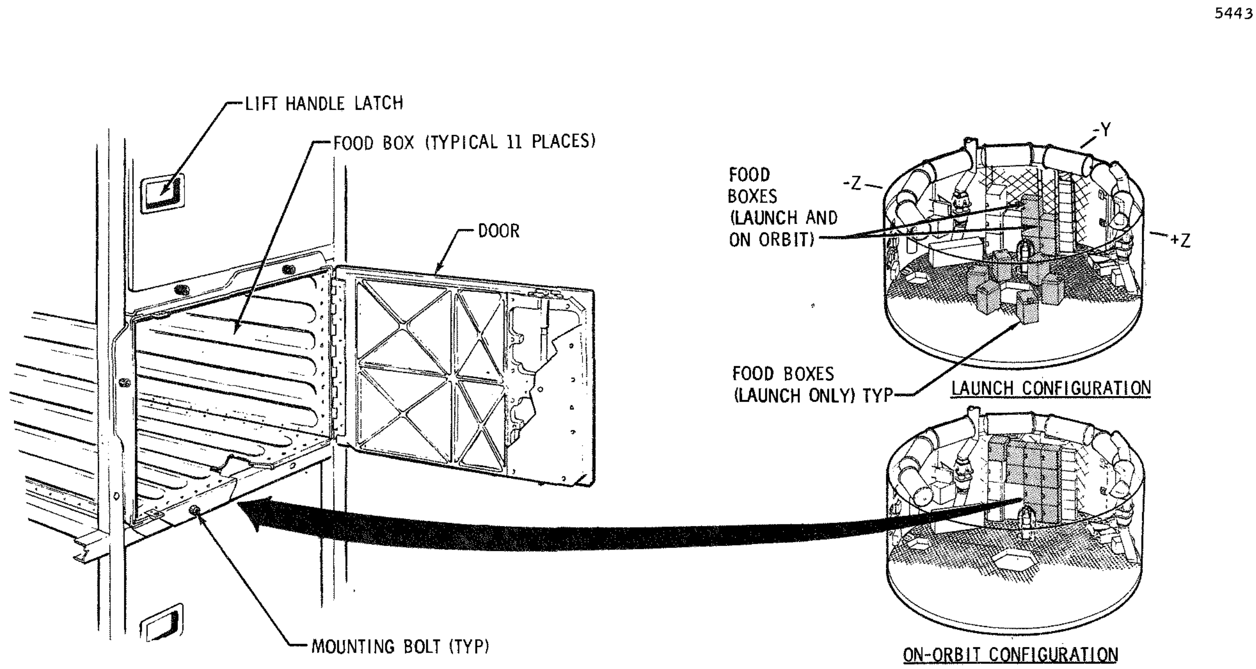



Figure 2.5.5-11 Food Boxes

the opening in the trash container door (paragraph 2.5.9). A friction-hinged trash lid covers the opening on the trash container door when the container is not in use. Velcro patches are used to maintain the trash lid in the closed position. A launch pin restrains the trash lid during launch and is removed upon SL-2 activation without the use of tools.

2.5.5.6.6 Food Boxes

Eleven food boxes provide launch and on-orbit stowage of ambient temperature foods for the SL-2, SL-3, and SL-4 missions (figure 2.5.5-11). Five of the 11 boxes are permanently mounted in the OWS forward compartment on the grid above the wardroom. The remaining six food boxes are dispersed on the forward compartment floor grid around the experiment compartment access opening to ensure structural integrity during launch. Upon SL-2 activation, the six dispersed food boxes will be unbolted from their launch stowed locations and bolted adjacent to the five permanently positioned boxes. Each food box door is also secured closed during launch with bolts. Upon SWS activation all food box launch bolts are removed by the SL-2 crew with the aid of tools.

Each food box is a sheet metal rectangular container of 8 $ft^3$. The food box doors are friction-hinged and are opened through the use of a lift handle latch. If the latch fails to unlatch, a latch release tool can be used for forced entry.

2.5.5.6.7 Food Freezers and Food Chiller

A three-chambered refrigerated unit in the OWS forward compartment and one in the wardroom, stores and preserves the entire mission supply of refrigerated foods in a controlled thermal environment vented to the cabin. The three-chambered unit in the OWS forward compartment is the STOWAGE FREEZER with each chamber storing a 28-day supply of frozen food (figure 2.5.5-12). The unit is a foam-filled shell with the primary and secondary loops of the refrigeration subsystem maintaining the frozen food at -10°F. Each freezer is accessible through a foam-filled outer door, fitted with a vented gasket and a trigger latch. A hinged inner door constructed of sheet metal is attached to the outer door by a short length of beta fabric strap. The sheet metal acts as a heat sink to conduct tne heat contained around the door area to the cooling coils. Each outer door is secured for launch with a launch pin inserted into the side of the door. The trigger latches on each door contain launch pins to prevent damage of the latch mechanism from launch loads. These launch pins are removed by the SL-2 crew upon SWS activation without the use of tools. A readout of each freezer's thermal environment is available on an indicator through selection of the proper freezer on RS DISPLAY SELECT 1 selector located on panel 616 and on telemetry (paragraph 2.5.10).

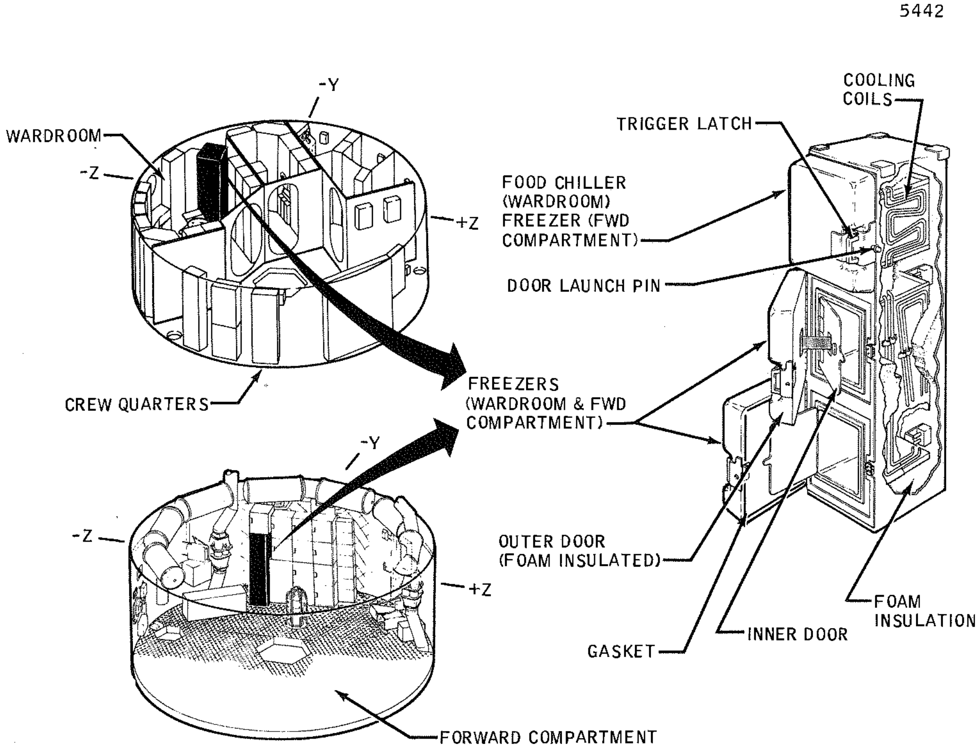



Figure 2.5.5-12 Food Freezers and Food Chiller

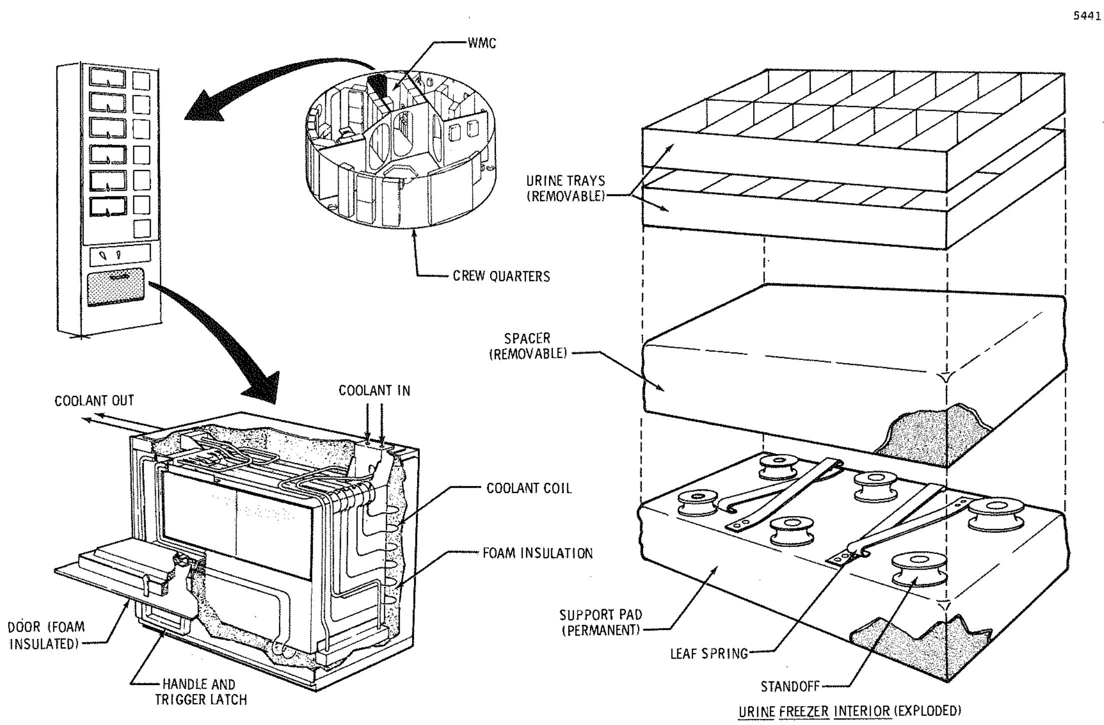



Figure 2.5.5-13 Urine Freezer

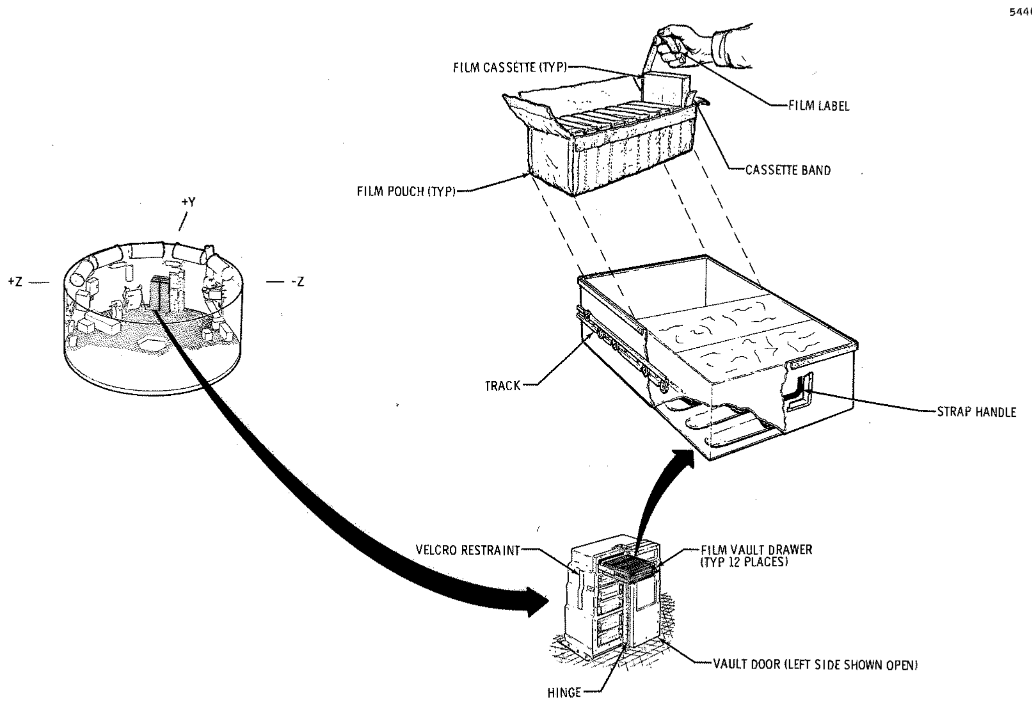



Figure 2.5.5-14 Film Vault (F10)

The three-chambered unit in the wardroom is the WARDROOM FREEZER/FOOD CHILLER which allots the lower two chambers to food freezing and the top chamber to food chilling. The two freezers provide a 28-day supply of frozen food each. The food chiller is launched empty of food and is used to chill and temporarily preserve unconsumed food. In addition, medical supplies are periodically stored in the chiller. The WARDROOM FREEZER/FOOD CHILLER is an identical unit to the STOWAGE FREEZER; however, the coolant loops are modified to permit food chiller operation at 45°F. Temperature readouts are available on panel 616 and on telemetry (paragraph 2.5.10).

2.5.5.6.8 Urine Freezer

A urine freezer, installed in the WMC, stores and preserves up to a 56-day accumulation of urine samples from three crewmembers.

The urine freezer is a foam-filled shell utilizing the primary and secondary loops of the refrigeration subsystem to maintain the stored urine samples below 0°F (figure 2.5.5-13). The front of the freezer features a hinged, foam filled door that has a vented gasket and a trigger latch. The freezer stows the urine samples in portable urine trays and can stow up to four urine trays simultaneously. The bottom of the freezer contains a permanently mounted support pad that maintains the urine trays in an accessible position at the top of the freezer through spring action. To prevent the trays from sticking to the freezer, only two urine trays are stowed in the urine freezer at any given time; a foam spacer is employed to transfer the spring force from the support pad to the two urine trays (paragraph 2.5.11). The freezer door permits only the top urine tray to slide out. The urine freezer is launched with a spacer and 2 empty urine trays. The trigger latch on the freezer door contains a launch pin to protect the latch mechanism from damage due to launch loads. This pin is removed by the SL-2 crew upon SWS activation without the use of tools. A readout of the thermal environment of the urine freezer is available on panel 616 and on telemetry (paragraph 2.5.11).

2.5.6.6.9 OWS Film Vault

Film vault F510 is a shielded, drawered vault located in the OWS forward compartment and stores hand-held camera film cassettes used for experimentation (figure 2.5.5-14). Two vault doors, hinged at the center of the vault, provide access to the drawers which contain packaged film cassettes. The doors are secured closed during launch by bolts which are removed by the SL-2 crew during SWS activation with the aid of tools. On-orbit, the doors are secured closed with two dial latches. The vault and its doors contain aluminum shielding to protect the stored unexposed film from radiation for its stored interval. Each side of the vault contains a strip of velcro which is utilized to temporarily restrain the cassettes as they are removed from the vault. When opened, the vault doors expose removable drawers which are deployed through the use of strap handles. Salt pads, used

5131

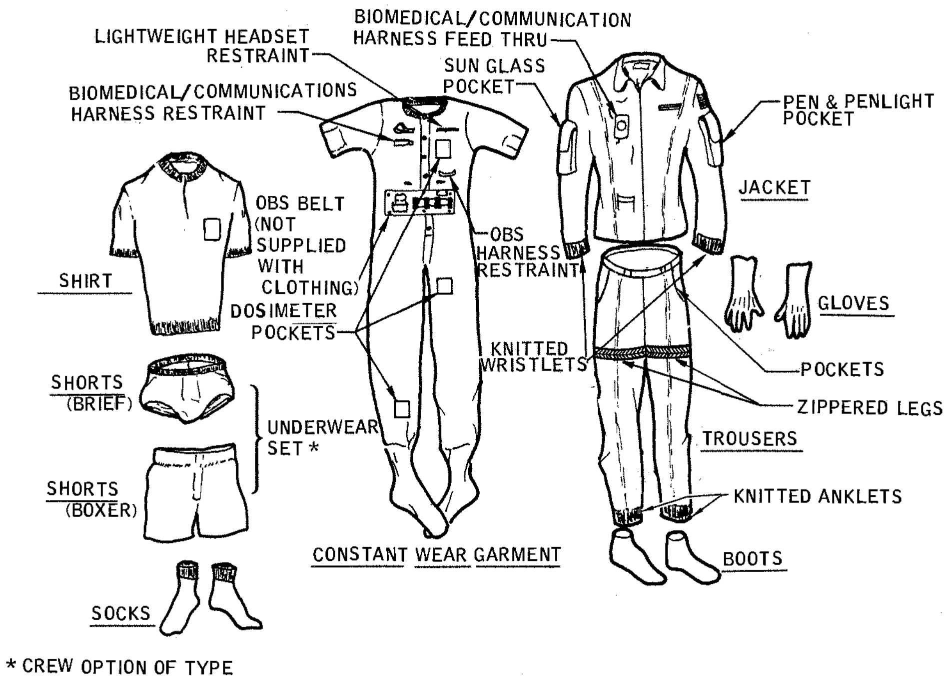



Figure 2.5.6-1 Shirtsleeve Clothing

for vault humidity control are stowed in the film vault drawers in sealed containers. During uninhabited periods of the SWS, the salt pads maintain the relative humidity of the vault at approximately 45 percent to protect the unexposed film from deteoriation.

The stowed film cassettes are individually banded and contained in armalon pouches which are lined with velcro strips. Each film cassette is labeled on its band as to the intended use of the stored film and is removed as required to support IVA photographic tasks. After the film has been exposed, it will be returned to the film vault for temporary stowage for eventual return to earth.

## 2.5.6 WEARING APPAREL

### 2.5.6.1 CLOTHING PROVISION

Skylab crews are provided with shirtsleeve clothing, stowed in clothing bags, and with a bump hat for use when performing potentially hazardous tasks.

### 2.5.6.2 SHIRTSLEEVE CLOTHING

Clothing is provided to support OA IVA operations in a shirtsleeve environment. The entire clothing provision for the duration of all three missions is launched aboard SL-1. The shirtsleeve clothing consists of fire-proof outer garments, cotton undergarments, and leather gloves and boots. The shirtsleeve clothing is sized to the individual crewmember. In addition, a backup clothing supply is provided if a substitute crewman is required.

The outer garments consist of jackets and trousers (figure 2.5.6-1). Pockets in the jackets permit stowage of small utility items such as pens and sunglasses. A feed-through in the jacket allows mating of the biomedical/ communications harness with the CCU/tee adapter. The trouser pockets are for temporary stowage of small items, especially when performing maintenance tasks. Each trouser leg has a zipper surrounding the thigh to convert the trousers into shorts for additional comfort. Jackets and trousers are identified with the crewman's name and are changed once a week. After use, outer garments are disposed of in a trash bag.

Undergarments (figure 2.5.6-1) consist of shirts, socks, and shorts and constant wear garments, which are used as long underwear. Socks and shorts are changed every two days, shirts once a week, and constant wear garments every two weeks. After use, undergarments are disposed of in a trash bag.

5022

| CLOTHING BAG CONTENTS (CLOTHING MODULE) | | CLOTHING BAG CONTENTS (BACKUP CLOTHING) (1) |
|---|---|---|
| 4 | JACKETS | JACKETS |
| 4 | TROUSERS | TROUSERS |
| 2 | CONSTANT WEAR GARMENTS | GLOVES |
| 1 PR | BOOTS | BOOTS |
| 14 | SHORTS (14 BRIEF OR 14 BOXER) | SHORTS |
| 1 PR | GLOVES | |
| 14 PR | SOCKS | |
| 4 | SHIRTS | |

NOTE:
(1) QUANTITY OF CONTENTS IS TBD
(2) 15 CLOTHING BAGS WITH CLOTHING MODULES AND 2 CLOTHING BAGS WITH BACKUP CLOTHING ARE SUPPLIED & ARE LAUNCHED ABOARD SL-1
(3) EACH CLOTHING BAG CONTAINS A 28 - DAY CLOTHING PROVISION

Figure 2.5.6-2 Shirtsleeve Clothing Allocation

Durable leather gloves and boots provide additional warmth when needed (figure 2.5.6-1). The gloves are also used when performing some maintenance tasks. Webbed-strap foot restraints, located in the crew quarters, afford crewmen restraint at the floor level while in bare feet, socks, and/or boots (paragraph 2.5.3). Gloves and boots are normally used for a month's duration and then disposed of in a trash bag.

Backup clothing consists of a size assortment of jackets, trousers, boots, and gloves with enough provided to properly clothe the substitute crewman for an entire 56-day mission. To obtain the additional items of constant wear garments, shorts, socks, and shirts, the substitute crewman will use those of the crewman he replaced.

2.5.6.3 CLOTHING BAGS

A 28-day supply of shirtsleeve clothing for each crewman is stowed in a clothing bag (figure 2.5.6-2). Fifteen clothing bags stow the SL-2, SL-3, and SL-4 supply of clothing for nominal use. Two additional clothing bags stow the 56-day supply of backup clothing.

The clothing bags are made of a fireproof fabric, with their access flaps secured with two webbed straps fitted with snaps (figure 2.5.6-3). Each clothing bag is labeled with a crewman's name, and backup clothing is identified as such. The SL-2 crew's clothing bags are launched in the crewman's sleep area stowage compartment. SL-3, SL-4, and backup clothing provisions are stowed in stowage compartments in the wardroom. When the 28-day clothing supply is depleted, a full clothing bag is transferred to the crewman's sleep area for ready accessibility.

2.5.6.4 BUMP HAT

One adjustable size, hard-shell "hard hat" is used to protect the crewman's head while he is performing the T020 experiment or maintenance tasks in confined areas. The bump hat is stowed in the OWS.

2.5.7 EVA SUPPORT

2.5.7.1 EVA SUPPORT PROVISIONS

The EVA crewmen perform their extra-vehicular tasks at workstations fitted with provisions to support work activities conducted under zero-"G" conditions. During EVA, crewman wear spacesuits and are provided life support equipment to supply the spacesuit with oxygen for breathing and suit pressurization and also water for suit cooling. Facilities are provided for life support equipment servicing.

5475

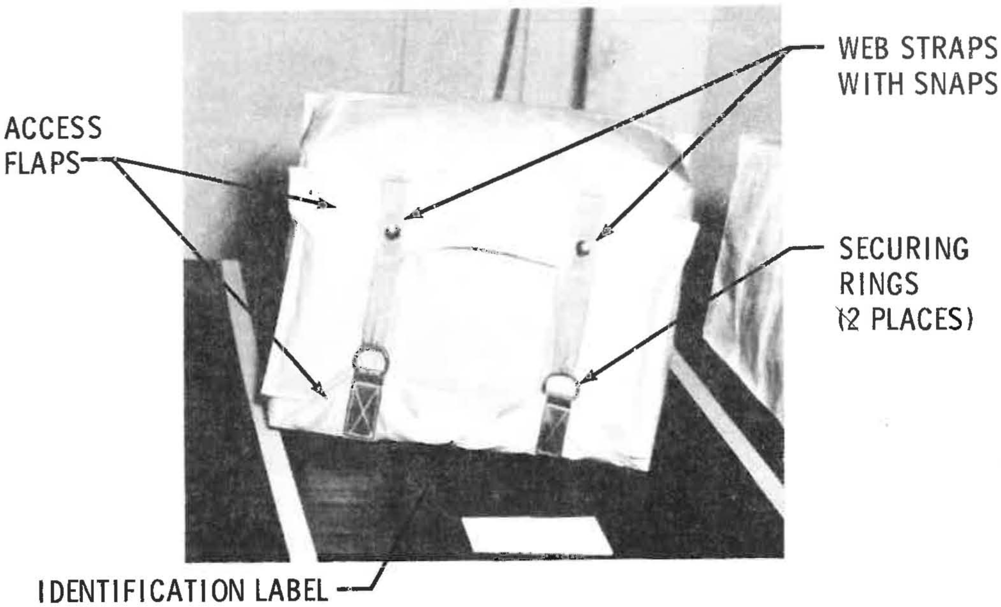



Figure 2.5.6-3 Clothing Bag

5222

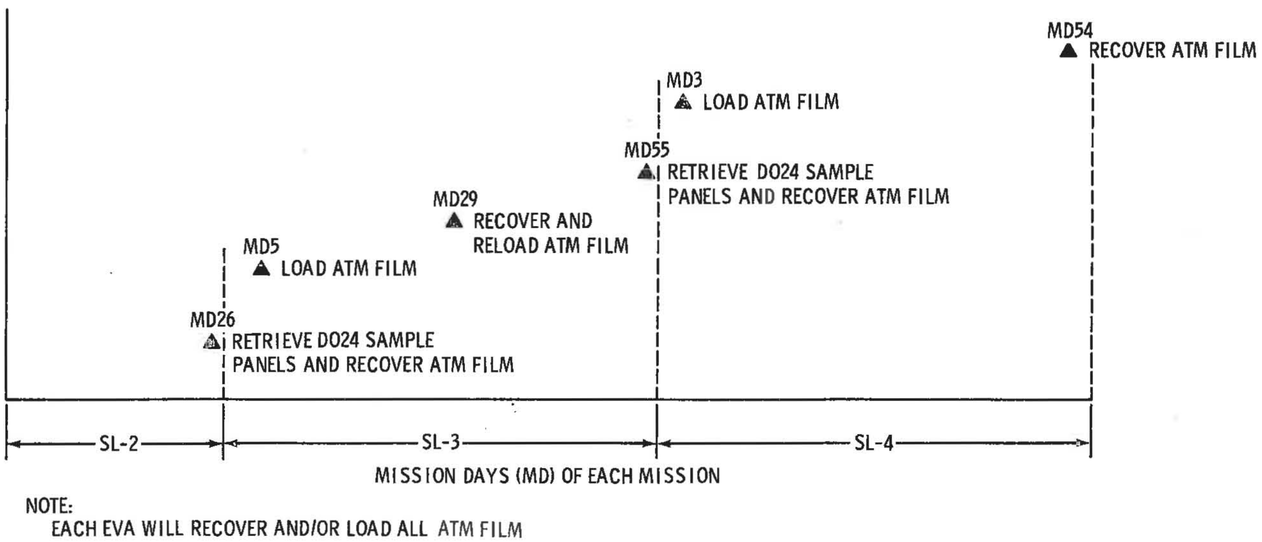



Figure 2.5.7-1 EVA Tasks Timeline

2.5.7.2 EXTRA-VEHICULAR TASKS

EVA's are conducted to support experimentation for the purposes of: (1) recovering exposed photographic film from ATM cameras and reloading the cameras with new film; and (2) retrieving D024 sample panels that have been exposed to the environment of space. A total of six EVA's are conducted throughout the Skylab missions: one during SL-2; three during SL-3, and two during SL-4 (figure 2.5.7-1). Two crewmembers will participate in each EVA; the third crewman will be stationed in the STS (paragraph 2.5.7.7 for EVA operations).

2.5.7.3 EVA WORKSTATIONS

The extra-vehicular tasks are performed at five workstations located on the AM exterior and on the ATM (figure 2.5.7-2). The EVA bay on the AM contains the FAS workstation and the replacement workstation; the ATM contains the center workstation, transfer workstation, and sun end workstation. Each workstation consists of a foot restraint to restrain the crewman while he performs film recovering/reloading tasks, film and equipment handling tasks, or equipment maintenance tasks. Each workstation will accomodate only one crewman.

The FAS workstation serves as the main operations area in support of the nominal extra-vehicular tasks. One crewman will occupy the FAS workstation continuously throughout the EVA (figure 2.5.7-2).

The replacement workstation is contained within the same bay area as the FAS workstation and is located adjacent to the EVA hatch (figure 2.5.7-2). From the replacement workstation, all contingency EVA procedures are conducted by one crewman in support of any off-nominal extra-vehicular tasks which are necessitated because of hardware failures.

The center workstation, transfer workstation, and sun end workstation are located on the ATM and serve as the work areas in which ATM camera and/or film handling, recovering, and reloading are accomplished (figure 2.5.7-2). One crewman will conduct the work tasks at each of the ATM workstations (refer to SLOH/ATM for ATM workstation descriptions).

2.5.7.4 EVA WORKSTATION PROVISIONS

The operational envelope of the workstations are outfitted with provisions to aid the crewmembers during EVA. The following provisions are delineated only for the FAS workstation and the replacement workstation, although most of these provisions are located at the ATM workstations (refer to SLOH/ATM for ATM workstation descriptions).

2.5.7.4.1 EVA Lighting

The EVA bay lighting network is controlled by a single switch in the lock compartment and provides illumination of the EVA bay area through five EVA lights (paragraph 2.5.4) (figure 2.5.7-3). Each light is encased with a wire-grid enclosure to protect its light bulb from damage. In addition to illuminating the EVA bay area, one of the five EVA lights is mounted on the D024 sample panel handrail to illuminate that area for sample panel retrieval.

2.5.7.4.2 EVA Handrails

A handrail network, provided for crewman hand restraint to permit one-handed work tasks to be accomplished, are located along the translation route between the AM and ATM workstations (EVA trail) (figure 2.5.7-3). The handrails also provide a convenient structure to which cameras may be mounted through use of the universal mount. The handrail adjacent to the EVA hatch opening is the replacement workstation and doubles as a foot restraint. The crewman's spacesuit boots are inserted under the handrail for restraint, freeing the crewman's hands and allowing him to perform the two-handed activities involved in the contingency extra-vehicular tasks. The handrails are colored blue and are marked with alphanumeric reference numbers for use in coordinating EVA procedures (paragraph 2.5.3).

2.5.7.4.3 PGA Foot Restraint

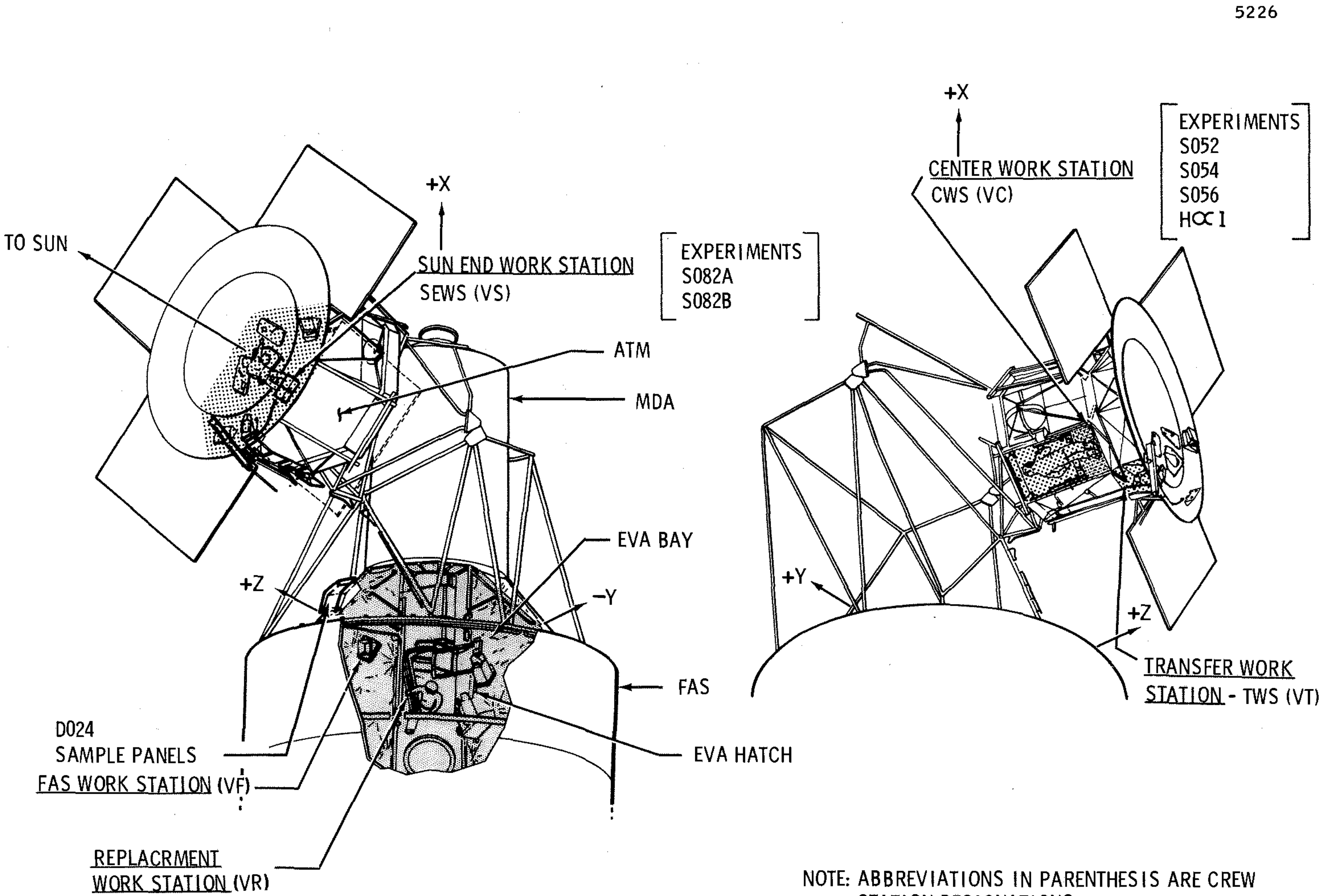
The PGA foot restraint (paragraph 2.5.3) located on the FAS in the EVA bay serves as the FAS workstation. The crewman's spacesuit boots are inserted into the foot restraint to free both hands to perform the nominal extravehicular tasks. During the nominal EVA timeline, one crewman will occupy the FAS workstation during the entire EVA to support the other crewman working at the ATM workstations.

2.5.7.4.4 LSU Clamp

Two LSU clamps (paragraph 2.5.3) are located in the EVA bay and provide a temporary restraint for the life support umbilical (LSU) of each crewman (figure 2.5.7-3). Shortly after each crewman egresses from the lock compartment into the EVA bay, each LSU will be inserted in an LSU clamp to restrain the umbilical outside the operating envelopes of the crewman. The LSU clamp will free the LSU if slight LSU side loads are encountered, to prevent umbilical damage due to its capture. LSU positioning stripes are marked on each LSU to indicate to the crewman the appropriate installation point for each LSU clamp.

2.5.7.4.5 Equipment Hook

The equipment hook is located adjacent to the EVA hatch opening in easy reach of the crewman at the FAS workstation, and provides a temporary, out-of-the-way restraint for equipment. Such items as a camera, the D024 return container or an extendible boom will be temporarily stowed and restrained in the equipment hook for ready accessibility (paragraph 2.5.3).




NOTE: ABBREVIATIONS IN PARENTHESIS ARE CREW STATION DESIGNATIONS

Figure 2.5.7-2 EVA Workstations

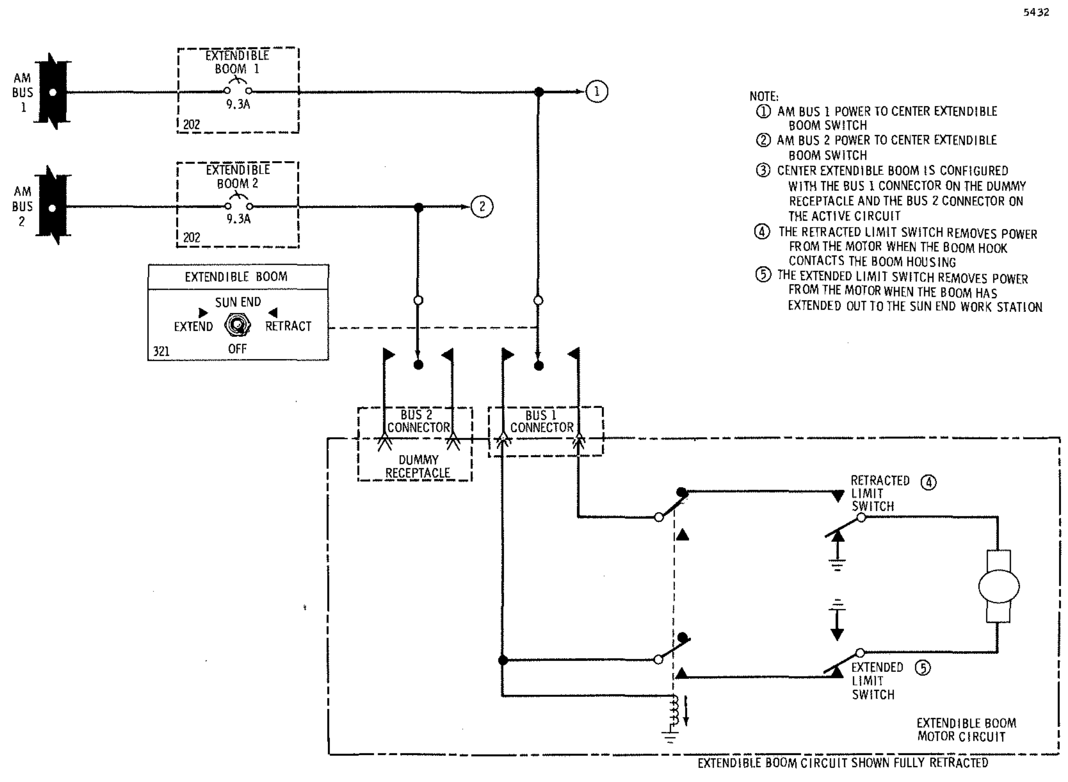



Figure 2.5.7-4 Extendible Boom Control -- Schematic

2.5.7.4.6 Film Tree Receptacle

The film to be transferred from workstation to workstation is temporarily stowed in the workstation area in film tree receptacles (figure 2.5.7-3). The film to be transported to VS (sun end workstation) and VC (center workstation) is temporarily stowed in the EVA bay, using the VS film tree receptacle and VC film tree receptacle (paragraph 2.5.3). After the crewmember occupies the FAS workstation, he accepts film from the crewman located in the lock compartment. This film is stowed in the film tree receptacles and is removed upon its transfer to the sun end or center workstations .

2.5.7.4.7 Extendible Boom

To transfer the ATM film between the FAS workstation and the center or sun end workstation, a remotely controlled, motorized extendible boom is employed to transport the film to the film receiving points near the center and sun end workstations (figure 2.5.7-3). Three extendible booms are utilized: (1) a center extendible boom to transport the ATM film to a target point immediately adjacent to the center workstation; (2) a sun end extendible boom to transport the film to the transfer workstation where the film is removed from the boom by the crewman and placed on the sun end workstation; and (3) a spare extendible boom which serves as a replacement for the center or sun end extendible boom.

The booms extend and retract through the action of electrically driven reels, which "pay-out" or "roll-back" two ribbons. The ribbons are stored in the flattened state on the reels. When an extendible boom switch is placed in the EXTEND position, the reels "pay-out" the flat ribbon through the boom housing. The pre-load built into the ribbon causes the ribbon to curl over into a cross section resembling a "double barrel shotgun". A boom hook is mounted on the end of the ribbon boom and restrains the ATM film as it is being transported. The boom hook is hinged at its base to permit "out-of-the-way" stowage when not in use.

The center extendible boom and the sun end extendible boom are powered from switches located on panel 321 adjacent to the EVA hatch opening in the EVA bay. This panel is easily accessible to the crewman located in the FAS workstation. The film is readily loaded or unloaded on the center or sun end extendible boom while the crewman is positioned in the FAS workstation.

The center extendible boom and the sun end extendible boom are supplied AM buses 1 and 2 power for operation through a zero-G electrical receptacle. However, for each extendible boom, one bus connector is connected to the boom circuitry while the other bus connector is stowed on a dummy receptacle located on the extendible boom mounting case (figure 2.5.7-4). In this way, the sun end extendible boom is normally connected to AM bus 1 and the center extendible boom to AM bus 2.

All the extendible booms are equipped with limit switches, which remove power from the extendible boom motor when the boom attains a fixed distance (figure 2.5.7-4). When any boom is extended out to the sun end workstation, its extended limit switch trips and removes power from its motor. When any boom is retracted to where the base of the boom hook contacts the boom housing, its retracted limit switch trips and removes power from its motor. Since no special automatic provisions are supplied for boom motor shutdown at the center workstation, the boom ribbon is striped at the predetermined length corresponding to the target point at the center workstation to cue the FAS workstation crewman that the target point has been reached.

If a failure disables the entire electrical operation of the boom or if the motor becomes incapable of extending or retracting the boom, a boom manual crank is provided on the housing to allow the crewman to manually operate the boom's travel. The extension or retraction in the manual mode is controlled by a manual EXT/RET selector on the boom housing.

In the event of a complete failure of one of the operational extendible booms, (CENTER or SUN END) a spare extendible boom is provided and stowed nearby (figure 2.5.7-3). The failed extendible boom is removed and replaced by the spare extendible boom with the crewmember in position at the replacement workstation. Mounting latches, locking devices and trigger release features are provided on each extendible boom to facilitate its removal and replacement.

2.5.7.4.8 Clothesline

If a failure occurs that incapacitates the extendible booms, a clothesline method of transporting film is used. The clothesline is stowed in a clothesline bag located adjacent to the sun end and center extendible boom mounting cases with one end of the clothesline permanently attached to a clothesline bracket (paragraph 2.5.3) located nearby. In use, the crewman removes the clothesline from its bag and translates out to the particular ATM workstation to install the end of the clothesline onto a similar bracket at each workstation. Two clotheslines are provided: one for the center workstation and one for the sun end workstation. All activities in the EVA bay associated with deploying the clothesline and loading and unloading film on the clothesline are accomplished with the crewman positioned in the replacement workstation. Clothesline clips (paragraph 2.5.3) are located in the EVA bay to maintain the clotheslines out-of-the-way during use.

2.5.7.4.9 Procedural Decals

Certain operational procedures that are or may be implemented during EVA are emplaced near the workstations for the crewman's reference. These are as follows:

- o Extendible boom operating procedure - located adjacent to the extendible boom control panel and readable from the FAS workstation.
- o Extendible boom replacement and clothesline operation contingency procedures - located adjacent to the EVA hatch opening and readable from the replacement workstation.

In addition, velcro is located at convenient points at the workstations in the lock compartment and on the EVA hatch to which the crew may affix procedures for use during EVA.

2.5.7.5 LIFE SUPPORT PROVISIONS

The spacesuit of each crewman is supplied with coolant water, electrical provisions, and pressurant/ breathing oxygen from SWS suit umbilical systems (SUS) (figure 2.5.7-5). These life support provisions are routed from the SUS to the spacesuit through an astronaut life support assembly (ALSA).

2.5.7.5.1 Spacesuit

Crewmembers use the A7LB spacesuit for all suited operational modes. The primary components of the A7LB spacesuit are the pressure garment assembly (PGA), the liquid cooling garment (LCG), the pressure helmet, the Skylab extravehicular visor assembly (SEVA), and EVA gloves (figure 2.5.7-6). One spacesuit is launched with each crewmember in the CM for his personal use throughout the mission.

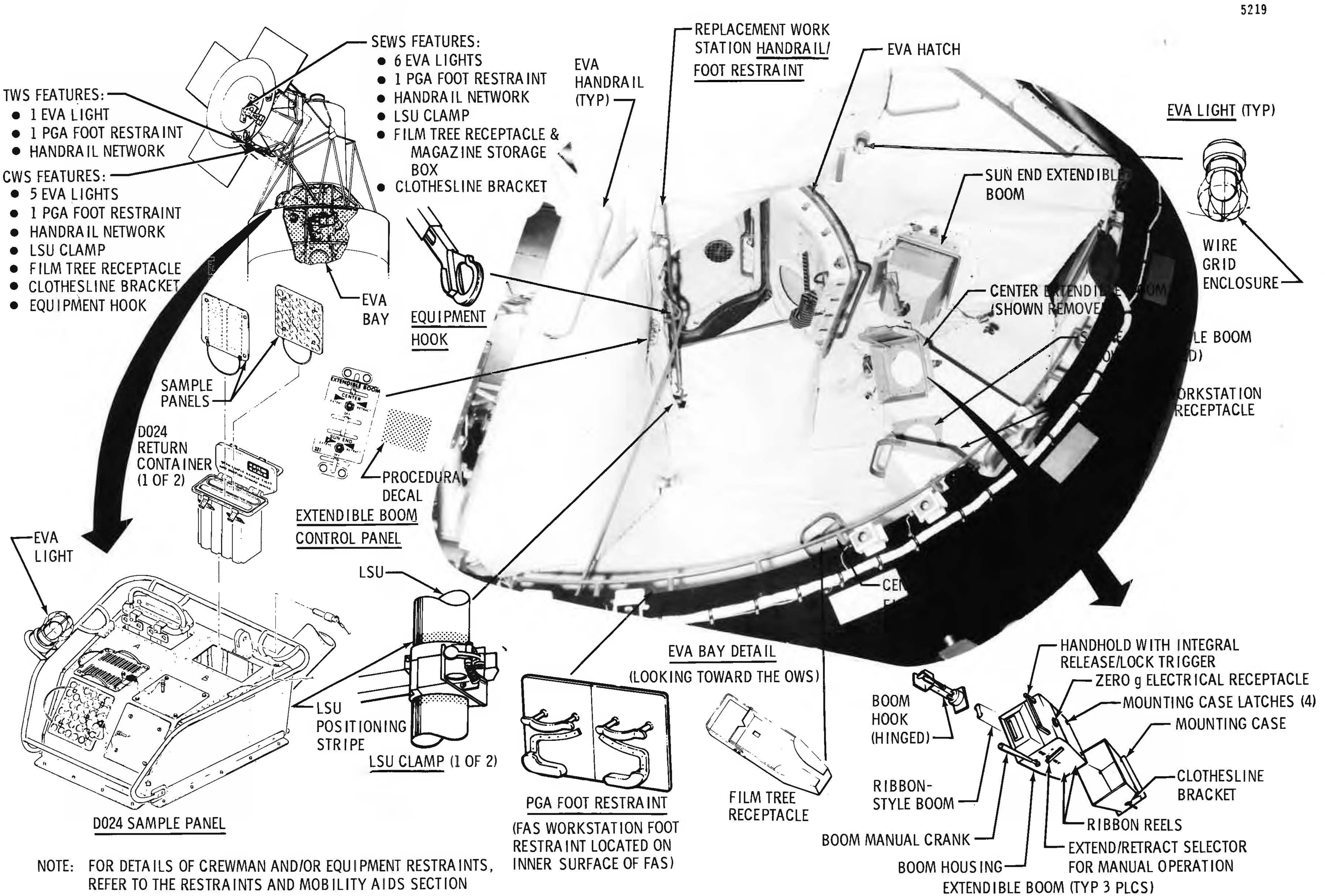
2.5.7.5.1.1 Pressure Garment Assembly

The PGA provides an oxygen environment for the crewman not only for breathing but also for spacesuit ventilation and pressurization. The PGA is supplied electrical provisions for bioinstrumentation and communications. One PGA for each crewman is launched with the crewman in the CM and is transferred to designated stowage areas in the OWS for on-orbit stowage. After each use, the PGA's will be dried at the suit drying stations (paragraph 2.5.7.6.2). At the end of the mission, the crewman's PGA is returned with him in the CM.

2.5.7.5.1.2 Liquid Cooling Garment

Inside the PGA, an LCG is worn next to the skin and is made up of a network of water-carrying tubes that provide body cooling. Cold water is routed into the tubing in the LCG, circulated about the crewman's body, and returned to the SWS for heat rejection.

The LCG's for each mission will be launched in the CM for that particular mission and are transferred to designated areas in the OWS for stowage. Each LCG is launched fully charged with water. After each use, the LCG surface will be air dried at the suit drying stations (paragraph 2.5.7.6.2). All the LCG's used during a particular mission will be transferred to a permanent stowage area in the OWS at the end of each mission.




NOTE: FOR DETAILS OF CREWMAN AND/OR EQUIPMENT RESTRAINTS, REFER TO THE RESTRAINTS AND MOBILITY AIDS SECTION

Figure 2.5.7-3 EVA Workstation Provisions

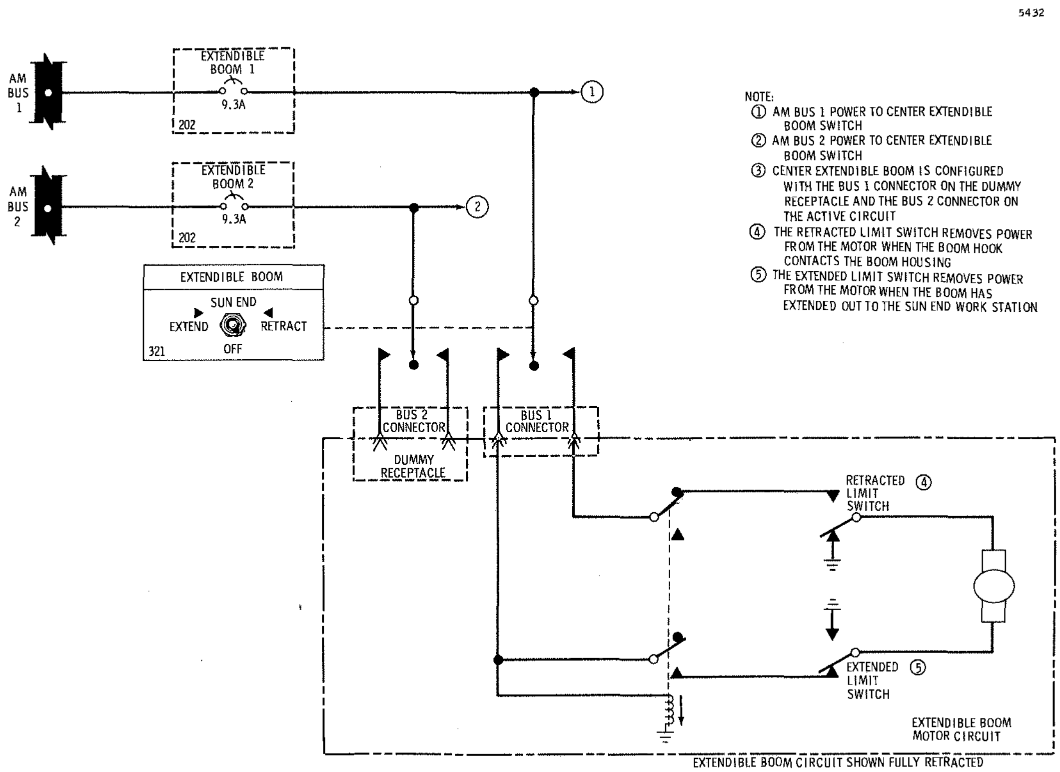



Figure 2.5.7-4 Extendible Boom Control -- Schematic

2.5.7.4.6 Film Tree Receptacle

The film to be transferred from workstation to workstation is temporarily stowed in the workstation area in film tree receptacles (figure 2.5.7-3). The film to be transported to VS (sun end workstation) and VC (center workstation) is temporarily stowed in the EVA bay, using the VS film tree receptacle and VC film tree receptacle (paragraph 2.5.3). After the crewmember occupies the FAS workstation, he accepts film from the crewman located in the lock compartment. This film is stowed in the film tree receptacles and is removed upon its transfer to the sun end or center workstations .

2.5.7.4.7 Extendible Boom

To transfer the ATM film between the FAS workstation and the center or sun end workstation, a remotely controlled, motorized extendible boom is employed to transport the film to the film receiving points near the center and sun end workstations (figure 2.5.7-3). Three extendible booms are utilized: (1) a center extendible boom to transport the ATM film to a target point immediately adjacent to the center workstation; (2) a sun end extendible boom to transport the film to the transfer workstation where the film is removed from the boom by the crewman and placed on the sun end workstation; and (3) a spare extendible boom which serves as a replacement for the center or sun end extendible boom.

The booms extend and retract through the action of electrically driven reels, which "pay-out" or "roll-back" two ribbons. The ribbons are stored in the flattened state on the reels. When an extendible boom switch is placed in the EXTEND position, the reels "pay-out" the flat ribbon through the boom housing. The pre-load built into the ribbon causes the ribbon to curl over into a cross section resembling a "double barrel shotgun". A boom hook is mounted on the end of the ribbon boom and restrains the ATM film as it is being transported. The boom hook is hinged at its base to permit "out-of-the-way" stowage when not in use.

The center extendible boom and the sun end extendible boom are powered from switches located on panel 321 adjacent to the EVA hatch opening in the EVA bay. This panel is easily accessible to the crewman located in the FAS workstation. The film is readily loaded or unloaded on the center or sun end extendible boom while the crewman is positioned in the FAS workstation.

The center extendible boom and the sun end extendible boom are supplied AM buses 1 and 2 power for operation through a zero-G electrical receptacle. However, for each extendible boom, one bus connector is connected to the boom circuitry while the other bus connector is stowed on a dummy receptacle located on the extendible boom mounting case (figure 2.5.7-4). In this way, the sun end extendible boom is normally connected to AM bus 1 and the center extendible boom to AM bus 2.

All the extendible booms are equipped with limit switches, which remove power from the extendible boom motor when the boom attains a fixed distance (figure 2.5.7-4). When any boom is extended out to the sun end workstation, its extended limit switch trips and removes power from its motor. When any boom is retracted to where the base of the boom hook contacts the boom housing, its retracted limit switch trips and removes power from its motor. Since no special automatic provisions are supplied for boom motor shutdown at the center workstation, the boom ribbon is striped at the predetermined length corresponding to the target point at the center workstation to cue the FAS workstation crewman that the target point has been reached.

If a failure disables the entire electrical operation of the boom or if the motor becomes incapable of extending or retracting the boom, a boom manual crank is provided on the housing to allow the crewman to manually operate the boom's travel. The extension or retraction in the manual mode is controlled by a manual EXT/RET selector on the boom housing.

In the event of a complete failure of one of the operational extendible booms, (CENTER or SUN END) a spare extendible boom is provided and stowed nearby (figure 2.5.7-3). The failed extendible boom is removed and replaced by the spare extendible boom with the crewmember in position at the replacement workstation. Mounting latches, locking devices and trigger release features are provided on each extendible boom to facilitate its removal and replacement.

2.5.7.4.8 Clothesline

If a failure occurs that incapacitates the extendible booms, a clothesline method of transporting film is used. The clothesline is stowed in a clothesline bag located adjacent to the sun end and center extendible boom mounting cases with one end of the clothesline permanently attached to a clothesline bracket (paragraph 2.5.3) located nearby. In use, the crewman removes the clothesline from its bag and translates out to the particular ATM workstation to install the end of the clothesline onto a similar bracket at each workstation. Two clotheslines are provided: one for the center workstation and one for the sun end workstation. All activities in the EVA bay associated with deploying the clothesline and loading and unloading film on the clothesline are accomplished with the crewman positioned in the replacement workstation. Clothesline clips (paragraph 2.5.3) are located in the EVA bay to maintain the clotheslines out-of-the-way during use.

2.5.7.4.9 Procedural Decals

Certain operational procedures that are or may be implemented during EVA are emplaced near the workstations for the crewman's reference. These are as follows:

- o Extendible boom operating procedure - located adjacent to the extendible boom control panel and readable from the FAS workstation.
- o Extendible boom replacement and clothesline operation contingency procedures - located adjacent to the EVA hatch opening and readable from the replacement workstation.

In addition, velcro is located at convenient points at the workstations in the lock compartment and on the EVA hatch to which the crew may affix procedures for use during EVA.

2.5.7.5 LIFE SUPPORT PROVISIONS

The spacesuit of each crewman is supplied with coolant water, electrical provisions, and pressurant/breathing oxygen from SWS suit umbilical systems (SUS) (figure 2.5.7-5). These life support provisions are routed from the SUS to the spacesuit through an astronaut life support assembly (ALSA).

2.5.7.5.1 Spacesuit

Crewmembers use the A7LB spacesuit for all suited operational modes. The primary components of the A7LB spacesuit are the pressure garment assembly (PGA), the liquid cooling garment (LCG), the pressure helmet, the Skylab extravehicular visor assembly (SEVA), and EVA gloves (figure 2.5.7-6). One spacesuit is launched with each crewmember in the CM for his personal use throughout the mission.

2.5.7.5.1.1 Pressure Garment Assembly

The PGA provides an oxygen environment for the crewman not only for breathing but also for spacesuit ventilation and pressurization. The PGA is supplied electrical provisions for bioinstrumentation and communications. One PGA for each crewman is launched with the crewman in the CM and is transferred to designated stowage areas in the OWS for on-orbit stowage. After each use, the PGA's will be dried at the suit drying stations (paragraph 2.5.7.6.2). At the end of the mission, the crewman's PGA is returned with him in the CM.

2.5.7.5.1.2 Liquid Cooling Garment

Inside the PGA, an LCG is worn next to the skin and is made up of a network of water-carrying tubes that provide body cooling. Cold water is routed into the tubing in the LCG, circulated about the crewman's body, and returned to the SWS for heat rejection.

The LCG's for each mission will be launched in the CM for that particular mission and are transferred to designated areas in the OWS for stowage. Each LCG is launched fully charged with water. After each use, the LCG surface will be air dried at the suit drying stations (paragraph 2.5.7.6.2). All the LCG's used during a particular mission will be transferred to a permanent stowage area in the OWS at the end of each mission.

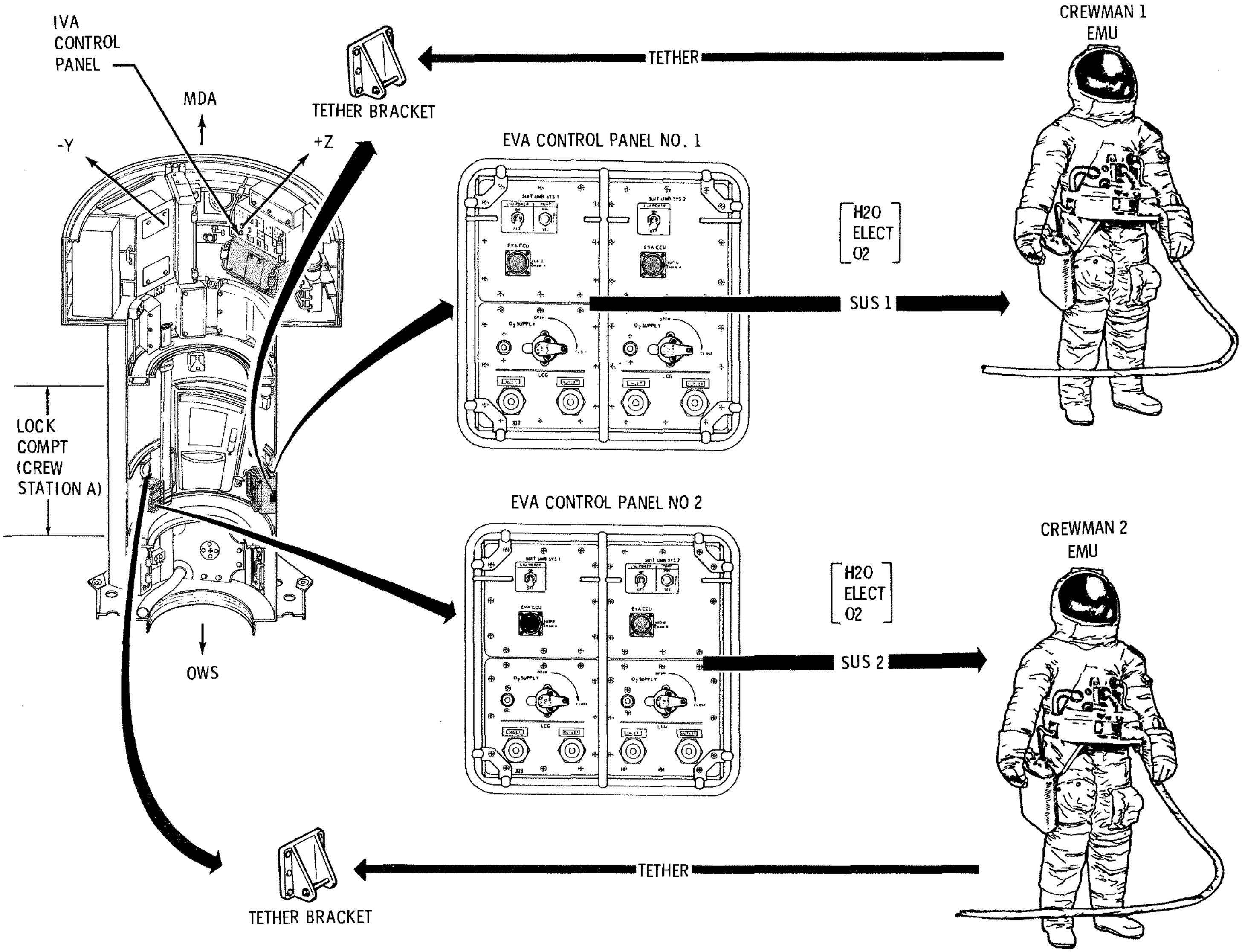



Figure 2.5.7-5 Life Support Provisions

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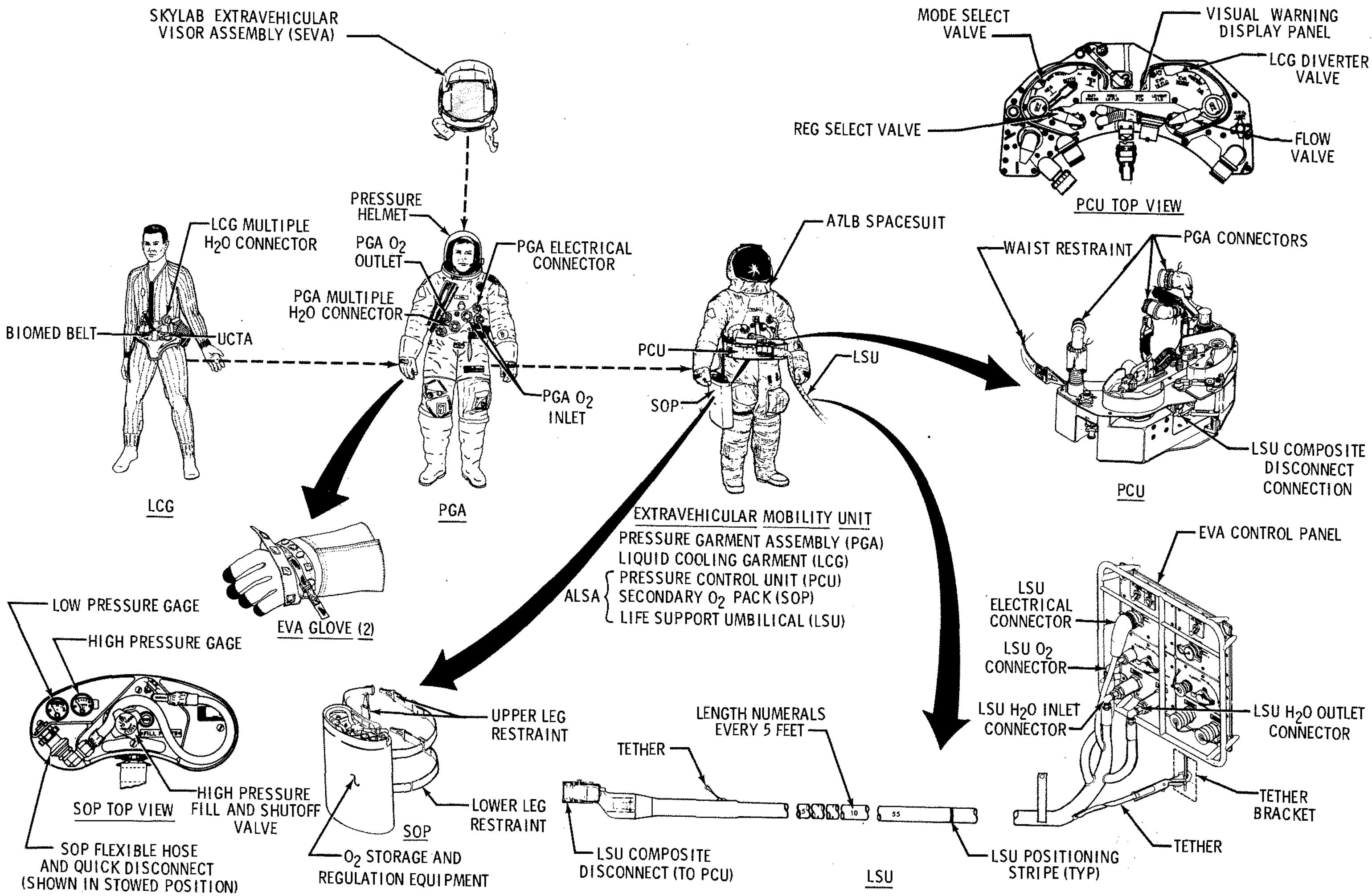


Figure 2.5.7-6 Crewman EVA Equipment

2.5.7.5.1.3 Pressure Helmet

The pressure helmet is a transparent, detachable enclosure and is supplied oxygen from the PGA to pressurize and ventilate the helmet with a provision to diffuse the oxygen about the crewman's head. The pressure helmet also provides an attachment for the SEVA.

One pressure helmet for each crewman is launched with the crewman in the CM and is transferred to the suit drying stations in the OWS, with its helmet stowage bag, for on-orbit stowage. The pressure helmet and its stowage bag are then returned with the crewman in the CM at the end of each mission.

2.5.7.5.1.4 Skylab Extravehicular Visor Assembly

The SEVA provides micrometeoroid and thermal protection for the pressure helmet while filtering out harmful light rays.

Three SEVA's are launched in SEVA stowage bags on the OWS forward compartment floor for use during all missions. Upon SL-2 activation, the crew will transfer the SEVA stowage bag and its contents to the suit drying stations.

2.5.7.5.1.5 EVA Gloves

EVA gloves are donned over the PGA to provide additional thermal and micrometeoroid protection of the hand and forearm area. The palm and finger areas of the EVA glove are provided with durable material to provide abrasion resistance for the glove during performance of work tasks.

Nine pair of EVA gloves are launched in the OWS, to be used three per mission. After their first use, the EVA gloves will be stowed in the SEVA stowage bag with the SEVA. At the end of each mission, the EVA gloves used during that mission will be transferred to a permanent stowage location in the OWS forward compartment for use as spares.

2.5.7.5.2 Astronaut Life Support Assembly

The PGA and the LCG are supplied suit umbilical system (SUS) provisions through the ALSA via a life support umbilical (LSU), a secondary O2 pack (SOP) and a pressure control unit (PCU) (figure 2.5.7-6). The SUS provisions from the SWS systems are routed to the EVA or IVA control panels, which serve as a central point to connect the LSU (figure 2.5.7-7). The LSU then supplies the PCU with the water, oxygen, and electrical provisions, which are regulated and distributed to the spacesuit by the PCU. A secondary supply of oxygen is available through use of the SOP when connected to the PCU oxygen circuit.

2.5.7.5.2.1 Life Support Umbilical

The LSU serves to connect the PCU with the EVA control panel for access to the SUS life support provisions. The 60 foot LSU transfers the LCG water, instrumentation data, electrical power, audio communications, biomed data, and oxygen from the EVA control panel quick-disconnects to a single composite quick-disconnect located on the PCU (figure 2.5.7-6 and -7). A tether, which is slightly shorter than the LSU, is provided on the LSU, to connect to the PCU and to a lock compartment tether bracket. This attaches the crewmember to the SWS and assures that excessive structural loads are not applied to the umbilical's components. Positioning stripes are marked on the LSU to identify the point at which the LSU is to be inserted into the LSU clamp. The LSU is also marked in 5-foot intervals to aid in visually tracking the deployed length of the LSU.

Two LSU's are launched aboard SL-1 in a "wet" condition (fully charged with water) and are stowed until ready for use during the SL-2 EVA in two LSU containers, located in the lock compartment adjacent to the EVA control panels (paragraph 2.5.5). Four additional LSU's are stowed in the OWS forward dome area in a "dry" condition: two for use on the SL-3 EVA's and the remaining two for use on the SL-4 EVA's. Prior to the use of the "dry" LSU's, they will be serviced with water and stowed in the two LSU containers. At the end of each mission, the "wet" LSU's will be drained and stowed in the OWS for use as spares (paragraph 2.5.7.6.1).

2.5.7.5.2.2 Secondary O2 Pack

The SOP is a self-contained unit that stores an oxygen supply at 6000 psi for use as a secondary oxygen source for the PCU if the LSU supplied oxygen fails. The SOP is worn on the crewman's thigh and is fitted with a flex hose and quick-disconnect to supply O2 to the PCU oxygen circuit (figures 2.5.7-6 and -7). Opening the SOP high-pressure fill and shutoff valve will supply the stored high-pressure oxygen to an SOP regulator, which provides the proper supply pressure to the PCU (figure 2.5.7-8). This oxygen is utilized on a demand basis by the PCU when the LSU oxygen pressure decays below normal. Two SOP's are launched aboard SL-1, one located in the MDA and one located in the OWS. Each CSM is launched with two SOP's stowed onboard. These SOP's will be transferred to the SWS and made available for use. Each EVA crewman will wear one SOP connected to the PCU.

2.5.7.5.2.3 Pressure Control Unit

The PCU is the centralized point of control of the ALSA components and is fitted to the waist of the spacesuit to permit easy access to its controls. From the PCU, the crewman controls his water and oxygen circuit as supplied by the LSU (figure 2.5.7-7). A control module within the PCU manages instrumentation tasks and distributes electrical power. The PCU has a tether loop to connect the LSU tether for crewman restraint.

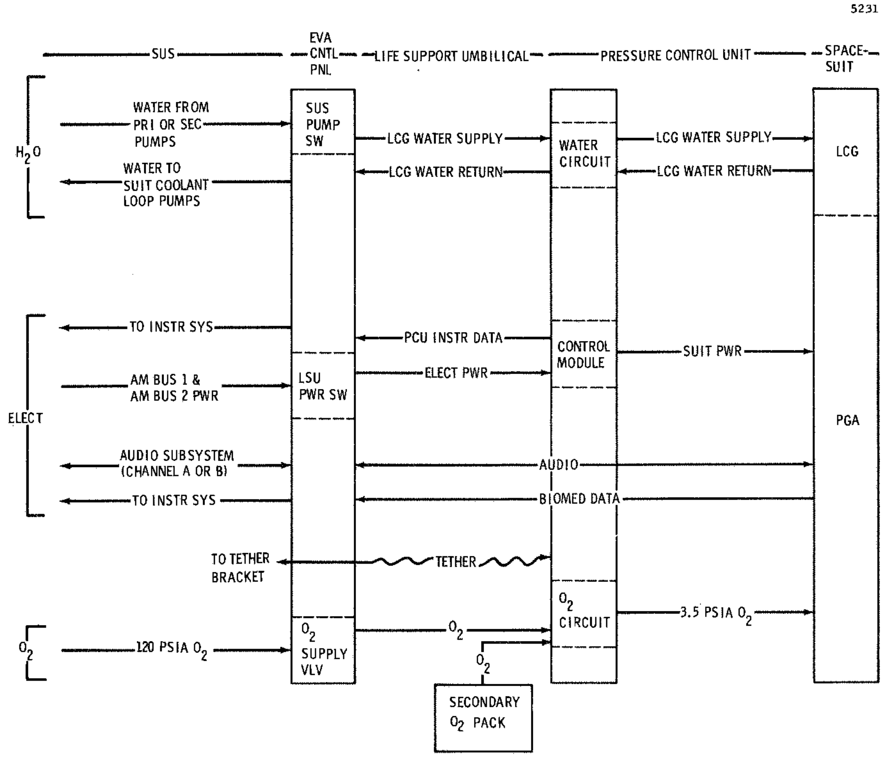


Figure 2.5.7-7 Life Support Systems - Functional Diagram

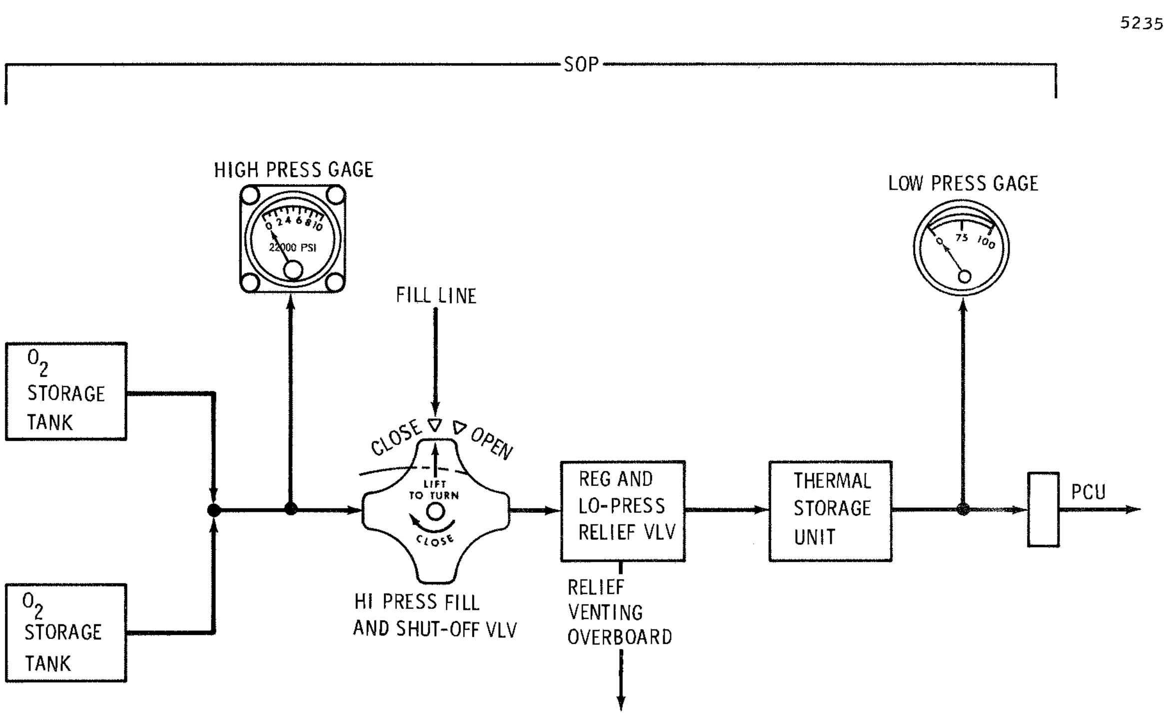


Figure 2.5.7-8 ALSA SOP -- Functional Diagram

The water circuit in the PCU contains a manually operated LCG water diverter valve that bypasses LCG coolant water to obtain the desired degree of crewman thermal comfort (figure 2.5.7-9). The heavier the workload, the more suit coolant water required by the crewman to remove body heat. The LCG is continuously supplied water, even when the LCG water diverter valve is bypassing the maximum amount.

The O2 circuit in the PCU contains an arrangement of regulators and orifices to permit suit pressurization and ventilation while supplying oxygen for breathing. Oxygen is normally provided to the PCU from the LSU oxygen supply through the LSU composite disconnect. Another quick-disconnect is located on the PCU to attach the SOP for a backup supply of O2. In addition, an auxiliary O2 quick-disconnect is located on the PCU for attachment of an additional SOP to permit an uninterrupted supply of O2 if the on-line SOP is in use and almost depleted.

The oxygen is routed to the PCU parallel regulation system through a REG selector valve. The regulators may be independantly selected (REG 1 or REG 2) or may be paralleled (BOTH). The paralleling provides automatic backup regulation in the event of a regulator failure. Regulator 1 is the primary regulator and is set at a slightly higher regulation pressure than regulator 2. In the BOTH position, if regulator 1 outlet pressure decays, then regulator 2 begins operating at its lower regulation pressure to maintain the suit pressure.

The MODE SELECT valve is used by the crewman to provide an ambient pressure reference for regulator operation (absolute mode "ABS") or to isolate the ambient pressure from the regulators ($\Delta$ P). The $\Delta$ P mode is used to inflate the suit during EVA preparations in the lock compartment while the ambient pressure is above the normal suit pressure of 3.8 psia. The ABS mode is normally used during EVA when the ambient pressure level is less than the normal suit pressure.

The oxygen supplied to the PGA from the PCU regulators is returned to the PCU to be non-propulsively vented overboard through the PCU. The O2 return circuit contains a debris filter to protect the downstream orifices from clogging or damage. If the O2 return flow through the debris filter becomes restricted, a relief valve begins flowing to bypass the debris filter, allowing continuous flow of the O2 return circuit. The O2 return circuit also provides the suit pressure monitoring point that controls regulator 1 and regulator 2 operation in maintaining suit pressure. In addition, the O2 return circuit is fitted with a flow control system to provide crewman control of suit ventilation flow rates. The FLOW valve permits crewman selection of various orifices for different modes of operation. A continuous bleed from the regulators provides automatic control of the O2 return circuit bleed valve and maintains the bleed valve open to ensure sufficient suit ventilation during lock compartment operations at habitation pressure. As the suit is inflated, the bleed flow control pressure from the regulators closes the bleed valve, thereby terminating the high bleed flow overboard.

The control module in the PCU receives AM buses 1 and 2 power from the LSU to power its instrumentation and to provide mike power and biomed power to the suited crewman. The control module processes PCU O2 and H2O parameters for transmission as instrumentation data to the SWS instrumentation system. Certain critical O2 circuit parameters are provided a special processing in the control module to warn the crewman of O2 circuit anomalies. If any of these warning parameters exceed predetermined limits, the appropriate PCU visual warning display panel nomenclature illuminates and simultaneously generates an audio warning tone to the suited crewman. An AUDIO RESET switch is provided on the side of the PCU to extinguish the audio warning tone, but the out-of-tolerance parameter remains illuminated on the visual warning display panel until the parameter is back in tolerance. A single TEST switch is provided on the side of the PCU which permits the crewman to simultaneously illuminate all the parameters on the visual warning display panel while generating the audio warning tone. Audio communications to/from the suited crewman and crewman biomed data are routed to the LSU through the PCU without any processing.

Two PCU's will be launched in the OWS for use as spares. The PCU's are launched in a "dry" state (without a water charge) and must be serviced with water on-orbit while connected to the LSU prior to use. Two PCU's are also launched aboard each CM to be transferred to the OWS for stowage and use. The PCU's are launched in a "wet" state but are serviced with water on-orbit, since the dry LSU's must be serviced while connected to a PCU's for the SL-3 and SL-4 missions. At the end of each mission, the PCU/LSU combination will be drained and stowed in the OWS for use as spares (paragraph 2.5.7.6.1). One PCU will be used by each crewman during suited activities.

2.5.7.6 LIFE SUPPORT EQUIPMENT SERVICING

Facilities are provided to aid the crewman in servicing the LSU's and PCU's and to dry the spacesuits to maintain this equipment in an operational mode. In addition, two stations are designated in the OWS for suit donning/doffing.

2.5.7.6.1 <u>LSU/PCU Servicing</u>

The LSU/PCU water circuits will be charged with water on-orbit to remove all air trapped in the LSU's and PCU's for protection of the suit coolant loop pumps and to allow the suit coolant loops to operate at maximum water capacity. The charging will be accomplished once during the SL-3 and -4 missions prior to the first mission EVA for the to facilitate on-orbit storage for possible future use and to preclude the possibility of damage from ice formation. The LSU/PCU combination is serviced while the LSU is stowed in the lock compartment LSU container. A 60-foot flexible WATER SERVICING UMBILICAL is used to charge the LSU/PCU combination with water (figure 2.5.7-10). The WATER SERVICING UMBILICAL is also used to transfer water from an OWS water tank to the LSU's located in

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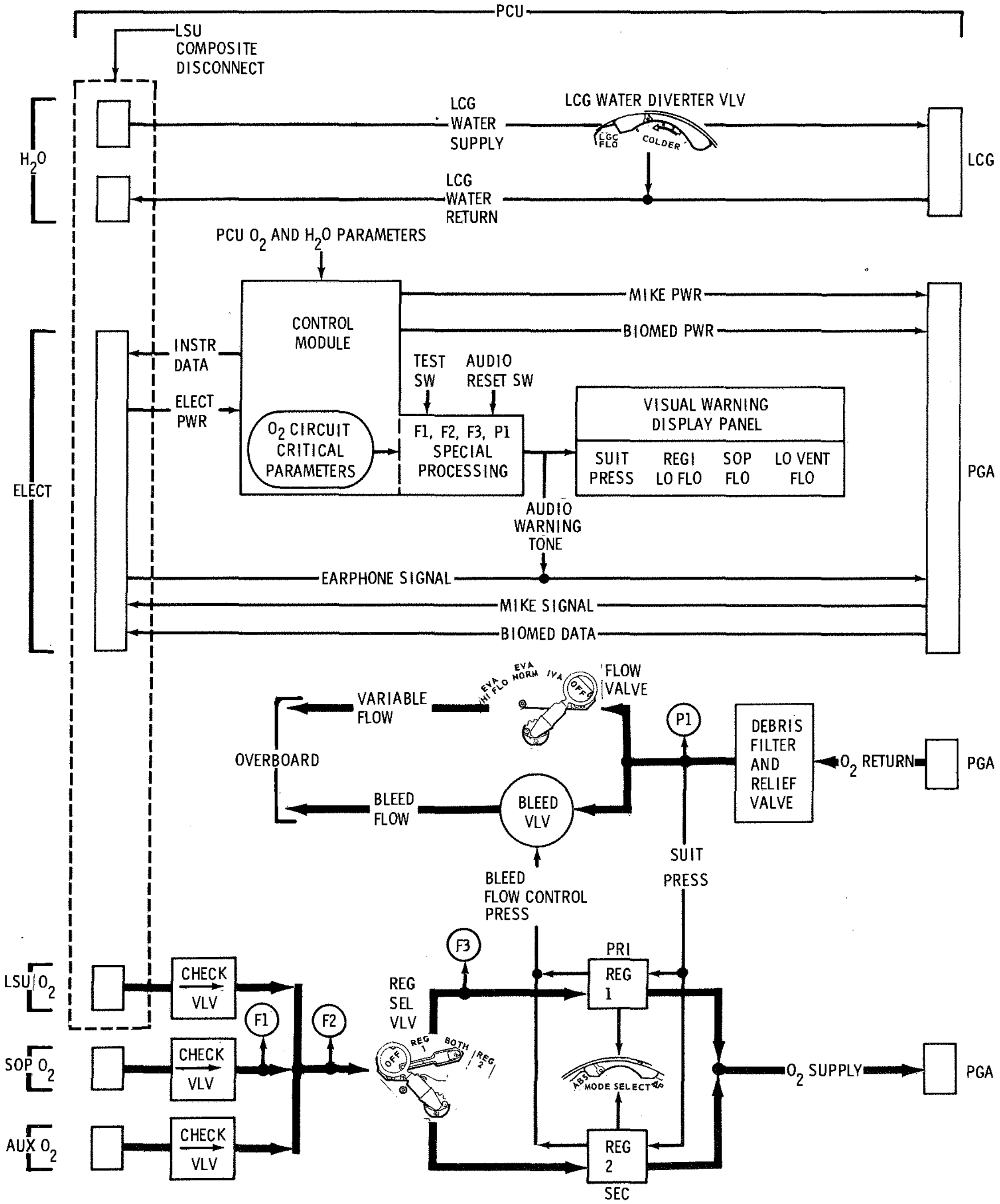


WARNING PARAMETERS
F1 - SOP FLO
F2 - LO VENT FLOW
F3 - REG 1 LO FLOW
P1 - SUIT PRESS (HI OR LO)

BIOMED DATA
SUBJECT I. D.
HEART RATE
ZPN
BODY TEMP
ECG

INSTR DATA
SUIT PRESS
LCG INLET WATER TEMP
LCG OUTLET WATER TEMP
SUIT INLET GAS TEMP
SUIT OUTLET GAS TEMP

Figure 2.5.7-9 ALSA PCU -- Functional Diagram

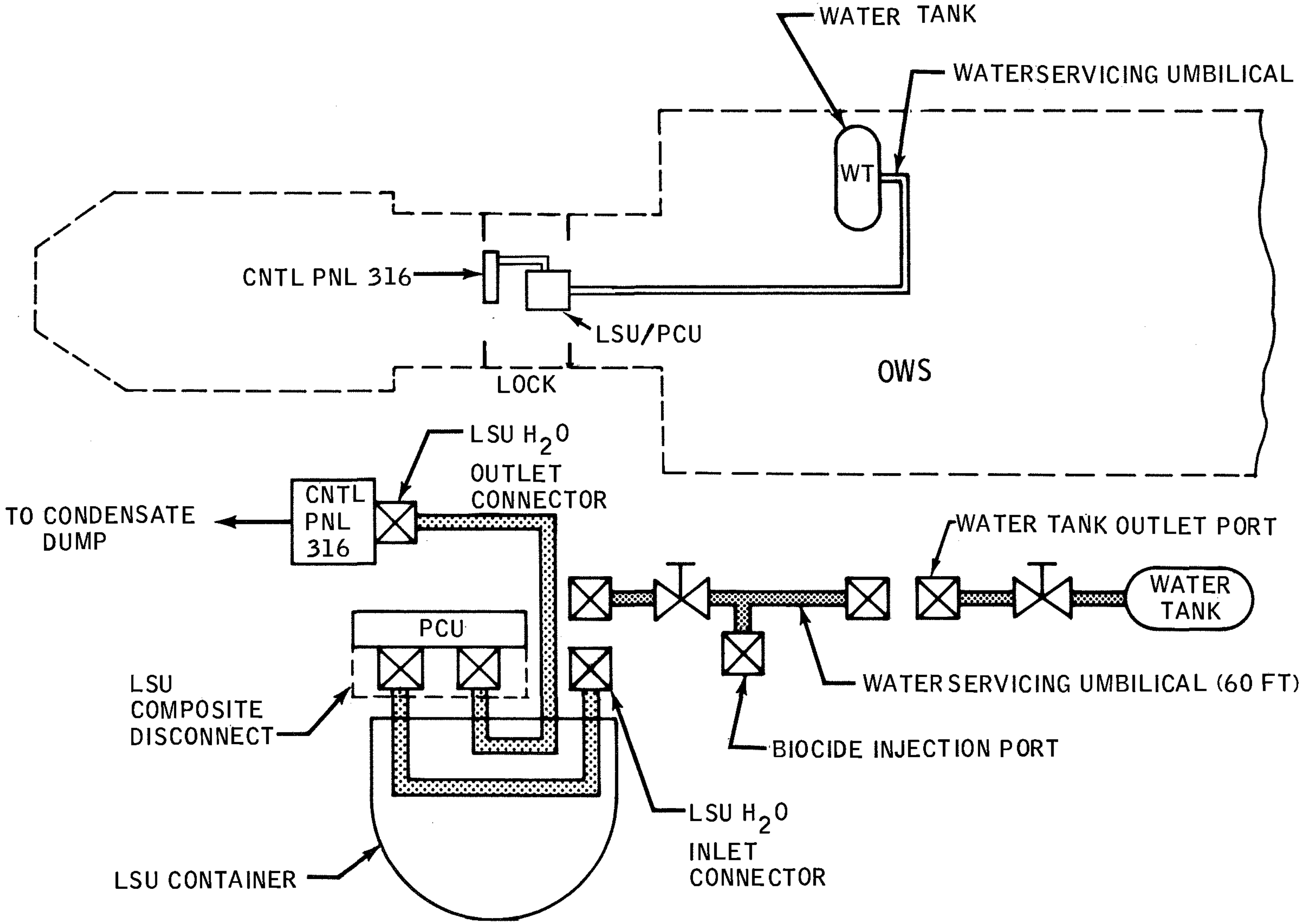


Figure 2.5.7-10 LSU/PCU Servicing -- Functional Diagram

the LSU containers. The WATER SERVICING UMBILICAL is connected to an OWS water tank on one end and connected to the LSU H2O inlet connector on the other end. The LSU composite disconnect is mated to the PCU, and the LSU H2O outlet connector is connected to the VACUUM SOURCE quick-disconnect on panel 316 to complete the water loop. The LSU/PCU combination is then evacuated, using the VACUUM SOURCE VALVE on panel 316. The water tank water is then allowed to fill the LSU/PCU. A predetermined amount of water servicing biocide (diopotassium hydrogen phosphate) is injected into the servicing water at the umbilical's biocide injection port to inhibit corrosion within the LSU/PCU and the suit coolant loops.

The LSU/PCU combinations used during a particular mission will be drained at the end of that mission. The LSU/PCU is drained by attaching the LSU H2O outlet quick-disconnect to the VACUUM SOURCE quick-disconnect on panel 316. The VACUUM SOURCE VALVE is then opened to evacuate the LSU/PCU combination of water.

2.5.7.6.2 Suit Drying Facilities

Water will condense on the interior of the PGA during use. To remove the accumulation of water after each PGA use, the OWS is outfitted with a suit dryer to be used in conjunction with nearby suit drying stations.

2.5.7.6.2.1 Suit Dryer

The suit dryer is located in a stowage compartment in the OWS forward dome and is used to blow cabin air through the PGA to accomplish drying. The suit dryer contains two hoses to simultaneously dry two PGA's (figure 2.5.7-11). A blower unit, with integral power switch control, is mounted in the suit dryer stowage compartment and provides the airflow. A high-power accessory adapter cable and a high-power accessory cable is used to connect the blower unit to a convenient HI POWER ACCESSORY OUTLET for suit dryer operation (figure 2.5.7-12). Cabin air is drawn into the blower unit through a filter and is routed to a manifold that distributes the air through two hoses to each PGA. The hoses connect to the PGA O2 inlet quick-disconnects and allow cabin air to enter the suit. The air exits the PGA through the neck opening which is left open to the cabin environment. When the suit dryer is not in use, the hoses are stowed in the suit dryer stowage compartment, with the PGA hose connectors stowed in dummy hose connectors. The dummy hose connectors are fitted with orifices to preclude "deadheading" of the blower unit airflow in the event that the blower unit is inadvertently turned on while the hoses are stowed. The blower unit is replaceable through use of a quick-release mount. A spare blower unit is stowed in an OWS spare parts stowage compartment in the OWS forward dome and is also interchangeable with either the fecal/urine collector blower unit or the vacuum cleaner blower unit. The filter on the suit dryer blower unit is removable with two latches to facilitate cleaning and for attachment to replacement blower units.

2.5.7.6.2.2 Suit Drying Stations

To locate the PGA's in the OWS for drying purposes and also for on-orbit PGA stowage, two suit drying stations are provided on the OWS forward compartment floor below the suit dryer and adjacent to the T013 structure (figure 2.5.7-11); each suit drying station accomodates one A7LB spacesuit. Each drying station is fitted with a portable PGA foot restraint (paragraph 2.5.3), into which the boots of the PGA are inserted, to restrain the suit at the floor level. A PGA hanger strap (paragraph 2.5.3) is used to stretch the PGA into an extended state by tethering the neck area of the PGA to the platform foot restraint. The LCG's are air dried in the OWS atmosphere adjacent to the PGA's. A short strap is used to restrain the legs of the LCG to the OWS forward compartment floor and an LCG hanger (paragraph 2.5.3) is used to restrain the LCG neck area to the T013 structure. A SEVA stowage bag containing a SEVA and a pair of EVA gloves is stowed in a helmet bag with a pressure helmet. The helmet bag is conveniently located on each T013 structure for on-orbit stowage and ready accessibility. Two complete A7LB spacesuits are located at the suit drying stations during drying operations and when they are not in use. The third A7LB spacesuit is stowed in a designated stowage area in the OWS when not in use.

2.5.7.6.2.3 Suit Donning/Doffing Stations

The two EVA crewmen will don and doff their spacesuits, SOP's, and PCU's at suit donning/doffing stations in the OWS. The portable PGA foot restraints located at the suit drying stations are used to restrain the crewmembers during suit donning/doffing activities. Since a large operating envelope is necessary to don and doff the spacesuit, the portable PGA foot restraints will be relocated to a less restricted area on the OWS forward compartment floor where each crewman can don his spacesuit without assistance. The suit doffing activities will be conducted at the same location, with the portable PGA foot restraint being relocated at the suit drying station following suit doffing to facilitate drying operations.

2.5.7.7 EVA OPERATIONS

EVA operations are summarized for a typical EVA encompassing the preparations for EVA, the activities conducted during the EVA, and the securing from the EVA.

2.5.7.7.1 EVA Preparations

The two crewmen actively involved in the EVA will don their spacesuits at the suit donning stations. The third crewmember will simultaneously configure the SWS systems for EVA. The two suited crewmen will transfer to the lock compartment while the third crewman stations himself in the STS with his spacesuit. The crewman stationed in the STS conducts system housekeeping during the EVA and monitors EVA. Equipment and ATM film required for the EVA is transferred from the MDA to the lock compartment for temporary stowage. Following attachment of the ALSA's to the spacesuits and to the EVA control panels, the EVA crewmembers will check out the ALSA, spacesuit, and suit umbilical systems to verify operational readiness for EVA. The lock compartment hatches are then closed and the lock compartment is depressurized.

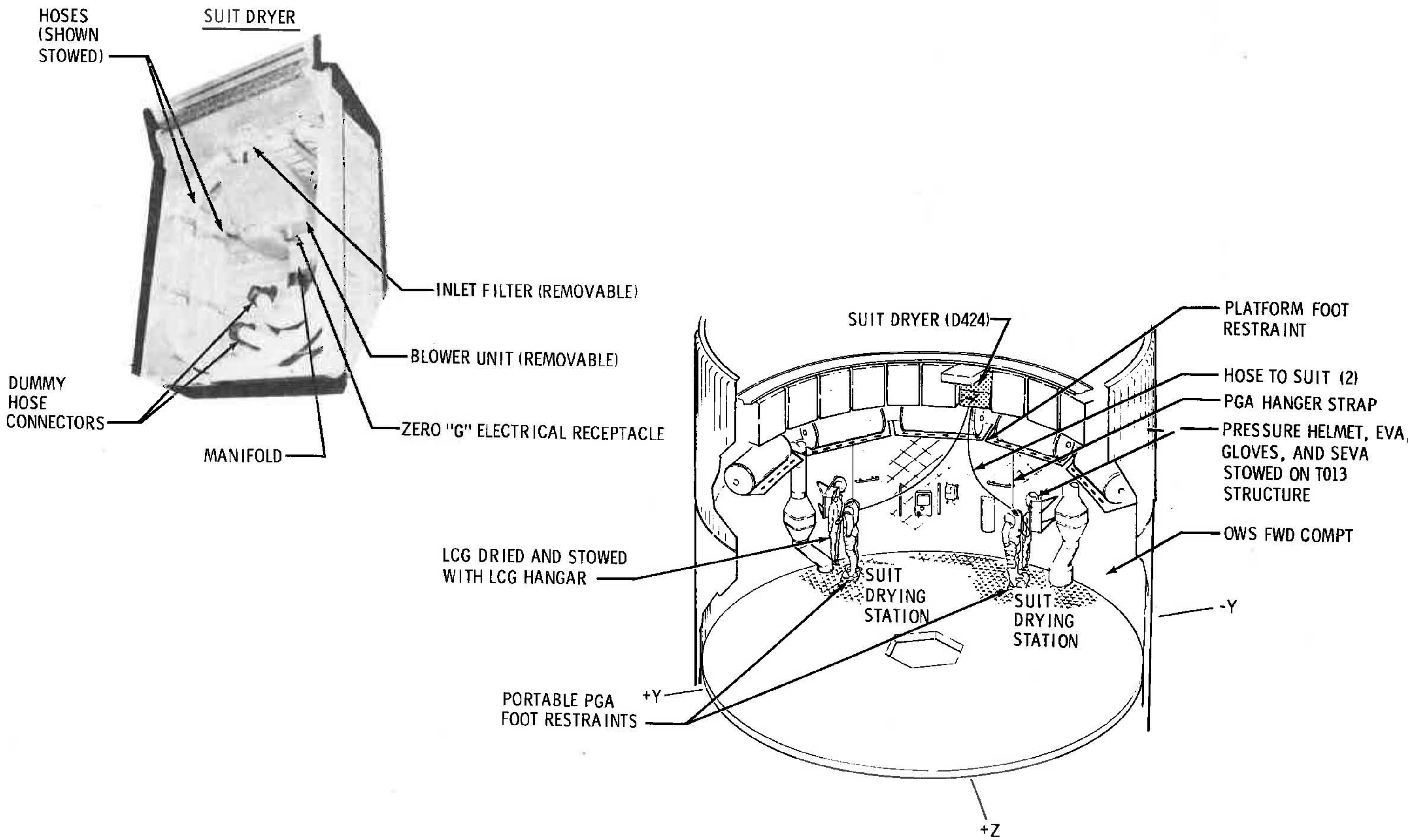


Figure 2.5.7-11 Suit Drying Facilities

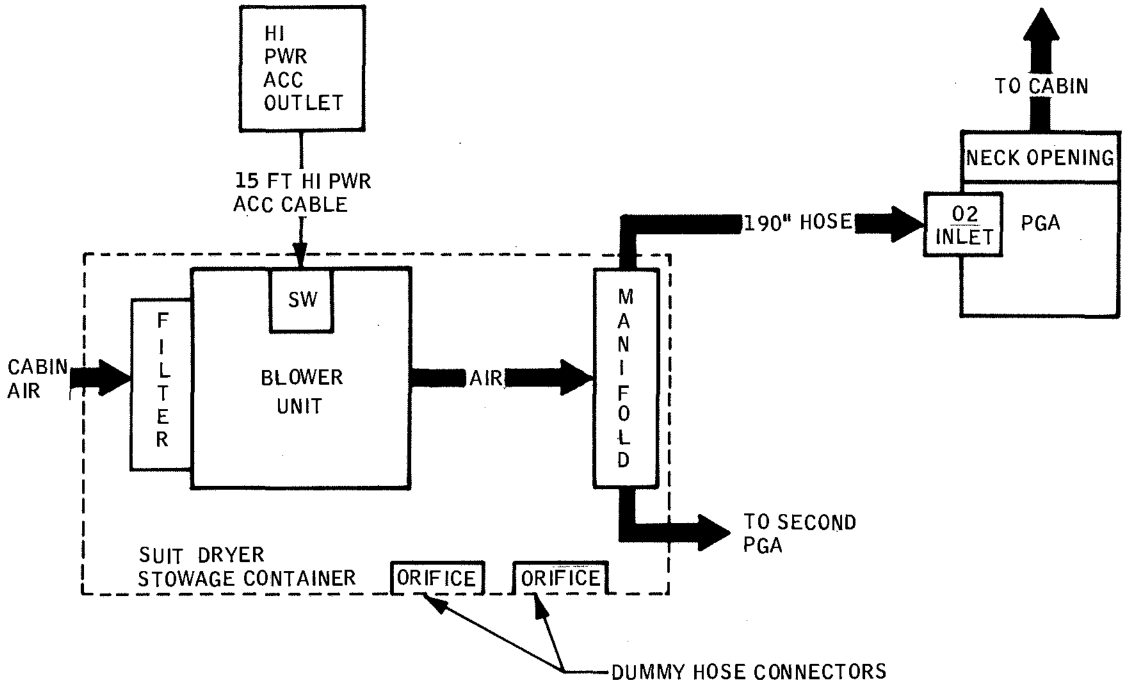


Figure 2.5.7-12 Suit Dryer -- Functional Diagram

2.5.7.7.2 EVA Activities

Upon opening of the EVA hatch, crewman 1 egresses from the lock compartment into the EVA bay and positions himself in the FAS workstation. Crewman 2 then hands out the equipment and ATM film to crewman 1 for temporary stowage in the EVA bay. Crewman 2 then egresses from the lock compartment into the EVA bay. At this point, if D024 sample panel retrieval is required, crewman 2 will retrieve the appropriate samples and hand the D024 return container with its stowed samples to crewman 1 for temporary stowage in the EVA bay area. Crewman 2 then translates along the EVA trail to the center workstation. Crewman 1 manages the LSU's during the egress to prevent entanglement. Crewman 1 loads the center extendible boom with the center workstation film provision and extends to boom out to the center workstation, where crewman 2 recovers/reloads the ATM cameras with film. The center extendible boom is retracted by crewman 1 with the recovered center workstation film. This procedure is duplicated for the sun end film provision on the sun end extendible boom. However, instead of crewman 2 positioning himself at the sun end workstation to receive the film, crewman 2 positions himself at the transfer workstation where he receives the sun end film provision and then locates the film provison at the sun end workstation. After the sun end extendible boom is retracted with the recovered film provision, crewman 2 ingresses into the lock compartment. Crewman 1, still located in the FAS workstation, transfers the equipment and film from the temporary stowage locations in the EVA bay to crewman 2 for temporary stowage in the lock compartment. Crewman 1 then ingresses into the lock compartment and closes the EVA hatch.

2.5.7.7.3 EVA Securing

Following pressurization of the lock compartment, the suited crewmen deactivate the suit umbilical systems and the ALSA and open the lock compartment hatches. The suited crewmen then doff their spacesuits at the suit doffing stations and transfer their spacesuits to the suit drying stations for PGA and LCG drying operations. The third crewman returns his spacesuit to stowage in the OWS. The SWS systems are then reconfigured for habitation and the recovered ATM film is transferred to MDA film vaults to be eventually returned to earth.

2.5.8 OFF DUTY EQUIPMENT

2.5.8.1 ENTERTAINMENT PROVISIONS

The crewmen are supplied entertainment during their off-duty hours by provisions located in a stowage compartment in the wardroom.

2.5.8.2 OFF DUTY SCHEDULING

Each day, two crewman are simultaneously scheduled off duty for 1 hour shortly before the sleep period. In order to provide increased ATM viewing, the third crewman is stationed at the ATM C&D panel during this time and relinquishes his off-duty period for that particular day. Crew assignments are scheduled so that a different crewman is stationed at the ATM C&D console during the daily off-duty period. In addition, the crewmen are periodically scheduled a day off. The off-duty hours each day and on the day off are provided for crew rest and recreation, although the day off will also include debriefings, nominal systems monitoring, and mission planning functions.

2.5.8.3 OFF DUTY EQUIPMENT PROVISIONS

To provide entertainment for crewmen during their off-duty hours, stowage compartment W714 is provided with the off-duty equipment: audio entertainment equipment, playing card equipment, library, dart throwing equipment, exercise equipment, binoculars, and balls. The food table is used as an off-duty area for using most of the off-duty equipment provisions.

2.5.8.3.1 Audio Entertainment Equipment

A permanently located tape player, secured in a mounting case on the backside of the W714 stowage compartment door, provides monaural or stereophonic playback of pre-recorded tape cassettes through internal speakers, external speakers, or headsets (figure 2.5.8-1). The tape player also allows monaural recording on the tape cassettes through one of the two microphones stowed in the microphone kit in stowage compartment W714.

The tape player receives power from either an external source or internal batteries. For external power, a short power cord is stowed with the tape player and connects the tape player with one of the panel 711 UTILITY OUTLETS in the W714 stowage compartment. This cord reduces the 28 vdc power supply to 6 vdc for tape player operation. Four replaceable batteries contained in the tape player provide a self-powered unit. A resupply of batteries is conveniently available in battery tubes (four batteries per tube) stowed in a W714 battery dispenser. One end of the battery tube is open to permit easy battery access.

Tape cassette material is monitored through speakers internal to the tape player or by using two, external, 6-inch wide-range speakers mounted adjacent to the tape player on the stowage compartment door. A removable speaker cord connects the speakers with the tape player. For individual use, headsets with headphone plugs are stowed in W714 along with a supply of headset earpieces for connection to the tape player. Forty-eight tape cassettes are stowed on the W714 door immediately below the tape player and are restrained by two snap-fitted straps for convenient access (figure 2.5.8-1). The tape cassettes are made up of either stereophonic or monaural prerecorded material selected by the crews. Each tape cassette contains 1 hour of prerecorded material (30 minutes per side) and are individually packaged in tape cassette boxes.

An additional tape player identical to the tape player in the W714 stowage compartment is stowed in the stowage area above the tissue dispensers in each of the three sleep areas, for the private use of the crewman. Although internal battery power may be used to operate these tape players, three long power cords are stowed in a power cord kit in stowage compartment W714 for use with the sleep area tape players. The long power cord connects the tape player to a UTILITY OUTLET and reduces the 28 vdc power supply to 6 vdc for tape player operation.

2.5.8.3.2 Playing Card Equipment

Four decks of standard playing cards with the NASA emblem on the back of each card are stowed in stowage compartment W714. To permit card-playing in zero-G, a card retainer kit is stowed in W714 and contains five card deck retainers and five card retainers. The retainers hold the cards in place as a deck (card deck retainer) or individually for player use (card retainers). Card playing is normally at the food table with the table top in place. The retainers are held to the table top by magnets.

2.5.8.3.3 Library

Approximately 36 commercial, crew-selected paperback books compose the library and are restrained in a partitioned segment of stowage compartment W714 by snap-fitted straps (figure 2.5.8-1). Three book covers are also stowed in W714 to facilitate identification in the library of an in-use book and its user.

2.5.8.3.4 Dart Throwing Equipment

A dart kit with 12 darts and a dart board are stowed in stowage compartment W714. The dart board has velcro hook on the back for placement at any convenient velcro location in the OWS. The target side of the dart board has velcro pile superimposed on a standard target face. Each dart is a standard dart with velcro hook substituted for the pointed shaft.

2.5.8.3.5 Exercise Equipment

Each crewmember is provided with an exer-gym kit containing an exer-gym in-flight exerciser to conduct isometric exercises. In addition, six hand exercisers, shaped to fit the hand, are used to maintain grip strength. All exercise equipment is stowed in stowage compartment W714.

2.5.8.3.6 Binoculars

A pair of center-focus binoculars is stowed in stowage compartment W714.

| OFF DUTY EQUIPMENT PROVISIONS | | | |
|---|---|---|---|
| 3 | TAPE PLAYERS | 4 | PLAYING CARD DECKS |
| 2 | SPEAKERS | 5 | CARD DECK RETAINERS |
| 1 | SPEAKER CORD | 5 | CARD RETAINERS |
| 4 | HEADSETS | 36 | BOOKS |
| 16 | HEADSET EARPIECES | 3 | BOOK COVERS |
| 2 | MICROPHONES | 1 | DART BOARD |
| 1 | SHORT POWER CORD | 12 | DARTS |
| 3 | LONG POWER CORDS | 3 | EXER- GYMS |
| 240 | BATTERIES | 6 | HAND EXERCISERS |
| 48 | TAPE CASSETTES | 1 | BINOCULARS |
| | | 3 | BALLS |

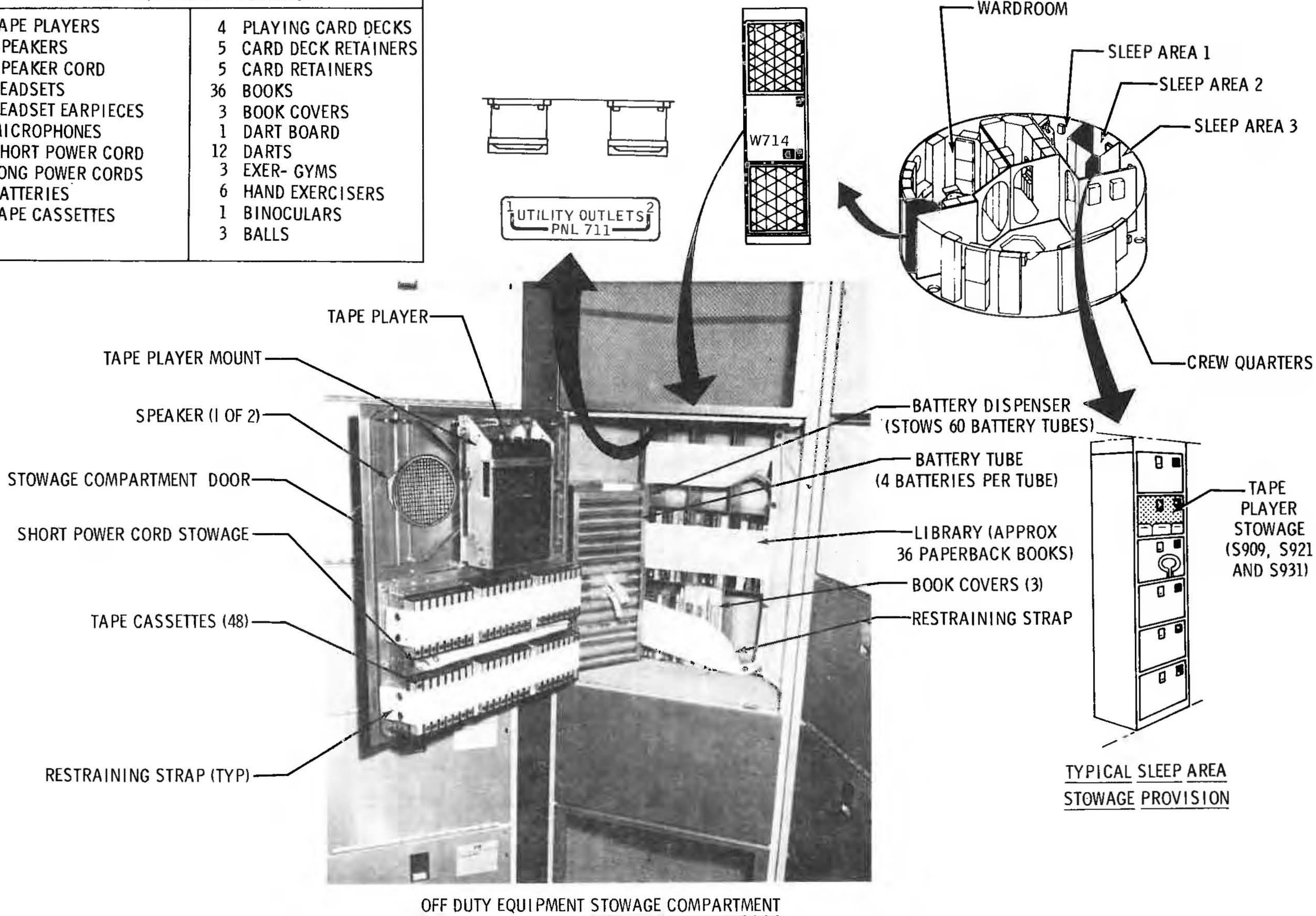


Figure 2.5.8-1 Off-Duty Equipment

2.5.8.3.7 Balls

Three plastic-covered foam balls are stowed in a ball kit in stowage compartment W714.

2.5.9 TRASH DISPOSAL

2.5.14.1 TRASH DISPOSAL PROVISIONS

The trash disposal subsystem is used for the collection of all SWS trash and its disposal through a trash disposal airlock into the waste tank.

2.5.9.2 TRASH MANAGEMENT

Any item that is biologically active after its use (clothing, filters, food cans, urine bags, sleep restraints, hygiene kits, tissues, wipes, towels, washcloths, etc.) is considered as trash and is to be disposed of in the waste tank. Scheduled housekeeping tasks throughout the mission week provide for the periodic disposal of these items. Any item that is biologically inactive after its useful life, will be placed into permanent storage in SWS stowage compartments. This type of trash management minimizes the cycles on the trash disposal airlock, decreasing the probability of trash disposal airlock failures and minimizes the cabin air loss into the waste tank. In addition, trash volume and weight in the waste tank is held to a low level, which assures accommodation of all items to be disposed of and minimizes changes in vehicle c.g.

2.5.9.3 TRASH COLLECTION

Biologically active trash is disposed of into the waste tank in trash collection bags which provide for controlled off-gassing of liquids contained in the trash. Controlled venting via the trash bags prevents excessive waste tank pressures, which assures efficient operation of the waste tank liquid dump (paragraph 2.5.14). In addition, bagged trash minimizes the formation of large ice crystals, which may collect on and clog the screens in the waste tank. Two types of trash collection bags are provided: (1) trash bags that serve as trash receiving stations within the OWS, and (2) disposal bags for use in bagging large items.

2.5.9.3.1 Trash Bags

Certain stowage compartments in the OWS are allotted to the collection of trash in a trash container (paragraph 2.5.5). Eight trash containers are located in the OWS: one in the experiment compartment, two in the wardroom, one in the WMC, three in the sleep compartment (one in each sleep area), and one in the OWS forward compartment (figure 2.5.9-1). Each trash container accommodates a trash bag which accepts and retains all trash inserted into the bag. Four hundred and twenty trash bags are grouped in packages of 7, 8 and 45 trash bags per package. These packages are stowed in stowage compartments throughout the OWS and are used as resupply provisions. The filled trash bags are then disposed of into the waste tank through the trash disposal airlock.

Small trash from throughout the OA is brought to one of the eight trash containers for disposal. The trash is inserted through the hole in the trash container door, directly into the trash bag mounted onto the backside of the door. The trash bag contains a split, flexible diaphram through which the trash is inserted into the bag. The 6 1/2 inch diameter of the diaphram constrains the use of the bag to small items such as tissues, towels, washcloths, etc. The trash bag is 13 1/2 inches in diameter by 15/14 inches long and is constructed of armalon. The bag is impermeable in the OA habitable atmosphere, but will vent vapors when exposed to the vacuum of the waste tank.

The trash bags in the wardroom and the WMC are replaced daily, other trash bags are replaced weekly. When a trash bag is removed from the trash container, a bag-mounted, adhesive-backed diaphram cover is sealed into place over the diaphram to seal-off the opening. The bag is then placed in the trash disposal airlock for disposal into the waste tank. The trash bag is restrained in the airlock by three bag-mounted restraint tabs, which fit over three restraining pins in the airlock. One side of the tab is open to permit rapid bag release from the pin during the trash ejection cycle.

2.5.9.3.2 Disposal Bags

Disposal bags are used for large items (urine bags, sleep restraints, food overcans, charcoal filters, etc.) which do not fit into the trash bags. Three hundred and fifty-two disposal bags, grouped in packages of 35 and 37 disposal bags per package, are stowed in stowage compartments throughout the OWS. When a large item is to be disposed of, a disposal bag is obtained from one of the stowage compartments and transferred to the work area. The disposal bag is secured near the work area by the bag's velcro lining or its snaps (figure 2.5.9-1). The snaps mate with the SWS snap pattern (paragraph 2.5.3). "Stays" in the bag opening maintain the bag open or shut. After use, the bag is sealed shut by a snap tab on the bag and disposed of into the waste tank through the trash disposal airlock. The disposal bag is restrained in the trash disposal airlock by the same type of restraining tabs used for the trash bags.

The disposal bags are 13 1/2 inches in diameter by 21 inches long. The roll-over sealing feature of the bag reduces the useful volume of the bag by 20 percent and the length by about 4 inches. Each bag is constructed of armalon and is impermeable in the OA habitable atmosphere; however, the bag will vent vapors when exposed to the vacuum of the waste tank.

2.5.9.4 TRASH DISPOSAL AIRLOCK

The trash disposal airlock is used to transfer trash in trash bags and in disposal bags from the habitation area into the waste tank. The trash disposal airlock is located in the center of the waste tank/habitation

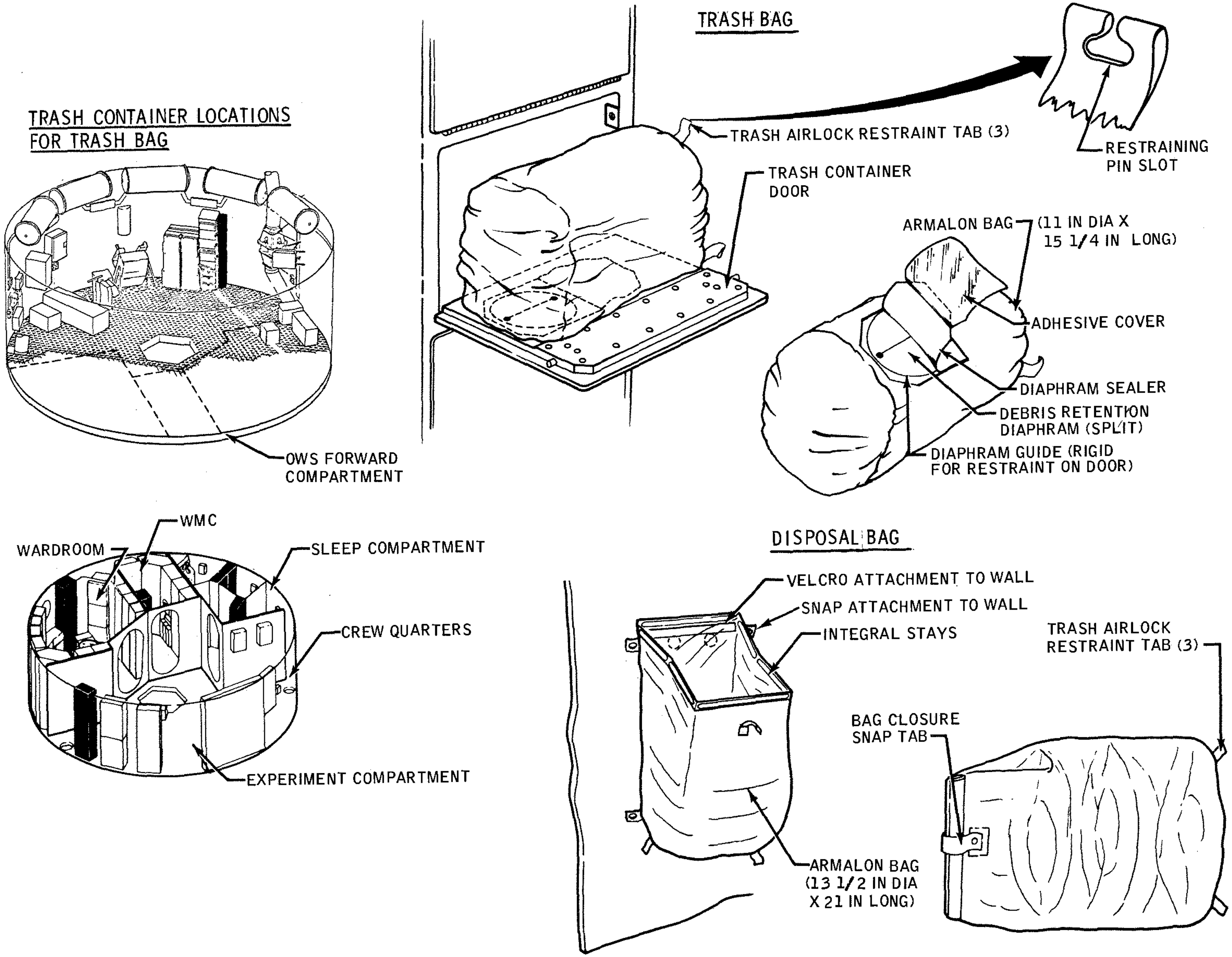


Figure 2.5.9-1 Trash Collection Bags

area bulkhead and protrudes slightly into the experiment compartment through an opening in the crew quarters floor (figure 2.5.9-2). The trash disposal airlock will be used on the average of five times a day to dispose of accumulated debris.

The interior of the airlock contains a trash lock, which houses the trash collection bags when they are placed in the trash disposal airlock. The trash lock is approximately 14 inches in diameter and 18 inches long. Three restraining pins are located on the upper ring of the trash lock to restrain the trash collection bags after insertion into the trash lock. The trash lock is isolated from the waste tank by a movable outer door and is isolated from the habitation area by a hinged lid. A manually-operated, VALVE/OUTER DOOR handle located on the airlock, controls pressure equalization for the airlock to the waste tank and from the airlock to the habitation area. The handle will exhaust and pressurize the entire volume of the trash disposal airlock when placed in the CLOSE/VENT or PRESS position.

A lid-mounted EJECTOR handle operates a scissors-type ejector within the trash lock; the ejector is stowed in the lid when not in use. The handle extends and retracts the ejector to expel trash from the trash lock into the waste tank.

The lid is retained in the closed position by a lock (LID LOCK). The VALVE/OUTER DOOR handle not only provides single-handle control of pressure equalization valves but controls the movement of the outer door (figure 2.5.9-3). An interlock between the VALVE/OUTER DOOR handle and the LID LOCK prevents opening of the outer door when the lid is open. In addition, a lid interlock plunger provides a second interlock to assure that the outer door cannot be opened when the lid is open. Both interlocks act on the VALVE/OUTER DOOR handle to lock it into the PRESS position. A pressure gage mounted on the lid indicates trash disposal airlock internal pressure.

To dispose of trash, the VALVE/OUTER DOOR handle is rotated to the PRESS position to equalize pressure between the airlock and the habitation area (figures 2.5.9-3 and -4). The LID LOCK is unlatched and the lid is opened. After trash is inserted into the trash lock, the lid is closed and the LID LOCK is latched. The VALVE/OUTER DOOR handle is rotated to CLOSE/VENT to equalize airlock and waste tank pressures. A final movement of the VALVE/OUTER DOOR handle to OPEN, opens the outer door and exposes the trash to the screened, trash disposal area in the waste tank. The EJECTOR handle on the lid is then rotated to EJECT, which expels the trash from the trash lock. The ejector mechanism translates the entire length of the trash lock to ensure positive expulsion of trash. After expulsion, the EJECTOR handle is released and returns to the CLOSE position. In this position, the ejector mechanism is maintained at the trash lock exit to prevent migration of trash into the trash lock while the outer door is being closed. After the ejection cycle is complete, the outer door is closed by placing the VALVE/OUTER DOOR handle to the CLOSE/VENT position. The EJECTOR handle is then moved to the RETRACT position to stow the ejector mechanism in the lid. The VALVE/OUTER DOOR handle is left in the CLOSE/VENT position when the airlock is not in use, to maintain a vacuum pressure in the trash disposal airlock to inhibit microbiological growth.

A manually operated VACUUM SHUTOFF valve, located on the trash disposal airlock, is used to seal off the airlock's waste tank vent line when maintenance is being performed on the airlock (figures 2.5.9-2 and -3). The O-ring seal on the lid is replaceable as well as the valve stem seals (vent plug) of the VALVE/OUTER DOOR handle through the use of tools. One spare part of each is stowed in an OWS spare parts stowage compartments. Each month, the trash lock will be cleansed with a bar of soap.

2.5.9.5 WASTE TANK TRASH CONTROL

The waste tank is fitted with a 16 mesh trash screen, which surrounds a 2233 cubic feet trash disposal area directly below the trash disposal airlock (figure 2.5.9-5). The screen extends vertically from the waste tank/habitation area bulkhead to the aft dome of the waste tank, and prohibits migration of solids to the waste tank NPV outlets and into the liquid dump ports in the liquid waste dump area. The screen mesh retains solid trash and ice particles while allowing only vapor to pass to the NPV port.

## 2.5.10 FOOD MANAGEMENT

### 2.5.10.1 FOOD MANAGEMENT PROVISIONS

The food management subsystem consists of the equipment and supplies required for the storage, preparation and consumption of SWS foods. The three crewmen are provided with a 140-day supply of food and beverages and use the wardroom as a kitchen.

Food is stored in food boxes, galley trays, food freezers, and a food chiller. A galley, components of the food table, food trays, and utensils, are provided for the preparation and consumption of the meals.

### 2.5.10.2 FOOD STORAGE

Food is stored in food cans and beverage packs which are grouped and packed in menu form in food overcans. The overcans are stored in bundles in food boxes and in food freezers. Wardroom-located galley trays and a food chiller permit temporary stowage of food when preparing meals and when managing leftovers.

#### 2.5.10.2.1 Food

Food is provided in two forms: ambient temperature food and frozen food. The ambient temperature food consists of dehydrated food and beverages, thermostabilized food (pre-prepared, moisturized food), dry bites and puddings. The frozen food consists of thermostabilized food, some of which must be heated prior to consumption. Food for all the Skylab missions is launched aboard SL-1.

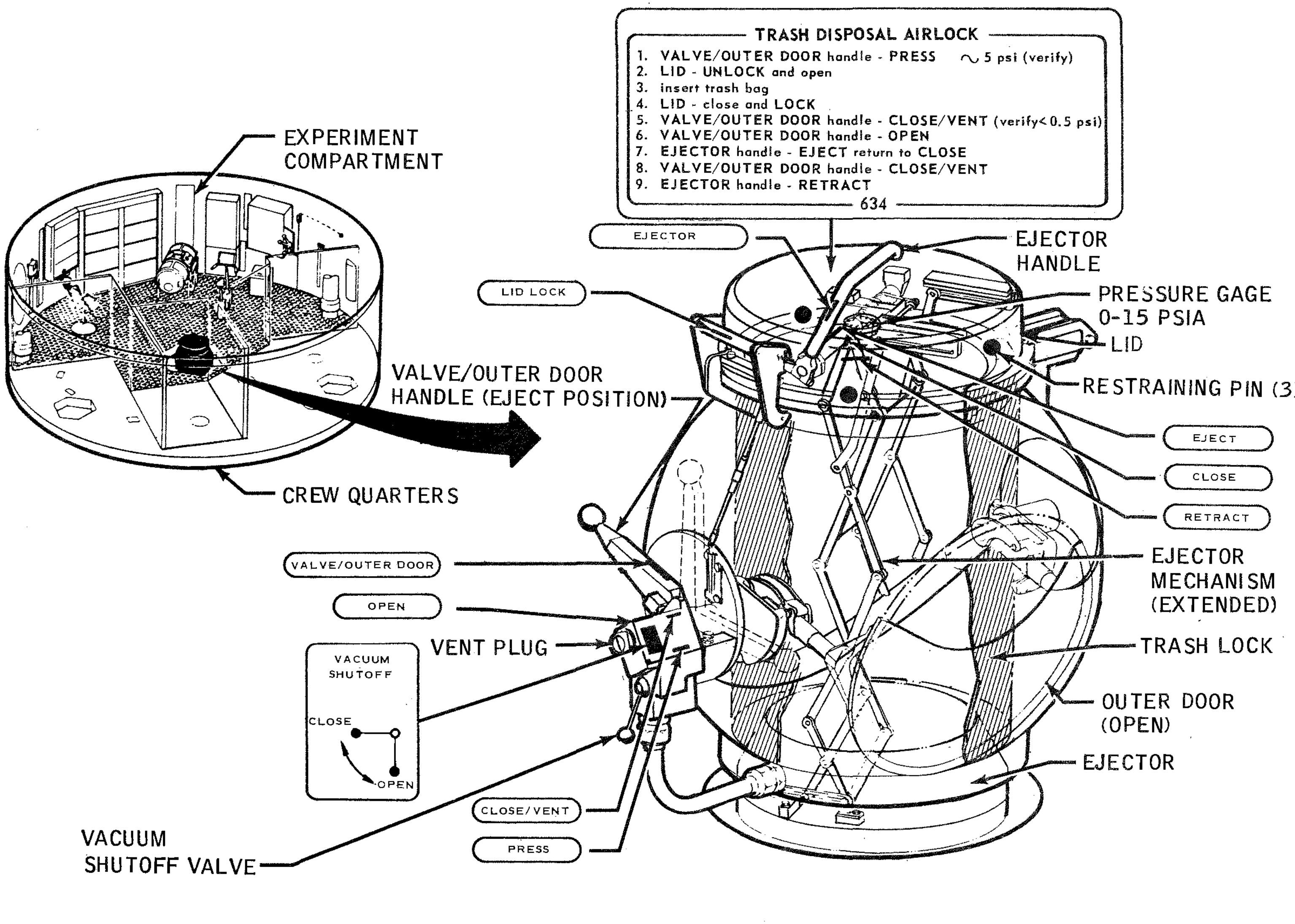


Figure 2.5.9-2 Trash Disposal Airlock

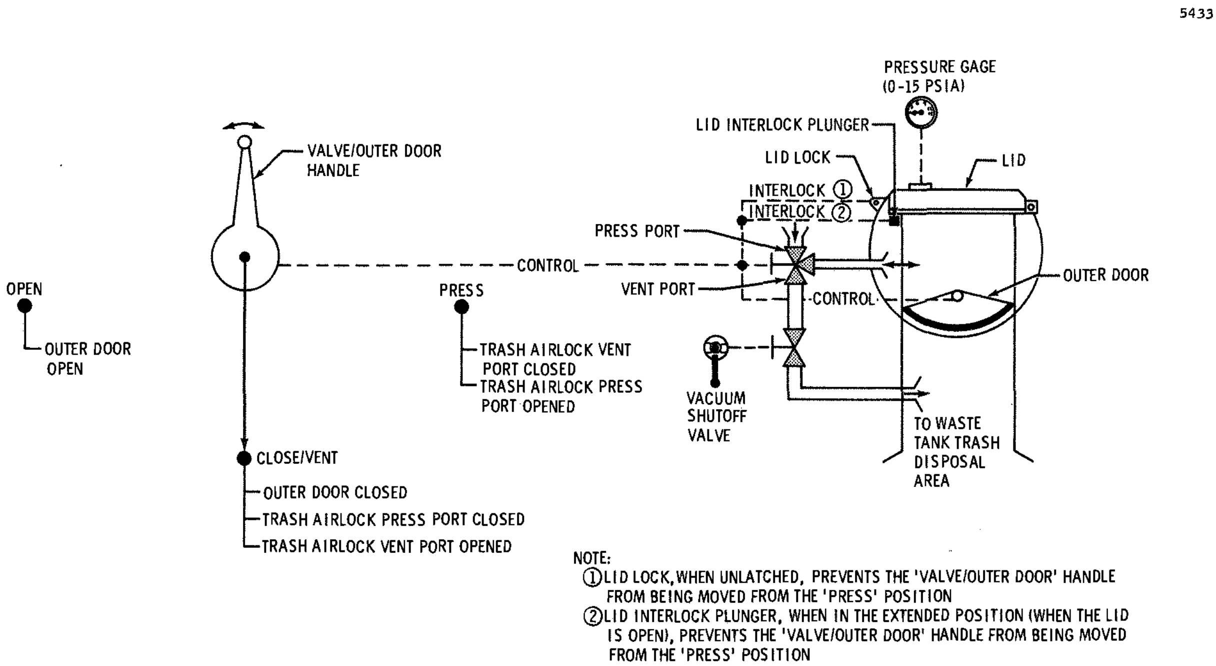


Figure 2.5.9-3 Trash Disposal Airlock -- Functional Diagram

2.5.10.2.2 Food Cans

Ambient temperature foods (excluding beverages) and frozen foods are vacuum packed in single meal portions in food cans (figure 2.5.10-1). Three types of food cans are used: large, small, and pudding. Pudding cans are slightly longer than small food cans. The food is prepared in the food can (heat frozen food or reconstitute dehydrated food) and is eaten using the food can as a dish. Each can is individually labeled as to its contents and rehydration water quantity, if required. All food cans contain pull-top lids which expose a flexible membrane (except in pudding cans) that covers the food. The flexible membrane retains the food in the can during lid removal and food preparation. The membrane is sliced at mealtime. The food cans containing dehydrated foods have integral reconstitution ports in the flexible membrane. Once the food is reconstituted, the flexible membrane is used to knead the water/food mixture into a homogenous substance.

2.5.10.2.3 Beverage Packs

Beverages are stored in the dehydrated state in beverage packs which collapse (accordian style) to facilitate storage and drinking (figure 2.5.10-1). Each beverage pack is labeled as to its contents and rehydration water quantity and contains a composite reconstitution/drinking port. The beverage pack is slightly longer than a small food can.

2.5.10.2.4 Food Overcans

The food cans and the beverage packs are packed in large and small food overcans (figure 2.5.10-1) which are sealed with screw-top lids and pressurized to 5 psia. The overcans withstand the pressure and acoustic environment of the launch and the atmospheric pressure fluctuations of SWS orbital operations. Each overcan has a removable liner which is used to retain the food cans and beverage packs during food overcan unloading. Each overcan contains 12 food cans or beverage packs which are packed and identified according to the menu for the particular crewman (man-menu). The overcans are stored in bundle form, two deep, which contains a mixture of large and small overcans.

2.5.10.2.5 Food Boxes

The entire supply of ambient temperature food for the SL-2, SL-3, and SL-4 missions is stored, in food overcan bundles, in eleven identical, non-refrigerated, vented food boxes (paragraph 2.5.5) located in the OWS forward compartment (figure 2.5.10-1).

The large and small food overcans are bundled two-deep, in mission menus and are restrained inside the food boxes with bulkhead type restraints and adjustable straps. Every seven days, a week's supply of food overcans is transferred from a food overcan bundle in one of the food boxes to galley trays.

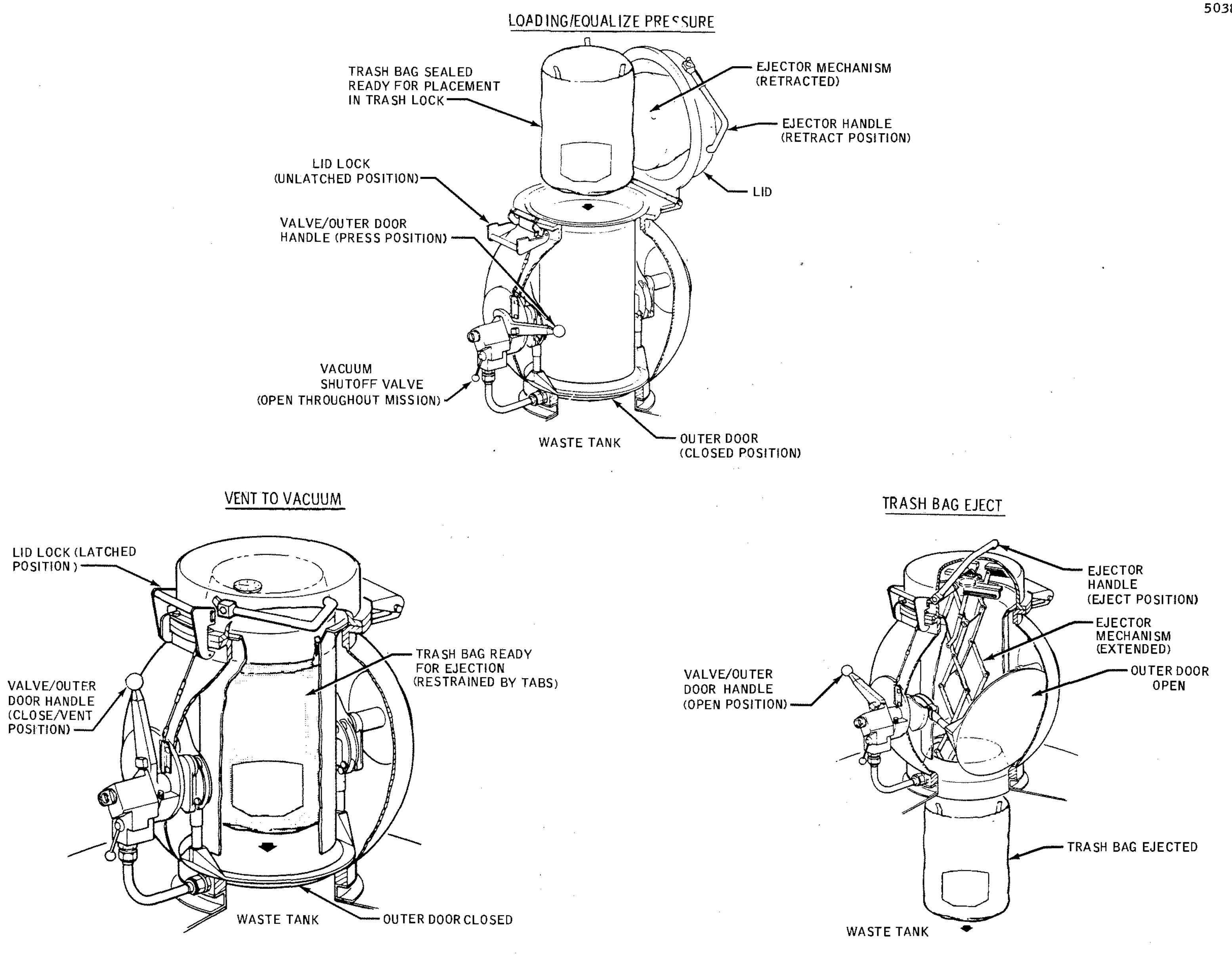


Figure 2.5.9-4 Trash Disposal Airlock -- Sequential Operation

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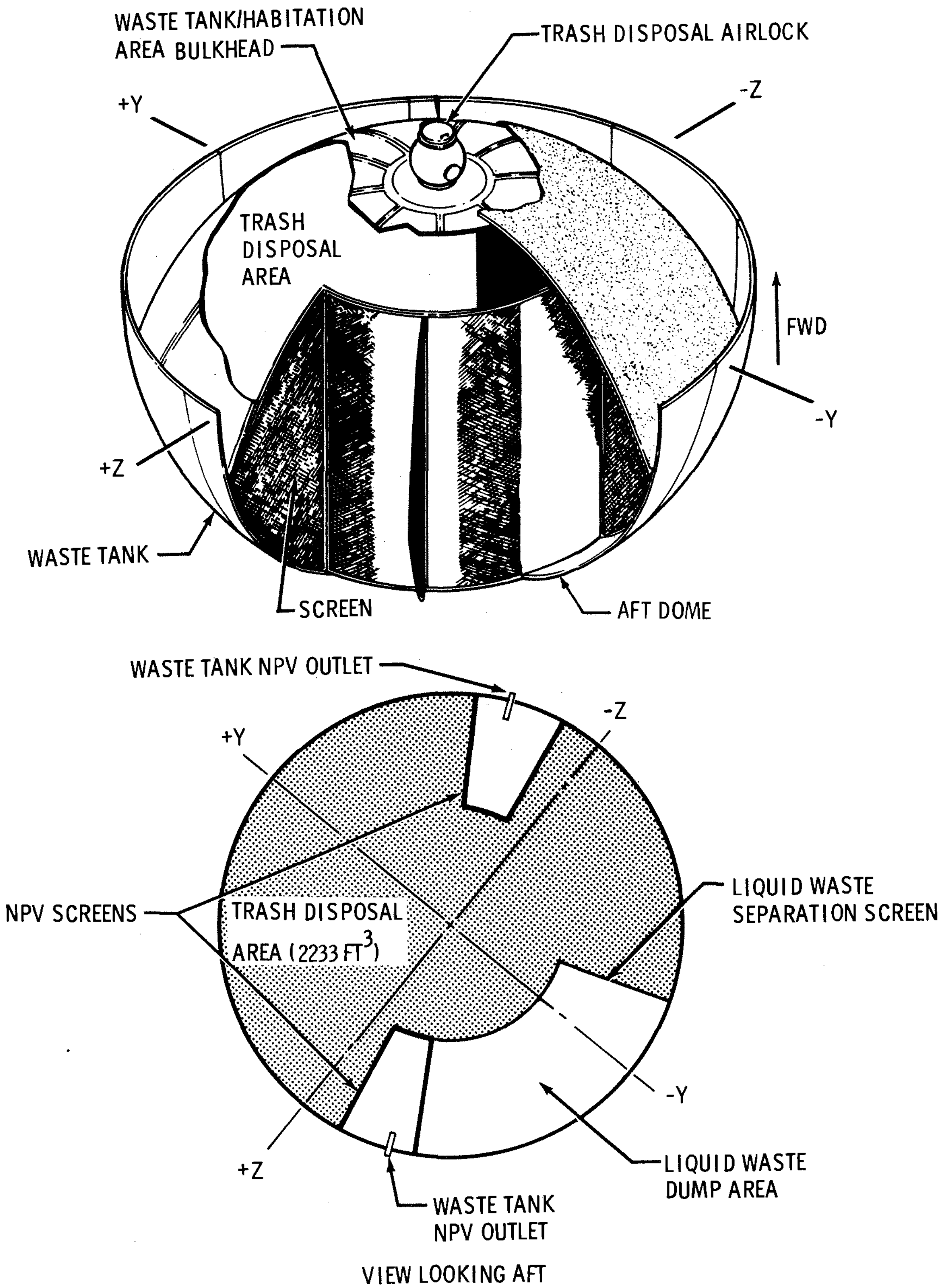



Figure 2.5.9-5 Waste Tank Trash Disposal

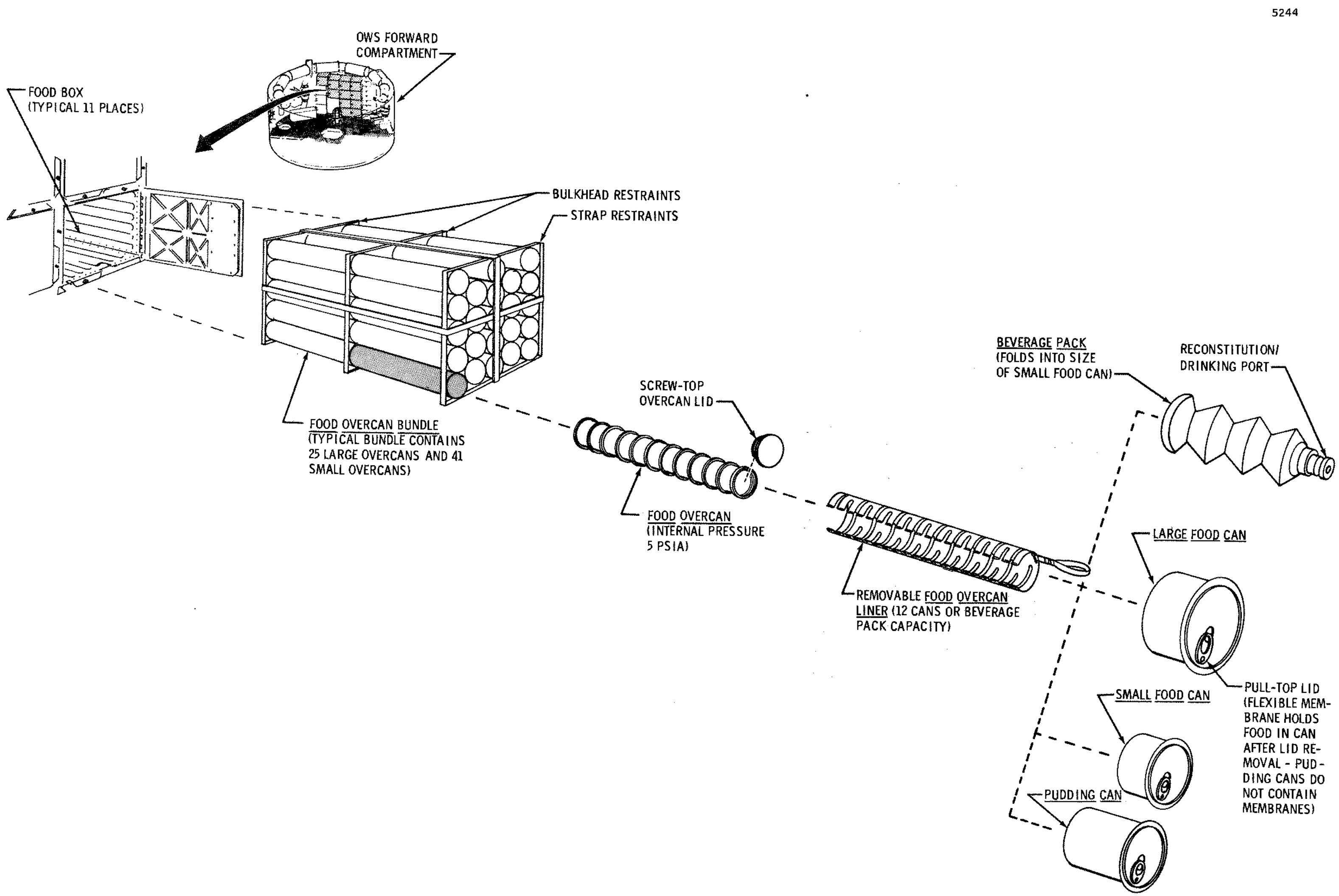



Figure 2.5.10-1 Ambient Food Storage

2.5.10.2.6 Galley Trays

The galley in the wardroom accomodates 22 galley trays which makes a weeks supply of food readily available for meal preparation (figure 2.5.10-2). The 22 galley trays, which stow food cans and beverage packs, consist of 5 galley trays per crewman for their individual menus, 1 galley tray for the weekly pudding supply, 1 galley tray per crewman for snacks (dry bites), and 1 galley tray per crewman for beverages. Each galley tray slides out on a track and may be completely removed from the galley. Each galley tray holds 20 items: large and small food cans, pudding cans, or beverage packs in partitioned segments. Galley tray identification to particular crewman is accomplished using the color coded "Snoopy" decals. The galley trays are secured during launch with launch pins which are removed upon SL-2 activation.

Every seven days, a week's supply of ambient temperature food is transferred in food overcans to the galley. The food cans and beverage packs are removed from the overcans and placed in the galley trays. The empty overcans and their liners are stowed in the galley food can disposal wells for use as a disposal device for empty food cans.

2.5.10.2.7 Stowage Freezers

Frozen foods for all missions will be stored in two types of food freezers, one of which constitutes the STOWAGE FREEZERS (paragraph 2.5.5) (The remaining freezers, the WARDROOM FREEZERS are discussed in a subsequent paragraph). The frozen food is stowed in food overcans which are stored in bundle form, two deep, containing a mixture of large and small overcans (figure 2.5.10-3). The STOWAGE FREEZERS are an assembly consisting of three freezer chambers with each storing a 28-day frozen food supply for three crewmembers.

The STOWAGE FREEZERS will be used to resupply the WARDROOM FREEZERS in 28-day intervals. The refrigeration subsystem primary and secondary loops maintains the frozen food at -10°F. Six temperature transducers are located in the STOWAGE FREEZERS to monitor the freezer temperature for display on panel 616 and on telemetry (figure 2.5.10-4).

2.5.10.2.8 Wardroom Freezers

The remainder of the 140-day frozen food supply is stored in two WARDROOM FREEZERS (paragraph 2.5.5). The WARDROOM FREEZERS provide low temperature food storage and ready accessibility to a 56-day supply of frozen food (28-day per each freezer) in two freezer chambers within a 3 chambered WARDROOM FREEZER/FOOD CHILLER (the third compartment is allotted to food chilling and is discussed in a subsequent paragraph). The frozen food is stowed in food overcans and in food overcan bundles as described for the STOWAGE FREEZERS (figure 2.5.10-3) The crewmen obtain frozen food from the WARDROOM FREEZERS during meal preparation activities. Food cans are removed from the food overcans based on menu requirements. The frozen food is packed in man-menu form in the food overcans and bundled in missions-menus. When WARDROOM FREEZER 1 is depleted (the conclusion of the SL-2 mission), it will be used as a utility freezer for the urine trays and the IMSS resupply/return medical kit thermal capacitor and to preserve a months accumulation of urine samples during the SL-3 and SL-4 missions. However, WARDROOM FREEZER 2 will be resupplied in 28-day intervals from the STOWAGE FREEZERS to permit ready access to frozen food. The refrigeration subsystem maintains the food temperature at -10°F. Four temperature measurements monitor the WARDROOM FREEZER temperature for on-board display and on telemetry (figure 2.5.10-5).

2.5.10.2.9 Food Chiller

The FOOD CHILLER is an integral part of the WARDROOM FREEZERS/FOOD CHILLER, occupying the upper chamber (paragraph 2.5.5) (figure 2.5.10-3). The FOOD CHILLER is launched empty and permits preservation of leftovers for 24 hours. The FOOD CHILLER doubles as a refrigerator for drugs, cultures, crewman and environmental samples and the IMSS resupply/return medical kit. The FOOD CHILLER temperature is maintained at 45°F by the refrigeration subsystem. Two temperature measurements monitor FOOD CHILLER temperature for display on panel 616 and on telemetry (figure 2.4.10-5).

2.5.10.3 FOOD PREPARATION AND CONSUMPTION

The crew uses the galley (in the wardroom) to provide their daily supply of food and also uses galley located equipment to prepare and dispose of food. At the food table the crew will make final preparations of the food, and heat and eat their meals. Meals are eaten from food trays, using utensils.

2.5.10.3.1 Galley

Initial food preparation is conducted at the galley. The seven stowage compartments and 22 galley trays which make up the galley permit the galley to be the central area for meal preparation. The galley stows the equipment and supplies used for meal preparation, consumption and cleanup after the meals.

The galley stores ambient food in food cans, and beverages in beverage packs in 22 galley trays (figure 2.5.10-6). The galley trays are resupplied every 7 days with food cans and beverage packs, all initially stowed in food overcans. Upon removal of the food cans and beverage packs from the food overcans, the overcans are transferred to three of the stowage compartments within the galley allocated to stowage of empty overcans. Six of these empty overcans are installed in the food can disposal wells in the galley (figure 2.5.10-6). This facility contains 6 food can disposal wells, 3 for large overcans and 3 for small overcans, which are accessed through separate spring loaded, hinged lids. Empty food cans and beverage packs will be disposed of in their appropriate size overcans in the disposal wells. When full, the overcans are placed in a disposal bag and replaced by empty overcans.

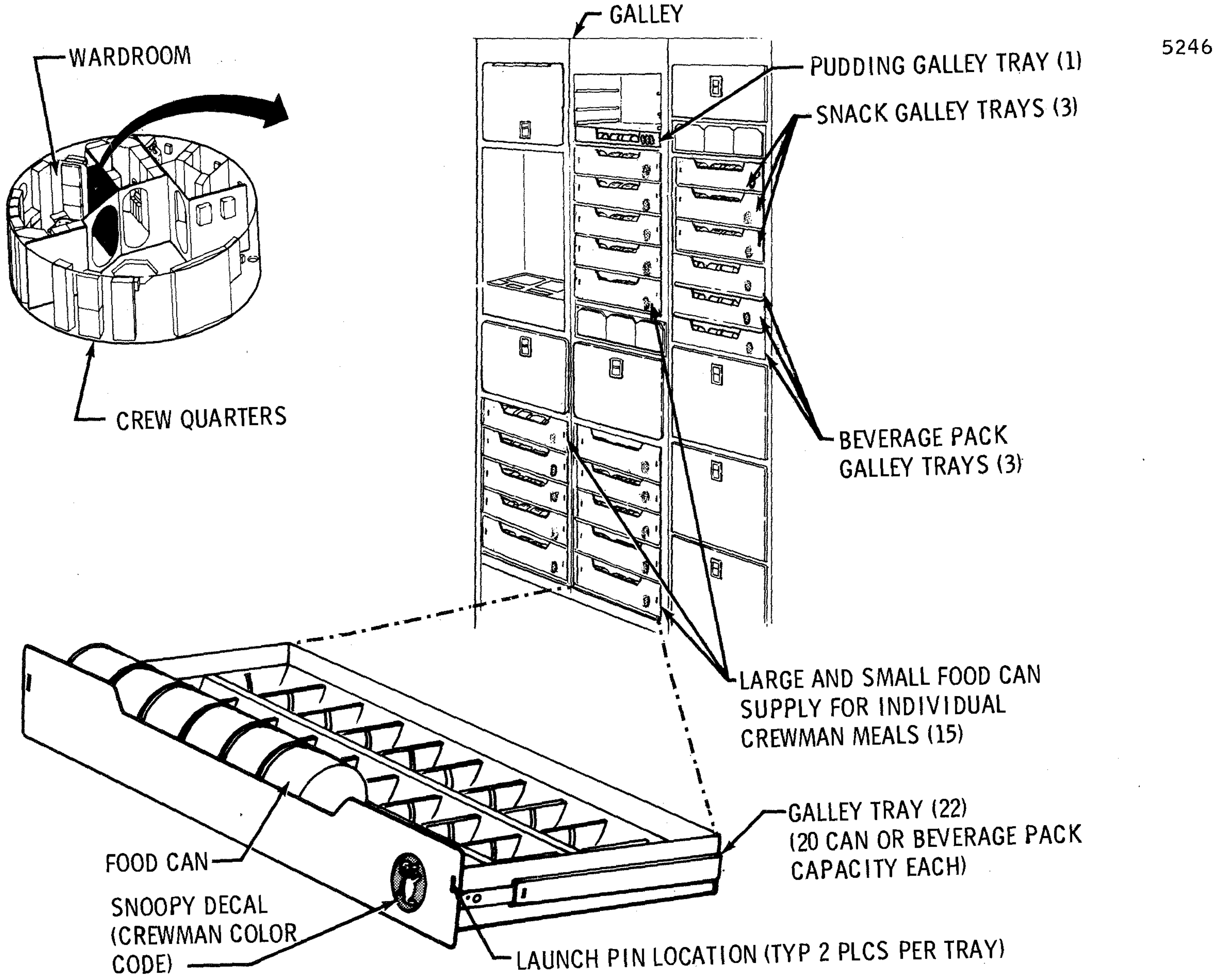
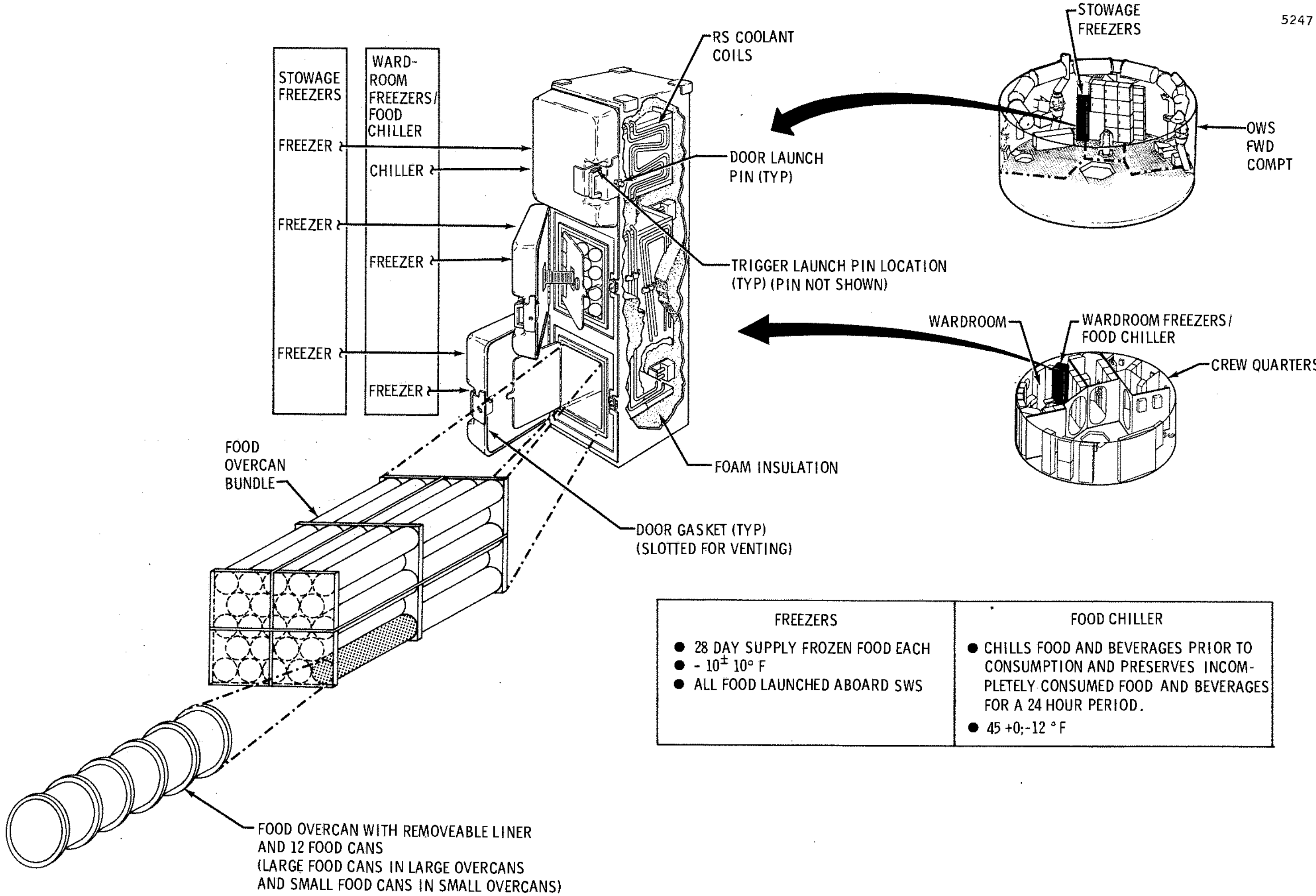



Figure 2.5.10-2 Ambient Food Supply - Daily




| FREEZERS | FOOD CHILLER |
|---|---|
| ● 28 DAY SUPPLY FROZEN FOOD EACH<br>● $-10 \pm 10$° F<br>● ALL FOOD LAUNCHED ABOARD SWS | ● CHILLS FOOD AND BEVERAGES PRIOR TO CONSUMPTION AND PRESERVES INCOMPLETELY CONSUMED FOOD AND BEVERAGES FOR A 24 HOUR PERIOD.<br>● 45 +0;-12 °F |

Figure 2.5.10-3 Chilled and Frozen Food Storage and Supply

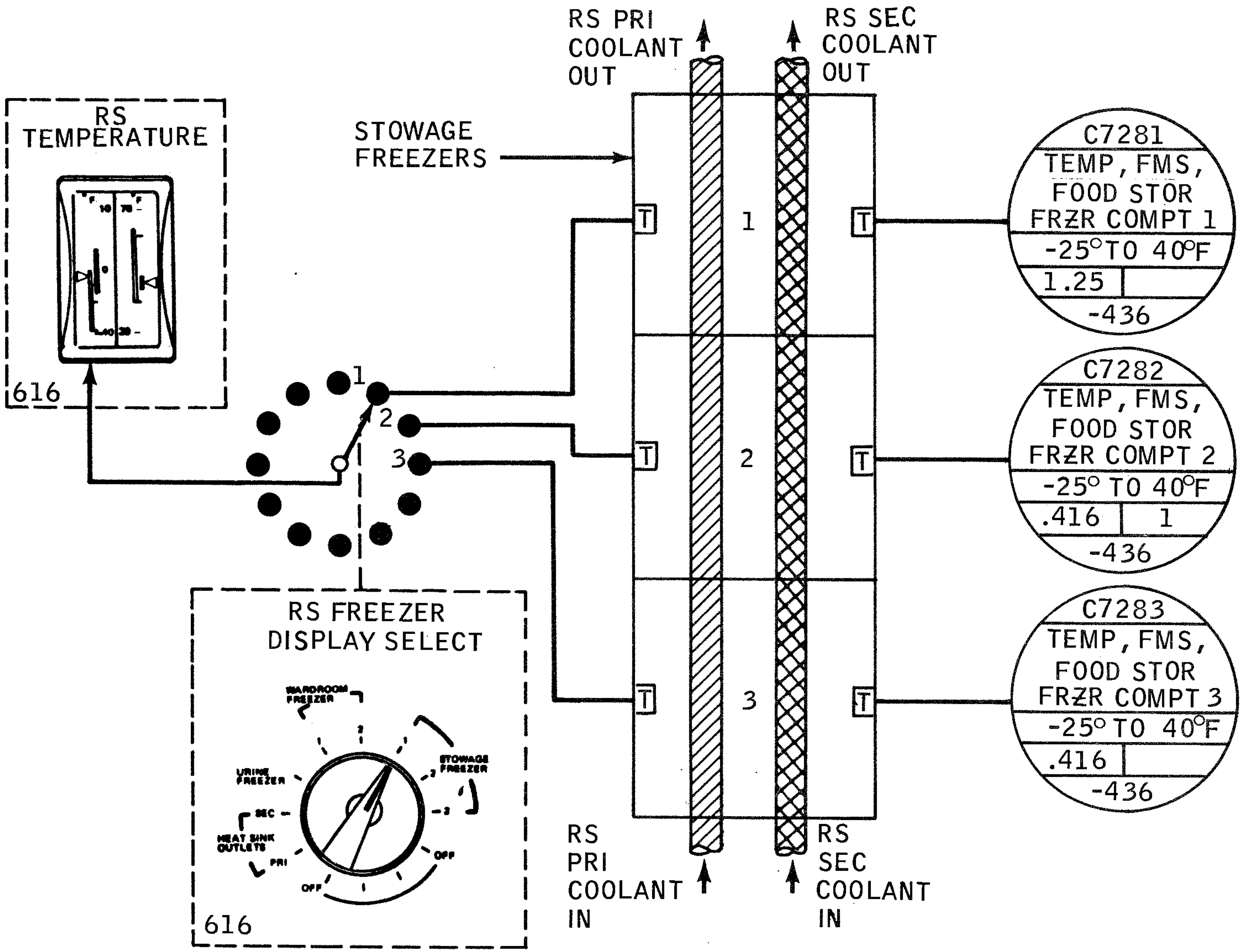



Figure 2.5.10-4 Stowage Freezers -- Functional Diagram

# WARDROOM FREEZERS/FOOD CHILLER FUNCTIONAL DIAGRAM

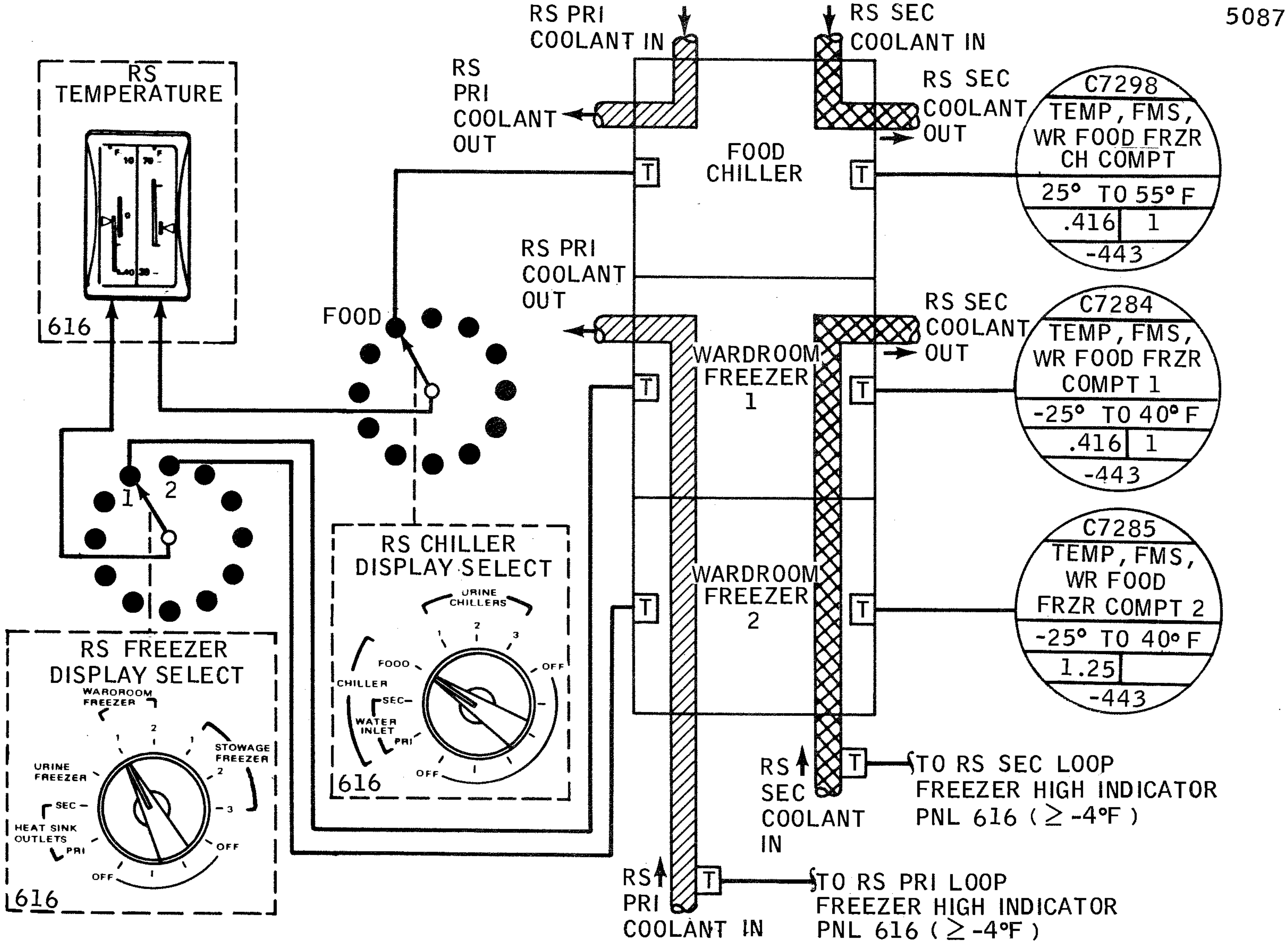
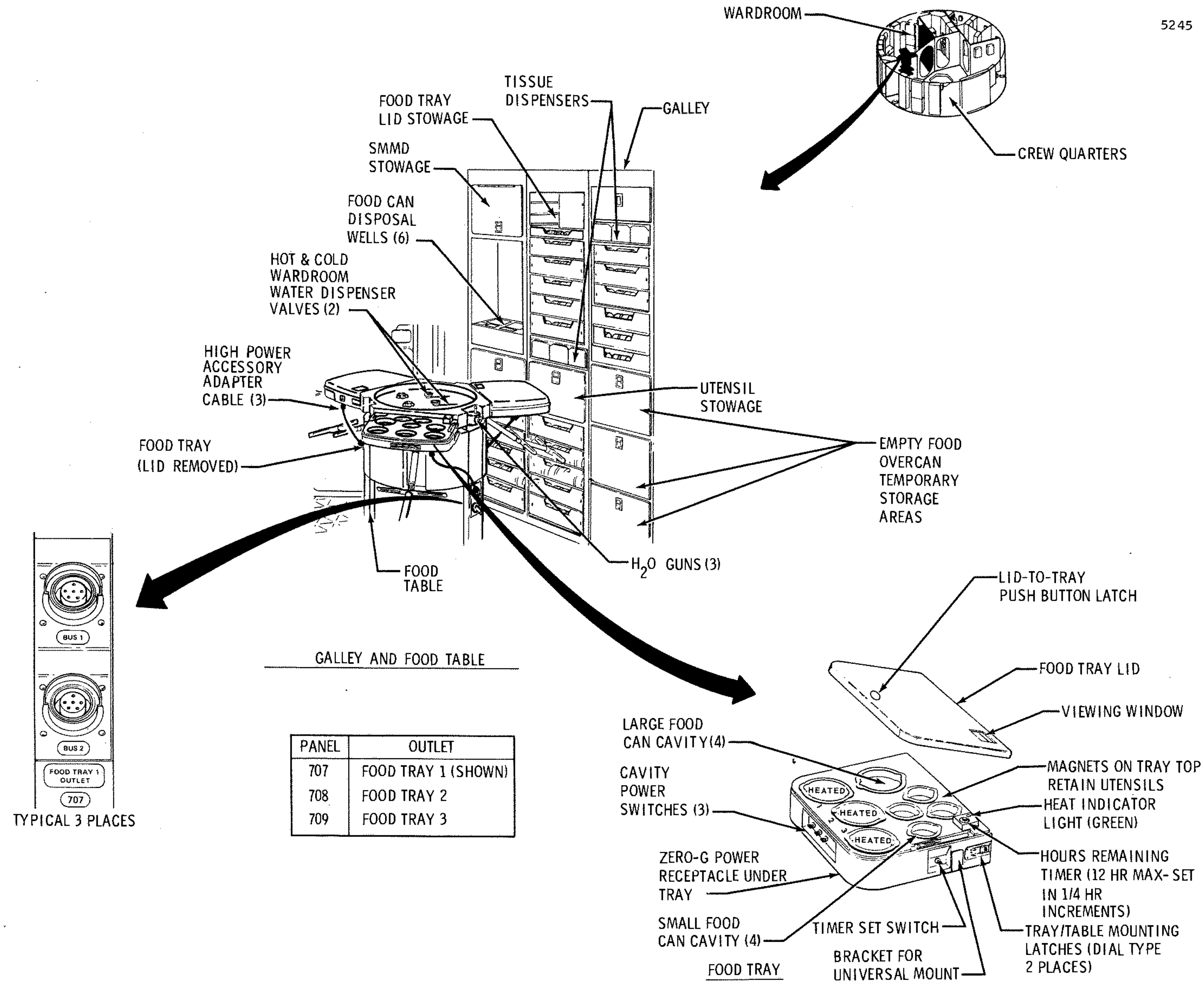



Figure 2.5.10-5 Wardroom Freezers/Food Chiller -- Functional Diagram




| PANEL | OUTLET |
|---|---|
| 707 | FOOD TRAY 1 (SHOWN) |
| 708 | FOOD TRAY 2 |
| 709 | FOOD TRAY 3 |

Figure 2.5.10-6 Food Preparation and Consumption Equipment

A utensil stowage compartment in the galley stows the eating utensils for each crewman. Two tissue dispensers are also provided to support the cleaning of the various food system implements and the galley equipment. A SMMD is stowed in the galley to weigh unconsumed food for documentation purposes.

2.5.10.3.2 Food Table

Final food preparation and the consumption of the food is accomplished at the food table. The food table allows 3 crewmen to simultaneously heat their food and to eat the meals in an efficient and comfortable manner as well as to support components of the water system (paragraph 2.5.12).

The food table pedestal houses the water chiller and the wardroom H2O heater. The water chiller provides cold water to a cold wardroom water dispenser valve on the table's upper surface for chilled reconstitution of dehydrated foods and beverages. In addition, the water chiller provides cold water to 3-H2O guns for drinking water. One H2O gun is allocated to each crewman and is mounted on the periphery of the table's pedestal (figure 2.5.10-6). The wardroom H2O heater provides hot water to a hot wardroom water dispenser valve on the table's upper surface for hot reconstitution of dehydrated foods and beverages.

Three eating stations at the food table serve as a separate food heating and consumption facility for each crewman (figure 2.5.10-6). Each eating station has a foot and thigh restraint to restrain the crewman in a comfortable manner (paragraph 2.5.3). One H2O gun is located at each eating station. A food tray, which heats the crewman's food, is provided a mount at each eating station. OWS bus 1 and OWS bus 2 zero-G outlets are located at each station to provide bus power selection for that particular eating station's food tray.

A removable table top is stowed above the food table on the ceiling grid when not in use.

2.5.10.3.3 Food Trays

One portable food tray per crewman is used to heat frozen food in large food cans and to serve the crewman with his entire meal. The food trays contain 8 food can cavities, 4 for large food cans and 4 for small food cans (including pudding cans and beverage packs). Three of the large food can cavities are heated; individual cavity power switches and a timer control heater use (figure 2.5.10-6). A removable food tray lid is used when the food is heating and is stowed in the food tray lid stowage area in the galley when not in use. Each of the three food trays and food tray lids are color coded with "Snoopy" decals. Two dial-type latches are located on the food tray to secure the tray to the food table mount. A zero-G receptacle is located under the food tray to supply power to the tray from the food table power outlets via a high power accessory adapter cable. A universal mount bracket located adjacent to the TIMER SET switch is attached to the universal mount (paragraph 2.5.3) when the crewmember eats at his particular workstation. Magnets, dispersed about the surface of the food tray, retain the utensils of the crewman during food preparation and when eating.

Operationally, the food tray may be connected to either the BUS 1 or BUS 2 outlets on the food table. Power is then supplied to the three food tray cavity power switches (figure 2.5.10-7).

Each cavity power switch controls a single, heated large food can cavity in three modes: (1) AUTO; (2) OFF; (3) ON. The selection of the AUTO position allows the HOURS REMAINING timer to be set with the TIMER SET switch to the time delay desired (12 hours maximum) prior to automatic turn-on of the selected food cavity. The food can cavity heater will then remain on until manually turned off. The cavity power switch OFF position disables that particular food cavity from receiving power. The cavity power switch ON position provides power directly to that particular food can cavity, bypassing the timer circuit. In either the AUTO mode or the ON mode, a green HEAT light comes on whenever power is routed to any one of the food cavities. Control of the food can cavity is by a temperature controller, which maintains the food temperature between 143° and 155°F. An overtemp cutoff circuit for each food can cavity permanently disables that particular cavity from further use as a heating area if the cavity overheats. Two spare food trays are provided.

The crewmen eat three meals per day at the food table. At the end of each meal, the food trays are filled for the next meal, and the timers are set for the appropriate time interval.

For SI-1 launch, the food trays are restrained on the floor grid in the wardroom with straps. The trays are removed from the floor and mounted on the food table during each SWS activation. They are returned to the floor grid during each SWS deactivation to permit access to the water system components in the food table pedestal.

2.5.10.3.4 Eating Utensils

Reusable eating utensils are supplied in sets. One utensil set is allocated to each crewman and three additional sets are spares (9 sets total). A set consists of a knife, spoon, and fork, all 3/4 size, and is made of magnetic stainless steel. The knife has a pointed tip to pierce and slice the flexible membranes contained in some food cans. The utensils are retained on the food trays and in the utensil stowage compartment in the galley with magnets. Disinfectant-moistened pads, obtained from a galley-located tissue dispenser, will be used to cleanse the utensils after each use.

2.5.11 WASTE MANAGEMENT

2.5.11.1 WASTE MANAGEMENT PROVISIONS

The waste management subsystem provides the supplies and equipment necessary for hygienic collection, processing, storage and return or disposal of waste products (feces, urine and vomitus) for the three crewmen of each mission. A vacuum cleaner is supplied to collect free-floating debris within the OA. The WMC is the center of waste

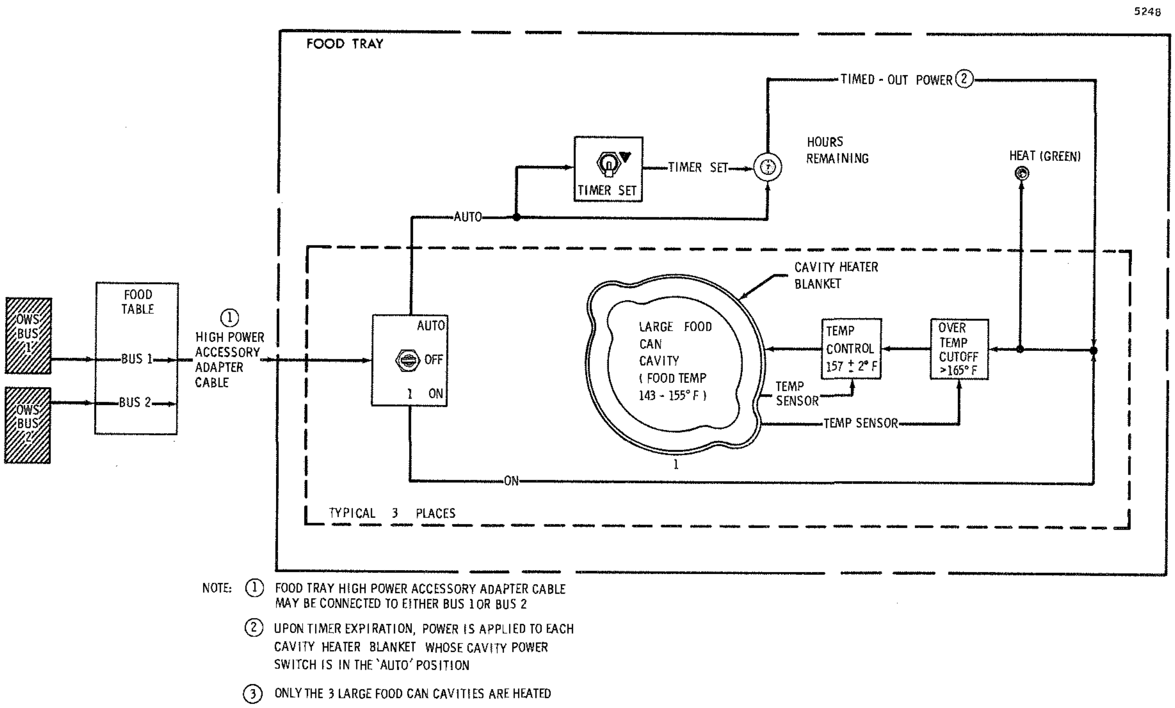



Figure 2.5.10-7 Food Tray -- Functional Diagram

management functions and contains the supplies and equipment used during collection, processing, storage, and management of body wastes.

2.5.11.2 WASTE MANAGEMENT SUPPLIES

Waste management supplies for collection of waste material consist of fecal bags, contingency fecal bags, urine collection provisions and contingency urine cuffs to collect and to retain a crewman's body wastes. Collection bags are provided to support waste management activities for normal operational usage, for contingency collection modes, and facilitate hygienic waste collection, waste processing and on-orbit storage and/or disposal. Vacuum cleaner bags are also supplied to collect and to retain cabin debris.

Collection bags are constructed of an impermeable outer material with an opening of sufficient size to allow waste material and air to enter (figure 2.5.11-1). A vapor port on each collection bag (except the urine bag) allows air and vapors to pass through and exit the bag. The vapor port contains a millipore filter with a hydrophobic surface; water and solid material cannot exit through this vapor port. Liquid waste material in the bag is repelled from the vapor port by the hydrophobic surface and is attracted to the side of the bag opposite the vapor port by a hydrophobic surface. Collection bags also include a sealable closure to permit positive retention of the collected wastes during storage or disposal. A data entry tag is provided as an integral part of the fecal bags, contingency fecal bags and sample containers to permit each crewman to record pertinent data for use during post-flight analysis.

2.5.11.2.1 Fecal Bags

Fecal bags are utilized to collect fecal matter in the fecal collector (fecal/urine collector) (figure 2.5.11-2). The fecal bag permits collection of feces while installed in the fecal collector utilizing a gravity substitute airflow technique (suction). Cabin air and the fecal matter are drawn into the collection bag utilizing a blower. Air is then allowed to escape from the bag while the fecal material is retained in the bottom of the bag through the suction effect.

Fecal bags are obtained from a fecal bag dispenser (paragraph 2.5.5) in the WMC. A single bag is removed and inserted into the fecal collector. With the gravity substitute airflow blower operating, fecal matter is retained in the bag during the waste collection function. A vapor port provided on the bag passes only vapors from the bag. Solids and liquids are retained in the bag by the millipore filter on the vapor port in conjunction with the action of the hydrophobic and hydrophilic surfaces. The wiping function is accomplished using wipes; the wipes are disposed of in the fecal bag. Adhesive sealing features on the bag opening insure waste isolation from the external environment.

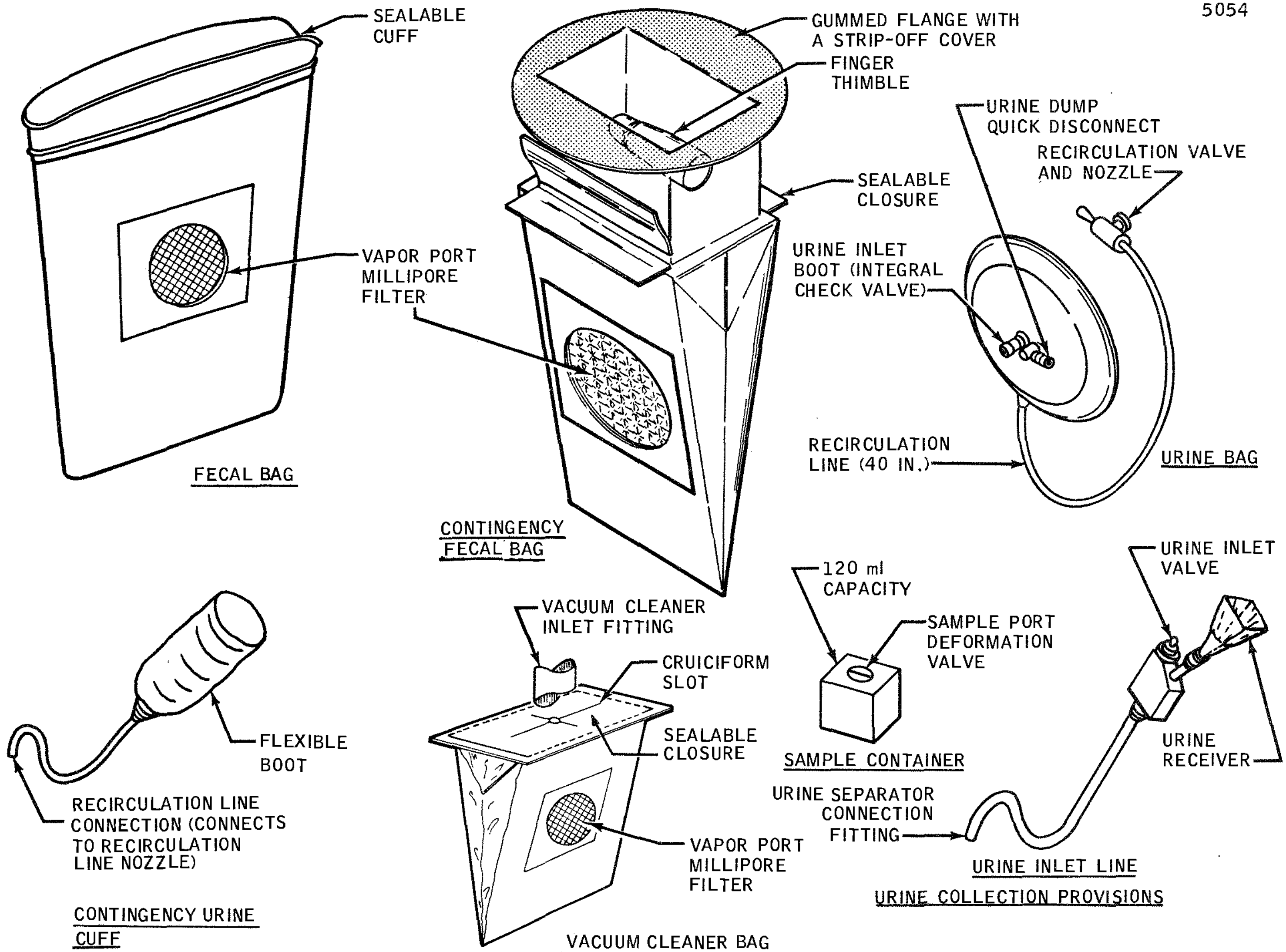



Figure 2.5.11-1 Waste Management Collection Bags

After the bag is sealed and removed from the fecal collector, the bag and its contents are weighed on the specimen mass measuring device (SMMD) in the WMC. Pertinent data is recorded on the bag's data entry tag. The bag and its contents then undergo waste processing to a powdered form to facilitate on-orbit storage and preservation (figure 2.5.11-3). During waste processing, all trapped air and water is removed from the waste material through the application of mechanical pressure, heat and exposure to vacuum pressure. When waste processing is complete, the bag is transferred to a stowage compartment in the WMC for eventual return to earth in a fecal return bundle.

2.5.11.2.2 Contingency Fecal Bags

Contingency fecal bags are provided for the contingency collection of fecal matter and for normal collection of vomitus. The bags collect feces or vomitus without the aid of gravity substitute airflow or a collection facility. The bag utilizes a gummed flange which facilitates a positive adhesion to the buttocks during defecation (figure 2.5.11-1). A finger thimble is provided integral to the bag to perform the primary wiping function. The secondary wiping function is accomplished using wipes; the wipes are disposed of in the bag. An adhesive closure seals the bag for containment of waste material.

For use as a vomitus bag, the crewman does not remove the strip-off cover, but presses the bag firmly to the mouth area when vomit collection is desired.

The bag features are similar to those of the fecal bag to permit mass determination, data entry, waste processing, and on-orbit storage for eventual return to earth in a fecal return bundle (figure 2.5.11-3).

2.5.11.2.3 Urine Collection Provisions

The urine collection provisions of urine inlet lines, urine bags, and sample containers are used to collect urine in urine drawers (fecal/urine collector) in conjunction with a gravity substitute airflow. Each of the three urine drawers (one per crewman) contains a urine inlet line, a urine bag and a sample container to collect, to store, and to sample at the end of each day's collection cycle the urine from each crewman (figure 2.5.11-1). The collection cycle ends after the morning urination.

2.5.11.2.3.1 Urine Inlet Lines

The urine inlet line connects to a urine separator in the urine drawer and routes urine from the crewman to the urine separator in the drawer. The crewman urinates into a boot-type urine receiver on the inlet line through a urine inlet valve (figure 2.5.11-1). A mount (urine receptacle) is provided on the fecal/urine collector which restrains the urine inlet valve while maintaining the valve in the open position during urination. The urine inlet valve is spring-loaded closed. Three urine inlet lines are used, one per crewman, and are disposed of in a disposal bag after the daily urine collection cycle is completed (figure 2.5.11-3). Replacement urine inlet lines are made readily available from a limited supply in a WMC stowage compartment. The WMC supplies are replenished periodically from packages of urine inlet lines stowed in OWS forward dome stowage compartments.

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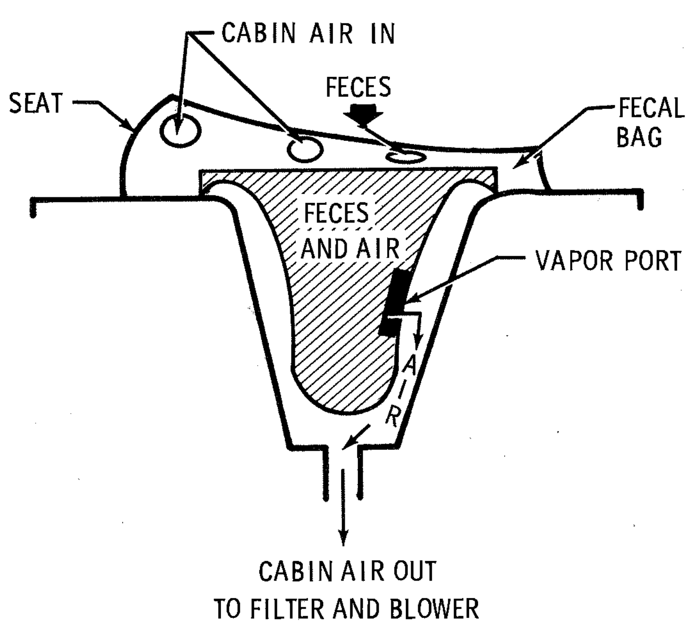


Figure 2.5.11-2 Fecal Collector -- Functional Diagram

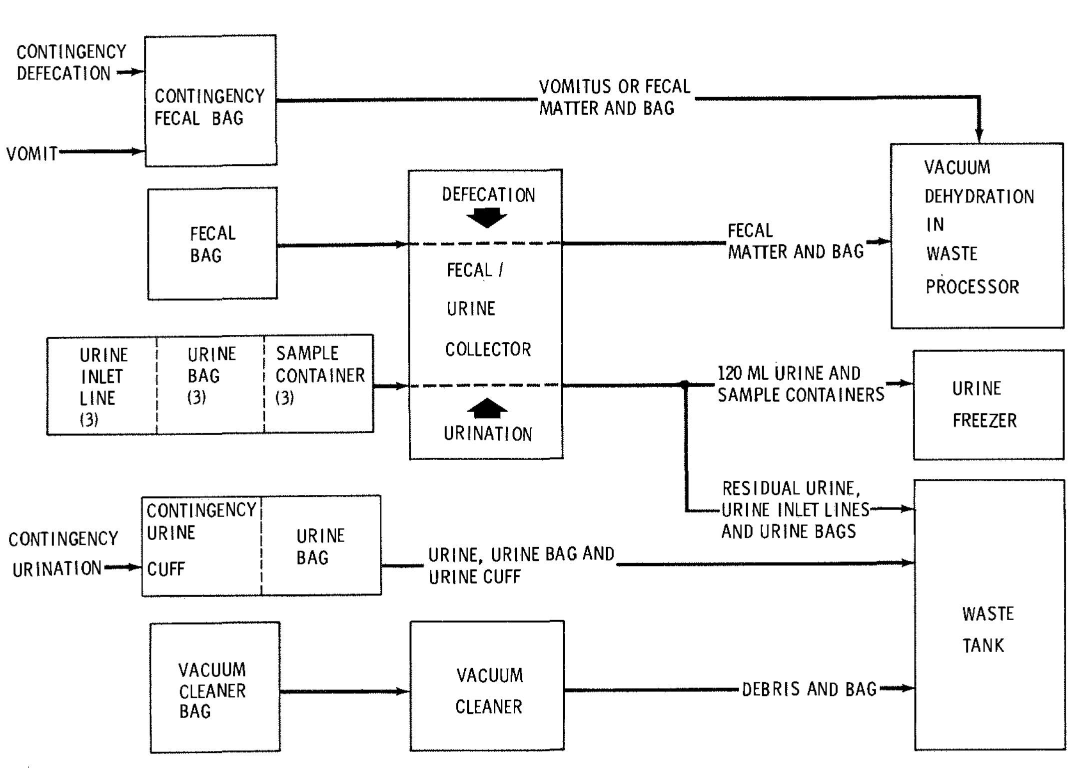


Figure 2.5.11-3 Collection Bag Usage Scheme

2.5.11.2.3.2 Urine Bags

Urine bags attach to the urine separators in the urine drawers and provide urine storage during the 24-hour collection cycle period for sample withdrawal. One urine bag is used in each urine drawer and connects to the drawer's urine separator with a urine inlet boot (figure 2.5.11-1). This boot routes urine from the urine separator into the urine bag. A check valve inside the boot retains the collected urine in the bag. A urine dump quick-disconnect is provided on the urine bag for use in disposing of the urine in the backup mode using urine dump equipment. A recirculation line is attached to the bag and contains a thumb-operated recirculation valve which is spring-loaded closed. The recirculation line is used to mix the urine in the bag prior to its sampling at the end of the 24-hour collection period. At this time the nozzle of the recirculation valve is inserted into the urine receiver of the urine inlet line. Urine is then allowed to recirculate from the bag through its recirculation line, through the urine inlet line, into the urine separator and back into the bag. The recirculation line is then used to route urine to a sample container after through mixing. The recirculation line is also used with the contingency urine cuff when collecting urine in the backup mode.

Each crewman uses one urine bag per day and disposes of his urine bag and the urine into a disposal bag at the end of the daily urine collection cycle after sample withdrawal (figure 2.5.11-3). Replacement urine bags are made readily available from a limited supply in a WMC stowage compartment. The WMC supplies are replenished periodically from packages of urine bags stowed in OWS forward dome stowage compartments.

2.5.11.2.3.3 Sample Containers

At the end of the daily urine collection cycle, the urine which has been accumulating in the urine bag over a 24-hour period will be sampled using a sample container. Three sample containers are used daily (one per crewman) and are contained in a SAMPLE CONTAINER door on each urine drawer. The sample container will expand to a volume of approximately 120 ml. during urine sample withdrawal. The sample containers are stowed in the collapsed state and evacuated of all air. A deformation valve (football pin valve) on the sample container accepts the insertion of the recirculation valve nozzle to obtain a sample from the urine bag (figure 2.5.11-1). The sample container then expands to the sampled volume while being restrained behind the SAMPLE CONTAINER door. The three sample containers (one from each crewman) are then transferred to the urine freezer for on-orbit preservation for eventual return to earth in a urine return container (figure 2.5.11-3).

Replacement sample containers are made readily available from a limited supply in a WMC stowage compartment. The WMC supplies are replenished periodically from packages of sample containers stowed in OWS forward dome stowage compartments.

2.5.11.2.4 Contingency Urine Cuffs

Contingency urine cuffs are used as a backup mode of collecting urine if the urine drawer is inoperative. The cuff connects to the recirculation valve nozzle on the urine bag and permits urine collection without the aid of gravity substitute airflow or a collection facility (figure 2.5.11-1). Urination is accomplished directly into the cuff's flexible boot which passes the urine to the recirculation line and into the urine bag. The contingency urine cuff, the urine bag and its contents are then placed in a disposal bag for disposal through the trash disposal airlock. Contingency urine cuffs are stowed until required for use in OWS forward dome stowage compartments.

2.5.11.2.5 Vacuum Cleaner Bags

Vacuum cleaner bags are provided for use in the vacuum cleaner to collect and retain particulate matter and water utilizing gravity substitute airflow from the vacuum cleaner blower. Upon installation in the vacuum cleaner, the vacuum cleaner inlet fitting inserts itself into the cruciform slot on the debris bag when the bag's access door is closed to permit air and debris to be directed into the bag (figure 2.5.11-1). The air then exits the debris bag through the vapor port while solids and liquids are retained in the bag. When sufficiently full, or at 7-day intervals, the debris bag is sealed, removed, and disposed of in the trash disposal airlock (figure 2.5.11-3).

2.5.11.3 WASTE MANAGEMENT EQUIPMENT

Waste management equipment associated with the collection, processing, storage and return or disposal of waste material is provided through use of a fecal/urine collector, waste processors, urine freezer, urine dump equipment, fecal return bundles, urine return containers, and a vacuum cleaner.

2.5.11.3.1 Fecal/Urine Collector

The fecal/urine collector is a rigid, wall-mounted unit which provides the hardware items necessary to collect feces and urine from each crewman (figure 2.5.11-4). The unit contains one fecal collector for collection of a single defecation and three urine drawers, one per crewman, to collect each urination and to store the urine in a chilled state for a 24 hour period. A fecal/urine collector blower unit provides a gravity substitute airflow (suction) to draw and retain the waste material into the fecal collector and into the urine drawer during waste collection (figure 2.5.11-5). The gravity substitute airflow is filtered through a fecal collector filter to remove noxious odors prior to its recirculation back into the cabin by the blower unit.

The fecal/urine collector permits one crewman to accomplish defecation and urination simultaneously while seated on the collector. Body stabilization is attained through use of collector-mounted crewman restraints consisting of a lap belt and two handholds (paragraph 2.5.3). The urine receptacle, utilized for attaching the urine inlet valve of the urine bag, is located at a convenient height to facilitate standing urination. The urine receptacle is movable into two different positions to accomodate comfortable body positioning during seated or standing urination. A pair of light-duty foot restraints (paragraph 2.5.3) is located in front of the fecal/urine collector to permit standing urination and to allow the crewman to conduct maintenance on the fecal/urine collector.

2.5.11.3.1.1 Fecal Collector

The fecal collector is an integral part of the fecal/urine collector and consists of a fecal collection receptacle, a mesh liner and a hinged seat (figure 2.5.11-6). The hinged seat provides access to the mesh liner to permit installation of a fecal bag. The seat is contoured and contains airflow holes to allow cabin air to be drawn into the the fecal bag as a gravity substitute airflow. The seat upon closure, provides an integral seal between the fecal bag and the fecal collection receptacle and between the seat and the buttocks of the crewman. Gravity substitute air flow through the seat airflow holes, draws the feces into the fecal bag where it is retained. Air drawn from the cabin into the fecal bag is exhausted through the collection bag's vapor port, through the mesh liner and into the fecal collection receptacle. The cabin air is then passed on to the fecal collector filter and the blower unit (figure 2.5.11-5). The fecal bag is removed from the fecal collector after each defecation and replaced immediately with a new bag. The fecal bag with its contents is then vacuum dried in a waste processor to facilitate on-orbit storage.

2.5.11.3.1.2 Urine Drawers

Three urine drawers are located at the base of the fecal/urine collector, one assigned to each crewman through the use of "Snoopy" decals. The urine drawers provide a facility to collect, temporarily store for 24-hours, measure and sample the urine from three crewmen. Each drawer contains the facilities to accept the urine (urine inlet line), to separate the air from the urine (urine separator), to collect and store the urine (urine bag) and to withdraw a urine sample, once daily (sample container). Each urine drawer is also serviced with RS coolant to refrigerate the urine bag, to cool the urine separator and is provided with a gravity substitute airflow from the collector's blower unit.

Two banks of switches, BLOWER/SEPARATOR BUS 1 POWER and BUS 2 POWER switches, are located on the fecal/urine collector cabinet adjacent to the fecal collector. The switches are used to simultaneously power the collector's blower unit and the drawer's urine separator.

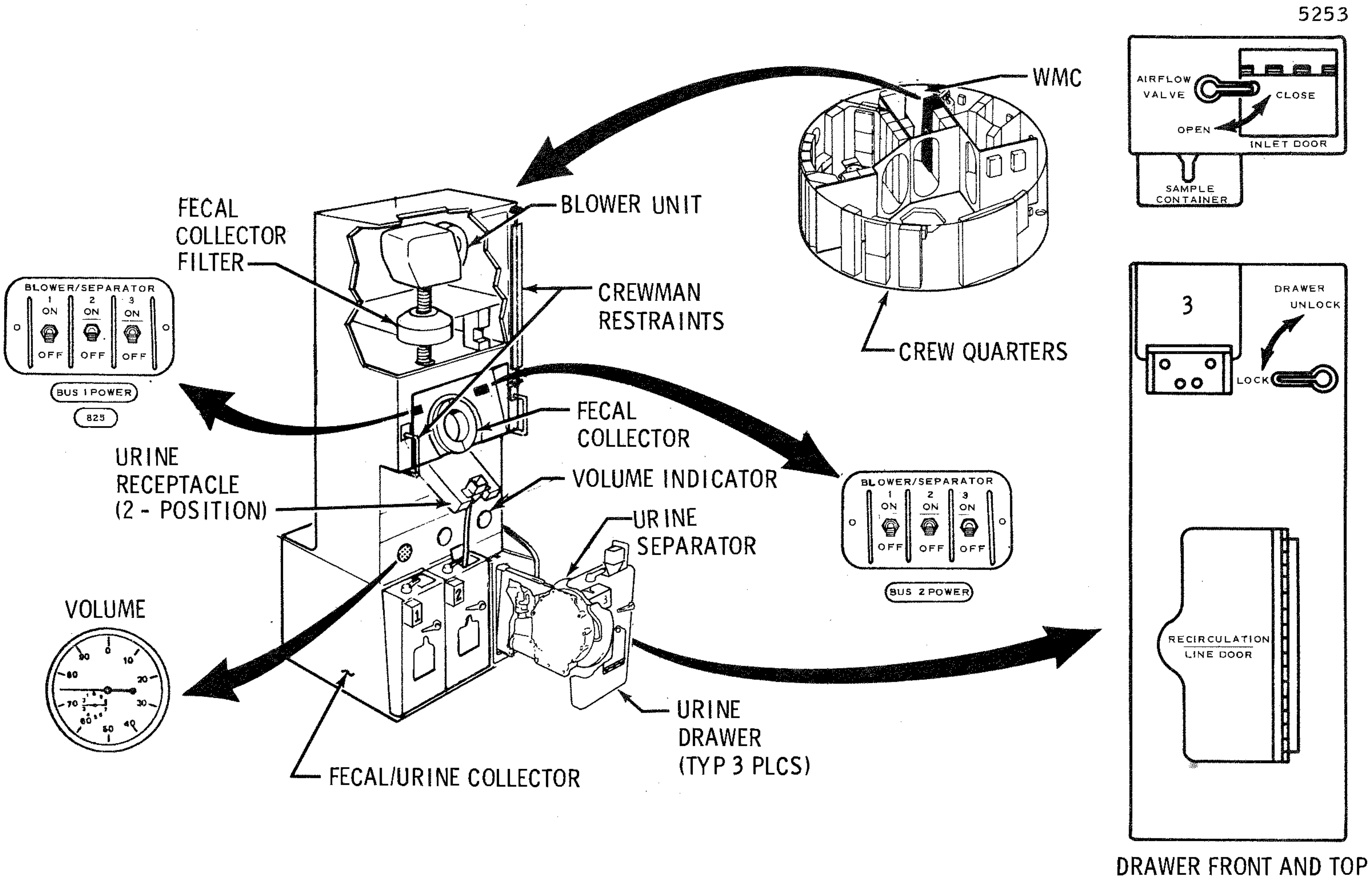


Figure 2.5.11-4 Fecal/Urine Collector

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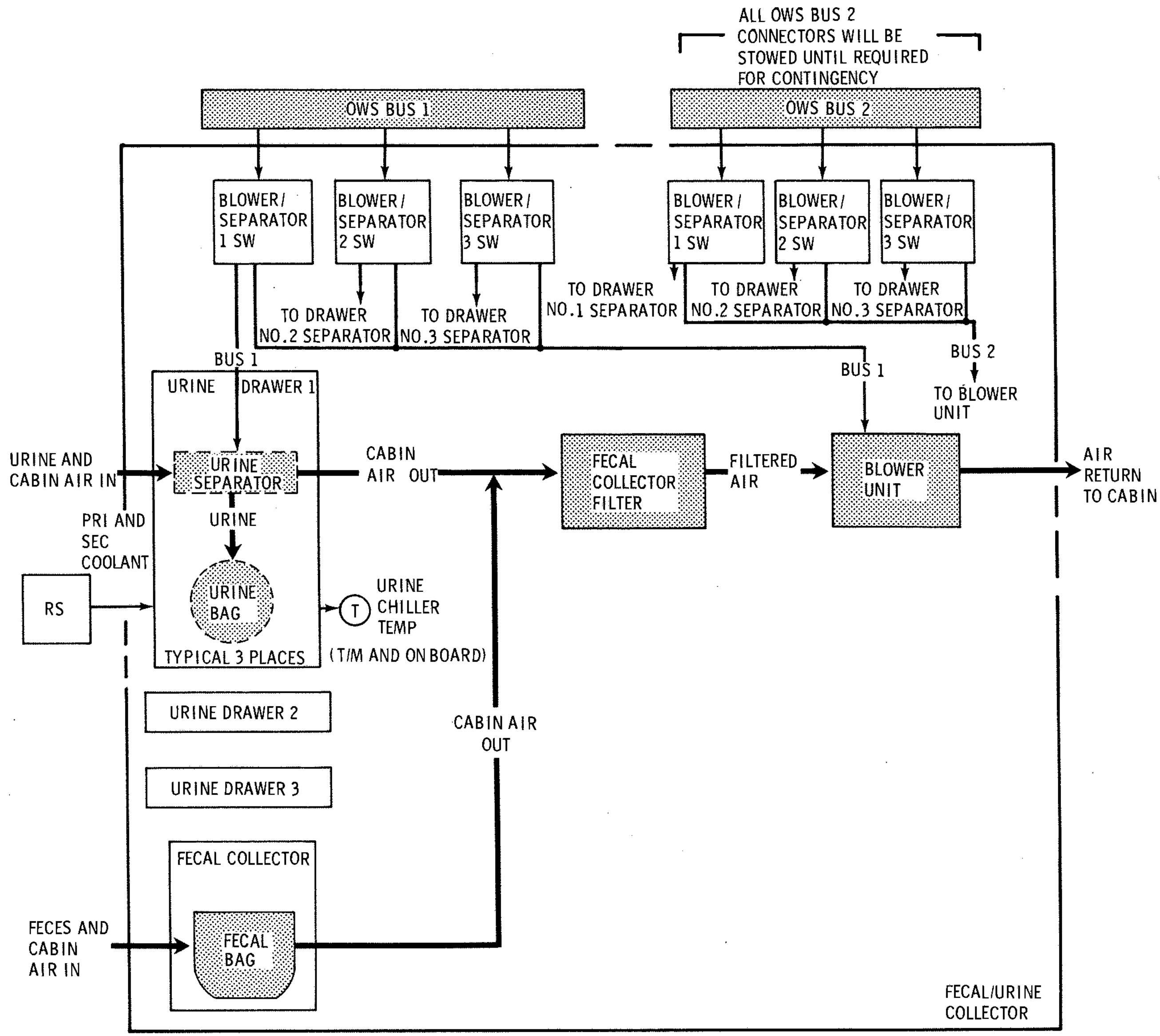


Figure 2.5.11-5 Fecal/Urine Collector -- Block Diagram

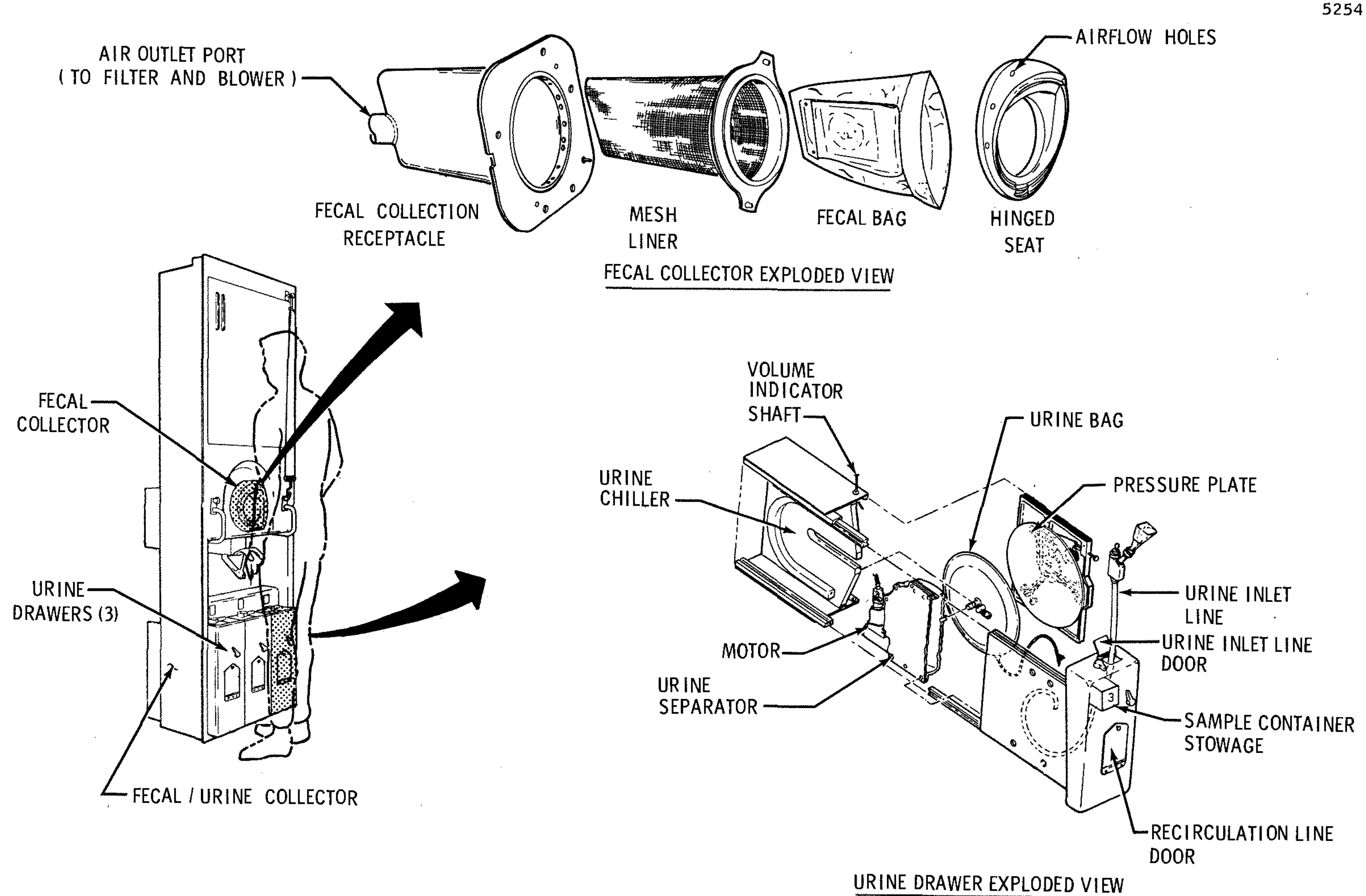


Figure 2.5.11-6 Fecal and Urine Collection Facilities

In use, the crewman will select his drawer using the AIRFLOW VALVE which permits gravity substitute airflow to draw the air into the urine separator. The appropriate blower/separator switch on the fecal/urine collector is then turned on to start the drawer's urine separator and to start the collector's blower unit (figure 2.5.11-5). The crewman then emplaces the urine inlet valve on the urine receptacle which opens the valve and permits the urine receiver to receive urine. The cabin air and the crewman's urine are drawn through the urine inlet line and into the urine separator (figure 2.5.11-7). Here the urine and air are separated by centrifugal action with the urine being passed into the urine bag and the cabin air being routed to the filter and blower. Upon completion of urination, the AIRFLOW VALVE is closed and the blower/separator switch is turned off; however, an interlock circuit permits the urine separator to continue operating for three minutes to empty the separator of all urine. This operation is repeated over the 24-hour urine collection cycle with the urine being pooled each time in the urine bag. This accumulation of urine is refrigerated by a cold plate type urine chiller which is supplied RS primary and secondary coolant to preserve the urine at approximately 60°F. The urine separator also contacts the urine chiller with two heat sink plates to cool the separator prior to urine collection. The urine chiller in each drawer contains two temperature readouts, one for on-board display on panel 616 and one on telemetry (figure 2.5.11-8).

At the end of the 24-hour urine collection cycle,a sample of the accumulated urine is taken. The urine is first mixed to obtain a homogeneous solution as described in paragraph 2.5.11.2.3.2. The volume of the urine is determined through use of a VOLUME indicator above the urine drawer. This information is recorded on the sample container's data entry tag. A sample is then extracted from the urine bag into the sample container as described in paragraph 2.5.11.2.3.3. The sample container is then transferred to the urine freezer and the residual urine in the urine bag and the urine inlet line are disposed of. The sample container, urine bag, and urine inlet line are immediately replaced with resupply units stowed in a WMC stowage compartment.

2.5.11.3.1.3 Urine Separators

One removable urine separator is located in each urine drawer (figure 2.5.11-6) and is used to separate the cabin air from the crewman's urine during the collection process. The urine separator is powered by a removable motor which is supplied OWS bus power from panel 825 blower/separator switches on the fecal/urine collector cabinet (figure 2.5.11-9). A time delay circuit is provided to allow the separator to run for additional 3 minutes after the blower/separator switch is positioned off to empty the separator of residual urine. A separate circuit breaker for each separator is provided within the fecal/urine collector cabinet.

Each urine separator contains a urine inlet which attaches to the drawer's urine inlet line (figure 2.5.11-10). The urine inlet routes the cabin air and the crewman's urine into the vaned separator. The spinning action of the vanes acts on the urine/air mixture and propells the urine to the periphery of the separator through centrifugal action. The cabin air exhausts through the center of the separator through a replaceable filter to the air outlet for routing to the filter and blower. A urine outlet on the separator housing picks up the urine at the separator's periphery and routes it to the urine inlet boot of the urine bag. A heat sink plate, mounted on the top and bottom of the separator housing, is used to contact the urine chiller for thermal conditioning of the urine separator. The separator is chilled to prevent it from increasing the temperature of the urine during the separation process. Upon completion of the 24-hour urine collection cycle and after sample withdrawal, the urine separators are flushed with water to decontaminate the separators (paragraph 2.5.12).

One urine separator is provided for the personal use of each crewman. The additional separators are stowed in OWS forward dome stowage compartments along with one spare. The urine separators and their motors for the SL-2 mission are launched on the sleep compartment/experiment compartment partition in the experiment compartment. Upon SL-2 activation, the crew will install the urine separators in the urine drawers, using tools. Each subsequent mission's crewmen will then install their urine separators using the original three motors. The used separators are placed in OWS forward dome stowage compartments. Two spare motors and three spare urine separator power cables are stowed in spare parts stowage compartments in the OWS forward dome.

2.5.11.3.1.4 Fecal Collector Filter

The fecal collector filter (figure 2.5.11-4) is located within the fecal/urine collector cabinet behind a hinged door and removes odors resulting from defecation and urination. The filter processes all the air used during waste collection prior to its entering the blower (figure 2.5.11-5). The filter removes the odors by passing the air through an annular bed of activated charcoal. The filter is replaced every 28 days and the replacements are stowed in OWS spare parts stowage compartments in the OWS forward dome.

2.5.11.3.1.5 Blower Unit

The fecal/urine collector blower unit (figure 2.5.11-4) is located within the fecal/urine collector cabinet behind a hinged door and provides a gravity substitute air flow for the hygienic collection of feces and urine. The blower unit exhausts cabin air back into the WMC which is drawn through the fecal collector and the urine drawers and passed through the fecal collector filter (figure 2.5.11-5). The blower unit is replaceable, should it fail, with a spare provided in a spare parts stowage compartment in the OWS forward dome. The blower unit is also interchangeable with the suit dryer blower unit (paragraph 2.5.7) and the vacuum cleaner blower unit which may also be utilized as replacement parts. Quick release mounting techniques are employed on each of the three blower units to facilitate interchangeability.

The collector's blower unit is normally powered from OWS bus 1 through the BLOWER/SEPARATOR BUS 1 POWER switches located adjacent to the fecal collector (figures 2.5.11-4 and -5). A short power cord with a zero-G connector then routes power to the blower unit. In the event that OWS bus 1 power is unavailable, OWS bus 2 power may be utilized through the BLOWER/SEPARATOR BUS 2 POWER switches located opposite to the bus 1 switches. To accomplish this, the bus 1 power cord is removed from the blower unit and the short power cord from the bus 2 circuit is

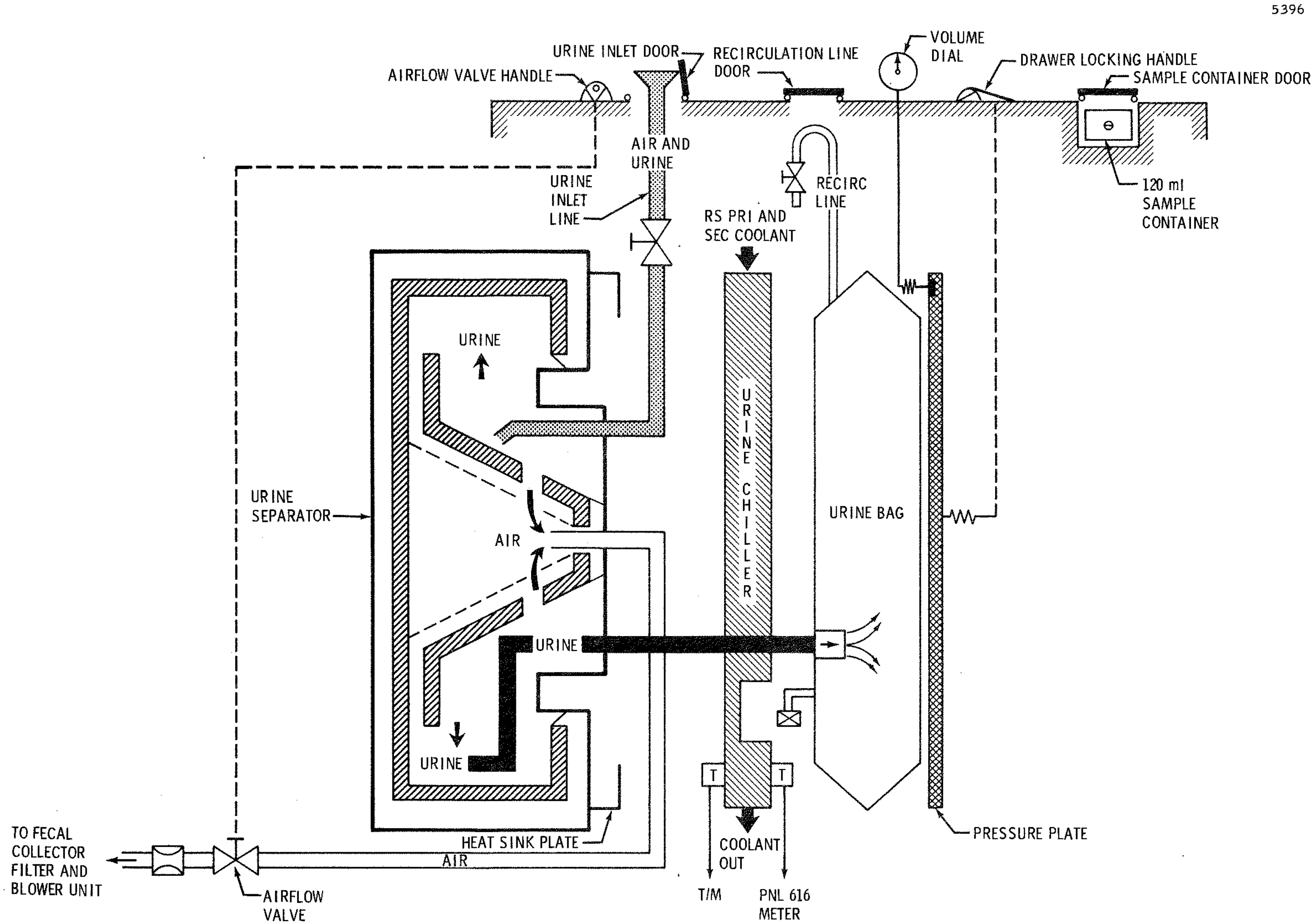


Figure 2.5.11-7 Typical Urine Drawer -- Schematic

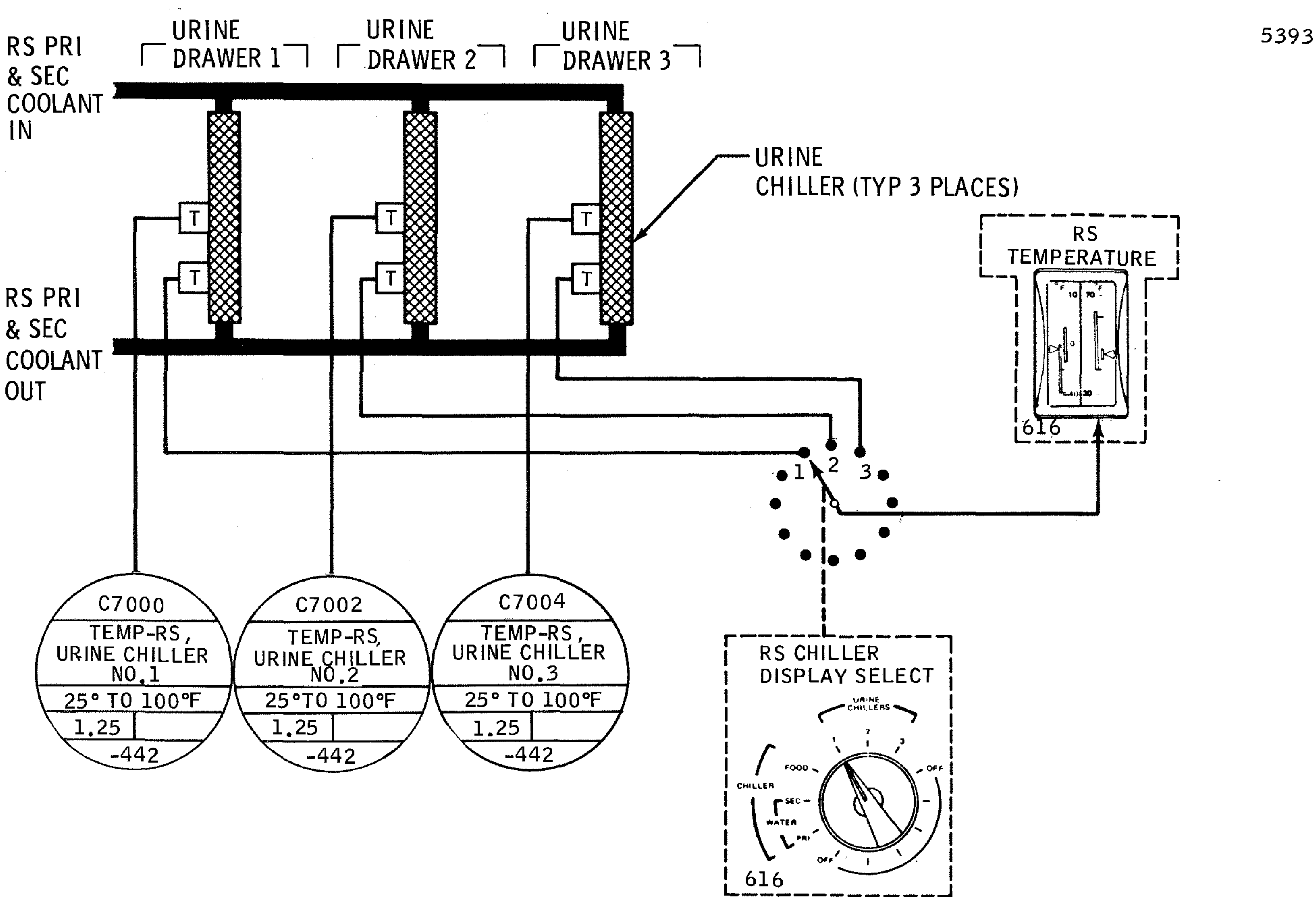


Figure 2.5.11-8 Urine Chiller -- Functional Diagram

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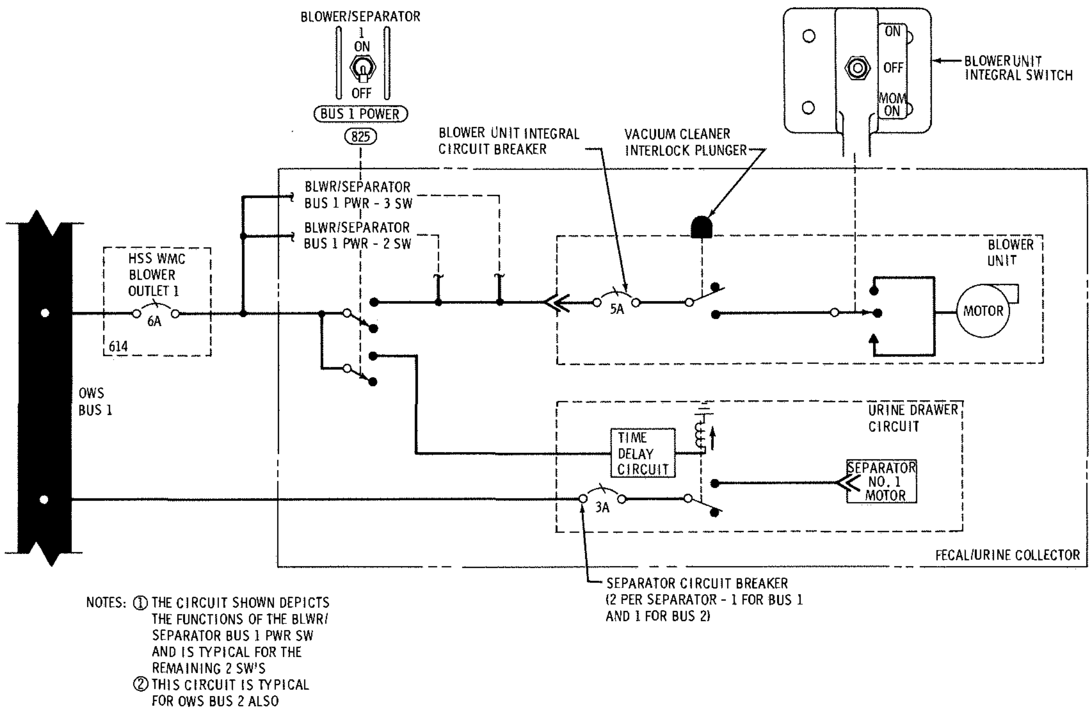


Figure 2.5.11-9 Fecal/Urine Collector -- Schematic

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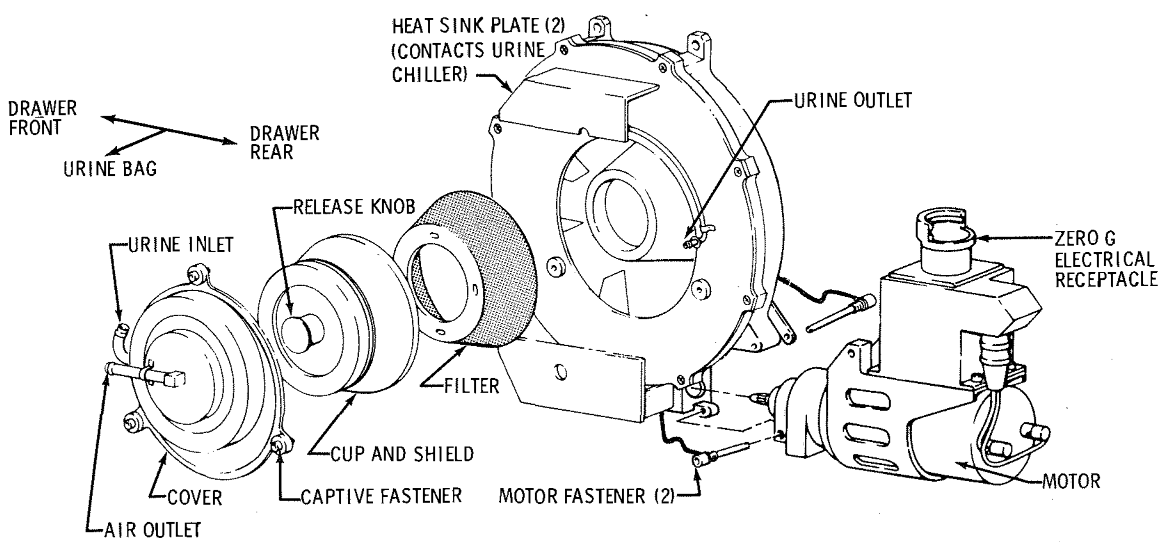


Figure 2.5.11-10 Urine Separator -- Exploded View

connected to the blower unit (figure 2.5.11-5). The blower unit contains an integral circuit breaker, (figure 2.5.11-5) readily accessible in a recess on the blower unit's housing. A vacuum cleaner interlock, for use when the blower unit is utilized in the vacuum cleaner is over-ridden when used in the fecal/urine collector. The plunger-type interlock on the blower unit's housing is actuated continuously while installed in the fecal/urine collector utilizing an over-ride stub permanently located on the blower unit's mount in the collector cabinet. Once the blower unit is mounted in the fecal/urine collector, the over-ride stub depresses the interlock plunger and maintains the relay on the power supply contact. Integral switch control is provided on the handle of the blower unit to supply power to the blower motor continuously (ON position) or momentarily (MOM ON position-for use in the vacuum cleaner). Prior to the installation of the blower unit in the fecal/urine collector, the blower unit's integral power switch is actuated to the ON position. This configuration enables the blower/separator bus power switches on the fecal/ urine collector to accomplish master control.

2.5.11.3.2 <u>Waste Processors</u>

The waste processors preserve those organic and inorganic constituents of vomit and feces required to support the medical experiments. The waste processors vacuum-dry the vomit and feces specimens in their collection bags so that the powdered residue may be safely stored on-orbit until returned to earth.

Six independent waste processors are wall-mounted in the WMC (figure 2.5.11-11). Each processor utilizes mechanical pressure, an electric heating element and waste tank vacuum pressure to accomplish the drying of the waste material. Each processor will accomodate one fecal bag or one contingency fecal bag and is controlled by individual control and display panels which include a timer, manually set by the crewman to automatically initiate and terminate the drying cycle. The drying time is selected as a function of the waste material's mass. The waste processor control and display panels are replaceable with one spare provided in a spare parts stowage compartment in the OWS forward dome.

Each waste processor contains a hand-operated VACUUM/CABIN VENT valve which is interlocked to the DOOR LOCK/UNLOCK handle (figure 2.5.11-11). This interlock prevents inadvertent opening of the processor door while the unit is processing. The VACUUM/CABIN VENT valve handle protrudes over the chamber door and must be rotated to the horizontal position to permit door actuation; however, the interlock is removable to permit separate handle action. Upon rotation of the VACUUM/CABIN VENT valve to the CABIN position, the vacuum outlet to the waste tank is sealed off and cabin air is bled into the processor. When the processor pressure is equalized with the cabin, the door can be opened. The collection bag containing the waste material is then placed in the open processor and the door is closed. The VACUUM/CABIN VENT valve is rotated to the VACUUM position to lock the door shut and to open the processor to the vacuum of the waste tank. A processor pressure plate is actuated upon door closure which applies a slight force to the collection bag, aiding in the expulsion of the vapors through the bag's vapor port. The crewman then selects the desired drying interval for the particular mass of waste material in the bag. Automatic waste processing has now been initiated as a 15-minute delay timer begins counting down to permit sufficient collection bag deflation prior to the application of heat (figure 2.5.11-12). Upon expiration of the 15-minute delay timer, the green TIMER light is illuminated and the temperature control circuit is activated with the processor heater being thermostatically controlled to 145°F. This temperature will be sufficient, with the reduced pressure in the chamber, to cause the water in the waste material to evaporate and to be exhausted through the VACUUM/CABIN VENT valve into the waste tank utilizing the waste processor vacuum vent line (paragraph 2.5.14). Upon expiration of the HOURS REMAINING timer, the heater element is turned off automatically, completing the waste processing. The collection bags are then removed and transferred to a storage area in the WMC for eventual return to earth in fecal return bundles.

In the event that the processor temperature exceeds 165°F, an overtemp cut-off circuit will activate, illuminating the amber OVERTEMP light, removing timer and heater power and permanently disabling the processor from further use.

A LAMP TEST switch is provided on panel 800 in the WMC to check out the waste processor status lights. Activating the switch to the bus 1 or bus 2 position will illuminate all the TIMER lights and the OVERTEMP lights on all six waste processors simultaneously (figure 2.5.11-12).

The waste processor door seals are replaceable with a spare stowed in a spare parts stowage compartment in the OWS forward dome.

2.5.11.3.3 <u>Urine Freezer</u>

The urine freezer (paragraph 2.5.5) is located in the WMC immediately below the waste processors and provides interim low-temperature storage of urine samples for eventual return to earth at the end of the mission. The 120 ml. urine samples, which are contained in sample containers, are retained in urine trays which hold 42 sample containers (2 weeks accumulation) in partitioned segments (figure 2.5.11-11). Two urine trays are stacked in the freezer at all times together with either three tanks of thermal capacitor (SL-2 mission) or with a spacer (SL-3 and SL-4 missions).

An integral thermal capacitor composed of dodecane wax is contained in a sealed bottom compartment of each urine tray. The dodecane wax, after being thermally conditioned in the freezer, maintains the sample containers below 14°F during the return to earth portion of the mission in a urine return container.

For the SL-2 mission. the urine freezer is launched with two urine trays and with three removable tanks of thermal capacitor (dodecane wax) to assure thermal stabilization of the trays prior to the installation of the initial urine samples from the SL-2 crew. The tanks will accompany the SL-2 urine trays in the urine return container during the return-to-earth portion of the SL-2 mission to provide an additional heat sink and filler material in the SL-2 urine return container. At the end of the SL-2 mission when the urine freezer is emptied, a spacer,

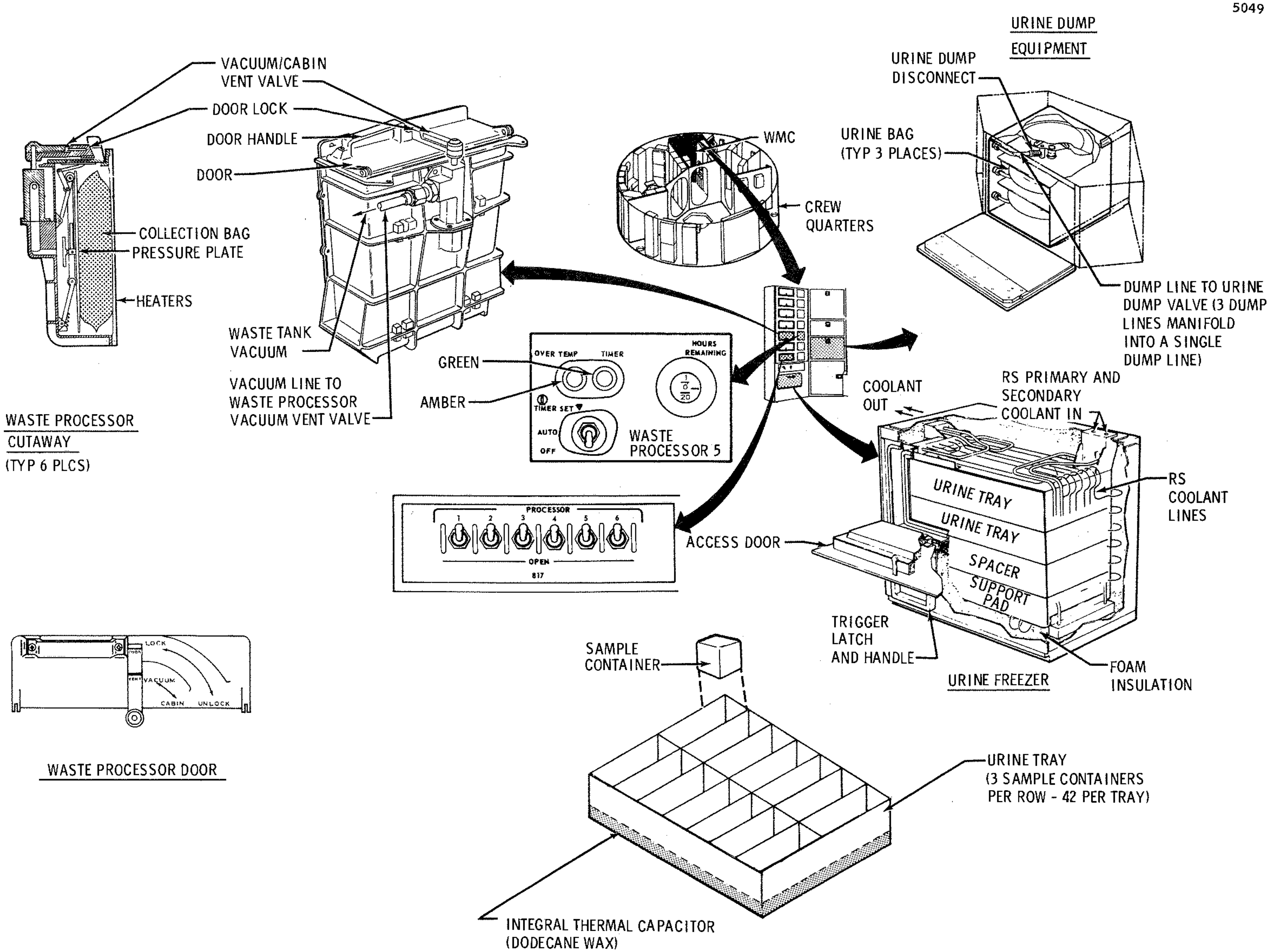


Figure 2.5.11-11 Waste Processing and Urine Management Facilities

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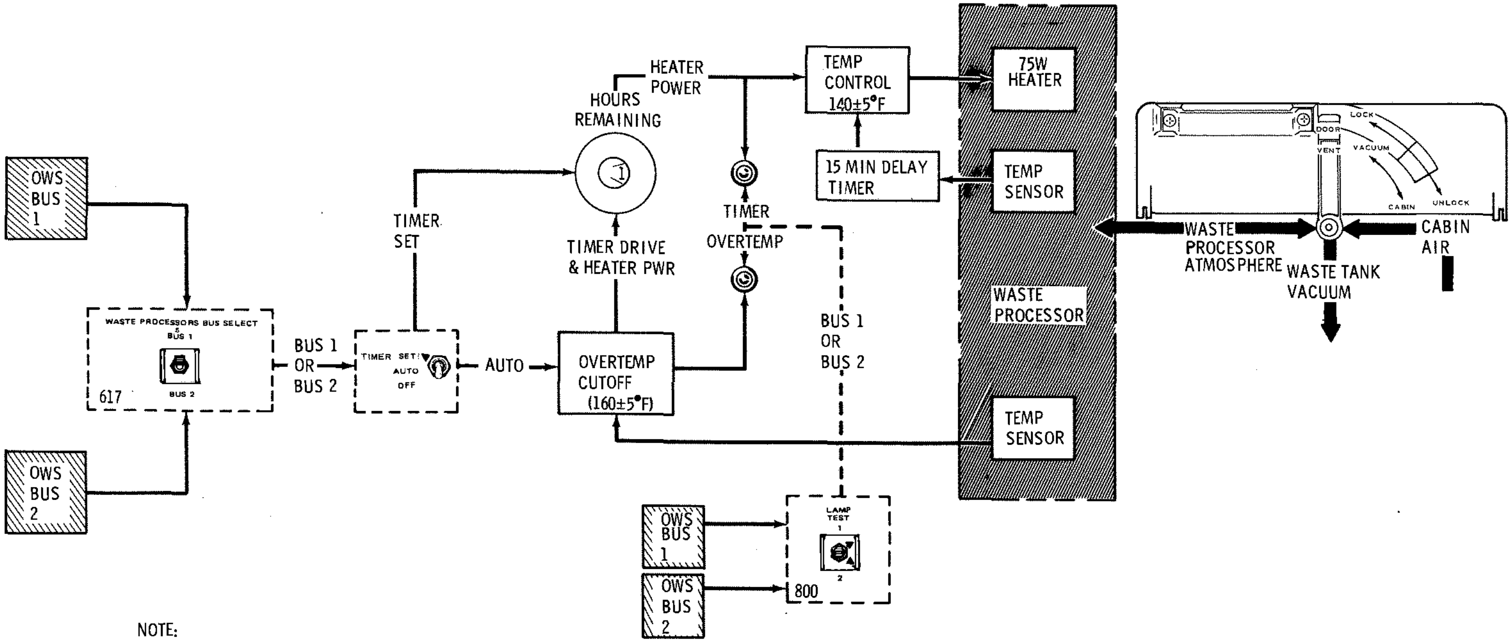



NOTE:

- WASTE PROCESSOR 5 CIRCUIT SHOWN. ALL PROCESSOR CIRCUITS ARE IDENTICAL
- 15 MIN DELAY TIMER INHIBITS THE OPERATION OF THE HEATER FOR THE FIRST 15 MINUTES OF WASTE PROCESSOR OPERATION

Figure 2.5.11-12 Typical Waste Processor -- Functional Diagram

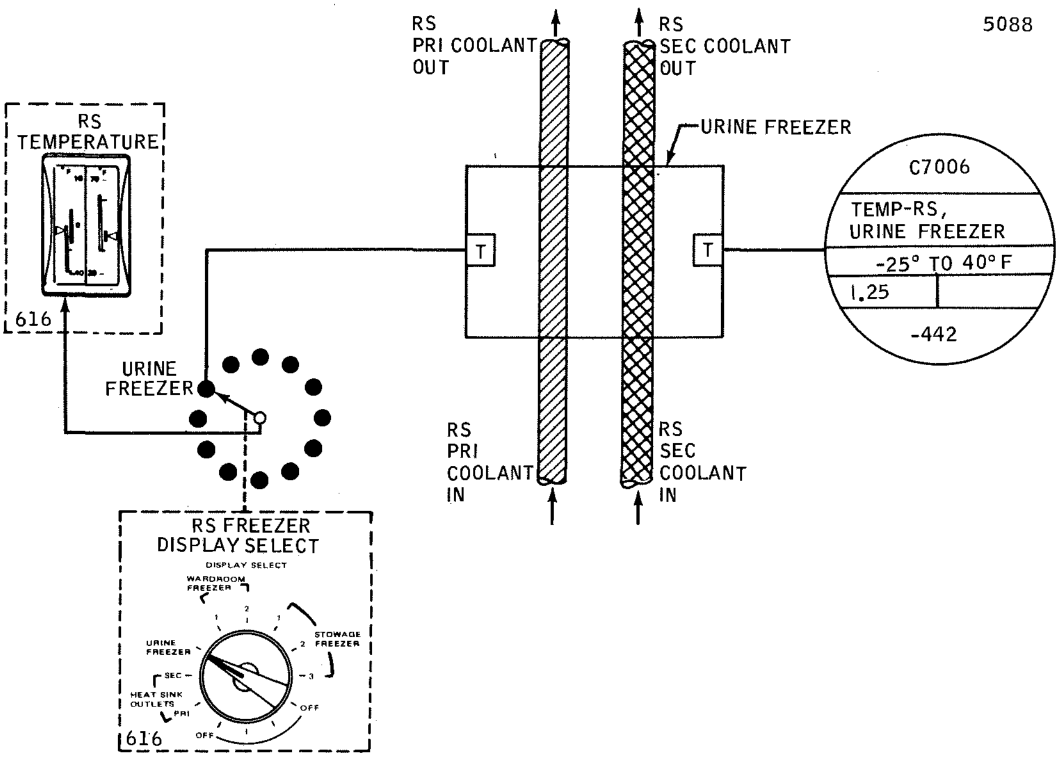



Figure 2.5.11-13 Urine Freezer -- Functional Diagram

which remains in the freezer thereafter, is inserted into the urine freezer together with two empty urine trays. The remaining two urine trays for the next mission are stowed in WARDROOM FREEZER 1 (food depleted during SL-2 mission) for thermal conditioning. After the first 28-days of the SL-3 mission, the urine freezer will be filled with frozen samples. These sample containers in their urine trays will be transferred to WARDROOM FREEZER 1 for storage during the remainder of the mission. The two empty urine trays which occupied the wardroom freezer since the previous SWS deactivation, will be transferred to the urine freezer. At the end of the SL-3 and SL-4 missions, four filled urine trays used on each of these missions will be returned to earth in a urine return container. The SL-3 and SL-4 mission supply of urine trays and the urine freezer spacer are stowed in the urine return containers until ready for use.

Two temperature measurements are located in the urine freezer for on-board display on panel 616 and on telemetry (figure 2.5.11-13).

2.5.11.3.4 Urine Dump Equipment

The urine dump equipment is utilized as a backup means to dispose of a days accumulation of urine in urine bags using a liquid dump method to the waste tank.

The urine dump equipment is located in the WMC stowage compartment H822 adjacent to the fecal/urine collector (figure 2.5.11-11). The compartment contains the facilities to store, for a 24-hour period, three urine bags containing the urine remaining after sample withdrawal. Upon the completion of the 24-hour holding period or when desired during this time period, the crew may dump the urine into the waste tank through the urine dump (paragraph 2.5.14). This procedure will be utilized in the event of the failure of the primary disposal method (the trash disposal airlock) or when disposal of liquids into the waste tank is prohibited due to operating constraints during experimentation periods.

The urine dump equipment stowage compartment is subcompartmentized into a three-tiered area, one tier for each urine bag. Each tier is fitted with a dump line containing a quick-disconnect which mates with the urine dump quick-disconnect on the urine bag. Each dump line manifolds into a single urine dump line and URINE DUMP valve on panel 818. Opening of the URINE DUMP valve provides waste tank vacuum pressure to the urine dump equipment dump lines to permit urine to flow from the urine bags into the waste tank.

Urine bags will be transferred to the urine dump equipment immediately upon their removal from the urine drawers when this backup method of disposal is desired. Normally, the three urine bags containing the residual urine will be immediately disposed of into the waste tank through the trash disposal airlock.

2.5.11.3.5 Fecal Return Bundles

Twenty-five fecal return bundles are provided for use by the SL-2, SL-3, and SL-4 crews to return the mission accumulation of fecal matter and vomitus deposits, contained in processed collection bags, to earth.

The fecal return bundles (figure 2.5.11-14) are beta fabric bags which are provided separate fecal return bundle straps to secure the return bundle to adjacent equipment in the CM during deorbit and recovery operations.

Processed fecal bags and contingency fecal bags are stowed on-orbit in a stowage compartment in the WMC. At the end of each mission these collection bags are gathered up and placed in fecal return bundles in varying quantities, so as to limit the volume of the return container to its particular stowage envelope in the CM. The fecal return bundles are then transferred to the CM and secured at predetermined locations using the fecal return bundle straps.

2.5.11.3.6 Urine Return Containers

Three urine return containers are stowed in the OWS forward compartment and are utilized to preserve up to a 56-day accumulation of urine samples during the return to earth in the CM.

Each urine return container features top loading, utilizing a removable lid retained by eight latches and is attached to the return container with a short tether (figure 2.5.11-14). An open pressure equalization port is located in the lid to maintain the internal pressure of the return container equivalent to the cabin pressure. The return containers utilize an "ice chest" design, that is, a container shell filled with foam insulation. Four CM-type bulkhead mounting brackets are located on the underside of each return container to permit positive restraint in the CM or restraint in its stowed location in the OWS. Alignment stripes are provided on the container to aid the crewman in the installation of the return container on its mounts. An identical mounting technique is employed in both the OWS and in the CM. While stowed in the OWS, two of the three urine return containers provide on-orbit stowage of eight urine trays (four per return container), urine return container filler material, and a urine freezer spacer. The remaining two urine trays are launched in the urine freezer.

Upon completion of each mission, the urine samples in their urine trays, are transferred from the urine freezer to the mission's urine return container. The four empty urine trays stowed in the return container are then removed. Two are placed in the urine freezer and two are placed in WARDROOM FREEZER 1. The SL-2 crew will insert the urine freezer spacer in the urine freezer upon SL-2 deactivation and transfer the three dodecane tanks in the freezer to the SL-2 urine return container. The urine return container lid is secured into place and the return container and its contents are then transported to the CM. The urine samples are maintained in the frozen state through the phase change of the thermal capacitor in the urine trays in conjunction with the thermally insulated return container. In this manner, the urine is maintained below 14°F during CM deorbit and recovery operations.

2.5.11.3.7 Vacuum Cleaner

The vacuum cleaner (figure 2.5.11-15) is used to collect and retain particulate matter, water and debris utilizing a gravity substitute airflow (suction) provided by a blower unit. The vacuum cleaner is a portable, self-contained unit powered from any convenient HI POWER ACCESSORY OUTLET. The vacuum cleaner utilizes a vacuum cleaner bag which retains the debris for eventual disposal.

The vacuum cleaner is stowed for ready accessibility in OWS forward compartment locker compartment F522 together with its attachments, hose and caddy. A beta fabric caddy completely encloses the blower unit and provides pouch-type stowage and convenient access of vacuum cleaner accessories (figure 2.5.11-15). A waist tether stows around the caddy when not in use. A short strap provides caddy stowage of the 15 foot hi-power accessory cable when the cable is not in use. The short strap is also used to secure the cable to convenient structure to restrain the cable when it is deployed for use. Three attachments are provided: (1) A surface tool for screen cleaning and for collection of loose and free floating debris; (2) a crevice tool to facilitate the cleaning of confined areas; and (3) a brush attachment for removal of dirt and debris adhering to surfaces. A 4-foot long flexible hose is supplied which connects to the vacuum cleaner inlet fitting and provides a tool/hose adapter with a locking feature for the attachments. The hose together with the vacuum cleaner and 15-foot power cable provides a radius of operation of approximately 20 feet from the HI POWER ACCESSORY OUTLET.

A vacuum cleaner bag access door is hinged to the blower unit through the use of one latch. The access door is used to install and remove the vacuum cleaner bag when full or at weekly intervals. Blower unit airflow and debris enters the vacuum cleaner through the inlet fitting on the access door and passes into the bag. The suction-type airflow retains the debris in the bag while the air exits the bag through the bag's vapor port. Air is then exhausted through NPV's located on both sides of the blower unit to negate any vacuum cleaner motion produced by the exhausting airflow. The blower unit is controlled by a blower unit integral power switch located on the carrying handle. The blower unit integral power switch features a MOM ON position and an ON position for short term usage or for extended usage. The blower unit's circuit is as described for the fecal/urine collector blower unit and as depicted in figure 2.5.11-9. The vacuum cleaner interlock plunger is operative when the blower unit is utilized as a vacuum cleaner. The plunger is depressed when a vacuum cleaner bag is installed (enabling the circuit) and extended when the bag is removed (disabling the circuit) insuring against inadvertant operation of the vacuum cleaner when the vacuum cleaner bag is not in place.

The inlet adapter of the vacuum cleaner is completely removable to allow the blower unit to be interchanged with other blower units. The vacuum cleaner blower unit is identical to the fecal/urine collector blower unit and to the suit dryer blower unit (paragraph 2.5.7) and may be interchanged with each other in the event of

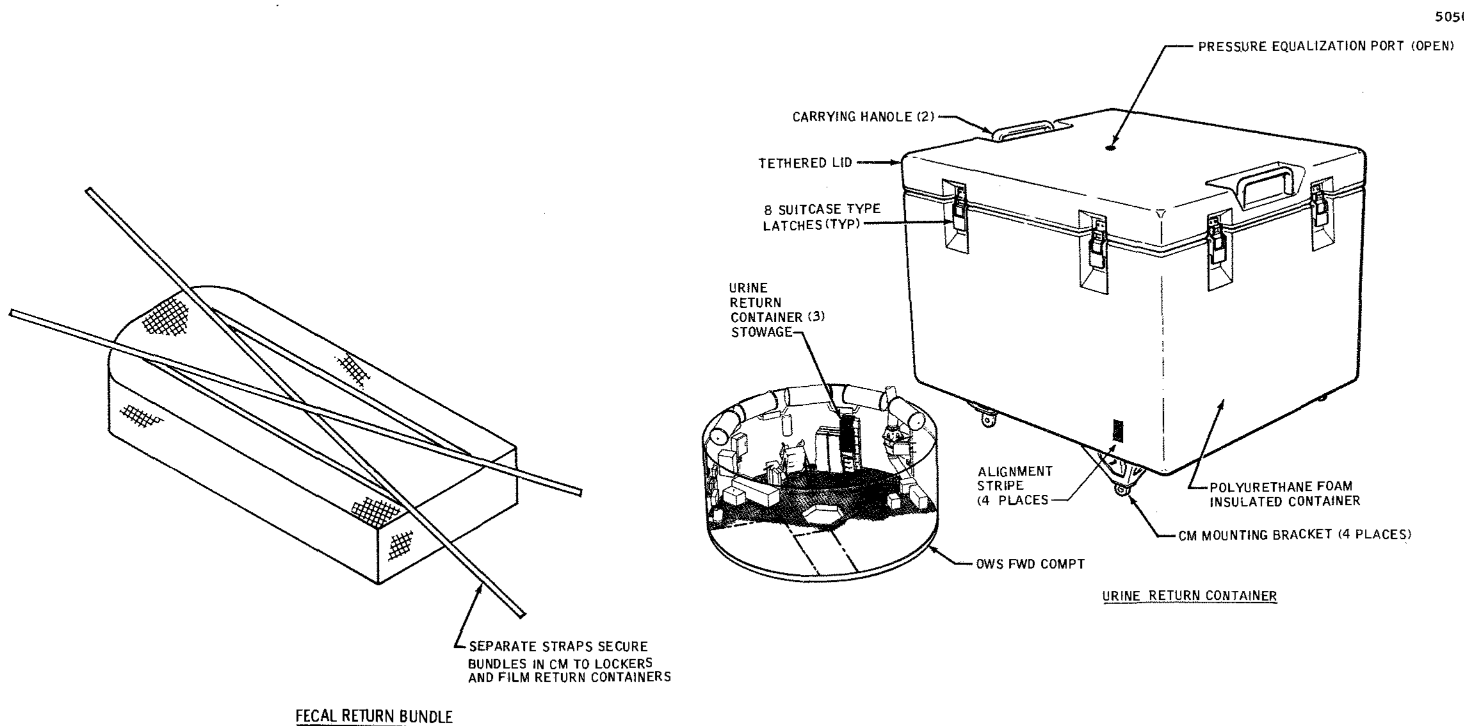



Figure 2.5.11-14 Return Containers

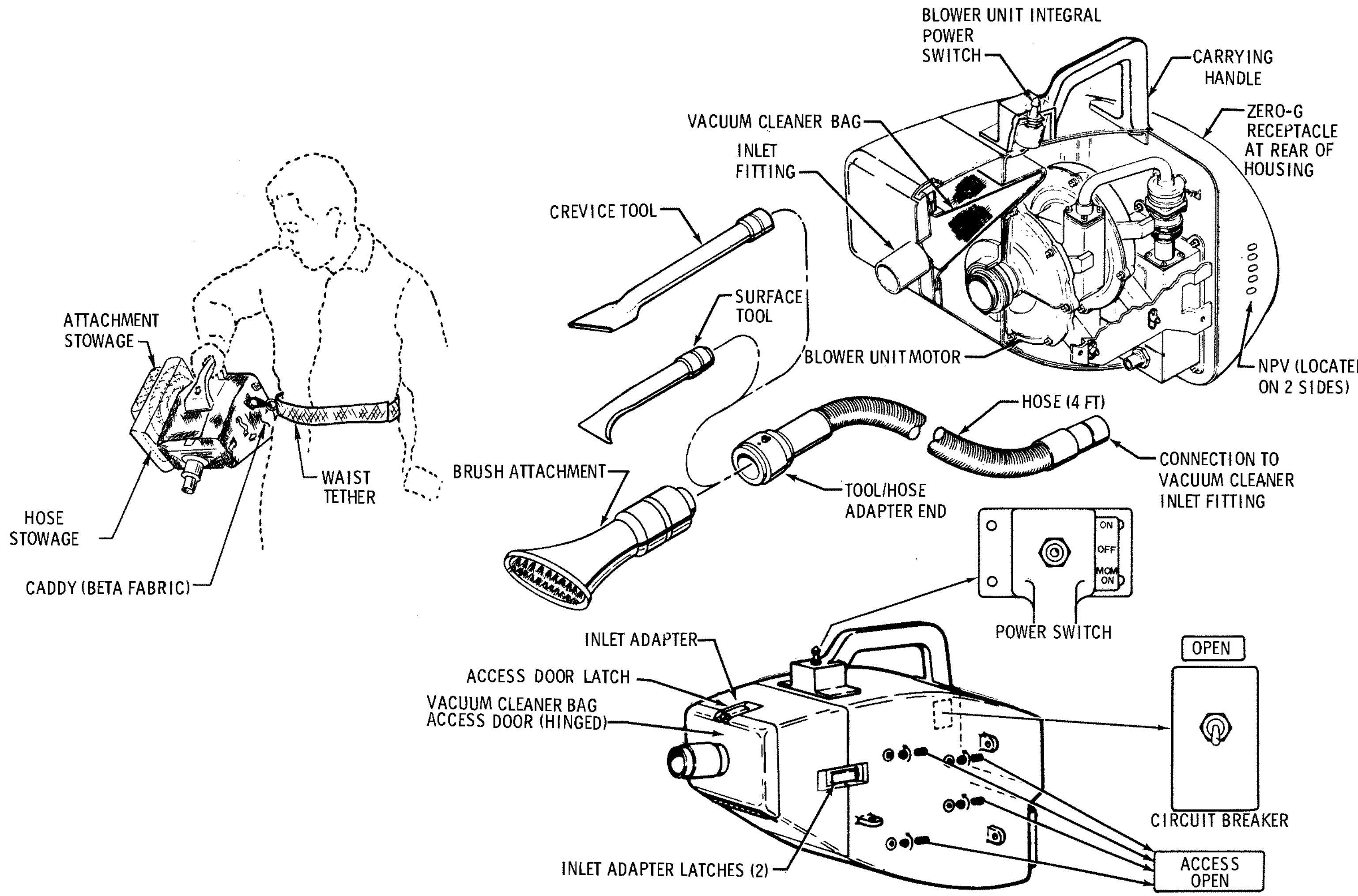



Figure 2.5.11-15 Vacuum Cleaner and Accessories

failure. Quick release mounting techniques employed on each of the 3 blower units are also identical, to facilitate portability and interchangeability. In addition, a spare blower unit is stowed in a spare parts stowage compartment in the OWS forward dome.

2.5.12 WATER SYSTEM

2.5.12.1 WATER SYSTEM PROVISIONS

The water system provided within the OWS supplies crewmembers with potable water for food reconstitution and drinking and water for personal hygiene and housekeeping. Water for these purposes is contained in water storage provisions and is distributed by water networks to water management equipment and water usage facilities (figure 2.5.12-1). Water purification equipment is provided to maintain microbiological control within the water system.

2.5.12.2 WATER STORAGE PROVISIONS

Water is stored on-orbit in water tanks (WT) located in the OWS forward compartment. A contingency supply of water is available through use of a portable water tank.

2.5.12.2.1 Water Tanks

Ten water tanks are located in the OWS forward compartment (figure 2.5.12-2); each water tank is an independent unit, launched with approximately 5700 gallons of purified water and supplied with a nitrogen gas pressurant to maintain water supply pressure. Each water tank is composed of a cylinder containing water and a sealed bellows assembly immersed in the water (figure 2.5.12-2). The sealed bellows assembly forms a N2 gas chamber, which is supplied with N2 pressurant controlled from panel 500. Water surrounds the N2 gas chamber and is provided a constant pressure during usage (bellows assembly extends as water is withdrawn from the water tank).

A pressure of 35 psig is continuously maintained in the N2 gas chamber during habitation through N2 pressure regulation (paragraph 2.4.4). When the bellows assembly has extended to the end of the water tank, depleting that tank, residual water (approximately 9 gallons) remains trapped around the bellows assembly. Hand-operated valves isolate each water tank's water chamber and N2 gas chamber from the remainder of the system.

The water tanks (WT) are identified 1 through 10 and are assigned to particular water networks: (a) WT 1, WT 2, WT 3, WT 4, WT 5, and WT 10 are assigned to the wardroom water network; (b) WT 6 is assigned to the urine system flush water network; (c) WT 7 and WT 8 are assigned to the WMC water network; and (d) WT 9 is provided as a contingency water tank in the event that additional water is required due to excessive water consumption or due to a failure of one of the water tanks (figure 2.5.12-1). A WATER OUTLET PORT quick-disconnect is located on each water tank for connecting and disconnecting water distribution lines. In use, only one water tank at a time is connected to its particular water line; the sequence of water tank usage is predetermined (figure 2.5.12-3).

In addition to the hand-operated valves used to isolate the water tank's water chamber (WATER OUTLET VALVE) and the N2 gas chamber (PRESSURIZATION VALVE), each water tank contains water tank servicing equipment to facilitate ground filling of water (using the GSE BLEED port) and to permit water purification (figure 2.5.12-4). Purity of the water is maintained by using iodine as a biocide. The water is periodically sampled on-orbit by use of the SAMPLE PORT valve. If the on-orbit sample analysis reveals a need to purify the water, iodine will be injected into the tank through the IODINE INJECTION PORT, with dissolution obtained through operation of the agitator pump.

Two water tank heater blankets are used on each water tank to maintain the water temperature at approximately 60°F during all mission phases (figure 2.5.12-4). Redundancy is provided (figure 2.5.12-5) since both bus 1 and bus 2 heater blankets will be operated simultaneously. The two control sensors on each heater blanket are remotely located on the water tank to assure proper temperature distribution throughout the water chamber. An overtemp sensor provides heater blanket control at a slightly higher water temperature in the event of a failure of one of the control sensors.

One of the water tanks will be used as a water servicing tank after it has been partially depleted. This water tank will be isolated from the water networks and subsequently used to replenish the water in the ATM C&D/EREP cooling system and in the suit cooling systems. In addition, this water tank will be used to charge the LSU's and PCU's (paragraph 2.5.7).

Water quantity, for each water tank, is available only on telemetry. This information is used not only to track water usage, but to perform water purification.

2.5.12.2.2 Portable Water Tank

One portable water tank is provided in the OWS for use as a contingency water supply in the event of a water network failure and for the wardroom water network fill, soak, and flush during SL-3 and SL-4 activation. The portable water tank is an independent and completely portable tank that accommodates a self-contained pressurization unit and a 3-gallon water supply. The portable water tank is mounted in the OWS forward compartment on a wall bracket below WT 1 and WT 2 (figure 2.5.12-2). The portable water tank is launched and stowed on-orbit in this location and may be removed for use through operation of a single quick-release fastener.

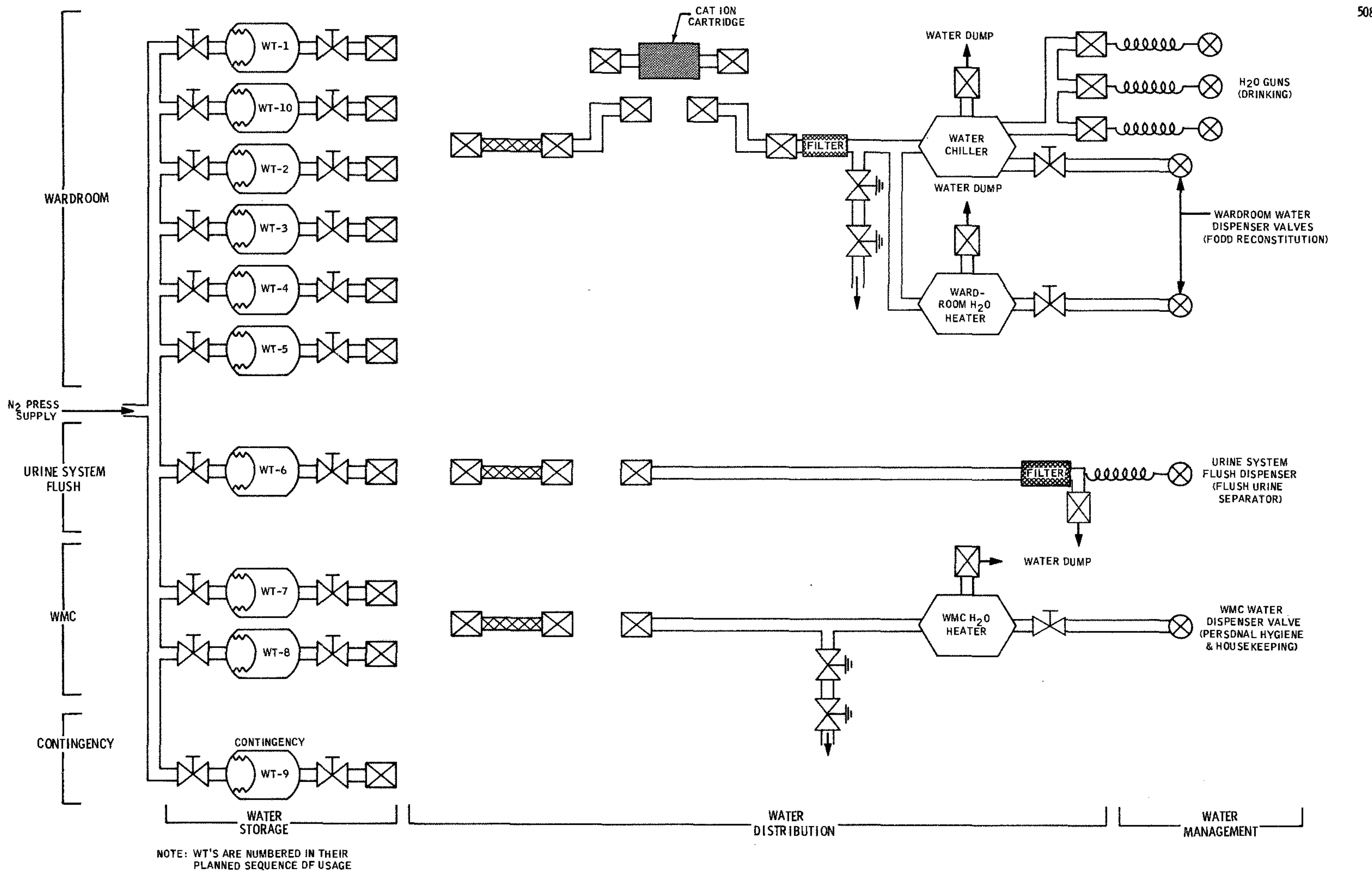



Figure 2.5.12-1 Water System -- Functional Flow

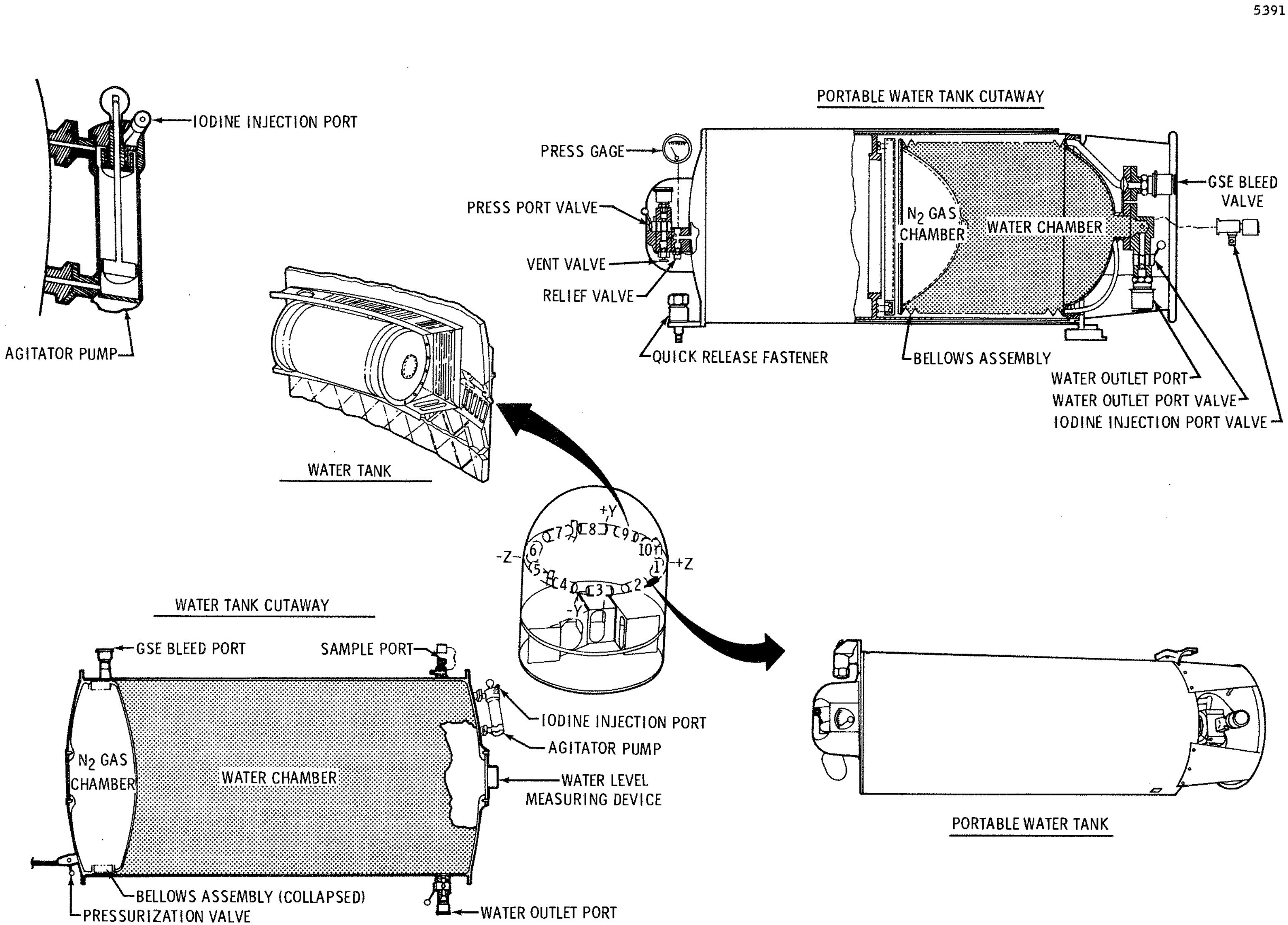



Figure 2.5.12-2 Water Storage Provisions

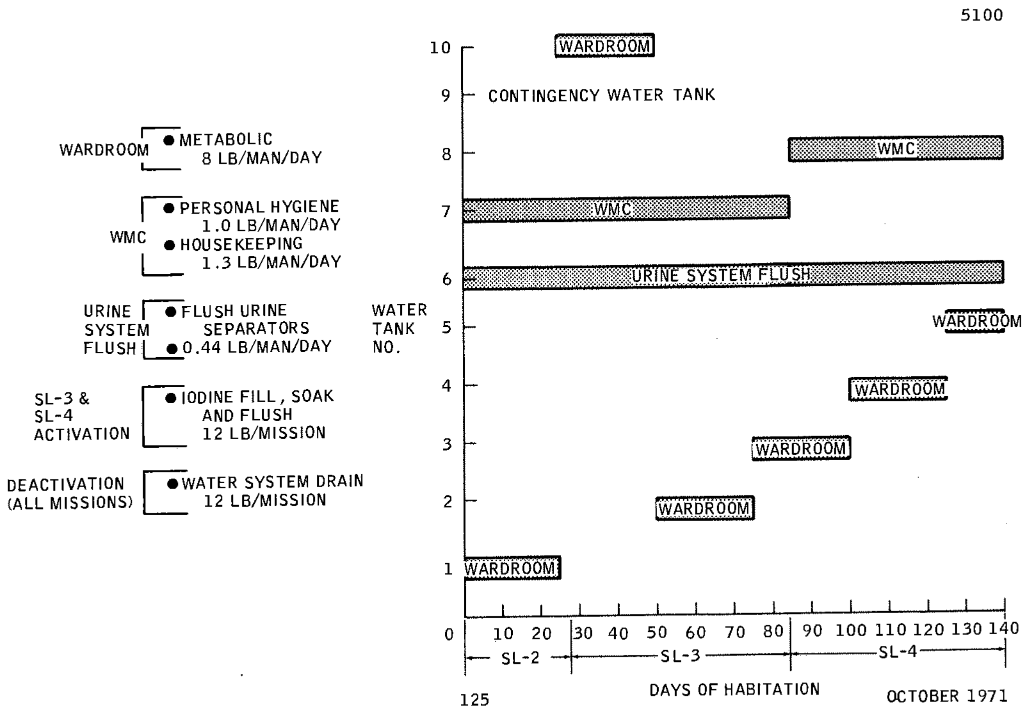
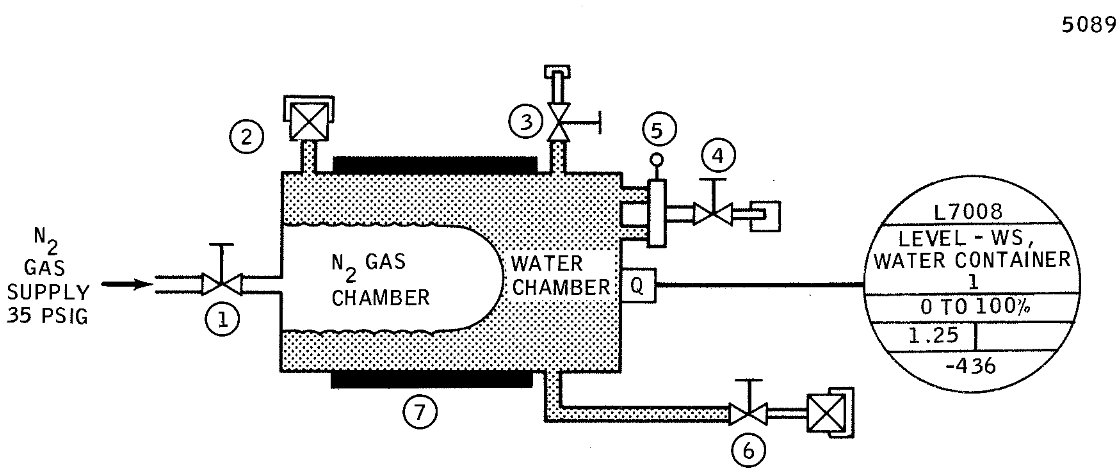



Figure 2.5.12-3 Water Tank Budget




WATER TANK SERVICING EQUIPMENT

1. PRESSURIZATION VALVE
2. GSE BLEED PORT
3. SAMPLE PORT VALVE
4. IODINE INJECTION PORT VALVE
5. AGITATOR PUMP
6. WATER OUTLET VALVE
7. HEATER BLANKET

NOTE: WT 2 THRU WT 10 ARE INSTRUMENTED BY MEASUREMENTS L7009 THRU L7017 RESPECTIVELY

Figure 2.5.12-4 Typical Water Tank -- Schematic

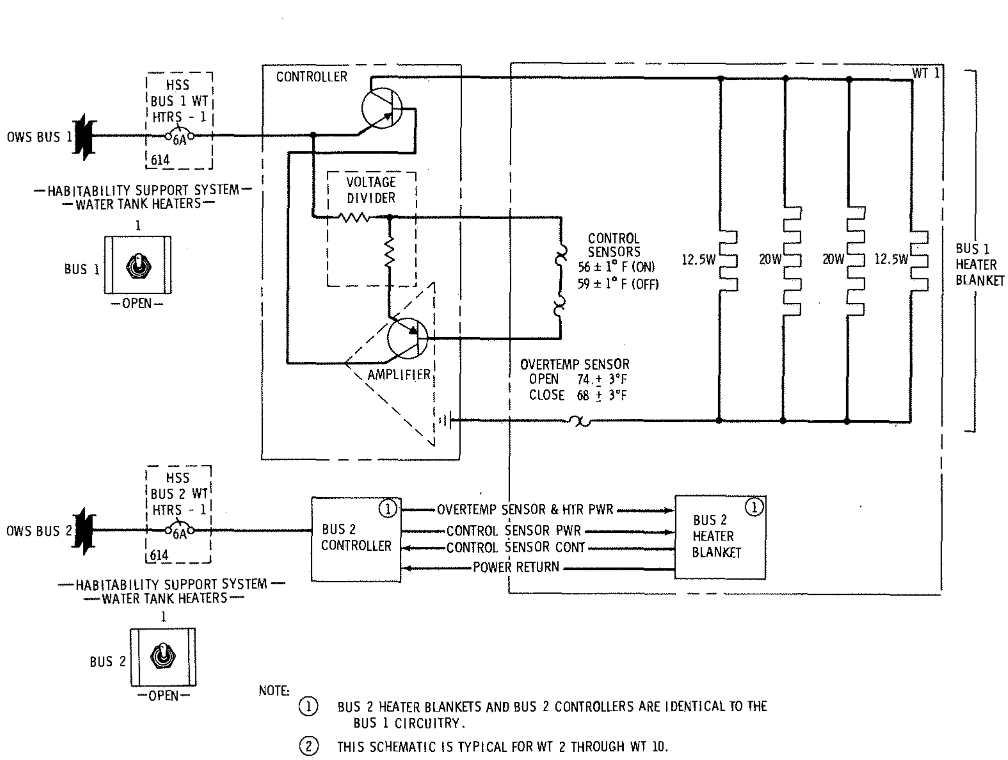



Figure 2.5.12-5 Typical Water Tank Heater Blanket -- Schematic

The portable water tank is a cylinder, housing an N2 gas chamber that surrounds a sealed bellows assembly accommodating its water supply in a water chamber (figure 2.5.12-2). The N2 gas chamber provides self-contained pressurization of the water chamber, utilizing a pre-charged volume of N2 pressurant. The N2 gas chamber pressure is monitored by the crewman on a pressure gage located on the portable water tank (figure 2.5.12-6). The N2 pre-charge is conducted prior to launch while the tank is empty. The tank is launched in this configuration and, prior to its first on-orbit use, the N2 gas volume will be vented by the crew to a lower pre-charge pressure, using the push-button vent valve. Over pressure protection for the tank is provided by an integral relief valve. The N2 gas chamber may be repressurized through the PRESSURIZATION PORT using the NITROGEN FILL hose connected to the 35 PSI N2 PORTABLE WATER TANK PRESSURIZATION connector on panel 500. The portable water tank pressurization valve contains an orifice that will permit N2 gas chamber pressurization from the 150 PSI N2 connector on panel 500, if the 35 psi port becomes inoperable. Water for the portable water tank is obtained from a water tank through use of one of the water hoses.

For use as a contingency water supply, the portable water tank may be transported near the usage area if one of the water networks fails. Location in these instances will be on the OWS forward compartment floor above either the wardroom or the WMC. The quick-release fastener on the portable water tank permits retention on any grid surface. A water hose with an appropriate dispenser is then passed through the grid into the using area. For use in the WMC, a quick-disconnect is attached to, and protrudes through, the ceiling above the WMC H2O heater, since the WMC ceiling grid is completely enclosed with a liner. A dispenser may then be connected to the ceiling-mounted quick-disconnect.

Also, upon SL-3 and SL-4 activation, the wardroom water network will be filled, soaked, and flushed with a concentrated iodine solution in water to remove microbiological contamination incurred during storage. To accomplish this, the portable water tank is filled with water from a water tank; the portable water tank is then injected with 40 units of iodine to establish a 100-ppm iodine concentration in the water. The wardroom water network is filled with this concentrated solution and allowed to soak for a 1-hour period with the portable water tank connected. At the end of the soak period, the concentrated solution and the water-iodine solution remaining in the portable water tank are flushed into the waste tank.

2.5.12.3 WATER NETWORKS

Water is distributed from the water tanks to the water management equipment through three independent and isolated water networks: wardroom water network, urine system flush water network, and WMC water network.

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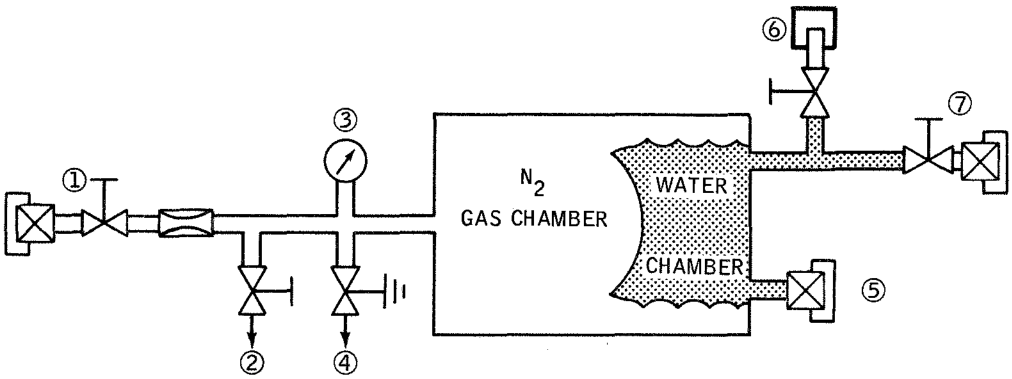


1. PRESS PORT VALVE
2. VENT VALVE ( PUSH BUTTON )
3. PRESS GAUGE (0-80 PSIG)
4. RELIEF VALVE (CRACK 51 PSIG - RESEAT 45 PSIG)
5. GSE BLEED PORT
6. IODINE INJECTION PORT VALVE
7. WATER OUTLET PORT VALVE

- LAUNCH EMPTY - $GN_2$ PRECHARGE 20 TO 25 PSIG FOR LAUNCH.
- ON ORBIT $GN_2$ PRESS EMPTY 18 TO 22 PSIG
- WATER PRESSURE FULL $35 ^{+5}_{-3.5}$ PSIG
- WATER CHAMBER CAPACITY 26 TO 27.5 LBS
- $N_2$ GAS CHAMBER VOLUME - 2225 $IN^3$ ( BELLOWS COLLAPSED )
  - 1500 $IN^3$ ( BELLOWS EXTENDED )

Figure 2.5.12-6 Portable Water Tank -- Schematic

Each water network is launched empty of water and is filled with water during each SWS activation (paragraph 2.5.14). Upon each SWS deactivation, the networks are drained and then allowed to remain exposed to the SWS atmosphere during storage. The water networks are only connected to the water tanks during habitation.

2.5.12.3.1 Wardroom Water Network

The wardroom water network supplies water tank water to the food table in the wardroom, where the water is chilled or heated (figure 2.5.12-7) for food reconstitution and drinking. The wardroom water network is composed of two water hoses, a water supply line, a cat ion cartridge, a filter, relief valves, a water heater, and a water chiller (figures 2.5.12-1 and -7).

2.5.12.3.1.1 Wardroom Water Hoses

Two flexible water hoses of different lengths (WARDROOM 1 and WARDROOM 2), with quick-disconnects, are provided (figure 2.5.12-8) to connect the desired water tank to the wardroom water supply line. The WARDROOM 1 water hose connects WT 1, WT 2, WT 3, or WT 10 to the water supply line; the WARDROOM 2 water hose is used in conjunction with the WARDROOM 1 water hose to connect WT 4 and WT 5 to the water supply line. When not in use, the water hoses are stowed on the platform foot restraint, utilizing quick-release clamps. The water hoses are used only during manned phases of the missions. During storage, the wardroom water network is exposed to the SWS atmosphere through a WARDROOM PURGE FITTING (filter) on the WARDROOM 1 and/or WARDROOM 2 water hose(2) quick-disconnect to control microbiological growth in the wardroom water network. The water hose quick-disconnects and their "O" rings are replaceable, with spares provided in the WATER SYSTEM EQUIPMENT container. A spare water hose is stowed in a spare parts stowage compartment in the OWS forward dome.

2.5.12.3.1.2 Wardroom Water Supply Line

The wardroom water supply line consists of a tubing-run from the WARDROOM WATER port quick-disconnect below WT 2, (figure 2.5.12-9) to the wardroom food table (figure 2.5.12-7). The tubing is routed down the habitation area tank wall and under the experiment compartment floor.

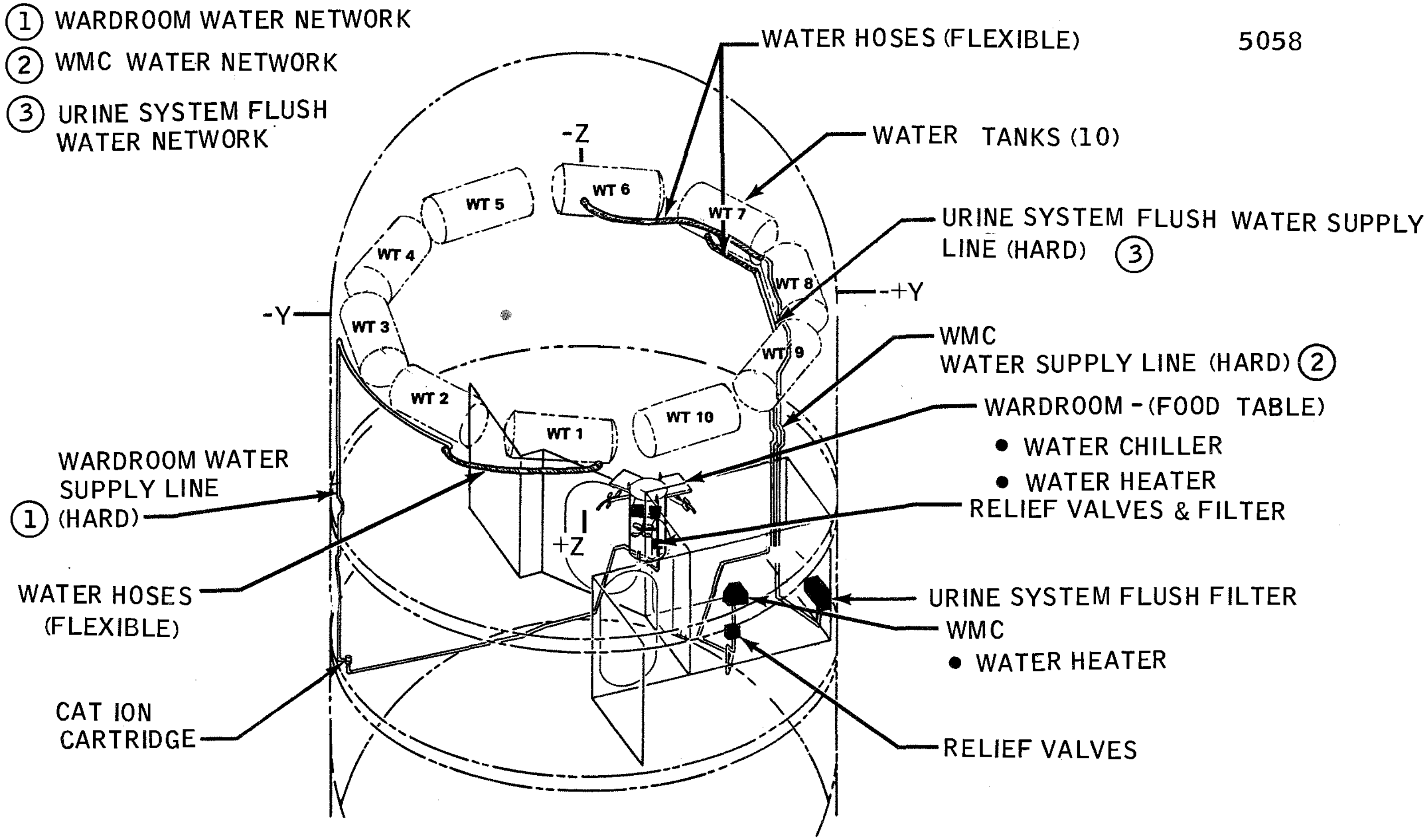


Figure 2.5.12-7 Water Distribution

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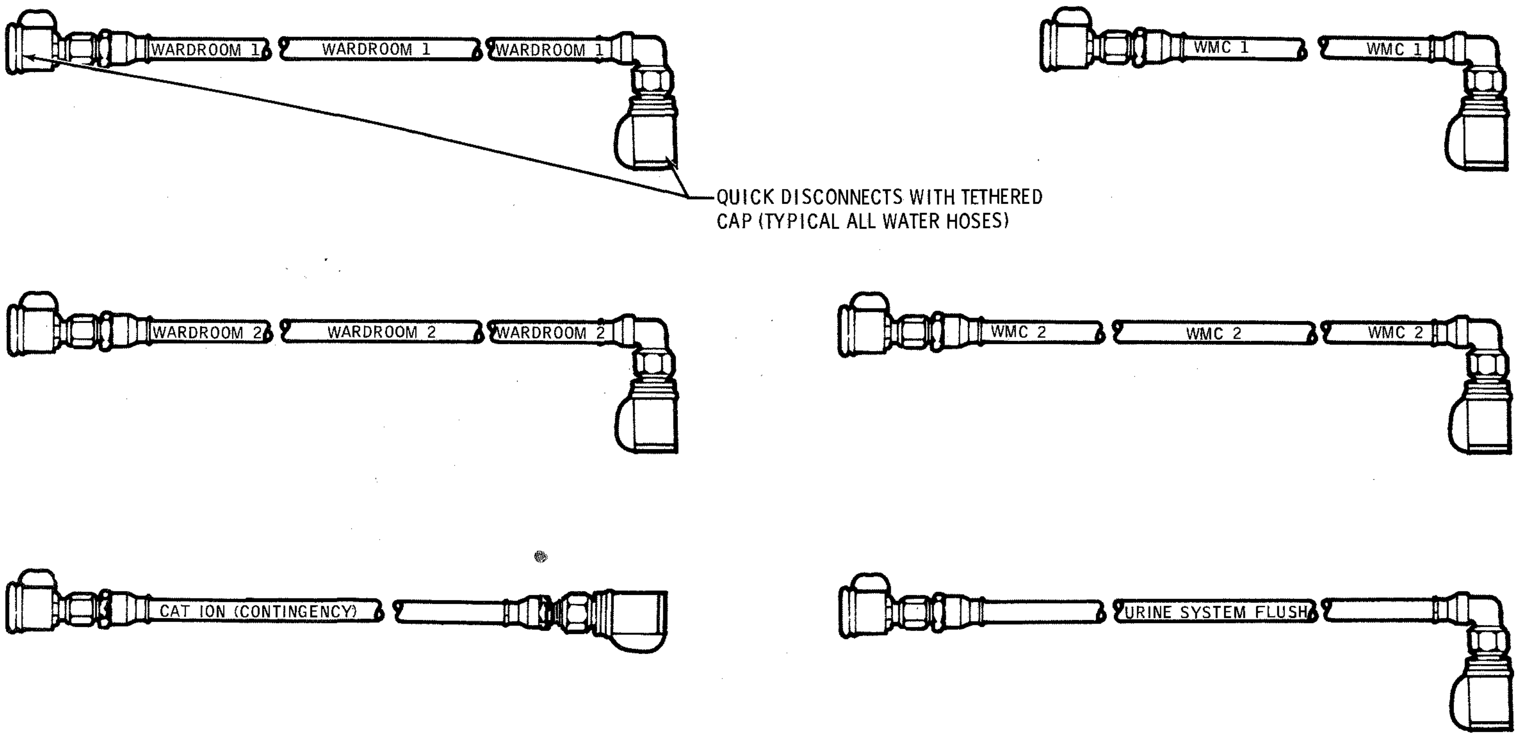


| WATER HOSE | LENGTH (IN.) | USE |
|---|---|---|
| WARDROOM 1 | 118 | WT 1, 2, 3, 4, 5, & 10 TO WARDROOM WATER PORT |
| WARDROOM 2 | 148 | WT 4&5 TO WARDROOM WATER PORT |
| WMC 1 | 28 | WT 7 TO WMC WATER PORT |
| WMC 2 | 148 | WT 8 TO WMC WATER PORT |
| CAT ION (CONTINGENCY) | 56 | CAT ION CARTRIDGE TO PORTABLE WATER TANK |
| URINE SYSTEM FLUSH | 28 | WT 6 TO URINE FLUSH WATER PORT |

Figure 2.5.12-8 Water Hose Configurations

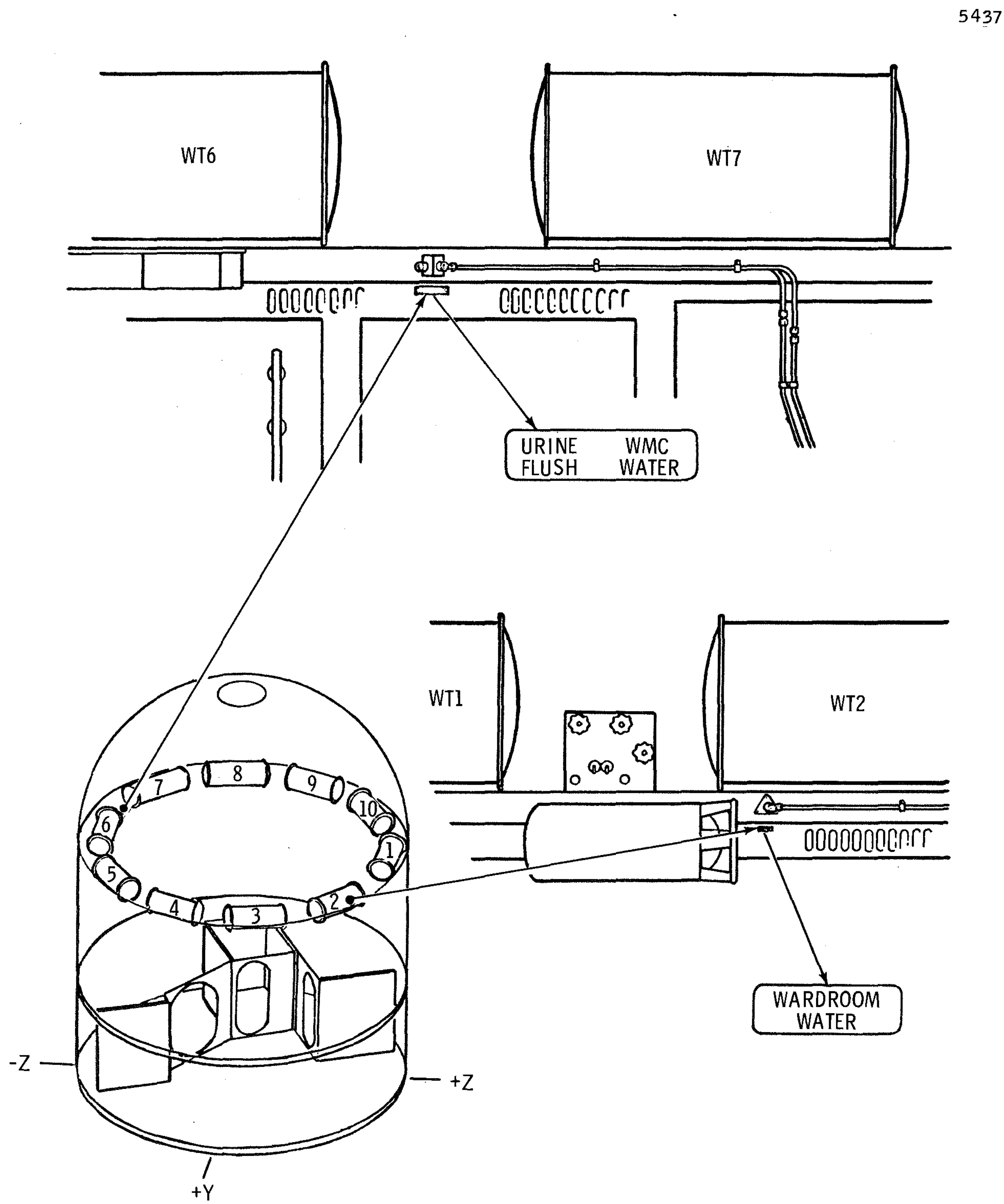


Figure 2.5.12-9 Water Port Locations

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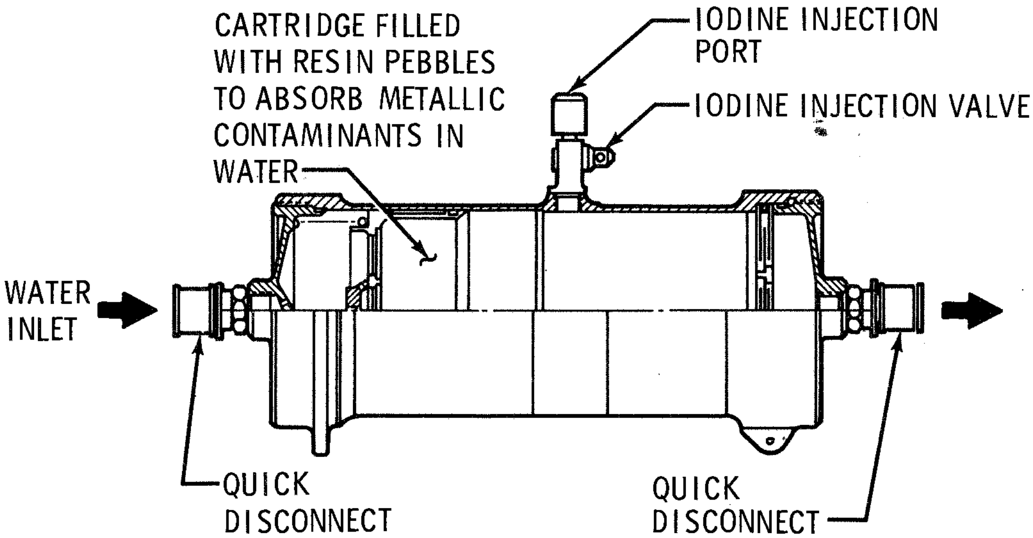



Figure 2.5.12-10 Cat Ion Cartridge

2.5.12.3.1.3 Cat Ion Cartridge

A removable cat ion cartridge (figure 2.5.12-10) is in the wardroom water network to remove metallic substances contained in the wardroom water supply which result from the reaction of the water purification biocide (iodine) with the water tank materials. The cartridge minimizes the crew intake of certain minerals and essentially "softens" the water. The cartridge, fitted with quick-disconnects, is located under the LBNP experiment (figure 2.5.12-7) and is installed with a quick-release type mount, similar to the waste management system blower unit mounts. The cartridge is connected to the wardroom water supply line during each SWS activation and is removed upon each SWS deactivation. When the cartridge is removed, the wardroom water supply line quick-disconnects are remated to maintain a flow path, allowing water network filling and draining. The cartridge is launch-charged with a water/iodine solution; upon each SWS deactivation, the biocide concentration is maintained by the injection of iodine through its iodine injection port into the cartridge (figure 2.5.12-10).

If the wardroom water network fails, the cartridge will be used with the portable water tank to continue support of wardroom functions. A quick-release mount, installed under the water tank foot restraint between WT 1 and WT 2, holds the cartridge for contingency use. Using a wardroom water hose, the cartridge is attached to a water tank and connected to the portable water tank with the CAT ION (CONTINGENCY) water hose. The portable water tank is then filled with water that has been "softened" by the cartridge. The portable water tank is then located above the wardroom for use. The cartridge is used only for wardroom water supply.

2.5.12.3.1.4 Wardroom Water Network Filter

The wardroom water network filter is upstream of the water chiller and water heater in the food table (figures 2.5.12-1 and -7). The filter screens out small particles, which may clog dispensers and interfere with the thermal conditioning of the water.

2.5.12.1.3.5 Wardroom Water Network Relief Valves

The wardroom water network relief valves, located in the food table upstream of the water chiller and water heater (figures 2.5.12-1 and -7), are installed in series and set at the same pressure. The relief valves will maintain a water supply pressure at a maximum of 58 psig in the event of an overpressurization. The relief valves vent directly into the interior of the food table pedestal.

2.5.12.3.1.6 Wardroom H2O Heater

The wardroom H2O heater, located in the food table, is made accessible to the crewman by a hinged panel on the food table pedestal. The heater heats and stores water for the hot wardroom water dispenser valve (figure 2.5.12-11). A strip heater surrounding the reservoir maintains water in a heated state within the water heater. A control sensor is provided for water temperature control (figure 2.5.12-12). In addition, a water overtemp sensor will maintain the water slightly above the nominal using temperature is a water overtemperature condition occurs. If the water heater is inadvertently operated while empty of water, the heater overtemp sensor will detect the overheating of the water heater reservoir and will cycle the strip heater on and off to limit reservoir wall temperatures to 300°F. The HSS WARDROOM H2O HTR circuit breaker is closed after water system activation and opened prior to water system deactivation.

A WATER HEATER OUTLET VALVE, located on the heater's water outlet port, allows the water heater to be isolated from the hot wardroom water dispenser valve. A WATER HEATER DUMP PORT on the heater, fitted with a quick-disconnect, mates with one of two water dump vacuum lines stowed nearby. The wardroom H2O heater, along with the entire wardroom water network is filled and drained using the vacuum provision subsystem wardroom water dump during each SWS activation and deactivation (paragraph 2.5.14).

2.5.12.3.1.7 Water Chiller

The water chiller, located in the food table, is made accessible to the crewman by means of a hinged panel on the food table pedestal. The water chiller supplies chilled water to the cold wardroom water dispenser valve and H2O guns (figure 2.5.12-13). Water entering the water chiller is cooled in a fin-lined reservoir, which uses refrigeration subsystem primary and secondary coolant to refrigerate the water. The water in the reservoir is protected from freezing by the refrigeration subsystem coolant loop logic unit, which monitors water chiller coolant inlet temperature. If the coolant inlet temperature becomes less than 33°F, the logic unit will automatically turn on the active loop's CHILLER LOW indicator on panel 616 while simultaneously switching to the backup coolant loop (figure 2.5.12-14). An RS DISPLAY SELECT 2 selector and RS temperature gage on panel 616 permits onboard monitoring of the water chiller's coolant inlet temperatures.

The chilled water is routed to a WATER CHILLER OUTLET VALVE to supply the cold wardroom water dispenser valve (figure 2.5.12-14). The water outlet valve is used to isolate the water chiller from the dispenser, facilitating dispenser removal and replacement. Chilled water is also routed to three quick-disconnects that supply water to the H2O guns. One of the H2O gun supply lines contains a WATER CHILLER SAMPLE PORT and valve to permit sampling of chiller water in determination of the biocide degradation from the water tank to the water management equipment.

A WATER CHILLER DUMP PORT, located on the reservoir, is fitted with a quick-disconnect that mates with one of two water dump vacuum lines stowed nearby. The water chiller and the entire wardroom water network are filled and drained, using the vacuum provision subsystem wardroom water dump, during each SWS activation and deactivation (paragraph 2.5.14).

2.5.12.3.2 Urine System Flush Water Network

The urine system flush water network supplies water tank water to the water management (urine system flush) equipment located in the WMC corner stowage compartment. This equipment is used to flush residual urine from the urine separators in the fecal/urine collector, thus minimizing cross-contamination of the crewman's daily urine pool with the previous day's trapped urine. The urine system flush water network is composed of a water hose, a water supply line, and a filter (figures 2.5.12-1 and -7).

2.5.12.3.2.1 Urine System Flush Water Hose

One flexible URINE SYSTEM FLUSH water hose, with quick-disconnects, connects WT 6 to the urine system flush water supply line (figure 2.5.12-8). When not in use, the water hose is stowed on the platform foot restraint utilizing quick-release clamps. The water hose is connected during each SWS activation and is disconnected during each SWS deactivation. During storage, the urine system flush water network is exposed to the SWS atmosphere through installation of a URINE SYSTEM FLUSH PURGE FITTING (filter) on the water hose quick-disconnect; this controls microbiological growth in the urine system flush water network. The water hose quick-disconnects and their "O" rings are replaceable, with spares provided in the WATER SYSTEM EQUIPMENT container. A spare water hose is stowed in a spare parts stowage compartment in the OWS forward dome.

2.5.12.3.2.2 Urine System Flush Water Supply Line

The urine system flush water supply line consists of a tubing-run from the URINE FLUSH water port quick-disconnect between WT 6 and WT 7, (figure 2.5.12-9) to the WMC corner stowage cabinet (urine dump equipment) (figure 2.5.12-7). The tubing is routed down the habitation area tank wall and under the WMC floor. The URINE FLUSH WATER port quick-disconnect attaches the URINE SYSTEM FLUSH water hose for water network operation.

2.5.12.3.2.3 Urine System Flush Water Network Filter

The urine system flush water network filter is located in the WMC corner stowage cabinet upstream of the urine system flush dispenser (figures 2.5.12-1 and -7). The filter screens out small particles that may interfere with the operation of the dispenser. The line between the filter and the dispenser contains a water dump port quick-disconnect that mates with the URINE SYSTEM FLUSH DUMP hose for filling and draining of the urine system flush water network during each SWS activation and deactivation (paragraph 2.5.14).

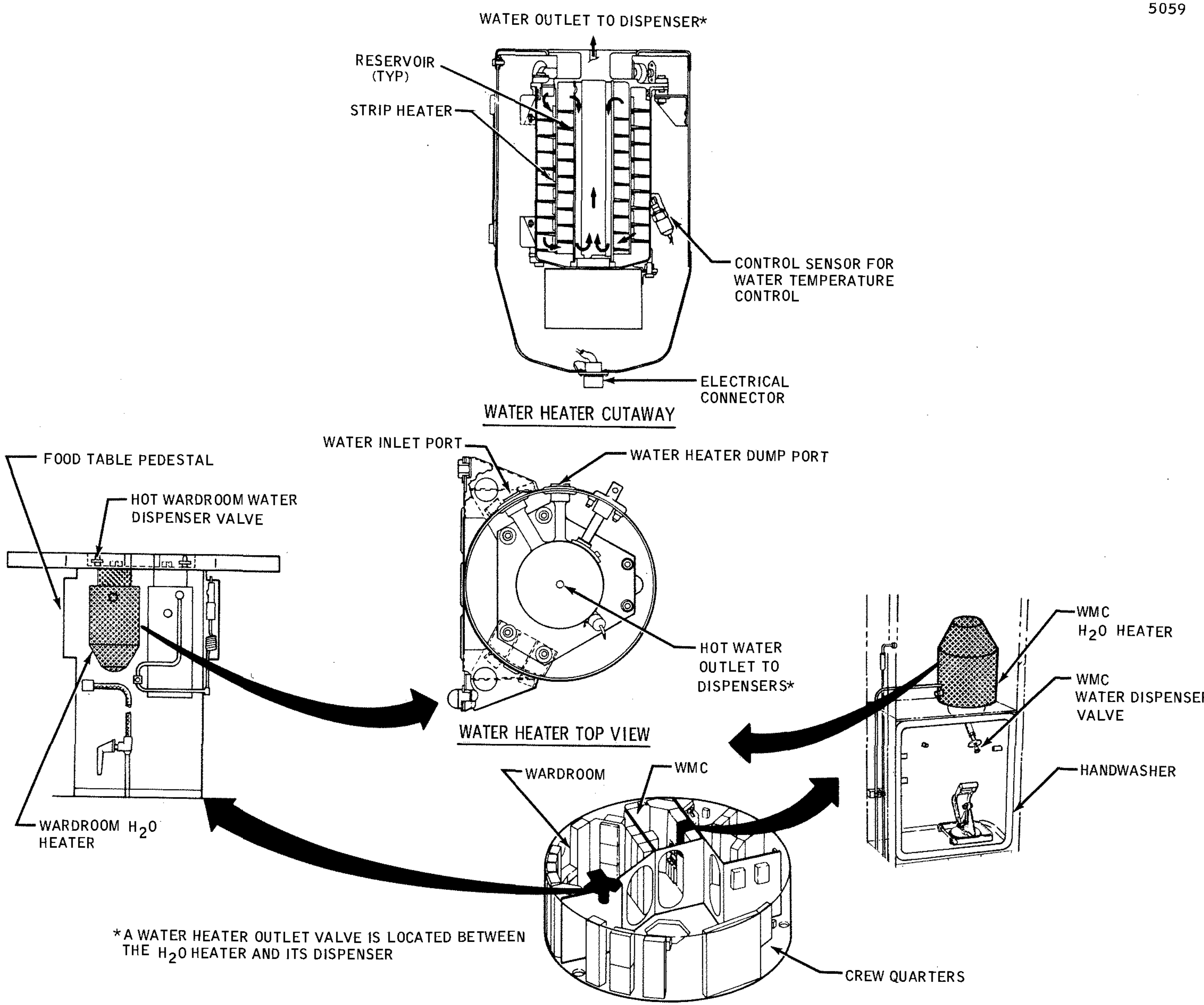
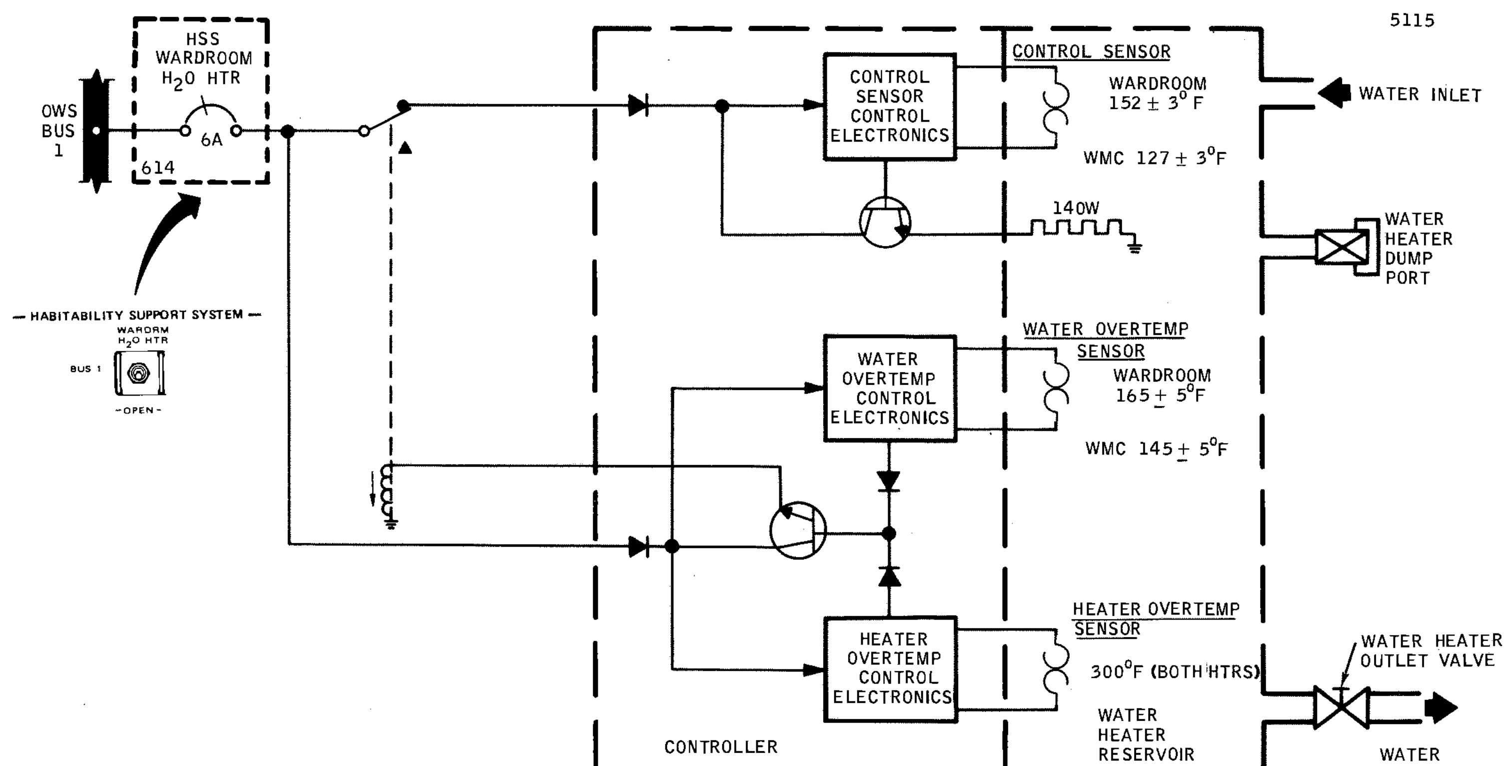



Figure 2.5.12-11 Wardroom and WMC H2O Heaters




NOTE: THE ABOVE CIRCUITRY IS TYPICAL FOR THE WMC $H_2O$ HEATER WITH THE NOTED VALUES.
THE SINGLE EXCEPTION IS THAT THE WMC $H_2O$ HEATER IS POWERED FROM <u>OWS BUS 2</u> THROUGH A SEPERATE 6 AMP CIRCUIT BREAKER

Figure 2.5.12-12 Water Heater -- Functional Diagram

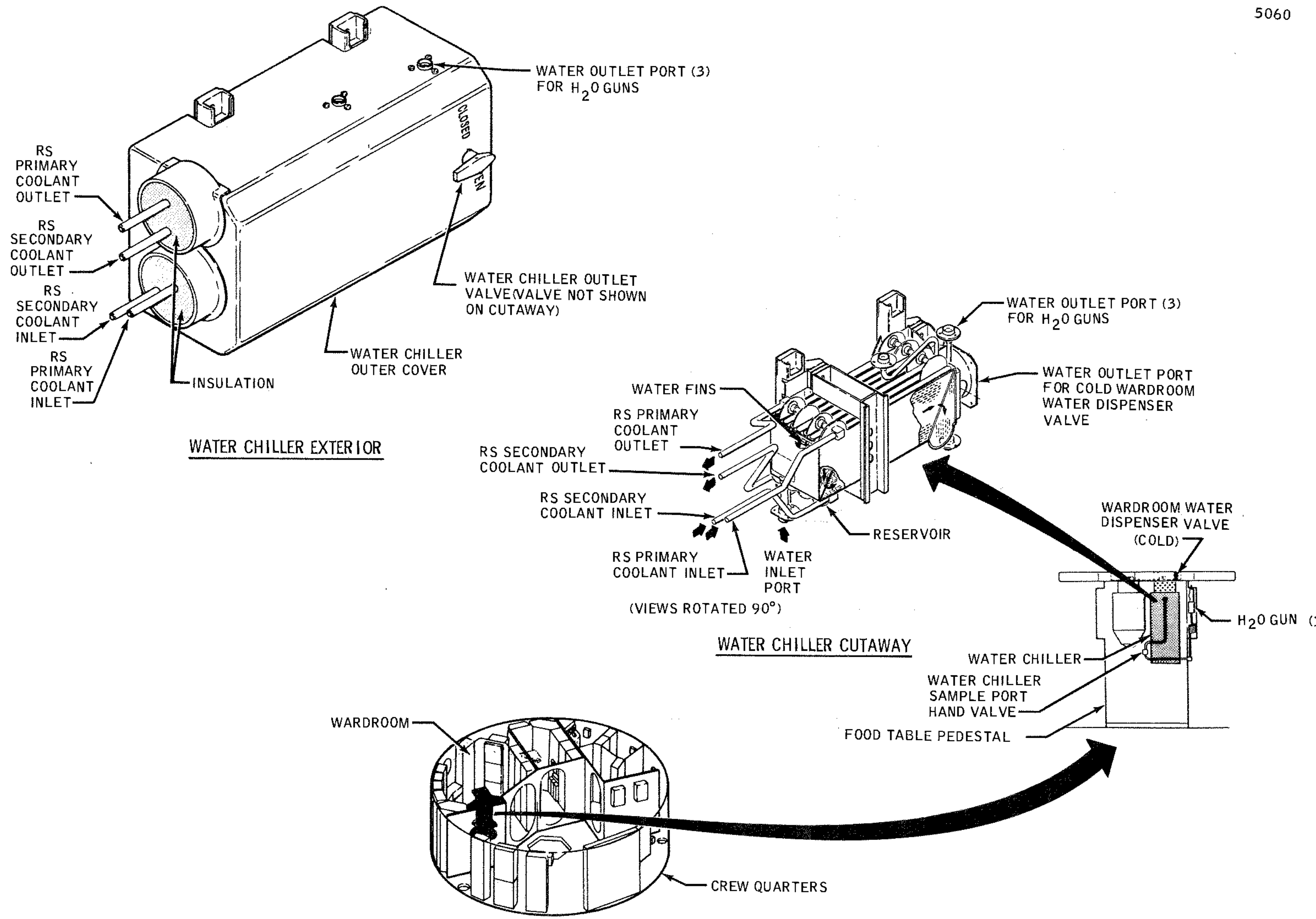



Figure 2.5.12-13 Water Chiller

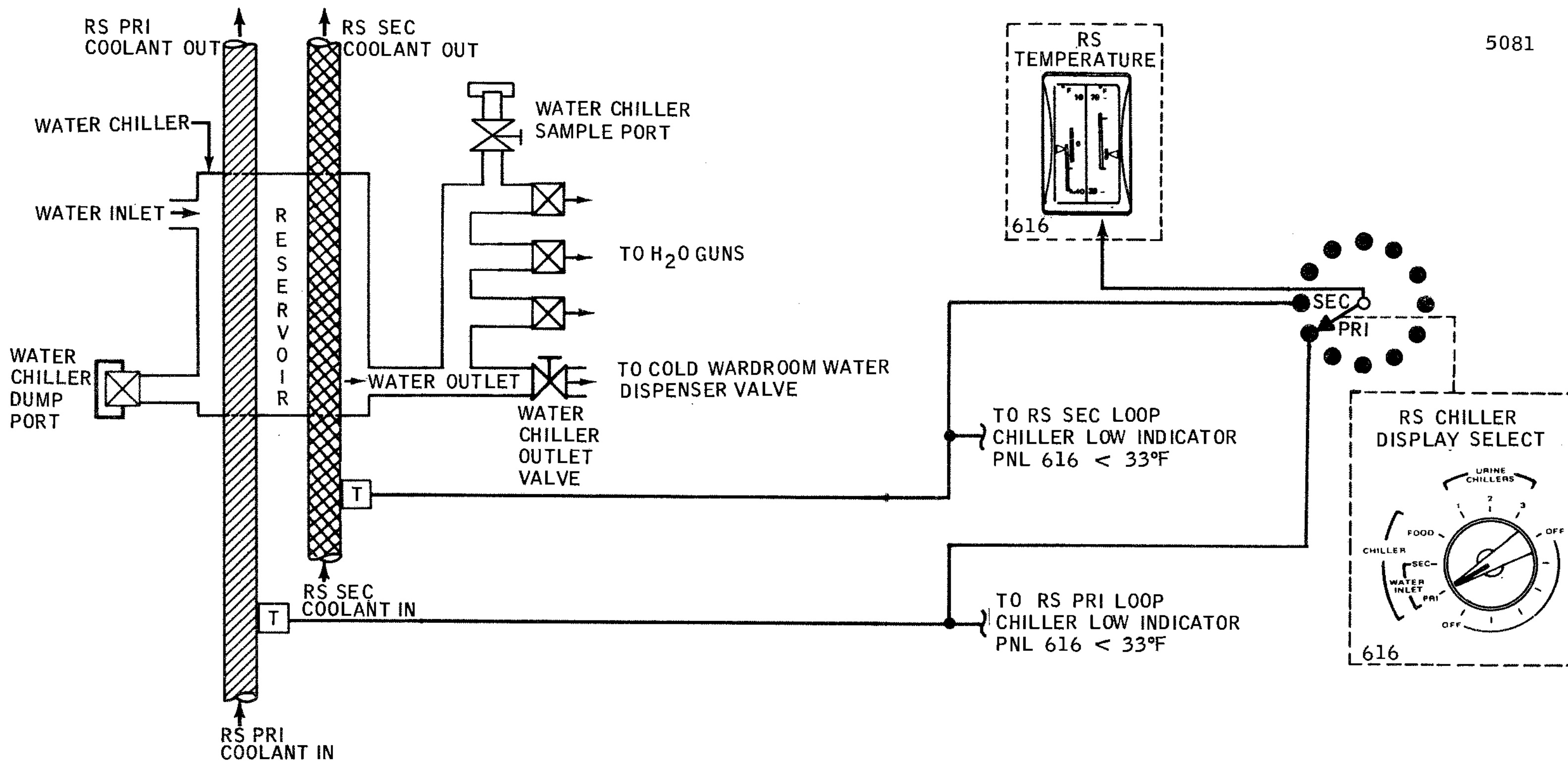



Figure 2.5.12-14 Water Chiller -- Functional Diagram

2.5.12.3.3 WMC Water Network

The WMC water network supplies water tank water to the water heater in the WMC, where the water is heated and routed to a dispenser for body cleansing and housekeeping purposes. The WMC water network is composed of two water hoses, a water supply line, relief valves, and a water heater (figures 2.5.12-1 and -7).

2.5.12.3.3.1 WMC Water Hoses

Two flexible water hoses of different lengths (WMC 1 and WMC 2) with quick-disconnects connect the desired water tank to the WMC water supply line. The WMC 1 water hose connects WT 7 to the WMC water supply line, and the WMC 2 water hose connects WT 8 to the WMC water supply line. When not in use, the water hoses are stowed on the platform foot restraint, utilizing quick-release clamps. A water hose is connected to the desired water tank upon each SWS activation and is removed upon each SWS deactivation. During storage, the WMC water network is exposed to the SWS atmosphere, through installation of a WMC PURGE FITTING (filter) on the water hose quick-disconnect, to control microbiological growth in the WMC water network. The water hose quick-disconnects and their "O" rings are replaceable with spares provided in the WATER SYSTEM EQUIPMENT container. A spare water hose is stowed in a spare parts stowage compartment in the OWS forward dome.

2.5.12.3.3.2 WMC Water Supply Line

The WMC water supply line consists of a tubing-run from the WMC WATER port quick-disconnect between WT 6 and WT 7 (figure 2.5.12-9), to the water heater in the WMC. The tubing is routed down the habitation area tank wall and under the wardroom and WMC floor (figure 2.5.12-7). The quick-disconnect between WT 6 and WT 7 is used to attach a WMC water hose for water network operation.

2.5.12.3.3.3 WMC Water Network Relief Valves

The relief valves in the WMC water network are located below the handwasher in the WMC and upstream of the WMC H2O heater (figures 2.5.12-1 and -7). The two relief valves, installed in series and set at the same pressure, will maintain a water supply pressure at a maximum of 58 psig in the event of an overpressurization. The relief valves vent directly into the interior of the stowage compartment below the handwasher.

2.5.12.3.3.4 WMC H2O Heater

The WMC H2O heater is located in a stowage compartment above the handwasher in the WMC (figure 2.5.12-11). Access to the heater is gained through a hinged door. The WMC H2O heater supplies hot water for body cleansing and housekeeping purposes through use of the WMC water dispenser valve. Temperature control is described in paragraph 2.5.12.3.1.6 and depicted in figure 2.5.12-12. The WMC H2O heater is identical to the wardroom H2O heater except for the temperature settings on the heater. The HSS WMC H2O HTR circuit breaker is closed after water system activation and opened prior to water system deactivation.

A WATER HEATER OUTLET VALVE is located on the water heater's water outlet port and permits WMC water network isolation from the WMC water dispenser valve (figure 2.5.12-12). A WATER HEATER DUMP PORT on the heater is fitted with a quick-disconnect that mates with a water dump vacuum line stowed nearby. The WMC H2O heater and its entire water network are filled and drained utilizing the vacuum provision subsystem WMC water dump during each SWS activation and deactivation (paragraph 2.5.14).

2.5.12.4 WATER MANAGEMENT EQUIPMENT

Water supplied by each of the water networks is used through the water management equipment water dispensers. Water dispensers include: (1) wardroom water dispenser valves and H2O guns (wardroom water network), (2) a urine system flush dispenser (urine system flush water network), and (3) a WMC water dispenser valve (WMC water network).

All of the dispensers are launched empty of water. Upon each SWS activation after water system activation, the dispensers are bled to remove trapped air; upon each SWS deactivation after water system deactivation, the dispensers are bled to remove trapped water (paragraph 2.5.12.5.2).

2.5.12.4.1 Wardroom Water Dispenser Valves

The wardroom water network supplies water to two wardroom water dispenser valves (figure 2.5.12-15), one cold and one hot, for reconstituting dehydrated foods and beverages. Each is located on the upper surface of the food table within easy reach of each crewmember. The water chiller, mounted in the food table pedestal, provides chilled water to the cold wardroom water dispenser valve; the internal table-mounted water heater supplies hot water to the hot wardroom water dispenser valve. Insulated lengths of tubing connect the dispensers to their respective source to provide food and beverage reconstitution at near chiller/heater temperatures. Each dispenser interfaces with a food can or beverage pack at its reconstitution port. Each dispenser provides the amount of water designated on the food can or beverage pack.

The wardroom water dispenser valves are charged, using the volume selector to select the desired water quantity on the selector scale displayed on the table's surface (figures 2.5.12-15 and -16). The crewman rotates the charge/dispense selector to CHARGE, to fill the dispenser's accumulator with the selected volume of water. The crewman may view the charging process by observing the movement of the piston position indicator on the dispenser. The food can or beverage pack's reconstitution port is then placed over the dispense port. Discharge

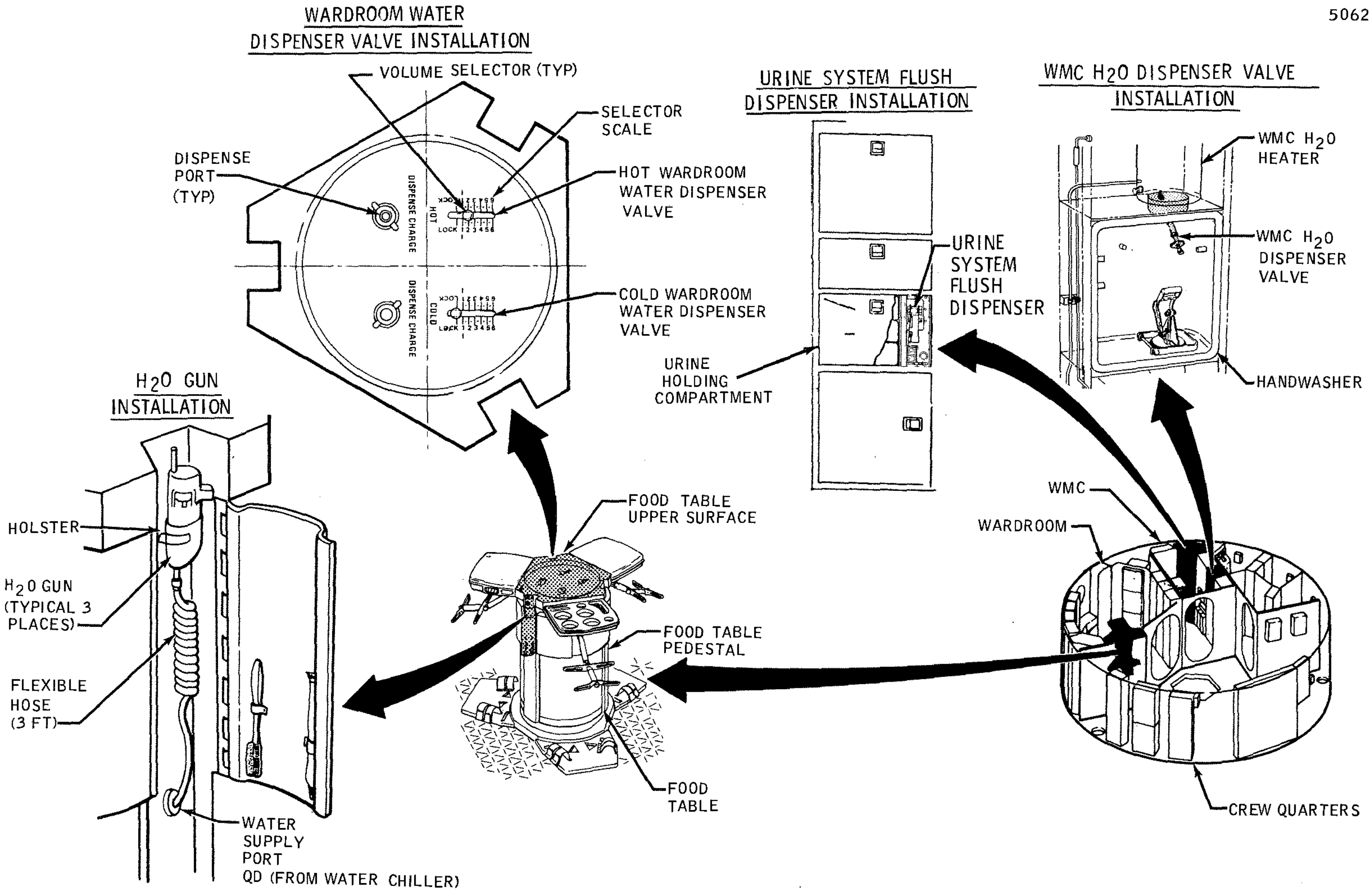



Figure 2.5.12-15 Water Management Dispensers -- Installation

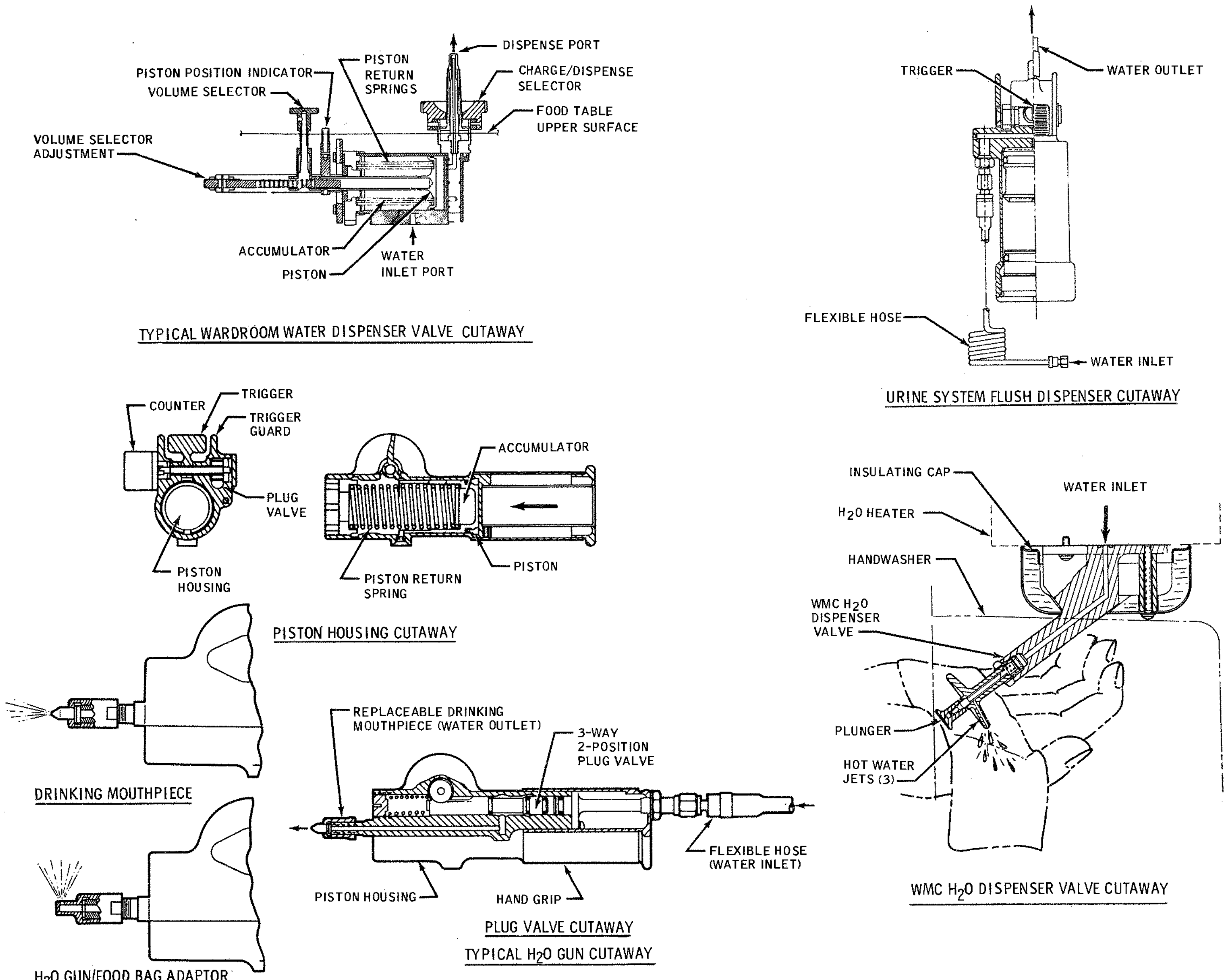



Figure 2.5.12-16 Water Management Dispensers

of the water into the food can or beverage pack is accomplished by setting the charge/dispense selector to DISPENSE and depressing the dispense port inward. The discharge cycle may be verified by the crewman by again observing the movement of the piston position indicator on the dispenser.

The wardroom water dispenser valves are removable to facilitate replacement. One spare is provided in the WATER SYSTEM EQUIPMENT container.

2.5.12.4.2 H2O Guns

Three H2O GUNS (figure 2.5.12-15) for drinking purposes are supplied water from the wardroom water network. They are located on the food table pedestal, adjacent to each eating station, to provide a convenient and separate drinking device for each crewmember. Chilled water is supplied to each gun from the water chiller located in the food table pedestal. Each H2O gun is stored in a separate holster around the periphery of the food table's pedestal and is connected to the water chiller by a coiled, flexible hose and a quick-disconnect. The H2O guns are fitted with replaceable drinking mouth-pieces, with spares stowed in the WATER SYSTEM EQUIPMENT container and identified as H2O GUN RESUPPLY provisions. The H2O gun discharges chilled water in small, drinkable quantities through operation of a trigger mounted on the H2O gun's handgrip (figure 2.5.12-16). Actuation of the trigger allows a fixed quantity of chilled water to be charged into the gun's accumulator. Immediately following charging, the cycle continues uninterrupted into a discharge mode that expels the accumulator water through the mouthpiece.

Each crewmember will use a personal drinking mouthpiece and will use his designated (color coded) H2O gun to facilitate water management through use of a three-digit counter mounted on the gun's handgrip. The counter maintains a continual record of the number of H2O gun actuations. To provide metabolic experimentation data, each crewmember will enter in the log book the total number of H2O gun actuations during a 24-hour period. The counter will record up to 999 cycles and will be periodically reset to zero.

The H2O guns also provide backup capability to the cold wardroom water dispenser valve. An H2O GUN/FOOD BAG ADAPTER, provided in the WATER SYSTEM EQUIPMENT container, will interchange with the drinking mouthpieces on the H2O guns, thus allowing reconstitution of food or beverages with chilled water (figure 2.5.12-16). The H2O guns are then trigger-operated to obtain reconstitution water in 1/2-ounce increments. The H2O GUN/FOOD BAG ADAPTER is only used with the food or beverage reconstitution ports; therefore, it will be necessary to reinstall the drinking mouthpiece to permit drinking. Each H2O gun's flexible hose is fitted with a quick-disconnect at the hose/table interface (figure 2.5.12-15). If an H2O gun fails, one spare and its flexible hose may be obtained from the WATER SYSTEM EQUIPMENT container. A PORT TANK/H2O GUN ADAPTER is also provided in the WATER SYSTEM EQUIPMENT container to permit installation of an H2O gun onto the portable water tank.

Each H2O gun is restrained for launch by a clamp with two bolts. The launch restraints will be removed by the SL-2 crew upon SWS activation.

2.5.12.4.3 Urine System Flush Dispenser

One urine system flush dispenser is used to flush the urine separators in the fecal/urine collector. The dispenser is located in a recess adjacent to the three-tiered urine dump equipment in the WMC (figure 2.5.12-15) for convenient access. The urine separators are water-flushed daily with the dispenser to preclude cross-contamination of the day's urine pool with the previous day's urine pool. Actuation of the urine system flush dispenser trigger ejects a fixed volume of water (figure 2.5.12-16). Four trigger actuations are sufficient to decontaminate each urine separator. A coiled, flexible hose provides efficient stowage and a large radius of operation.

The urine system flush dispenser is restrained for launch by a clamp with two bolts. The launch restraints will be removed by the SL-2 crew upon SWS activation.

2.5.12.4.4 WMC H2O Dispenser Valve

The WMC water network supplies water to a WMC H2O dispenser valve located in the handwasher (figure 2.5.12-15). The dispenser is provided hot water from the WMC H2O heater to allow partial body cleansing and housekeeping. The dispenser contains a plunger which, when depressed, expels three jets of water in a continuous stream into the crewman's hand (figure 2.5.12-16). The water temperature at the hot water jets is maintained at near-heater temperature by a foam-insulating cap at the WMC H2O heater's base and by foam insulation around the major portion of the dispenser. The dispenser's shaft and plunger protrude through the top of the handwasher into its interior for ready accessibility.

The WMC H2O dispenser valve is removable, with one spare provided in the WATER SYSTEM EQUIPMENT container.

2.5.12.5 WATER USAGE FACILITIES

The water usage facilities consist of: (1) a partial body cleansing facility for crewman personal hygiene maintenance, and (2) water bleeding provisions to allow removal of trapped air and water from water management dispensers.

2.5.12.5.1 Partial Body Cleansing Facility

A partial body cleansing facility is provided in the form of a handwasher. The handwasher is located in the WMC and is provided with a supply of hot water from the WMC H2O dispenser valve to allow partial body cleansing and housekeeping.

The handwasher is a metallic box, opening into the WMC to permit access to handwasher-mounted equipment (figure 2.5.12-17). The equipment consists of soap holders, a squeezer, a handrail, and a squeezer bag. The WMC H2O dispenser valve protrudes through the top of the handwasher to provide a convenient hot water supply. A pair of light-duty foot restraints, located below the handwasher on the WMC floor, restrains the crewman during personal hygiene activities at the handwasher (paragraph 2.5.3).

Four magnetic soap holders are located in the handwasher to retain the soap, each of which contains a metallic insert (figure 2.5.12-17).

The squeezer is a hand-operated unit that permits the crewmember to compress a washcloth, thereby removing excess water from the washcloth (figure 2.5.12-17). The squeezer's operating handle, when rotated toward the crewman, drives a piston down into the washcloth squeezing area, compressing the cloth and removing the water. The squeezer is fitted with a latch and a hinge to permit crewman access to the washcloth squeezing area. The washcloth is inserted into the washcloth squeezing area, and the squeezer is latched shut. The crewman than rotates the operating handle while restraining himself with the handwasher-mounted handrail. The water entrained in the washcloth is forced out by piston action, and is directed into a squeezer bag located underneath the squeezer. When the operating handle is released, the flapper valve mounted in the piston opens and allows cabin air to enter the washcloth squeezing area to cause piston return. The flapper valve and the piston seal are replaceable, with spares provided in a spare parts stowage compartment in the OWS forward dome.

A squeezer bag is held firmly in place utilizing a squeezer-mounted dog-ear latch, which, when rotated, forms a watertight seal against the squeezer bag inlet and permits easy replacement of the squeezer bag. The squeezer bag collects all squeezed water in the bag and retains it through the use of a check valve installed on the squeezer bag inlet (figure 2.5.12-17). Biocide tablets, located in the squeezer bag (figure 2.5.12-17), deactivate the water/soap solution entering the squeezer bag. The tablets self-activate upon contact with the water/soap solution. Spare bags are provided to permit replacement each 2 to 3 days. The squeezer bags are then disposed of through the trash disposal airlock.

2.5.12.5.2 Water Bleeding Provisions

During SWS activation and deactivation, the water management equipment dispensers must be bled to remove trapped air or water.

To bleed the wardroom water dispenser valves and the H2O guns, an H2O GUN/DISPENSER SQUEEZER BAG ADAPTER is installed on a squeezer bag at the bag's inlet. The adapter fits the dispense port of the wardroom water dispenser valves and the mouthpiece of the H2O guns. Following wardroom water network filling or draining, the squeezer bag with the adapter is placed on the water outlet ports of the wardroom dispensers. The dispensers are cycled until the dispenser is filled (for activation) or until the dispenser is emptied (for deactivation). After the bleeding operations, the squeezer bag is disposed of through the trash disposal airlock and the H2O GUN/DISPENSER SQUEEZER BAG ADAPTER will be returned to stowage. The adapter is stowed in the WATER SYSTEM EQUIPMENT container.

The urine system flush dispenser and the WMC water dispenser valve are bled directly into washcloths which are disposed of in a trash bag.

2.5.12.6 WATER PURIFICATION

The water system is purified by using water purification equipment, with iodine used as the biocide.

The water tanks are ground serviced with purified water, using iodine to provide microbiological control within the water tank water until the SL-2 crew inhabits the SWS. The crews of each mission will use the water purification equipment to: (1) sample the water tank water periodically and determine its iodine concentration, and (2) add iodine as required to the water tank water to maintain the desired iodine concentration. The water purification equipment will also be utilized to: (1) inject iodine into the portable water tank for wardroom water network fill, soak, and flush and (2) inject a given quantity of iodine into the cat ion cartridge upon each SWS deactivation.

2.5.12.6.1 Water Purification Equipment

The water purification equipment is in a container mounted on the habitation area tank wall near the +Z SAL in the OWS forward compartment (figure 2.5.12-18). The container door is hinged and fitted with two dial-type latches. The container is also fitted with two pushbutton vent valves on the door, which, when depressed, equalize container pressure with cabin pressure to ensure safe door opening.

The water purification equipment is composed of the following units: (a) two water samplers, (b) two reagent containers, (c) one color comparator, (d) one waste sample container, (e) one iodine addition chart, (f) two iodine containers, and (g) two iodine injectors. Those pieces of purification equipment containing two units are divided into primary and backup units (figure 2.5.12-18).

2.5.12.6.1.1 Water Sampler

The water sampler (figure 2.5.12-19) is used to extract a sample of water from a water tank to determine its iodine content. The water sampler is portable and consists of a fitting that mates with the sample port on the water tank, a shutoff valve, an accumulator with a glass sight tube, and a piston. A water sample is taken by operating the piston slide and drawing the piston back until it reaches the end of its travel, thus filling the accumulator with a given amount of water.

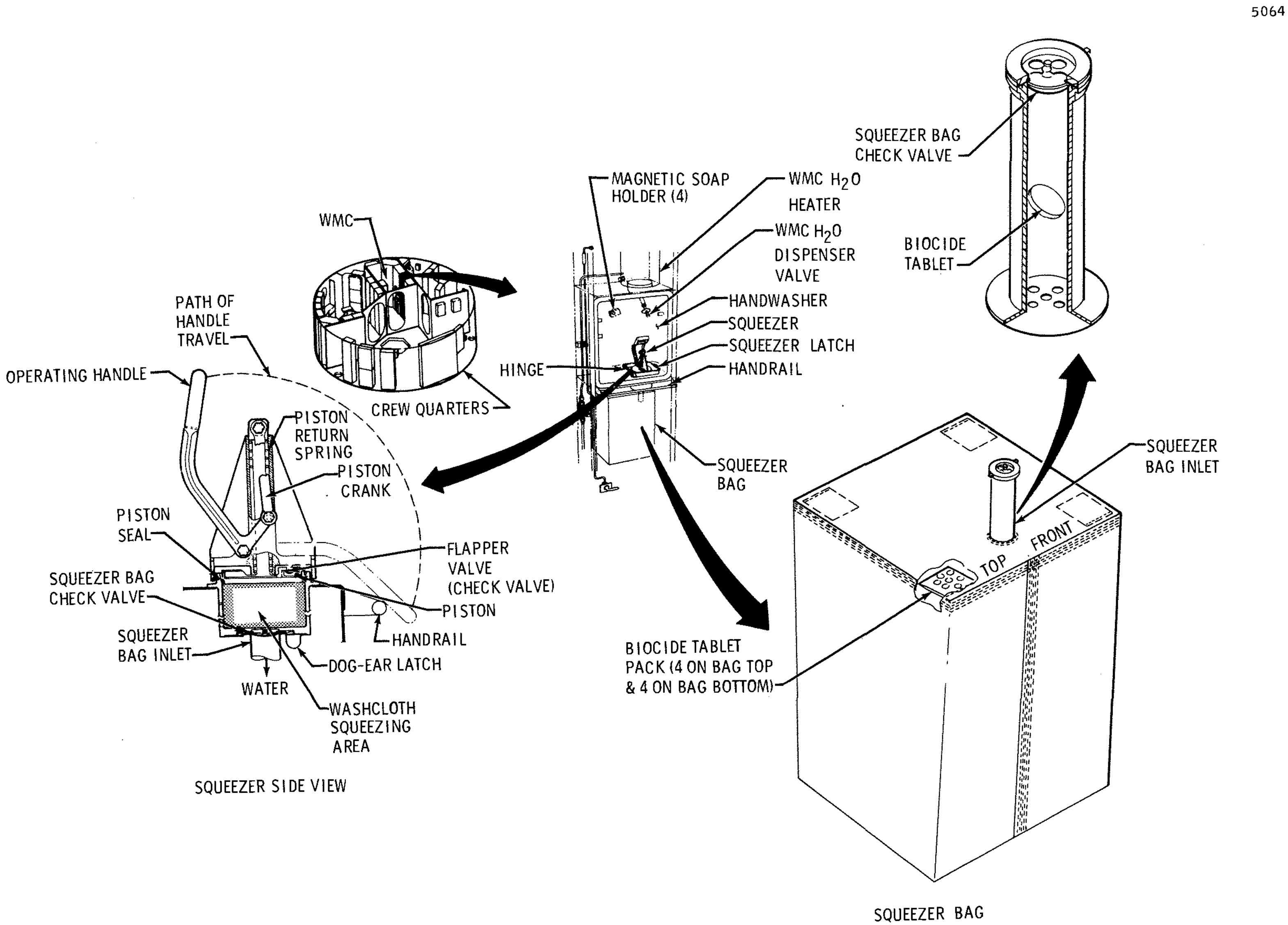



Figure 2.5.12-17 Partial Body Cleansing Facilities - Handwasher

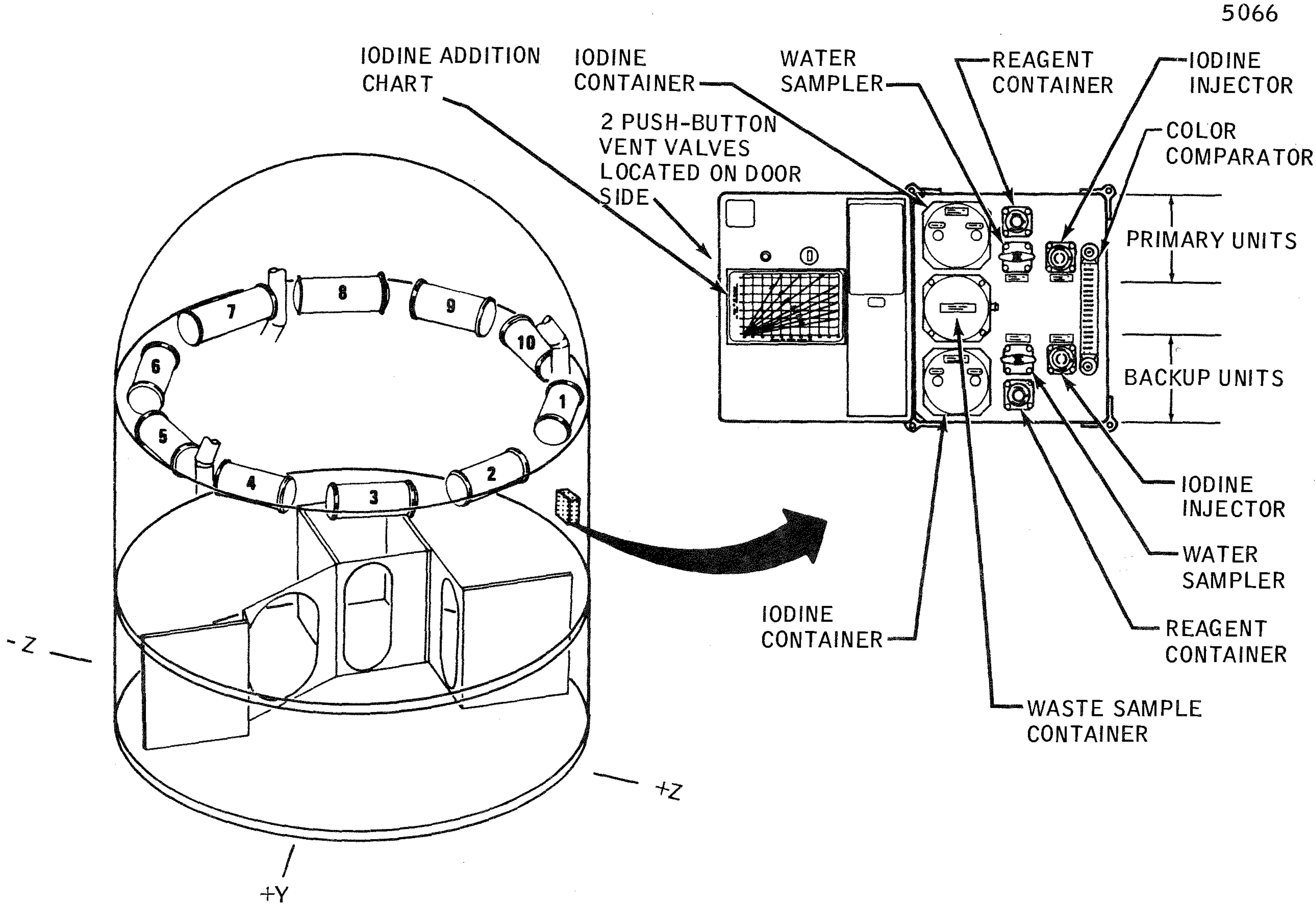



Figure 2.5.12-18 Water Purification Equipment

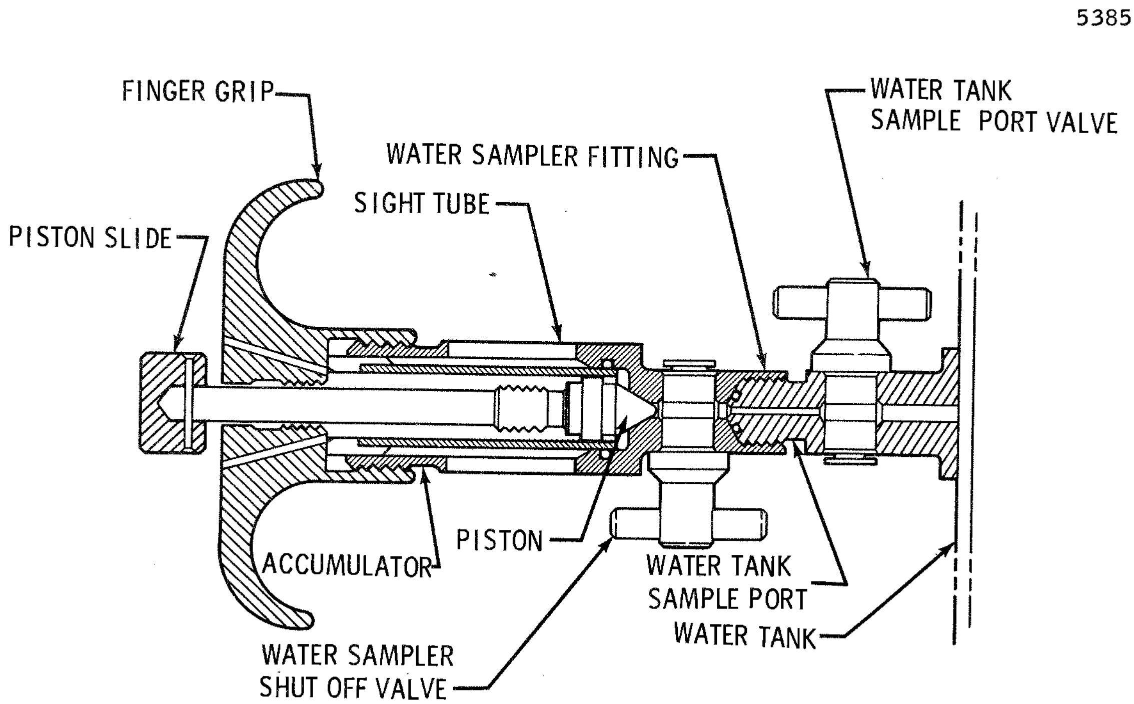



Figure 2.5.12-19 Water Sampler

To permit observation of the water sample, the sample is mixed with a reagent to convert the clear water sample to a blueish hue. The reagent is obtained from the reagent container (figure 2.5.12-20) by installing the water sampler onto the reagent container's transfer port. The reagent is withdrawn from the reagent container into the water sampler by engaging the threaded portion of the water sampler's piston slide into the threaded finger grip and rotating the piston slide until it "bottoms out". The proper amount of reagent has now been extracted from the reagent container. The water sampler is then agitated by the crewman to completely mix the reagent with the water sample, resulting in a blue solution as viewed through the sight tube.

2.5.12.6.1.2 Reagent Container

The reagent container is permanently attached to the water purification equipment container and stores the entire mission supply of amalo starch reagent (figure 2.5.12-20). The amalo starch reagent, when mixed with a water sample, tints the sample blue to aid the crewman in determining the iodine concentration in the water tank. The reagent is stored in its container under the pressure exerted by a positive expulsion bellows to facilitate transfer of the reagent to the water sampler. The reagent container's transfer port contains a shutoff valve and a threaded transfer port to permit reagent withdrawal.

2.5.12.6.1.3 Color Comparator

The color comparator is stowed in the water purification equipment container utilizing two calfax fasteners to facilitate quick removal and reinstallation (figure 2.5.12-21). The color comparator contains eight blue-tinted film windows and seven clear viewing ports, which are used to determine the iodine concentration in parts per million in a given water sample. The comparator is calibrated from 0 to 12 ppm with the blue color of the film increasing in intensity with the corresponding increase in iodine concentration.

After the water sample and reagent mixture have been agitated in the water sampler, the solution will appear some shade of blue as viewed through the water sampler's sight tube. The color comparator is then passed over the sight tube until the blue tint of the solution matches one of the blue-tinted film windows on the comparator. The solutions's tint is visually compared to the film's tint through the clear viewing port located adjacent to each film window. When the proper tint has been determined, the iodine concentration in ppm is read from the comparator above the appropriate film window.

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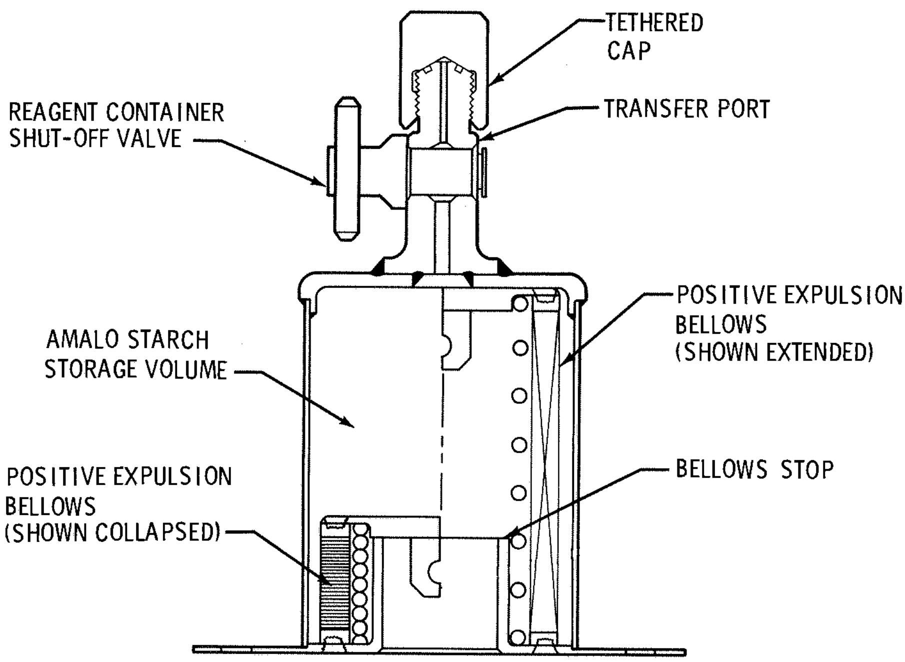


Figure 2.5.12-20 Reagent Container

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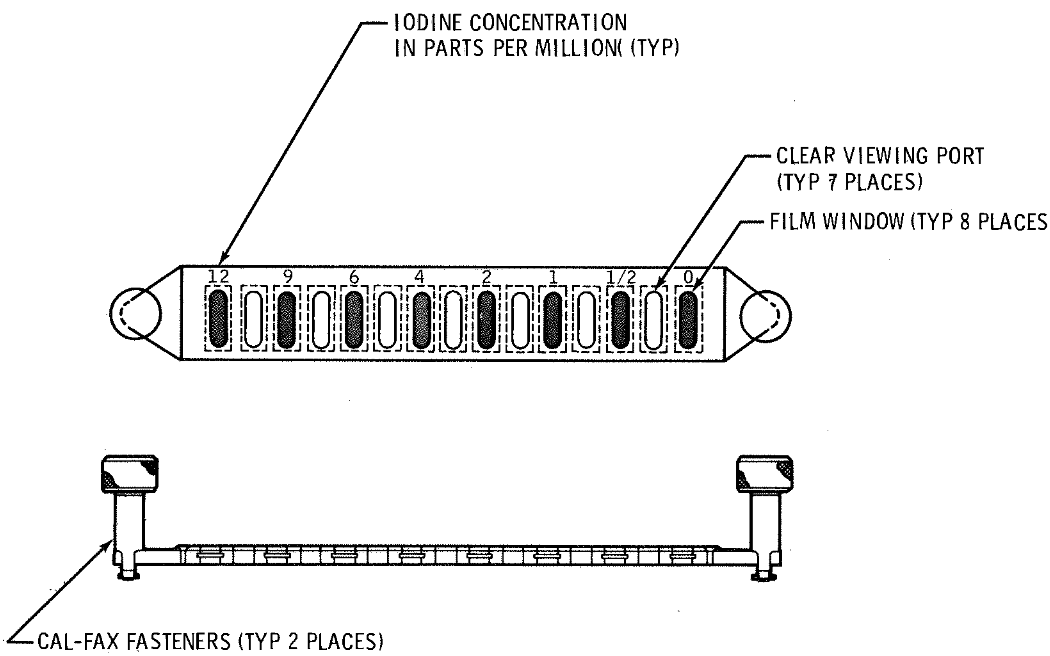


Figure 2.5.12-21 Color Comparator

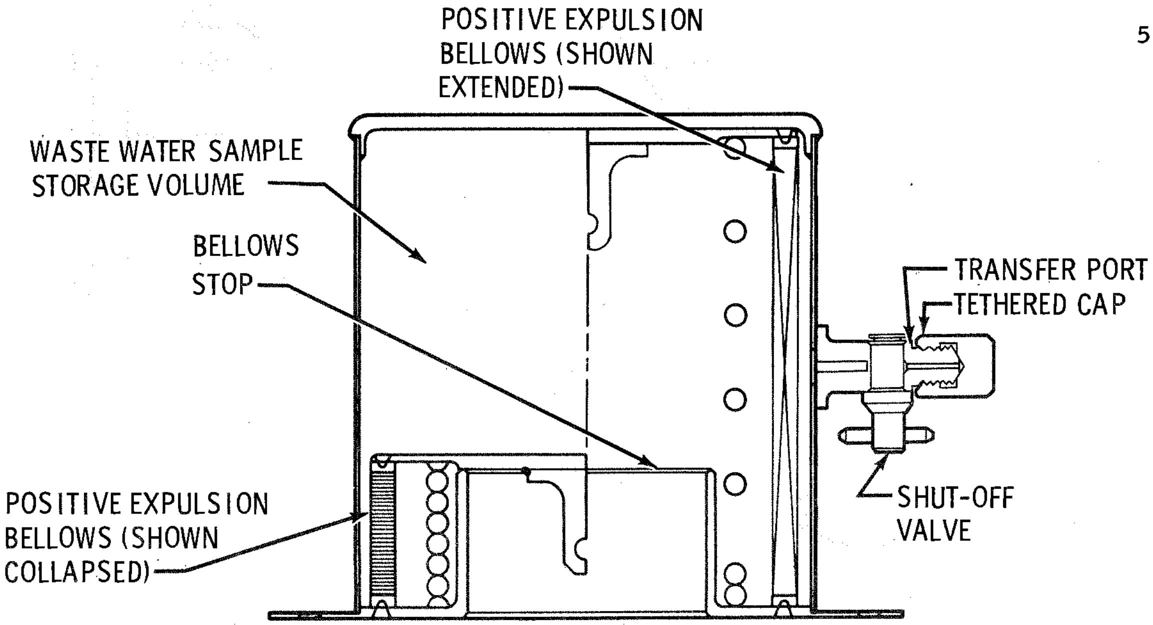


Figure 2.5.12-22 Waste Sample Container

2.5.12.6.1.4 Waste Sample Container

Upon completion of iodine concentration determination, the water sample and reagent solution contained in the water sampler is disposed of in a permanently mounted waste sample container. The water sampler is fastened onto the waste sample container's transfer port, and the solution is transferred through operation of the shut-off valves and the water sampler's piston slide.

The waste sample container is provided with a positive expulsion bellows to minimize air entrapment in the waste water sample storage volume (figure 2.5.12-22). The waste water sample storage volume permits storage of all water purification waste water for the duration of the missions.

2.5.12.6.1.5 Iodine Addition Chart

An iodine addition chart is permanently bonded to the water purification equipment container door and is used to determine the amount of iodine to be injected into the water tank to return its iodine concentration to the desired level (approximately 6 ppm). Each iodine concentration line on the chart (figure 2.5.12-23) is identified with noted concentrations in ppm. The noted concentration on a particular line is the iodine concentration as determined on the color comparator. The eight iodine concentration lines depict the delta between the desired iodine concentration level in the water tank (approximately 6 ppm) and the actual concentration as determined on the color comparator. Utilizing this "delta ppm" and the water volume remaining in the sampled water tank, the units of iodine to be injected into that particular water tank to attain the desired iodine concentration of 6 ppm are readily determined.

2.5.12.6.1.6 Iodine Container

If the iodine concentration in a particular water tank must be increased, the additive iodine is obtained from the iodine container (figure 2.5.12-24). The iodine container, permanently mounted in the water purification equipment container, stores a hightly concentrated biocide (iodine solution). This concentrated iodine solution is injected directly into the water tank water. The iodine stored in the iodine container permits water purification for the duration of all missions. A positive expulsion bellows aids in the transfer of the stored iodine into an iodine injector.

2.5.12.6.1.7 Iodine Injector

The iodine injector is a portable unit used to withdraw an appropriate amount of iodine from the iodine container and to inject this amount into a water tank. The injector's inlet fitting screws onto the iodine container's transfer port for iodine transfer (figure 2.5.12-25).

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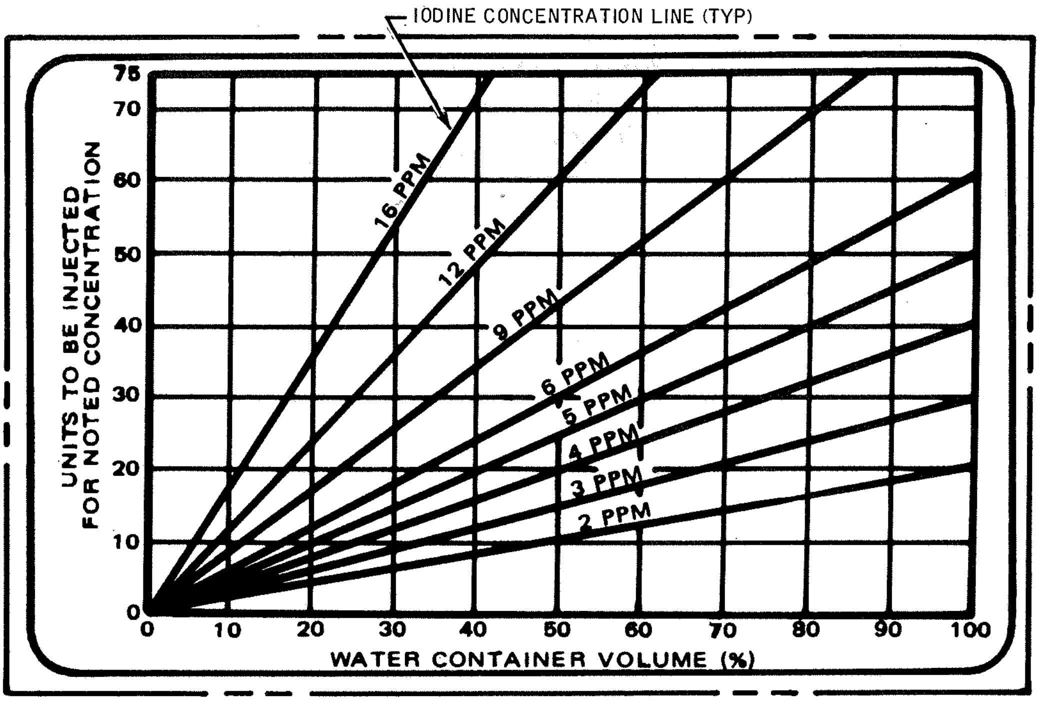


Figure 2.5.12-23 Iodine Addition Chart

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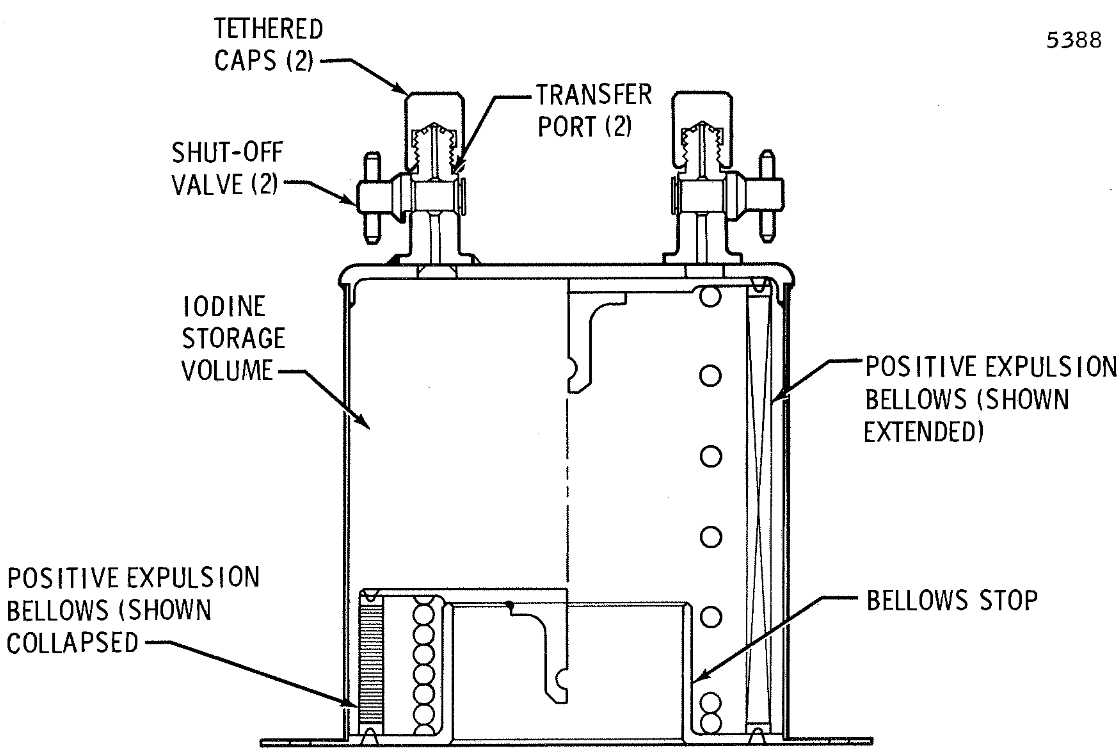


Figure 2.5.12-24 Iodine Container

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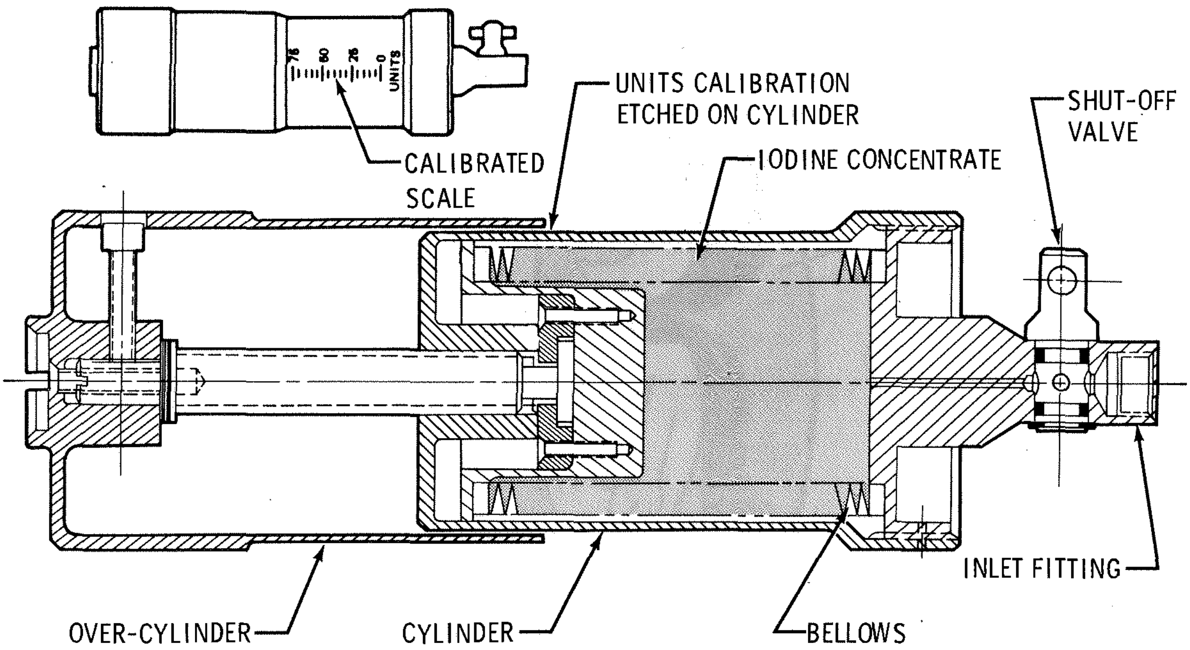


Figure 2.5.12-25 Iodine Injector

The iodine injector is obtained and installed on the iodine container. The over-cylinder on the injector is drawn back until the desired number of units of iodine appears on the injector's calibrated scale. This action withdraws the iodine concentrate from the iodine container and transfers it into the iodine injector. The injector is then removed from the iodine container and installed on the water tank's iodine injection port; the iodine concentrate is then injected into the water tank water by depressing the over-cylinder.

## 2.5.13 PERSONAL HYGIENE

### 2.5.13.1 PERSONAL HYGIENE SUPPLIES AND EQUIPMENT

The personal hygiene subsystem (hygiene kits, washcloths, towels, tissues, wipes, disinfectant pads, and soap) is used for crewmen skin health and grooming. The entire mission provisions of supplies and equipment are launched aboard SL-1 in the crew quarters stowage compartments. Color coding identifies personalized items of each crewman. A washcloth/towel drying area and a mirrors support personal hygiene functions.

### 2.5.13.2 CREWMAN COLOR CODING

The colors of red, white, and blue are assigned to the CDR, SPT, and PLT, respectively, to identify articles to be used by one particular crewman (figure 2.5.13-1). Items such as food trays, galley trays, H20 guns, and hygiene kits have "Snoopy" decals to identify the intended crewman. Other items such as washcloths and towels, are edge stitched with the particular color code; light blue is used instead of white. Items assigned to a specific crewman, such as clothing, are identified with the crewman's name. Additional crewman name labels are stowed in the label kits (paragraph 2.5.15).

### 2.5.13.3 HYGIENE KITS

Three types of hygiene kits are used: hygine kit 1 for the SL-2 crewmen, hygiene kit 2 for the SL-3 and SL-4 crewmen, and a resupply hygiene kit, which serves as a replenishing center for depleted personal hygiene supplies. Hygiene kits 1 and 2 are color coded with "Snoopy" decals to identify the individual crewman's kit. The hygiene kits are used for shaving, dental care, hair grooming, nail care and body deodorization.

#### 2.5.13.3.1 Hygiene Kit 1

Three hygiene kit 1's are launched in WMC stowage compartments, one assigned to each SL-2 crewman. Hygiene kit 1 is a 28-day provision of selected items to support individual crewman personal hygiene (figure 2.5.13-2). The hygiene kit is a flexible pouch, which has snaps to permit stowage on the backside of the WMC stowage

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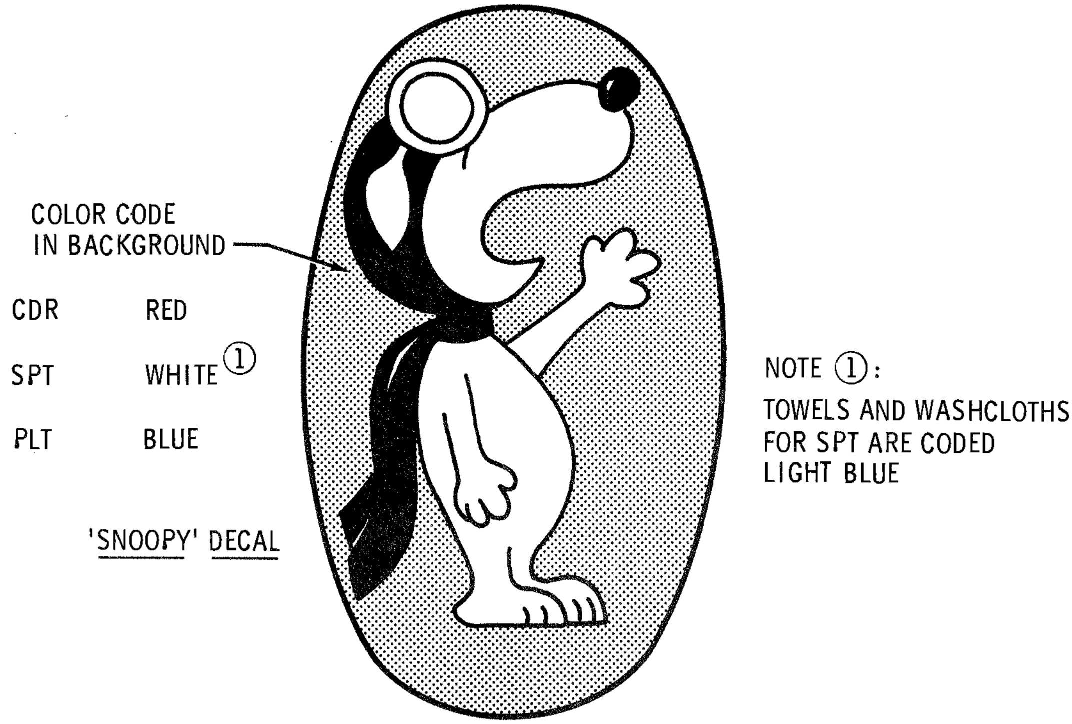


Figure 2.5.13-1 Crewman Color Coding

compartment doors. The door-mounted stowage permits ready access to the hygiene kit and its contents when the stowage compartment door is opened. All items contained in the hygiene kit are returned to the kit after use with the exception of the toothpaste and toothbrush. These two items are transferred to holders on the H2O gun housing at the food table upon SWS activation, for use after each meal. At the end of the SL-2 mission, the three hygiene kit 1's and their contents will be disposed of.

2.5.13.3.2 Hygiene Kit 2

Six hygiene kit 2's are launched in the sleep compartment for stowage until the SL-3 and SL-4 missions. Three hygiene kit 2's are used by the SL-3 crewmen, and the remaining three will be used by the SL-4 crewmen. Upon SL-3 and SL-4 activation, three kits are transferred to the WMC stowage compartments allocated to hygiene kit stowage. Configuration and use of hygiene kit 2 are similar to that of hygiene kit 1 with one exception; as the personal hygiene supplies deplete in the kit, they are replenished by supplies stowed in a hygiene resupply kit. At the end of each mission, the in-use hygiene kit 2's and their contents are disposed of.

2.5.13.3.3 Resupply Hygiene Kit

One resupply hygiene kit, stowed in a sleep compartment stowage compartment, is used to resupply hygiene kit 2's.

2.5.13.4 WASHCLOTHS

Two washcloths are allocated to each crewman per day (840 total). Each washcloth is 12 inches square, reusable, and fabricated from rayon, polynosic terrycloth. The total washcloth provision is separated into two-week supplies (for 1 crewmember), and each two-week ration is inserted into a washcloth module. "Snoopy" decals are used on the washcloth module's face for crewman identification. Each washcloth is edged with stitching of the crewman's color code. However, light blue stitching is used for the SPT color code of white.

Each washcloth module is a sheet aluminum box containing 28 folded washcloths. Thirty washcloth modules are provided: 10 red, 10 white and 10 blue. A 3-inch diameter hole in the face of each module allows retrieval of individual washcloths (figure 2.5.13.2). A spring-feed device, integral to the module and located at the rear, advances the remaining washcloths to an accessible position behind the opening, replacing the removed item. Three removable modules in each crewman's identification color code are located in the WMC in the stowage compartment adjacent to the handwasher. A depleted module is replaced with a fresh module obtained from a

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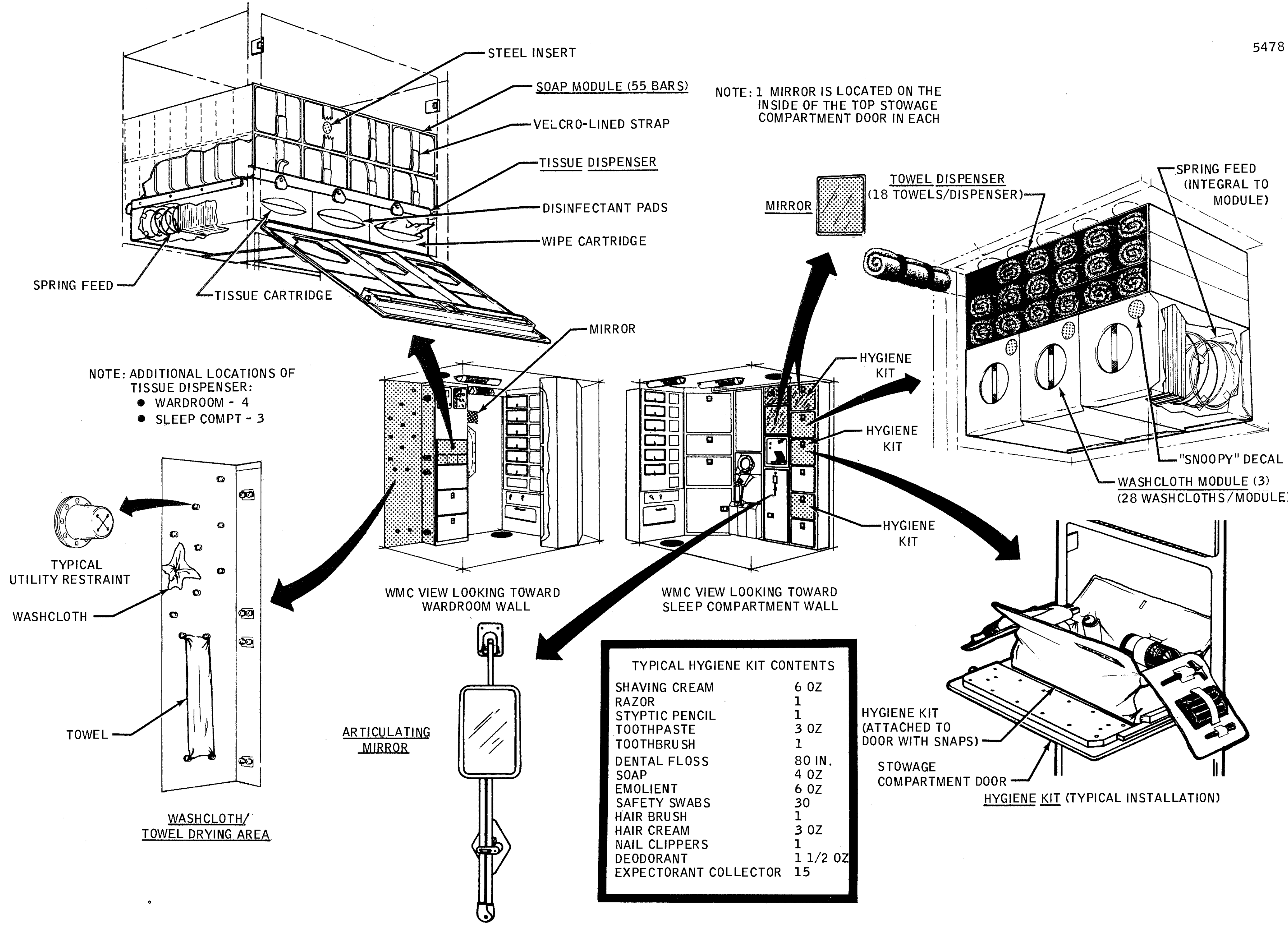



TYPICAL HYGIENE KIT CONTENTS

| | |
|---|---|
| SHAVING CREAM | 6 OZ |
| RAZOR | 1 |
| STYPTIC PENCIL | 1 |
| TOOTHPASTE | 3 OZ |
| TOOTHBRUSH | 1 |
| DENTAL FLOSS | 80 IN. |
| SOAP | 4 OZ |
| EMOLIENT | 6 OZ |
| SAFETY SWABS | 30 |
| HAIR BRUSH | 1 |
| HAIR CREAM | 3 OZ |
| NAIL CLIPPERS | 1 |
| DEODORANT | 1 1/2 OZ |
| EXPECTORANT COLLECTOR | 15 |

Figure 2.5.13-2 Personal Hygiene Provisions

wardroom stowage compartment. Washcloths are slightly moistened from the hot water dispenser in the handwasher (paragraph 2.5.12). Then a small amount of soap is applied directly to the washcloth. After washing, the washcloths are transferred to the washcloth/towel drying area to be dried in preparation for another use. At the end of each day, the in-use washcloths are disposed of in a trash bag.

2.5.13.5 TOWELS

One towel is allocated to each crewman per day (420 total) to facilitate skin drying subsequent to cleansing. Each towel is 14 by 32 inches, reusable, and fabricated from rayon, polynosic terrycloth. Each towel is edged with stitching of the crewman's color code; however, light blue stitching is used for the SPT color code of white. The towels are individually rolled and banded at both ends (figure 2.5.13-2). The bands are easily removed and disposed of when the towel is put into use. Towels are provided in a three-tiered towel dispenser which stows 18 towels in their rolled and banded form (paragraph 2.5.5).

One towel dispenser is located in the WMC, directly above the washcloth modules, and 4 towel dispensers are located in wardroom stowage compartments. Towel dispensers are launched with a supply of 18 towels (six per crewman); resupply towels in rolled and banded form are stowed in sleep compartment and forward dome stowage compartments. The towels will be used from the WMC dispenser which is removable when empty to be replaced with a wardroom-stowed dispenser. The empty WMC towel dispenser is then refilled with towels and stowed in a wardroom stowage compartment for eventual reuse in the WMC.

After use, towels are transferred to the washcloth/towel drying area to be dried in preparation for another use. At the end of each day, the in-use towels are disposed of in a trash bag.

2.5.13.6 TISSUE

Tissues are contained in fireproof aluminum foil lined pasteboard cartridges and are made available from a segment of a tissue dispenser located in the wardroom, WMC, and sleep compartment (paragraph 2.5.5). Tissues are used for equipment and compartment cleansing, for personal use, and for small cleaning tasks. Upon completion of a given cleaning operation, the tissue is disposed of in a trash bag.

Each tissue is fabricated from Kimberly Clark "kay dry" material and measures 5 inches by 8 7/16 inches. The tissues are supplied to the crew in 11 cartridges with 392 tissues packed in a cartridge (4312 total). The cartridges are provided with tear-out front sections and tear-out rear sections. The tear-out front section forms a cutout, which exposes the tissues when accessed through the opening in the dispenser (figure 2.5.13-2). The tear-out rear section allows the spring-feed device in the dispenser to advance the remaining tissue into an accessible position, replacing the removed tissue. Upon depletion of a tissue cartridge, the cartridge is removed from the dispenser and replaced with a fresh cartridge obtained from wardroom stowage compartments.

2.5.13.7 WIPES

Wipes are contained in cartridges that are identical to the tissue cartridges and are dispensed from a segment of a tissue dispenser located in the WMC, sleep compartment, and wardroom (paragraph 2.5.5). The wipes are used as toilet tissue, for equipment cleaning and for compartment cleansing.

Each wipe is fabricated from Kimberly Clark "kay dry" material, measures 5 inches by 16 7/8 inches, and is twice the length of tissues. The wipes are supplied to the crew in 18 cartridges containing 196 wipes each (3528 total), with tear-out front and rear sections as described for tissue cartridges (figure 2.5.13-2). Upon depletion of a wipe cartridge, the cartridge is removed from the dispenser and replaced with a fresh cartridge obtained from wardroom stowage compartments.

When used as toilet tissue, the wipes are obtained from their dispenser while the crewmember is seated on the fecal/ urine collector. The tissue is then deposited in the fecal bag. The wipes that are used for equipment and compartment cleansing are deposited in a trash bag after use.

A wipe holder is provided as an aid when cleaning in confined areas and permits the restraint of the wipe while the crewman manipulates the holder into hard-to-get-at areas.

2.5.13.8 DISINFECTANT PADS

Disinfectant pads are provided for use to eliminate and to prevent microbiological growth on equipment associated with waste management, food management, personal hygiene, and trash disposal. The disinfectant pads are pre-moistened with a water/iodine solution and individually packaged in aluminum foil. The packaged disinfectant pads are made available to the crew from one segment of a tissue dispenser located in the WMC and in the wardroom (figure 2.5.13-2). After use, the pads are disposed of in a trash bag.

2.5.13.9 SOAP

Soap is provided in bar form, individually packaged in aluminum foil. One soap bar is allocated to each crewman per two weeks for personal hygiene and five soap bars per month are allocated for compartment and trash disposal airlock cleaning. Each soap bar measures 1 inch by 2 inches by 3 inches, and contains neutrogena, which acts as a mild anti-bacterial agent. Imbedded in the center of each soap bar is a stainless steel disc which provides a restraining mechanism for the soap when mated with the magnetic soap holders in the handwasher (figure 2.5.13-2). The handwasher contains four of these post-type soap holders, three for crewman soap restraint and one for the soap used in compartment and equipment cleaning (paragraph 2.5.12).

The total soap provision of 55 bars is made readily available to the crew in a soap module installed above the tissue dispenser in the WMC (figure 2.5.13-2). The soap module is an armalon bag, compartmentized by aluminum dividers into eight segments. Each segment contains approximately seven soap bars banded together with a velcro-lined strap. The crewman uses the strap to feed the bars of soap into an accessible position at the front of the module. After removal from the module, the soap is transferred to the handwasher for in-use restraint. At the end of each two-week period, the in-use soap is disposed of in a trash bag.

2.5.13.10 WASHCLOTH/TOWEL DRYING AREA

The washcloth/towel drying area is immediately adjacent to the entrance of the WMC on the WMC/wardroom partition. This facility holds nine washcloths and three towels for drying in the SWS atmosphere while being restrained at the surface of the WMC/wardroom partition and at the side panel of a vertical assembly of stowage compartments (figure 2.5.13-2).

The drying area surfaces are fitted with 21 utility restraints, permanently attached to the surfaces (paragraph 2.5.3). Each restraint contains a cruciform slit, which accepts and retains the item to be dried. Thirteen restraints are appropriately spaced on the WMC/wardroom partition to accommodate nine washcloths and one towel. Eight restraints are appropriately spaced on the side panel of the stowage compartments to accommodate two towels. Towels are restrained at each corner; whereas washcloths are restrained at their center. These utility restraints are also provided in portable form to permit temporary washcloth, towel, tissue, or wipe restraint for ready access (paragraph 2.5.3).

2.5.13.11 MIRRORS

Unbreakable polished stainless steel mirrors are permanently located in the WMC and sleep compartment. The two mirrors mounted above the handwasher aid the crewman in performing partial body cleansing, hair-brushing, and nail clipping (figure 2.5.13-2). The third mirror is located directly opposite the fecal/urine collector, above the cutout in the WMC/wardroom partition for use as an additional personal hygiene area when two crewmen are performing simultaneous personal hygiene functions in the WMC.

A CM-type articulating mirror is permanently attached to the stowage compartment door, is movable, and is easily reached while the crewman is seated on the fecal collector. The crewman will use the articulating mirror during fecal collection functions.

One mirror is bonded to the top stowage compartment door in each of the sleep areas for personal use by the crewman.

2.5.14 <u>VACUUM PROVISIONS</u>

2.5.14.1 VACUUM DUMP AND VACUUM VENT SYSTEMS

The vacuum provisions subsystem consists of five dump lines, connecting OWS crew compartments to a screen-isolated liquid dump area in the waste tank, and an experiment compartment vacuum venting provision. The wardroom water dump, waste processor vacuum vent, urine dump, WMC water dump, and refrigeration pump package vacuum vent are vented into the waste tank; the M171 vacuum vent and the M092 LBNP vacuum vent are vented directly overboard. The liquids and gases dumped into the waste tank are non-propulsively vented overboard, while the experiment compartment provision is vented to the vacuum of space through the experiment compartment tank wall.

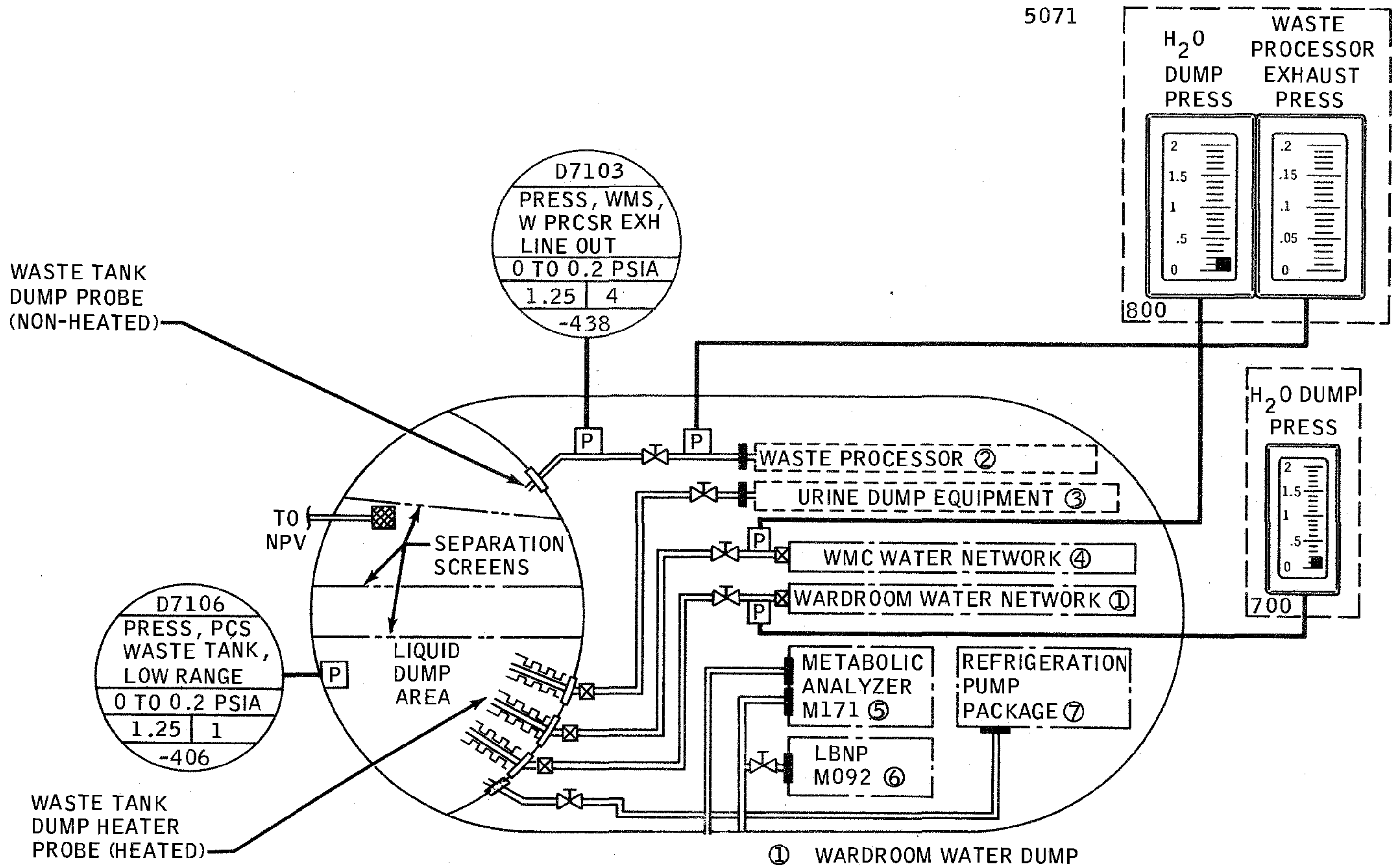
Each vent system includes a hand-operated shutoff valve, stainless steel and flexible tubing, and brazed fittings. Nozzle heaters on three waste tank liquid dump probes prevent freezing of the liquid on the nozzle.

2.5.14.2 WARDROOM WATER DUMP

The wardroom water dump (figure 2.5.14-1) provides for wardroom water network evacuation into the waste tank. Dumping is accomplished through quick-disconnects, flexible hoses, tubing, a hand valve, and a heated waste tank discharge nozzle (dump heater probe).

The flexible hose is stowed in the food table pedestal and mates with the wardroom H2O heater or water chiller with quick-disconnects. The hose is connected to the WATER DUMP hand valve on panel 706 in the food table, which in turn routes the water to its dump heater probe for disposal into the waste tank. A pressure measurement upstream of the panel 706 WATER DUMP hand valve is displayed on panel 700 for on-board use during water dump. Water dumps are terminated when the pressure decreases to $\lessapprox$ 0.7 psia.

Water is dumped into the waste tank through a replaceable dump heater probe which contains two zero-G connectors (bus 1 and bus 2), a quick-disconnect, and a dual-element nozzle heater (figure 2.5.14-2). The dump heater probe's heated nozzle extends into the waste tank. Separate control of each heater element is with an H2O DUMP HEATER switch on panel 700 (figure 2.5.14-3). An H2O DUMP HEATER light on panel 700 illuminates during heater operation; in addition, a remote DUMP HEATER light on panel 617 illuminates whenever <u>any</u> of the three dump heater probes are powered. The dump heater probe must be powered for 15 minutes preceeding <u>any</u> dump to clear the nozzle of any ice blockage. A spare dump heater probe is provided in a spare parts stowage compartment in the OWS forward dome.




① WARDROOM WATER DUMP
② WASTE PROCESSOR VACUUM VENT
③ URINE DUMP
④ WMC WATER DUMP
⑤ M171 VACUUM VENT
⑥ M092 LBNP VACUUM VENT
⑦ REFRIGERATION PUMP PACKAGE VACUUM VENT

Figure 2.5.14-1 Vacuum Dump and Vacuum Exhaust Systems

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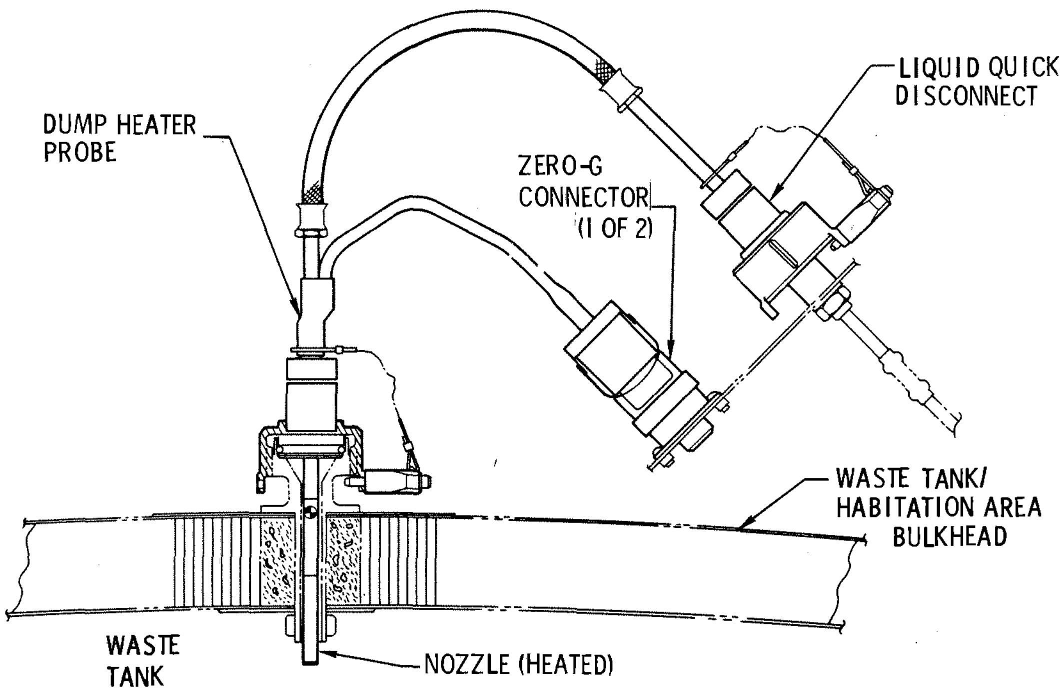


Figure 2.5.14-2 Dump Heater Probe

The wardroom water dump will be used upon SWS activation to evacuate the wardroom water network prior to filling operations. For SL-3 and SL-4 activation, an additional iodine fill and soaking operation is performed on the wardroom water network with the iodine/water solution dumped through the wardroom water dump after the 1-hour soak period (paragraph 2.5.12). Upon SWS deactivation, the wardroom water network is drained of water.

2.5.14.3 WASTE PROCESSOR VACUUM VENT

The waste processor vacuum vent (figure 2.5.14-1), located in the WMC, provides the vacuum source for the six waste processors. The vacuum vent consists of an exhaust to the vacuum of the waste tank, a hand valve, and pressure transducers to indicate vent line blockage. Vapors resulting from the dehydration of fecal matter and vomitus are routed from the waste processors, through tubing, to a dump port on the waste tank/habitation area bulkhead and discharged into the vacuum of the waste tank.

Vapors are vented from each of the waste processors through an integral waste processor vacuum valve to a manifold. The manifold connects to a WASTE PROCESSOR VACUUM VENT hand valve located on panel 818, below the waste processors. This hand valve is used to isolate the waste processors from waste tank pressure during launch, is opened upon each SWS activation to allow waste processor operation, and is closed upon each SWS deactivation to prevent loss of cabin air.

2.5.14.4 URINE DUMP

The urine dump (figure 2.5.14-1), located in the WMC, is used as an alternate method of disposing urine into the waste tank. Urine is expelled from the urine dump equipment through tubing, a hand valve, and a heated waste tank discharge nozzle (dump heater probe). The three flexible hoses in the urine dump equipment are manifolded into a single line, which is connected to a hand-operated URINE DUMP valve located on panel 818, below the waste processors. The URINE DUMP valve is opened when urine is dumped into the waste tank.

The urine dump heater probe is configured and operates like the wardroom water dump heater probe using a DUMP HEATERS URINE switch and indicator on panel 800.

2.5.14.5 WMC WATER DUMP

The WMC water dump, located in the WMC, provides for evacuation of the WMC water network, urine system flush water network and condensate control system into the waste tank (figure 2.5.14-1). The WMC water dump uses quick-disconnects, flexible hoses, tubing, a hand valve, and a heated waste tank discharge nozzle (dump heater probe). A flexible hose with a quick-disconnect stowed below the handwasher mates with the WMC $H_2O$ heater for

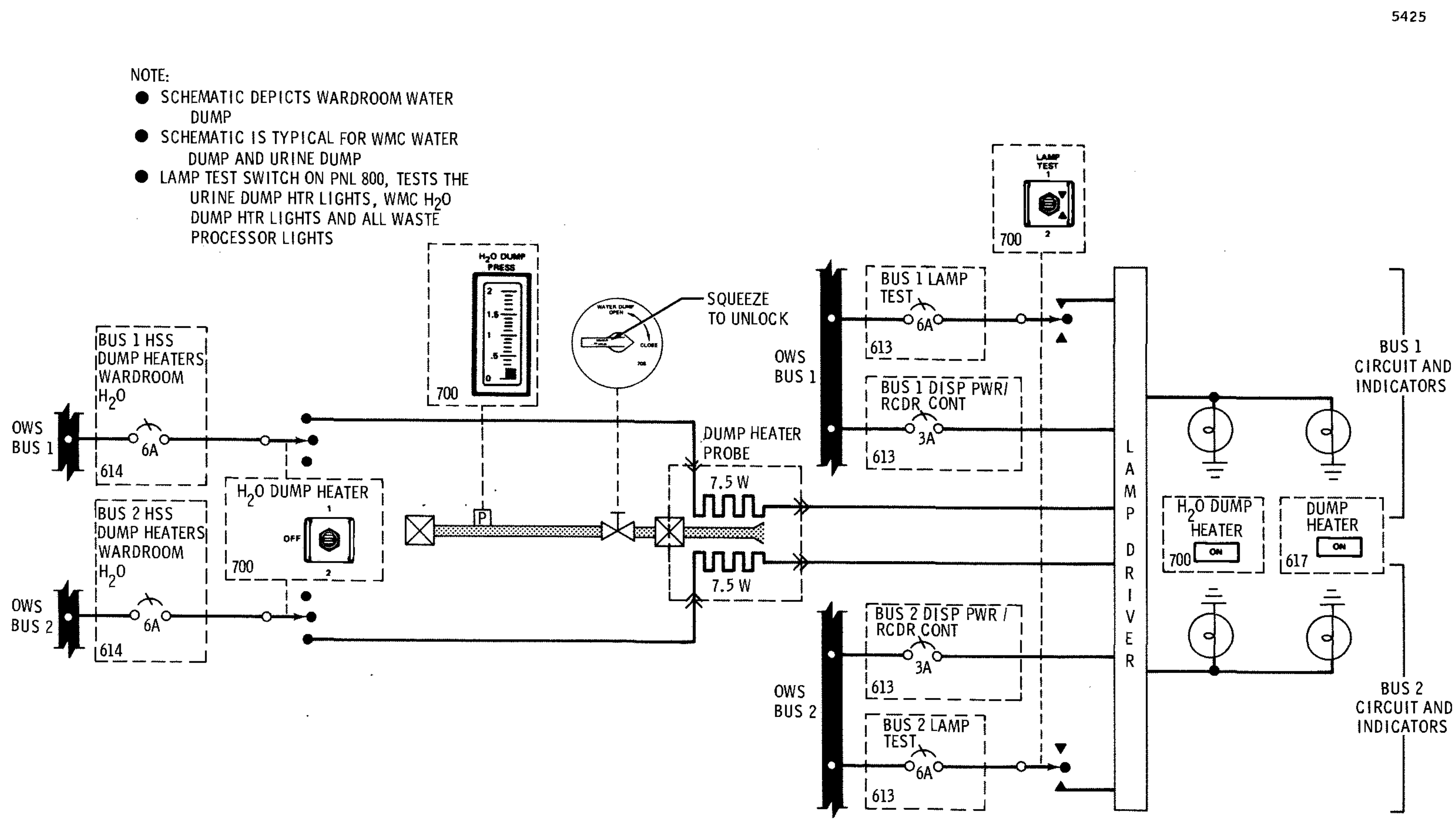


Figure 2.5.14-3 Typical Vacuum Provision Schematic

WMC water network dump, with the URINE SYSTEM FLUSH DUMP hose for urine system flush water network dump, and with the condensate control system dump line for condensate tank dump. The flexible hose is connected to a WATER DUMP hand valve on panel 831, which routes the water to its dump heater probe for disposal into the waste tank. The configuration and operation of the dump heater probe is like the wardroom water dump heater probe using a DUMP HEATERS H2O switch and indicator on panel 800. A pressure measurement upstream of the panel 831 WATER DUMP hand valve is displayed on panel 800 for on-board use for water dump termination. Water dumps are terminated when the pressure decreases to $\lesssim$ 0.7 psia.

The WMC water dump will be used upon SWS activation to evacuate the WMC water network and urine system flush water network prior to water filling operations. During the habitation period, the condensate tank will be periodically dumped through a dump line that connects the condensate tank with the WMC. Upon SWS deactivation, the WMC water network and the urine system flush water network will be drained of water.

2.5.14.6 M171 VACUUM VENT

Two vacuum lines are connected to the M171 metabolic analyzer (figure 2.5.14-1). Both lines are routed directly to vacuum through the experiment compartment tank wall. One line aids in the operation of the mass spectrometer while the other permits methane gas to vent overboard. The venting from the M171 experiment is controlled from valving internal to the experiment.

2.5.14.7 M092 LBNP VACUUM VENT

A vacuum line on the M092 LBNP experiment permits evacuation of the M092 experiment through a panel 625 M092 LBNP VACUUM VENT hand valve to a penetration in the experiment compartment tank wall (figure 2.5.14-1). The venting flow control from the M092 LBNP experiment is controlled from valving internal to the experiment. The M092 LBNP VACUUM VENT valve is opened only during the M092 experimentation periods.

2.5.14.8 REFRIGERATION PUMP PACKAGE VACUUM VENT

The active components (pumps, valves, etc.) of the refrigeration subsystem (RS) are completely encased in the OWS forward compartment with a sealed enclosure. The interior of this enclosure is vented to the vacuum of the waste tank through a panel 1001 REFRIGERATION PUMP PACKAGE VACUUM VENT hand valve located in the OWS aft compartment (figure 2.5.14-1). If refrigerant begins leaking from any RS component in the sealed enclosure, it will vent into the waste tank. The REFRIGERATION PUMP PACKAGE VACUUM VENT hand valve is opened prior to launch of SL-1 and remains open thereafter.

2.5.14.9 WASTE TANK LIQUID DUMP AREA

The liquids from the wardroom water dump, the urine dump, and the WMC water dump are discharged into a screened liquid dump area in the waste tank through dump heater probes. The waste processor vacuum vent and the refrigeration pump package vacuum vent are discharged into the screened liquid dump area through non-heated dump ports. The liquid dump area is enclosed by a 16 mesh screen for a volume of 380 cubic feet (figure 2.5.14-4). Of this volume, 116 cubic feet is allocated to waste processor venting and is screened off from the remainder of the liquid dump area with a 16 mesh screen to prevent blockage of the waste processor vacuum vent line by ice crystals from liquid dumps.

As liquids enter the waste tank, they partially vaporize and partially freeze because of the vacuum environment. The vapors and small ice crystals pass through the screens to be non-propulsively vented overboard. The large ice crystals are trapped behind the screens to prevent possible blockage of the NPV vent lines. The screens also serve to prevent garbage in the trash disposal area from migrating into the liquid dump area and clogging the discharge ports.

2.5.15 ORBITAL MAINTENANCE

2.5.15.1 IN-FLIGHT MAINTENANCE

In-flight maintenance for the SWS is conducted using portable maintenance equipment and spare parts to accomplish tasks associated with scheduled maintenance and unscheduled maintenance.

2.5.15.1 PORTABLE MAINTENANCE EQUIPMENT

Portable maintenance equipment (a label kit, a repair kit, tool kits, tool caddies, and utility belts) is provided to support in-flight maintenance tasks (figure 2.5.15-1).

2.5.15.1.1 Label Kit

The label kit is a 3-by-4-inch box which contains two types of adhesive-backed labels to reidentify operational equipment or personal items: crewman labels (with the name of the crewmember pre-printed on the label) to identify personal items and blank labels for use with a marking pen to reidentify equipment and stowed items, to flag malfunctioning items, etc.

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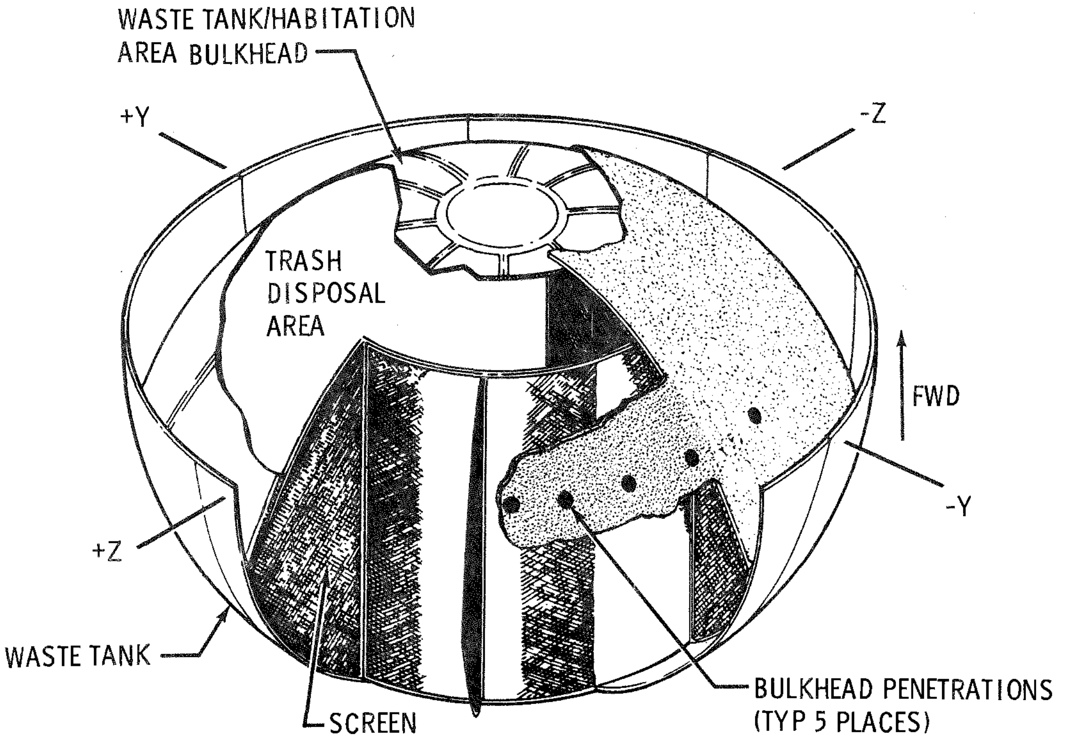


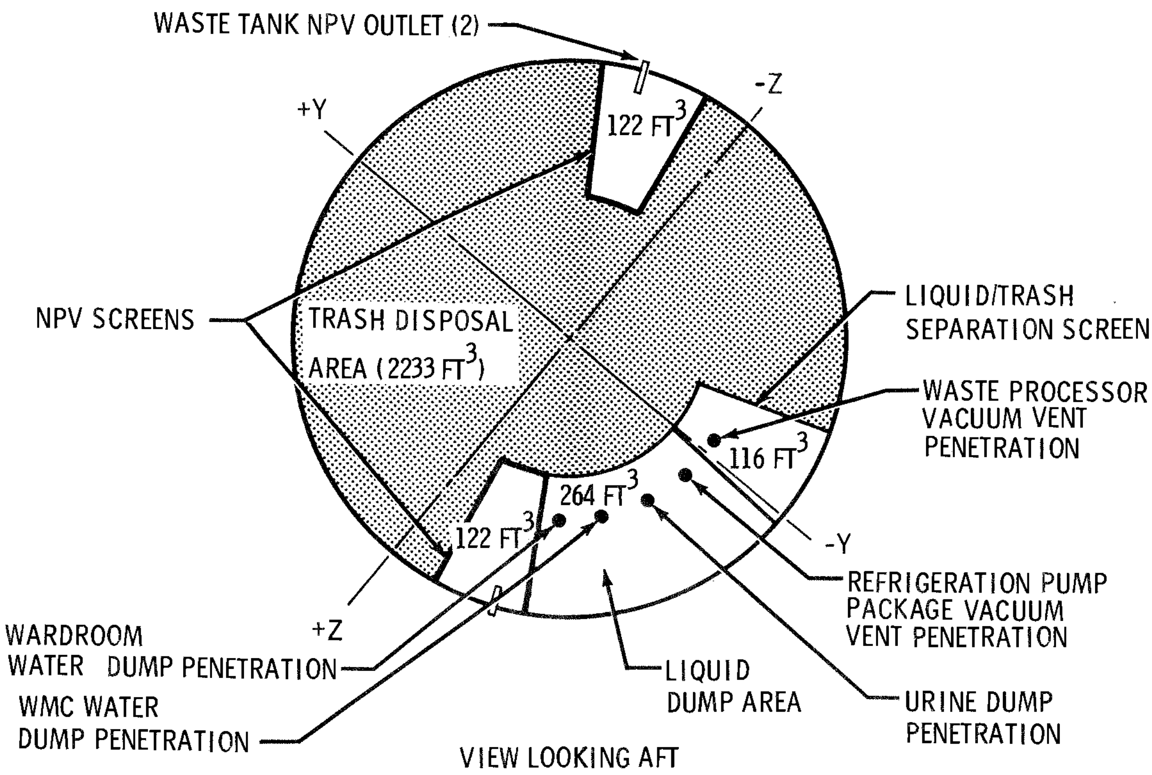


Figure 2.5.14-4 Waste Tank Liquid Dump Area

2.5.15.1.2 Repair Kit

The repair kit contains the supplies to perform small meteoroid puncture repairs on the pressurized SWS structure, miscellaneous housekeeping repairs, and atmosphere leak detection. The repair kit is a portable, drawered, metal box containing a carying handle. When not in use, it is stowed in an experiment compartment stowage compartment (figure 2.5.15-1). The drawers slide out and are removable to facilitate portability. Each of the five drawers and the repair kit contains a universal mount bracket which accepts the universal mount (paragraph 2.5.3) for restraint of the drawers or the box on convenient structure during repair tasks.

Blister-type meteoroid patches are used to repair pressure structure leaks in the SWS. The leak detector is provided to detect atmosphere leaks around penetrations in the SWS pressurized structure or leaks resulting from meteoroid punctures. The teflon tape and sealant putty are for use in sealing joints, and tape is provided to repair fabric damage to items such as air ducts and sleep area privacy curtains. Adhesive-backed velcro and grid-mounted snaps are supplied to permit convenient restraint of repair kit stowed items.

2.5.15.1.3 Tool Kits

Two types of tool kits are provided to stow tools: tool kit 1 and tool kit 2 contain the tools required to perform all maintenance tasks; the hatch tool kit contains the tools required to force the SWS hatches if they become jammed.

2.5.15.1.3.1 Tool Kit 1 and Tool Kit 2

Two tool kits (tool kit 1 and tool kit 2) are stowed in two wardroom stowage compartments and provide stowage of those tools used during scheduled and unscheduled maintenance tasks (figure 2.5.15-1). Each tool kit is a portable, drawered, metal box with a carrying handle. Each tool kit has five drawers mounted on tracks, which provide a means for holding the drawers in the open and closed positions and also to allow removal of an individual drawer for use as a separate unit. The tool kit box contains a universal mount bracket and each drawer track doubles as a universal mount bracket to accept the universal mount (paragraph 2.5.3) for kit or drawer restraint on convenient structure.

Each drawer contains inserts made from fluorocarbon foam with top and base skins of fluorocarbon rubber sheets. The tools are held in place in cutouts in the inserts by the press-fit friction method. The location of each tool is identified both on the insert and the drawer front. Tools provided include various sizes of sockets, open end/box wrenches, screwdrivers, screwdriver bits, a vise, a speeder handle, a spin-type handle, a ratchet handle, a pin straightener, and common type tools. The tools are arranged in each drawer such that each tool is readily accessible and visible for selection and withdrawal.

The tools are engraved with size and part number to aid in identification. The drive tools, sockets, and bits are 3/8-inch square and provide optimum versatility and interchangeability. Detachable sockets, handles, and attachments are such that the male tangs can be inserted into the corresponding female opening without undue force and can be manually detached without the use of tools or keys. All tools contain velcro hook patches to permit retention on the tool caddy, on the utility belt or to OA-located velcro. The ratchet is a reversing gearhead type. The vise can be mounted to open grid (paragraph 2.5.3) of the OWS/MDA by an integral mount. The tool finish is electroplated nickle to prevent chipping or flaking during use. The grips, handles, and housing materials are knurled aluminum.

2.5.15.1.3.2 Hatch Tool Kit

A hatch tool kit will be provided for stowage in the MDA and will contain tools required for disassembly of the AM forward hatch, AM aft hatch, and OWS hatch, should a hatch jam during opening. The kit will include sockets, a ratchet handle, a pinch bar, wrenches, a tool caddy, and a utility belt.

2.5.15.1.4 Tool Caddies

The tool caddy is a portable tool carrier which restrains tools and small parts for ready accessibility during maintenance tasks. Large or long tools are restrained through use of pocket-type restraints with elastic strips (figure 2.5.15-1). Two see-through pouches with slotted, fluorocarbon rubber diaphrams on one side provide temporary stowage of small tools and small parts. The caddy also contains velcro lining to retain tools with velcro patches. The tool caddy contains four snaps which attach to the SWS snap pattern (paragraph 2.5.3) for restraint on the utility belt or on convenient structure. Three tool caddies are provided: one stowed in the hatch tool kit and two stowed in sleep compartment stowage compartments.

2.5.15.1.5 Utility Belts

The utility belt is a portable, adjustable belt worn around the crewman's waist and is used to restrain the tool caddy, disposal bags, and miscellaneous items while conducting maintenance tasks. The utility belt is constructed of armalon with velcro lining around the belt to retain velcro lined items, bags and tools. The belt is 3 inches wide, contains a stainless steel buckle and eyelets, and is adjustable to the crewman's waist size. Snap studs located on the belt are configured similar to the SWS snap pattern (paragraph 2.5.3) to retain the tool caddy disposal bags, or any item fitted with snap sockets. Three utility belts are provided: one stowed in the hatch tool kit and two stowed in sleep compartment stowage compartments.

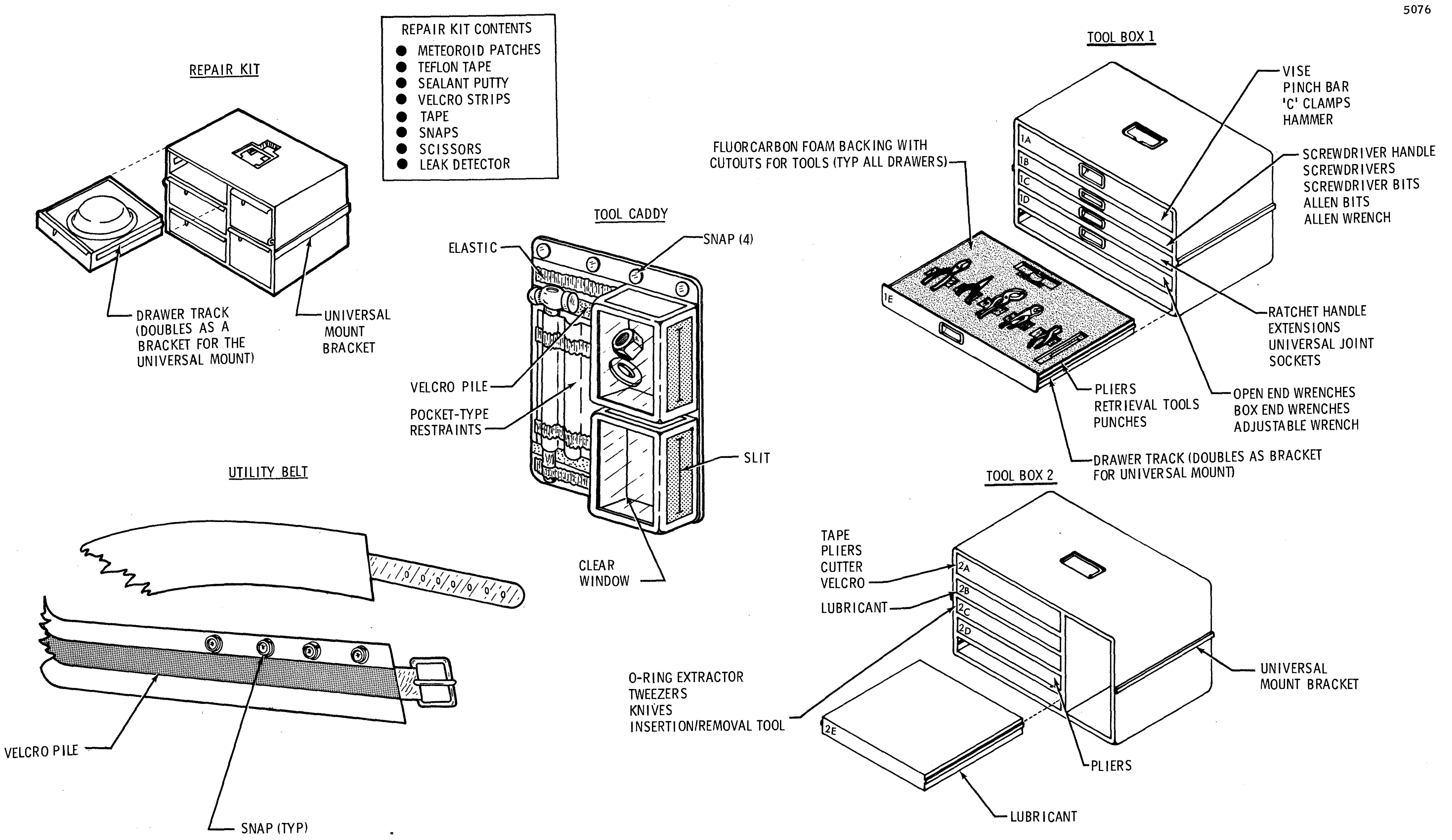


Figure 2.5.15-1 Portable Maintenance Equipment

2.5.15.2 SPARE PARTS

Selected spare parts are provided to permit in-flight replacement of those components or systems whose degradation, malfunction, failure or damage to critical hardware could affect crew safety, crew efficiency, or mission success (figure 2.5.15-2). Spare parts are stowed in: M124, M125, and M161 stowage compartments in the MDA; M201, M202, M203, M301, M302, and M305 stowage compartments in the AM; and D424, D426, D428, D430, D432, D434, D436, D438, D440, D442, and D444 stowage compartments in the OWS (paragraph 2.5.5).

Spare parts may be transported to and from the work area using a disposal bag (paragraph 2.5.9), which doubles as a parts carrier/trash collection bag and attaches to the utility belt or SWS-located snaps or velcro.

2.5.15.3 SCHEDULED MAINTENANCE

Scheduled maintenance consists of those in-flight housekeeping tasks and component replacement tasks to be accomplished on a regular periodic basis to allow optimum equipment life. It includes tasks such as inspections, cleaning and replacement of various filters and screens. These tasks are scheduled in the mission timeline to preclude equipment degradation and failure.

Housekeeping tasks consist of: systems periodic verification, changing teleprinter paper, dumping the condensate control system, disposing of trash, replacing and disposing of trash collection bags, cleaning trash disposal airlock, vacuuming screens and loose floating particles, and conducting pre- and post-sleep checklists. Scheduled maintenance tasks are illustrated for the SL-3 and SL-4 missions on figure 2.5.15-3; the SL-2 tasks are similar to those shown in the first 28 days of the SL-3 or SL-4 mission.

Out-of-service components that are not biologically active are marked with red tape, identified as out-of-service with a marking pen, and placed in a stowage compartment for permanent storage. Biologically active out-of-service components are placed in a trash collection bag and disposed of through the trash disposal airlock.

2.5.15.4 UNSCHEDULED MAINTENANCE

Unscheduled maintenance consists of those in-flight repair tasks not scheduled in the mission timeline (figure 2.5.15-4).

Unscheduled maintenance is accomplished upon detection of discrepancies noted on operating equipment during normal operations or while performing scheduled maintenance. It includes fault isolation, repair, and re-verification. Repair consists primarily of the removal and replacement of the failed items; however, certain items such as the triangle shoes and vent sealing devices can be repaired, after being replaced with an operable item, and restowed as spares.

Biologically active and inactive out-of-service components are treated as described in scheduled maintenance.

2.5.16 <u>CREW SAFETY PROVISIONS</u>

2.5.16.1 SAFETY AIDS

Equipment is provided in the SWS to aid the crewmen in containing and extinguishing a fire. An inflight medical support system (IMSS) is used by the crew for the maintenance of health and to treat illness or injury. A Van Allen belt dosimeter permits ground monitoring of the radiation dosage rate received by the crew.

2.5.16.2 FIRE FIGHTING

To combat a fire in the SWS, the crew is provided with a fire alert network, fire fighting provisions, escape route provisions and fire alert operations.

2.5.16.2.1 <u>Fire Alert Network</u>

Twenty-two fire sensors are mounted in strategic locations in the SWS to continuously monitor a specific area for indications of a fire (section 2.8). In the event of a fire in any area of the SWS, the appropriate area fire light on control panels 207 and 617 will turn-on, indicating an MDA/STS FIRE, AM AFT FIRE, OWS FWD FIRE, OWS CREW QTRS FIRE, or OWS EXP FIRE. Simultaneously. a siren fire-tone will issue from two klaxons, one located in the OWS forward compartment and one in the AM forward compartment. Once the crewman translates to the area of the fire, the source of the fire can be pinpointed through visual scanning of the fire sensor control panels in the area for an illuminated red light. The red light identifies the fire sensor that initiated the fire detection.

2.5.16.2.2 <u>Fire Fighting Provisions</u>

Fire ports are located on some SWS panels to provide an access port for fire suppression. Fire extinguishers are provided for use in suppressing a confined fire.

2.5.16.2.2.1 Fire Ports

Fire ports are red-outlined circular holes located on the surfaces of enclosed volumes which contain combustible material or electrical components. The fire ports permit the insertion of the fire extinguisher delivery tube to allow rapid access to the area behind the enclosure.

5482

| SPARE PART | NO. OF SPARE PARTS | STOWAGE LOCATION |
|---|---|---|
| WINDOW HEATING CONTROL UNIT | 1 | M124 |
| WINDOW HEATER CABLE | 1 | M124 |
| VIDEO SWITCH | 1 | M124 |
| CO2 ABSORBER (CSM) | 10 | M125 |
| MOL SIEVE FAN | 1 | M168 |
| SOLIDS TRAPS | 28 | M168 |
| TELEPRINTER PAPER ROLL | 156 | M201 |
| TELEPRINTER | 1 | M202 |
| TELEPRINTER SPOOL | 2 | M202 |
| TELEPRINTER PAPER CARTRIDGE | 1 | M202 |
| PORTABLE TIMER BATTERY | 4 | M202 |
| TONE GENERATOR BATTERY | 12 | M202 |
| WATER SEPARATOR PLATE | 4 | M202 |
| PPO2 SENSOR | 9 | M202 |
| CO2 FILTER CARTRIDGE INLET ENDPLATE | 1 | M202 |
| CO2 FILTER CARTRIDGE OUTLET ENDPLATE | 1 | M202 |
| CONDENSATE TANK MODULE | 1 | M203 |
| CO2 ACTIVE FILTER CARTRIDGE INLET | 20 | M301 |
| CO2 PASSIVE FILTER CARTRIDGE INLET | 20 | M301 |
| CO2 ACTIVE FILTER CARTRIDGE OUTLET | 12 | M301 |
| CO2 PASSIVE FILTER CARTRIDGE OUTLET | 12 | M301 |
| 10 WATT BULB | 120 | M301 |
| 20 WATT BULB | 24 | M301 |
| EVA/IVA COOLANT GAS SEPARATOR | 2 | M302 |
| DIGITAL DISPLAY UNIT | 1 | M305 |
| TAPE RECORDER | 1 | D424 |
| | 3 | D438 |
| URINE SEPARATOR POWER CABLE | 3 | D426 |
| | 1 | D428 |
| URINE SEPARATOR | 1 | D428 |
| URINE SEPARATOR MOTOR | 2 | D428 |
| URINE SYSTEM FLUSH DISPENSER | 1 | D428 |
| FLOODLIGHT BULB | 6 | D430 |
| INTERCOM BOX | 2 | D430 |
| WMC CHARCOAL FILTER | 2 | D430 |
| | 2 | D434 |
| MOL SIEVE CHARCOAL FILTER | 2 | D430 |
| | 1 | D432 |
| | 2 | D434 |
| WMC DEBRIS COLLECTOR SCREEN | 20 | D432 |
| | 3 | D434 |
| PLV FAN | 1 | D432 |
| | 8 | D442 |
| FIRE SENSOR | 6 | D432 |
| FIRE SENSOR CONTROL PANEL | 2 | D432 |
| WASTE PROCESSOR CONTROL PANEL | 1 | D436 |
| VAN ALLEN BELT DOSIMETER | 1 | D436 |
| BLOWER UNIT | 1 | D436 |
| H2O GUN | 1 | D438 |
| H2O GUN MOUTHPIECE | 6 | D438 |
| WATER HOSE QUICK DISCONNECT | 3 | D438 |
| WARDROOM WATER DISPENSER VALVE | 1 | D438 |
| WMC WATER DISPENSER VALVE | 1 | D438 |
| SQUEEZER PISTON SEAL | 3 | D438 |
| TRASH DISPOSAL AIRLOCK LID SEAL | 1 | D438 |
| SQUEEZER FLAPPER VALVE | 1 | D440 |
| TRASH DISPOSAL AIRLOCK VENT PLUG SEAL | 1 | D440 |
| VENT SEALING DEVICE O-RING | 4 | D440 |
| WASTE PROCESSOR DOOR SEAL | 3 | D440 |
| DUMP HEATER PROBE | 1 | D440 |
| DUCT HEATER | 1 | D442 |
| WATER HOSE | 1 | D444 |

Figure 2.5.15-2 Spare Parts and Maintenance Supplies

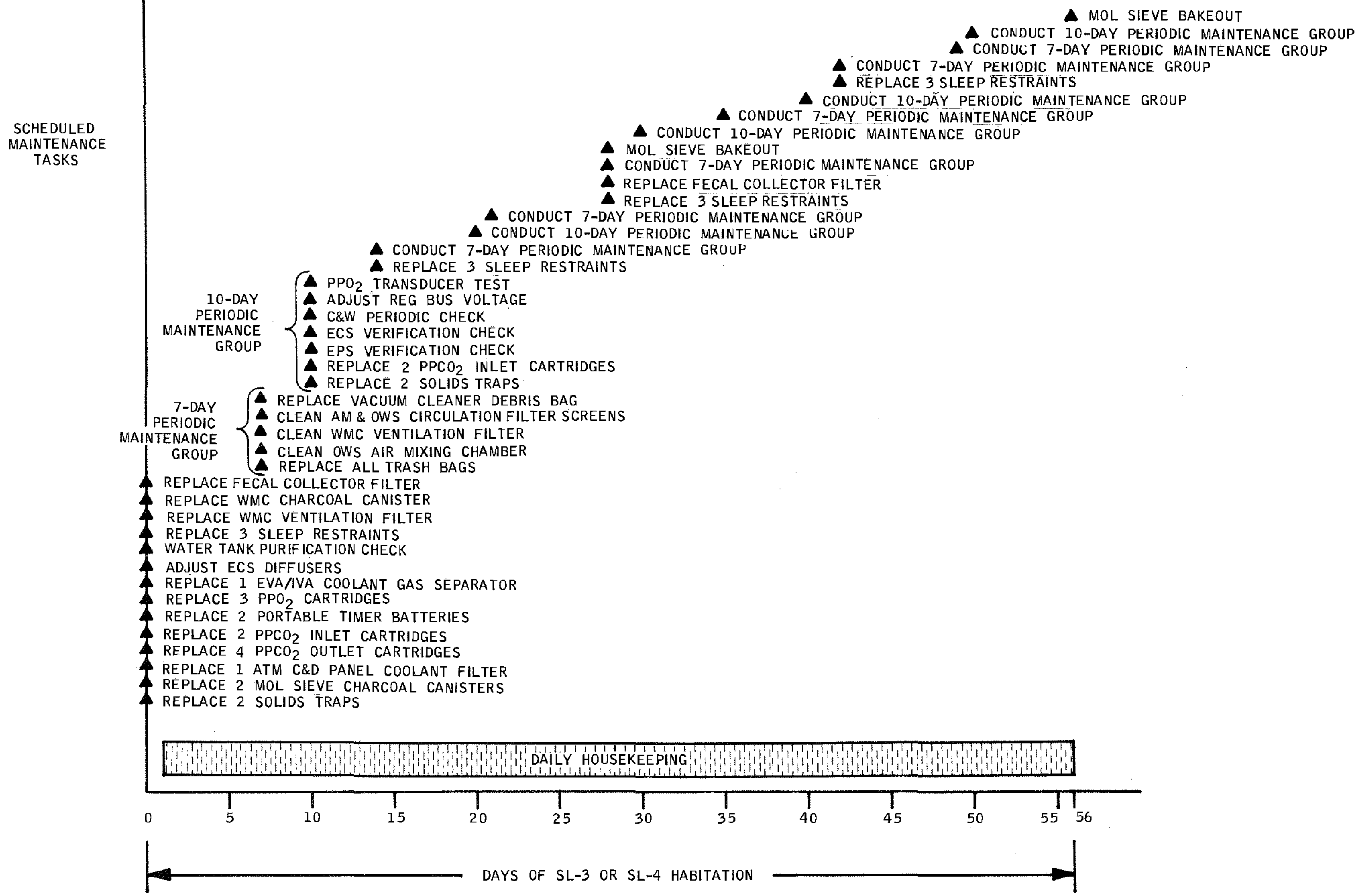


Figure 2.5.15-3 SL-3 and SL-4 Scheduled Maintenance Tasks Timeline

5483

| CLASSIFICATION | REPLACEABLE ITEM |
|---|---|
| ACCESSORIES | TRIANGLE SHOE GRID CLEAT<br>TAPE RECORDER<br>CONDENSATE TANK MODULE<br>DIGITAL DISPLAY UNIT<br>DUCT HEATER<br>PPO2 SENSOR<br>INTERCOM BOX<br>TELEPRINTER<br>TELEPRINTER PAPER CARTRIDGE<br>TELEPRINTER SPOOL<br>URINE & WATER DUMP HEATER PROBES<br>WATER SEPARATOR PLATE<br>WINDOW HEATER CONTROLS<br>WATER HOSE<br>WATER HOSE Q/D<br>VIDEO SWITCH<br>FIRE SENSOR<br>FIRE SENSOR CONTROL PANEL<br>WASTE PROCESSOR CONTROL PANEL<br>VAN ALLEN BELT DOSIMETER |
| FANS | AM HEAT EXCHANGER FAN<br>MDA FAN<br>OWS HEAT EXCHANGER FAN<br>DUCT FAN<br>PORTABLE FAN<br>FECAL/URINE COLLECTOR BLOWER UNIT<br>SUIT DRYER BLOWER UNIT<br>VACUUM CLEANER BLOWER UNIT<br>WMC VENTILATION FAN |
| LIGHTS | 10 WATT BULB<br>20 WATT BULB<br>MDA & OWS FLOODLIGHT BULB |
| SEALS | TRASH DISPOSAL AIRLOCK LID SEAL<br>TRASH DISPOSAL AIRLOCK VENT-PLUG SEAL<br>SQUEEZER PISTON SEAL<br>WASTE PROCESSOR DOOR SEAL<br>VENT SEALING DEVICE O-RING |
| VALVES | H2O GUN<br>WARDROOM WATER DISPENSER VALVE<br>WMC WATER DISPENSER VALVE<br>URINE SYSTEM FLUSH DISPENSER<br>SQUEEZER FLAPPER VALVE |

Figure 2.5.15-4 Unscheduled Maintenance Tasks

2.5.16.2.2.2 Fire Extinguishers

Five portable fire extinguishers are launched in their using locations in the SWS (and one in the CM): one in the MDA above the ATM C&D console; one in the OWS dome adjacent to the OWS hatch, one on the OWS forward compartment floor grid adjacent to the experiment compartment egress opening; one on the experiment compartment/wardroom partition in the experiment compartment; and one on the experiment compartment/sleep compartment partition in the experiment compartment (figure 2.5.16-1). These five extinguishers are located along the escape route from the crew quarters compartments to the CM and are placed in the general area of the fire sensor locations. The fire extinguishers are used to suppress confined fires and to control unconfined fires.

A quick-release mount releases the fire extinguisher as it is removed from its restrained position (figure 2.5.16-2). Rollers on the mount aid in fire extinguisher removal. A launch restraint on the mount restrains the fire extinguisher during launch. The launch restraints are removed upon SWS activation. The MDA fire extinguisher launch restraint is reinstalled at each SWS deactivation for subsequent dockings.
during each SWS deactivation.

The fire extinguisher tank contains an aqueous gel (hydroxy methyl cellulose) to create two cubic feet of fire suppressant foam for a duration of thirty seconds. A freon pre-charge of 250 psi provides extinguishing agent expulsion and is separated from the gel by a polyethylene bellows. A rupture disc at the top of the tank will burst, expelling the gel, if the tank pressure exceeds approximately 350 psi. A rigid, pivotable delivery tube with a composite nozzle is used to direct the foam at the fire. The composite nozzle consists of a spreader nozzle attached to the delivery tube nozzle using a ball-lock mechanism for rapid removal of the spreader nozzle. The spreader nozzle is used to provide wide area coverage of the foam when fighting an unconfined fire. To combat confined fires, as when using the fire ports, the spreader nozzle is removed and the delivery tube nozzle is inserted into the fire port or directed at the fire. To operate the extinguisher, the safety-pin on the hand grip must be removed to allow depressing of the trigger. Once the trigger is depressed, a diaphragm is ruptured which provides a continuous, un-interruptable expulsion of foam. The delivery tube and its composite nozzle are stowed in a clip on the side of the tank when not in use.

2.5.16.2.3 <u>Escape Route Provisions</u>

Egress openings are provided for rapid egress from the crew quarters area toward the CSM (figure 2.5.16-1). Fire extinguishers, Skylab oxygen mask assemblies (SOMA) and secondary O2 packs (SOP) are readily available along the escape route to aid in rapid response to a fire alert. To further isolate a fire to one particular area, the OWS hatch, the AM aft hatch, the AM forward hatch and/or the MDA hatch can be secured into place while traversing the escape route to enhance crew safety. An emergency escape from the crew quarters to the CM, without stopping to obtain any equipment, will take approximately 3 minutes.

2.5.16.2.4 <u>Fire Alert Operations</u>

When a fire alert occurs, the crewmen will translate to either panel 207 or panel 617 to observe the area fire lights. A crewmember then obtains a fire extinguisher and dons an SOMA/SOP while traversing to the fire. Simultaneously the remaining crewmen will isolate affected buses, shut down the atmosphere and/or ventilation control systems, terminate coolant loop operation, and cap gas interchange ducts within the module (MDA, AM or OWS) in which the fire was detected. The crewman arriving at the area of the fire will locate the fire either visually from flame/smoke or using the nearest fire sensor control panel. The fire will then be extinguished through a fire port or by direct application of foam to the fire area. If required, the SWS hatches may be secured into place to isolate the fire to a particular area. If escape to the CSM is necessitated, the crew will enable ground control of all systems to provide continued implementation of corrective action.

2.5.16.3 INFLIGHT MEDICAL SUPPORT SYSTEM

The IMSS provides the equipment and supplies for treatment of illness or injury and provides first aid, resuscitation and supportive measures to aid in the return of a crewman to earth-based facilities in the event of major illness or injury. This is accomplished through use of a drug supply medical kit, treatment equipment medical kit, laboratory equipment medical kit, and diagnostic/treatment equipment. A resupply/return medical kit is also provided for the transporting of medical supplies and samples from/to earth in the CM.

2.5.16.3.1 <u>Drug Supply Medical Kit</u>

The drug supply medical kit stores six drug cans (two per mission) containing six types of medical drugs stowed in stowage compartment W706 and are used to resupply the treatment equipment medical kit with topical drugs for SL-3 and SL-4 missions. Topical drugs and pills are individually packaged and placed in drug cans. The drug can is sealed in a 15 psi environment. A can-opener is stowed in the treatment equipment medical kit for use in opening the drug cans. At the end of each mission, any opened drug cans and their contents will be disposed of in a trash bag. Orally administered drugs are launched in this kit, along with a resupply of topical drugs. The topical drugs for the SL-2 mission are launched in the treatment equipment medical kit.

2.5.16.3.2 <u>Treatment Equipment Medical Kit</u>

The treatment equipment medical kit is stowed in stowage compartment W707 and is used to provide a ready accessibility to drugs which have been transferred from the drug supply medical kit to the treatment equipment medical kit in their pressurized drug cans (paragraph 2.5.16.3.1). At the end of each mission, any opened drugs and drug cans are disposed of in a trash bag. Two cylindrical cans containing two identical minor surgery kits are also provided in the kit to permit extraction of small foreign objects from the skin or for creating and closing small surgical and puncture openings. After use, the minor surgery kit is disposed of. A log book is launched in the OWS flight data file (W742-W745) and is transferred to the treatment equipment medical kit upon SL-2 activation. The log is divided into three removable sections, one for each mission, which is returned with each CM. The log will be used to document the use of the IMSS components.

2.5.16.3.3 Laboratory Equipment Medical Kit

The laboratory equipment medical kit is stowed in stowage compartment W708 and provides a means to perform inflight medical analysis through the use of an incubator, a microscope kit, a slide strainer, a microbiology kit and a hematology/urinalysis kit.

The incubator is permanently mounted in W708 and is used to grow cultures for analysis in isolating micro-organisms to aid in diagnosing the probable cause of a crewman's illness. A slide drying compartment is provided as part of the incubator. Both the slide drying compartment and the incubator have separate control switches, heater power and automatic heater controls which maintain the incubator at 95°F and the slide drying compartment at 158°F. Power is supplied to the incubator/slide drying compartment through a zero-G receptacle which is used in conjunction with a high power accessory cable and high power accessory adapter cable to connect to any HI POWER ACCESSORY OUTLET. If required for use, the incubator/slide drying compartment will be used for a 48-hour period. The microscope kit provides a portable microscope, lenses, slides and slide treatment equipment to aid in micro-organism identification. Slide straining equipment is stowed near the microscope kit to supplement the microscope kit equipment. The microscope uses replaceable batteries to power its light source. A battery supply is stowed in the diagnostic kit.

The microbiology kit provides the equipment to perform antibiotic sensitivity testing as a diagnostic aid in the selection of appropriate medical treatment measures, to collect samples taken from the affected crewman at the time of illness for inflight or post flight analysis, and to obtain environemntal and crew samples throughout the mission. The microbiology kit is portable and has snaps to attach to the work table or to SWS located snaps.

The urinalysis kit provides the equipment and supplies to assist in performing microscopic examination, determining specific gravities of samples and identifying certain body substances. The hematology kit supplies the equipment to obtain white blood cell and homoglobin information. A hemoglobin meter provided in the hematology kit uses replaceable batteries to power its light source. A battery supply is stowed in the diagnostic kit. The hematology/urinalysis kit is portable and is fitted with snaps to attach to the work table or to SWS located snaps.

The laboratory equipment medical kit has a hinged, sheet metal surface for use as a medical workstation. Operational areas are provided on the workstation for mounting the microscope, slides and associated equipment for processing cultures while analysis is being conducted. The workstation folds into the kit when not in use. A cutout on the workstation's surface permits electrical operation of the incubator while the workstation is not in use.

2.5.16.3.4 Diagnostic/Treatment Equipment

The diagnostic/treatment equipment consists of five kits and a work table stowed in stowage compartment W709. The five kits are the diagnostic kit, catheterization kit (stowed inside the therapeutic kit), therapeutic kit, bandage kit and dental kit which provide the additional equipment and supplies to diagnose crewman illness or injury and to subsequently treat the condition. In the event of serious illness or injury, the kits provide the means to implement temporary corrective measures to enhance crewman survival until a return to earth can be accomplished.

The diagnostic kit provides the equipment to perform a physical examination through use of a stethoscope, a blood-pressure measuring device, neurological examination instruments, and eye, ear and oral examination equipment. The diagnostic kit contains an ophthalmoscope,otoscope, and a head-mount light which use replaceable batteries to power their light sources. A battery supply is stowed in the diagnostic kit.

The diagnositc kit is portable and has snaps to attach to the work table or to SWS located snaps.

The catheterization kit and the therapeutic kit contain equipment to remove obstructions from a crewman's breathing passage and to establish a controlled airway in the unconscious crewman. The therapeutic kit contains injectable drugs, syringes and a laryngoscope which uses replaceable batteries to power its light source. A battery supply is stowed in the diagnostic kit. The therapeutic kit is portable and has snaps to attach to the work table or to SWS located snaps.

The bandage kit supplies various configurations of bandages, swabs, dressings, gauze and associated equipment for treating minor injuries and fractures. The bandage kit is portable and has snaps to attach to the work table or to SWS-located snaps.

The dental kit provides dental instruments to cope with inflight dental emergencies such as infections, tooth fractures, etc. A dental mirror light supplied in the kit, uses replaceable batteries to power its light source. A battery supply is stowed in the diagnostic kit. The dental kit is portable and has snaps to attach to the work table or to SWS-located snaps.

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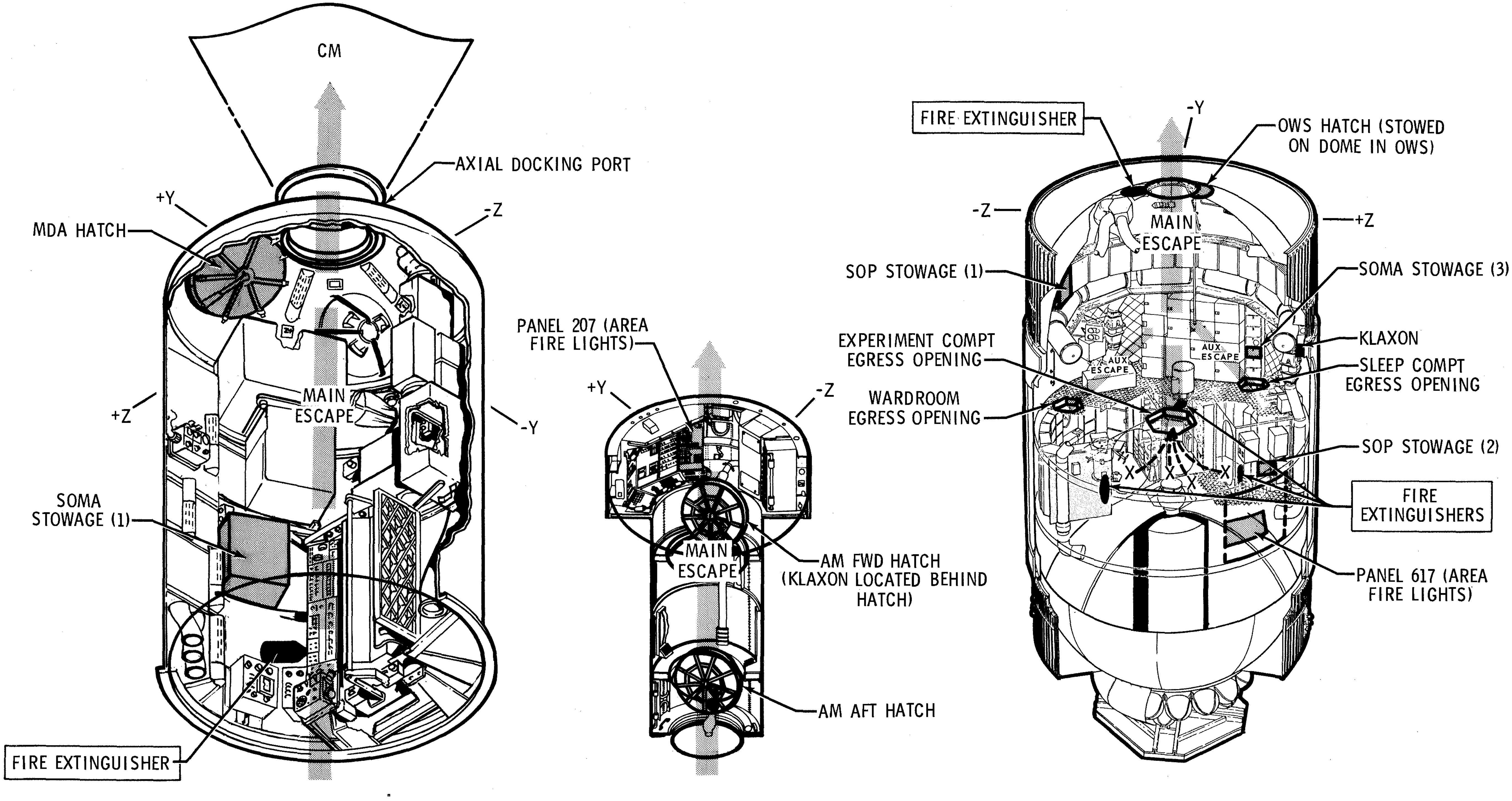
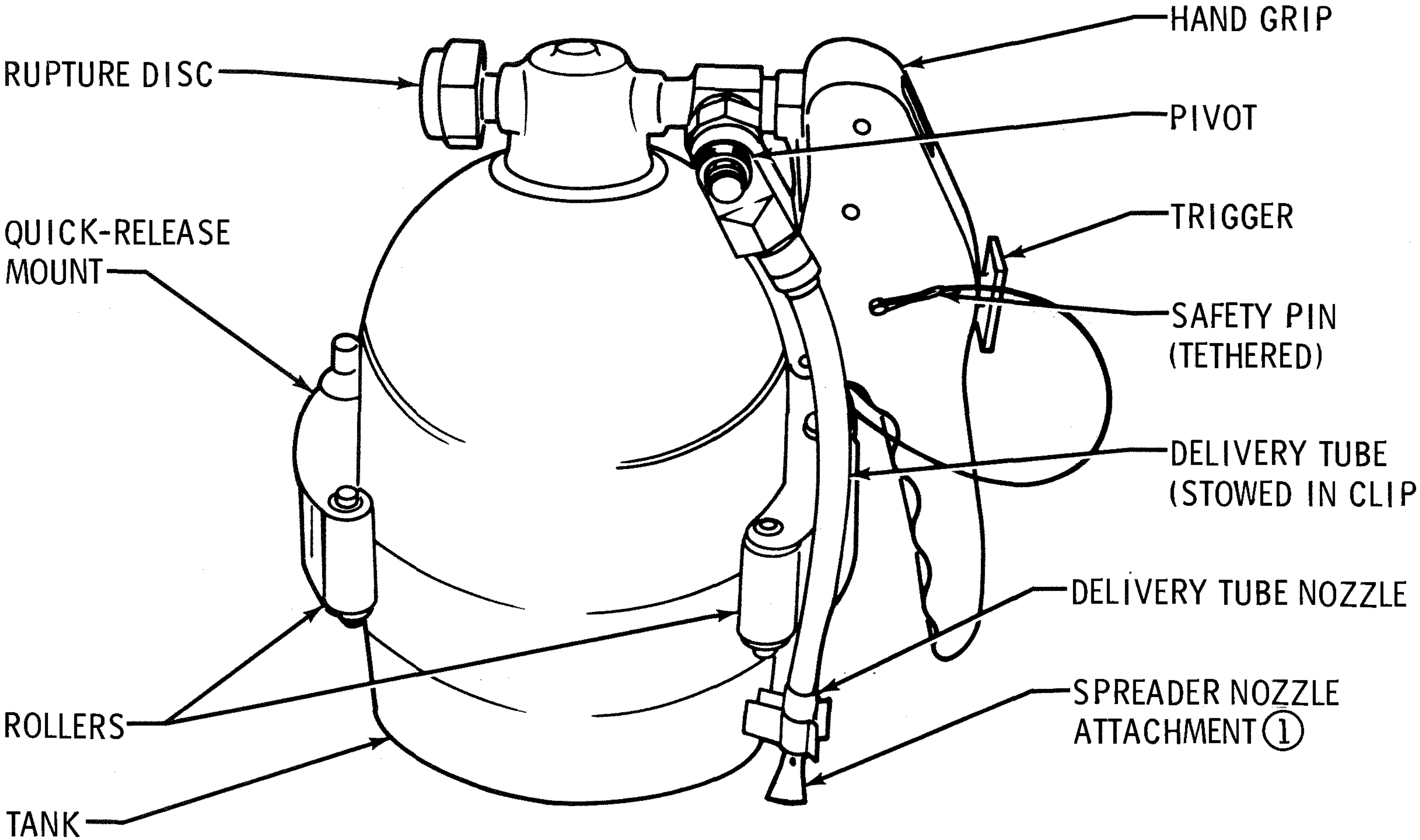



Figure 2.5.16-1 SWS Fire Fighting Provisions




NOTE: ① THE SPREADER NOZZLE CONNECTS TO THE DELIVERY TUBE NOZZLE WITH A QUICK RELEASE BALL-LOCK MECHANISM

Figure 2.5.16-2 Fire Extinguisher

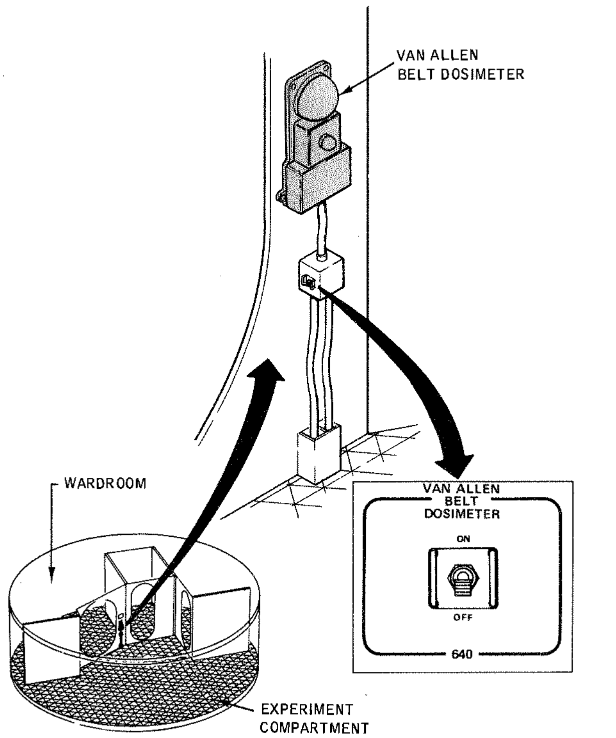



Figure 2.5.16-3 VABD Installation

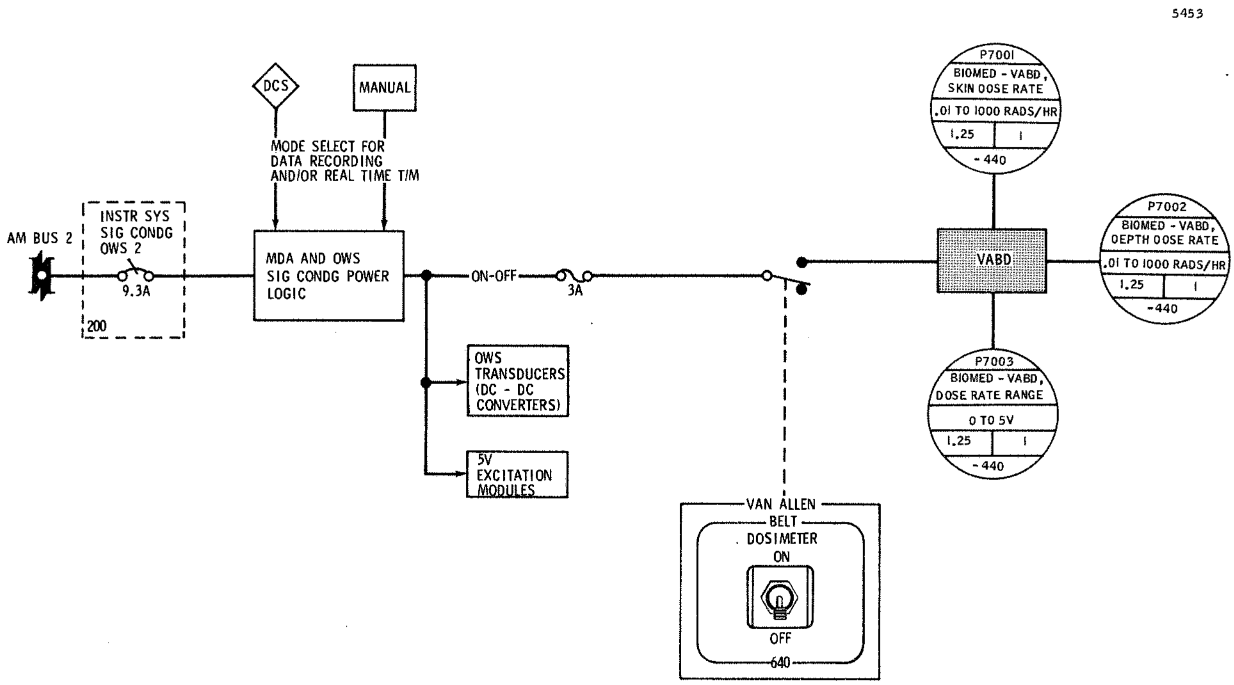



Figure 2.5.16-4 VABD Schematic

A portable work table, stowed in W709, permits medical diagnosis and treatment in areas away from the IMSS stowage compartment. The work table is expandable and provides temporary stowage and restraint of the portable medical kits when performing medical tasks. The work table has a bracket which accepts the installation of the universal mount to facilitate work table restraint on convenient structure (paragraph 2.5.3). The SWS snap-pattern located on the work table serves to restrain the portable kits.

2.5.16.3.5 Resupply/Return Medical Kit

The resupply/return medical kit is used to replenish the non-refrigerated drug provisions in the IMSS at the beginning of each mission and to supply that particular mission with refrigerated drugs packed in pressurized drug cans. At the end of each mission, the kit is used to return to earth specimen samples from the crewman and from the environment for post flight analysis. The resupply/return medical kit is a foam insulated cylinder containing segments of heat-sink material (distilled water) to maintain the contents of the kit in a refrigerated state, until the kit is offloaded on the ground or in the SWS. Upon SWS activation, the resupply/return medical kit will be transferred from the CSM to the wardroom. Here the topical drugs are replenished and the refrigerated drugs are transferred to the FOOD CHILLER (W754) with the resupply/return medical kit, for on-orbit stowage. The kit separates into two halves for stowage in the FOOD CHILLER. At the end of each mission, the unused refrigerated drugs will be disposed of in a trash bag. Also, the heat sink will be removed and placed in WARDROOM FREEZER 1 (W755) for thermal conditioning. Upon SWS deactivation, the cooled heat sink will be placed in the resupply/return medical kit together with returning samples and stowed in the CM. The heat-sink will preserve the samples during the return-to-earth in the CM.

2.5.16.4 VAN ALLEN BELT DOSIMETER

A replaceable Van Allen belt dosimeter (VABD) is located on the experiment compartment/wardroom partition in the experiment compartment and permits ground monitoring of the radiation dosage rate to which the crewmen are exposed (figure 2.5.16-3).

The VABD receives power from AM bus 2 whenever the ground or the crewman desires to operate the data recorder and/or transmit real time telemetry (figure 2.5.16-4).

The VAN ALLEN BELT DOSIMETER [ON-OFF] switch on panel 640 is left in the ON position and the INSTR SYS SIG CONDG OWS 2 circuit breaker on panel 200 is closed throughout the manned and unmanned phases of the Skylab missions to provide power for continuous radiation monitoring; however, due to instrumentation system reconfigurations during unmanned phases, the VABD will only operate periodically. The VAN ALLEN BELT DOSIMETER switch will be temporarily positioned OFF if VABD maintenance is required. In the event that the VABD fails, a spare is provided in a spare parts stowage compartment in the OWS forward dome.

The VABD will transmit to the ground the radiation dosage rate impinging on the crewmen's skin and the radiation dosage rate the crewmen are receiving at bone depth. Although this information is accurate only for the immediate area around the VABD, the data is extrapolated to provide crew dosage rates throughout the SWS. Radiation dosage will be detected during each pass over the South Atlantic Anomoly, at the uppermost northern and southern latitude nodes, and in the event that a solar flare occurs. The crew is limited to a maximum dosage rate. If this rate is exceeded, the crew will transfer to the CM where additional protection is provided by the shielding on the CM. These excessive dosage rates are not expected to be encountered during the Skylab mission durations. The VABD will be used in conjunction with the radiation survey meter and the personal radiation dosimeters (refer to SLOH/CSM for details).

2.5.17 INSTRUMENTATION AND GROUND COMMANDS

See table 2.5.17-1 for a complete listing of the crew system measurements. Table 2.5.17-2 is a complete list of the digital commands associated with crew systems.

TABLE 2.5.17-1 INSTRUMENTATION LIST

| NO. | MEASUREMENT NUMBER | DESCRIPTION | TELEMETER RANGE | ONBOARD DISPLAY | |
|---|---|---|---|---|---|
| | | | | DISPLAY RANGE | PANEL NO. |
| | C7000-442 | TEMP-RS, URINE CHILLER NO. 1 | 25 to 100°F | | |
| | C7001-442 | TEMP-RS, URINE CHILLER NO. 1 | | 30 to 70°F | 616 |
| | C7002-442 | TEMP-RS, URINE CHILLER NO. 2 | 25 to 100°F | | |
| | C7003-442 | TEMP-RS, URINE CHILLER NO. 2 | | 30 to 70°F | 616 |
| | C7004-442 | TEMP-RS, URINE CHILLER NO. 3 | 25 to 100°F | | |
| | C7005-442 | TEMP-RS, URINE CHILLER NO. 3 | | 30 to 70°F | 616 |
| | C7006-442 | TEMP-RS, URINE FREEZER | -25 to 40°F | | |
| | C7007-442 | TEMP-RS, URINE FREEZER | | -40 to 10°F | 616 |
| | C7022-436 | TEMP-FMS, FOOD STWG FRZR COMPT 1 | | -40 to 10°F | 616 |
| | C7023-436 | TEMP-FMS, FOOD STWG FRZR COMPT 2 | | -40 to 10°F | 616 |
| | C7024-436 | TEMP-FMS, FOOD STWG FRZR COMPT 3 | | -40 to 10°F | 616 |
| | C7025-443 | TEMP-FMS, WR FOOD FRZR COMPT 1 | | -40 to 10°F | 616 |
| | C7026-443 | TEMP-FMS, WR FOOD FRZR COMPT 2 | | -40 to 10°F | 616 |
| | C7027-443 | TEMP-FMS, WR FOOD CHILLER COMPT | | 30 to 70°F | 616 |

TABLE 2.5.17-1 INSTRUMENTATION LIST (cont'd)

| NO. | MEASUREMENT NUMBER | DESCRIPTION | TELEMETER RANGE | ONBOARD DISPLAY DISPLAY RANGE | ONBOARD DISPLAY PANEL NO. |
|---|---|---|---|---|---|
| | C7281-436 | TEMP-FMS, FOOD STOR FRZR COMPT 1 | -25 to 40°F | | |
| | C7282-436 | TEMP-FMS, FOOD STOR FRZR COMPT 2 | -25 to 40°F | | |
| | C7283-436 | TEMP-FMS, FOOD STOR FRZR COMPT 3 | -25 to 40°F | | |
| | C7284-443 | TEMP-FMS, WR FOOD FRZR COMPT 1 | -25 to 40°F | | |
| | C7285-443 | TEMP-FMS, WR FOOD FRZR COMPT 2 | -25 to 40°F | | |
| | C7298-443 | TEMP-FMS, WR FOOD FRZR CH COMPT | 25 to 55°F | | |
| | D7103-438 | PRESS-WMS, W PRCSR EXH LINE OUT | 0 to .2 PSIA | | |
| | D7104-442 | PRESS-WMS, W PRCSR EXH LINE INL | | 0 to .2 PSIA | 800 |
| | D7106-406 | PRESS-PCS, WASTE TANK, LOW RANGE | 0 to .2 PSIA | | |
| | D7107-406 | PRESS-PCS, WASTE TANK, SENSOR 1 | 0 to 50 PSIA | | |
| | D7108-406 | PRESS-PCS, WASTE TANK, SENSOR 2 | 0 to 50 PSIA | | |
| | D7124-443 | PRESS-WS, WARDROOM DUMP LINE | | 0 to 2 PSIA | 700 |
| | D7125-442 | PRESS-WS, WMC DUMP LINE | | 0 to 2 PSIA | 800 |
| | K324-512 | EVENT DCS 04, LIGHTING-DOCK GRP 1 | 0 or 28 VDC | | |
| | K325-512 | EVENT DCS 05, TRAK LTS TX OFF/ARM | 0 or 28 VDC | | |
| | K348-512 | EVENT DCS 28, LIGHTING-DOCK GRP 2 | 0 or 28 VDC | | |
| | K7330-440 | EVENT-DUMP HEATER ON | | ON = DUMP | 617 |
| | K7331-442 | EVENT-WS, WMC DUMP HEATER ON | | ON = DUMP | 800 |
| | K7332-443 | EVENT-WS, WR DUMP HEATER ON | | ON = DUMP | 700 |
| | K7333-442 | EVENT-WMS, URINE DUMP HEATER ON | | ON = DUMP | 800 |
| | L7008-436 | LEVEL-WS, WATER CONTAINER 1 | 0 to 100% | | |
| | L7009-436 | LEVEL-WS, WATER CONTAINER 2 | 0 to 100% | | |
| | L7010-436 | LEVEL-WS, WATER CONTAINER 3 | 0 to 100% | | |
| | L7011-436 | LEVEL-WS, WATER CONTAINER 4 | 0 to 100% | | |
| | L7012-436 | LEVEL-WS, WATER CONTAINER 5 | 0 to 100% | | |
| | L7013-436 | LEVEL-WS, WATER CONTAINER 6 | 0 to 100% | | |
| | L7014-436 | LEVEL-WS, WATER CONTAINER 7 | 0 to 100% | | |
| | L7015-436 | LEVEL-WS, WATER CONTAINER 8 | 0 to 100% | | |
| | L7016-436 | LEVEL-WS, WATER CONTAINER 9 | 0 to 100% | | |
| | L7017-436 | LEVEL-WS, WATER CONTAINER 10 | 0 to 100% | | |
| | M314-522 | VOLT, TRACKING LIGHT 1 | 0 to 5 VDC | | |
| | M315-522 | VOLT, TRACKING LIGHT 2 | 0 to 5 VDC | | |
| | M316-522 | VOLT, TRACKING LIGHT 3 | 0 to 5 VDC | | |
| | M317-522 | VOLT, TRACKING LIGHT 4 | 0 to 5 VDC | | |
| | P7001-440 | BIOMED-VABD, SKIN DOSE RATE | .01 to 1000 RACS/HR | | |
| | P7002-440 | BIOMED-VABD, DEPTH DOSE RATE | .01 to 1000 RACS/HR | | |
| | P7003-440 | BIOMED-VABD, DOSE RATE RANGE | 0 to 5 VDC | | |

TABLE 2.5.17-2 DCS COMMAND LIST

| DCS COMMAND | COMMAND TITLE | FUNCTION | OCTAL CODE |
|---|---|---|---|
| 4-1 | LIGHTING - DOCKING GROUP 1 | OFF<br>ON | 760<br>761 |
| 28-4 | LIGHTING - DOCKING GROUP 2 | OFF<br>ON | 766<br>767 |
| S210 | PRIMARY TRACKING LIGHTS | ON | 42260 |
| S293 | SECONDARY TRACKING LIGHTS | ON | 45304 |
| S211 | TRACKING LIGHTS | OFF | 46260 |
| S292 | TRACKING LIGHTS AUTO SWITCHOVER | DISABLE | 41304 |
| 5-1 | TRACKING LIGHTS TX FUNCTION | OFF<br>ARM | 710<br>711 |
| 343<br>347 | EVA LIGHTS POWER | INHIBIT<br>ENABLE | 40177<br>40002 |

2.5.18 FAILURE MODES

(TBS)

2.5.19 PERFORMANCE AND DESIGN DATA

(TBS)

2.5.20 OPERATIONAL LIMITATIONS AND RESTRICTIONS

(TBS)

SUBSECTION 2.6

INSTRUMENTATION SYSTEM

2.6.1 INTRODUCTION

The instrumentation system monitors the Multiple Docking Adapter/Airlock Module/Orbital Workshop (MDA/AM/OWS) systems, provides data for onboard displays and onboard storage, and transmits real time (R/T) pulse code modulation (PCM), delayed time (D/T) PCM, and D/T voice to the Manned Space Flight Network (MSFN).

The data monitored can be grouped into four categories:

- o Spacecraft systems parameters
- o Event occurence
- o Crew biomedical
- o Experiment

The instrumentation system consists of the power, PCM, recording, and transmission subsystems.

2.6.2 SYSTEM INTERFACES

Because the instrumentation system is a monitoring/data acquisition system, it interfaces with all other systems in terms of measurements (pressure, temperature, etc.)

Figure 2.6.2-1 depicts the interfaces with other systems. The Communication System provides the antennas for transmission to the MSFN and audio voice inputs for tape recording. The Digital Command System/Time Reference System (DCS/TRS) provides control discretes from the MSFN and time reference signals. The time is used for correlation of all R/T and D/T PCM and D/T VOICE. The Environmental Control System (ECS) provides thermal conditioning for the equipment. The Electrical Power System (EPS) supplies 24 to 30 vdc power. The instrumentation system takes elapsed time from the DCS/TRS and reconstitutes it into an output to experiments. The instrumentation system also provides recording capability on its tape recorders for experiment PCM outputs. Other experiment requirements (such as voice recording, time correlation, spacecraft system data, environmental conditions, and high sample rate recordable format allocations) are satisfied by the instrumentation system. The Crew System routes and controls power to EVA or IVA crewmen for biomedical measurements.

6002

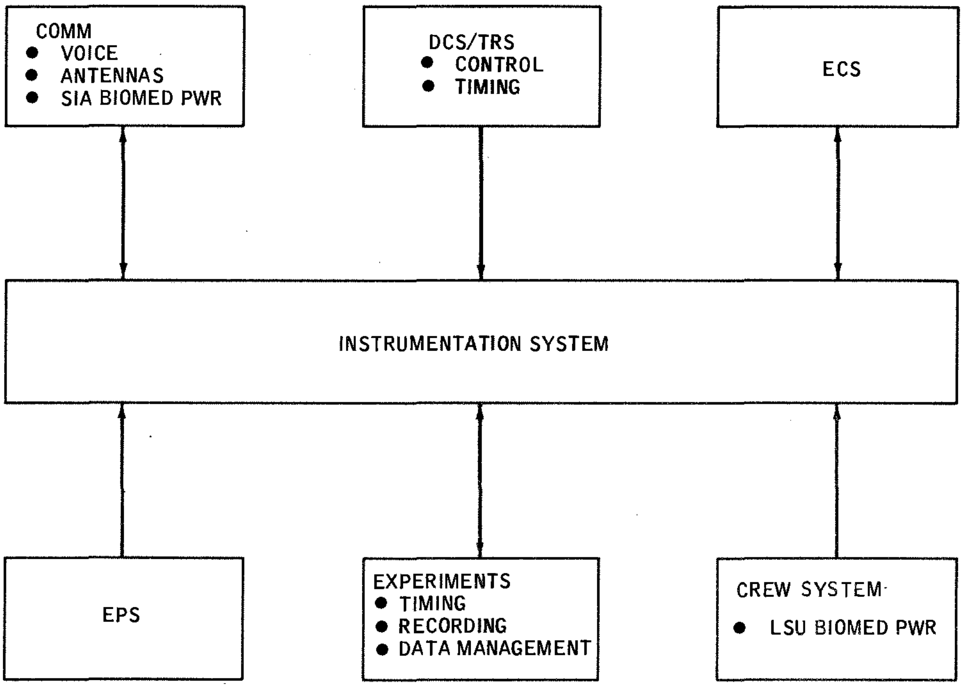



Figure 2.6.2-1 System Interfaces

2.6.3 FUNCTIONAL DESCRIPTION

The instrumentation system performs two basic functions: supplying signals to onboard displays and processing telemetry (TM) and voice signals for transmission to the MSFN. The TM provides the parameters necessary to determine the operational status of the various systems. Figure 2.6.3-1 illustrates the basic system.

2.6.3.1 POWER SUBSYSTEM (Figure 2.6.3-2)

The power subsystem consists of the MDA signal conditioner, three AM DC-DC converters, two AM panel indicator DC-DC converters, nine OWS DC-DC converters, and associated control and selection logic. During tape recording or transmission operations, the AM DC-DC converters supply conditioned power to the PCM subsystem and AM tape recorders. The AM panel indicator DC-DC converters supply conditioned power to the AM panel indicator transducers when the AM DC-DC converters are not active. The OWS displays are powered by the OWS display subsystem independent of the instrumentation system. On/off control of the subsystem power supplies is controlled from MSFN commands or manual switch operations for tape recording or transmissions.

2.6.3.1.1 MDA Signal Conditioner

The MDA signal conditioner, consisting of four 6.6-vdc power supplies, is used to power temperature transducers in the MDA. The input power is supplied from AM bus 2 by the SIGNAL CONDITIONING - MDA circuit breaker (panel 200). The power supplies are turned on automatically any time R/T TM or tape recording is initiated.

2.6.3.1.2 AM DC-DC Converters

Each of the three DC-DC converters provides outputs of +5 vdc, +24 vdc, and -24 vdc. The input power for converter 1 is from AM bus 1 by CONVERTERS 1 circuit breaker (panel 200). Converters 2 and 3 are powered from AM bus 2 by CONVERTERS 2 and 3 circuit breakers, respectively (panel 200).

Two converters are always selected for operation at all times. One is positioned to supply regulated power to INST bus A and the other to INST bus B. Selection of converters can be accomplished by either MSFN or onboard control. The CMD position on the CONVERTERS switch (panel 204) allows MSFN selection. Operationally, the converters are turned on automatically any time there is a system requirement for their outputs. These requirements originate from tape recording or transmission operations of the system.

2.6.3.1.3 AM Panel Indicator DC-DC Converters

Each of the two DC-DC converters provides outputs of +5 vdc, +24 vdc, and -24 vdc. The input power for the primary and secondary units is from AM buses 1 and 2 through DISPLAY CONVERTERS INPUT - PRI and SEC circuit breakers (panel 200), respectively. During unmanned portions of the mission, the DISPLAY CONVERTER switch (panel 204) is in the OFF position, disabling both converters. In either the PRI or SEC position, the selected converter is assigned to supply power for some AM panel indicator transducers when the AM DC-DC converters are inactive. One of the AM DC-DC converters is automatically assigned to power some AM panel indicator transducers when the PCM subsystem is activated.

2.6.3.1.4 OWS DC-DC Converters

Each of the nine DC-DC converters provides an output of 5 vdc. The input power for units 1, 2, 3, 4, and 5 is from AM bus 1 through SIGNAL CONDITIONING - OWS 1 circuit breaker (panel 200). The input power for units 6, 7, 8, and 9 is from AM bus 2 through SIGNAL CONDITIONING - OWS 2 circuit breaker (panel 200). Each unit also is protected by a 3-ampere fuse on its input power line. The converters are turned on automatically any time R/T TM or tape recording is initiated.

2.6.3.1.5 Transducer Group and PCM Bus Select Logic

The PCM bus select logic is controlled by ground commands only. The logic selects INST bus A or B for input power to the PCM subsystem and tape recorders. This logic in conjunction with the AM DC-DC converter selection logic, selects the converters that supply power to the system. The normal operating mode is BUS A select. In this mode, the PCM bus is supplied by INST bus A for the programmer, interface box and the DATA recorder. The EXP RCDR bus is supplied by INST bus B for the EXP 1 and EXP 2 recorders.

Transducer group 1 and 2 bus select logic, which is controlled by ground commands only, selects either INST bus A or B, independently, for transducer group 1 and 2 input power. The normal operating mode is with both transducer groups powered by INST bus A. Each transducer group has circuit breakers on each of the three regulated voltage output lines for use in fault isolation. The circuit breakers are TRANSDUCER GROUP 1 (2), +5V, +24V, and -24V (panel 200).

2.6.3.1.6 OWS Multiplexer Heaters

Each of the 12 multiplexers mounted in the OWS requires a thermostatically controlled electric heater to maintain acceptable temperature limits. Each heater is protected by a 3-ampere fuse. OWS MUX HEATERS 1 and 2 circuit breakers (panel 200) each supply AM buses 1 and 2 power to six heaters. AM bus 1 heaters are for low level multiplexers B, L, M, and Q and high level multiplexers E and K. AM bus 2 heaters are for low level multiplexers D, H, and J and high level multiplexers D, J, and T. The thermostats open at 50 $\pm$ 5°F and close at 35 $\pm$ 5°F.

6013

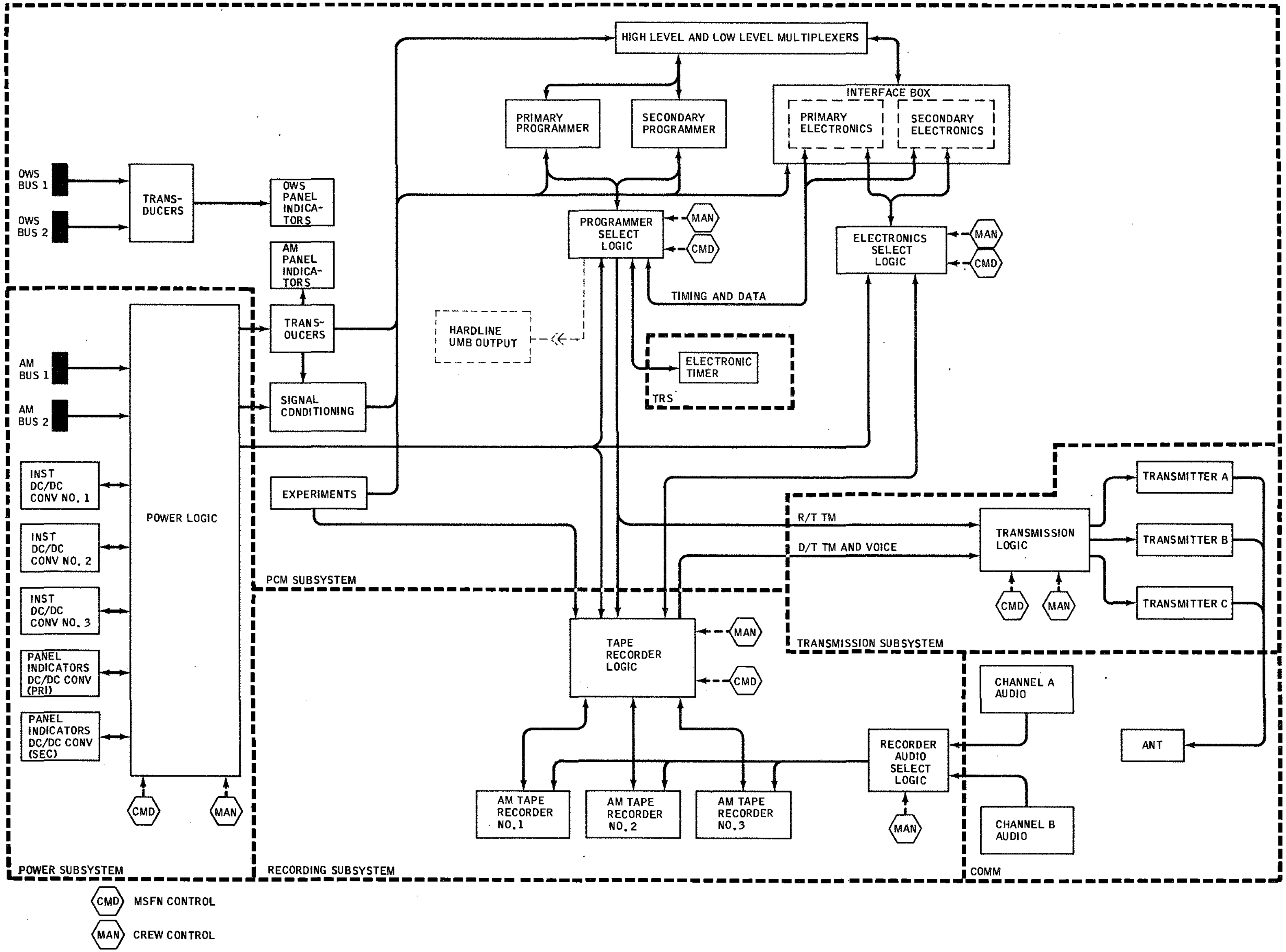



Figure 2.6.3-1 Functional Schematic

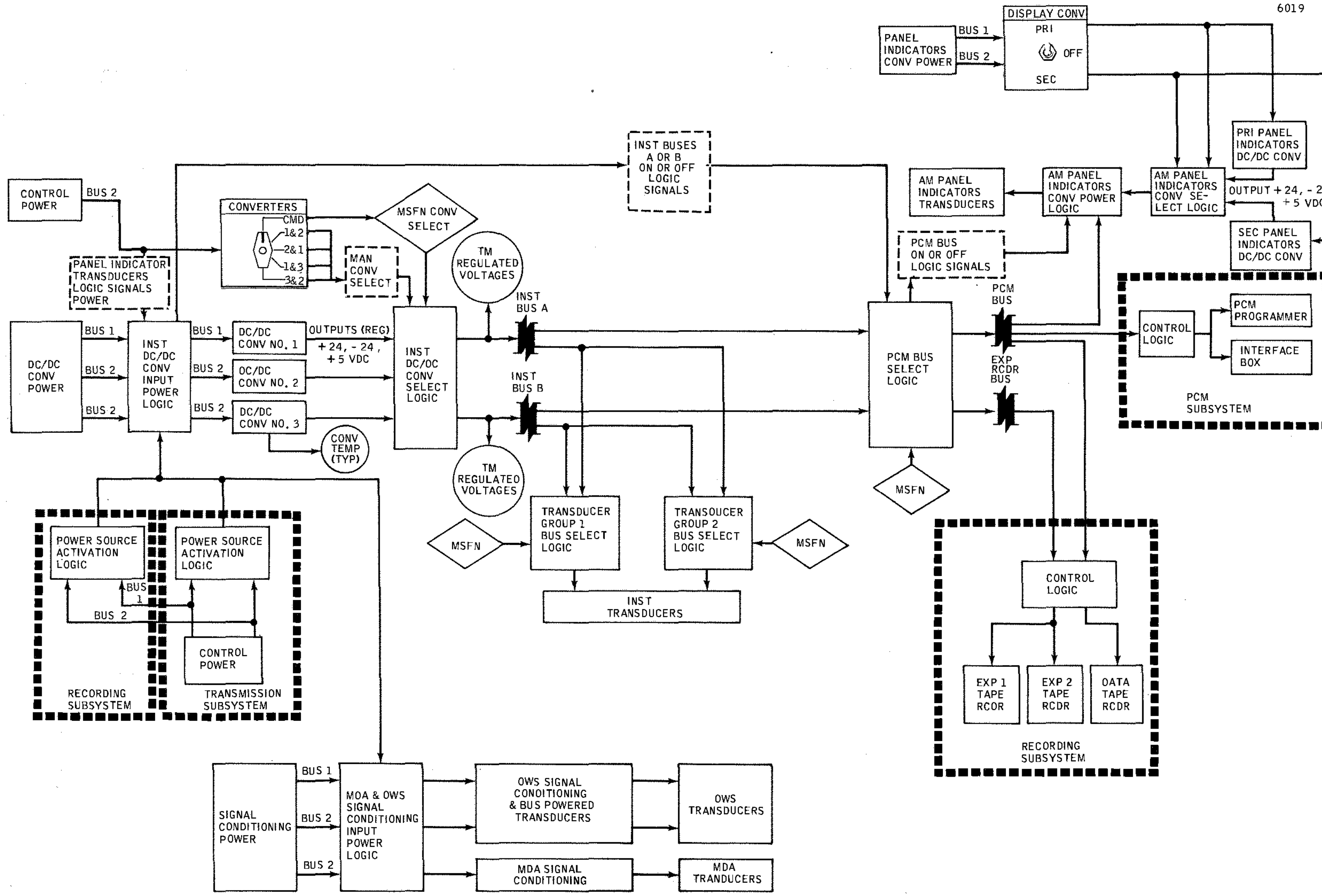



Figure 2.6.3-2 Power Subsystems

2.6.3.2 PCM SUBSYSTEM (Figure 2.6.3-3)

The PCM subsystem, consisting of the transducers, signal conditioners, multiplexers, programmers and interface box, is the heart of the system. It performs the tasks of:

- o Gathering all measurements
- o Conditioning transducer outputs to be compatible for input to a multiplexer
- o Encoding and formating of all measurements
- o Analog to digital conversion
- o Reconstituting elapsed time for outputting to experiments M509 and T013
- o Providing a 51.2-kbps real time bit stream to the transmission subsystem
- o Providing four recordable subframes to the recording subsystem

The elapsed time, reconstituted by the interface box for experiments, is a 24-bit parallel time word. It is updated every 100 milliseconds by the interface box.

The 51.2-kbps real time output to the transmission subsystem is the output, in digital 8-bit word form, of all measurements in the system. A complete sampling of all measurements requires 2.4 seconds.

The four recordable subframe outputs to the recording subsystem are at 5.12-kbps. Subframe 1 is known as DATA. It contains housekeeping systems, biomedical, and event occurence measurements. Subframe 2 is the primary experiment monitoring subframe in the system. It is time shared by the recording subsystem onto the EXP 1 tape recorder. Subframe 3 is for supplemental experiment monitoring. It consists of only two 320-samples-per-second (SPS) high-level analog channels. It is an output to the recording subsystem time shared onto the EXP 2 tape recorder. Subframe 4, also known as DATA 2, contains supplemental housekeeping measurements. It is also time shared onto the EXP 2 tape recorder.

2.6.3.2.1 Programmer and Electronics Select Logic

The programmers are selected manually by placing the PROGRAMMER switch (panel 204) in either the PRI or SEC position. Placing the switch in CMD enables MSFN control of the selection. The interface box redundant electronics are selected manually by placing the ELECTRONICS switch (panel 204) in either the PRI or SEC position. Placing the switch in the CMD position enables MSFN control of the selection. The CMD position is the normal operating mode.

Manual control power for the electronics select logic is obtained from AM bus 2 through the CONTROL ELECTRONICS MAN circuit breaker (panel 200). MSFN control power for the electronics select logic is obtained from AM bus 1 through the CONTROL ELECTRONICS CMD circuit breaker (panel 200). Manual control power for the programmer select logic is obtained from AM bus 2 through the CONTROL PROGRAMMER MAN circuit breaker (panel 200). MSFN control power for the programmer select logic is obtained from AM bus 1 through the CONTROL PROGRAMMER CMD circuit breaker (panel 200).

Both the active programmer and active interface box electronics are powered by -24 vdc from the PCM bus in the power subsystem.

2.6.3.3 RECORDING SUBSYSTEM (Figure 2.6.3-4)

The recording subsystem consists of tape recorders, recorder selection logic, and tape recording logic. This subsystem has the responsibility of providing information storage capability onboard primarily when the vehicle is out of contact with MSFN stations.

2.6.3.3.1 Tape Recorders

There are three identical two-track tape recorders available for use in the AM. The tracks are identified as A and B. Track A can record PCM inputs of 5.12 kbps or 5.76 kbps. Track B can record voice inputs from 300 to 3000 Hz. There are three modes of operation for each recorder:

| | |
|---|---|
| Record | - Forward running tape at 1 7/8 ips, erasing old data and recording new |
| Playback or dump | - Reverse running tape at 22 times record speed. A playback discrete to enter this mode will override the record mode |
| Fast forward or rewind | - Same tape speed as playback; however, in the record direction. Data will not be erased or recorded. This mode of operation has top priority in the recorder, overriding both a record and a playback, and can be initiated only by MSFN. |

2.6.3.3.2 Tape Recorder Selection

Tape recorder selection is controlled by MSFN or by the crew. With the TAPE RECORDERS - CONTROL switch (panel 204) in the CMD position, MSFN can select tape recorders in combinations as shown:

| #1 | #2 | #3 |
|---|---|---|
| DATA/VOICE | EXP 1/VOICE | EXP 2 |
| DATA/VOICE | EXP 2 | EXP 1/VOICE |
| EXP 1/VOICE | DATA/VOICE | EXP 2 |
| EXP 1/VOICE | EXP 2 | DATA/VOICE |

In the MANUAL SELECT position the crew has full flexibility of selections, including OFF.

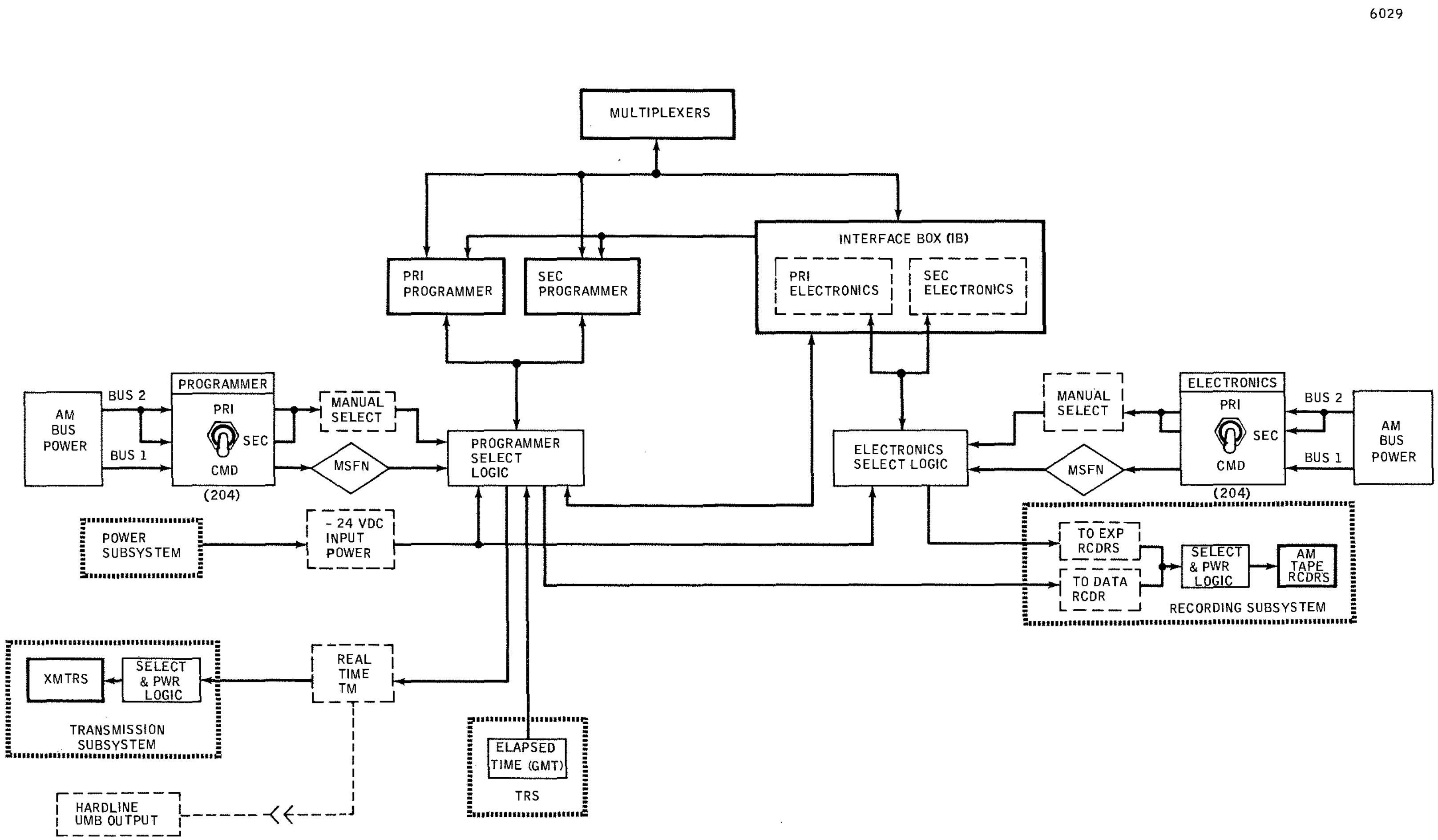



Figure 2.6.3-3 PCM Subsystem

6018

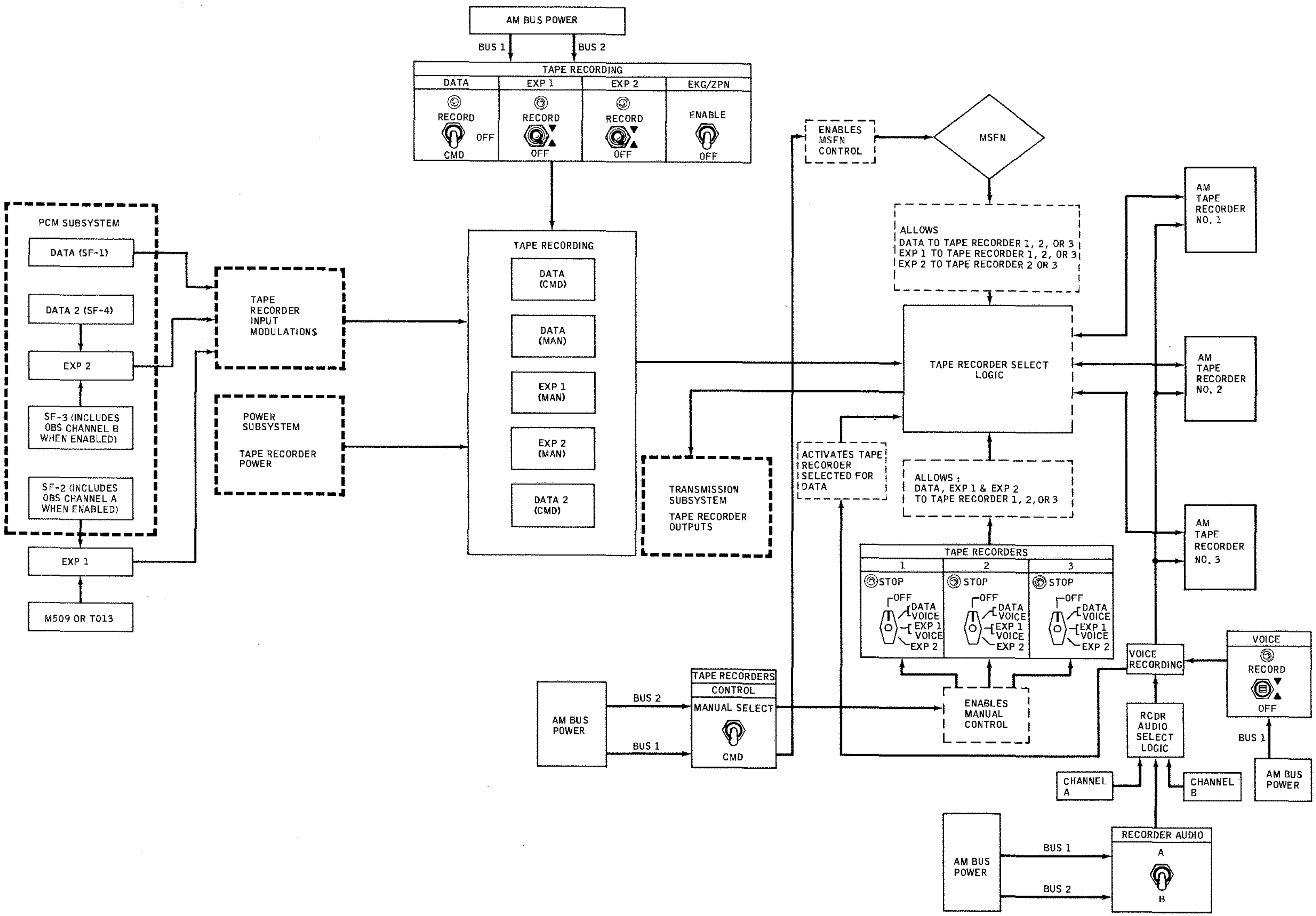



Figure 2.6.3-4 Recording Subsystem

2.6.3.3.3 Tape Recording (Figure 2.6.3-5)

2.6.3.3.3.1 DATA and DATA 2

DATA recording is the operation of storing on the selected DATA/VOICE tape recorder the subframe 1 output from the PCM subsystem. It is controlled from MSFN or by the crew depending on the position of the TAPE RECORDING DATA switch (panel 204). The CMD position enables MSFN recording; the RECORD position accomplishes a crew-desired recording. In either the CMD or RECORD position, MSFN is enabled for recording DATA 2 on the EXP 2 selected recorder if it is not in use by the crew. In the OFF position, neither DATA or DATA 2 may be recorded. The OFF position, however, does not prohibit DATA from being recorded in support of a crew-initiated VOICE recording.

2.6.3.3.3.2 VOICE

VOICE recording is the operation of applying the selected audio communication channel A or B as determined by the RECORDER AUDIO switch (panel 204) to the DATA/VOICE recorder for onboard storage. When VOICE recording is initiated at any one of the 13 intercom boxes or by the VOICE switch (panel 316), the same operation takes place as a DATA recording; in addition, VOICE is directed to the "B" track of all three tape recorders. Either or both of the other two recorders will also record VOICE on their "B" tracks if they are running in a record mode.

2.6.3.3.3.3 EXP 1

EXP 1 recording is the operation of storing onboard either subframe 2 from the PCM subsystem or experiments M509 or T013 PCM bit streams. Subframe 2 is selected by positions A, B, C, D, or E on the MODE SELECT - EXP 1 switch (panel 617); M509 is selected with position G and T013 with position H. Positions A through E also select several high sample rate experiment measurements for input into subframe 2. EXP 1 recording can be initiated from any of three onboard locations: TAPE RECORDING - EXP 1 switch (panel 204), and TAPE RECORDERS - EXP 1 switches (panels 542 and 617). Termination of recording must be accomplished from the same module (AM or OWS) from which it was initiated. When VOICE and EXP 1 recordings are both initiated, VOICE will be recorded on track "B" of the selected EXP 1/VOICE recorder.

2.6.3.3.3.4 EXP 2

EXP 2 recording is the operation of storing onboard the subframe 3 output of the PCM subsystem. Two high sample rate experiment measurements are time shared inputs to subframe 3. They are selected by the crew utilizing the MODE SELECT - EXP 2 switch (panel 617). EXP 2 recording can be initiated from any of three onboard locations: TAPE RECORDING - EXP 1 switch (panel 204) and TAPE RECORDERS - EXP 1 switches (panels 542 and 617). Termination of recording must be accomplished from the same module (AM or OWS) from which it was initiated. When VOICE and EXP 2 recordings are both initiated, VOICE will be recorded on track "B" of the selected EXP 2 recorder.

2.6.3.3.3.5 Operational Biomedical System (OBS)

The capability exists for simultaneously recording the physiological measurements of two crewmen. The measurements include heart rate, body temperature, subject identification (ID), impedance pneumograph (ZPN), and electrocardiogram (EKG). OBS channels A and B parallel entirely the audio channels A and B except at EVA panels 317 and 323. Panel 317 entirely contains OBS channel A and panel 323 contains OBS channel B. The heart rate, ID, and body temperature for both OBS channels are recorded as part of subframe 1 on the DATA recorder. The EKG and ZPN for both channels are assigned to R/T TM only when the TAPE RECORDING - EKG/ZPN switch (panel 204) is in the OFF position. With the switch in the ENABLE position, EKG and ZPN for OBS channel A are time shared onto subframe 2 in lieu of two high sample rate experiment measurements selected by the MODE SELECT -EXP 1 switch (panel 617) in the OWS. OBS channel B's EKG and ZPN are time-shared in the same manner with measurements of the MODE SELECT - EXP 2 switch (panel 617). During an OBS recording, experiments M092, M093, M131, M171, M509, T013, and S073/T027 photometer cannot be recorded.

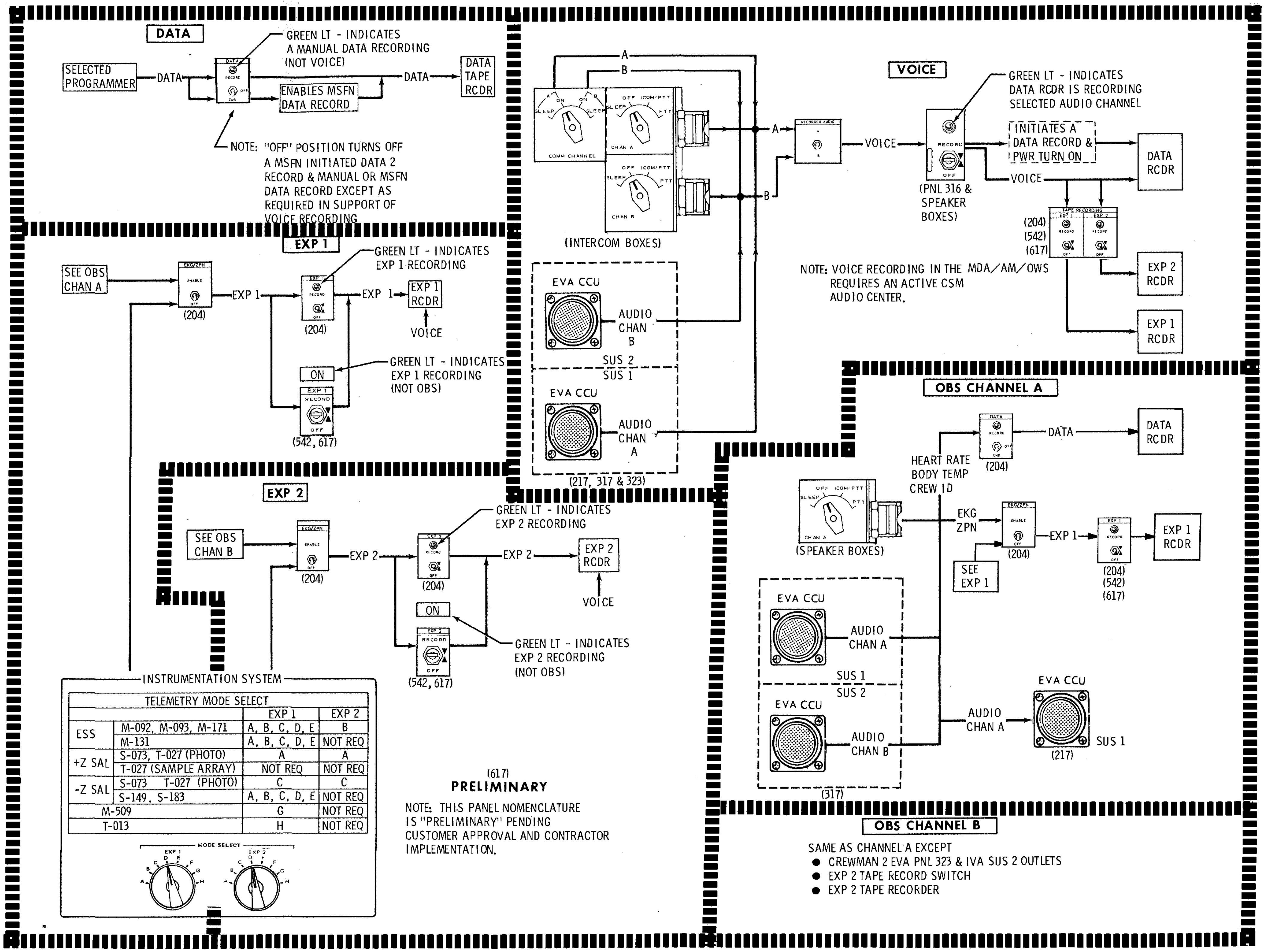
2.6.3.4 TRANSMISSION SUBSYSTEM (Figure 2.6.3-6)

The transmission subsystem has the responsibility of downlinking to MSFN R/T TM and all stored information onboard in the recording subsystem. This subsystem can either be controlled by the MSFN or by the crew. There are four transmitters in the system: a 230.4-MHz (2-watt) launch and a 230.4-MHz (10-watt) orbit, both identified as transmitter A; a 246.3-MHz (10-watt) transmitter B, and a 235.0-MHz (10-watt) transmitter C.

2.6.3.4.1 Launch/Orbit Transmitter Selection

Sequentially, following in the launch of SL-1, the "A" orbit transmitter is selected by MSFN. The 10-watt transmitters are not used during launch because of corona in the quadriplexer and coaxial switches. The 2-watt transmitter is used during launch and early initial orbit. AM TM transmission must be interrupted, allowing coaxial switches to be operated without RF power applied for this selection. In addition to switching the transmitter input power and modulation, this selection logic also transfers a coaxial switch in the output modulation and carrier line.

6202




| TELEMETRY MODE SELECT | | EXP 1 | EXP 2 |
|---|---|---|---|
| ESS | M-092, M-093, M-171 | A, B, C, D, E | B |
| | M-131 | A, B, C, D, E | NOT REQ |
| +Z SAL | S-073, T-027 (PHOTO) | A | A |
| | T-027 (SAMPLE ARRAY) | NOT REQ | NOT REQ |
| -Z SAL | S-073 T-027 (PHOTO) | C | C |
| | S-149, S-183 | A, B, C, D, E | NOT REQ |
| M-509 | | G | NOT REQ |
| T-013 | | H | NOT REQ |

Figure 2.6.3-5 Tape Recording Flow Diagram

6031

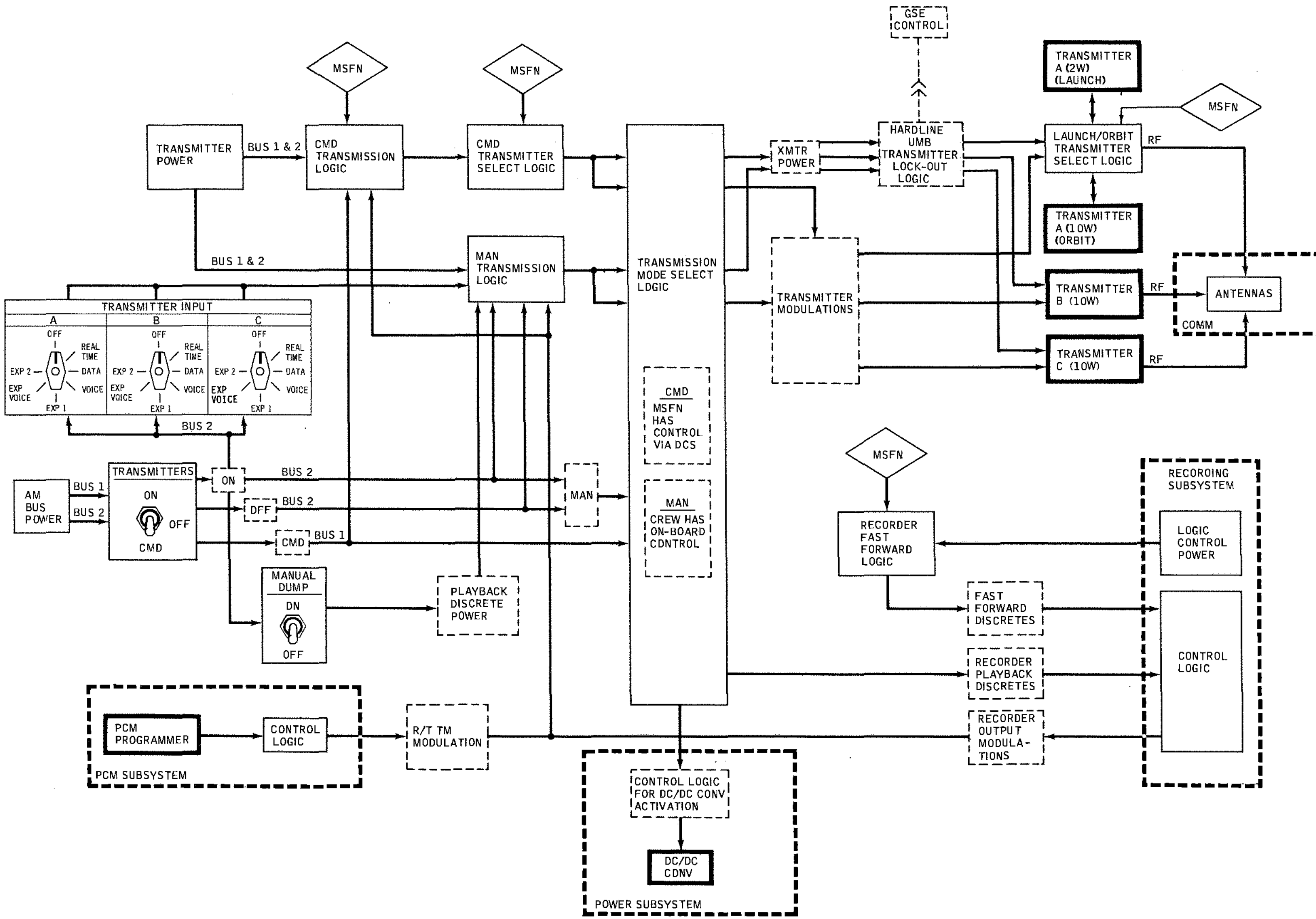



Figure 2.6.3-6 Transmission Subsystem

2.6.3.4.2 Hardline Transmission

R/T TM can be transmitted hardline by onboard logic controlled by ground support equipment. Logic onboard simply interrupts input power to all transmitters. There is a buffered R/T TM output from the PCM subsystem routed out the OWS forward skirt umbilical. To accomplish this, R/T TM is initiated by normal means with transmitter power locked out.

2.6.3.4.3 MSFN Transmission

A MSFN-controlled transmission is enabled when the TRANSMITTERS switch (panel 204) is in the CMD position. It is divided into two facets: transmitter/modulation selection and transmission. For transmitter selection, MSFN has six DCS commands for controlling onboard logic that, in various combinations, allow any modulation to be transmitted by any transmitter. For transmission of R/T TM, there are two means: normal and backup. The backup capability should only be used during manned flight without simultaneously dumping the DATA or EXP 1 tape recorders or in the orbital storage phase. (The alternate route for R/T modulations, preempts the VOICE and EXP VOICE outputs from the recording subsystem.)

The dumping of recorders is accomplished in two steps. First, an "enable" command is sent that turns on all required equipment and also puts the desired recorder in a record mode. At this point, the MSFN is receiving unmodulated carrier frequencies from the transmitters selected for recorder dumping. Second, an "execute" command is sent that applies the playback discrete to the recorder, causing the tape to reverse directions, increase to dump speed, and begin outputting the modulations. One transmitter is required per track of a tape recorder. MSFN has only certain possible combinations of recorder dumping:

- o DATA - Should only be used by itself when it is certain no VOICE is on the "B" track (as during orbital storage)
- o DATA & VOICE - This command dumps the DATA recorder
- o EXP 1 & EXP VOICE - This command dumps the EXP 1 recorder and takes operational priority over a DATA & VOICE dump command by system logic
- o EXP 2 - This command dumps only the "A" track of the EXP 2 recorder. The VOICE recorded on the "B" track is given up as redundant VOICE to that which is on the DATA and EXP 1 recorders

In addition to the normal commands for transmission, the MSFN also has exclusive control over fast forward commands, which are active independent of the position of the TRANSMITTERS switch (panel 204). These commands, one for each of the DATA, EXP 1, and EXP 2 recorders, will drive the tape recorder into a fast forward mode of operation, during which the output modulations of the tape recorder are open circuited.

All transmission and fast forward commands (except backup R/T TM) have an automatic reset (turn-off) from the TRS Tx function register when Tx = 0. Normally Tx will be set to equal zero shortly after the anticipated loss of signal at a given ground station.

2.6.3.4.4 Crew Transmission

A crew-controlled transmission is enabled when the TRANSMITTERS switch (panel 204) is in the ON or OFF position. The OFF position inhibits all AM TM transmission. The crew utilizes the three TRANSMITTER INPUT A, B, and C switches and the adjacent MANUAL DUMP switch. The TRANSMITTER INPUT switches, one for each transmitter, select the desired combinations of tape recorder outputs and/or R/T TM for transmission. The modulations should be selected on the TRANSMITTER INPUT switches prior to placing the TRANSMITTERS switch in the ON position. This prevents dialing through powered switch contacts, which causes unnecessary relay logic action. After the modulations are selected and the TRANSMITTERS switch is turned ON, all system equipment required for the transmission is active. At this point, the MSFN is receiving R/T TM if selected and is also receiving unmodulated carrier frequencies from the transmitters selected for recorder dumping. The tape recorders are powered and are in a record mode of operation. Following subsequent R/T voice link coordination with MSFN, the crew places the MANUAL DUMP switch in the ON position. This action places the selected tape recorder in a playback mode of operation, the recorded information thus modulates the transmitters. As discussed in paragraph 2.6.3.4.3, the MSFN fast forward command capability is still active.

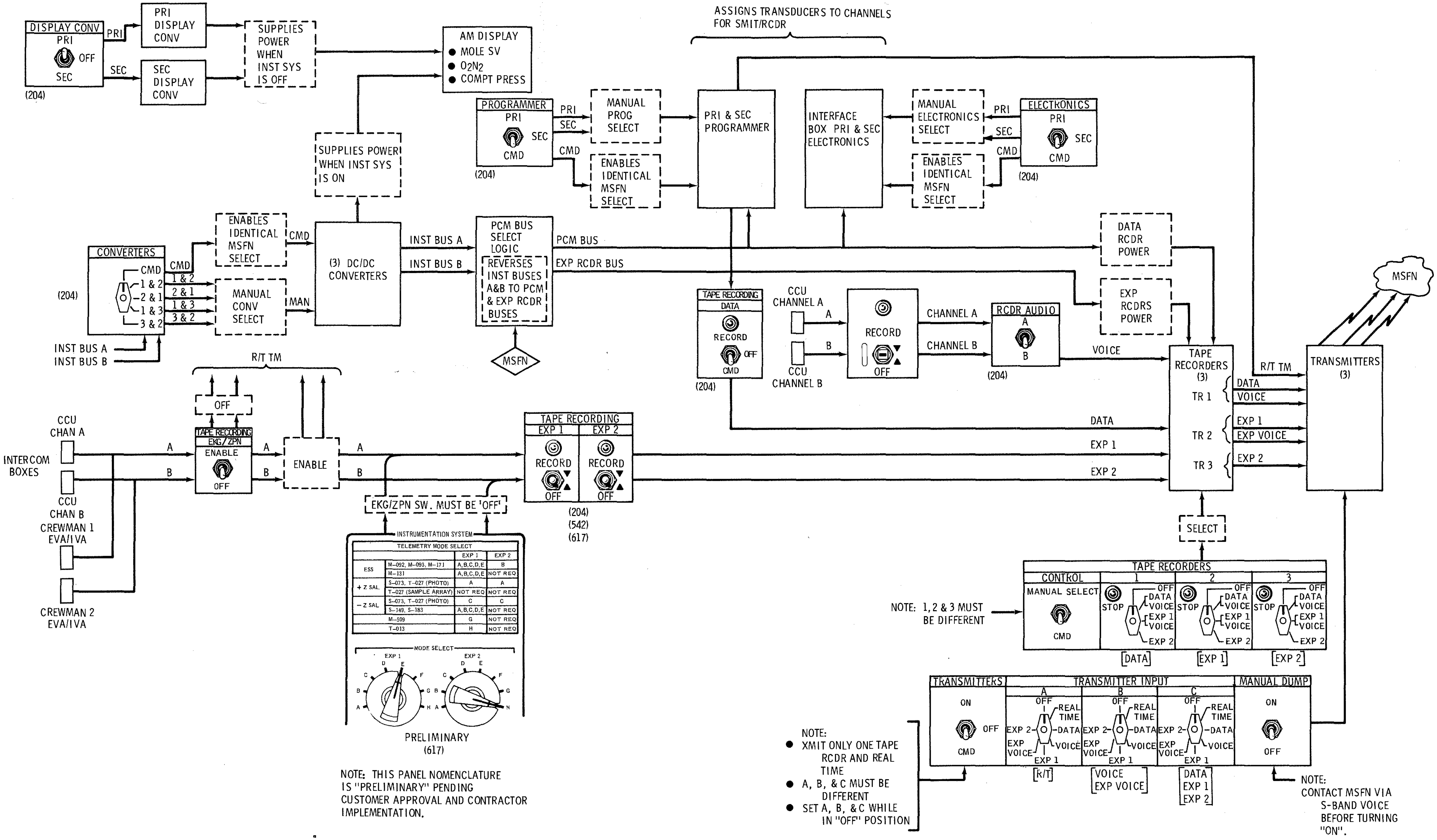
2.6.3.5 OPERATIONAL FLOW

Figure 2.6.3-7 illustrates an overall system operational flow.

2.6.3.6 PCM TM FORMATS

The TM downlinked to the MSFN is the R/T TM and D/T TM. (Experiments T013 and M509 PCM formats are not described in this handbook).

The R/T TM format is an 8-bit binary coded word, with the most significant bit transmitted first, at a rate of 51.2 kbps. A complete measurement scan consists of 96 master frames and requires 2.4 seconds for completion. One master frame is composed of 160 words at 40 samples per second, providing an output of 6400 words per second. All encoding is performed by using the 40-samples-per-second master frame scan rate as a base. The encoding consists of submultiplexing or super commutating input data to obtain sample rates of .416, 1.25, 10, 20, 40, 80, 160, and 320 samples per second. A master frame is composed of subframes 1, 2, 3, 4, and 5; synchronization and synchronization complement words; and 15 channels of direct insert




2.6.3-7 Operational Flow Diagram

high sample rate analog measurements. Each subframe is composed of 16 words of the 160-word master frame at 40 samples per second, providing 640 words per second per subframe. Thus, the five subframes use 3200 words per second of the 6400-words-per-second R/T TM output. The direct insert high sample rate analog measurements utilize 2960 words, and the remaining 240 words are assigned to the synchronization and synchronzation complement words.

Subframes 1, 2, 3, and 4 are extracted from the R/T TM format and routed to the tape recorders for storage. Subframe 5 is not recordable. Subframe 1 corresponds to DATA, subframe 2 corresponds to EXP 1, subframe 3 corresponds to EXP 2, and subframe 4 corresponds to DATA 2. These outputs are 5.12 kbps at 8 bits per word, 640 words per second with the most significant bit first. A complete subframe measurement scan requires 2.4 seconds.

Each PCM word consists of one of three types of data: analog, discrete, or digital. Analog parameters use a complete 8-bit word with zero percent of full scale represented as 00000001 and 100 percent represented as 11111110. Each PCM word for discrete parameters contains eight measurements, one per bit. Discrete words are composed of two types of measurements: bilevel and bilevel pulse. In the bilevel, a true is represented by a "one" and a false by a "zero" in the respective bit location of the PCM word. In the bilevel pulse parameter, true and false level representation is the inverse of the bilevel parameter. Digital words are constructed by using as many sequential 8-bit PCM words as required to represent the respective digital word. For example, a 24-bit digital word would sequentially occupy three 8-bit PCM words in a subframe format. Figures 2.6.3-8 and 2.6.3-9 illustrate the basic R/T and D/T PCM formats. The D/T PCM is recorded in the above formats, and dump is in reverse.

2.6.3.7 PROTON SPECTROMETER (figure 2.6.3-10)

The proton spectrometer measures the energy spectrum and intensity, as well as pitch angle distribution, of electrons and protons trapped in the radiation belts of the South Atlantic Anomaly.

The knowledge of the energy spectrum of the particles will aid in the design of spacecraft shielding structures, the choice of films and film developing procedures, and the determination of radiation dosages being received by the crew. The proton spectrometer should not be confused with the Electron/Proton Spectrometer or radiation survey meter, both in the CSM, which measures the particle flux of the (external-to-vehicle) radiation field and monitors the ambient strength of the (internal-to-vehicle) radiation field, respectively. The proton spectrometer will be operational for the manned and unmanned missions of SL-1, 2, 3, and 4.

The spectrometer has no spares for replacement or maintenance scheduled. The crew interface will be on a contingency, real-time basis. Power for the instrument is provided by AM Bus 1 through the "PROTON SPECT" circuit breaker on panel 202 and a "PROT SPECT" ON/CMD/OFF switch on panel 208. In the nominal mode, the instrument will be turned on and off by ground command, through the AM DCS. Verification that the proton spectrometer is turned on can be obtained from the nominal indications of the two housekeeping measurements, "Detector Head Temperature" and "Electronics Package Temperature". Measurements transmitted to the MSFN indicate the strength of the radiation field external to the MDA, which would alert ground operations of possible radiation danger to the crew and possible damage to Apollo Telescope Mount film.

2.6.4 SUBSYSTEM AND MAJOR COMPONENT DESCRIPTION

2.6.4.1 POWER SUBSYSTEM

The MDA/AM/OWS power subsystem contains the MDA signal conditioner, AM DC-DC converters, AM panel indicator DC-DC converters, and OWS DC-DC converters. These units provide regulated voltage outputs derived from 24 to 30 vdc input bus power.

2.6.4.1.1 MDA Signal Conditioner (Figure 2.6.4-1)

2.6.4.1.2 AM DC-DC Converter (Figure 2.6.4-2)

There are three AM DC-DC converters in the AM. The input bus power excites an oscillator. The oscillator output is transformer-coupled to a power amplifier. The amplifier output is again transformer-coupled to two rectifier and filter circuits. Each rectifier output is routed to a regulator and to the voltage reference and amplifier circuit. Internal sensing and feedback circuits provide the regulator outputs of $24\pm0.3$ vdc and $-24\pm0.3$ vdc. The -24 output is internally used to excite another oscillator. The oscillator output is transformer-coupled, rectified, regulated, and filtered to provide an output of $5 \pm .005$ vdc. External sensing provides a feedback circuit for output voltage regulation.

2.6.4.1.3 AM Panel Indicator DC-DC Converter (Figure 2.6.4-3)

There are four AM panel indicator DC-DC converters in the AM. Two are used as C&W signal conditioning display converters in the caution and warning system. The input bus power excites an oscillator. The oscillator output is transformer-coupled into three separate rectifier and regulator circuits to provide the outputs. Internal regulator feedback circuits provide the regulator outputs of $24\pm0.42$ vdc, $-24\pm0.42$ vdc, and $5\pm0.075$ vdc.

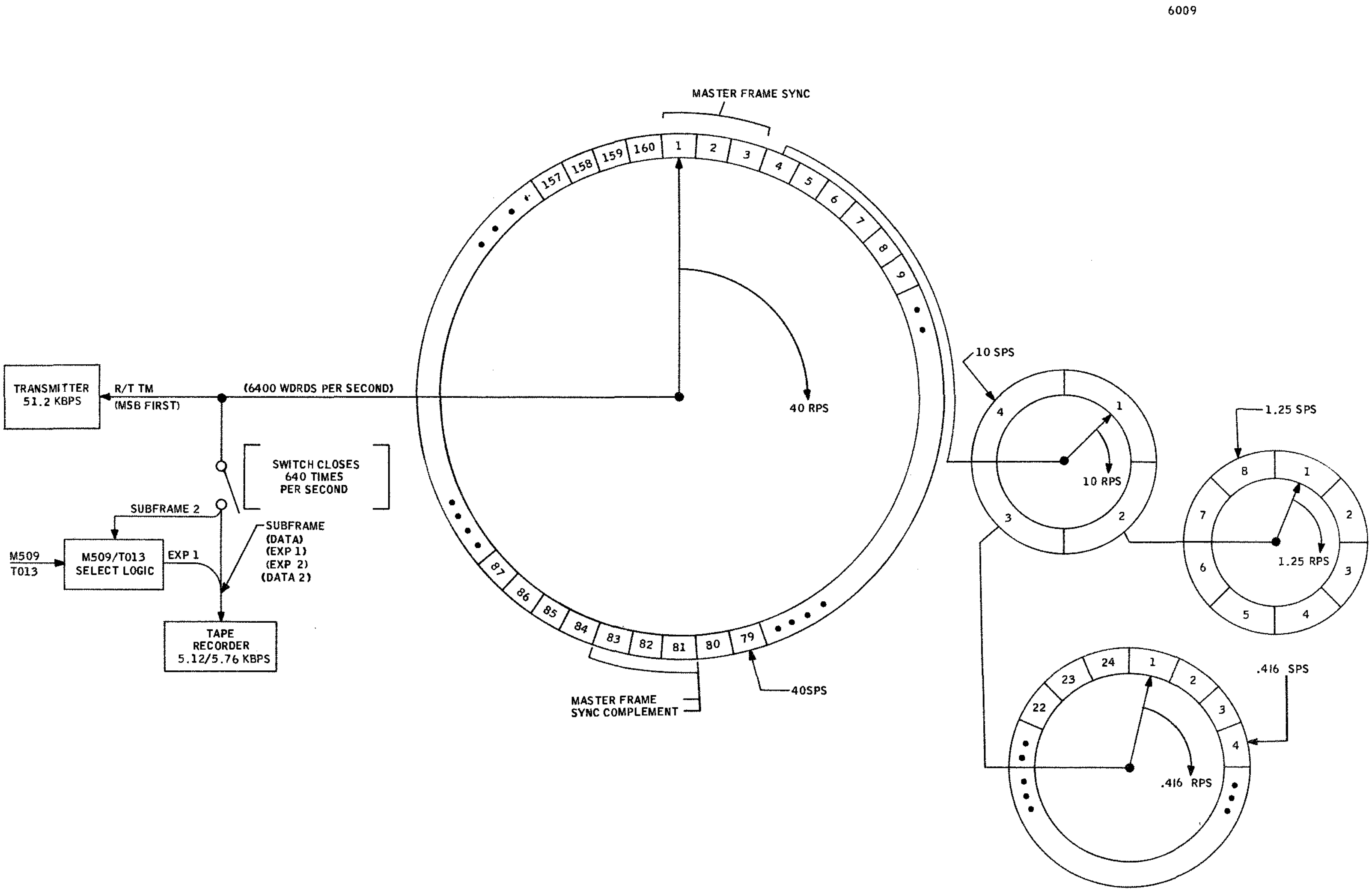



Figure 2.6.3-8 PCM Format (Sample Rates)

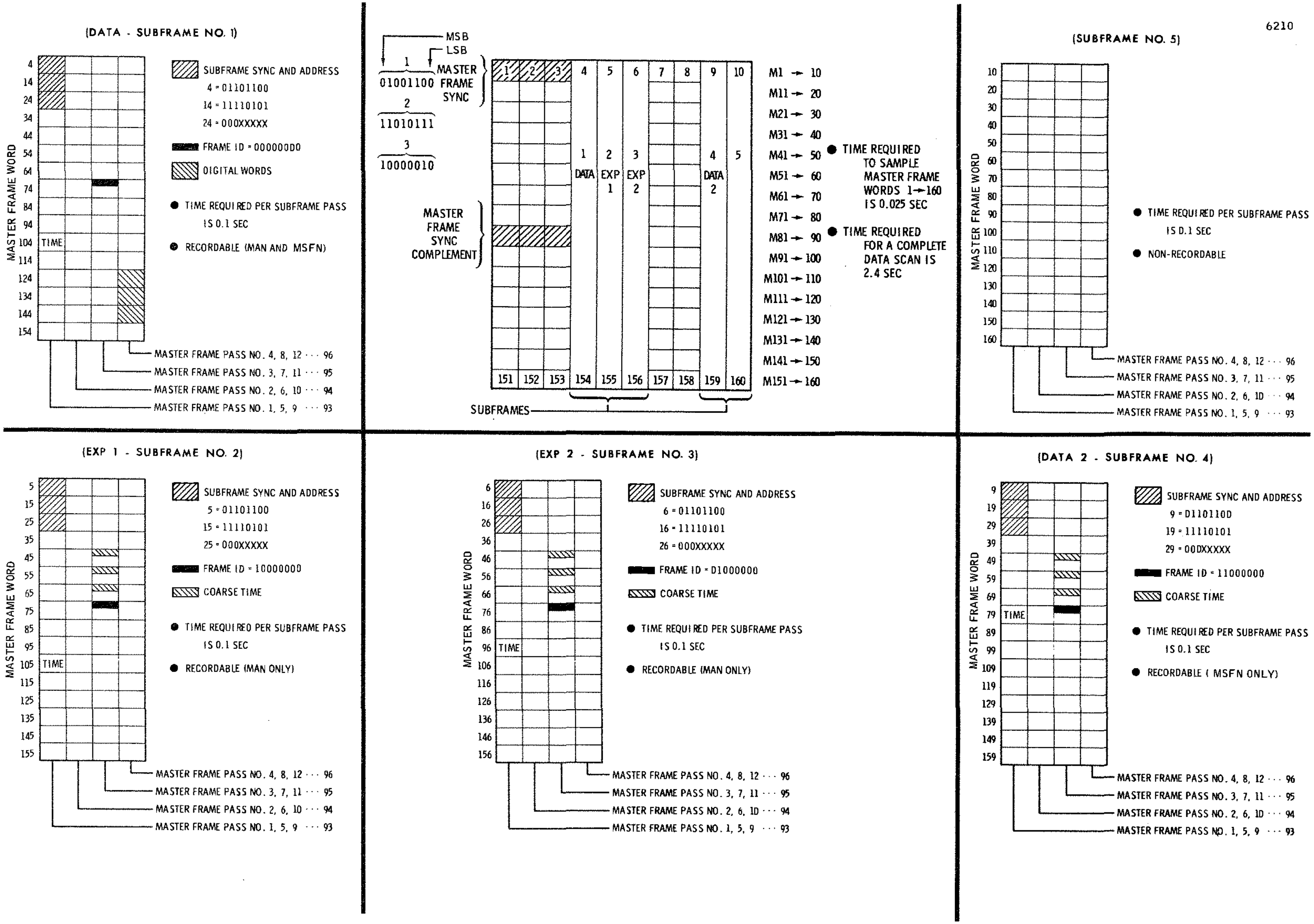
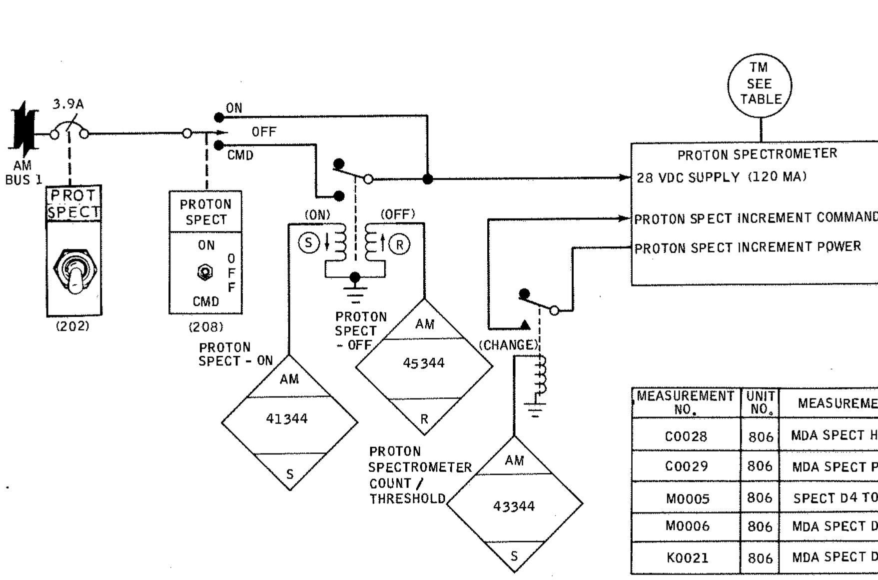



Figure 2.6.3-9 PCM Format




| MEASUREMENT NO. | UNIT NO. | MEASUREMENT NAME | MEASUREMENT RANGE | SUBFRAME | SAMPLE RATE |
|---|---|---|---|---|---|
| C0028 | 806 | MDA SPECT HEAD TEMP | -103 to +167 °F | 5 | 1.25 |
| C0029 | 806 | MDA SPECT PKG TEMP | -103 to 160°F | 5 | 1.25 |
| M0005 | 806 | SPECT D4 TOTAL | TBS | 1 | 1.25 |
| M0006 | 806 | MDA SPECT D1/D2 DDTM | TBS | 1 | 1.25 |
| K0021 | 806 | MDA SPECT DIGIT WORD | 12 BIT DIG | 1 | 10 |

Figure 2.6.3-10 Proton Spectrometer

TO BE SUPPLIED

Figure 2.6.4-1 MDA Signal Conditioner

AM DC-DC CONVERTER

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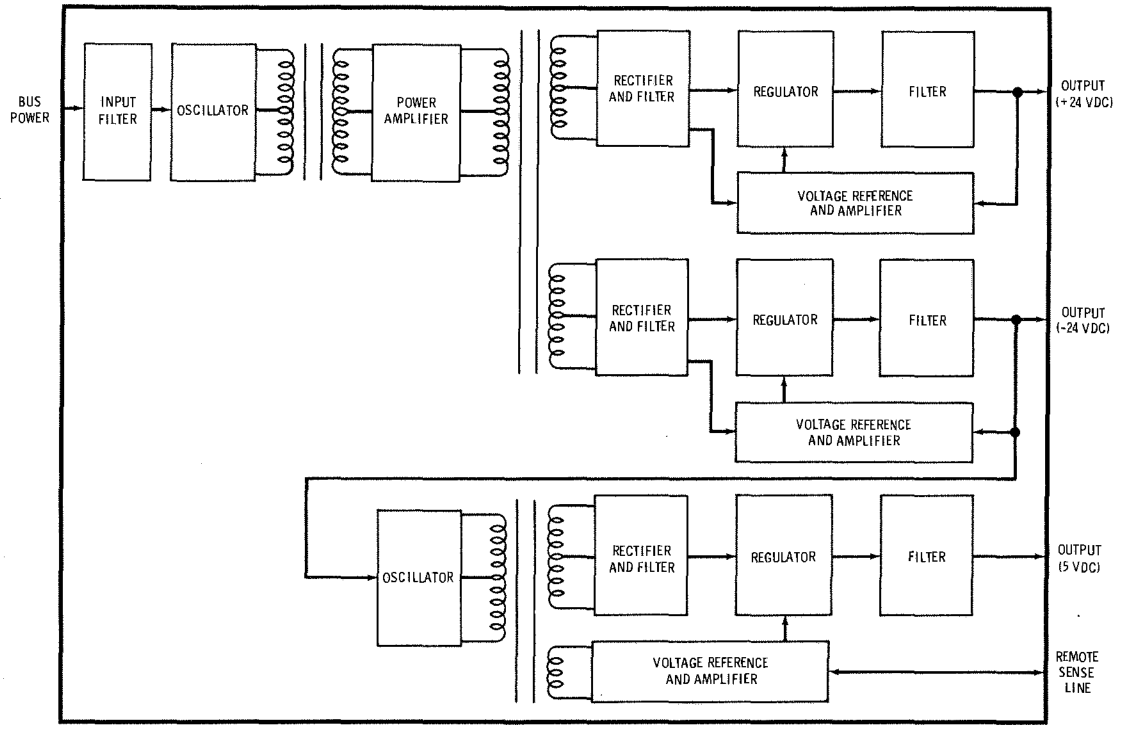


Figure 2.6.4-2 AM DC-DC Converter

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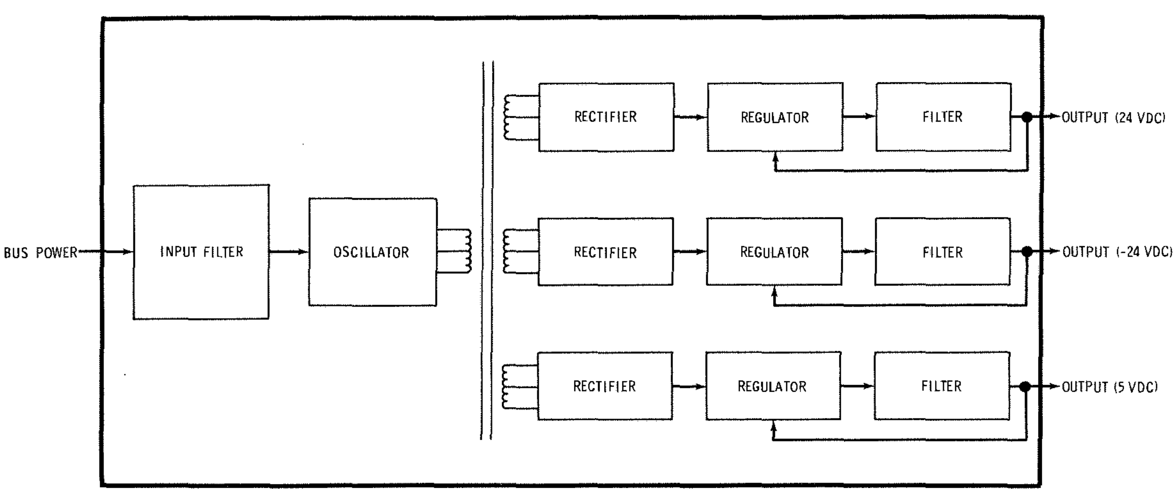


Figure 2.6.4-3 AM Panel Indicator DC-DC Converter

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OWS DC-DC CONVERTER

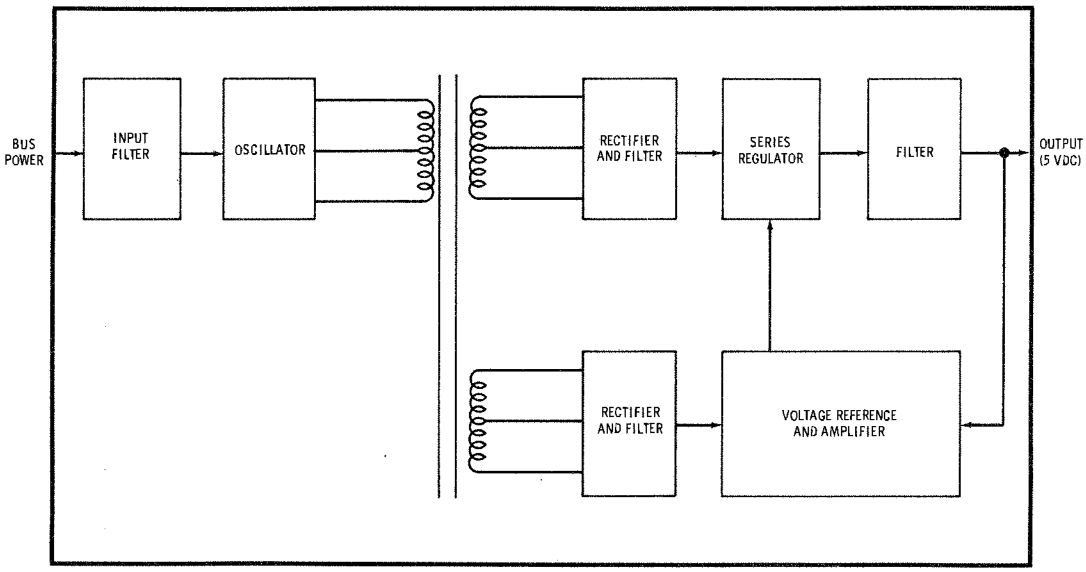


Figure 2.6.4-4 OWS DC-DC Converter

2.6.4.1.4 OWS DC-DC Converter (Figure 2.6.4-4)

There are nine OWS DC-DC converters in the OWS. The input bus power excites an oscillator. The oscillator output is transformer-coupled, rectified, and regulated. Internal voltage sensing and feedback circuits provide the regulator output of 5$\pm$0.01 vdc.

2.6.4.2 PCM SUBSYSTEM

2.6.4.2.1 Transducers

Transducers are used to transform physical or electrical stimuli into electrical signals compatible with meters, telemetry, caution and warning, etc.

2.6.4.2.1.1 Temperature (Figure 2.6.4-5)

The majority of temperature measurements use a temperature-sensitive resistive-element that completes a Wheatstone bridge circuit. The bridge circuit is excited by a regulated DC voltage. The bridge differential output is representative of the resistive element temperature.

The MDA and AM temperature transducers utilize an integral sensor-bridge scheme with a two-wire interconnection. The flat surface temperature transducer has its bridge circuit in a separate module but within a foot of the sensor's location. The curved surface and probe-type temperature transducers contain a bridge circuit and sensor in the same module. The OWS uses sensors separated from the bridge circuit. The bridge circuit connects to the sensor with a twisted-shielded three-wire system. The three-wire system is used to ground-calibrate the temperature transducer to compensate for wire resistance.

The temperature-sensitive resistive elements are made with annealed pure platinum wire, wound in a strain-free manner and bonded in ceramic insulation for maximum stability and repeatability. The bridge circuit consists of fixed precision resistors that produce an output of 0 to 20 millivolts.

2.6.4.2.1.2 Dew Point Temperature (Figure 2.6.4-5)

The dew point temperature transducer uses a sensor and remote electronics package to measure dew point temperature. The sensor contains a dew point detector and resistive element. The electronics package contains the control electronics for the dew point detector, a Wheatstone bridge for the resistive element and a DC amplifier to provide a 0 to 5 vdc output. The dew point detector consists of a mirror surface thermally bonded to

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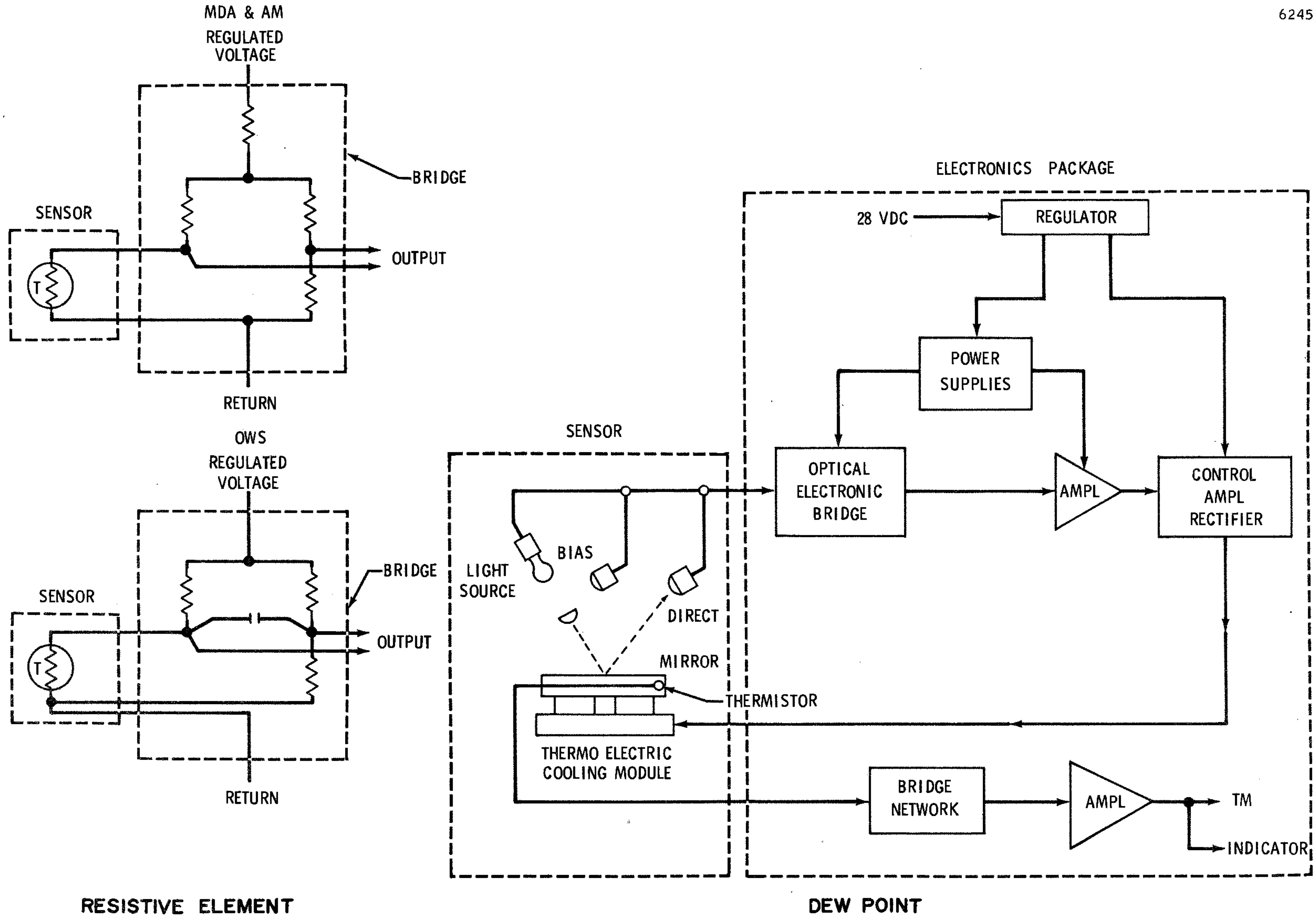


Figure 2.6.4-5 Temperature Transducers

a thermoelectric device, a light source, and two photocells (direct and bias). The thermo-electric device (similar to a thermocouple) provides cooling of the mirror's surface when excited with a DC voltage. The mirror, illuminated by the light source, reflects visible light to direct and bias photocells. The two photocells provide a control signal to an amplifier in the electronics package. The control signal is amplified and used to adjust the control amplifier output to the thermoelectric device. As the mirror surface approaches the dew point temperature, condensation occurs and reduces the reflectivity of the mirror. At a reflectivity corresponding to a minimum dew point thickness, the photocell bridge circuit stabilizes, and mirror temperature is kept contant. The dew point temperature is sensed as the mirror surface temperature. The electronics package contains a 28-vdc bus excited DC-DC converter that provides regulated voltages to the photocell bridge circuit, bridge amplifier, control amplifier, temperature bridge and output amplifier.

2.6.4.2.1.3 Pressure (Figure 2.6.4-6)

o Potentiometer - This device, used most commonly by the MDA and AM pressure measurements, is a potentiometer excited with regulated DC voltage, and is mechanically linked to a bourdon tube or bellows that moves as pressure varies. The output signal (0 to 5 vdc) depends on the wiper position. This type is used for measuring absolute pressure and differential pressures except for extremely low pressure ranges.

o Variable Reluctance Type - For low differential pressure measurements ($<$6 psid) in the AM a variable reluctance sensor in an AC Wheatstone bridge circuit is used. The AC bridge is excited by an oscillator that is powered from a regulated voltage. Pressure deflects a diaphragm holding two coils. This deflection causes the coil's reluctance to change, thus changing the AC voltage in the AC bridge. The AC bridge's differential output is amplified and rectified to a 0 to 5 vdc signal.

o Strain Gauge Type - This device is used by the OWS for 50, 75, 1000 and 3500 psia measurements. It consists of a Wheatstone bridge circuit with four strain-gauge sensors all mounted on a bending beam or bonded on the pressure circuit. The transducer uses an internal DC-DC converter to provide a regulated voltage to the bridge circuit. Pressure deflects a diaphragm causing the four strain gages to change resistance, thus unbalancing the bridge to provide a low level output. The output is amplified and filtered to a 0 to 5 vdc output.

o Variable Capacitance Type - For 8 psia pressure measurements in the OWS, a variable capacitance sensor with one plate attached to a diaphragm is used. Pressure deflects the diaphragm and plate, causing a capacitance change. The diaphragm and plate are part of a negative feedback loop of a charge amplifier. The charge amplifier is essentially an amplifier with a capacitive-coupled, stable square wave input reference signal. The amplifier output then varies inversely with the feedback loop capacitance. The charge amplifier output is rectified and filtered. Then a stable bias voltage is subracted to provide DC voltage pressure indication. This DC voltage is amplified to a 0 to 5 vdc output. The transducer uses an internal DC-DC converter to provide regulated voltages to the square-wave generator, amplifiers, and detector.

o Variable Inductance Type - The 0.3-psid AM measurements use a transducer with a sensor that serves as the secondary winding of a moveable core transformer. The transformer core is attached to a pressure diaphragm. The primary winding is excited by an oscillator. As the pressure deflects the diaphragm, the transformer core varies the mutual inductance and the induced voltage in the differential secondary winding. The differential secondary winding voltage is rectified and amplified to a 0 to 5 vdc output. An internal DC-DC converter provides regulated voltages to the oscillator and output amplifier.

2.6.4.2.1.4 O2 Partial Pressure (Figure 2.6.4-7)

The oxygen partial pressure transducer consists of two subassemblies, a replaceable sensor and a permanently fixed electronics package. The sensor consists of an electrochemical cell that provides a voltage to the electronics package. The electrochemical cell includes two electrodes and electrolytes that provide a voltage across an output resistor. The sensor diffuses the oxygen through a membrane into the cell. The cell's voltage is proportional to the pressure of oxygen. The electronics package amplifies the cell voltage and provides a 0 to 5 vdc output. The 28 vdc bus power is DC-DC converted to regulated voltages for amplification.

2.6.4.2.1.5 CO2 Partial Pressure (Figure 2.6.4-7)

A PPCO2 transducer contains two replaceable filters, two ion chambers, a bridge circuit, and a differential current amplifier. The inlet gas stream is divided into two streams. The reference stream is filtered to remove H2O and CO2 while the measurement stream filter removes only H2O. Both streams flow into identical ion chambers that contain a small amount of radioactive material which emits alpha particles for ionizing the gas molecules. The CO2 molecules ionize more readily than O2 and N2; therefore, the measurement stream current is higher than the reference stream current. The ion currents are algebraically summed and routed into the differential amplifier. The amplifier output is proportional to the partial pressure of the CO2. The amplifier operates off the -24 and +24 vdc regulated voltages.

2.6.4.2.1.6 Gas Flow (Figure 2.6.4-8)

The VCS duct flow rate measurements use a turbine type sensor and a remote electronics package. A sensor consists of a measuring turbine rotating on a slave turbine with an inductive coil located radially next to the tips of the measuring turbine blades. The electronics package contains an oscillator that provides a high frequency carrier to the sensor's inductive coil. As the turbine rotates each blade induces a pulse that modulates the high frequency carrier. The modulated carrier is then demodulated and converted to a 0 to 5 vdc output by a frequency to DC converter in the electronics package. The electronics package contains a DC-DC converter that provides regulated voltages to the oscillator and frequency to DC converter.

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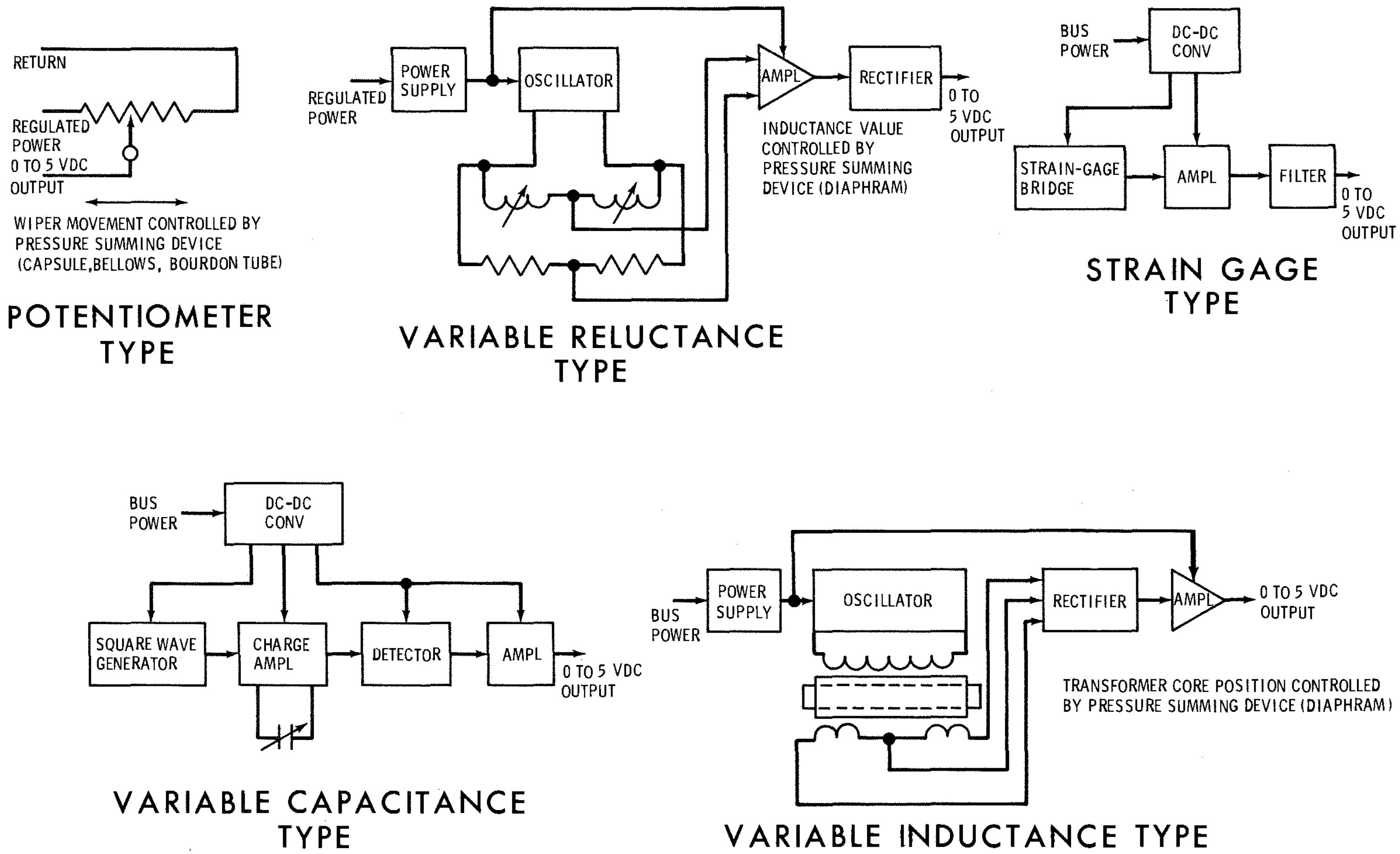


Figure 2.6.4-6 Pressure Transducers

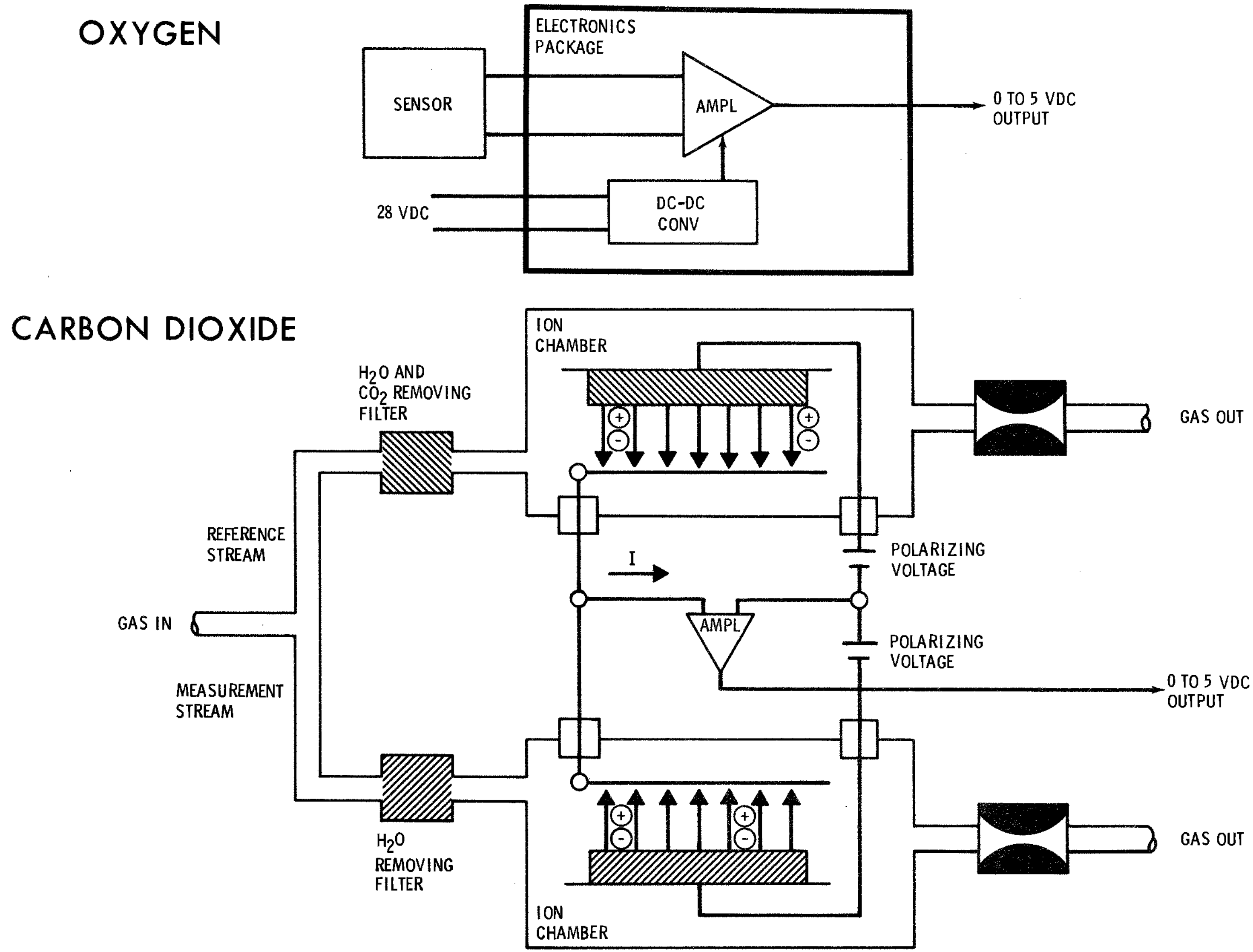


Figure 2.6.4-7 Partial Pressure Transducers

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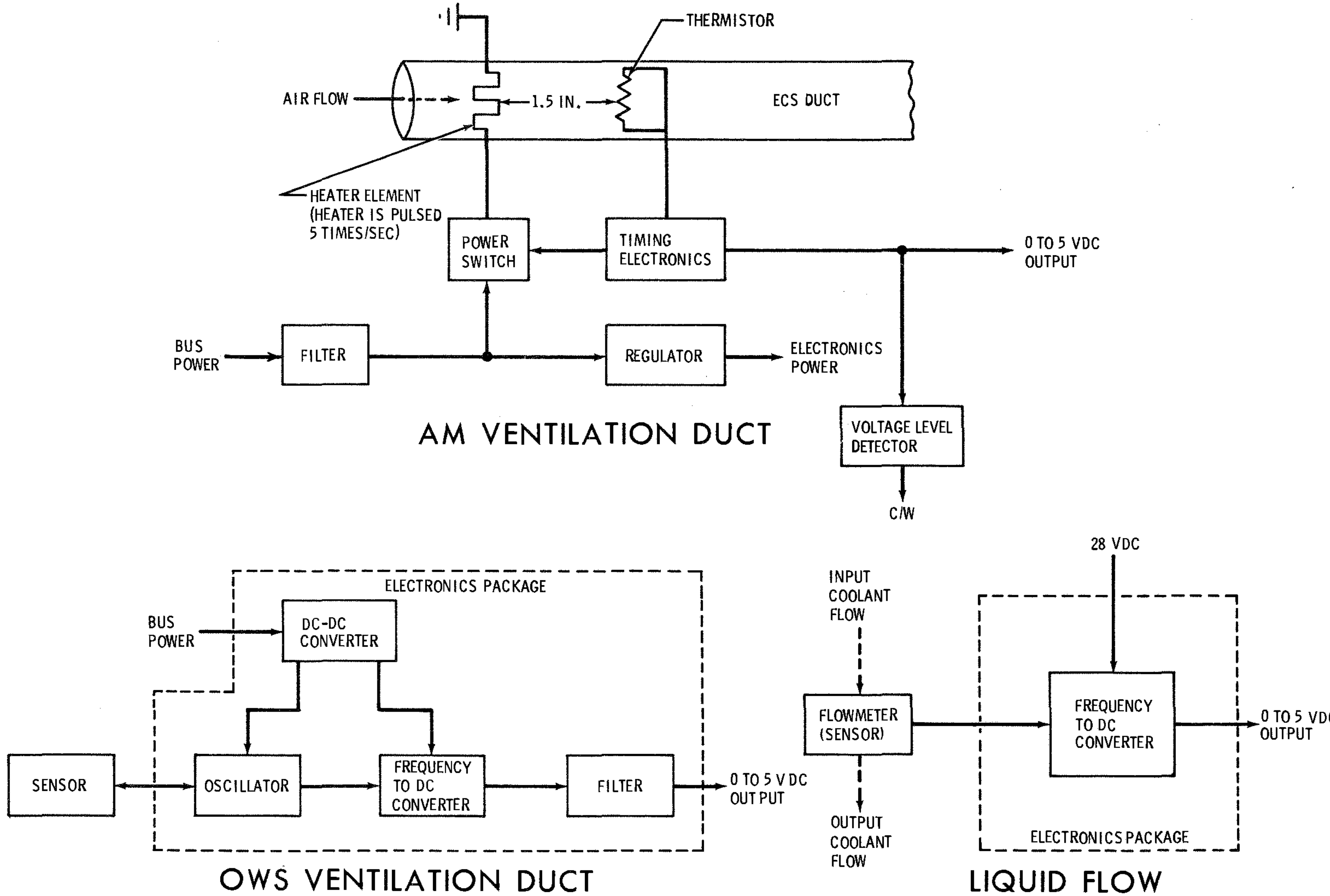



Figure 2.6.4-8 Flow Transducers

The AM ventilation duct flow rate measurements use a sensor and a remote electronics package. The sensor includes a resistive heater element and a temperature sensitive element. The transducer measures gas flow rate by introducing a heated pulse of gas with the heater element and timing the travel of the heated gas to the fixed location of the temperature sensor. The temperature sensor is connected to a charge amplifier. The electronics package contains a pulse generator that switches power on and off to the sensor's heater element. It also generates timing signals. The timing signals are summed with the charge amplifier output. The timing signals are integrated, amplified, and transformer-coupled and rectified for a 0 to 5 vdc output. The 28 vdc bus power is regulated for use by the pulse generator, charge amplifier and summing controls.

2.6.4.2.1.7 Liquid Flow (Figure 2.6.4-8)

The coolant flow rate measurement uses a turbine sensor and remote electronics package. The sensor includes a turbine and an inductive coil that senses the passage of the rotating turbine blades. The electronics package consists of a frequency to DC converter that is excited from 28 vdc bus power. The inductive coil in the sensor produces a pulse train as the turbine rotates. The pulse rate is proportional to the flow rate. The frequency to DC converter provides an isolated 0 to 5 vdc output.

2.6.4.2.1.8 Water Level (Figure 2.6.4-9)

The water tank level measurements use a transducer that is an echo sounder. The transducer initiates a pulse transmission in the water, and times its travel to the end of the water tank bladder and reflection back to the transducer to provide a 0 to 5 vdc output representing the travel distance. The transducer is powered from a 28-vdc bus and uses a DC-DC converter to provide regulated voltages to the electronics.

The transducer sensor that transmits and receives the pulse (in a manner similar to an antenna) is a piezoceramic with piezoelectric characteristics. The electronics timing is accomplished by a crystal-controlled oscillator. The oscillator frequency is divided down in a pulse control generator that triggers the transmitter. The control pulse activates the transmitter to produce a high voltage pulse of short duration that excites the piezoceramic. The piezoceramic resonates for a short duration propagating the pulse into the water. The control pulse generator also triggers the time counter that counts the timing signals from the oscillator during the travel of the pulse, and converts to a 7 bit binary code. The impinging echo resonants the piezoceramic and causes an electrical output that is connected to a receiver. The receiver is grounded during the pulse transmission to avoid premature triggering. The receiver output is then detected by a threshold trigger that generates a timing pulse to stop the time counter. The threshold trigger output is also grounded during the pulse transmission to avoid premature triggering.

The time counter then transfers the 7 bits of time to a register. This value is maintained in the register until another 7 bits are ready to be transferred. Since the pulse velocity varies with temperature of the water, a temperature measurement is made and used in the conditioning of the 7 bits of time into an analog value. The analog signal is then amplified to provide the 0 to 5 vdc output.

4.6.4.2.1.9 Position

The OWS solar array wing section position measurements use a potentiometer excited by regulated 5 vdc. The potentiometer responds to angular rotation as the wing panels deploy.

The thermal control system TEMP SELECT °F selector switch in the workshop is monitored by a potentiometer behind the dial. As the dial is rotated, the potentiometer's wiper is indicative of the temperature setting on the dial.

2.6.4.2.1.10 Voltage

A voltage is connected to the signal conditioner. The signal conditioner, depending on its design, attenuates, isolates and/or divides the input voltage into conditioned outputs.

2.6.4.2.1.11 Current (TBS)

2.6.4.2.1.12 Proton Spectrometer

The spectrometer consists of a detector head (which provides the logic requirements for particle counting) and electronics (which identifies particles and measures proton and electron energy) housed as separate instruments but installed in one container to form a single piece of equipment.

The proton spectrometer accepts particles within a 45-degree cone. Knowledge of the SWS ephemeris data and attitude data while passing through the South Atlantic Anomaly will yield information about the pitch angle distribution of the spiraling particles (electrons and protons).

2.6.4.2.1.13 Quartz Crystal Microbalance Contamination Monitor

Quartz Crystal Microbalance Contamination Monitor (QCM/CM) - Four QCM/CM's are mounted on the ATM Deployment Assembly to measure contamination in the area of the EREP. Each QCM/CM employs two quartz crystals, one essentially shielded and the other exposed to the environment. Each crystal oscillates at about 10 MHz. As contamination is deposited on the exposed crystal, its mass increases, and its resonant frequency decreases in proportion to the mass of the contamination. The frequency of the shielded and exposed crystals is compared, with difference in frequency (beat frequency) being proportional to mass. The beat frequency is converted to

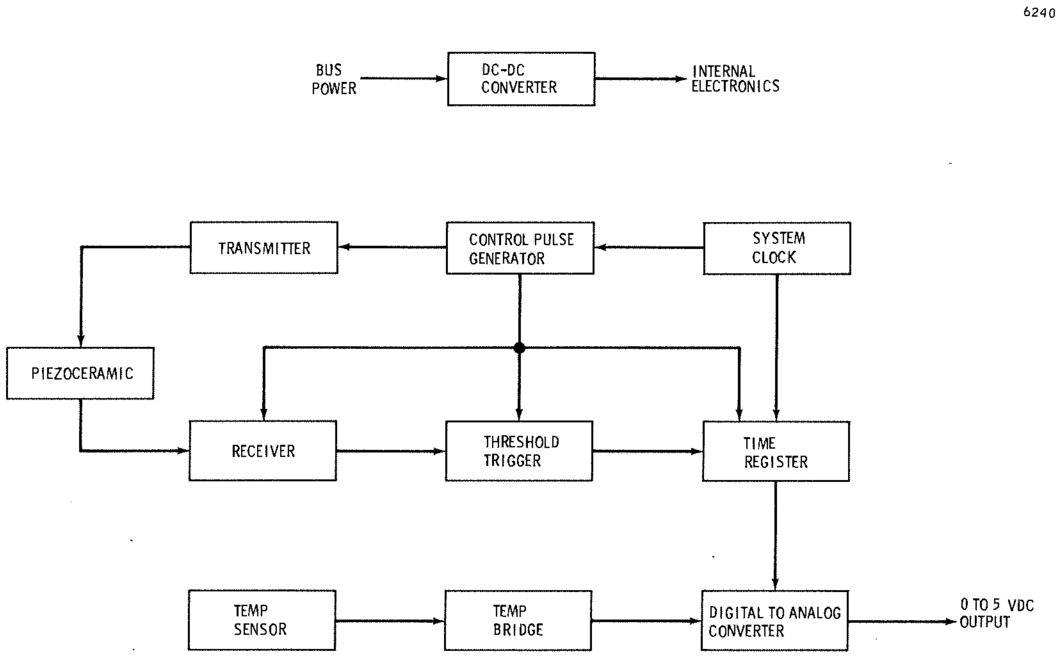



Figure 2.6.4-9 Water Level Transducer

a 0 to 5 VDC signal which is telemetered after undergoing further signal conditioning by a range expanding signal conditioner in the instrumentation packages. A 0 to 5 VDC signal which is representative of the crystal temperature is also telemetered. The full scale range of a QCM/CM is approximately 1.2 x $10^{-4}$ grams of deposited material.

2.6.4.2.2 Multiplexing/Encoding Components (Figure 2.6.4-10)

The multiplexing/encoding components sequentially sample all signals and put them into a serial PCM bit stream. All analog channels are time-multiplexed into one serial PAM stream. An analog to digital (A/D) converter encodes each analog pulse in the PAM stream into an 8 bit binary coded word. All the event channels (bilevel, bilevel pulse, and digital) are already in digital form. The event channels are sampled and time-multiplexed in sets of eight. The 8-bit coded analog measurements and the 8-bit sets of event measurements are sequenced into the output shift register to provide an output serial PCM bit stream. Pre-selected words of the serial PCM stream are stripped out into recordable PCM streams.

The multiplexing/encoding components consist of 25 multiplexers, two programmers and one fully redundant interface box. Only one programmer and half of the interface box are required for operation. There are no redundant multiplexers in the system.

The programmer and interface box convert -24 vdc input power to regulated voltages to be used for internal electronics and for the multiplexers. Multiplexer operation is totally dependent on the programmer and interface box operation.

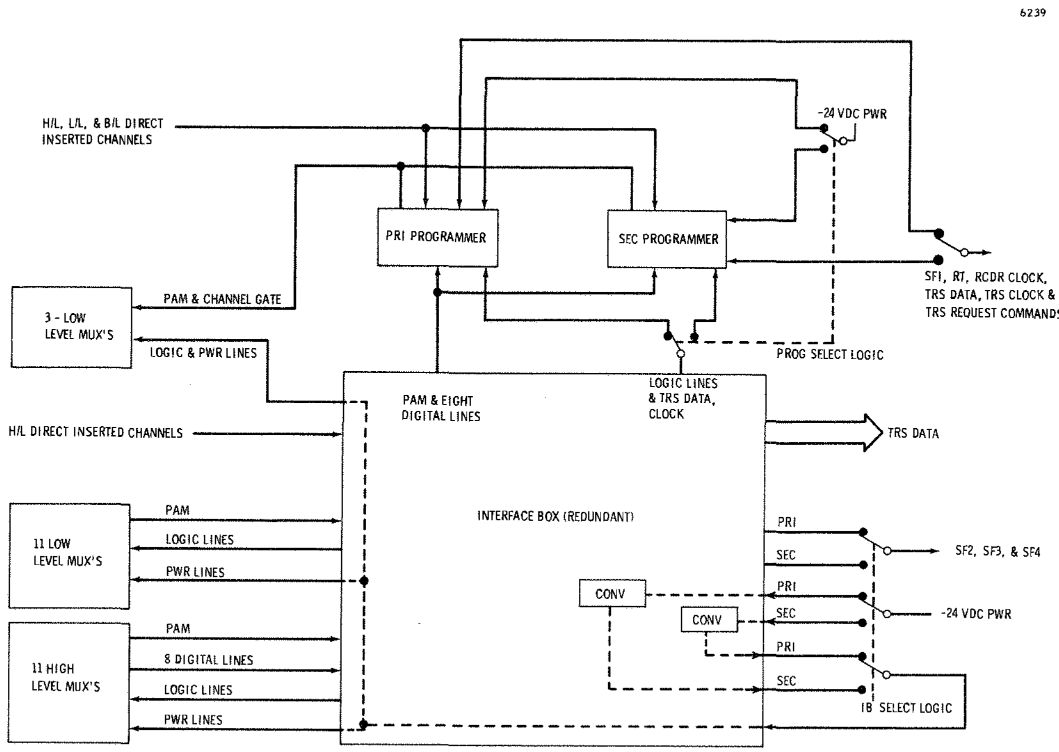



Figure 2.6.4-10 Multiplexing/Encoding Components Signal Flow

2.6.4.2.2.1 Multiplexers (Figure 2.6.4-11)

There are two types of multiplexers; low and high level. The low level multiplexer has thirty-two 0 to 20 mv analog input channels. The 32 channels are sampled and time-multiplexed to provide a serial 0 to 20 mv PAM stream to a DC amplifier. The DC amplifier's input and output are grounded between pulses by an amplifier clamp switch. The DC amplifier's 0 to 5 vdc PAM output is routed to a programmer or interface box.

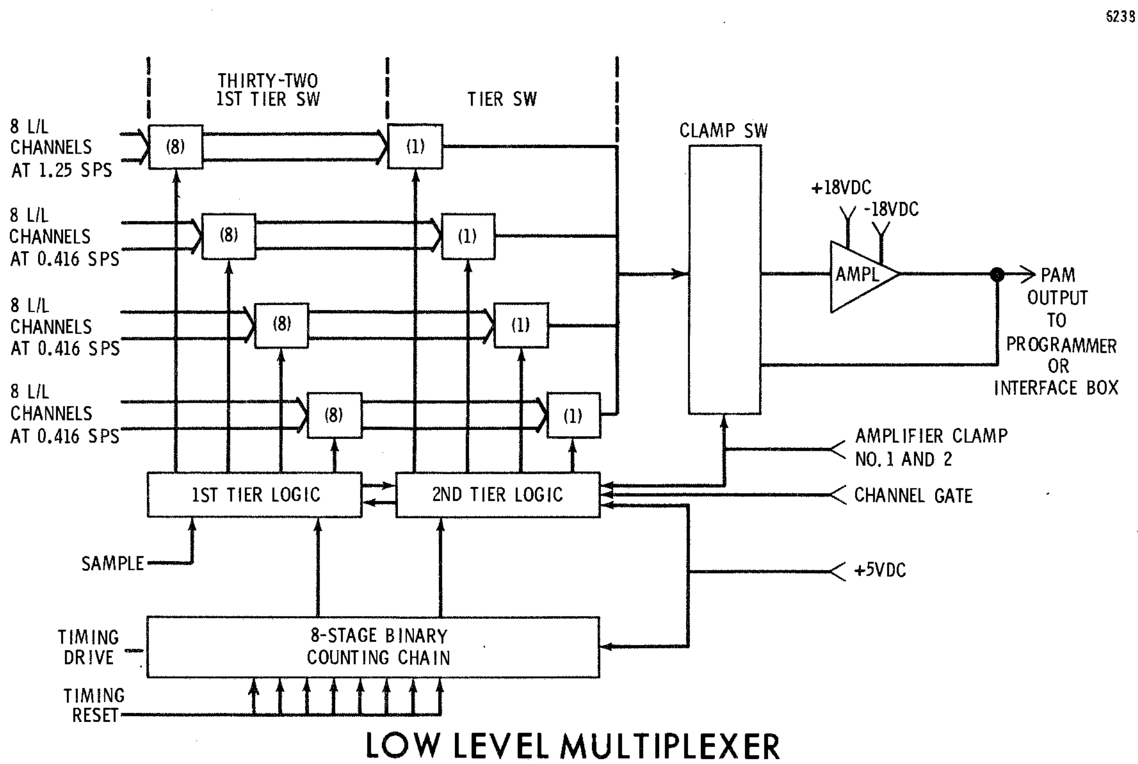
The high level multiplexer has thirty-two 0 to 5 volt analog input channels and forty event input channels. The 32 analog channels are sampled and time-multiplexed to provide a serial 0 to 5 vdc PAM output to the interface box. The 40 event channels include 24 bilevel and 16 bilevel pulse channels. The 24 bilevel channels are signal conditioned so that an input of 5 vdc or less results in a "zero" bit output and an input of 15 vdc or greater results in "one" bit output. The 24 signal conditioned outputs are sequentially sampled as three sets of eight channel groups that are bused by a diode matrix into eight parallel output lines.

The 16 bilevel pulse channels are signal conditioned to inverted outputs, so that any input of 5 vdc or less results in a "one" bit output and an input of 15 vdc or greater results in a "zero" bit output. If a momentary drop of an input to 5 volts or less occurs for at least 10 milliseconds, the next sampled output will remember the occurance by a "one" bit output. The 16 signal conditioned outputs are sequentially sampled in two sets of eight channel groups that are bused by a diode matrix into the eight parallel output lines that are connected to the interface box. The eight parallel lines are used for bilevel and bilevel pulse data.

2.6.4.2.2.2 Programmer and Interface Box (Figures 2.6.4-12 and -13)

The programmer contains its own internal multiplexers similar in operation to the low and high level multiplexers. The programmer can accomodate high level analog, low level analog and bilevel input signals. The interface box also contains its own internal multiplexer similar in operation to a high level multiplexer. The interface box can accomodate high level analog input signals.

The programmer powers its own internal electronics which includes a clock (used for all system timing), logic for three low level multiplexers, synchronization and digital time circuits, subframe 1 tape recorder output converter, and the electronics to provide a 51.2 kbps PCM output.



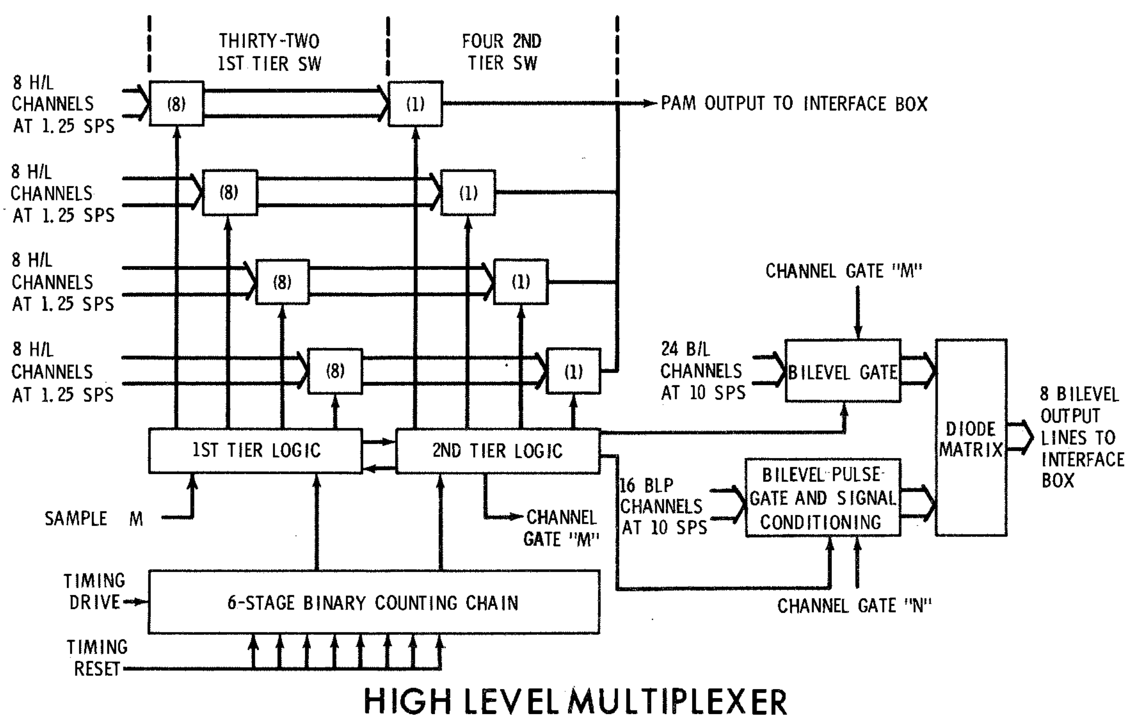




Figure 2.6.4-11 Multiplexer Block Diagram

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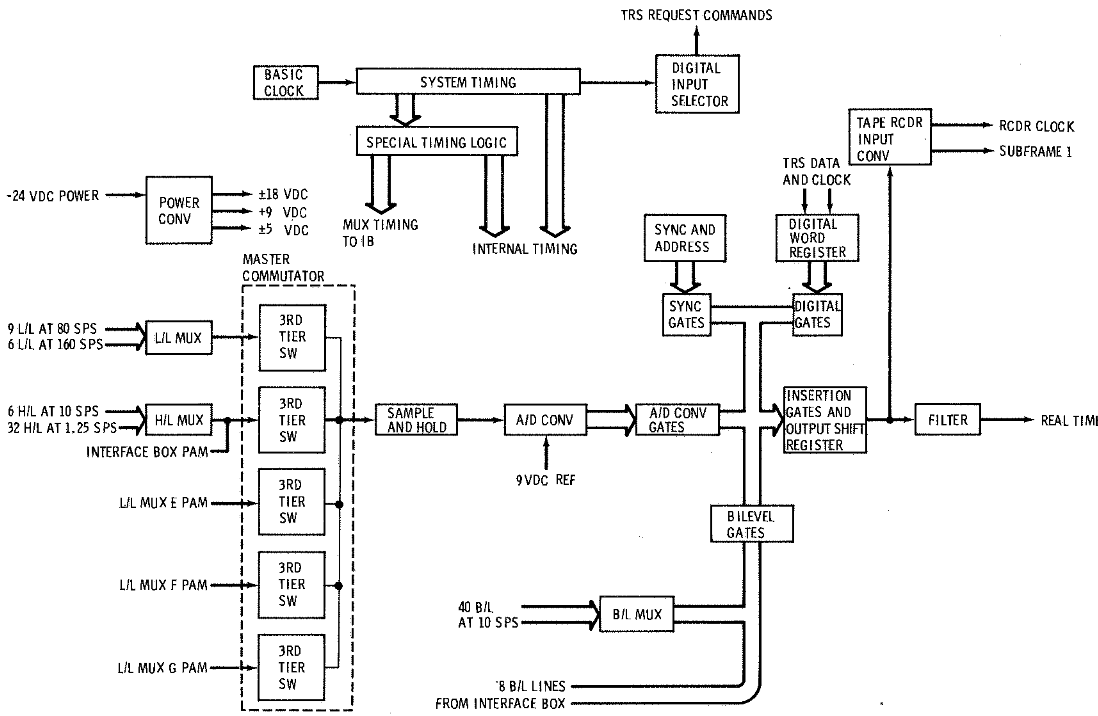


Figure 2.6.4-12 Programmer Block Diagram

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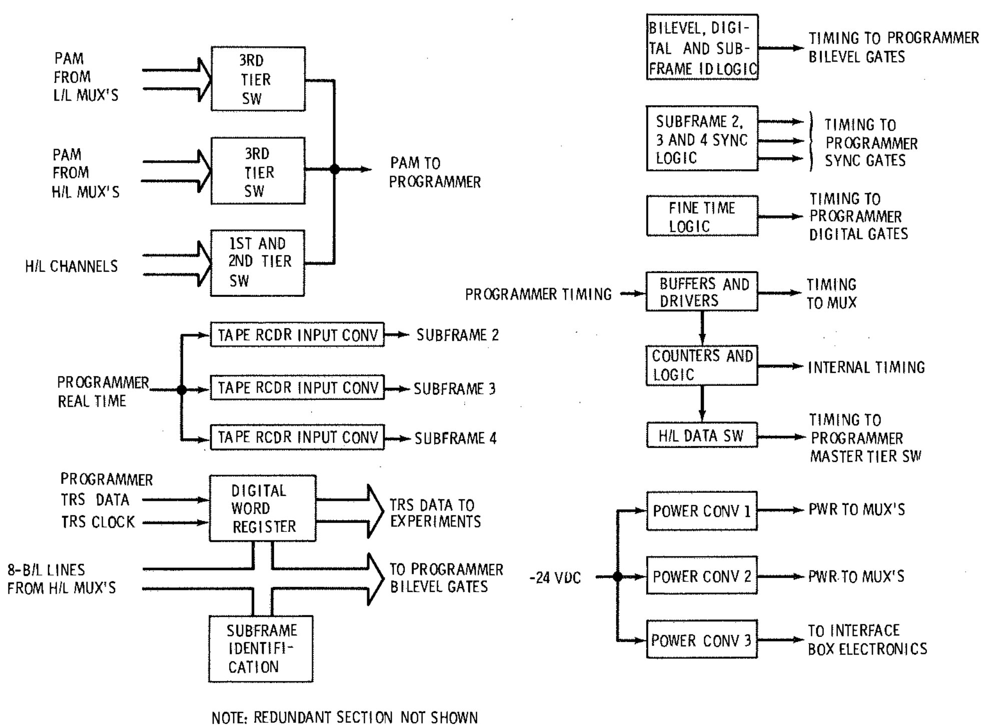


Figure 2.6.4-13 Interface Box Block Diagram

The interface box powers its own internal electronics, which includes all the logic to operate and accept 22 multiplexers, provides timing and subframe identification to the programmer for subframe 2, 3, 4 and 5 formats, and accepts and outputs digital time to experiments.

The typical analog channel will be sampled and time-multiplexed through 1st and 2nd tier switches. If the channel is a 0 to 20 mv low level analog (figure 2.6.4-14), it will then be amplified to a proportional 0 to 5 vdc level. The low and high level analog (figure 2.6.4-15) channels, except for the interface box's multiplexer channels that are first routed through a 3rd tier switch, are sent to a master tier switch. Now the analog channel is switched through one of the five master tier switches into a high impedance buffer amplifier of the sample and hold circuit. The sample and hold circuit buffers, samples and holds the 0 to 5 vdc analog signal. The new stretched 0 to 5 vdc signal appears at the A/D converter where it is digitized into an eight bit binary code. The A/D converter successively approximates the signal voltage by comparing it with a sequence of eight voltages generated internally. If the signal voltage is greater or less than a comparison voltage, a binary "one" or a binary "zero", respectively, is generated. This results in an 8-bit pattern of "ones" and "zeros" with the most significant bit representing a voltage increment of 2.500 vdc and the next bit equal to 1.250 vdc and so forth to the least significant bit. Upon completion of the encoding process, the 8 bits are gated in parallel through the A/D converter gates and the insertion gates to the output shift register. The A/D converter gates are inhibited whenever synchronization, digital time and event channels are being shifted into the output shift register. The 8-bit word is then shifted out serially with the most significant bit first. This serial 51.2 kbps bit stream is filtered and transformer coupled to the transmission subsystem. The unfiltered 51.2 kbps bit stream also appears at the input of four tape recorder output converters that produce four 5.12 kbps bit streams for recording.

The bilevel and bilevel pulse channels (figure 2.6.4-16) accept event measurements that are signal conditioned into "zero" or "one" bit outputs. The outputs are sequentially sampled in sets of 8 bilevel channels or 8 bilevel pulse channels that are dioded together into eight parallel output lines. All high level multiplexers output lines (bilevel and bilevel pulse) are connected to the interface box where they are bused together into eight load resistors that are outputted to the programmer. The interface box's digital time and subframe identification words are gated in parallel to the eight output lines to the programmer. The programmer's direct inserted bilevel channels are sequentially sampled in sets that are dioded into eight parallel lines that are bused with the eight parallel lines from the interface box. The eight parallel lines route sets of 8 bilevel channels, 8 bilevel pulse channels, 8 bits of digital time and 8 bits of subframe identification to the bilevel gates and then through the insertion gates to be inserted in the output shift register to become part of the serial 51.2 kbps PCM stream with the analog measurements.

The digital time channels (figure 2.6.4-17) are groups of 8 bits of a 24-bit digital time word received from the electronic timer of the Timer Reference System. The 24-bit digital time represents either elapsed time (Te) or time to go to redundant DCS receiver/decoder (Tr). Both time values are requested by separate commands from the programmer digital input selector circuit. The Te request command to the electronic timer occurs every 100 milliseconds. The Tr request command to the electronic timer occurs once every 2.40 seconds, out of phase with the Te commands. After receipt of either command, the electronic timer provides a serial output of 24-bits in parallel with 24 clock (shift) pulses at a 8.192 kHz rate. The 24 clock pulses are used to shift the 24 bits into the programmer and interface box 24 stage registers. The register in the programmer provides Te and Tr data to subframe 1. The interface box register provides subframes 2, 3 and 4 elapsed time. The 24-bits of digital Te in the registers is designated as coarse time and the eight least significance bit (LSB) set is designated as fine time. At the proper time of each 100 millisecond update of Te, the programmer registers eight LSB stages are read to the output shift register to provide fine time for subframe 1 measurement. The eight LSB stages of the digital register are connected in parallel to eight digital gates and then through the insertion gates to the output shift register. Once every 2.40 seconds after a fine time update, the digital register has the Tr time shifted in and at the same time shifts out the remaining Te bits. At the proper time the output shift register inserts the 24-bit Tr word into the subframe 1 time slots of the PCM stream.

The interface box digital register shifts in the 24 bits identical to the programmer digital register. The register is read by three sets of output gates that route the bits through eight digital gates to the programmer bilevel gates.

At the proper time of each 100 milliseconds update of Te to the interface box register, the fine time is read to the output shift register for subframes 2, 3, and 4 measurements. Once every 2.40 seconds, the entire 24 bits is read into the output shift register for subframes 2, 3, and 4 coarse time. Also, the subframe identification words are activated and read into the output shift register once every 2.40 seconds for each subframe.

The programmer provides the 24-bit master frame synchronization words, 19-bit subframe synchronization words and address count to the output shift register through the synchronization, and insertion gates. At the proper time, the master frame and subframe synchronization words are activated and read into the output shift register in 8-bit sets. The 5-bit address count identifies every 100 millisecond interval with a sequential binary count and recycles every 2.40 seconds. The 5-bit count is read in the third 8-bit set with the last three bits of each 19-bit subframe synchronization word.

The remaining electronics provide four different 5.12-kbps PCM output streams to the tape recorders. The output shift register's output is routed to four tape recorder converter circuits. The circuit in the programmer gates in only subframe 1 words that are shifted into a recorder shift register at a 51.2-kbps rate. Since in a subframe one word occurs as every tenth word of the real time output, the recorder register has its 8-bit word shifted out at a 5.12-kbps rate to achieve the 5.12-kbps PCM stream. The 5.12-kbps recordable output format is accomplished by a momentary ground during the shifting out process. This output

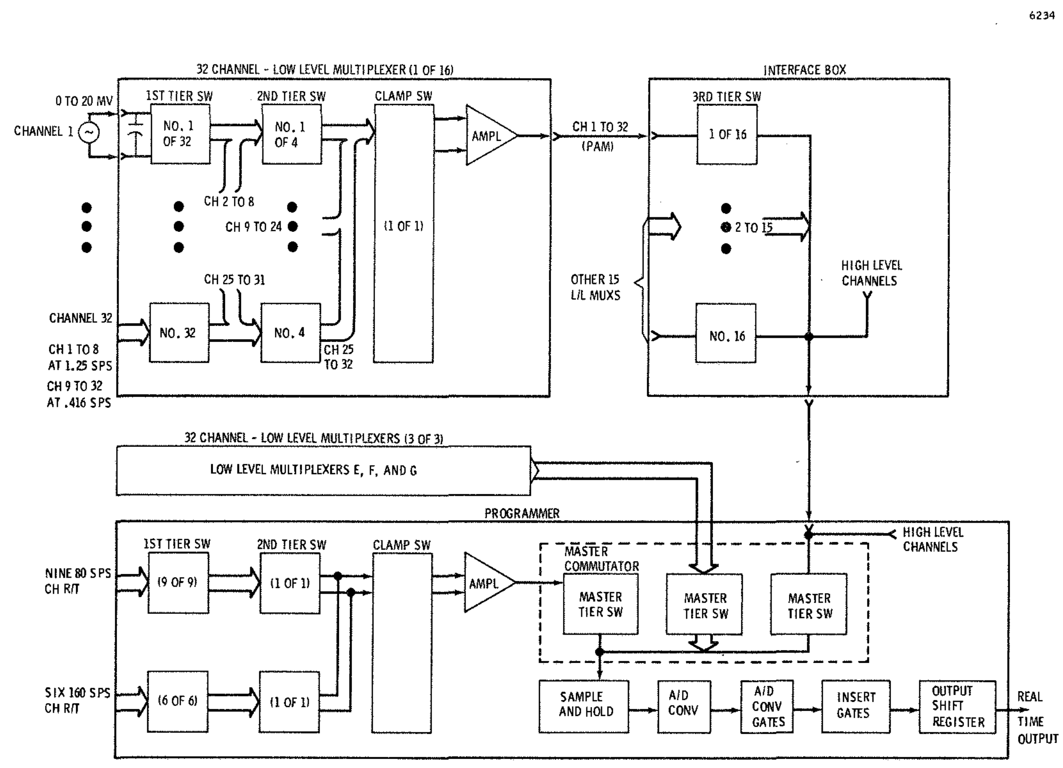


Figure 2.6.4-14 Low-Level Analog Channels

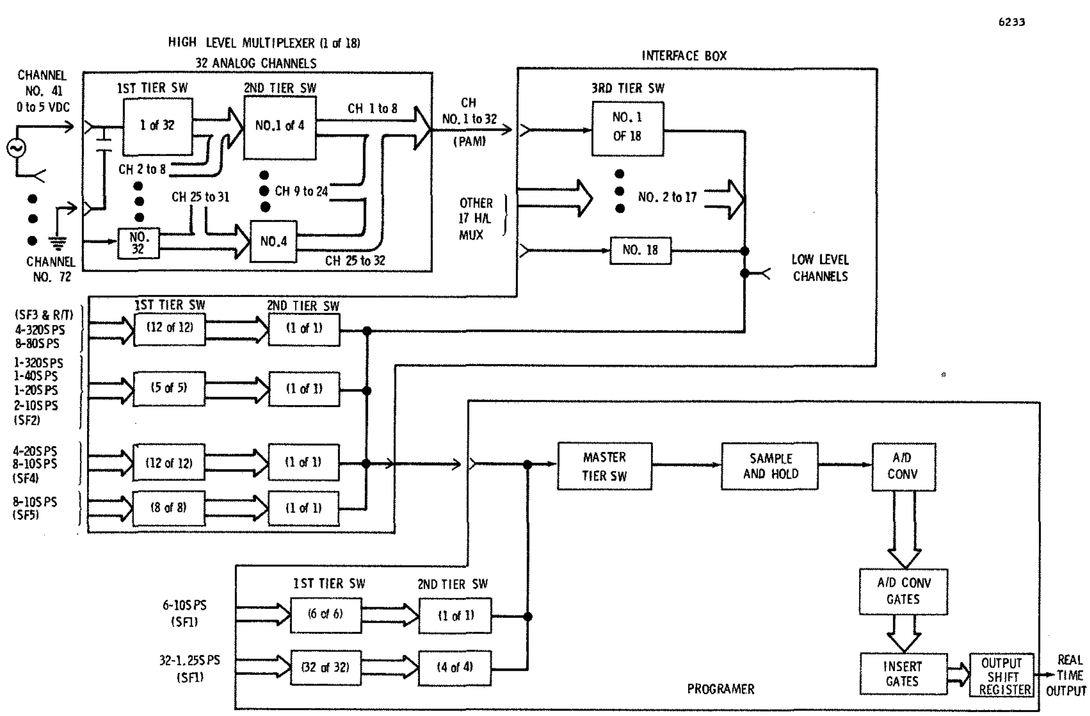


Figure 2.6.4-15 High-Level Analog Channels

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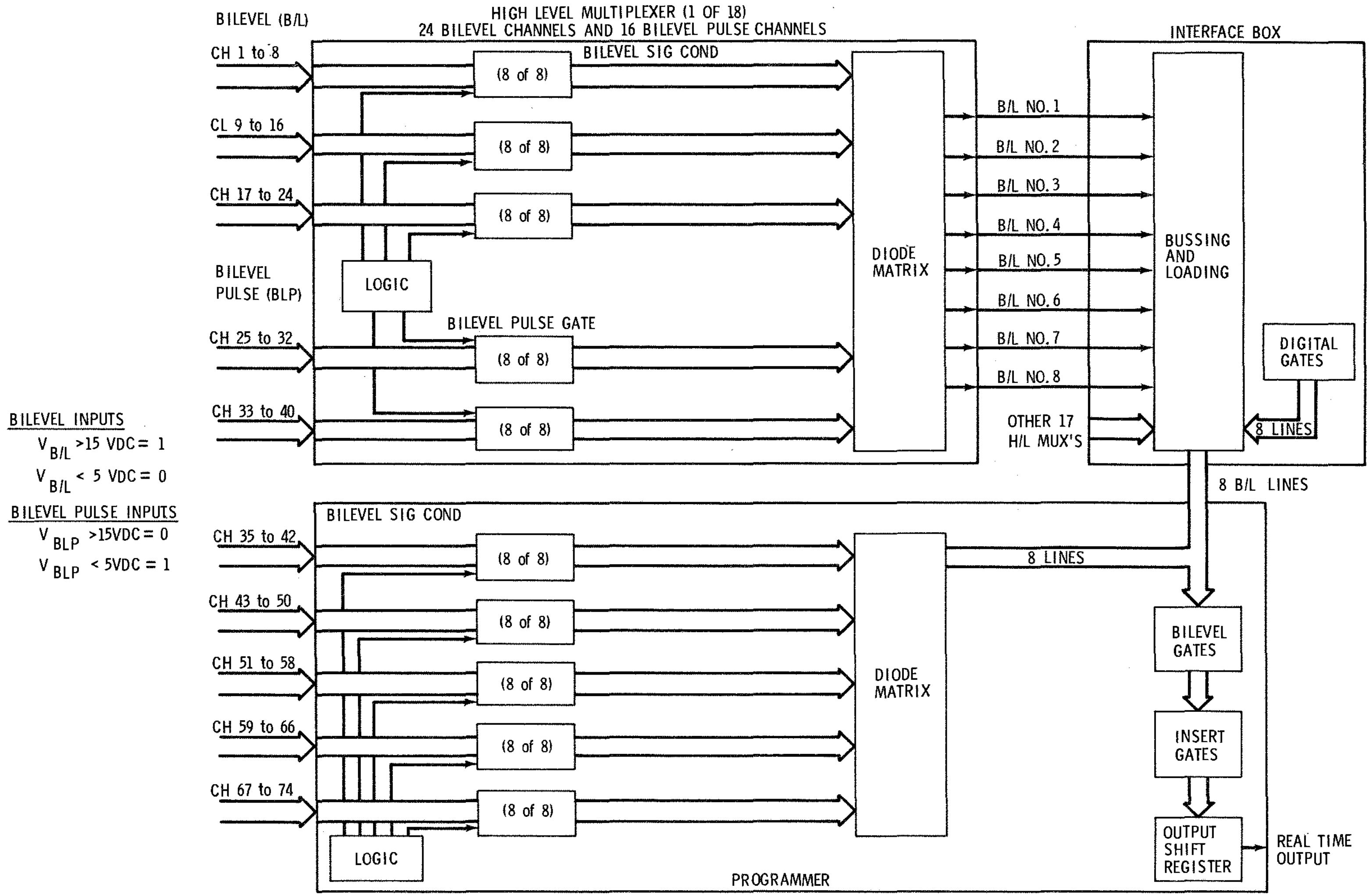


Figure 2.6.4-16 Bilevel and Bilevel Pulse Channels

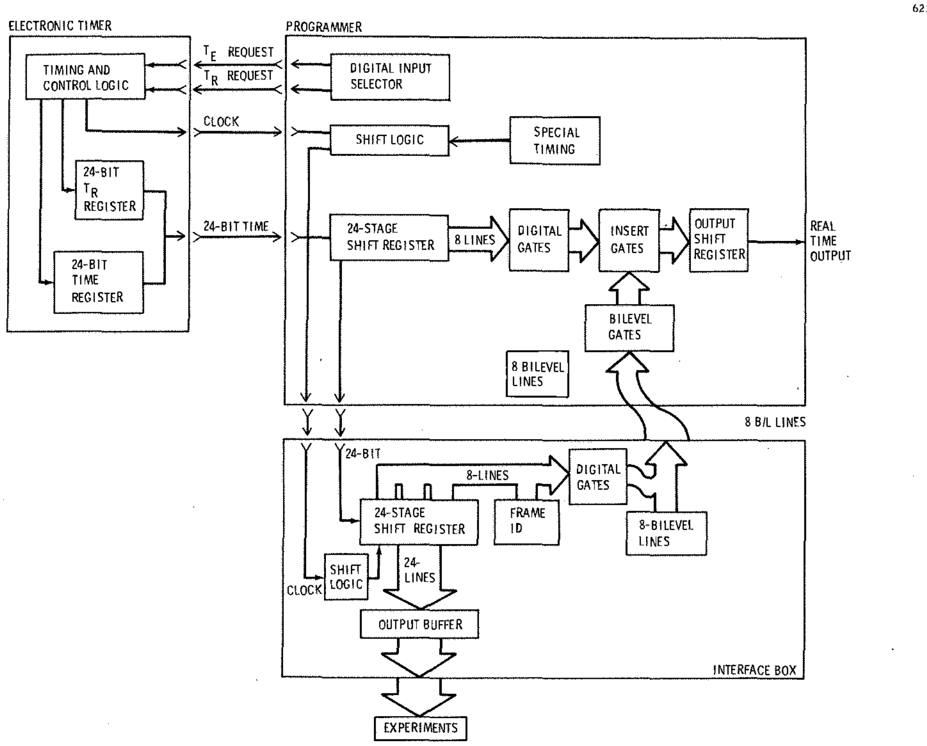


Figure 2.6.4-17 Digital Time Channels

is transformer-coupled to the tape recorders. The tape recorder clock signal is derived from the electronics timing signal. The subframes 2, 3, and 4 tape recorder converters in the interface box operate similar to the subframe 1 tape recorder converter in the programmer.

2.6.4.3 TAPE RECORDER (Figure 2.6.4-18)

The tape recorder is a two-track, audio/digital, record and reproduce machine. The tape travels between two concentric reels, with four negator springs to maintain equal tape tension. The tape is fed from the reels over the tape deck by a twisted 90-degree turn to the erase head, past a drive capstan to the record/playback head, and then through a similar path back to the other reel.

The record speed is 1 7/8 ips with a playback speed of 41 1/4 ips. This means 22 minutes of recording is played back in 1 minute. The magnetic tape is erased in the record mode to allow a new recording to be made. In the playback mode, the tape reverses direction and plays back the recording in reverse order. Replay of the playback requires a fast forward discrete (non-record mode at 41 1/4 ips) to reposition the tape, then removal of the discrete to initiate a playback mode again. The recorder has two end-of-tape limit switches that turn the recorder off to prohibit the tape from completely unwinding from the reels. The tape recorder has approximately 4 hours of recording time.

The tape motion output detects tape reel motion. A neon lamp powered from a 400-Hz inverter illuminates through the spoked tape reel that is in line with a photocell. As the spoked reel rotates, indicating tape motion, it cuts the light on and off to the photocell developing an AC voltage. The AC voltage is detected and conditioned into the output.

The recorder uses regulated +24 vdc to energize a 1 7/8 ips clutch or a 41 1/4 ips clutch for drive capstan speed. The motor is driven from two 400-Hz inverter signals, 90 degrees out of phase. The +24 vdc powers the inverter that excites the motor.

The digital record electronics accepts the 5.12 kbps PCM bit stream and the clock signal to provide a diphase coded signal to the record head. A data bit "zero" is represented by a square wave at one-half the clock frequency; a data bit "one" is represented by a square wave at the clock frequency. The digital playback electronics accepts the diphase signal from the playback head and decodes, converts, and filters it for transmission.

The analog record electronics accepts an audio signal of 300 Hz to 3000 Hz from the communication system for direct recording. The analog playback electronics accepts the audio signal from the playback head and amplifies and conditions the signal for an output to the transmission subsystem.

6230

## TAPE RECORDER BLOCK DIAGRAM

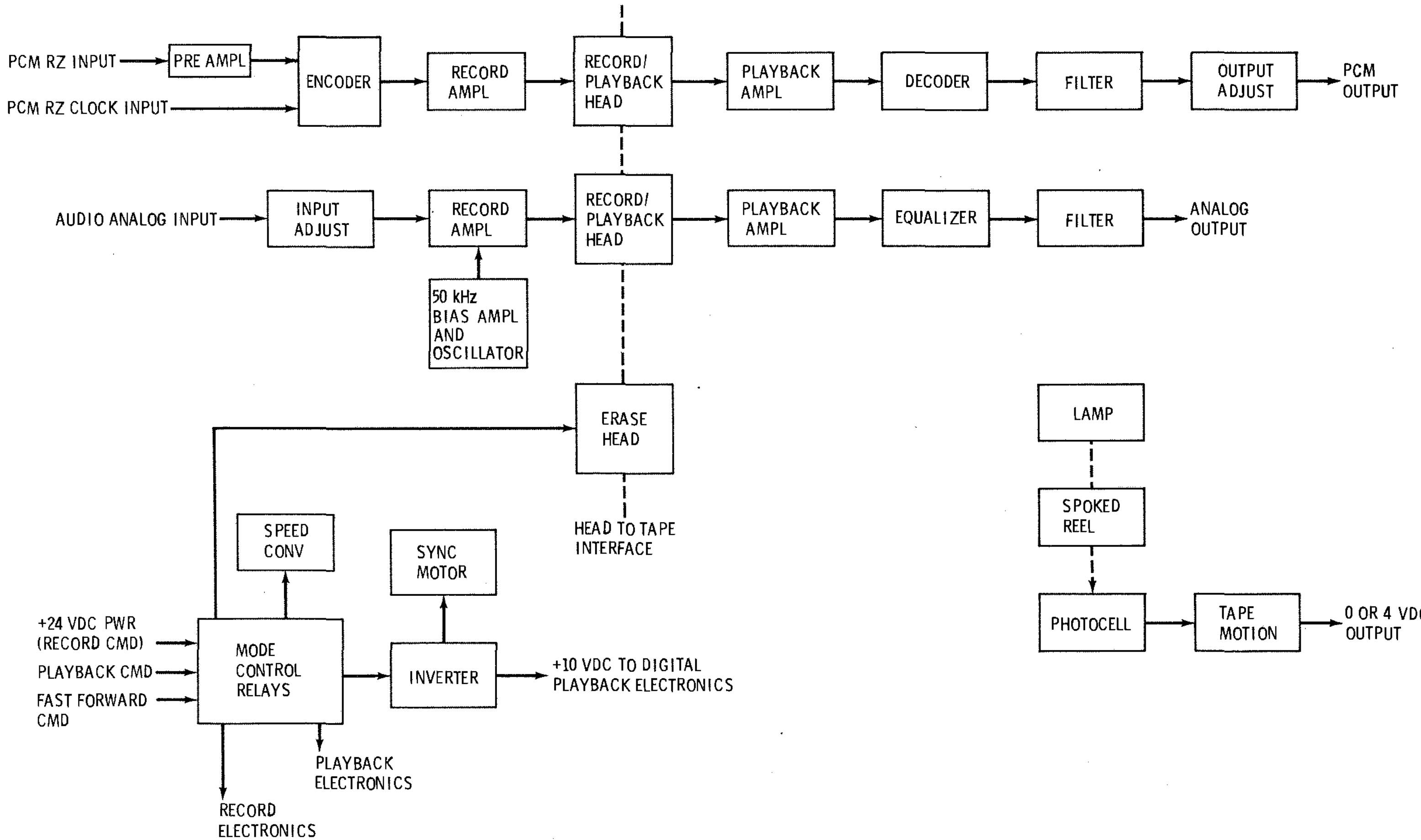


Figure 2.6.4-18 Tape Recorder Block Diagram

2.6.5 FAILURE MODES

The system failure modes and the effect on mission capability are given in table 2.6.5-1.

TABLE 2.6.5-1 FAILURE MODES

| FAILURE | INDICATIONS (See Note 1) | VEHICLE CAPABILITY |
|---|---|---|
| AM DC-DC Converter 1 | Erroneous data (TM or Meters) or inability to transmit or record. | Only two converters are required simultaneously. Select redundant unit by either DCS or crew control (panel 204). |
| AM DC-DC Converter 2 | Unable to record or transmit EXP 1, EXP VOICE, EXP 2, DATA 2, M509, T013, and OBS channels A and B. | Only two converters are required simultaneously. Select redundant unit by either DCS or crew control (panel 204). |
| PRI AM Panel Indicator DC-DC Converter | None while AM DC-DC Converter 1 is active. When inactive, zeroing of some meter readings in the AM. | Used only for meters when PCM bus is inactive. Secondary unit selection capability by crew (panel 204). |
| PRI PCM Programmer | Detectable by evaluation of transmitted vehicle telemetry. (Poor quality data typical indication.) | Secondary programmer must be selected by either DCS or crew control (panel 204). |
| PRI Interface Box Electronics | Detectable by evaluation of transmitted vehicle telemetry. (Poor quality data typical indication.) | Secondary electronics must be selected by either DCS or crew control (panel 204). |
| L/L or H/L Multiplexer | Detectable by evaluation of transmitted vehicle telemetry. (Poor quality data typical indication.) | No backup capability for failed units(s). |
| Tape Recorder | Illuminated STOP status light and/or non-illuminated tape recording status lights when commanded to operate, or poor quality data. | Replace failed unit with onboard spares. |

Note 1 - Circumstances are dependent on particular component failures within unit.

2.6.6 PERFORMANCE AND DESIGN DATA

2.6.6.1 AM DC-DC CONVERTER

- o Input voltage - 18 to 30.5 vdc
- o Input power - 113 watts maximum
- o Output voltage - +24 $\pm$ 0.75% vdc
  - -24 $\mp$ 0.75% vdc
  - +5 $\pm$ 0.5% vdc
- o Output power - 10 to 40 watts on +24 vdc
  - 7.5 to 30 watts on -24 vdc
  - 0.12 to 1.5 watts on vdc
- o Operating temp range - 0°F to 120°F
- o Non-operating temp range - -20°F to 160°F

2.6.6.2 AM PANEL INDICATOR DC-DC CONVERTER

- o Input voltage - 19 to 34 vdc
- o Input power - 29 watts maximum
- o Output voltage - +24 $\pm$ 1.25% vdc
  - -24 $\mp$ 1.25% vdc
  - +5 $\pm$ 0.075 vdc
- o Output power - 0 to 8 watts on +24 vdc
  - 0 to 5 watts on -24 vdc
  - 0 to 1 watt on +5 vdc
- o Operating temp range - 0°F to 160°F
- o Non-operating temp range - -20°F to 160°F

2.6.6.3 OWS DC-DC CONVERTER

- o Input voltage - 24 to 30 vdc
- o Input power - 6 watts maximum
- o Output voltage - +5 ± 0.01 vdc
- o Output power - 0 to 1 watt
- o Operating temp range - 0°F to 195°F
- o Non-operating temp range - -40°F to 195°F

2.6.6.4 MDA SIGNAL CONDITIONER

- o Input voltage - -24 to 30 vdc
- o Input power - 5 watts maximum
- o Operating temp range - -40°F to 150°F
- o Non-operating temp range - -40°F to 160°F

2.6.6.5 PROGRAMMER

- o Input voltage - -24 ± 0.5 vdc
- o Input power - 6.3 watts
- o Inputs
  - 9 L/L at 80 SPS
  - 6 L/L at 160 SPS
  - 6 H/L at 10 SPS
  - 32 H/L at 1.25 SPS
  - 24-bit digital words at 0.416 SPS
  - 8-bit digital words at 10 SPS
- o Outputs
  - 51.2 kbps serial NRZ-C at 0.88 ± .04V peak-to-peak (R/T TM)
  - 5.12 kbps serial RZ at 5 + 1.0 V -0.5V peak-to-peak (subframe 1)
  - 5.12 kbps serial clock signals for subframes 1, 2, 3 & 4 at 5+1.0V -0.5V peak-to-peak
- o Operating temp range - 0°F to 160°F
- o Non-operating temp range - -20°F to 160°F

2.6.6.6 INTERFACE BOX

- o Input voltage - -24 ± 0.5 vdc
- o Input power - 18.3 watts
- o Inputs
  - 18 H/L at 10 SPS
  - 5 H/L at 20 SPS
  - 1 H/L at 40 SPS
  - 8 H/L at 80 SPS
  - 5 H/L at 320 SPS
- o Outputs
  - 5.12 kbps serial RZ at 5 +1.0V -0.5V peak-to-peak (subframes 2, 3, & 4) 24-bit parallel elapsed time word
- o Operating temp range - 0°F to 160°F
- o Non-operating temp range - -20°F to 160°F

2.6.6.7 LOW LEVEL MULTIPLEXER

- o Input voltage
  - +18 ± 0.15 vdc
  - -18 ∓ 0.15 vdc
  - +5 vdc (5.5 ± 0.3 vdc)
- o Input power
  - 0.036 watts on +18 vdc
  - 0.043 watts on -18 vdc
  - 0.060 watts on +5 vdc
- o Inputs
  - 8 L/L at 1.25 SPS
  - 24 L/L at 0.416 SPS
- o Operating temp range - 0°F to 160°F
- o Non-operating temp range - -20°F to 160°F

2.6.6.8 HIGH LEVEL MULTIPLEXER

- o Input voltage
  - +5 vdc (5.5 ± 0.3 vdc)
  - -5 vdc (-6.19 ± 0.3 vdc)
- o Input power
  - 0.050 watts on +5 vdc
  - 0.020 watts on -5 vdc
- o Inputs
  - 32 H/L at 1.25 SPS
  - 24 B/L at 10 SPS
  - 16 BLP at 10 SPS
- o Operating temp range - 0°F to 160°F
- o Non-operating temp range - -20°F to 160°F

2.6.6.9 TAPE RECORDER

| | |
|---|---|
| o Input voltage | - 24 ± 1% vdc |
| o Input power | - 14.5 watts (record mode) |
| | - 15.5 watts (playback and fast forward modes) |
| o Inputs | - 5.12 kbps RZ (subframes 1, 2, 3 & 4) and a 5.12 kbps clock |
| | - 5.76 kbps RZ (experiments M509 & T013) and a 5.76 kbps clock |
| | - 300 to 3000 Hz audio @ 1.5 VRMS nominal |
| o Outputs | - 112.6 kbps NRZ-space at 2.0 ± 0.5 V peak-to-peak |
| | - 126.7 kbps NRZ-space at 2.0 ∓ 0.5 V peak-to-peak |
| | - 6.6 to 66kHz at 2.0V ± 3db peak-to-peak |
| o Tape start and transition times | - power off to record (10 sec) |
| | - record to playback (3 sec) |
| | - playback to record (1 sec) |
| | - fast forward to/from record or playback (15 sec) |
| o Operating temp range | - 40°F to 120°F |
| o Non-operating temp range | - -20°F to 160°F |

2.6.6.10 QUARTZ CRYSTAL MICROBALANCE CONTAMINATION MONITOR

| | |
|---|---|
| o Input voltage | - 23.25 to 24.3 vdc |
| o Input current | - 35 milliamps (max) |
| o Beat frequency output | |
| o Sensitivity | - $10^8$ Hz/gm (nominal) |
| o Frequency range | - 0 to 12 KHz |
| o Amplitude (AC component) | - 10 to 15 volts peak-to-peak |
| o Amplitude (DC component) | - 8 to 9 vdc |
| o Output impedance | - 10K ohms |
| o Mass disposition output | |
| o Sensitivity | - 45 mvdc/microgram (nominal) |
| o Output impedance | - 10K ohms |
| o Crystal temperature | |
| o Range | - -55°F to +160°F |
| o Output impedance | - 10K ohms |
| o Operating temperature range | - -70°F to +160°F |
| o Non-operating temperature range | - -100°F to +160°F |
| o Operating life | - 9000 hours |

2.6.7 OPERATIONAL LIMITATIONS AND RESTRICTIONS

The operational limitations and restrictions for the system are as follows:

- o The interface box electronics contains internal power supply modules which are protected from overload by current limiters. These can be reset by interrupting the -24 vdc input power for a minimum period of 10 seconds.
- o Voice recording in the AM/MDA/OWS requires an active CSM audio center.
- o Select desired TAPE RECORDERS 1, 2 & 3 positions prior to moving the TAPE RECORDERS CONTROL switch to MANUAL SELECT.
- o Select desired TRANSMITTER INPUT A, B & C positions prior to moving the transmitters switch to ON.

2.6.8 INSTRUMENTATION AND GROUND COMMANDS

| MEASUREMENT NUMBER | DESCRIPTION | TELEMETRY RANGE | ONBOARD DISPLAY DISPLAY RANGE | ONBOARD DISPLAY PANEL |
|---|---|---|---|---|
| C301-512 | TEMP-TM XMTR NO A CASE (2 watt) | 0 TO 200°F | - | - |
| C302-512 | TEMP-TM XMTR NO B CASE | 0 TO 200°F | - | - |
| C303-512 | TEMP-TM XMTR NO C CASE | 0 TO 200°F | - | - |
| C304-512 | TEMP-TM XMTR NO A CASE (10 watt) | 0 TO 200°F | - | - |
| C501-514 | TEMP-DC-DC CONVERTER NO. 1 | -55 TO 200°F | - | - |
| C502-514 | TEMP-DC-DC CONVERTER NO. 2 | -55 TO 200°F | - | - |
| C503-514 | TEMP-DC-DC CONVERTER NO. 3 | -55 TO 200°F | - | - |
| K322-502 | EVENT-DCS 02, DATA RCDR FAST FWD | ZERO = ON | - | - |
| K326-512 | EVENT-DCS 06, DATA DUMP ENABLE | ZERO = ON | - | - |
| K330-512 | EVENT-DCS 10, EXP 1 + VOICE DUMP ENABLE | ZERO = ON | - | - |
| K331-512 | EVENT-DCS 11, R/T TELEMETRY | ZERO = ON | - | - |
| K332-512 | EVENT-DCS 12, EXP 2/DATA 2 DUMP ENABLE | ZERO = ON | - | - |
| K335-512 | EVENT-DCS 15, DATA RCDR EXECUTE | ZERO = DUMP | - | - |
| K336-512 | EVENT-DCS 16, DATA + VOICE DUMP ENABLE | ZERO = ON | - | - |
| K339-512 | EVENT-DCS 19, EXP 2/DATA 2 RCDR FAST FWD | ZERO = ON | - | - |
| K346-512 | EVENT-DCS 26, EXP 1 RCDR FAST FWD | ZERO = ON | - | - |
| K351-512 | EVENT-DCS 31, EXP 1 RCDR DUMP EXECUTE | ZERO = DUMP | - | - |
| K352-512 | EVENT-DCS 32, EXP 2/DATA 2 RCDR DUMP EXECUTE | ZERO = DUMP | - | - |

2.6.8 INSTRUMENTATION (cont'd)

| MEASUREMENT NUMBER | DESCRIPTION | TELEMETRY RANGE | ONBOARD DISPLAY DISPLAY RANGE | PANEL |
|---|---|---|---|---|
| K374-512 | POSITION-COAX SWITCH 2W or 10W | ONE = 10 WATT | - | - |
| K505-509 | EVENT-T/R 1 PLAYBACK MODE DETECT | 2.25V = PLAYBACK | - | - |
| K506-509 | EVENT-T/R 2 PLAYBACK MODE DETECT | 2.25V = PLAYBACK | - | - |
| K507-509 | EVENT-T/R 3 PLAYBACK MODE DETECT | 2.25V = PLAYBACK | - | - |
| K508-509 | EVENT-T/R 1 TAPE MOTION MONITOR | 4V = MOTION | - | - |
| K509-509 | EVENT-T/R 2 TAPE MOTION MONITOR | 4V = MOTION | - | - |
| K510-509 | EVENT-T/R 3 TAPE MOTION MONITOR | 4V = MOTION | - | - |
| K511-513 | EVENT-SUBFRAME 1 (P) I.D. | 00000000 | - | - |
| K512-513 | EVENT-SUBFRAME 2 (Q) I.D. | 10000000 | - | - |
| K513-513 | EVENT-SUBFRAME 3 (R) I.D. | 01000000 | - | - |
| K514-513 | EVENT-SUBFRAME 4 (S) I.D. | 11000000 | - | - |
| K911-513 | EVENT-T/R 1 MALFUNCTION | - | DISCRETE | 204 |
| K912-513 | EVENT-T/R 2 MALFUNCTION | - | DISCRETE | 204 |
| K913-513 | EVENT-T/R 3 MALFUNCTION | - | DISCRETE | 204 |
| K919-509 | EVENT-DATA TAPE MOTION MONITOR | - | DISCRETE | 204 |
| K920-509 | EVENT-EXP 1 TAPE MOTION MONITOR | - | DISCRETE | 204 |
| K921-509 | EVENT-EXP 2 TAPE MOTION MONITOR | - | DISCRETE | 204 |
| M501-513 | VOLT-PROG LL 15 PERCENT FULL SCALE REF | 3 MV = 15 PCT | - | - |
| M502-513 | VOLT-PROG LL 75 PERCENT FULL SCALE REF | 15 MV = 75 PCT | - | - |
| M503-513 | VOLT-LL MUX C 15 PERCENT FULL SCALE REF | 3 MV = 15 PCT | - | - |
| M504-513 | VOLT-LL MUX C 75 PERCENT FULL SCALE REF | 15 MV = 75 PCT | - | - |
| M505-513 | VOLT-LL MUX E 15 PERCENT FULL SCALE REF | 3 MV = 15 PCT | - | - |
| M506-513 | VOLT-LL MUX E 75 PERCENT FULL SCALE REF | 15 MV = 75 PCT | - | - |
| M507-513 | VOLT-LL MUX F 15 PERCENT FULL SCALE REF | 3 MV = 15 PCT | - | - |
| M508-513 | VOLT-LL MUX F 75 PERCENT FULL SCALE REF | 15 MV = 75 PCT | - | - |
| M509-513 | VOLT-LL MUX G 15 PERCENT FULL SCALE REF | 3 MV = 15 PCT | - | - |
| M510-513 | VOLT-LL MUX G 75 PERCENT FULL SCALE REF | 15 MV = 75 PCT | - | - |
| M511-514 | VOLTAGE-INSTRU BUS A +24 VDC | 0 TO 48 VDC | - | - |
| M512-514 | VOLTAGE-INSTRU BUS A -24 VDC | 0 TO -48 VDC | - | - |
| M513-514 | VOLTAGE-INSTRU BUS A +5 VDC | 4.5V = 100 PCT | - | - |
| M514-513 | VOLT-LL MUX N 15 PERCENT FULL SCALE | 3 MV = 15 PCT | - | - |
| M515-513 | VOLT-LL MUX N 75 PERCENT FULL SCALE | 15 MV = 75 PCT | - | - |
| M516-513 | VOLT-LL MUX P 15 PERCENT FULL SCALE | 3 MV = 15 PCT | - | - |
| M517-513 | VOLT-LL MUX P 75 PERCENT FULL SCALE | 15 MV = 75 PCT | - | - |
| M518-513 | VOLT-LL MUX B 15 PERCENT FULL SCALE | 3 MV = 15 PCT | - | - |
| M519-513 | VOLT-LL MUX B 75 PERCENT FULL SCALE | 15 MV = 75 PCT | - | - |
| M520-514 | VOLTAGE-INSTR BUS B +24 VDC | 0 TO 48 VDC | - | - |
| M521-514 | VOLTAGE-INSTR BUS B -24 VDC | 0 TO -48 VDC | - | - |
| M522-514 | VOLTAGE-INSTR BUS B +5 VDC | 4.5V = 100 PCT | - | - |
| K7323-440 | EVENT-DAS, EXP 1 TAPE RCDR, ON | - | DISCRETE | 542,617 |
| K7324-440 | EVENT-DAS, EXP 2 TAPE RCDR, ON | - | DISCRETE | 542,617 |
| M7031-411 | VOLT-DAS LO LEVEL MUX D, REF HI | 0 TO 20 MV | - | - |
| M7032-411 | VOLT-DAS LO LEVEL MUX D, REF LO | 0 TO 20 MV | - | - |
| M7033-411 | VOLT-DAS LO LEVEL MUX Q, REF HI | 0 TO 20 MV | - | - |
| M7034-411 | VOLT-DAS LO LEVEL MUX Q, REF LO | 0 TO 20 MV | - | - |
| M7035-411 | VOLT-DAS LO LEVEL MUX H, REF HI | 0 TO 20 MV | - | - |
| M7036-411 | VOLT-DAS LO LEVEL MUX H, REF LO | 0 TO 20 MV | - | - |
| M7037-411 | VOLT-DAS LO LEVEL MUX K, REF HI | 0 TO 20 MV | - | - |
| M7038-411 | VOLT-DAS LO LEVEL MUX K, REF LO | 0 TO 20 MV | - | - |
| M7039-411 | VOLT-DAS LO LEVEL MUX M, REF HI | 00 TO 20 MV | - | - |
| M7040-411 | VOLT-DAS LO LEVEL MUX M, REF LO | 0 TO 20 MV | - | - |
| M7041-404 | VOLT-DAS LO LEVEL MUX J, REF HI | 0 TO 20 MV | - | - |
| M7042-404 | VOLT-DAS LO LEVEL MUX J, REF LO | 0 TO 20 MV | - | - |
| M7043-404 | VOLT-DAS LO LEVEL MUX L, REF HI | 0 TO 20 MV | - | - |
| M7044-404 | VOLT-DAS LO LEVEL MUX L, REF LO | 0 TO 20 MV | - | - |
| M7045-411 | VOLT-DAS HI LEVEL MUX D, REF HI | 0 TO 5 VOLTS | - | - |
| M7047-411 | VOLT-DAS HI LEVEL MUX E, REF HI | 0 TO 5 VOLTS | - | - |
| M7051-411 | VOLT-DAS HI LEVEL MUX H, REF HI | 0 TO 5 VOLTS | - | - |
| M7053-411 | VOLT-DAS HI LEVEL MUX J, REF HI | 0 TO 5 VOLTS | - | - |
| M7054-411 | VOLT-DAS HI LEVEL MUX K, REF HI | 0 TO 5 VOLTS | - | - |
| C003-544 | TEMP-QCM 1 +X AMB CRYSTAL OUTPUT | -70 TO 160°F | - | - |
| C004-544 | TEMP-QCM 1 -X AMB CRYSTAL OUTPUT | -70 TO 160°F | - | - |
| C005-544 | TEMP-QCM 3 +Z AMB CRYSTAL OUTPUT | -70 TO 160°F | - | - |
| C006-544 | TEMP-QCM 4 +Z 50F CRYSTAL OUTPUT | -70 TO 160°F | - | - |
| M015-544 | VOLT-QCM 1 +X AMB COURSE MASS OUT | 0 TO 5 VDC | - | - |
| M016-544 | VOLT-QCM 1 +X AMB EXPAND MASS OUT | 0 TO 5 VDC | - | - |
| M018-544 | VOLT-QCM 2 -X AMB COURSE MASS OUT | 0 TO 5 VDC | - | - |
| M019-544 | VOLT-QCM 2 -X AMB EXPAND MASS OUT | 0 TO 5 VDC | - | - |
| M021-544 | VOLT-QCM 3 +Z AMB COURSE MASS OUT | 0 TO 5 VDC | - | - |
| M022-544 | VOLT-QCM 3 +Z AMB EXPAND MASS OUT | 0 TO 5 VDC | - | - |
| M024-544 | VOLT-QCM 4 +Z 50F COURSE MASS OUT | 0 TO 5 VDC | - | - |
| M025-544 | VOLT-QCM 4 +Z 50F EXPAND MASS OUT | 0 TO 5 VDC | - | - |

GROUND COMMANDS

| DCS COMMAND | COMMAND TITLE | FUNCTION | OCTAL NO. | TELEMETRY DISCRETE | |
|---|---|---|---|---|---|
| S396 | INSTRUMENTATION SYSTEM - CONVERTERS | 1 + 2 | 41624 | | POWER SUBSYSTEM |
| S395 | | 1 + 3 | 46624 | | |
| S399 | INSTRUMENTATION SYSTEM - CONVERTERS | 3 + 2 | 47624 | | |
| S397 | | 2 + 1 | 45624 | | |
| S275 | PCM BUS SELECT | A | 46104 | | |
| S274 | | B | 42104 | | |
| S187 | INST GROUP 1 BUS SELECT | A | 46720 | | |
| S186 | | B | 42720 | | |
| S199 | INST GROUP 2 BUS SELECT | A | 47060 | | |
| S198 | | B | 43060 | | |
| S145 | INSTRUMENTATION SYSTEM - PROGRAMMER | PRI | 44220 | | PCM SUBSYSTEM |
| S144 | | SEC | 40220 | | |
| S333 | INSTRUMENTATION SYSTEM - ELECTRONICS | PRI | 45644 | | |
| S332 | | SEC | 41644 | | |
| S377 | TAPE RECORDING - DATA | OFF | 44424 | | RECORDING SUBSYSTEM |
| S376 | | RECORD | 40424 | | |
| S331 | TAPE RECORDING - DATA 2 | OFF | 46644 | | |
| S330 | | RECORD | 42644 | | |
| S155 | RECORDER SELECT 1 | RESET | 46620 | | |
| S154 | | SET | 42620 | | |
| S171 | RECORDER SELECT 2 | RESET | 46520 | | |
| S170 | | SET | 42520 | | |
| S195 | LAUNCH/ORBIT TRANSMITTER SELECT | LAUNCH(2W) | 46060 | | TRANSMISSION SUBSYSTEM |
| S194 | | ORBIT(10W) | 42060 | | |
| 11-2 | REAL TIME TM | OFF | 724 | K331 = 1 | |
| 11-2 | | ON | 725 | K331 = 0 | |
| S269 | BACKUP REAL TIME TM | OFF | 45604 | | |
| S268 | | ON | 41604 | | |
| 10-2 | EXP. 1 + EXP. VOICE DUMP ENABLE | OFF | 744 | K330 = 1 | |
| 10-2 | | ON | 745 | K330 = 0 | |
| 12-2 | EXP. 2/DATA 2 DUMP ENABLE | OFF | 764 | K332 = 1 | |
| 12-2 | | ON | 765 | K332 = 0 | |
| 6-1 | DATA DUMP ENABLE | OFF | 750 | K326 = 1 | |
| 6-1 | | ON | 751 | K326 = 0 | |
| 16-2 | DATA + VOICE DUMP ENABLE | OFF | 774 | K336 = 1 | |
| 16-2 | | ON | 775 | K336 = 0 | |
| 15-2 | DATA RCDR. DUMP EXECUTE | OFF | 734 | K335 = 1 | |
| 15-2 | | DUMP | 735 | K335 = 0 | |
| 31-4 | EXP. 1 RCDR. DUMP EXECUTE | OFF | 736 | K351 = 1 | |
| 31-4 | | DUMP | 737 | K351 = 0 | |
| 32-4 | EXP. 2/DATA 2 RCDR. DUMP EXECUTE | OFF | 776 | K352 = 1 | |
| 32-4 | | DUMP | 777 | K352 = 0 | |
| 2-1 | DATA RCDR. NON-RECORD FAST FWD. | OFF | 740 | K322 = 1 | |
| 2-1 | | ON | 741 | K322 = 0 | |
| 26-4 | EXP. 1 RCDR. NON-RECORD FAST FWD. | OFF | 746 | K346 = 1 | |
| 26-4 | | ON | 747 | K346 = 0 | |
| 19-3 | EXP. 2/DATA 2 RCDR. NON-RECORD FAST FWD. | OFF | 722 | K339 = 1 | |
| 19-3 | | ON | 723 | K339 = 0 | |
| S452 | TRANSMITTER MODULATION SELECT 1 | RESET | 41264 | | |
| S451 | | SET | 46264 | | |
| S454 | TRANSMITTER MODULATION SELECT 2 | RESET | 43264 | | |
| S453 | | SET | 45264 | | |
| S151 | TRANSMITTER MODULATION SELECT 3 | RESET | 47220 | | |
| S150 | | SET | 43220 | | |
| S409 | QCM CONTAMINATION MONITOR | OFF | 44524 | | MISC |
| S408 | | ENABLE | 40524 | | |
| S357 | PROTON SPECTROMETER | OFF | 45344 | | |
| S356 | | ON | 41344 | | |
| S358 | PROTON SPECT COUNT/THRESHOLD | CHANGE | 43344 | | |

SUBSECTION 2.7

DIGITAL COMMAND SYSTEM/TIME REFERENCE SYSTEM

## 2.7.1 INTRODUCTION

The Digital Command System (DCS) and Time Reference System (TRS) provide a data interface between the Manned Space Flight Network (MSFN) and the Saturn Workshop (SWS). The DCS receives and decodes real time commands uplinked from MSFN to provide ground control over various SWS systems during all mission phases, and backs up the Instrument Unit (IU) command system to activate the SWS. The TRS provides time reference data for onboard display and time correlation of telemetered data. The DCS provides real-time (R/T) MSFN control over the TRS, and the TRS provides time-dependent switching control over the DCS.

## 2.7.2 SYSTEM INTERFACES

The DCS interfaces with various SWS systems by providing control over relays within specific systems (figure 2.7.2-1). The TRS provides elapsed time to the instrumentation system and Earth Resources Experiment Package (EREP) for time correlation used to reduce ground data. The RF subsystem provides the antennae for reception of uplinked data from the MSFN to the DCS. The DCS transfers digital data to the teleprinting subsystem (section 2.7.3). Passive thermal control of the DCS/TRS is provided by the environmental control system (ECS). control system (ECS).

## 2.7.3 FUNCTIONAL DESCRIPTION

The DCS executes real-time commands from MSFN, transfers MSFN time updates to the TRS, and transfers teleprinter messages to the COMM teleprinting subsystem. The DCS (figure 2.7.3-1) consists of a primary and secondary receiver/decoder, four eight-channel DCS relay modules and a 480-channel Command Relay Driver Unit (CRDU).

Operating on either the primary or secondary receiver/decoder, the DCS receives an uplinked message through the RF subsystem. Each receiver/decoder contains two receivers. Receiver No. 1 of each receiver/decoder is connected to a single antenna and receiver No. 2 of each receiver/decoder is connected to one of three selectable antennae (section 2.2.3). Thus, each receiver/decoder has redundant radio frequency (RF) reception capability.

Only one receiver/decoder can be commanded at a time. The addressed receiver/decoder determines for which system (DCS, teleprinter, or TRS) the message is intended and routes it to that system for further processing. A command message to the DCS is routed by a receiver/decoder to the DCS relay modules or the CRDU. If the command is for the DCS relay modules, a receiver/decoder decodes the command word and activates a relay within the DCS relay modules to supply a contact closure to the using SWS system. If the command is for the CRDU, a receiver/decoder routes the command word to the CRDU, where it is decoded and enables a solid state relay driver to provide a control signal to the using SWS system. A message to the teleprinting subsystem is routed by a receiver/decoder to that subsystem where it is decoded and printed out. A message to the TRS is routed by a receiver/decoder to the TRS, where the time update is decoded and processed.

The TRS provides onboard time displays, generates time correlation for the instrumentation system and EREP, initiates time dependent switchover to redundant components within the DCS, and initiates time dependent equipment reset via the DCS. The TRS (figure 2.7.3-2) consists of a primary and secondary electronic timer, a primary and secondary time correlation buffer (TCB), two GMT clocks, an event timer, and four portable timers.

Each electronic timer has three timing registers: the elapsed time (Te) register, the time-to-go-to-redundant receiver/decoder (Tr) register, and the time-to-go-to-equipment reset (Tx) register. The selected electronic timer provides an elapsed time output to the instrumentation system and the respective TCB from the Te register, receives time updates for the Tx and Tr registers from a receiver/decoder, and provides a timing pulse to the event timer. The Te register is an incremental register which can be reset to zero but not updated. The elapsed time output from the Te register to the instrumentation system and the TCB provides for time correlation of telemetry data and a time base for onboard displays, respectively. The Tr and Tx registers are decremental registers, which can be updated from MSFN via a receiver/decoder. When the Tr register counts down to 30 seconds (TR-30), an output to activate the redundant receiver/decoder is provided. A similar output is provided to reset preselected spacecraft equipment via the DCS when the Tx register counts down to 0 seconds (TX-0).

The primary or secondary TCB receives the elapsed time output of the primary or secondary electronic timer Te register. The TCB converts this elapsed time word into a form acceptable to the GMT clocks and provides a high resolution time word to the EREP instrumentation system for time correlation.

The GMT clocks receive an elapsed time output from either the primary or secondary TCB and provide a digital display of time synchronized to Greenwich Meridian time (GMT). The maximum display capability of the clocks is 399 days, 23 hours, 59 minutes, and 59 seconds.

The event timer receives a timing pulse from either the primary or secondary electronic timer and provides a digital display of time that may be set to any desired indication by the crew to a maximum of 999 hours, 59 minutes, and 59 seconds.

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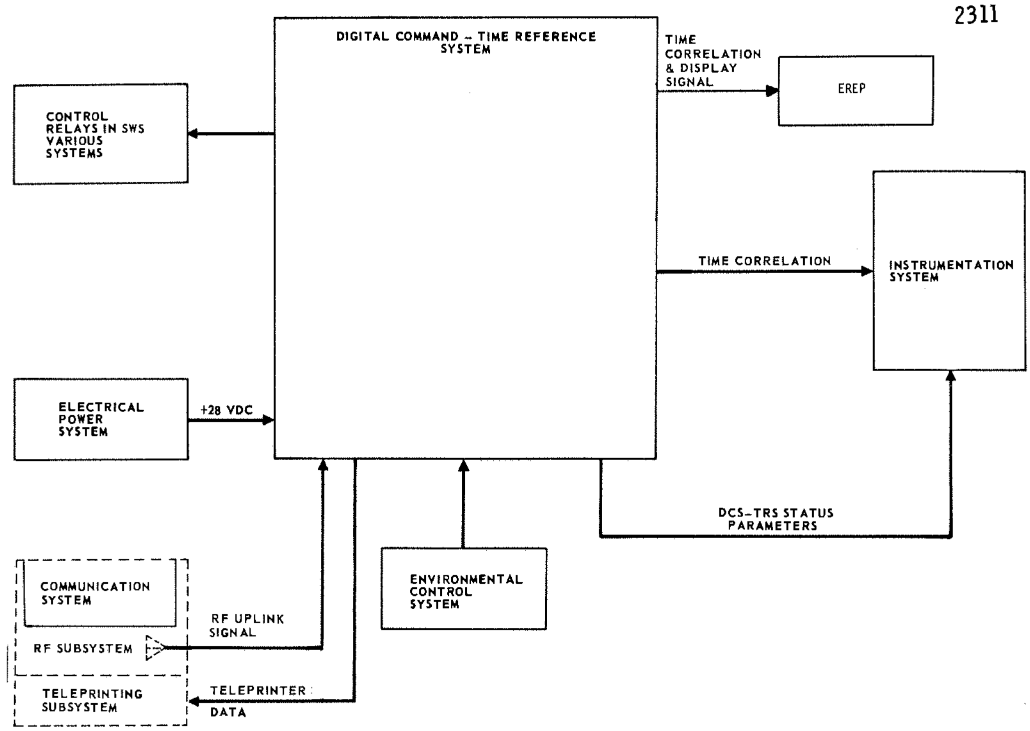


Figure 2.7.2-1 DCS/TRS Interfaces

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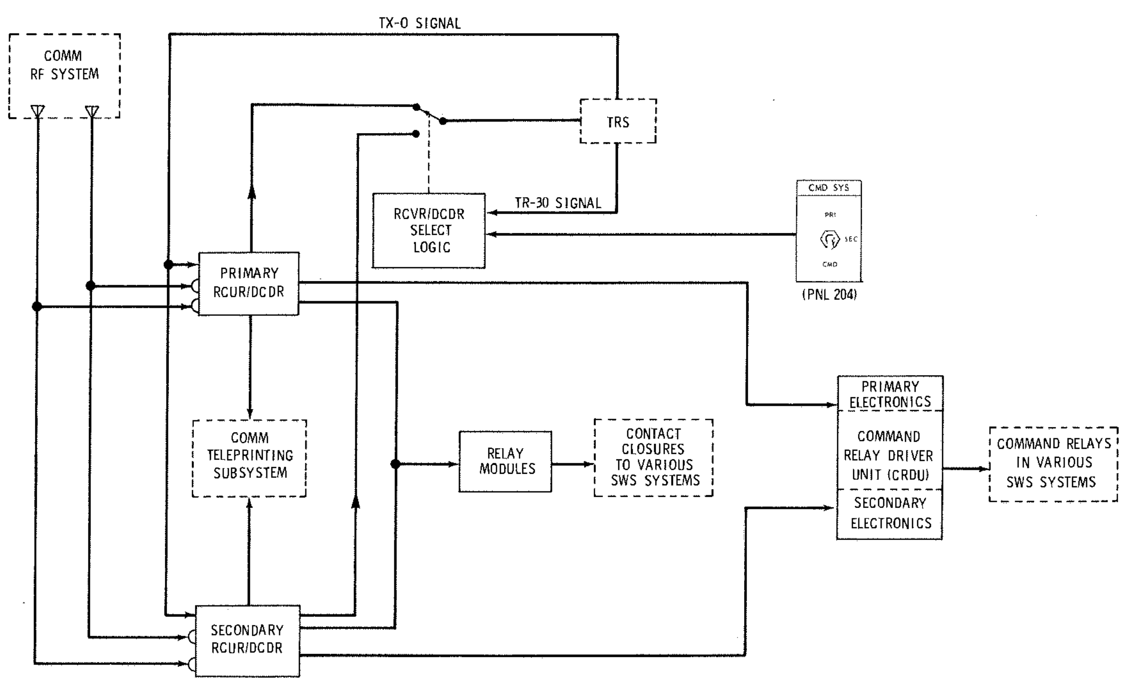


Figure 2.7.3-1 DCS Configuration

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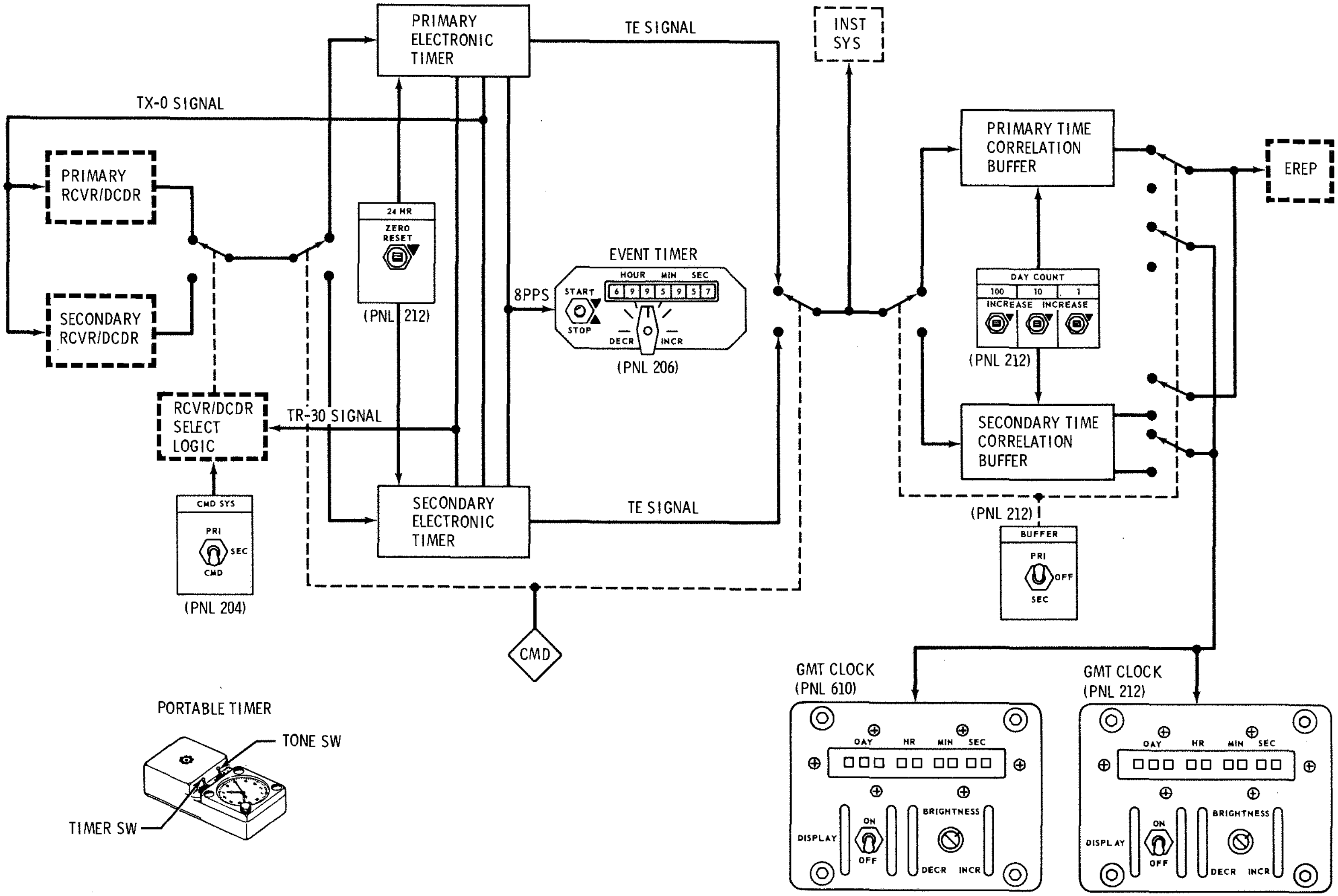


Figure 2.7.3-2 TRS Configuration

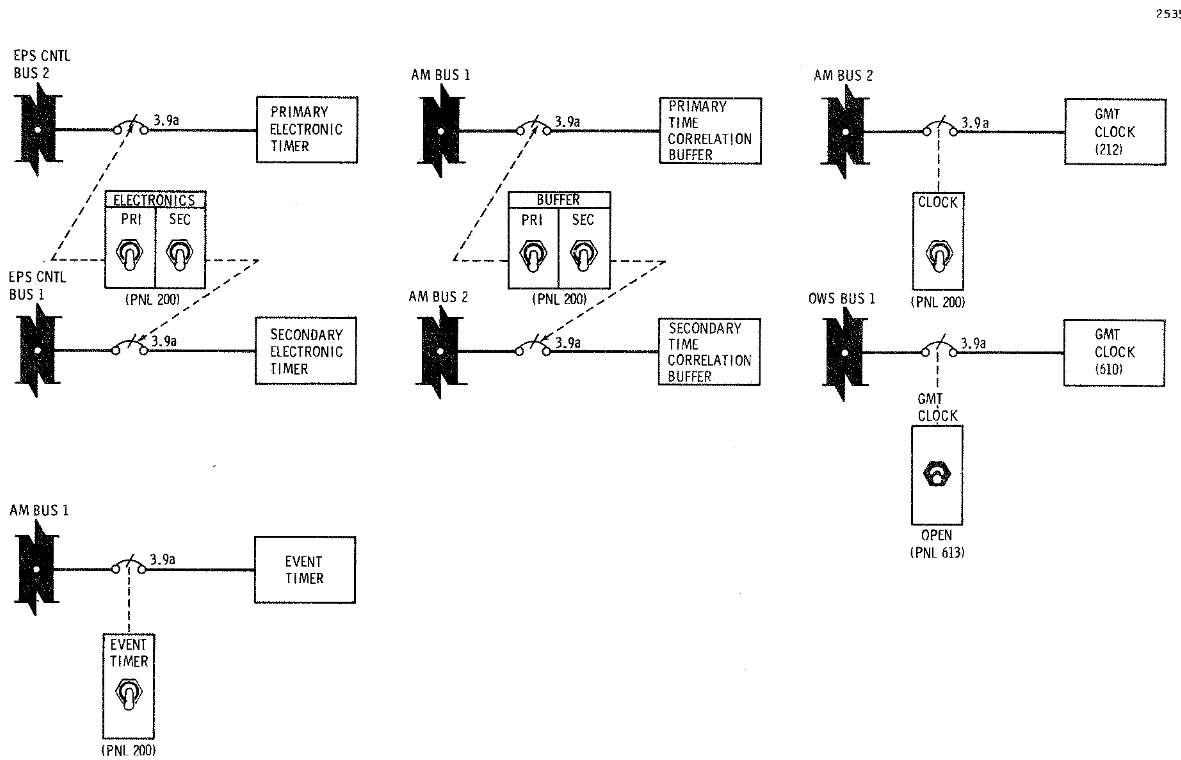


Figure 2.7.3-3 TRS Power Distribution

The portable timer provides a time-remaining display, and provides an audio output at a time preselected by the crew. The maximum display (setting) is 11 hours, 59 minutes, and 59 seconds.

2.7.3.1 DIGITAL COMMAND SYSTEM/TIME REFERENCE SYSTEM CONTROL

Both the primary receiver/decoder and the CRDU primary electronics receive power from EPS control bus 1 through CMD SYSTEM PRI circuit breaker (panel 200), while the secondary receiver/decoder and CRDU secondary electronics receive power from EPS control bus 2 through CMD SYSTEM SEC circuit breaker (panel 200). Power to the DCS relay modules is provided by either the primary or secondary receiver/decoder. The primary and secondary electronic timer, primary and secondary TCB's, and both GMT clocks receive power from separate power buses and circuit breakers, whereas the event timer receives power from a single power bus and circuit breaker (figure 2.7.3-3). The portable timer contains an internal power source (mercury batteries).

The primary and secondary receiver/decoder selection is provided by the CMD SYS switch on panel 204 (figure 2.7.3-4). Manual selection of the primary or secondary receiver/decoder is accomplished by selecting the PRI or SEC positions, respectively. The CMD position enables direct selection of the primary or secondary receiver/decoder by MSFN via the active receiver/decoder or indirect selection via the Tr-30 signal from the selected electronic timer. The Tr-30 signal switches power and the TRS update interface to the inactive receiver/decoder via the primary or secondary Tr-30 relay. The primary or secondary Tr-30 relay must be reset via MSFN (commands S342 and S280, respectively) to reenable the Tr-30 control switching after a receiver/decoder has been switched. The Tr-30 signal is generated when the selected electronic timer Tr register counts down to 30 seconds. MSFN's direct selection of the primary receiver/decoder is accomplished only through the secondary receiver/decoder (command 13-2) while direct selection of the secondary receiver/decoder is accomplished only through the primary receiver/decoder (command 27-4). The set-reset status of the Tr-30 relays and the direct MSFN selection relays result in the 12 different DCS operating modes (resulting from 10 operating conditions) itemized in figure 2.7.3-5. Tx-0 signal is generated when the selected electronic timer's Tx register counts down to 0 seconds. Tx-0 signal causes the active receiver/decoder to simultaneously reset a preselected group of relays in the DCS relay modules; this eliminates the necessity of several reset commands to turn off equipment as the SWS loses contact with a ground station.

The primary or secondary electronic timer is selected only by redundant MSFN set/reset commands S252/S253 and S334/S335, which switch the data inputs and outputs simultaneously (figure 2.7.3-2). The primary or secondary TCB is selected by manual control only via the BUFFER switch on panel 212. The BUFFER switch is a [illegible] switch that selects the primary TCB, secondary TCB, or deactivates both when in the PRI, SEC, or OFF posit[illegible] respectively.

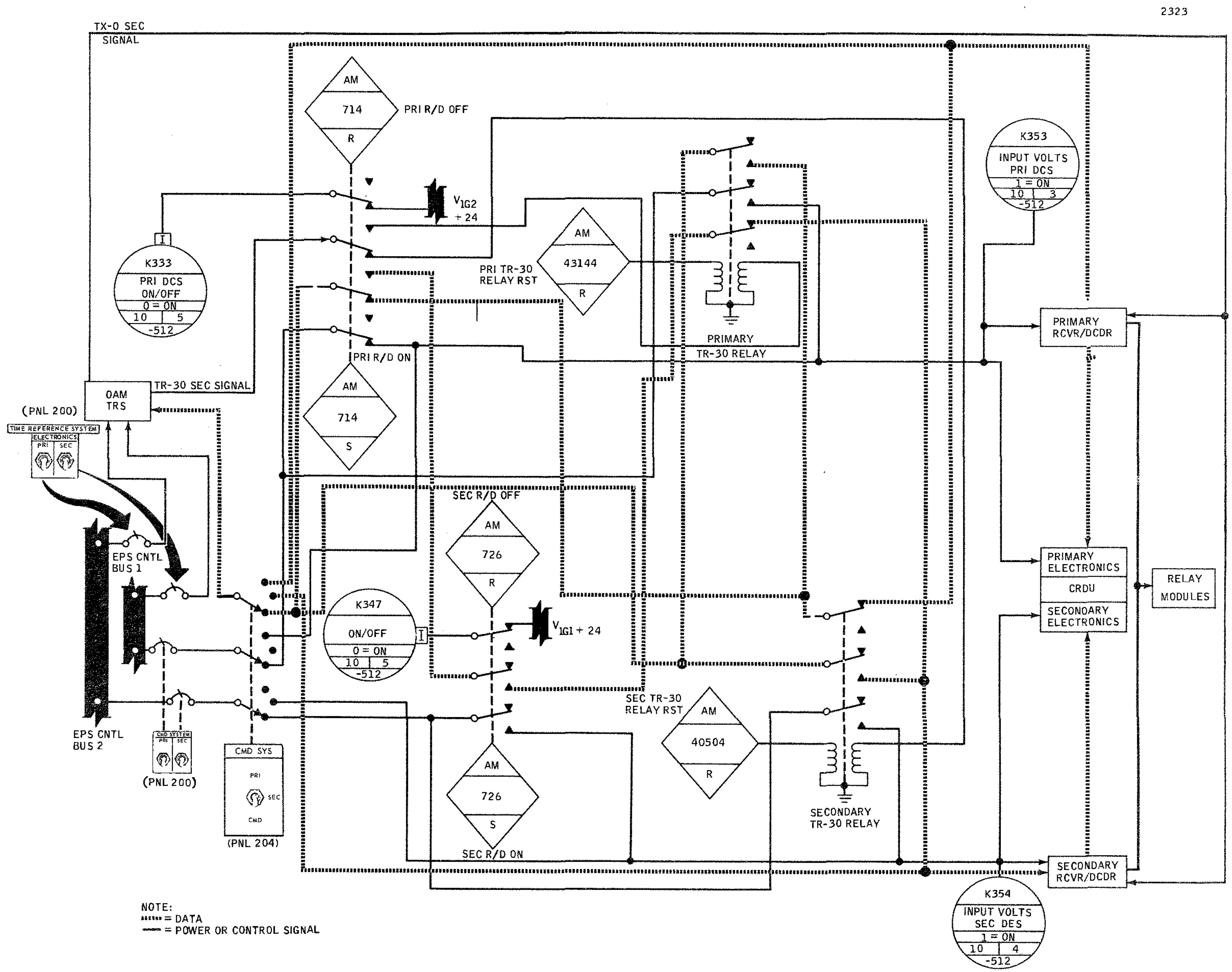


Figure 2.7.3-4 DCS Control -- Rcvr/Dcdr Control Switching Logic

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| | CONDITION | RCVR/DCDR CONFIG RELAY STATUS | | TR-30 SWITCHOVER RELAY STATUS | | TR-30 SWITCHOVER CAPABILITY | RCVR/DCDR POWERED | RCVR/DCDR LINKED TO TRS | TELEMETRY MONITORING POINTS | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CH 13 | CH 27 | TR-30 PRI | TR-30 SEC | SWITCHOVER TO | | | INPUT VOLTS PRI DCS (K353) | INPUT VOLTS SEC DCS (K354) | PRI DCS ON/OFF (K333) | SEC DCS ON/OFF (K347) |
| | 1 | SET | RESET | RESET | RESET | SEC | PRI | PRI | 1 | 0 | 0 | 1 |
| | 2 | RESET | SET | OFF | RESET | PRI | SEC | SEC | 0 | 1 | 1 | 0 |
| | 3 | SET | SET | RESET | RESET | SEC | PRI & SEC | PRI | 1 | 1 | 0 | 0 |
| | 4 | SET | RESET | RESET | SET | NONE | PRI & SEC | SEC | 1 | 1 | 0 | 1 |
| OFF NOMINAL MODES | 5 | RESET | SET | RESET | SET | PRI | SEC | SEC | 0 | 1 | 1 | 0 |
| | 6 | SET | SET | RESET | SET | NONE | PRI & SEC | SEC | 1 | 1 | 0 | 0 |
| | 7 | SET | RESET | SET | RESET | SEC | PRI | PRI | 1 | 0 | 0 | 1 |
| | 8 | RESET | SET | SET | RESET | NONE | PRI & SEC | PRI | 1 | 1 | 1 | 0 |
| | 9 | SET | SET | SET | RESET | SEC | PRI & SEC | PRI | 1 | 1 | 0 | 0 |
| | 10 | SET | RESET | SET | SET | NONE | PRI & SEC | SEC | 1 | 1 | 0 | 1 |
| | 11 | RESET | SET | SET | SET | NONE | PRI & SEC | SEC | 1 | 1 | 1 | 0 |
| | 12 | SET | SET | SET | SET | NONE | PRI & SEC | SEC | 1 | 1 | 0 | 0 |

Figure 2.7.3-5 DCS Control -- Operating Mode

The event timer (panel 206) is controlled by the face-mounted [START/STOP] and [DECR/INCR] switches in addition to the LIGHTING METER dimmer on panel 207. The [START/STOP] switch is a momentary, return-to-center switch that turns the event timer on and off. The [DECR/INCR] switch is a rotary switch that enables the event timer to count at the standard rate or to be set to any desired readout to a maximum of 999 hours, 59 minutes, and 59 seconds. The center (straight up) position of the [DECR/INCR] switch enables the event timer to indicate increasing time at the normal rate. The three cw and ccw positions of the [DECR/INCR] switch enable the event timer to display any desired readout by respectively increasing or decreasing the digital readout at 0.3, 4.0 and 25 times the normal time rate. The LIGHTING METER dimmer controls the brightness of the event timer's digital display (section 2.5.4).

The GMT clocks (panels 212 and 610) are controlled by the face-mounted DISPLAY switch and BRIGHTNESS control in addition to the ZERO RESET AND DAY COUNT switches on panel 212. The DISPLAY switch is a toggle switch that turns the clock on or off. The BRIGHTNESS control knob increases or decreases the brightness of the digital display. The ZERO RESET switch on panel 212 is a momentary toggle switch that resets the selected electronic timer TE register to 0 when activated to the up position. This causes the hour, minute, and second portion of the GMT clock displays to reset to 0. A periodic reset of the TE register (enabled via MSFN command S394) coincides with GMT midnight, thereby synchronizing the GMT clocks. The DAY COUNT switches on panel 212 are momentary toggle switches that enable the day display of the clocks to readout any desired day up to the maximum of 399. There are three switches associated with the DAY COUNT, one for each unit of the day display. When the corresponding switch is activated up to the 1, 10, or 100 position, the day counter in the selected TCB is increased by 1, 10, or 100 days, which is indicated by the GMT clocks.

The portable timers are controlled by the TIMER switch, TONE switch, [CLUTCH], and [SETTING KNOB]. The TIMER switch is a toggle switch that activates or deactivates the timing mechanism. The TONE switch is a toggle switch that activates or deactivates the tone mechanism. The [CLUTCH] (used when setting the portable timer) is a spring-loaded lever that disconnects the display hands from the timing mechanism when maintained in the down position. The [SETTING KNOB] is turned ccw to set the hour and minute hands.

### 2.7.3.2 DIGITAL COMMAND SYSTEM/TIME REFERENCE SYSTEM DATA FORMATS

The AM DCS command word contains a maximum of 30 data bits, which are transmitted most significant bit (MSB) first (figure 2.7.3-6). The addressed receiver/decoder receives the uplinked message and routes it to components within the DCS (relay module and CRDU), TRS (TX and TR), or teleprinter for processing.

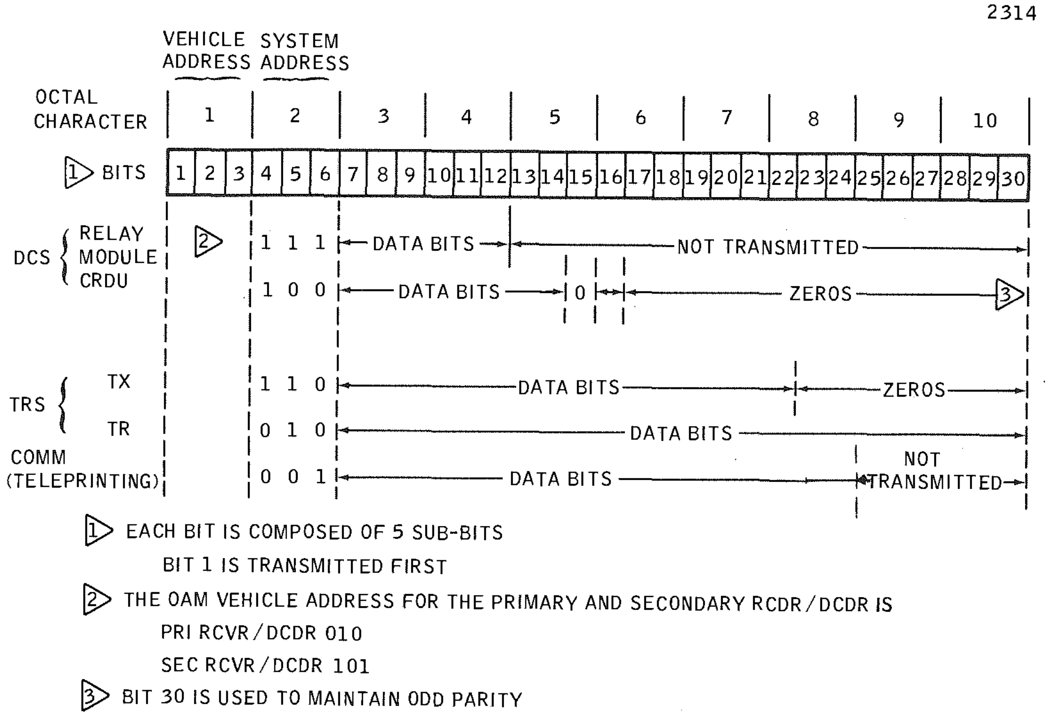


Figure 2.7.3-6 Command Code Format

## 2.7.4 SUBSYSTEM AND MAJOR COMPONENT DESCRIPTION

### 2.7.4.1 RECEIVER/DECODER

Each receiver/decoder (figure 2.7.4-1) contains two receivers (each connected to separate antenna) for command reception. The receiver outputs are routed to a sub-bit detector which routes sub-bits to a sub-bit decoder. The sub-bit decoder decodes groups of five sub-bits into data bits. The data bits are then shifted to the input register as well as the teleprinting subsystem. The input register routes the first three data bits to the vehicle and system address decoder which initiates a vehicle address sub-bit coding control signal and a vehicle address recognition signal in the receiver/decoder whose vehicle address is recognized. The vehicle address sub-bit coding control signal causes the sub-bit decoder to change state and a different sub-bit decoding technique is used to decode the other data bits. The different sub-bit decoding technique is to preclude a wrong vehicle address being generated by random message bits. The rest of the message is then shifted into the input register which sends the next three data bits to the vehicle and system address decoder. The vehicle and system address decoder decodes the three data bits to determine the DCS component for which the message is intended. If the message is intended for DCS relay modules, a system address signal enables the relay module decoder to accept the data. The relay module decoder decodes the data and sends a common set or common reset power signal to all relays in the relay modules and grounds the coil of the commanded relay. If the message is intended for the CRDU, a system address signal enables the timing and interface logic to accept the data and a ready signal is sent to the CRDU. The ready signal enables the CRDU clock pulses to shift data from the timing and interface logic to the CRDU. Similarly, if the message is intended for the Tx or Tr register of the selected electronic timer, a system address signal enables the timing and interface logic to accept the data and send a corresponding Tx or Tr ready signal to the electronic timer. The ready signal enables the TRS clock pulses to shift the data from the timing and interface logic to the appropriate electronic timer register. The Tx=0 signal from the operative electronic timer is routed to the relay module decoder which enables the common relay reset signal in addition to simultaneously grounding the coils of a preselected group of relays. As indicated before, the sub-bit decoder shifts all data to the COMM teleprinting subsystem and the vehicle address recognition signal to the teleprinter is enabled when a receiver/decoder recognizes its vehicle address. The teleprinting activation signal enables the timing and interface logic to send the system address interrogate signal to the teleprinting subsystem when the teleprinting system address is recognized by the vehicle and system address decoder. The system address interrogate signal and vehicle address recognition signal enable the teleprinting subsystem to process the message (section 2.2.4).

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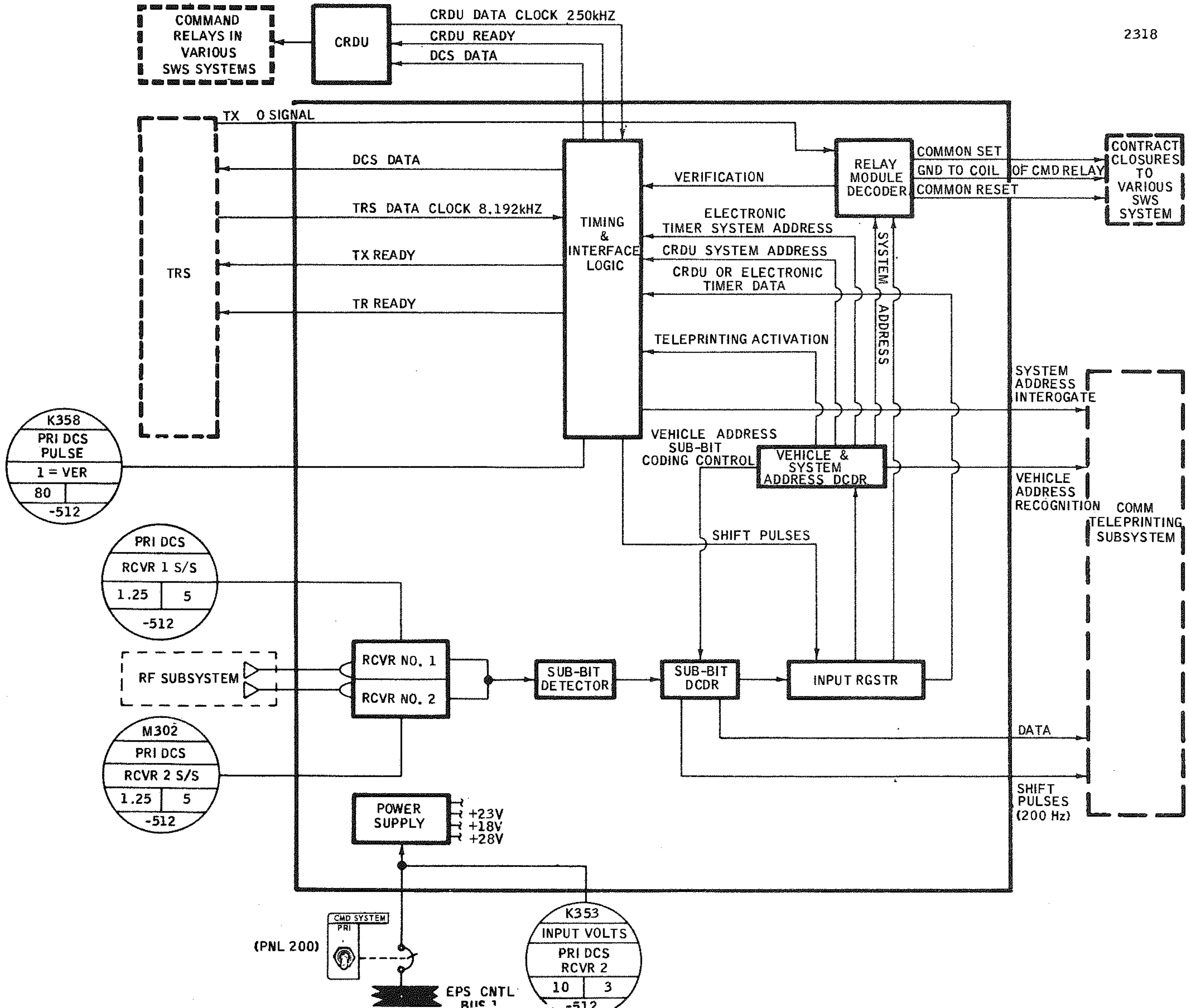


Figure 2.7.4-1 Rcv/Dcdr Operation

A verification pulse from the timing and interface logic is downlinked to MSFN via the instrumentation system. The verification pulse is generated when the timing and interface logic receives the TRS or CRDU clock pulses in response to the corresponding ready pulse, or when the common set or reset signal is sent to the relay modules from the relay module decoder (no verification pulse exists for a teleprinter message).

An internal power supply provides regulated power at various voltages to power the receiver/decoder circuits all of which are solid state. The on/off status of input power to the internal power supply is monitored by the instrumentation system as is the signal strength of each receiver/decoder.

2.7.4.2 DCS RELAY MODULE

Each DCS relay module contains eight magnetic-latching relays (figure 2.7.4-2). A relay is set or reset when its specific ground signal and the common set or common reset power signal is received from the active receiver/decoder. Only one relay at a time can be activated by this method. A preselected group of relays can be reset simultaneously, however, when the Tx-0 signal enables the receiver/decoder to send a common reset power signal and the appropriate group of ground signals corresponding to the particular relays to be reset. The instrumentation system monitors the set/reset status of each relay.

2.7.4.3 CRDU

The CRDU contains redundant primary and secondary electronics which are connected to the primary and secondary receiver/decoder respectively (figure 2.7.4-3). The ready pulse from the active receiver/decoder is delayed by a 3-millisecond (ms) monostable in the corresponding CRDU electronics before the timing control generates the shift pulses (data clocks) to insure that the instrumentation system has enough time to read the previous message. The shift pulses clock in data from the receiver/decoder to the CRDU input register and parity counter. The parity counter counts the number of binary ones and generates an enable signal to the CRDU relay drivers if the number of binary ones is odd (odd parity). The odd parity requirement precludes random RF noise on the data interface lines from generating invalid command messages. The enable signal and the 3 ms delay signal generate the validity pulse that is monitored by the instrumentation system. The data in the input register is routed in parallel to the instrumentation system for downlinking to MSFN and to the decoding logic. The decoding logic decodes the message to determine which relay driver is to be activated. One of the 480 relay drivers is activated and sends the driving pulse to a corresponding CRDU command relay. The EPS inhibits 144 relay drivers (corresponding to commands S0 through S143) when the EPS is put into the manual mode (section 2.1.3). The CRDU electronics includes integrated circuits which are supplied with a regulated +5 VDC from an internal power supply.

2.7.4.4 ELECTRONIC TIMER

Each electronic timer (figure 2.7.4-4) contains three magnetic shift registers: Te, Tx, and Tr. The Te register counts up from 0 seconds by cycling its time word through an incremental circuit every 1/8 second. The Tx and Tr registers can be updated via a receiver/decoder. A receiver/decoder sends a Tx or Tr ready signal which enables the selected electronic timer timing and control logic to generate shift pulses (data clock). The shift pulses clock in the data from the receiver/decoder to the corresponding Tx or Tr register. The Tx or Tr register receives the data time word and routes it through a corresponding decremental circuit every 1/8 second in order to count down.

When the Tx register counts down to Tx-0 seconds, it activates Tx relay for 50 ms via a 50 ms monostable. The Tx relay routes 28 vdc supplied by a receiver/decoder back to the receiver/decoder as the Tx-0 signal. The Tx relay also routes the 28 vdc supplied by the receiver/decoder to the common contact of the Te relay. When the Te relay is set (command S294) and Tx=0, a count inhibit signal resets the Te register to 0 seconds and furnishes at Tx-0 closure to a TCB. The Te register can be reset to 0 seconds manually when the ZERO RESET switch (panel 212) is activated to generate the count inhibit signal and the Tx closure signal to the TCB. The Tx closure signal insures that the TCB will request the reset Te register data upon Te relay reset

When the Tr register counts down to Tr-30 seconds, it sets the Tr relay, which provides the Tr-30 signal to the DCS. At Tr-0 seconds, the Tr relay is reset, thus disabling the Tr-30 signal.

The instrumentation system monitors the Tr register and uses the Te register data by periodically initiating a Tr or Te request signal. The timing and control logic responds to the Te or Tr request signal by generating shift pulses (data clocks) to shift the data out of the corresponding register into the instrumentation system. The Te register shifts its data into the buffer register when an elapsed time control signal is received from the selected TCB. The TCB then shifts the Te time word out of the buffer register. The TCB also receives an 8 pulse-per-second (pps) synchronization signal from the timing and control logic. The timing and control logic also provides an 8-pps signal to drive the event timer. An internal power supply provides a regulated +12 vdc to the electronic timer internal electronics.

2.7.4.5 TCB

Either the primary or secondary TCB (figure 2.7.4-5) can be selected for use with either electronic timer. Each TCB contains an oscillator and countdown chain to generate the various shift pulses. An electronic timer provides the TCB countdown chain with an 8-pps synchronization signal. The elapsed time control signal is generated from the countdown chain and request generator every 1/8 second to enable the transfer of data from the selected electronic timer Te register. The TCB then shifts the elapsed time data into the input register. A Tx closure signal from the electronic timer or ZERO RESET switch generates the elapsed time control signal and the arm reset signal to reset the electronic timer Te relay. The data in the input register is shifted in parallel

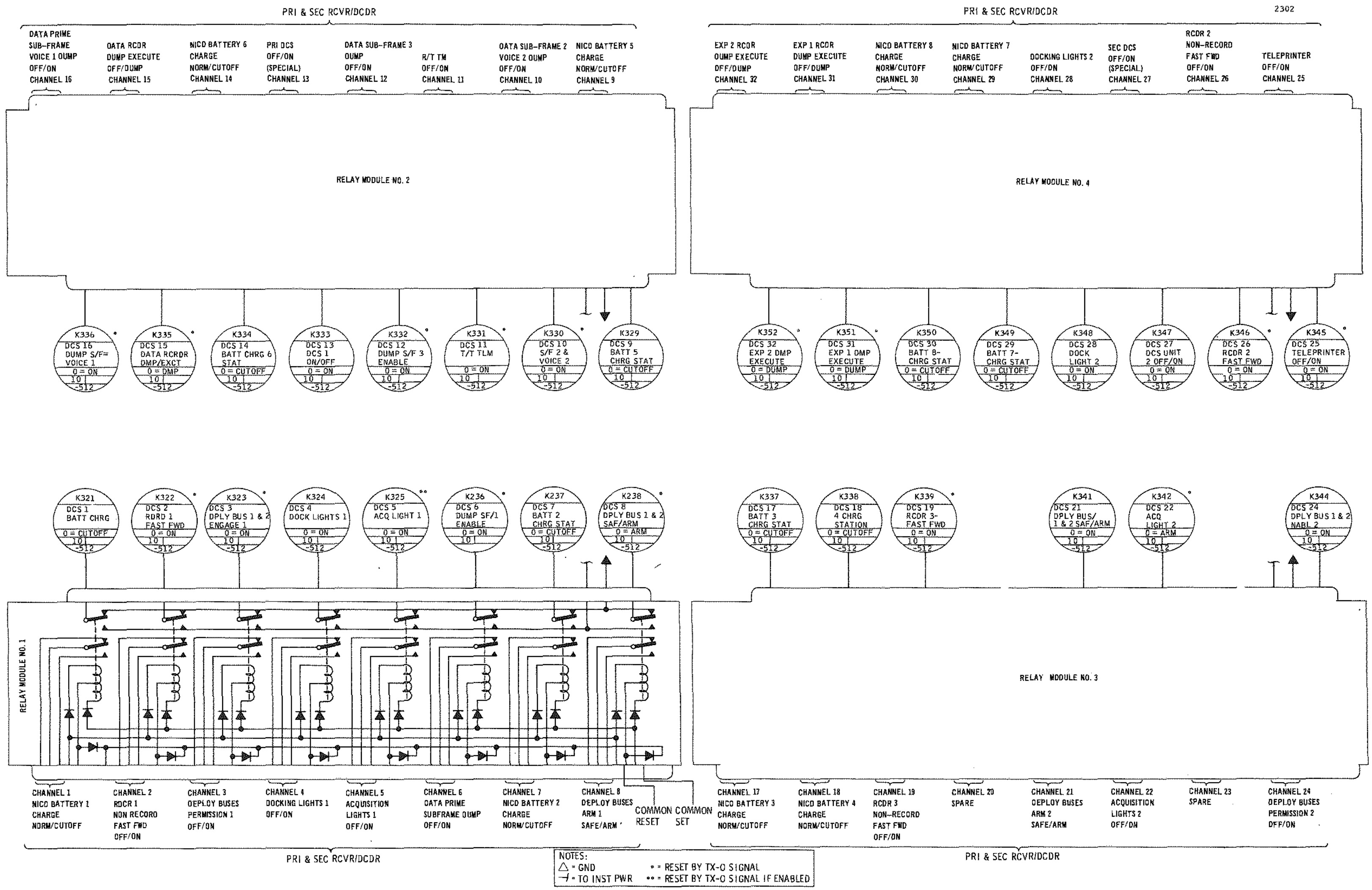


Figure 2.7.4-2 Relay Module Operation

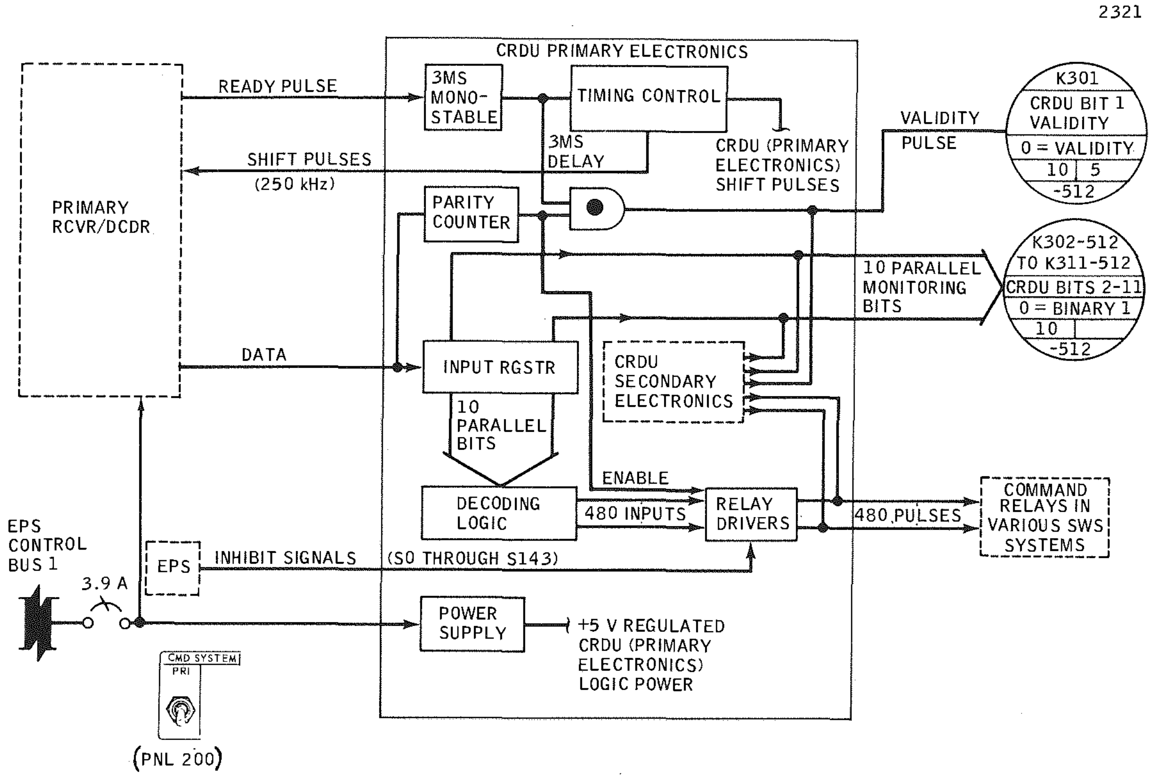


Figure 2.7.4-3 CRDU Operation

to the binary-coded-decimal (BCD) converter, which converts the binary data to the BCD data used to drive the GMT clock. The BCD data and six binary bits of data (containing fine time correlation information) are serially shifted to EREP. The BCD data is serially shifted to the GMT clocks when the six-bit register contains integer seconds (no fraction of seconds) as determined by the integer detector. The DAY COUNT switch (panel 212) will allow the crew to override the BCD input to the 24-hour-day detector at anytime. The TCB contains an internal power supply that provides regulated +5 vdc and +10 vdc to the TCB internal electronics.

2.7.4.6 GMT CLOCK

Each GMT clock (figure 2.7.4-6) has an input register that receives the BCD data from a TCB. The data is transferred to the BCD-to-dot-matrix-converter, which converts the data to a form capable of driving the digital display. The digital display displays the data (TE register data with DAY COUNT override capability) in a 5 x 7-dot matrix of light emitting diodes (LED's). The display illumination may be increased or decreased by adjusting the face mounted, BRIGHTNESS control to the respective INCR or DECR position. The BRIGHTNESS control varies the display illumination by varying the duty cycle of the LED excitation (100 Hz square wave) from 1 percent to 70 percent. The face mounted DISPLAY switch controls the input power to the GMT clock.

2.7.4.7 EVENT TIMER

The event timer (figure 2.7.4-7) receives an 8-pps signal from an electronic timer. This 8-pps enables the stepping logic to drive a stepping motor in the forward direction (1, 2, 3, 4) when the face mounted [DECR/INCR] switch is in the center position. The update timing logic enables the stepping logic to drive the stepping motor in the backward (4, 3, 2, 1) or forward (1, 2, 3, 4) direction at 0.3, 4.0 or 25 times the normal rate when the [DECR/INCR] switch is in the respective DECR or INCR positions. The stepping motor mechanically drives a seven-digit display which is composed of seven rotary wheels. Each rotary wheel contains the numbers 1 through 9 with the exception of the 10-minute and 10-second wheels, each of which contain the numbers 1 through 5. The event timer contains an internal power supply that provides a regulated +12 vdc to the internal electronics. Power is directly supplied to the stepping motor when the [START/STOP] switch has been activated to the START position or when the [DECR/INCR] switch is in the DECR or INCR position.

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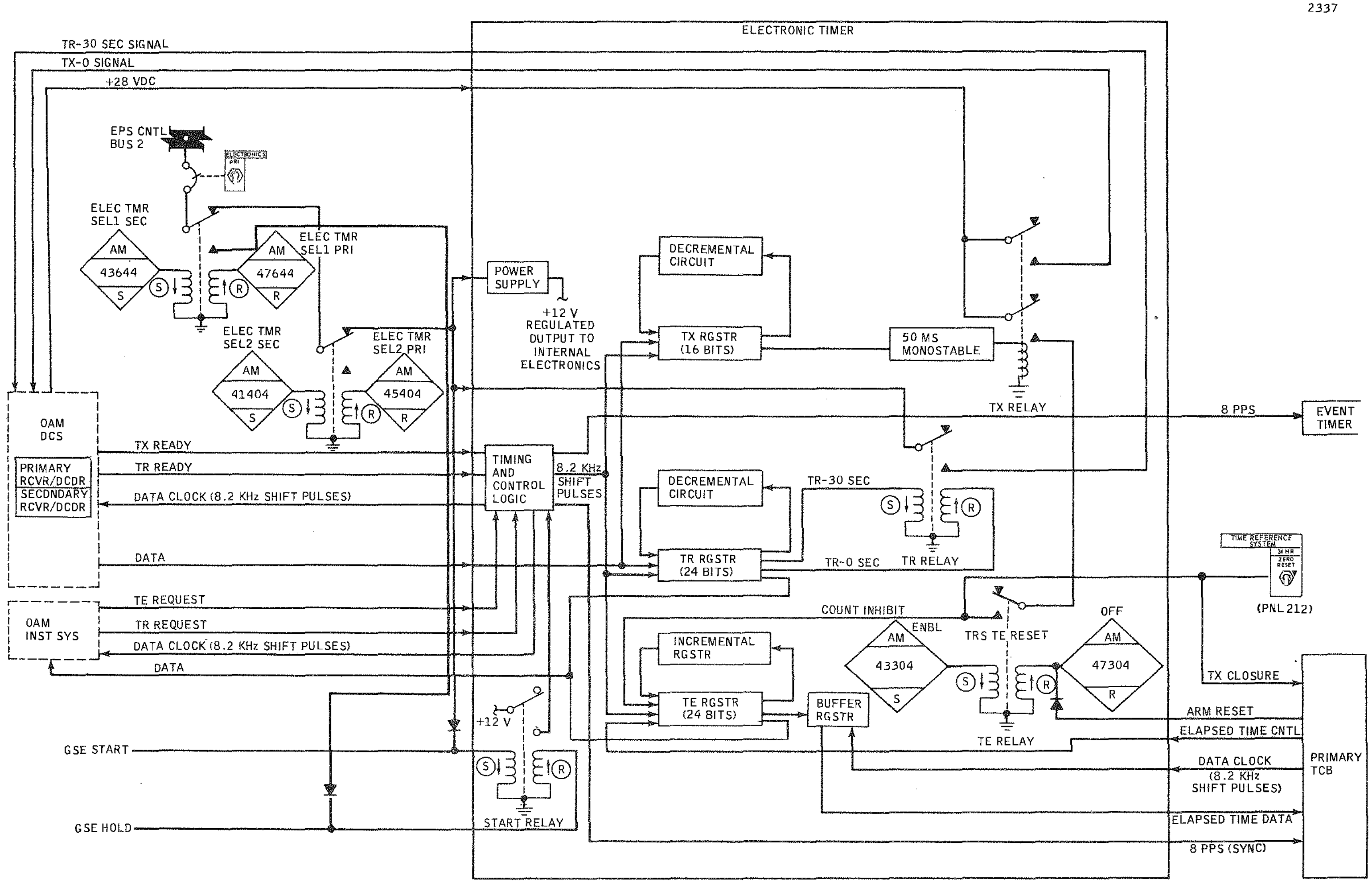


Figure 2.7.4-4 Electronic Timer Operation

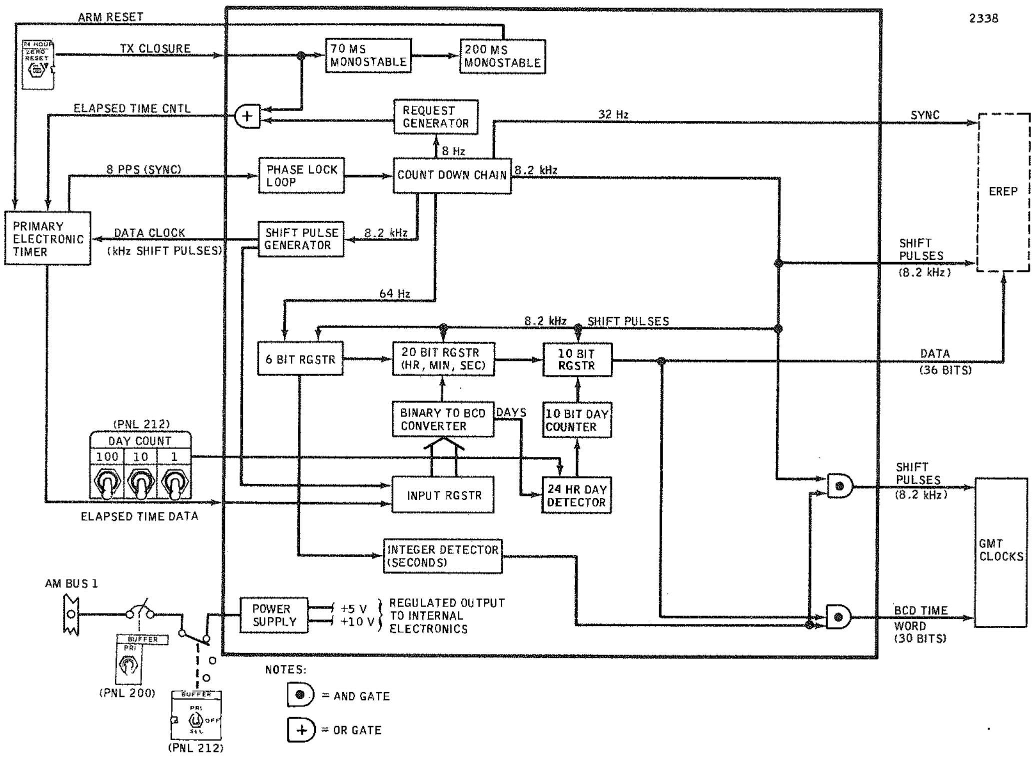


Figure 2.7.4-5 TCB Operation

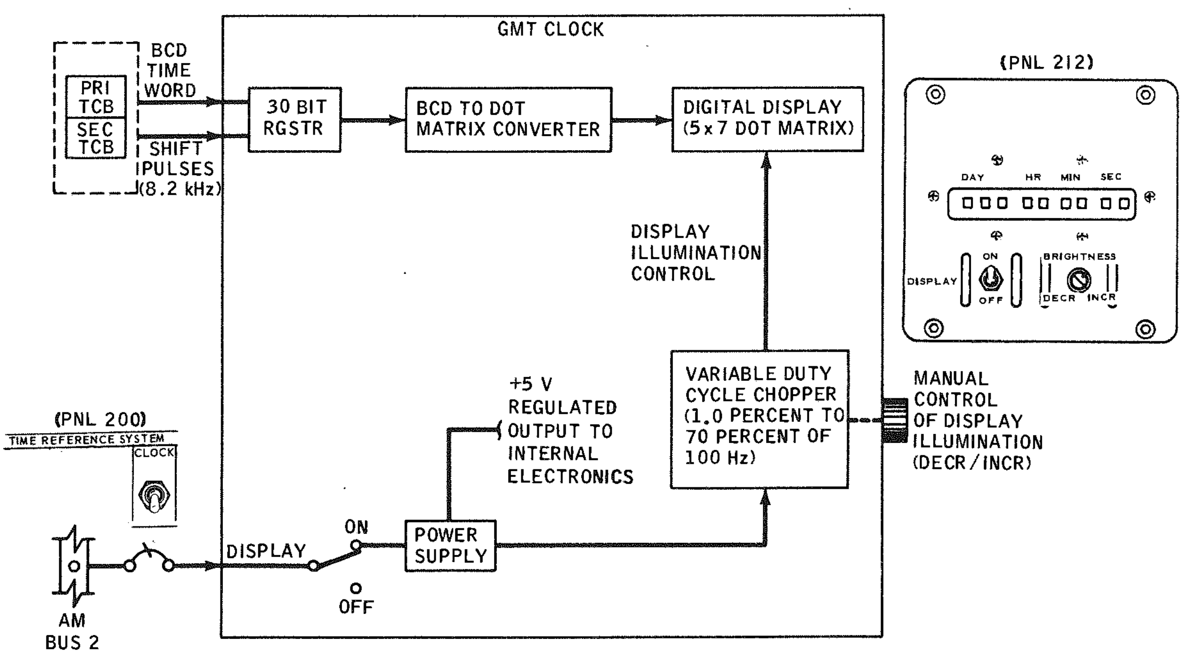


Figure 2.7.4-6 GMT Clock Operation

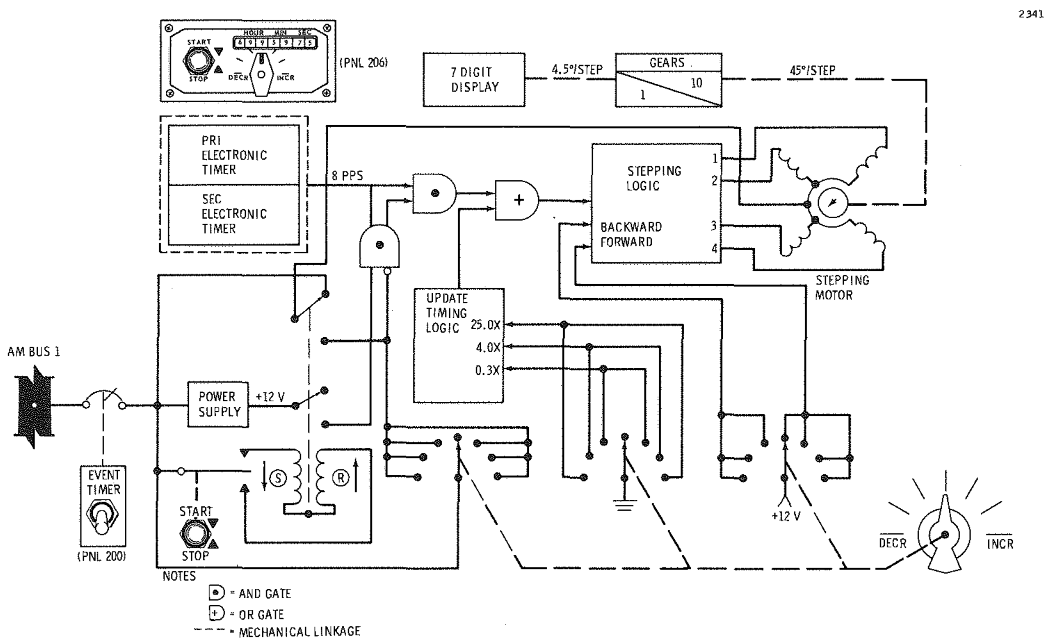


Figure 2.7.4-7 Event Timer Operation

2.7.4.8 PORTABLE TIMER

The portable timer (figure 2.7.4-8) contains a timing mechanism which drives the hour, minute, and second hands. A clutch is used to disengage the timing mechanism from the display to allow setting of the hands. When the hour, minute, and second hands pass 12, an 800-Hz tone is initiated. The portable timer contains one mercury battery for the timing mechanism and two mercury batteries for the tone mechanism. Power to the timing and tone mechanism is enabled by the TIMER and TONE switches.

2.7.5 FAILURE MODES

The DCS/TRS failure modes and effect of major components are identified in table 2.7.5-1.

TABLE 2.7.5-1 DCS/TRS FAILURES MODES

| FAILURE | INDICATION | VEHICLE CAPABILITY |
|---|---|---|
| Primary Receiver/ Decoder | Uplinked DCS commands addressed to one or more of the following systems are not processed:<br><br>System — Indication<br>Teleprinter - Absence of on board printed data and absence of Teleprinter Message Complete TM indication<br>DCS Relay Modules - Loss of relay module output control functions or absence of DCS verification pulse on TM.<br>CRDU Commands - Loss of CRDU output control functions, absence of DCS Verification Pulse on TM and invalid or static CRDU TM bits.<br>Electronic Timer Tr Update - Absence of DCS Verification Pulse on TM or unupdated DCS Reset Time word on TM | AM DCS commands must be processed through the secondary receiver/decoder. If the secondary receiver/decoder is not ON it must be activated by (1) selecting the CMD SYS sw to SEC or (2) waiting till the Tr-30 second signal from the TRS performs an automatic switchover. If both primary and secondary receiver/decoders are in the CMD mode and the Tr-30 second switchover has not occurred, the primary receiver/ decoder must be commanded OFF through the secondary receiver/decoder in order to link the TRS to the secondary receiver/decoder. |

TABLE 2.7.5-1 DCS/TRS FAILURE MODES (cont'd)

| FAILURE | INDICATION | VECHICLE CAPABILITY |
|---|---|---|
| | Electronic Timer Tx update - Absence of DCS Verification Pulse on TM or selected equipment is not reset at Tx-0. | |
| DCS Relay Module (1, 2, 3, or 4) | Loss of command control of equipment receiving contact closure signals from the failed DCS relay module. | Where applicable, equipment control must be performed using on-board switches. Command functions which cannot be performed by on-board switching are lost for the duration of the mission. |
| Command Relay Driver Unit (CRDU) (A electronics addressed through the Primary Receiver/Decoder) | Unable to execute a single command, a group of commands, or all uplinked CRDU command functions depending on nature of failure or no validity pulse or TM discretes are erroneous | CRDU B electronics must be used by activating secondary receiver/decoder either by DCS command through the primary receiver/decoder or selecting CMD SYS sw to SEC. CRDU commands processed by B electronics must be sent through the secondary receiver/decoder. |
| Electronic Timer (Primary) | GMT Clocks and EREP time displays display invalid time. Te or Tr time words in the TM readout are invalid; or EREP data recording time anotations are invalid; or Tx or Tr functions are disabled; or event timer doesn't run. | Secondary Electronic timer must be selected by DCS command. Valid GMT time correlation will be available at the following GMT midnight if a TRS Te reset is performed. The TCB day count registers may require manual updating using the DAY COUNT switches. |
| Event Timer | Digital display of event time on panel 206 is invalid. | None |
| TCB | Invalid GMT time is displayed at any or all of the following stations: GMT clock panel 206, GMT clock panel 610, and the EREP time display. | Secondary TCB must be activated by selecting TIME REFERENCE SYSTEM BUFFER sw to SEC. The TCB day count register will require manual updating using the DAY COUNT switches. |
| GMT Clock | Invalid GMT time is displayed | The GMT clock must be replaced by an onboard spare. |
| Portable Timer | Invalid countdown time or absence of tone | A total of four Portable Timers are carried onboard. An alternate must be used. |

## 2.7.6 PERFORMANCE AND DESIGN DATA

Since the receiver/decoder , DCS relay module, CRDU electronics, electronic timer, TCB, GMT clock and portable timer each have redundant counterparts of identical design, the performance and design data for a typical component will be provided in each case.

### 2.7.6.1 RECEIVER/DECODER

RCVR/DCDR
- Input voltage . . . . . . . . . . . . . . . . . . . . . . . . . . 22 to 33 vdc
- Input power . . . . . . . . . . . . . . . . . . . . . . . . . . 12.5 watts @ 27 vdc
- Receiver frequency . . . . . . . . . . . . . . . . . . . . . . 450 MHz
- Modulation . . . . . . . . . . . . . . . . . . . . . . . . . . 1 kHz and 2kHz phase shift keyed
- Maximum command repetition spacing
  - o Relay . . . . . . . . . . . . . . . . . . . . . . . . . . 20 ms
  - o CRDU . . . . . . . . . . . . . . . . . . . . . . . . . . 255 ms
  - o Elect-timer . . . . . . . . . . . . . . . . . . . . . . . 16 ms
  - o Teleprinter . . . . . . . . . . . . . . . . . . . . . . . 5 ms

### 2.7.6.2 DCS RELAY MODULE

- Input voltage
  - o Set . . . . . . . . . . . . . . . . . . . . . . . . . . 23 vdc for 15 ms
  - o Reset . . . . . . . . . . . . . . . . . . . . . . . . . . 18 vdc for 15 ms
- Coil current
  - o Set . . . . . . . . . . . . . . . . . . . . . . . . . . 0.02 amp
  - o Reset . . . . . . . . . . . . . . . . . . . . . . . . . . 0.01 amp
- Channels per relay module . . . . . . . . . . . . . . . . . . 8 set/reset channels

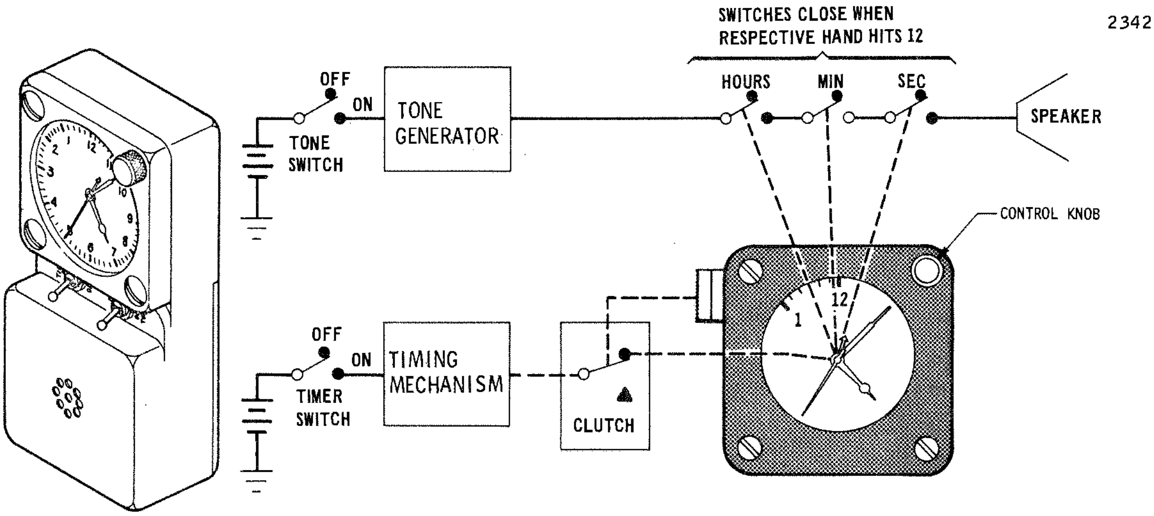


Figure 2.7.4-8 Portable Timer Operation

2.7.6.3 CRDU

| | |
|---|---|
| Input voltage | 22 to 30 vdc |
| Input power | 40.5 watts @ 27 vdc |
| Output | |
| o 480 relay drivers | 0.85 amp for 200 ms |

2.7.6.4 ELECTRONIC TIMER

| | |
|---|---|
| Input voltage | 22 to 30 vdc |
| Input power | 7.2 watts @ 27 vdc |
| Crystal oscillator frequency | 1.049 MHz |
| Typical accuracy | 0.125 second/day |
| Output to event timer | 8-pps |
| Te register | |
| o Capacity | 582 hours, 32 minutes, 31.875 seconds |
| o Bit capacity | 24 |
| o Resolution | 0.125 second |
| Tx register | |
| o Update capacity | 2 hours, 16 minutes, 31.8575 seconds |
| o Bit capacity | 16 |
| o Resolution | 0.125 second |
| Tr register | |
| o Update capacity | 582 hours, 32 minutes, 31.875 seconds |
| o Bit capacity | 27 bits |
| o Resolution | 0.125 second |

2.7.6.5 TCB

| | |
|---|---|
| Input voltage | 22 to 30 vdc |
| Input power | 17.8 watts @ 27 vdc |
| Oscillator frequency | 1.049 mHz |
| Typical accuracy | 0.125 second/day |
| Output to EREP | |
| o Time word | 30 bits binary coded decimal |
| o Resolution | 15.625 ms (6 bits binary) |

Output to GMT clocks
- o Time word . . . . . . . . . . . . . . . . . . . . . . . . . 30 bits binary coded decimal
- o Resolution . . . . . . . . . . . . . . . . . . . . . . . . 1.0 second

2.7.6.6 GMT CLOCK

Input voltage . . . . . . . . . . . . . . . . . . . . . . . . . 22 to 30 vdc
Input power . . . . . . . . . . . . . . . . . . . . . . . . . . 10.8 watts @ 27 vdc
Timing input . . . . . . . . . . . . . . . . . . . . . . . . . 30 bits binary coded decimal
Typical accuracy . . . . . . . . . . . . . . . . . . . . . . . 0.125 second/day
Display capacity . . . . . . . . . . . . . . . . . . . . . . . 399 days, 23 hours, 59 minutes, 59 seconds

2.7.6.7 EVENT TIMER

Input voltage . . . . . . . . . . . . . . . . . . . . . . . . . 22 to 30 vdc
Input power . . . . . . . . . . . . . . . . . . . . . . . . . . 4.3 watts @ 27 vdc
Timing input . . . . . . . . . . . . . . . . . . . . . . . . . 8 pulses/second (from electronic timer)
Accuracy . . . . . . . . . . . . . . . . . . . . . . . . . . . 0.125 second/day
Display capacity . . . . . . . . . . . . . . . . . . . . . . . 999 hours, 59 minutes, 59 seconds
Counting rates
- o Count up or down 25 ± 25% times normal rate
- o Count up or down 4 ± 25% times normal rate
- o Count up or down $0.\overline{3}$ ± 25% times normal rate
- o Normal rate

2.7.6.8 PORTABLE TIMER

Input voltage
- o Timing mechanism (one 75 ma-hr Hg battery) . . . . . . . . . . . 1.4 vdc (nominal)
- o Tone mechanism (two 500ma-hr Hg battery) . . . . . . . . . . . 5.4 vdc (nominal)

Input power
- o Timing mechanism . . . . . . . . . . . . . . . . . . . . . . 8.4 microwatts (nominal)
- o Tone mechanism . . . . . . . . . . . . . . . . . . . . . . . 0.1 watts without tone (nominal)
  1.0 watts with tone (nominal)

Tunning fork frequency . . . . . . . . . . . . . . . . . . . . 360 Hz
Typical accuracy . . . . . . . . . . . . . . . . . . . . . . . 0.6 second/day
Audio output
- o Frequency . . . . . . . . . . . . . . . . . . . . . . . . . 800 Hz
- o Sound pressure level (SPL) output . . . . . . . . . . . . . . . 70 db SPL at 5 PSIA
- o Tone duration . . . . . . . . . . . . . . . . . . . . . . . continuous

2.7.7 OPERATIONAL LIMITATIONS AND RESTRICTIONS

The limitations and restrictions imposed on the DCS/TRS during the mission are as follows:

o The following repetition spacing between consecutive uplinked commands are required for DCS processing:

| | Last Bit Previous Message to First bit of Next |
|---|---|
| CRDU Commands | 255 ms |
| Tr or Tx Commands | 16 ms |
| Real Module Commands | 20 ms |
| Teleprinter (full line format) | 5 ms |

o The primary receiver/decoder must be turned of to address the Electronic timer through secondary receiver/decoder if both are on in the CMD mode and a Tr-30 second switchover has not occurred.

o MSFN can transmit the same command a maximum of seven consecutive times at the minimum spacing if the command is to be processed by the CRDU. If the CRDU command is processed seven consecutive times, a 30-second cooldown interval is required prior to retransmission of the same command.

2.7.8 INSTRUMENTATION AND GROUND COMMANDS

| MEASUREMENT NUMBER | DESCRIPTION | TELEMETRY RANGE | ONBOARD DISPLAY DISPLAY RANGE | ONBOARD DISPLAY PANEL NO. | FUNCTION |
|---|---|---|---|---|---|
| K301-512 | EVENT, CRDU BIT 1 - VALIDITY | 1=CRDU 0 | NONE | NONE | INDICATES A VALID CRDU MESSAGE (ODD PARITY AND PROPER TIMING) |
| K302-512 | EVENT, CRDU BIT 2-LSB | 1=CRDU 0 | NONE | NONE | INDICATES A BINAR 0 IN BIT 1 (LSB) OF CRDU INPUT RGSTR |
| K303-512 | EVENT, CRDU BIT 3 | 1=CRDU 0 | NONE | NONE | INDICATES A BINARY 0 IN BIT 2 OF CRDU INPUT RGSTR |
| K304-512 | EVENT, CRDU BIT 4 | 1=CRDU 0 | NONE | NONE | INDICATES A BINARY 0 IN BIT 3 OF CRDU INPUT RGSTR |
| K305-512 | EVENT, CRDU BIT 5 | 1=CRDU 0 | NONE | NONE | INDICATES A BINARY 0 IN BIT 4 OF CRDU INPUT RGSTR |
| K306-512 | EVENT, CRDU BIT 6 | 1=CRDU 0 | NONE | NONE | INDICATES A BINARY 0 IN BIT 5 OF CRDU INPUT RGSTR |
| K307-512 | EVENT, CRDU BIT 7 | 1=CRDU 0 | NONE | NONE | INDICATES A BINARY 0 IN BIT 6 OF CRDU INPUT RGSTR |
| K308-512 | EVENT, CRDU BIT 8 | 1=CRDU 0 | NONE | NONE | INDICATES A BINARY 0 IN BIT 7 OF CRDU INPUT RGSTR |
| K309-512 | EVENT, CRDU BIT 9 | 1=CRDU 0 | NONE | NONE | INDICATES A BINARY 0 IN BIT 8 OF CRDU INPUT RGSTR |
| K310-512 | EVENT, CRDU BIT 10 | 1=CRDU 0 | NONE | NONE | INDICATES A BINARY 0 IN BIT 9 OF CRDU INPUT RGSTR |
| K311-512 | EVENT, CRDU BIT 11 | 1=CRDU 0 | NONE | NONE | INDICATES A BINARY 0 IN BIT 10 OF CRDU INPUT RGSTR |
| K333-512 | EVENT DCS UNIT 1 - OFF/ON | 0=ON | NONE | NONE | INDICATES THAT POWER AND THE TRS INTERFACE HAS BEEN ROUTED TO PRIMARY RCVR/DCDR AND POWER HAS BEEN ROUTED TO CRDU PRIMARY ELECTRONICS. THIS VERIFIES THE DCS UNIT 1-ON COMMAND (13-2) WHICH CAN BE SENT VIA THE SECONDARY RCVR/DCDR ONLY |
| K347-512 | EVENT, DCS UNIT 2 - OFF/ON | 0=ON | NONE | NONE | INDICATES THAT POWER AND THE TRS INTERFACE HAS BEEN ROUTED TO THE SECONDARY RCVR/DCDR AND POWER HAS BEEN ROUTED TO CRDU SECONDARY ELECTRONICS. THIS VERIFIES THE DCS UNIT 2 - ON COMMAND (27-4) WHICH CAN BE SENT VIA THE PRIMARY RCVR/DCDR ONLY |
| K353-512 | EVENT, INPUT VOLTS - DCS NO. 1 | 1=ON | NONE | NONE | INDICATES THAT VOLTAGE IS BEING APPLIED TO THE PRIMARY RCVR/DCDR |
| K354-512 | EVENT, INPUT VOLTS - DCS NO. 2 | 1=ON | NONE | NONE | INDICATES THAT VOLTAGE IS BEING APPLIED TO THE SECONDARY RCVR/DCDR |
| K358-512 | EVENT, DCS 1 VERIFICATION PULSE | 1=VERIFI-CATION | NONE | NONE | INDICATES THAT THE PRIMARY RCVR/DCDR HAS SENT THE FIRST DATA BIT TO A USING SYSTEM (TRS, TELEPRINTING, CRDU OR RELAY MODULES) |

2.7.8 INSTRUMENTATION AND GROUND COMMANDS (cont'd)

| MEASUREMENT NUMBER | DESCRIPTION | TELEMETRY RANGE | ONBOARD DISPLAY DISPLAY RANGE | PANEL NO. | FUNCTION |
|---|---|---|---|---|---|
| K358-512 | EVENT, DCS 2 VERIFICATION PULSE | 1=VERIFICATION | NONE | NONE | INDICATES THAT THE SECONDARY RCVR/DCDR HAS SENT THE FIRST DATA BIT TO A USING SYSTEM (TRS, TELEPRINTING, CRDU OR RELAY MODULE) |
| K501-512 | EVENT, ELAPSED TIME (FINE) | LSB=1/8 sec. 8 bit word | NONE | NONE | USED FOR TIME CORRELATION OF THE OAM INST SYS |
| K502-512 | EVENT, ELAPSED TIME (COARSE) | LSB=1/8 sec. 24 bit word | NONE | NONE | INDICATES THE TIME WORD VALUE CONTAINED IN THE ELAPSED TIME RGSTR AND IS ALSO USED FOR THE CORRELATION OF THE OAM INST SYS |
| K503-512 | EVENT, DCS RESET TIME | LSB=1/8 sec. 24 bit word | NONE | NONE | INDICATES THE TIME WORD VALUE IN THE TR RGSTR (i.e. TIME REMAINING UNTIL AUTOMATIC SWITCHOVER TO REDUNDANT (RCVR/DCDR) |
| M301-512 | VOLT SIG STRENGTH, RCVR 1, DCS-1 | 0-20 mv | NONE | NONE | INDICATES THE RF SIGNAAL STRENGTH REACHING RCVR 1 OF THE PRIMARY RCVR/DCDR |
| M302-512 | VOLT SIG STRENGTH, RCVR 2, DCS-1 | 0-20 mv | NONE | NONE | INDICATES THE RF SIGNAL STRENGTH REACHING RCVR 2 OF THE PRIMARY RCVR/DCDR |
| M303-512 | VOLT SIG STRENGTH, RCVR 1, DCS-2 | 0-20 mv | NONE | NONE | INDICATES THE RF SIGNAL STRENGTH REACHING RCVR 1 OF THE SECONDARY RCVR/DCDR |
| M304-512 | VOLT SIG STRENGTH, RCVR 2, DCS-2 | 0-20 mv | NONE | NONE | INIDCATES THE RF SIGNAL STRENGTH REACHING RCVR 2 OF THE SECONDARY RCVR/DCDR |

GROUND COMMANDS

| DCS COMMAND | FUNCTION | OCTAL CODE |
|---|---|---|
| 13-2 | CMD SYS-PRI DCS (FROM SEC DCS) - OFF | 714 |
| 13-2 | CMD SYS-PRI DCS (FROM SEC DCS) - ON | 715 |
| 27-4 | CMD SYS-SEC DCS (FROM PRI DCS) - OFF | 726 |
| 27-4 | CMD SYS-SEC DCS (FROM PRI DCS) - ON | 727 |
| S342 | PRIMARY Tr-30 RELAY RESET | 43144 |
| S280 | SECONDARY Tr-30 RELAY RESET | 40504 |
| S335 | ELECTRONIC TIMER SELECT 1 - PRI | 47644 |
| S334 | ELECTRONIC TIMER SELECT 1 - SEC | 43644 |
| S253 | ELECTRONIC TIMER SELECT 2 - PRI | 45404 |
| S252 | ELECTRONIC TIMER SELECT 2 - SEC | 41404 |
| S295 | TRS ELAPSED TIME RESET - OFF | 47304 |
| S294 | TRS ELAPSED TIME RESET - ENABLE | 43304 |

SUBSECTION 2.8

CAUTION AND WARNING SYSTEM

## 2.8.1 INTRODUCTION

The Caution and Warning System (C&WS) monitors the CSM, ATM, AM, and OWS for malfunction (or system out-of-limit) conditions categorized as caution, warning, or emergency, and identifies malfunctions by visual and distinctly coded audible alarms. Functionally, the caution and warning system is divided into a caution and warning (C&W) subsystem and an emergency subsystem. The caution and warning subsystem monitors OA systems performance parameters categorized as caution and warning conditions. The emergency subsystem monitors two hazardous conditions: fire in the MDA, AM, and OWS and a rapid decrease in pressure (rapid $\Delta P$) within the OA. Each subsystem is futher divided into two subsystems, providing redundant parallel parameter monitoring and malfunction indicators. The C&WS is active only when the SWS is manned. No ground control of the C&WS is provided.

## 2.8.2 SYSTEM INTERFACES

The status of the ATM APCS, EPS and TCS are monitored by the SWS C&WS via contact closures in the ATM systems (figure 2.8.2-1). A ground commanded crew alert function can be sent to either the AM DCS or to the CSM UP DATA LINK (UDL). The AM DCS interface provides a warning category "CREW ALERT" parameter in the SWS C&WS. The CSM UDL interface provides a "CREW ALERT" parameter in the CSM C&WS. The CSM C&WS produces a warning category "CSM" parameter to the SWS C&WS when any active CSM C&WS parameter or loss of main bus A & B power in the CSM triggers the CSM C&WS (figure 2.8.2-2). Status of the MDA/AM/OWS EPS and ECS is monitored by the SWS C&WS. The EPS and ECS provide electrical power and thermal control to the OA C&WS electronic components. Intercom boxes located in the MDA and OWS provide distribution of C&W tones and MASTER ALARM lights for the SWS C&WS. SWS C&WS status is provided by the MDA/AM/OWS instrumentation system.

## 2.8.3 FUNCTIONAL DESCRIPTION

The components used for caution and warning condition detection (high or low limit detection) consist of C&W sensors 1 (2), C&W detector module 1 (2), C&W signal conditioning display converters pri (sec), and C&W detectors located in the system being monitored (figure 2.8.3-1). Emergency condition detection is provided by two rapid $\Delta P$ sensors located in the STS, and 22 fire sensors - 2 in the MDA, 8 in the AM, and 12 in the OWS.

An electronics assembly, the Caution and Warning Unit, receives +28 vdc discrete signals from the detectors and powers the appropriate visual and aural alarms. Within the Caution and Warning Unit are four subunits; C&W subunits 1 and 2, and Emergency subunits 1 and 2. C&W subunits 1 and 2 monitor the caution and warning detectors and +28 vdc signals from emergency subunits 1 and 2. The C&W subunits also provide signals and power to the following:

- o C&W status lights (panels 207 and 616)
  Caution lights are yellow, warning lights are red
- o MASTER ALARM lights (panels 206 and 616 and MDA/OWS intercom boxes)
  Color is red
- o MEMORY RECALL light (panel 206)
  Color is yellow
- o C&W audible tones to the MDA/OWS intercom boxes
  Caution tone is a continuous 1 kHz and warning tone is an interrupted 1 kHz

Emergency subunits 1 and 2 monitor the fire and rapid $\Delta P$ sensors, and provide signals, power, and contact closures to the following:

- o Area fire status lights (panel 207 and 616)
  Color is red
- o RAPID $\Delta P$ status lights (panels 207 and 616)
  Color is red
- o Emergency audible tones to the klaxons
  Fire tone is a siren and the rapid $\Delta P$ tone is a modulated buzzer
- o Contact closures to the C&W subunits for control of the MASTER ALARM lights and warning tone during an emergency condition

The primary controls and displays are on panels 202, 206, and 207 in the STS. Panel 202 contains all the circuit breakers that supply electrical power to the system. Panel 206 is the master control panel from which all the major control functions can be initiated as follows:

- o MASTER ALARM (red pushbutton light) - Provides a master alarm reset to C&W and emergency subunits 1 and 2 and is illuminated by a caution, warning, or emergency condition.
- o MEMORY RECALL (yellow pushbutton light) - Provides a memory recall signal to C&W subunits 1 and 2 and is illuminated by a caution or warning condition.
- o CLEAR switch - Provides a memory clear signal to C&W subunits 1 and 2.
- o POWER C&W switch - Applies or disables electrical power to C&W subsystems 1 and 2 simultaneously.
- o POWER EMERGENCY 1 and 2 switch - Applies or disables electrical power to emergency subsystems 1 and 2, respectively.

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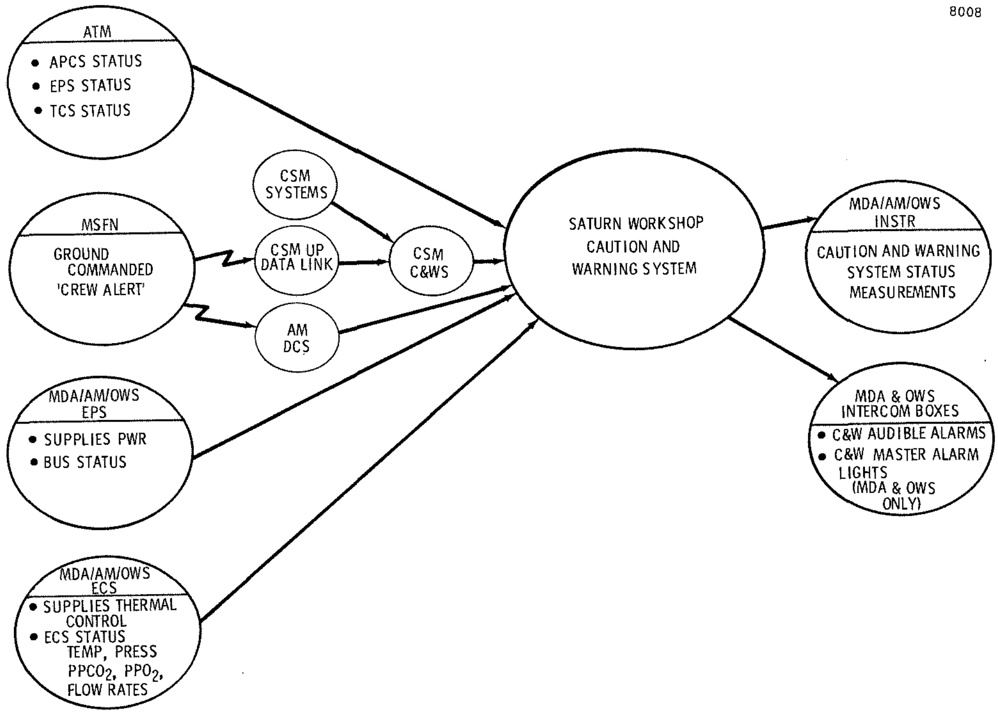


Figure 2.8.2-1 System Interfaces

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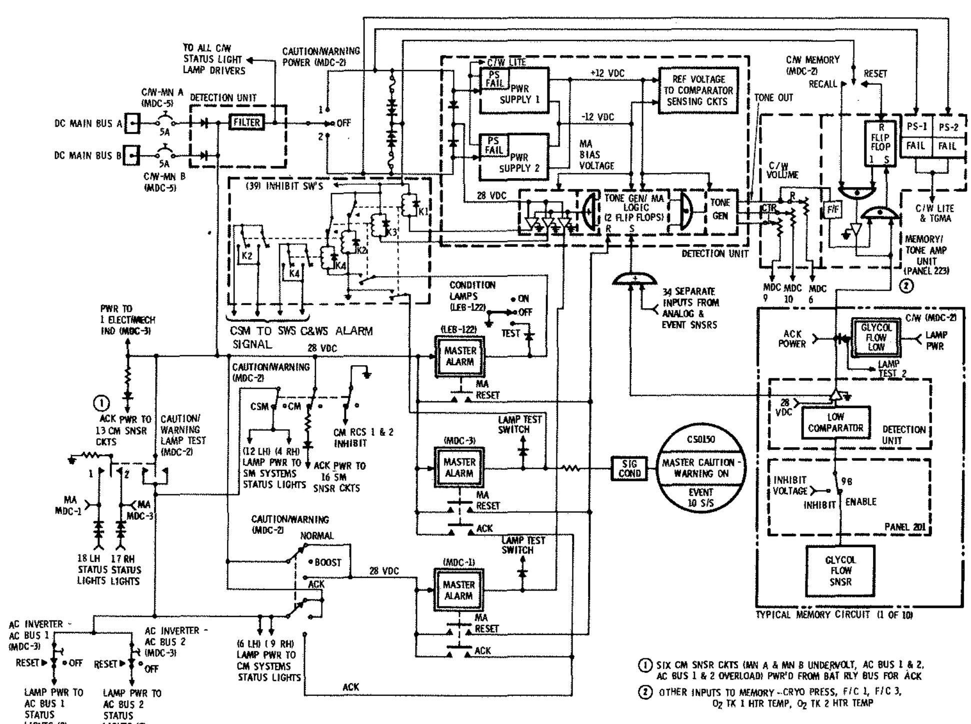


Figure 2.8.2-2 CSM Caution/Warning Subsystem

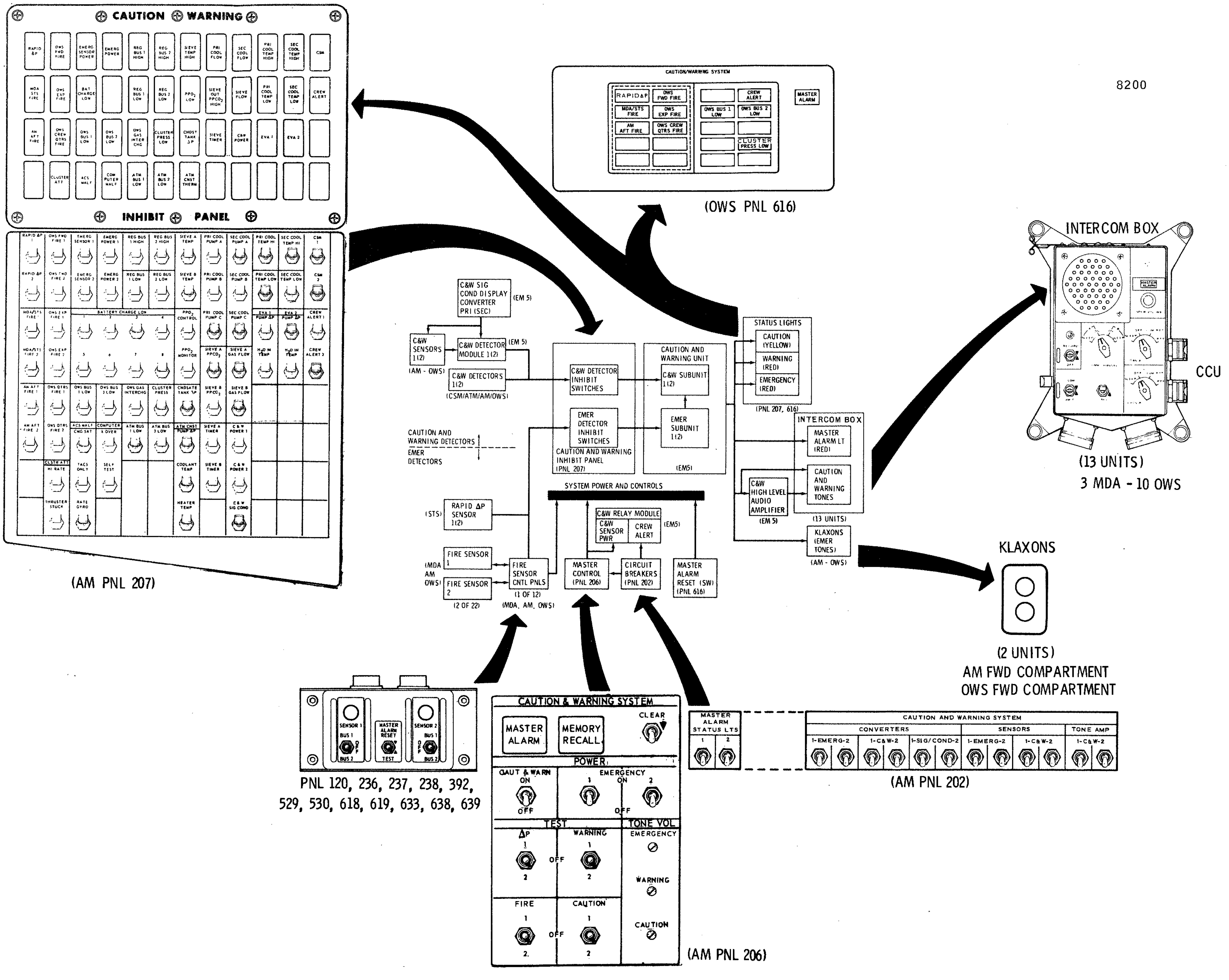


Figure 2.8.3-1 SWS C&W System

- o TEST ΔP switch - Provides test capability of ΔP sensors 1 and 2 and the emergency subunits 1 and 2 ΔP electronics.
- o TEST FIRE switch - Provides test capability of the fire condition electronics in emergency subunits 1 and 2.
- o TEST WARNING switch - Provides test capability of the warning condition electronics in C&W subunits 1 and 2.
- o TEST CAUTION switch - Provides test capability of the caution condition electronics in C&W subunits 1 and 2.
- o TONE VOL EMERGENCY/WARNING/CAUTION - Provides volume control of the emergency, warning, and caution tones - Requires the screwdriver located on panel 206 for adjustment.

Panel 207 C&W INHIBIT PANEL is the primary status light display and detector inhibit panel for all parameters monitored by the system. Caution (yellow), warning (red), and emergency (red) lights on this panel provide indications of out-of-limit conditions in the OA systems monitored. The inhibit switches inhibit or enable detector inputs to the caution and warning unit. The inhibit position prevents actuation of the audible and visual alarms associated with the inhibited parameter. Panel 616 contains auxiliary display and controls: one control function (MASTER ALARM reset) identical to the MASTER ALARM reset on panel 206 and status lights for all the emergency parameters, plus two caution and two warning parameters. Twelve fire sensor control panels (panel 120 typical) provide individual control and test of the fire sensors plus a MASTER ALARM RESET control function identical to that provided by panels 206 and 616. Each MDA and OWS intercom box contains a MASTER ALARM status light that will come on each time a caution, warning, or emergency alarm is initiated, and provides the caution or warning tone via the INTERCOM speaker and through channels A and B CCU's (figure 2.8.3-2). Two types of C&W tones are used - a low-level tone, routed to the C&W high-level audio amplifier and to each intercom box and an amplified high-level tone (the output of the high-level amplifier) also routed to each intercom box. The low-level tone is provided to the CCU's and drives the INTERCOM speaker via the intercom box internal electronics. The high-level tone is used to drive the INTERCOM speaker in parallel with and independent of the intercom box electronics. The C&W tones are distributed through the respective control switches in each intercom box to the speaker and the channels A and B CCU's. The C&W tones are enabled to the CCU's when the respective control switch is in ICOM/PTT or ICOM mode, and to the speaker when the control switch is in channel A or B ON position. C&W tones are inhibited to the CCU's and the speaker when the respective control switch is in the "sleep" mode. An "AM ground commanded crew alert", CSM call, or AM call, overrides the sleep mode, enabling the tones. The C&W tones to channel A and B CCU's are completely disabled when the respective control switch is in the OFF position. The AM and OWS klaxons (each consisting of two speakers) provide the fire tone and/or the rapid ΔP tone. The emergency tones cannot be inhibited.

The C&W relay module houses control relays required for system operation.

2.8.3.1 CAUTION (WARNING) CONDITION DETECTION

Out-of-limit caution or warning conditions fall into two categories, continuous and transient. One, two, three, and eight caution (warning) parameters are OR'ed to drive a single status light on panel 207 and 616 if displayed in the OWS (figure 2.8.3-3).

Any one or any combinations of C&W detectors providing continuous +28 vdc discrete inputs to an OR-input channel produces the following:

- o Latches in the ON condition
  - Caution (warning) tone
  - Warning tone overrides caution tone if caution and warning conditions are present concurrently
  - MASTER ALARM lights (panels 206 and 616, and each intercom)
  - Telemetry parameters K369, K378, (K360, K375)
- o Stores in memory the system status light identity as displayed on panel 207 and illuminates the MEMORY RECALL light (panel 206)
- o Illuminates the appropriate system status light (panels 207 and 616) (system status light directly tracks detector output signal)

Depressing the illuminated MASTER ALARM pushbutton light (panels 206 and 616) or actuating the MASTER ALARM RESET/TEST switch on a fire sensor control panel turns off the caution (warning) tone, MASTER ALARM lights, and the caution (warning) TM events. In the case of a single parameter driving the status light, the malfunction signal source is easily identified; however, the inhibit switches (panel 207) or corresponding onboard displays must be utilized to identify the signal source for 2-OR, 3-OR, and 8-OR input channels. The inhibit switches also can be used to inhibit detectors providing erroneous or nuisance inputs to the systems.

The C&W memory provides capability to turn on the appropriate system status light (panels 207 and 616) for transient caution (warning) conditions. A transient caution (warning) condition produces a momentary +28 vdc discrete to the C&W subunits, which then provides the same output indications as for a continuous condition, except the system status light will momentarily come on. Depressing the illuminated MEMORY RECALL pushbutton light (panel 616) will illuminate the appropriate system status light (panels 207 and 616); however, the identity of the detector providing the out-of-limit signal will be lost in the case of the 2-OR, 3-OR, and 8-OR parameters. Actuation of the CLEAR sw (panel 206) clears all memory cells and turns off the MEMORY RECALL pushbutton light (panel 206).

2.8.3.1.1 <u>Caution (Warning) Subsystem Self Test</u>

TEST CAUTION (WARNING) switch (panel 206) provides capability to test C&W subunits 1 and 2 caution (warning) electronics and the C&W audible and visual indicators (figure 2.8.3-4). TEST CAUTION (WARNING) 1 turns off C&W subunit 2 and applies a test signal to all caution (warning) input channels in C&W subunit 1. All caution (warning) indicator drivers, memory cells, and audible and visual indicators driven by caution and warning subunit 1 are verified by this test mode. TEST CAUTION (WARNING) 2 turns off C&W subunit 1 and applies a test signal to all

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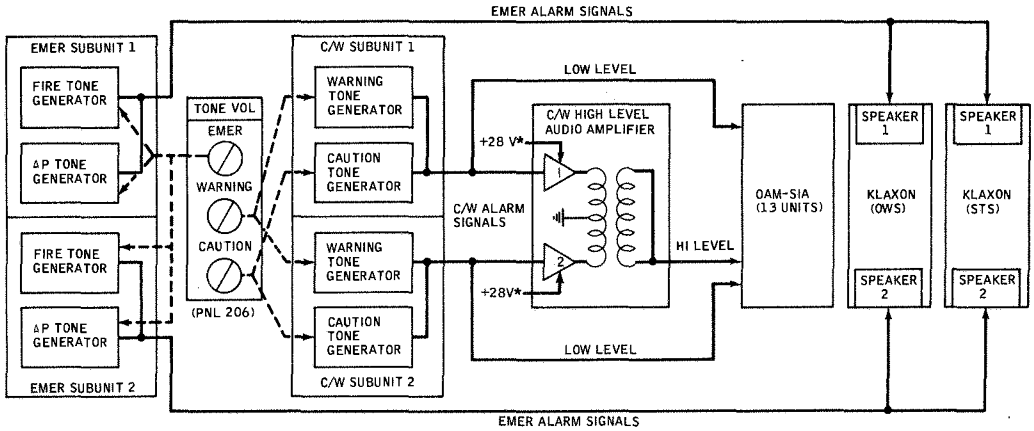
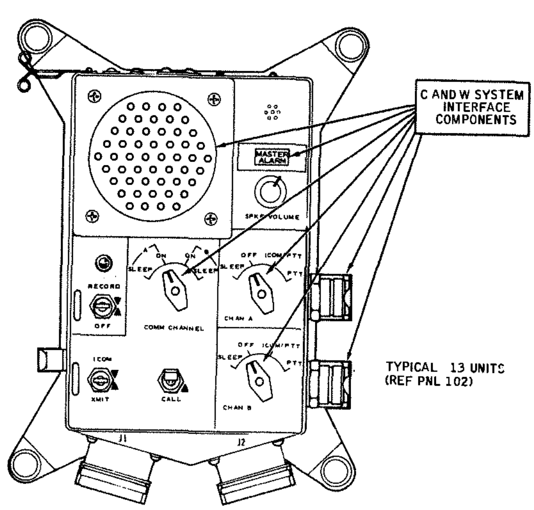
## AUDIBLE ALARM SIGNAL




* FROM C&W POWER ON SWITCH (PNL206)
A1 - FROM C&W TONE AMP C&W 1 CB (PNL 202)
A2 - FROM C&W TONE AMP C&W 2 CB (PNL 202)

## SPEAKER INTERCOM




TONE INFORMATION
C&W - 88db max
±10db adj
EMER - 95db max
±5db adj

NOTE:
CALL, XMIT OR ICOM SIGNAL FROM AN INTERCOM INHIBITS ALL C&W TONES AND VOICE SIGNALS TO THE HARDMOUNTED SPEAKER ON THAT STATION

## SIA - C/W AUDIO SIGNAL FUNCTIONAL INTERFACE

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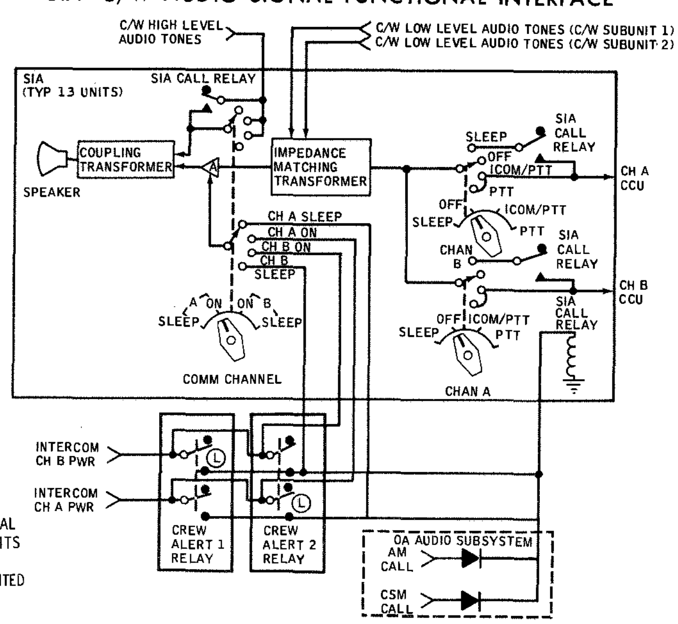



Figure 2.8.3-2 C&W Audible Alarms

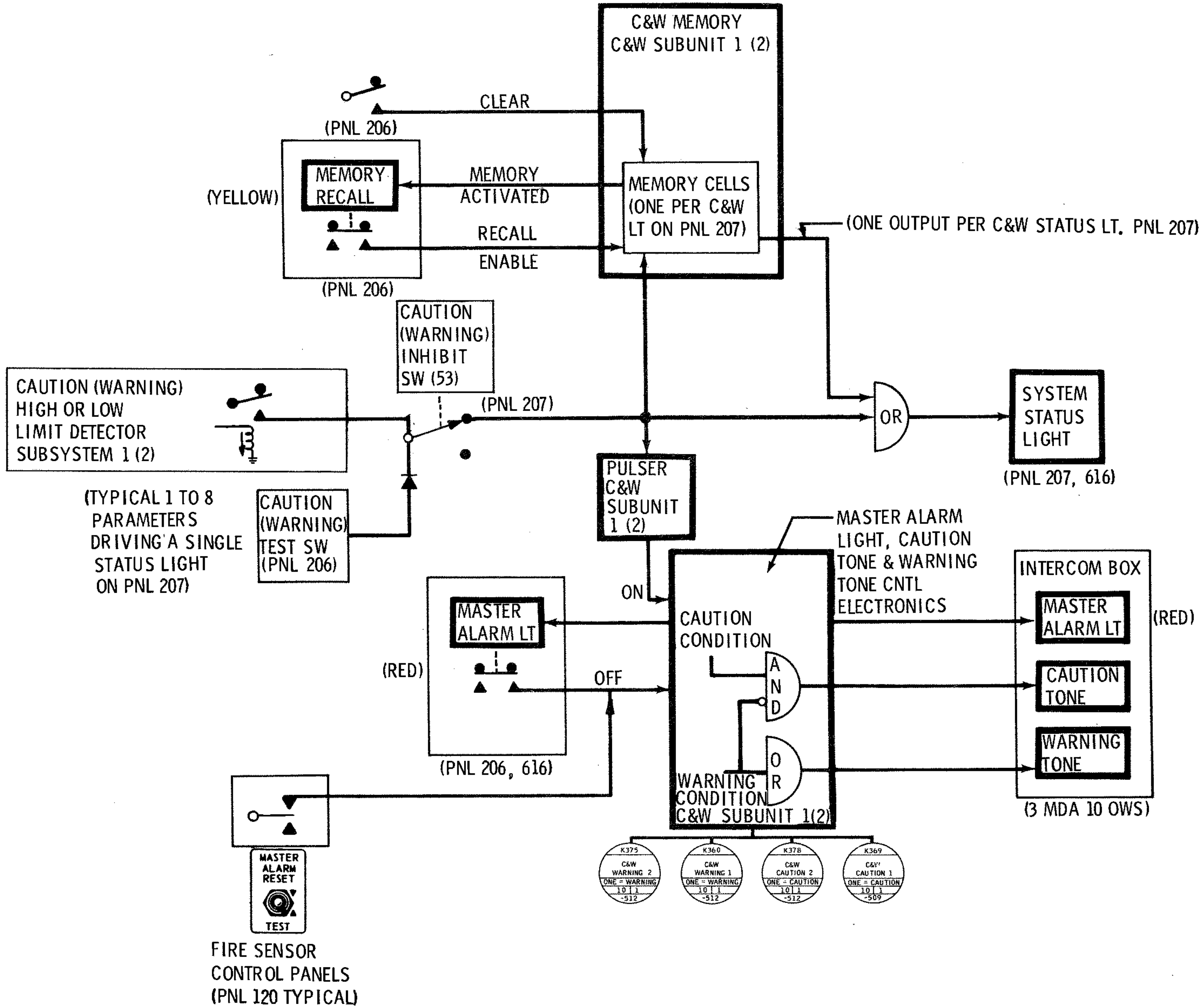



Figure 2.8.3-3 Caution(Warning) Detection

8202

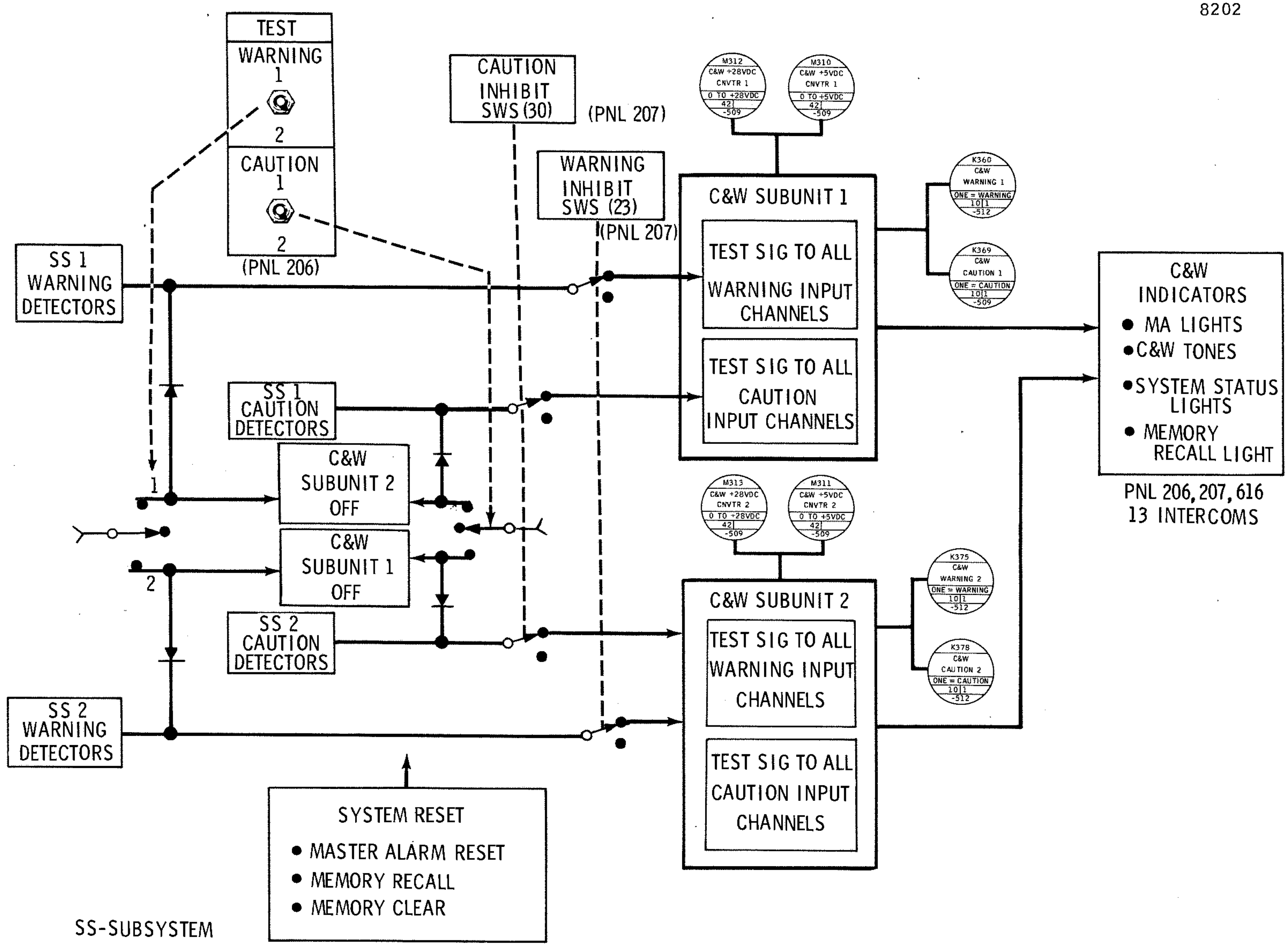



Figure 2.8.3-4 C&W Subsystem Self-Test

caution (warning) input channels in caution and warning subunit 2. After performing a master alarm reset and returning the test sw to OFF, verification of the memory cells in each subunit is performed by depressing the MEMORY RECALL pushbutton light (panel 206). Memory clear is accomplished by actuation of the CLEAR switch (panel 206).

2.8.3.2 RAPID ΔP DETECTION

Two rapid ΔP sensors located in the STS provide redundant monitoring of the OA internal pressure (figure 2.8.3-5). Upon sensing a decrease in OA internal pressure greater than or equal to 0.1 psia/min, each sensor provides +28 vdc discrete signals to emergency subunits 1 and 2, which produces the following:

o Latches in the ON condition
  Rapid ΔP tone
  RAPID ΔP light (panels 207 and 616)
  MASTER ALARM light (panels 207 and 616, and each intercom box)
  Warning tone
  Telemetry parameters K360, K375, K368, and K377

Depressing the illuminated MASTER ALARM pushbutton light (panels 206 and 616) or actuating the MASTER ALARM/RESET/TEST switch on a fire sensor control panel turns off the rapid ΔP tone, MASTER ALARM lights, warning tone, and the TM events and unlatches the RAPID ΔP status lights, which then track the ΔP sensor discretes. The RAPID ΔP status lights will remain on until the OA pressure decay rate decreases to less than 0.1 psia/min. RAPID ΔP 1 and RAPID ΔP 2 inhibit switches (panel 207) provide the capability to inhibit the ΔP sensors during system testing or in the event of a malfunctioning sensor.

2.8.3.2.1 Rapid ΔP Self-Test

TEST ΔP switch (panel 206) provides test capability of ΔP sensors 1 and 2, emergency subunits 1 and 2 ΔP electronics, and the audible and visual ΔP indicators (figure 2.8.3-5). Test ΔP 1 (2) position turns off emergency subunit 2 (1) and simultaneously applies a self-test command to both ΔP sensors 1 and 2. Verification of a specific ΔP sensor during a test is accomplished by use of RAPID ΔP 1 and RAPID ΔP 2 inhibit inhibit switches (panel 207). MASTER ALARM reset returns the system to the normal monitor mode.

2.8.3.3 FIRE DETECTION

Twenty-two ultra violet (UV) fire sensors provide fire coverage protection in the MDA, AM and OWS. The fire sensors are divided into 5 groups - MDA/STS FIRE (8 sensors), AM AFT FIRE (2 sensors), OWS FWD FIRE (3 sensors), OWS CREW QTRS FIRE (6 sensors) and OWS EXP FIRE (3 sensors) (figure 2.8.3-6). Twelve fire sensor control panels provide control of the 22 fire sensors. Panel 120, 236, 237 and 238 control the MDA/STS FIRE group, 392 controls the AM AFT FIRE group, 529 and 530 controls the OWS FWD FIRE group, and panel 618 and 619 controls the OWS EXP FIRE group, and panels 633, 638, and 639 control the OWS CREW QTRS FIRE group. The area fire lights (panels 207 and 616) provide identification of the respective fire sensor group providing the fire alarm. The fire sensor lights on the five sensor control panels must be used to identify the specific area and sensor within the group's coverage zone. Any one or any combination of fire sensors within a group upon detection of a fire will produce +28 vdc discretes to emergency subunits 1 and 2, which then produces the following (figure 2.8.3-7):

o Latches in the ON condition
  Area fire lights (panels 207 and 616)
  Fire tone
  MASTER ALARM lights (panels 206 and 616 and each intercom box)
  Warning tone
  SENSOR 1 and/or 2 identification light on the respective fire sensor control panel
  Telemetry parameters K367, K377, K360, and K375

Depressing the illuminated MASTER ALARM pushbutton light (panels 206 and 616) or actuating the MASTER ALARM RESET/TEST switch on any of the 12 fire sensor control panels to MASTER ALARM RESET turns off the fire tone, MASTER ALARM lights, warning tone, and TM events. The area fire light (panels 207 and 616) directly tracks the sensor output after a MASTER ALARM reset and the SENSOR 1 and/or 2 identification light remains latched on. The respective SENSOR 1 and/or 2 light can be turned off after eliminating the fire source by cycling the BUS 1/ BUS 2/OFF switch to OFF and back to the original BUS 1 or 2 position.

Two inhibit switches (FIRE 1 and FIRE 2 panel 207) per fire detection group provide the capability to inhibit the group's +28 vdc discrete output or the FIRE 1 and FIRE 2 test signals to emergency subunits 1 and 2.

2.8.3.3.1 Fire Detection Self Test

FIRE SENSOR TEST - Individual fire sensor testing is accomplished by the MASTER ALARM RESET/TEST switch on the respective remote fire sensor control panels (figure 2.8.3-8). Actuation of the MASTER ALARM RESET/TEST switch to TEST applies a test signal to an UV test source in sensors 1 and 2. Test of all 22 fire sensors requires application of test signals from all 12 fire sensor control panels. Individual fire sensor testing can be accomplished by turning power off to either sensor 1 or 2 as desired prior to performing the test. MASTER ALARM reset and cycling of the sensor power switch to off and back to the bus 1 or 2 position must be performed after each sensor test.

8203

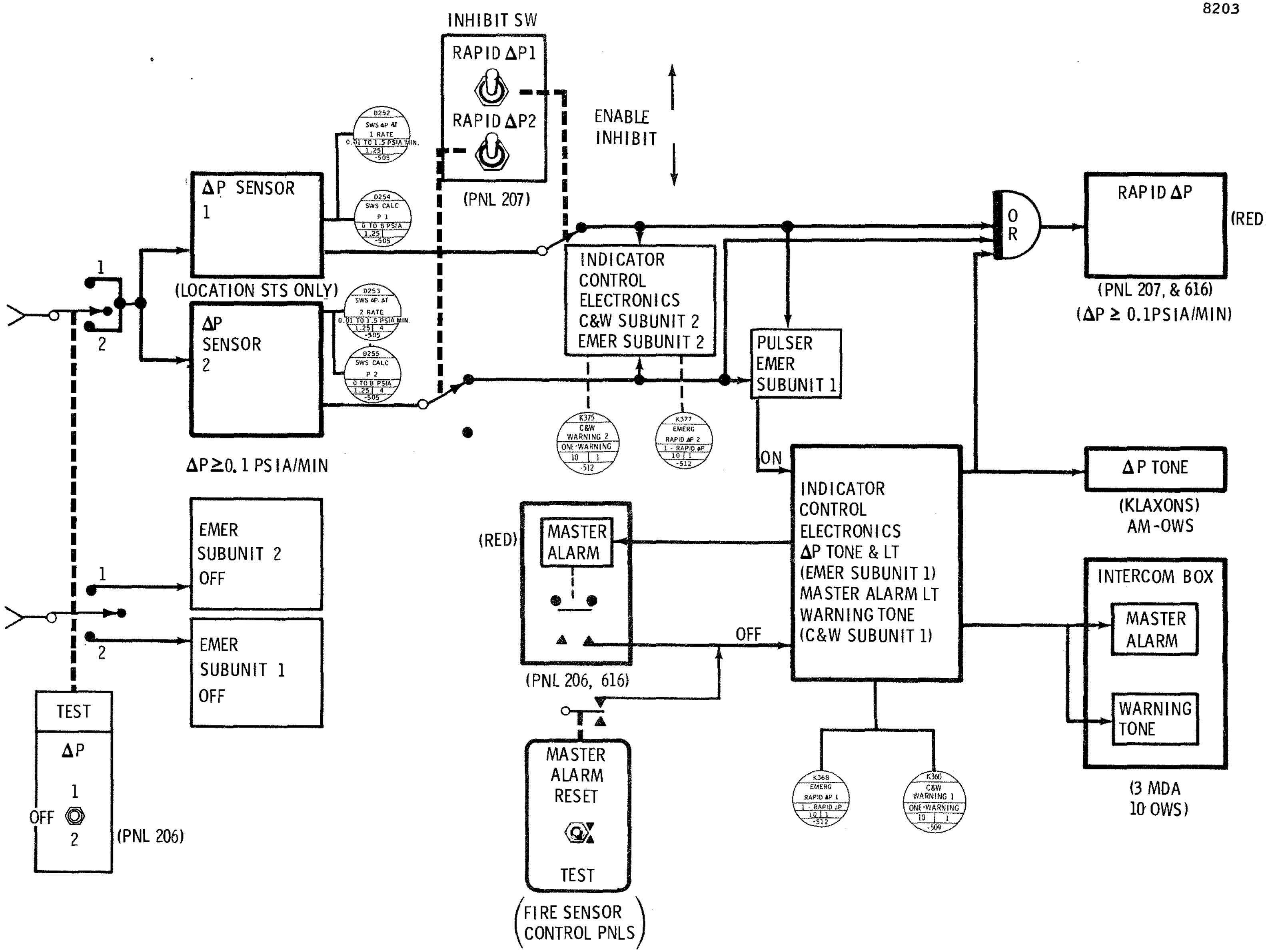



Figure 2.8.3-5 Rapid P Detection

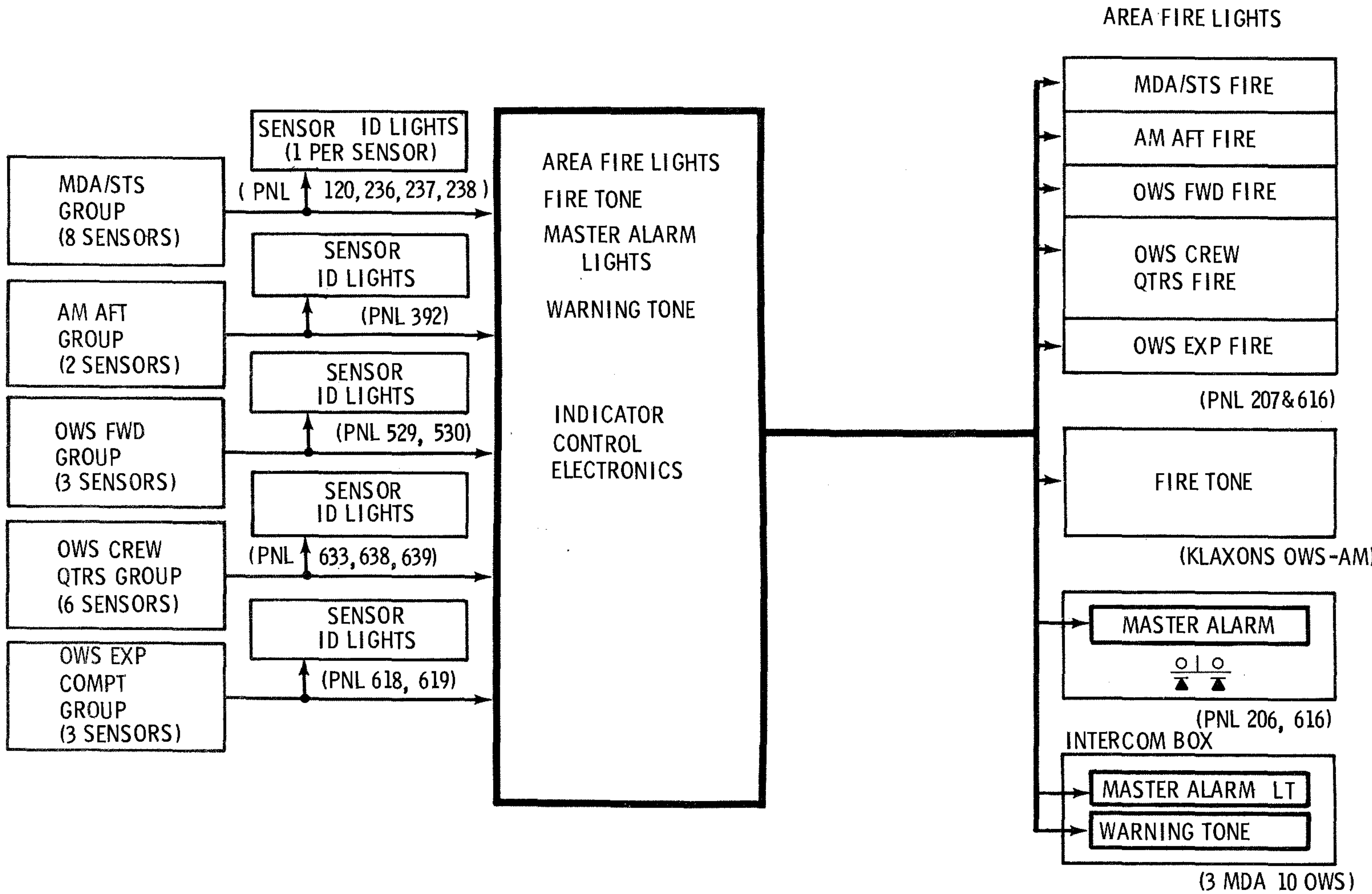



Figure 2.8.3-6 Fire Detection Subsystem

8205

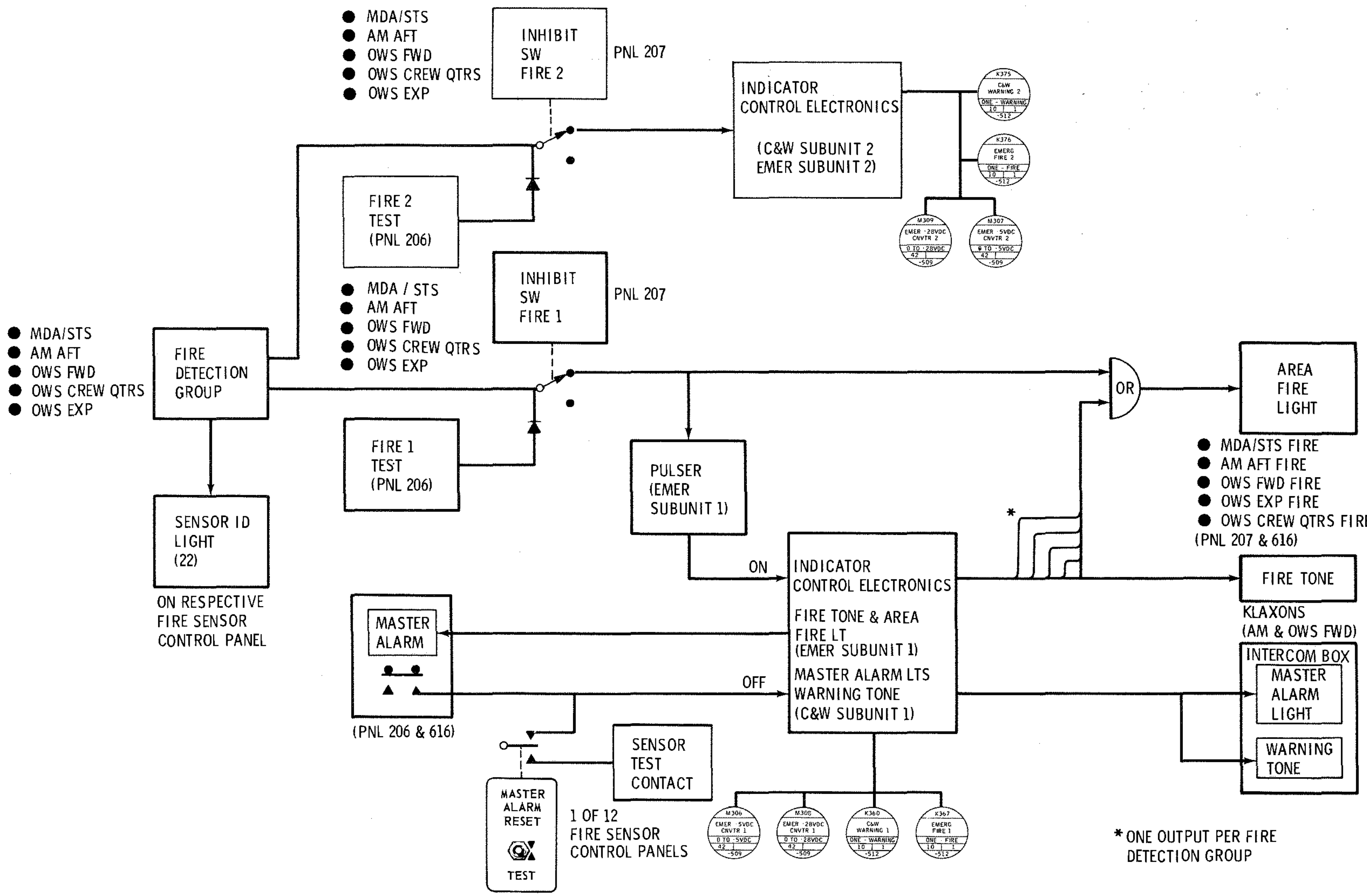



Figure 2.8.3-7 Fire Detection Functional

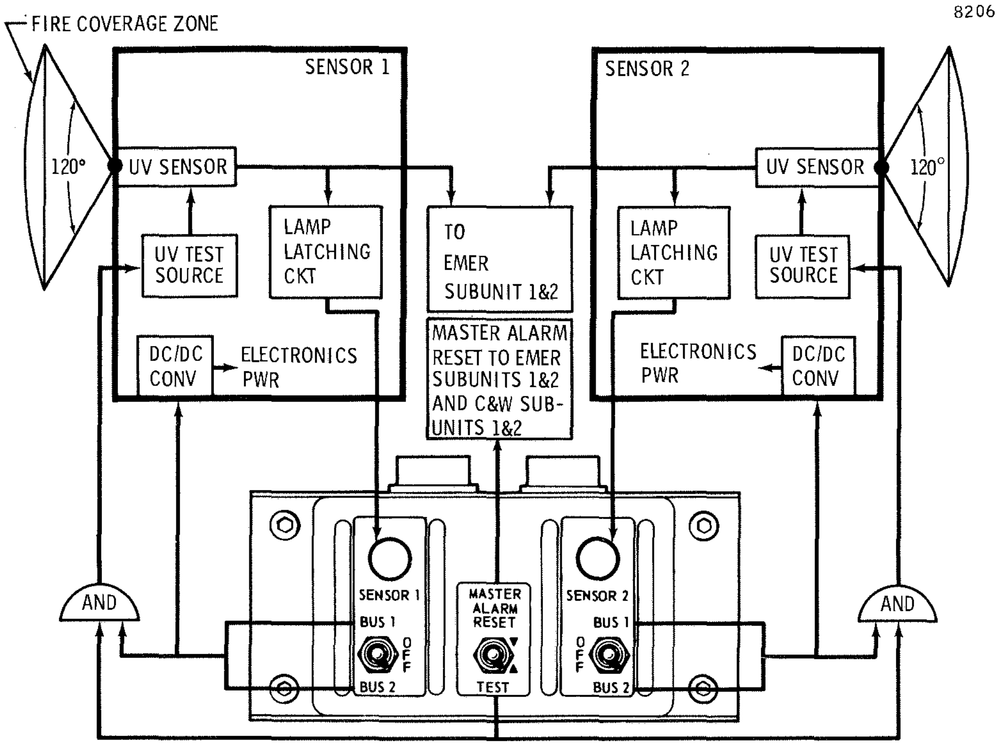



Figure 2.8.3-8 Fire Sensor Test

EMERGENCY SUBUNITS 1 AND 2 FIRE ELECTRONICS TEST - TEST FIRE 1/OFF/2 switch (panel 206) provides the capability to test the fire electronics section in emergency subunits 1 and 2 (figure 2.8.3-9). FIRE 1 position simultaneously turns off emergency subunit 2 and applies a test signal to all fire sensor monitor circuits in emergency subunit 1. System reset is performed by removing the test signal and performing a MASTER ALARM reset (panel 206, 616, or FIRE SENSOR CONTROL PANEL). TEST FIRE 2 position turns off emergency subunit 1 and applies a test signal to all fire sensor monitor circuits in emergency subunit 2. System reset is the same as above.

2.8.3.4 C&W SUBSYSTEM POWER

All circuit breakers for the C&W subsystem are located on panel 202, and the POWER CAUTION & WARNING ON/OFF switch (panel 206) controls power on and off to the subsystem (figures 2.8.3-10 and -11). EPS control bus 1 and AM bus 1 power is supplied to C&W subsystem 1, and EPS control bus 2 and AM bus 2 power is supplied to C&W subsystem 2. With a few exceptions (OWS GAS INTERCHANGE, and CONDENSATE TANK $\Delta$P), all electrical power to a subsystem can be disabled and all C&W parameters can be actively monitored by the remaining operative subsystem. (reference section 2.8.9 for sensor and detector power assignments).

2.8.3.5 EMERGENCY SUBSYSTEM POWER

All circuit breakers for the emergency subsystem are located on panel 202. Power on/off control is provided by POWER EMERGENCY 1 switch (panel 206) for subsystem 1 and POWER EMERGENCY 2 switch (panel 206) for subsystem 2 (figures 2.8.3-12 and -13). EPS control bus 1 supplies power to emergency subsystem 1 and EPS control bus 2 supplies power to subsystem 2. Either subsystem could be disabled and the remaining operative subsystem would provide monitoring of all emergency parameters; however, all fire sensor power switches would have to be configured to the operative subsystem (BUS 1 or 2).

NOTE: Electrical power to the MASTER ALARM lights (panels 206 and 207 and intercom box) and the warning tone is controlled by the C&W subsystem upon receipt of contact closures from the emergency subunits for either a fire or rapid $\Delta$P condition.

2.8.4 SUBSYSTEM AND MAJOR COMPONENT DESCRIPTION

2.8.4.1 CONTROLS AND DISPLAYS

Each C&W system indicator light (panels 206, 207, and 616) contains two lamp bulbs, one driven by C&W or emergency subunit 1 and the other by C&W or emergency subunit 2; these lamps are not inflight replaceable. The fire sensor control panels, and the fire sensor lamp assemblies on these panels, are inflight replaceable.

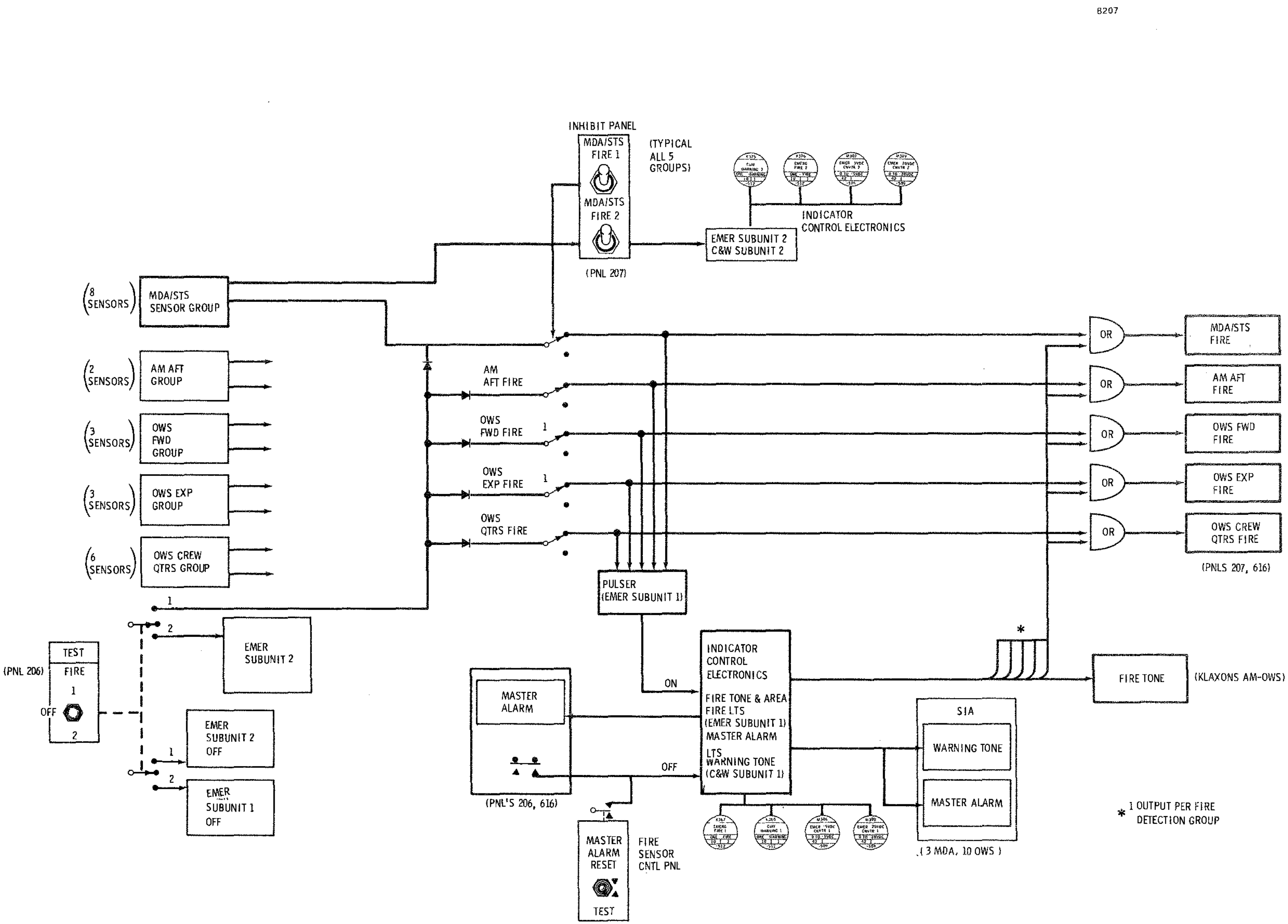



Figure 2.8.3-9 Emergency Subunits 1 & 2 Fire Electronics Test

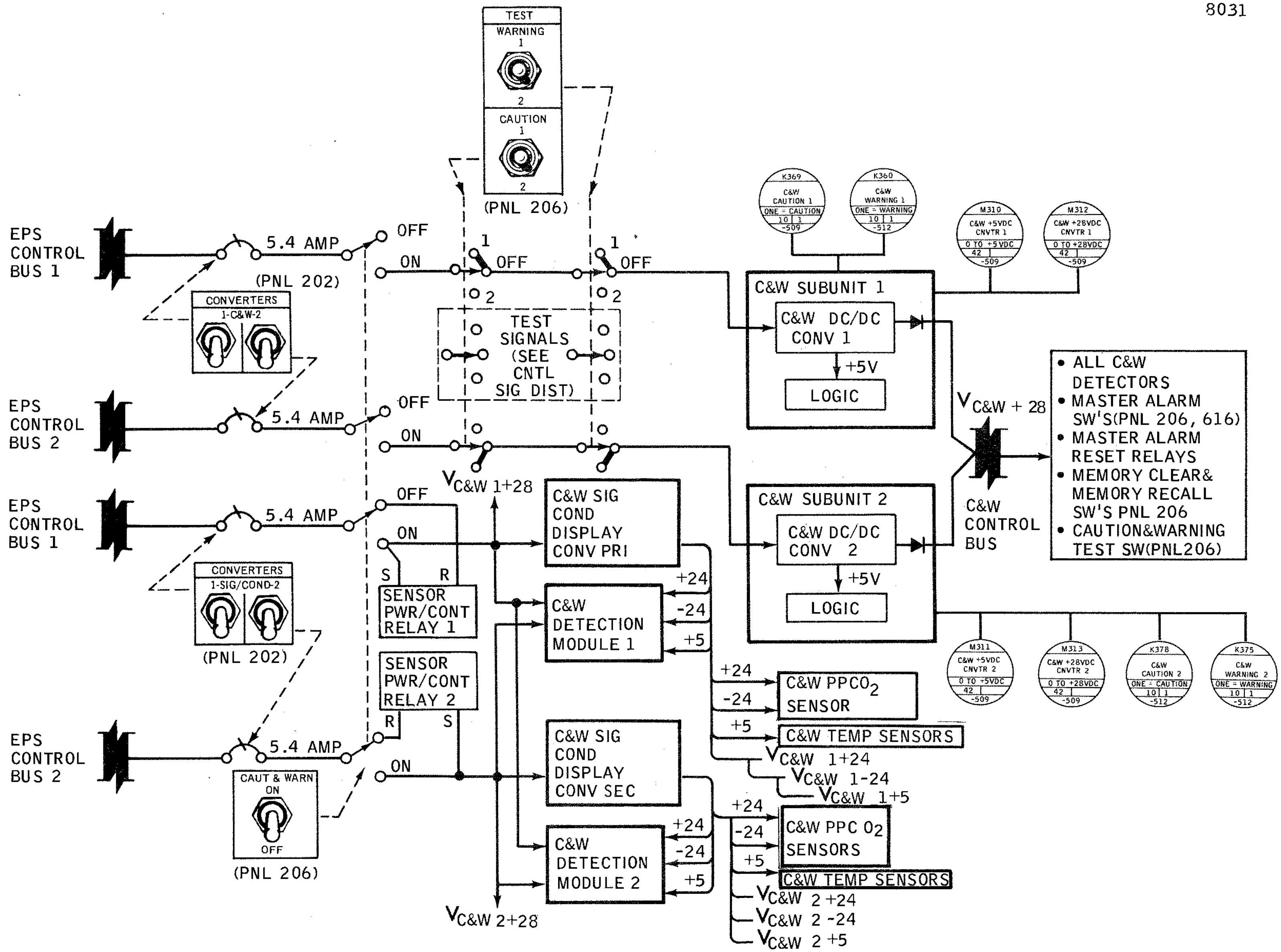



Figure 2.8.3-10 C&W Subsystem Power Distribution (Sheet 1)

8031.1

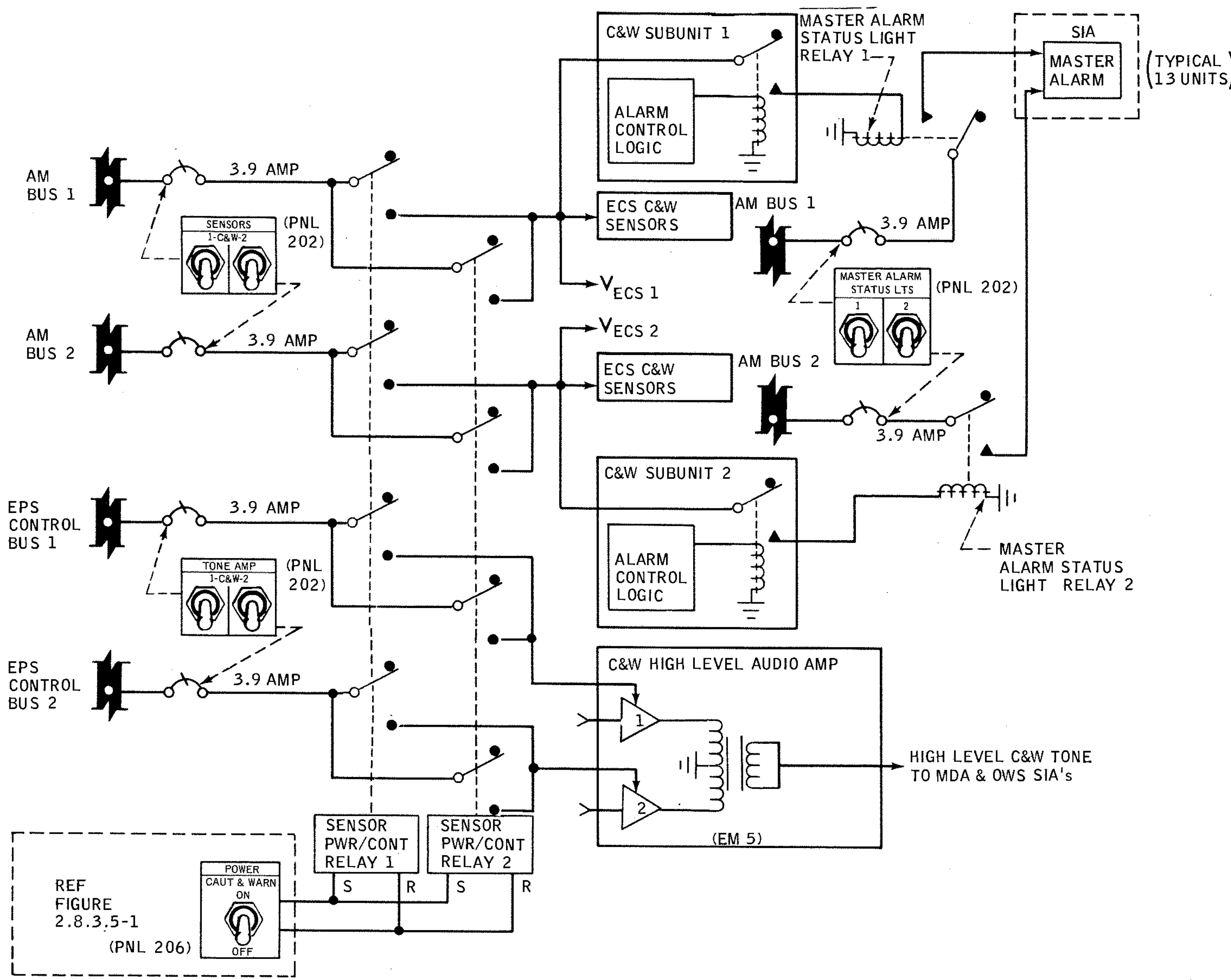



Figure 2.8.3-10 C&W Subsystem Power Distribution (Sheet 2)

8032

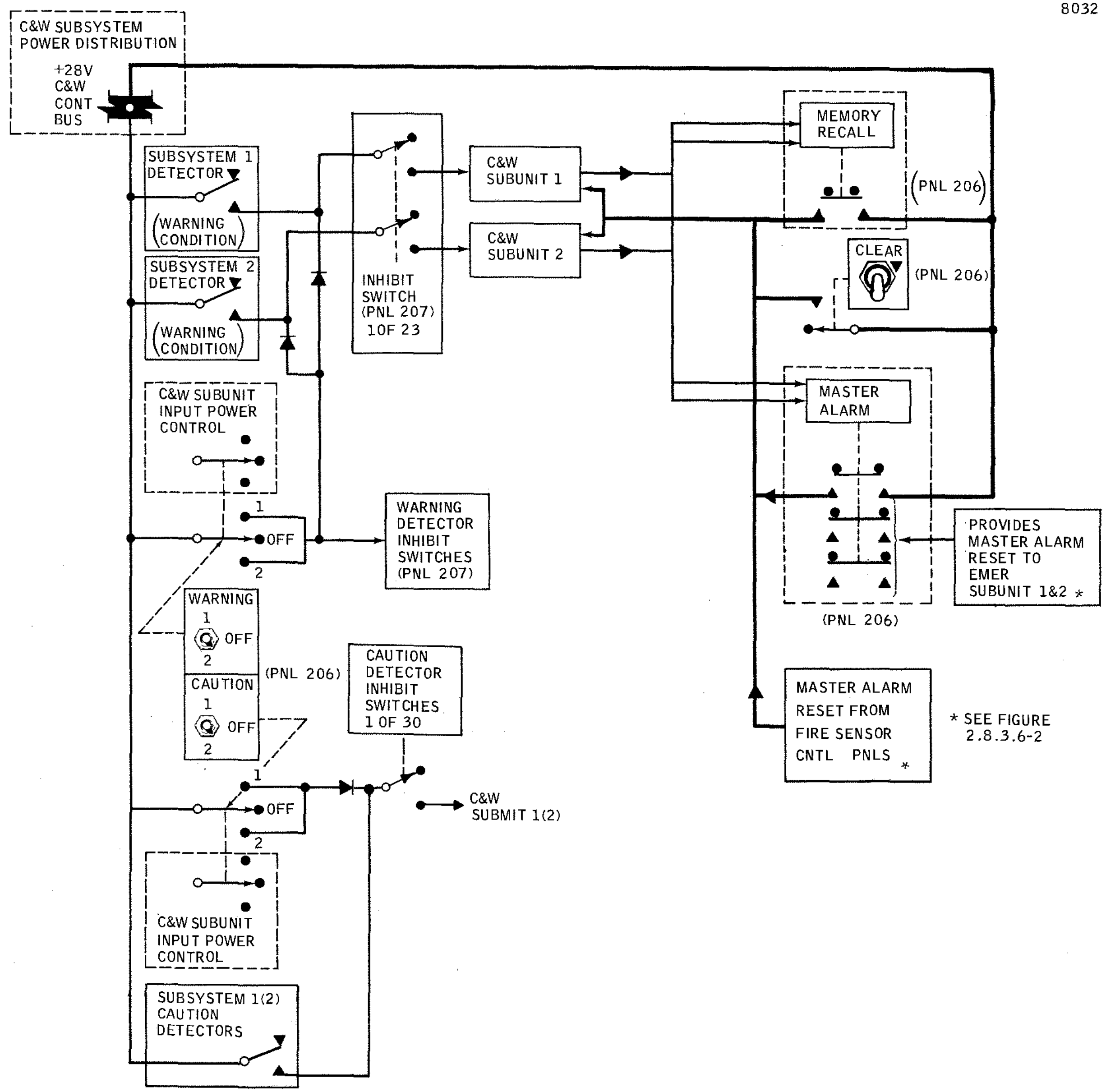



Figure 2.8.3-11 C&W Subsystem Control Signal Distribution

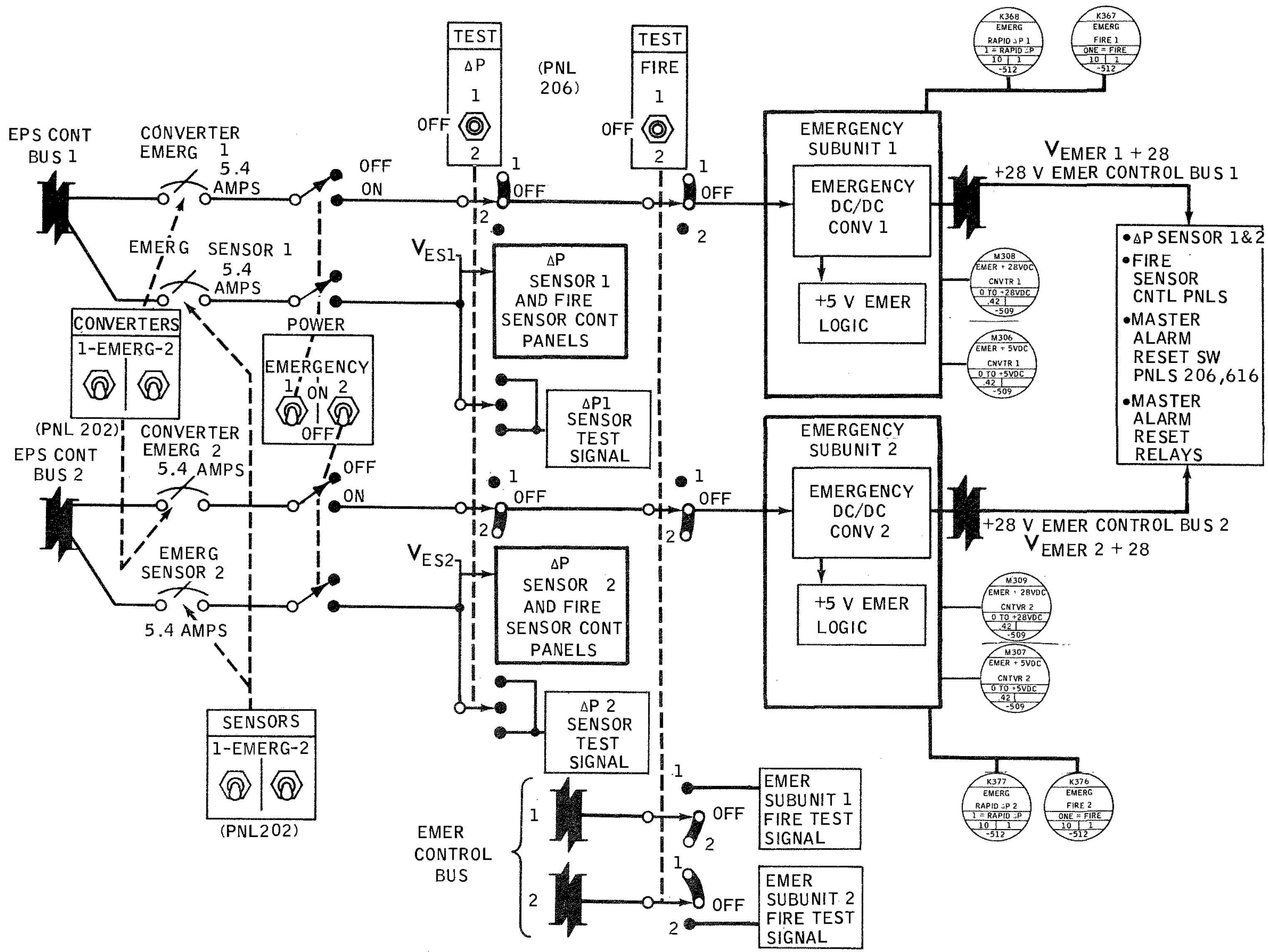



Figure 2.8.3-12 Emergency Subsystem Power Distribution

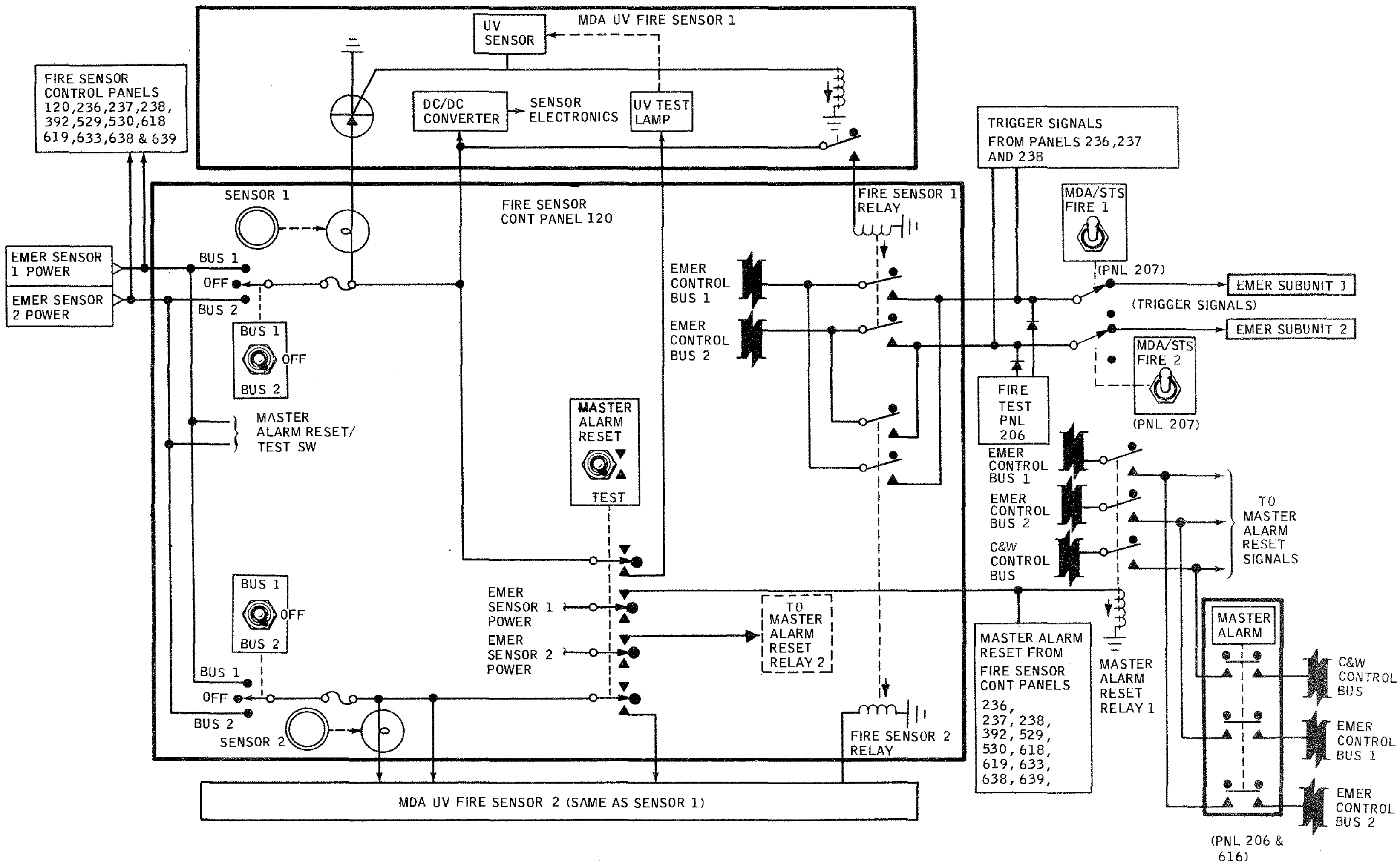



Figure 2.8.3-13 Fire Sensor Controls & Power Distribution (MDA/STS Group Typical)

8106

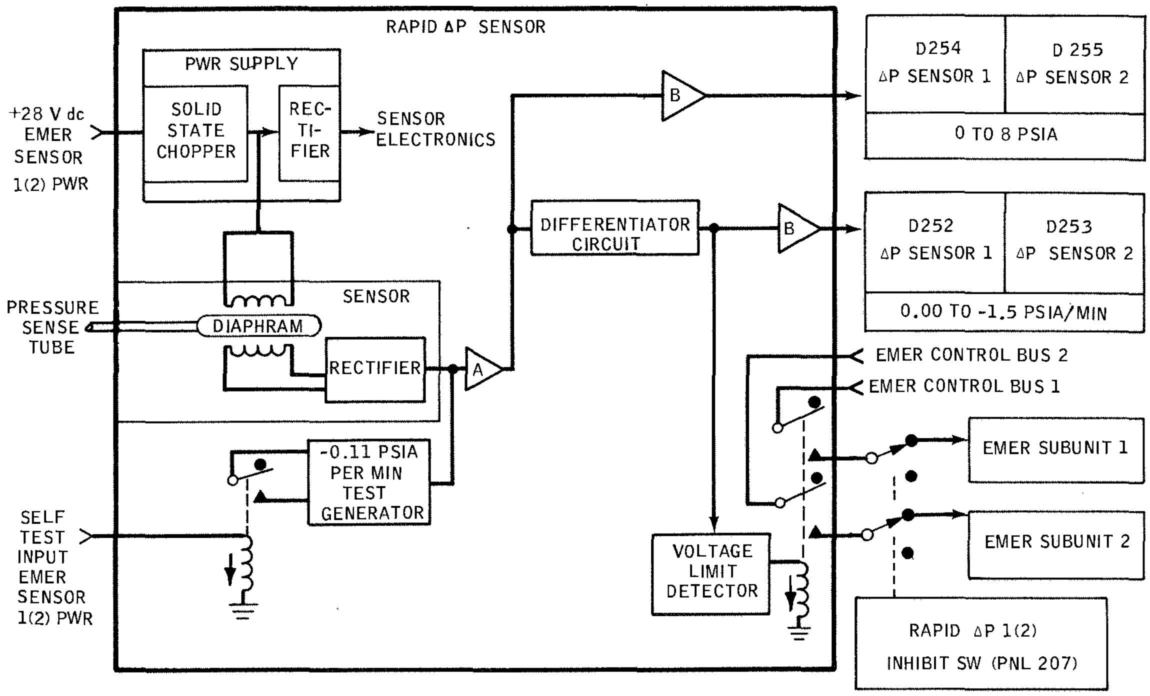



Figure 2.8.4-1 Rapid ΔP Sensor 1 (2)

2.8.4.2 CAUTION AND WARNING SENSORS AND DETECTORS

C&W detectors consist of mechanical absolute pressure and differential pressure detectors, gas flow detectors, SWS system relay contact closures, and voltage level detectors housed in the C&W detector modules. Sensors that provide inputs to the voltage level detectors in the C&W detection modules consist of temperature, PPCO2, PPO2, and signal wires from the electrical power system.

C&W DETECTOR MODULES 1 (2) - The C&W detector modules, cold plate mounted on electronics module 5, house the C&W voltage level detectors used to monitor temperature sensors, PPO2, PPCO2, the electrical power system, and the C&W signal conditioning display converters.

2.8.4.3 C&W SIGNAL CONDITIONING DISPLAY CONVERTER PRI (SEC)

C&W signal conditioning display converters, PRI (SEC) mounted on electronics module 5, use +28 vdc spacecraft power and supply +24 vdc, and -24 vdc to power voltage level detectors in C&W detector modules 1 (2) + 5 vdc to C&W temperature sensors, and ±24 vdc to C&W PPCO2 sensors. Monitoring of the C&W signal conditioning display converter PRI (SEC) is performed by a voltage level detector in C&W detector module 1 (2).

2.8.4.4 RAPID ΔP SENSORS

Each sensor requires +28 vdc for internal power and provides the following output signals (figure 2.8.4-1):

- o 0 to 8 psia to telemetry
- o 0.0 to-1.50 psia/min to telemetry
- o C&W contact closure at a pressure decay rate of 0.1 psia/min

A test signal is generated when ΔP 1 or ΔP 2 TEST (panel 206) is applied. The test signal causes the sensor to simulate (electronically) a leak rate of 0.11 psi/minute, resulting in a C&W contact closure. The two analog outputs to telemetry also track the test signal.

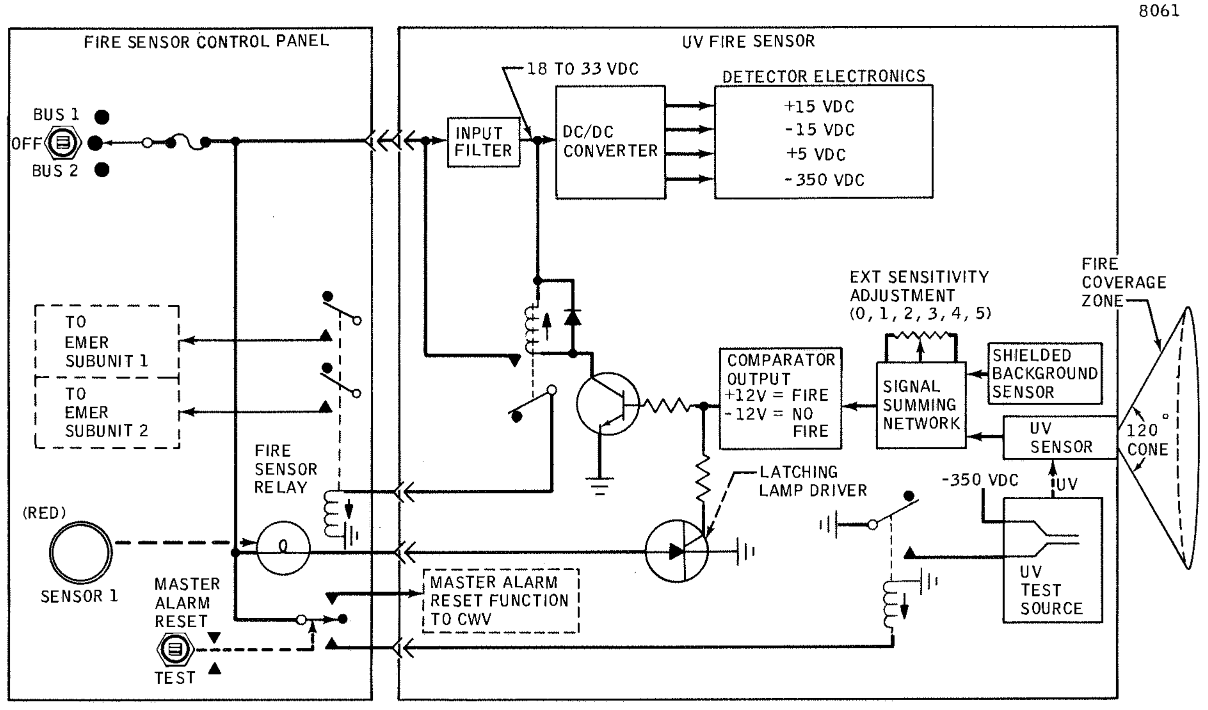



Figure 2.8.4-2 UV Fire Sensor

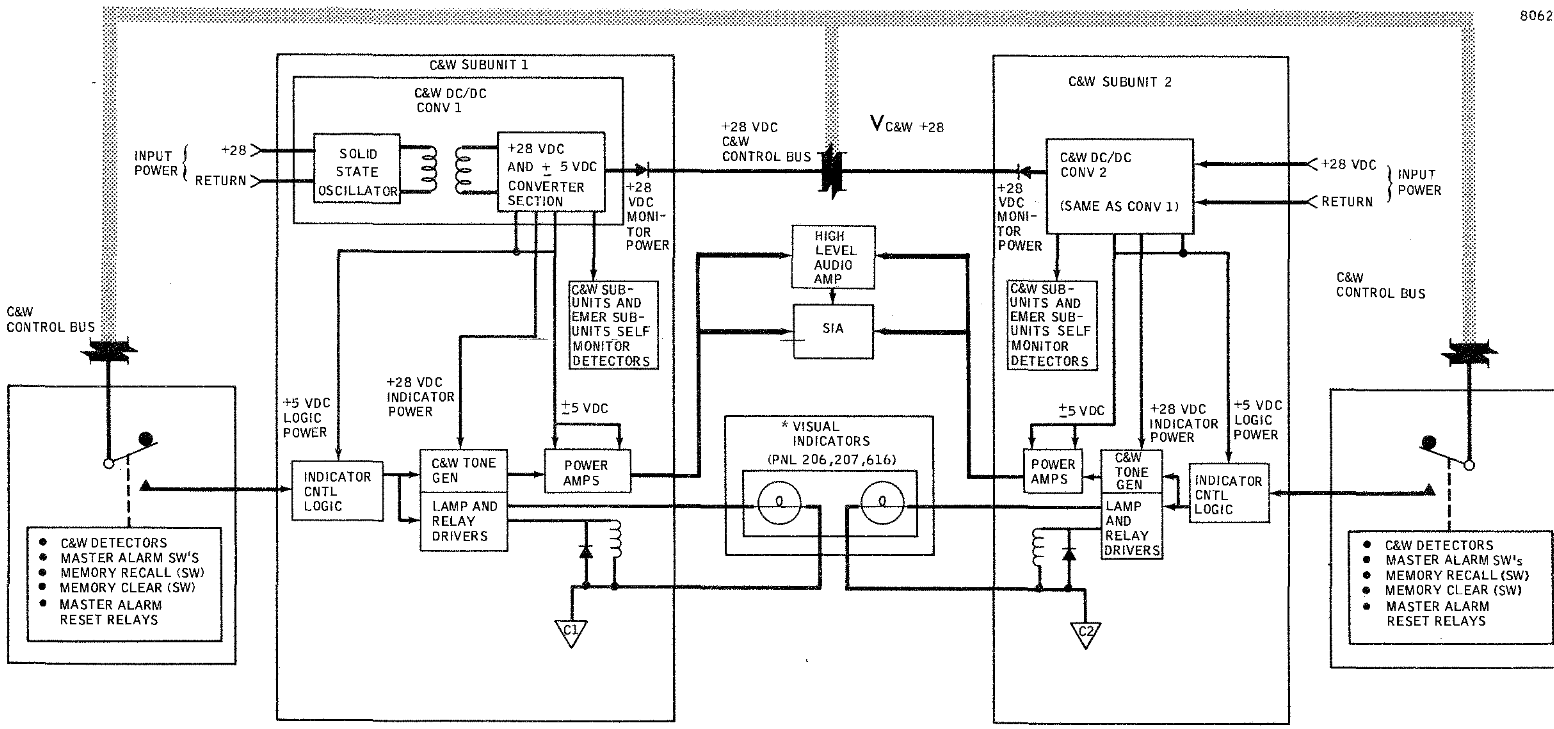
2.8.4.5 ULTRA VIOLET FIRE SENSOR ASSEMBLIES

Each UV fire sensor uses +28 vdc for internal power and provides two output signals upon sensing a flame within its coverage zone or application of the test signal (figure 2.8.4-2). One signal latches on the fire sensor identification light on the fire sensor control panel, and the other drives a relay in the fire sensor control panel as long as a flame is sensed. The coverage zone by each sensor is a 120-degree cone with the apex being the sensor element. An external sensivity adjustment (requiring a slot screwdriver) sets the sensor electronics sensitivity. Numerals 0 through 5 provide a range of 75 to 25 counts per second with position 4 (35 counts/sec) being the normal setting. The shielded background sensor provides protection against false alarms due to high energy particles in the South Atlantic Anomaly.

2.8.4.6 CAUTION AND WARNING UNIT

The caution and warning unit (CWU), coldplate mounted on electronics module 5, contains the controls and driver electronics for the caution, warning and emergency condition indicators. (audio and visual) The CWU is subdivided into C&W subunits 1 and 2 and emergency subunits 1 and 2 (figures 2.8.4-3 through -6).
4).

C&W Subunits 1 and 2
- Each subunit contains:
  - o +28 vdc control power
  - o +28 vdc indicator power
  - o +5 vdc logic and indicator power
  - o -5 vdc indicator power
  - o (3) +28 vdc outputs to the CWU self-monitor detectors
- Indicator Control Logic
  - o Controls caution and warning tone generators and the lamp and relay drivers
  - o Contains memory - 1 cell per each caution and warning condition status light on panel 207
  - o Uses +5 vdc logic power for operation
- Caution Tone Generator
  - o Uses +28 vdc indicator power
  - o Generates 1 kHz square wave
- Warning tone generator
  - o Uses +28 vdc indicator power
  - o Generates 1 kHz interrupted square wave (350 ms on and 350 ms off)
- Power amplifier
  - o Amplifies caution and warning tone generator output signals
  - o Uses +5 vdc logic power and -5 vdc indicator power




* C&W STATUS LIGHTS (PNL 207 AND 616)
MASTER ALARM LIGHTS (PNL 206 AND 616)
MEMORY CLEAR LIGHT (PNL 206)

NOTE:
C1 & C2 ARE ELECTRICALLY ISOLATED FROM EACH OTHER & STRUCTURE.

Figure 2.8.4-3 C&W Subunits 1 & 2

8221

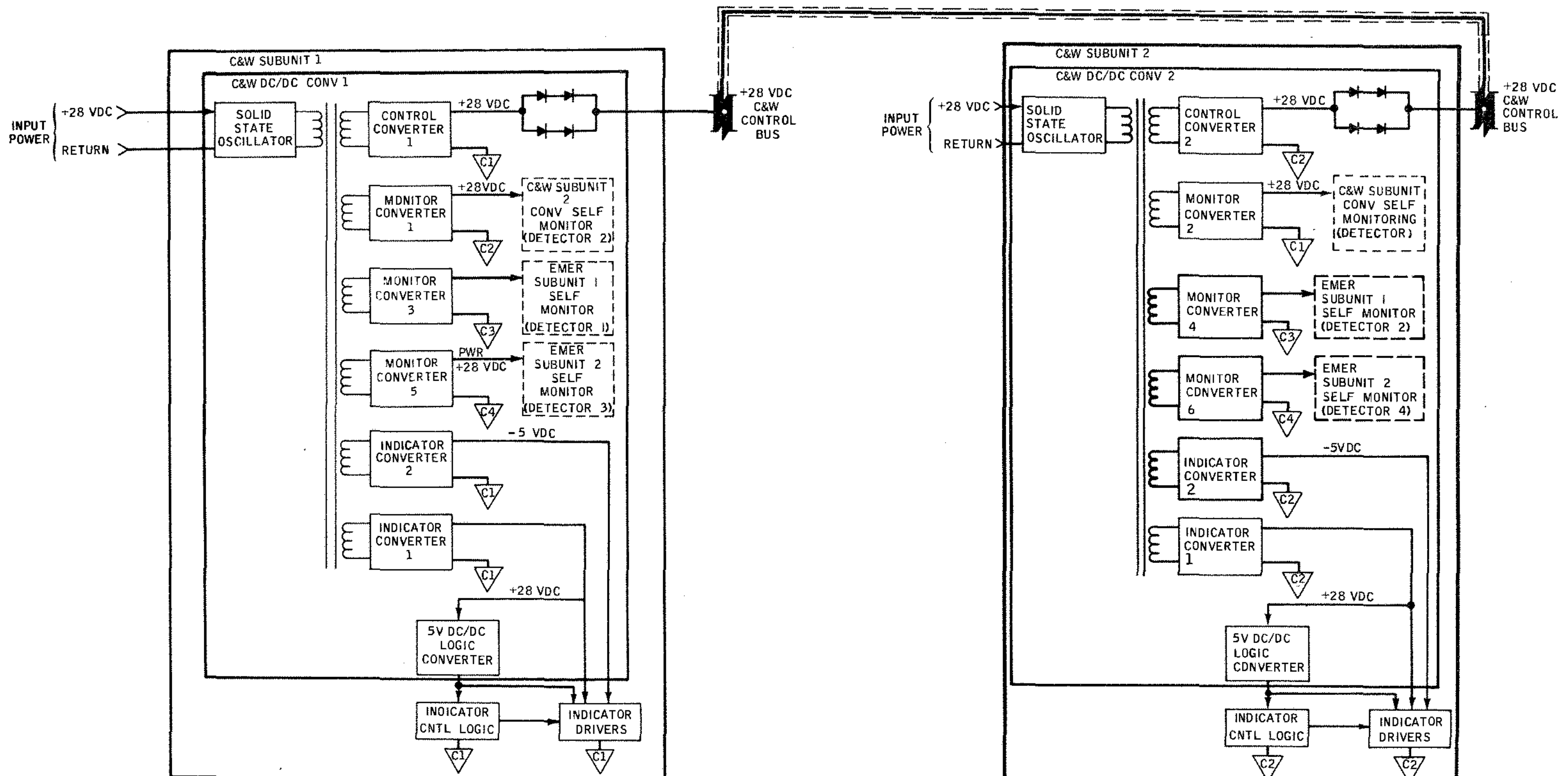
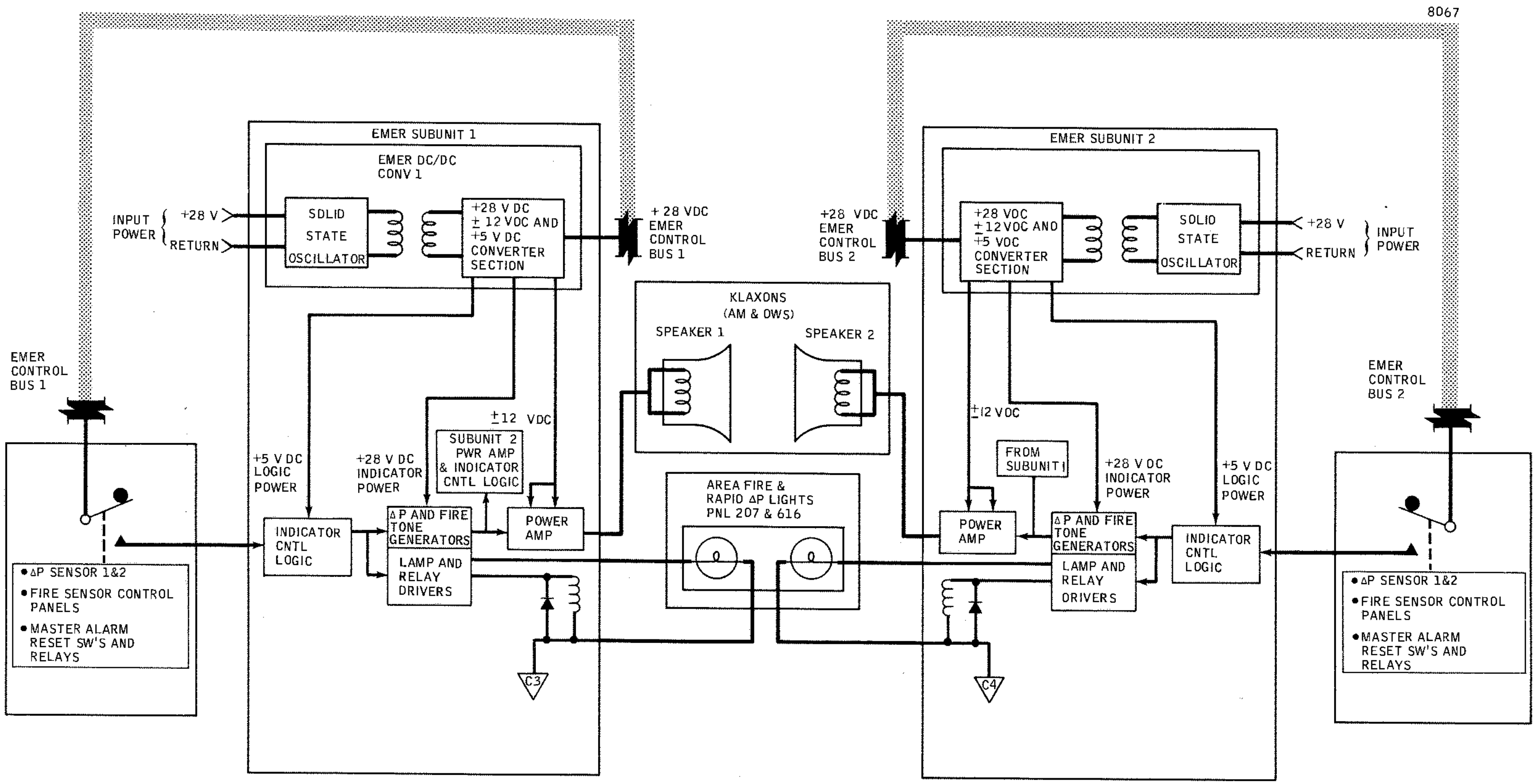


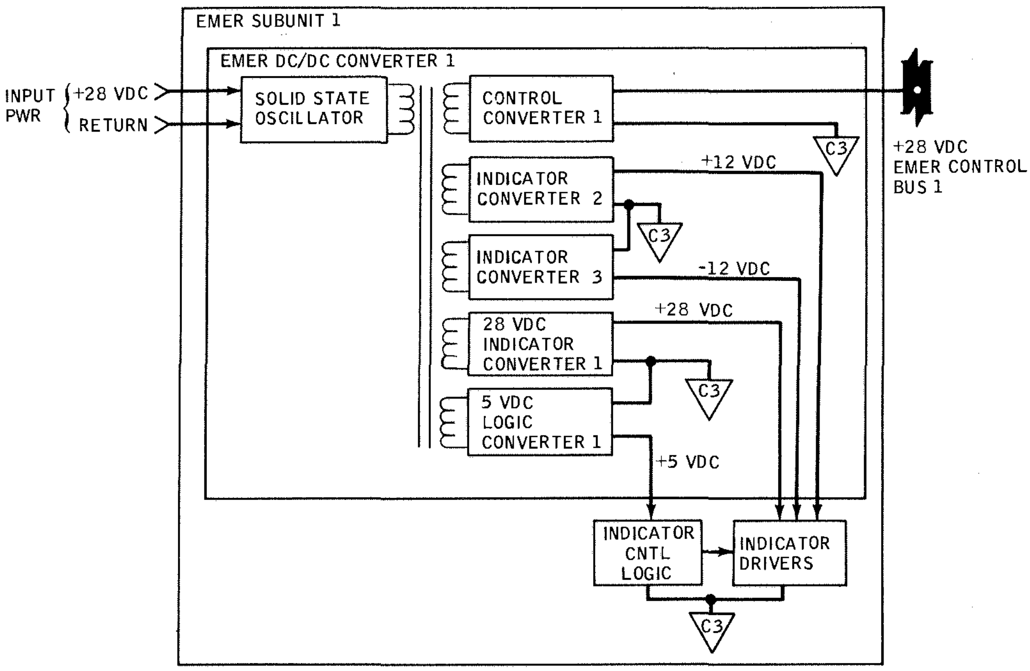

Figure 2.8.4-4 C&W Subunits DC/DC Converters




NOTE:
C3 & C4 ARE ELECTRICALLY ISOLATED FROM EACH OTHER & STRUCTURE.

Figure 2.8.4-5 Emergency Subunits 1 & 2

8223



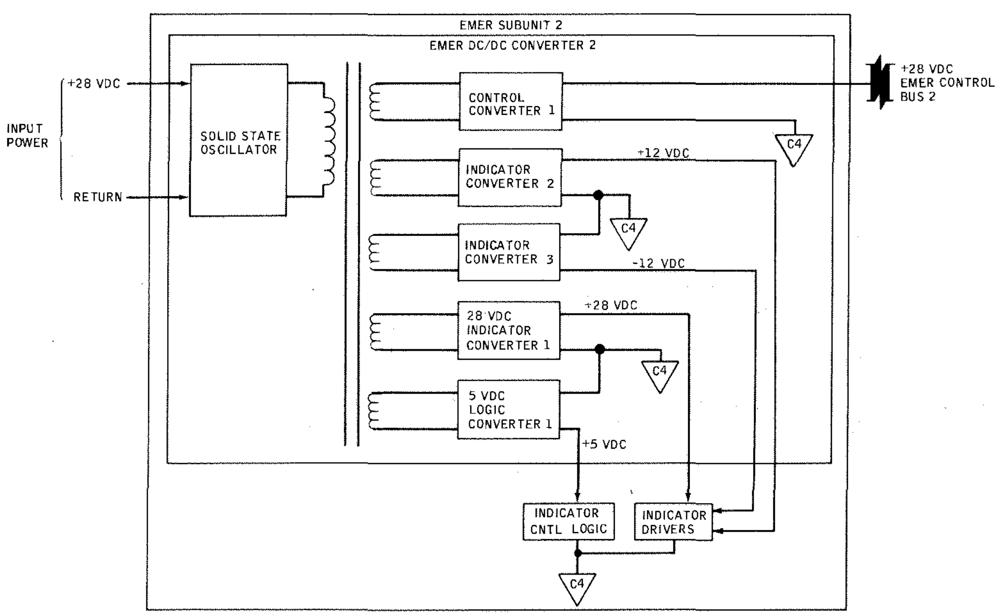




Figure 2.8.4-6 Emergency Subunits DC/DC Converters

Lamp and relay drivers
- o Provides +28 vdc indicator power to lamps on panels 206, 207 and 616, and relay driver power to internal relays, and relays in the C&W relay module

Three self-monitor detectors
- o One detector for the C&W subunit +5 vdc logic power and +28 vdc control power. C&W subunit 1 (2) detector is powered by +28 vdc monitor power from C&W subunit 2 (1).
- o Two detectors - One for each emergency subunit +5 vdc logic power and +28 vdc control power. Each C&W subunit monitors both emergency subunits 1 and 2.

NOTE: Each C&W subunit self-monitor detector applies a continuous MASTER ALARM reset and memory clear upon detection of an out-of-limit condition of either the +5 vdc logic or +28 vdc control power within that subunit. The emergency subunit self-monitor detector applies a continuous MASTER ALARM reset to that subunit upon detection of an out-of-limit condition of either the +5 vdc logic or +28 vdc indicator power. In essense, these reset and clear signals prohibit the malfunctioning subunit from initiating false alarms.

Automatic system reset circuit
- o Performs master alarm reset and memory clear within the respective C&W subunit approximately 150 ms after power turn-on

Emergency Subunits 1 and 2

Each subunit contains:

DC/DC converter, which supplies
- o +28 vdc control power
- o +28 vdc indicator power
- o $\pm$12 vdc indicator power
- o $\mp$5 vdc logic power

Indicator control logic
- o Controls $\Delta$P and fire tone generators and the lamp and relay drivers
- o Uses +5 vdc logic power for operation

$\Delta$P tone generation
- o Uses +28 vdc indicator power
- o Generates 2.5 kHz modulated with 270 Hz (buzzer tone)

Fire tone generator
- o Uses +28 vdc indicator power
- o Generates 666.6 Hz to 1470 Hz to 666.6 Hz (siren tone)

Power amplifier
- o Uses $\pm$12 vdc indicator power
- o Amplifies signal output by $\Delta$P and fire tone generators for driving the klaxons

Lamp and relay drivers
- o Provides +28 vdc to fire and rapid $\Delta$P indicators on panels 207 and 616 and internal relays

Automatic system reset circuit
- o Performs master alarm reset within emergency subunits 1 and 2 approximately 150 ms after power turn-on

2.8.4.7 C&W HIGH-LEVEL AUDIO AMPLIFIER

The C&W high-level audio amplifier, cold plate mounted on electronic module 5, is a power amplifier, used to amplify the caution and warning low-level tones (figure 2.8.3-2). The amplified tones are used for direct driving of the speaker in each intercom box. Two amplifiers are contained in one housing, one receiving +28 vdc power from EPS control bus 1 and C&W audio signals from C&W subunit 1 and the other receiving +28 vdc power from EPS control bus 2 and C&W audio signals from C&W subunit 2. Outputs from each amplifier are transformer-coupled to produce a single high-level signal for distribution to the 13 INTERCOMS.

2.8.4.8 C&W RELAY MODULE

The C&W relay module, mounted on electronic module 5, contains relays used for control of the C&W system, and some C&W related functions controlled by other SWS systems.

2.8.4.9 KLAXON (2 UNITS)

Each klaxon consists of two speakers mounted in a protective housing (figure 2.8.3-2). Speaker number 1 in each unit is driven by emergency subunit 1, and speaker 2 is driven by emergency subunit 2.

2.8.5 FAILURE MODES

| FAILURE | INDICATION | VEHICLE CAPABILITY |
|---|---|---|
| C&W Signal Conditioning Display Converter PRI (SEC) | C&W POWER lt (panel 207) and caution tone and possible parameter false alarms. | Possible loss of all C&W subsystem 1 (2) detectors powered by C&W signal conditioning display converter PRI (SEC). |
| Rapid $\Delta$P Sensor 1 (2) | Possibly none, depending on failure mode-may be detected during periodic testing. | Loss of redundant rapid $\Delta$P monitoring. |
| UV Fire Sensor | Possibly none, depending on failure mode-may be detected during periodic testing. | Loss of fire monitoring in the area covered by failed sensor until replaced. |
| Fire Sensor Control Panel | Possibly none, depending on failure mode-would be detected during periodic testing. | Depending on failure - possible loss of UV fire sensor controlled by failed circuitry until replaced. |
| Fire Sensor Lamp Assembly | None - would be detected during periodic testing. | Loss of respective UV fire sensor ID in case of a fire alarm until replaced. |
| Single C&W Indicator Lamp Bulb Panel 206, 207, 616 | None - would be detected during periodic testing. | Not replaceable - loss of redundancy in the respective visual indicator. |
| Single Klaxon Speaker (OWS or AM Klaxon) | None - would be detected during periodic testing. | Not replaceable - loss of 3 DB in the emergency tone volume from that klaxon. |
| C&W High-Level Audio Amplifier (One of Redundant Internal Amps) | None - would not be detected during periodic testing. | Not replaceable - loss of <u>TBS</u> DB in caution and warning tones. |
| C&W Subunit 1 (2) +28 vdc Control Power | C&W power lt (panel 207) and caution tone M312 (M313) 24 vdc. | Loss of redundant caution and warning condition monitoring. |
| C&W Subunit 1 (2) +5 vdc Logic Power | C&W Power lt (panel 207) and caution tone M310 (311) 4 vdc.<br><br>If M310 (311) = 0 vdc, all caution and warning condition lts (panel 207 and 616) on. | Loss of redundant caution and warning condition monitoring. |
| Emergency Subunit 1 (2) +28 vdc Control Power | EMER POWER lt (panel 207) and caution tone. M308 (M309) 24 vdc. | Loss of redundant fire and rapid $\Delta$P sensor monitoring. |
| Emergency Subunit 1 (2) +5 vdc Logic Power | EMER POWER lt (panel 207) and caution tone. M306 (M307) 4 vdc.<br><br>If M306 (M307) = 0 vdc, all area fire lts and rapid $\Delta$P lts ON (panels 207 and 616). Fire tone on @ low frequency and $\Delta$P tone on. | Loss of redundant fire and rapid $\Delta$P sensor monitoring. |
| <u>C&W Detectors</u> (not redundant) | | |
| CONDENSATE TANK $\Delta$P detector | Possibly none. | Loss of condensate tank $\Delta$P monitoring by C&W system. |
| SIEVE A or B Gas Flow Detector | Possibly none. | Loss of mol sieve A or B gas flow monitoring by C&W system. |
| OWS Gas Interchange Gas Flow Detector | Possibly none. | Loss of OWS gas interchange gas flow monitoring by C&W system. |

NOTE: ALL OTHER C&W detectors are redundant

2.8.6 PERFORMANCE AND DESIGN DATA

UV Fire Sensor Assembly
- o Input Voltage . . . . . . . . . . . . . . . . . . . . . . . . 18 to 33 vdc
- o Input Power . . . . . . . . . . . . . . . . . . . . . . . . 3.6 watts standby, 6 watts active
- o UV Spectrum Sensitivity . . . . . . . . . . . . . . . . . . 1850 to 2650A°
- o Response to Test. . . . . . . . . . . . . . . . . . . . . . Appx 1 sec
- o Size . . . . . . . . . . . . . . . . . . . . . . . . . . . 5.3 x 5 x 3.15 inch
- o Weight . . . . . . . . . . . . . . . . . . . . . . . . . . 5.8 lbs

Rapid$\Delta$P Sensors
- o Input Voltage . . . . . . . . . . . . . . . . . . . . . . . . 18 to 34 vdc
- o Input Power . . . . . . . . . . . . . . . . . . . . . . . . 4 watts (max) standby, 5.6 watts (max) active
- o Outputs . . . . . . . . . . . . . . . . . . . . . . . . . . 0 to 8 psia $\pm$ 2% to TM<br>0.00 to -1.5 psia/min $\pm$ 5% to TM
  - o Relay Closure to Emergency Subunits @-0.1 psia/min +0.01, -0.00 psia/min
- o Self Test
  - o Sensor triggers 8 to 10 sec after test signal applied
  - o Test signal duration 30 to 35 sec maximum
  - o Test Recovery time 30 sec
- o Size . . . . . . . . . . . . . . . . . . . . . . . . . . . Approximately 1 3/4 x 6 inches
- o Weight . . . . . . . . . . . . . . . . . . . . . . . . . . Approximately 2 lbs

C&W Signal Conditioning Display Converters
- o Input Voltage . . . . . . . . . . . . . . . . . . . . . . . . 18 to 34 vdc
- o Outputs . . . . . . . . . . . . . . . . . . . . . . . . . . $\pm$24 vdc $\pm$ 1.25%<br>$\pm$5 vdc $\pm$ 1.0% output
- o Size . . . . . . . . . . . . . . . . . . . . . . . . . . . Approximately 2x2 3/4x6 inches
- o Weight . . . . . . . . . . . . . . . . . . . . . . . . . . 2 lbs

C&W High Level Audio Amplifier
- o Input Voltage . . . . . . . . . . . . . . . . . . . . . . . . 22 to 30 vdc
- o Input power . . . . . . . . . . . . . . . . . . . . . . . . 10 watts standby (max), 100 watts active (max)
- o Input Signal . . . . . . . . . . . . . . . . . . . . . . . . 0.16 to 1.6 VRMS
- o Gain . . . . . . . . . . . . . . . . . . . . . . . . . . . 8 $\pm$ 10%
- o Output Limited . . . . . . . . . . . . . . . . . . . . . . . 32 $\pm$ 1, 2 VPP
- o Dimension . . . . . . . . . . . . . . . . . . . . . . . . . 5.03 x 9.03 x 7.22 inches
- o Weight . . . . . . . . . . . . . . . . . . . . . . . . . . 12 lbs

Klaxon
- o 2 Speakers/Unit
  - o Input Impedance . . . . . . . . . . . . . . . . . . . . . . 16 OHMS/speaker
  - o Frequency Response . . . . . . . . . . . . . . . . . . . . $\pm$ 8 db from 300 to 3000 Hz
  - o Output . . . . . . . . . . . . . . . . . . . . . . . . . . 95 db at 3 watts rms and 1000 Hz input<br>(Referenced to 0.002 dynes/cm2)

Caution and Warning Unit
- o Input Voltage . . . . . . . . . . . . . . . . . . . . . . . . 22 to 30 vdc
  - o Maximum Power . . . . . . . . . . . . . . . . . . . . . . 320 watts
  - o Average Power . . . . . . . . . . . . . . . . . . . . . . 100 watts
- o Response Time to Control (or malfunction) Input Signals . . . 20 ms
- o Tone Generator Outputs
  - o Voltage
    - o Emergency Adjustable . . . . . . . . . . . . . . . . . . . 2.1 to 7.35 VRMS
    - o Caution (Warning) Adjustable . . . . . . . . . . . . . . . 0.16 to 1.6 VRMS
  - o Frequency
    - o Fire . . . . . . . . . . . . . . . . . . . . . . . . . . 666.6 Hz to 1470 Hz to 666.6 Hz over 5 second period (SIREN)
    - o $\Delta$P . . . . . . . . . . . . . . . . . . . . . . . . . 270 Hz using 2.5 kHz components for 2.1 ms on and 1.6 ms off - Duty Cycle 215 ms on and 70 ms off (BUZZER)
    - o Caution . . . . . . . . . . . . . . . . . . . . . . . . . 1 kHz - continuous
    - o Warning . . . . . . . . . . . . . . . . . . . . . . . . . Interrupted 1 kHz - 350 ms on and 350 ms off
- o Lamp and Relay Drivers
  - o Output Voltage . . . . . . . . . . . . . . . . . . . . . . 28 $\pm$ 2 vdc
- o DC/DC Converters
  - o Control Converters (4) . . . . . . . . . . . . . . . . . . . 28 $\pm$ 2.0 vdc
  - o Logic Pwr Converter (4) . . . . . . . . . . . . . . . . . . 5 $\pm$ 0.5 vdc
- o TM Outputs
  - o DC/DC Converter Voltage Monitors (8) . . . . . . . . . . . . 0 to 20 MV
  - o Discretes . . . . . . . . . . . . . . . . . . . . . . . . . contact closure

## 2.8.7 OPERATIONAL LIMITATIONS AND RESTRICTIONS

There are no actual operational limitations and constraints in the C&W system; however, alarms will be triggered if power on/off, and inhibit switch operation is performed without regard to sequence.

The inhibit switches (panel 207) should be placed in the inhibit position until TBS seconds after completion of C&W and emergency subsystem power turn-on, to prevent erroneous alarms because of system sequential turn-on and warmup characteristics.

Alarms triggered as a result of operational activities

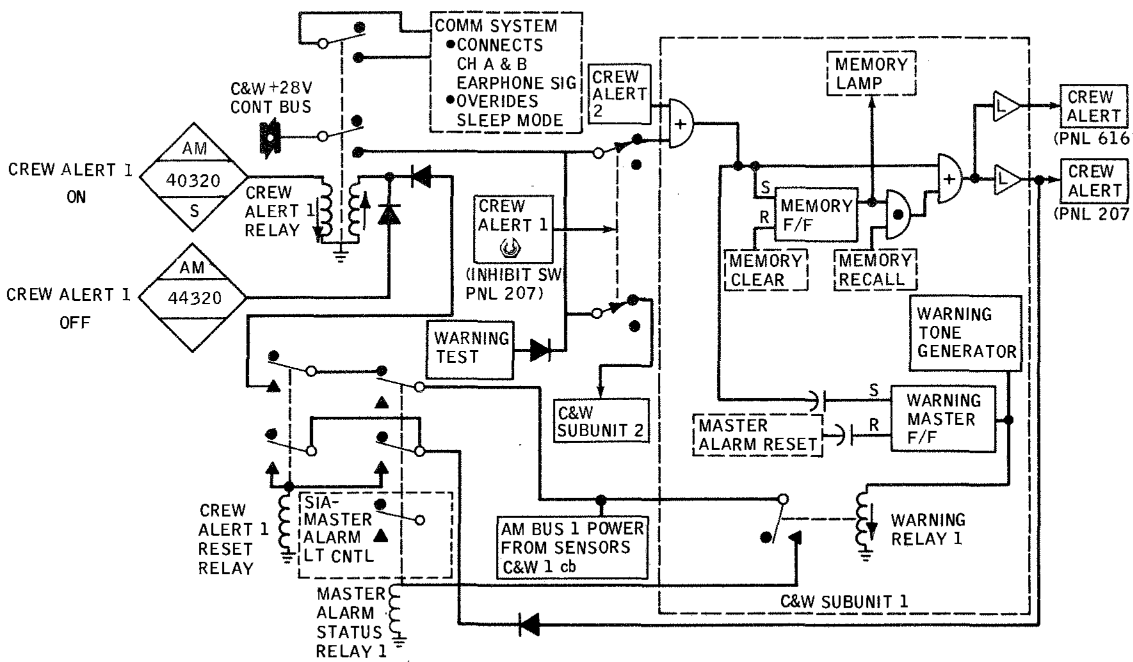
- o PRI (or SEC) COOL FLOW (WARNING)
  Triggered when PRI (SEC) PUMP A, B, or C is activated (panel 203)
- o SIEVE FLOW (CAUTION)
  Triggered when either SIEVE A or B FAN POWER is turned ON (panel 203)
- o OWS GAS INTERCHG (CAUTION)
  Triggered when AM FANS DUCT (panel 203) is turned on to high speed, or continuous if in low speed
- o CNDST TANK $\Delta$P (CAUTION)
  Triggered during initial activation of the C&W subsystem on SL-2, 3, and 4, and during condensate tank dump
- o EVA 1 (WARNING)
  Triggered upon turn-on of LCG PUMP PRI or SEC (panel 317)
- o EVA 2 (WARNING)
  Triggered upon turn-on of LCG PUMP PRI or SEC (panel 323)
- o RAPID $\Delta$P
  - (1) Triggered upon repressurization of the lock compartment after an EVA activity
  - (2) Triggered upon EMER POWER 1 and/or 2 turn on (panel 206) unless the $\Delta$P 1 and $\Delta$P 2 inhibit switches (panel 207) are in the inhibit position. Requires 30 seconds for stabilization after emergency power turn-on
  - (3) The $\Delta$P sensors require 30 seconds for recovery after performing either a $\Delta$P 1 or $\Delta$P 2 test (panel 206). If a $\Delta$P 1 (2) test has been performed, 30 seconds must elapse prior to performing another $\Delta$P test. If the test switch is returned to OFF after a MASTER ALARM reset, and 30 to 35 seconds after application of a test the sensors will again trigger the $\Delta$P indicators.
- o EMER POWER (CAUTION)
  Triggered during a $\Delta$P or FIRE test from panel 206
  Triggered when C&W power is turned on prior to EMER 1 and 2 power (panel 206) if EMER POWER 1 and 2 inhibit switches are enabled
- o C&W POWER (CAUTION)
  Triggered during a warning test from panel 206
- o EMER SENSOR POWER (CAUTION)
  Triggered when C&W power is turned on prior to EMER 1 and 2 power (pnl 206) if EMER SENSOR power 1 and 2 inhibit switches are enabled.
- o CREW ALERT (WARNING)
  The MSFN-commanded AM "CREW ALERT" is a warning condition and can be initiated by a ground-commanded crew alert 1 and/or 2 (figure 2.8.7-1). Performing a master alarm reset from panels 206 or 616 or a fire sensor control panel initiates a reset command to crew alert relays 1 and 2, thereby removing the crew alert function. Memory recall would be required to ascertain that a crew alert had been initiated if not determined prior to performing a master alarm reset.

## 2.8.8 INSTRUMENTATION AND GROUND COMMANDS

| MEASUREMENT NUMBER | DESCRIPTION | TELEMETRY RANGE |
|---|---|---|
| D252-505 | OA PRESS DECAY RATE - $\Delta$P SENSOR 1 | 0.0 to 1.5 psia/min |
| D253-505 | OA PRESS DECAY RATE - $\Delta$P SENSOR 2 | 0.0 to 1.5 psia/min |
| D254-505 | OA PRESS - (FROM $\Delta$P SENSOR 1) | 0 to 8 psia |
| D255-505 | OA PRESS - (FROM $\Delta$P SENSOR 2) | 0 to 8 psia |
| K367-509 | EMER FIRE CLOSURE 1 | ONE=FIRE |
| K368-509 | EMER $\Delta$P CLOSURE 1 | ONE=RAPID $\Delta$P |
| K376-509 | EMER FIRE CLOSURE 2 | ONE=FIRE |
| K377-509 | EMER $\Delta$P CLOSURE 2 | ONE=RAPID $\Delta$P |
| M306-509 | CWU-EMER 5 V CONV 1 | 0 to 5 vdc |
| M307-509 | CWU-EMER 5 V CONV 2 | 0 to 5 vdc |
| M308-509 | CWU-EMER 28 V CONV 1 | 0 to 28 vdc |
| M309-509 | CWU-EMER 28 V CONV 2 | 0 to 28 vdc |
| K360-509 | C&W WARNING CLOSURE 1 | ONE=WARNING |
| K369-509 | C&W CAUTION CLOSURE 1 | ONE=CAUTION |
| K375-509 | C&W WARNING CLOSURE 2 | ONE=WARNING |
| K378-509 | C&W CAUTION CLOSURE 2 | ONE=CAUTION |
| M310-509 | CWU-C&W 5V CONV 1 | 0 to 5 vdc |
| M311-509 | CWU-C&W 5V CONV 2 | 0 to 5 vdc |
| M312-509 | CWU-C&W 28 V CONV 1 | 0 to 28 vdc |
| M313-509 | CWU-C&W 28 V CONV 2 | 0 to 28 vdc |

## CREW ALERT 1

8222




## CREW ALERT 2

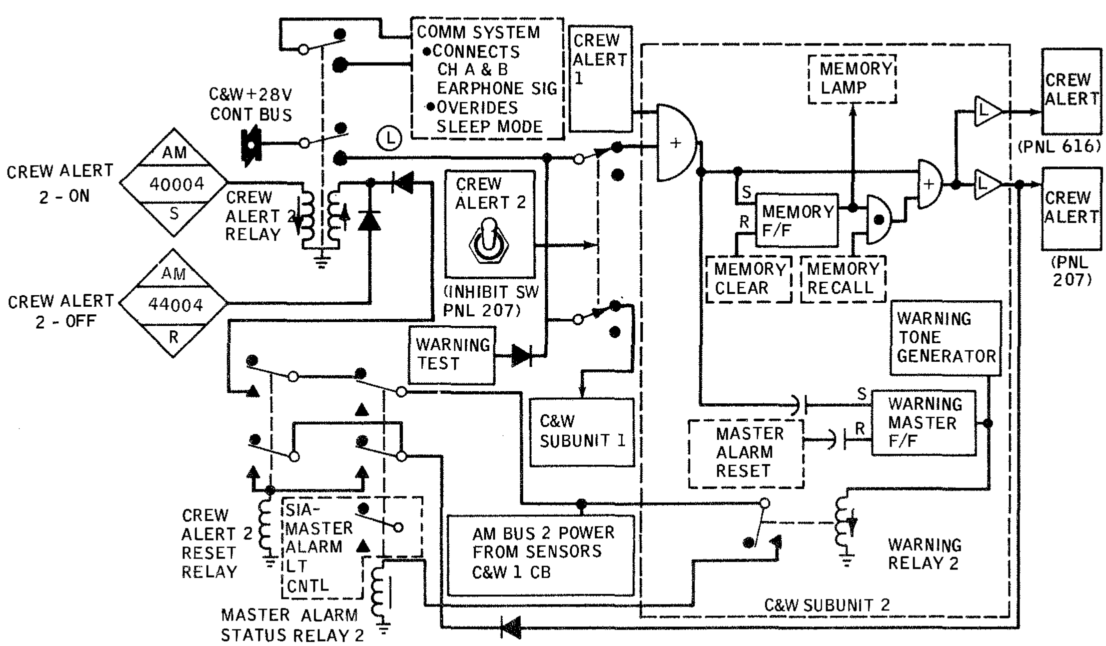



Figure 2.8.7-1 Crew Alert

GROUND COMMANDS

| CMD NO. | TITLE | ASSOCIATED TM MEAS |
|---|---|---|
| 44320 | CREW ALERT 1 - OFF | |
| 40320 | CREW ALERT 1 - ON | K360-509 and K375-509 |
| 44004 | CREW ALERT 2 - OFF | |
| 40004 | CREW ALERT 2 - ON | K360-509 and K375-509<br>K301 to K311<br>(CRDU Measurements) |

2.8.9 CAUTION/WARNING AND EMERGENCY PARAMETER SUMMARY

(See figures 2.8.9-1 and -2.)

8083 -1

| C & W DISPLAY TITLE (PNL 207 &616) | C & W INHIBIT SWITCH TITLE (PNL 207) | C&W DETECTORS | C & W SENSOR PWR $V_{C\&W}$ 1+24 | C & W SENSOR PWR $V_{C\&W}$ 1-24 | C & W SENSOR PWR $V_{C\&W}$ 1+5 | C & W SENSOR PWR $V_{C\&W}$ 2+24 | C & W SENSOR PWR $V_{C\&W}$ 2-24 | C & W SENSOR PWR $V_{C\&W}$ 2+5 | C & W SENSOR PWR $V_{ECS1}$ | C & W SENSOR PWR $V_{ECS2}$ | C&W DETECTION MODULE POWER $V_{C\&W}$ 1+24 | C&W DETECTION MODULE POWER $V_{C\&W}$ 1-24 | C&W DETECTION MODULE POWER $V_{C\&W}$ 1+5 | C&W DETECTION MODULE POWER $V_{C\&W}$ 2+24 | C&W DETECTION MODULE POWER $V_{C\&W}$ 2-24 | C&W DETECTION MODULE POWER $V_{C\&W}$ 2+5 | C&W DETECTION MODULE POWER $V_{C\&W}$ 1+28 | C&W DETECTION MODULE POWER $V_{C\&W}$ 2+28 | NOMINAL RANGE | TRIGGER LIMITS | CORRESPONDING INDICATORS (R) TM SENSOR REDUNDANT TO C&W (S) M SENSOR SAME AS TM: TM MEASURE-MENTS | CORRESPONDING INDICATORS: ON DISPLAY BOARDS | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EMERG SENSOR POWER (CAUTION) | EMERG SENSOR 1 | DETECTOR 1 | | | | | | | | | X | X | | | | | X | | 26 TO 30 VDC | V ≤ 25 ± 0.5 VDC | NONE | NONE | DETECTORS ACTIVE WHEN C&W SUBSYSTEM ENABLED |
| | | DETECTOR 2 | | | | | | | | | | | | X | X | | | X | | | | | |
| | EMERG SENSOR 2 | DETECTOR 1 | | | | | | | | | X | X | | | | | X | | 26 TO 30 VDC | V ≤ 25 ± 0.5 VDC | NONE | NONE | |
| | | DETECTOR 2 | | | | | | | | | | | | X | X | | | X | | | | | |
| EMERG POWER (CAUTION) | EMERG POWER 1 | SEE REMARKS | | | | | | | | | | | | | | | | | 26 TO 30 VDC<br>4.8 TO 5.8 VDC | V ≤ 24 ± 1.0 VDC<br>V ≤ 4 ∓ 0.3 VDC | M308 (R)<br>M306(R) | NONE | DETECTORS LOCATED INTERNALLY TO THE CAUTION AND WARNING UNIT AND ARE ACTIVE WHEN C&W SUBSYSTEM IS ENABLED |
| | EMERG POWER 2 | SEE REMARKS | | | | | | | | | | | | | | | | | 26 TO 30 VDC<br>4.8 TO 5.8 VDC | V ≤ 24 ± 1.0 VDC<br>V ≤ 4 ∓ 0.3 VDC | M309 (R)<br>M307 (R) | NONE | |
| C&W POWER (CAUTION) | C&W POWER 1 | SEE REMARKS | | | | | | | | | | | | | | | | | 26 TO 30 VDC<br>4.8 TO 5.2 VDC | V ≤ 24 ± 1.0 VDC<br>V ≤ 4 ∓ 0.3 VDC | M312(R)<br>M310 (R) | NONE | C&W DC/DC CONVERTER 1 AND 2 DETECTORS LOCATED INTERNAL TO THE CAUTION AND WARNING UNIT |
| | C&W POWER 2 | SEE REMARKS | | | | | | | | | | | | | | | | | 26 TO 30 VDC<br>4.8 TO 5.2 VDC | V ≤ 24 ± 1.0 VDC<br>V ≤ 4 ∓ 0.3 VDC | M313 (R)<br>M311(R) | NONE | |
| | C&W SIG COND | SEE REMARKS | | | | | | | | | | | | | | | | X | +24 ± .3 VDC<br>-24 ∓ .3 VDC<br>+ 5 ∓ .075 VDC | 26 ≤ V ≤ 22 VDC<br>-26 ≥ V ≥ -22 VDC<br>4.8 ≥ V ≥ 5.2 VDC | NONE | NONE | C&W SIGNAL COND DISPLAY CONV DETECTORS LOCATED INTERNAL TO THE C&W DETECTOR MODULES<br>DETECTORS ARE ACTIVE WHEN C&W SUBSYSTEM IS ENABLED |
| | | SEE REMARKS | | | | | | | | | | | | | | | X | | | | | | |
| REG BUS 1 HIGH (WARNING) | REG BUS 1 HIGH | DETECTOR 1 | | | | | | | | | X | X | | | | | X | | 26 TO 30 VDC | V ≥ 31.0 ± .62 VDC | M161 (R) | METER (R) PNL 206 | DETECTORS ACTIVE WHEN C&W SUBSYSTEM ENABLED |
| | | DETECTOR 2 | | | | | | | | | | | | X | X | | | X | | | | | |
| REG BUS 2 HIGH (WARNING) | REG BUS 2 HIGH | DETECTOR 1 | | | | | | | | | X | X | | | | | X | | 26 TO 30 VDC | V ≥ 31.0 ± .62 VDC | M162 (R) | METER (R) PNL 206 | DETECTORS ACTIVE WHEN C&W SUBSYSTEM ENABLED |
| | | DETECTOR 2 | | | | | | | | | | | | X | X | | | X | | | | | |
| BAT CHARGE LOW (CAUTION) | BATTERY CHARGE LOW 1 | DETECTOR 1 | | | | | | | | | X | X | | | | | X | | SOC > 30% (SEE REMARKS) | SOC ≤ 30% | M117 - PRI<br>M125 - SEC | METER (S) PNL 206 | THE SELECTED PRIMARY OR SECONDARY AMP HOUR INTEGRATOR PROVIDES A DISCRETE 10 VDC SIGNAL TO C&W DETECTOR AT SOC ≤ 30% THE PRIMARY OR SECONDARY AH INTEGRATOR IS SELECTABLE BY EITHER MANUAL OR DCS CMD.<br>DETECTORS ACTIVE WHEN C&W SUBSYSTEM ENABLED.<br>NOMINAL SOC IS A FUNCTION OF MISSION TIME. REF AM BATTERY SOC VS MISSION TIME CURVES. |
| | | DETECTOR 2 | | | | | | | | | | | | X | X | | | X | | | | | |
| | BATTERY CHARGE LOW 2 | DETECTOR 1 | | | | | | | | | X | X | | | | | X | | SOC > 30% (SEE REMARKS) | SOC ≤ 30% | M118 - PRI<br>M126 - SEC | METER (S) PNL 206 | |
| | | DETECTOR 2 | | | | | | | | | | | | X | X | | | X | | | | | |
| | BATTERY CHARGE LOW 3 | DETECTOR 1 | | | | | | | | | X | X | | | | | X | | SOC > 30% (SEE REMARKS) | SOC ≤ 30% | M119 - PRI<br>M127 - SEC | METER (S) PNL 206 | |
| | | DETECTOR 2 | | | | | | | | | | | | X | X | | | X | | | | | |
| | BATTERY CHARGE LOW 4 | DETECTOR 1 | | | | | | | | | X | X | | | | | X | | SOC > 30% (SEE REMARKS) | SOC ≤ 30% | M120 - PRI<br>M128 - SEC | METER (S) PNL 206 | |
| | | DETECTOR 2 | | | | | | | | | | | | X | X | | | X | | | | | |
| | BATTERY CHARGE LOW 5 | DETECTOR 1 | | | | | | | | | X | X | | | | | X | | SOC > 30% (SEE REMARKS) | SOC ≤ 30% | M121 - PRI<br>M129 - SEC | METER (S) PNL 206 | |
| | | DETECTOR 2 | | | | | | | | | | | | X | X | | | X | | | | | |
| | BATTERY CHARGE LOW 6 | DETECTOR 1 | | | | | | | | | X | X | | | | | X | | SOC > 30% (SEE REMARKS) | SOC ≤ 30% | M122 - PRI<br>M130 - SEC | METER (S) PNL 206 | |
| | | DETECTOR 2 | | | | | | | | | | | | X | X | | | X | | | | | |
| | BATTERY CHARGE LOW 7 | DETECTOR 1 | | | | | | | | | X | X | | | | | X | | SOC > 30% (SEE REMARKS) | SOC ≤ 30% | M123 - PRI<br>M131 - SEC | METER (S) PNL 206 | |
| | | DETECTOR 2 | | | | | | | | | | | | X | X | | | X | | | | | |
| | BATTERY CHARGE LOW 8 | DETECTOR 1 | | | | | | | | | X | X | | | | | X | | SOC > 30% (SEE REMARKS) | SOC ≤ 30% | M124 - PRI<br>M132 - SEC | METER (S) PNL 206 | |
| | | DETECTOR 2 | | | | | | | | | | | | X | X | | | X | | | | | |

Figure 2.8.9-1 C&W Parameters (Sheet 1)

8083-2

| C&W DISPLAY PANEL (PNL 207 & *616) | C&W INHIBIT SWITCH TITLE (PNL 207) | C&W DETECTORS | C&W SENSOR PWR | | | | | | | | C&W DETECTION MODULE POWER | | | | | | | | NOMINAL RANGE | TRIGGER LIMITS | CORRESPONDING INDICATORS (R) TM SENSOR REDUNDANT TO C&W (S) M SENSOR SAME AS TM | | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | $V_{C\&W}$ 1+24 | $V_{C\&W}$ 1-24 | $V_{C\&W}$ 1+5 | $V_{C\&W}$ 2+24 | $V_{C\&W}$ 2-24 | $V_{C\&W}$ 2+5 | $V_{ECS\,1}$ | $V_{ECS\,2}$ | $V_{C\&W}$ 1+24 | $V_{C\&W}$ 1-24 | $V_{C\&W}$ 1+5 | $V_{C\&W}$ 2+24 | $V_{C\&W}$ 2-24 | $V_{C\&W}$ 2+5 | $V_{C\&W}$ 1+28 | $V_{C\&W}$ 2+28 | | | TM MEASURE-MENTS | ON BOARD DISPLAYS | |
| REG BUS 1 LOW (WARNING) | REG BUS 1 LOW | DETECTOR 1 | | | | | | | | | X | X | | | | | X | | 26 TO 30 VDC | $V \leq 25 \pm 0.5$ VDC | M161 (R) | METER PNL 206 | DETECTORS ACTIVE WHEN C&W SUBSYSTEM ENABLED |
| | | DETECTOR 2 | | | | | | | | | | | | X | X | | | X | | | | | |
| REG BUS 2 LOW (WARNING) | REG BUS 2 LOW | DETECTOR 1 | | | | | | | | | X | X | | | | | X | | 26 TO 30 VDC | $V \leq 25 \pm 0.5$ VDC | M162 (R) | METER PNL 206 | DETECTORS ACTIVE WHEN C&W SUBSYSTEM ENABLED |
| | | DETECTOR 2 | | | | | | | | | | | | X | X | | | X | | | | | |
| * OWS BUS 1 LOW (CAUTION) | OWS BUS 1 LOW | DETECTOR 1 | | | | | | | | | X | X | | | | | X | | 25 TO 30 VDC | $V \leq 23.5 \pm .47$ VDC | M7002 (R) | METER PNL 617 | DETECTORS ACTIVE WHEN C&W SUBSYSTEM ENABLED. C&W LOW VOLTAGE SENSE 1 CB (PNL 613) & C&W LOW VOLTAGE SENSE 2 CB (PNL 613) PROVIDES MEASUREMENT SIGNALS. |
| | | DETECTOR 2 | | | | | | | | | | | | X | X | | | X | | | | | |
| * OWS BUS 2 LOW (CAUTION) | OWS BUS 2 LOW | DETECTOR 1 | | | | | | | | | X | X | | | | | X | | 25 TO 30 VDC | $V \leq 23.5 \pm .47$ VDC | M7003 (R) | METER PNL 617 | |
| | | DETECTOR 2 | | | | | | | | | | | | X | X | | | X | | | | | |
| SIEVE TEMP HIGH (CAUTION) | SIEVE A TEMP | DETECTOR (SEE REMARKS) | | | | | | | | | | | | | | | | | 375 TO 410°F | $T \geq 440 \pm 10$°F | NONE | METER PNL 203 | DETECTOR IS INTEGRAL TO ECS, AND IS ENABLED BY THE RESPECTIVE SIEVE A AND SIEVE B BAKEOUT HEATER SW'S (PNL 203). C&W SIGNALS AND METER SIGNALS ARE OBTAINED FROM OVERHEAT TEMP SENSOR CIRCUIT IN THE RESPECTIVE HEATER TEMP CONTROLLER. |
| | SIEVE B TEMP | DETECTOR (SEE REMARKS) | | | | | | | | | | | | | | | | | 375 TO 410°F | $T \geq 440 \pm 10$°F | NONE | METER PNL 203 | |
| PRI COOL FLOW (WARNING) | PRI COOL PUMP A | DETECTOR (REED SW) (SEE REMARKS) | | | | | | | | | | | | | | | | | 230 LBS/HR (1 PUMP) | N/A | D224(R) D222(R) | NONE | SINGLE DETECTOR (REED SWITCH) FOR EACH PUMP. REED SWITCH ACTUATED BY MECHANICAL MOVEMENT OF CHECK VLV ON RESPECTIVE PUMP OUTLET. THE RESPECTIVE C&W REED SWITCH CONTACTS ARE ARMED WHEN THE PUMP IS TURNED ON. |
| | PRI COOL PUMP B | DETECTOR (REED SW) (SEE REMARKS) | | | | | | | | | | | | | | | | | 230 LBS/HR | N/A | D224(R) D222(R) | NONE | |
| | PRI COOL PUMP C | DETECTOR (REED SW) (SEE REMARKS) | | | | | | | | | | | | | | | | | 230 LBS/HR | N/A | D224(R) D222 (R) | NONE | |
| SEC COOL FLOW (WARNING) | SEC COOL PUMP A | DETECTOR (REED SW) (SEE REMARKS) | | | | | | | | | | | | | | | | | 230 LBS/ HR | N/A | D225 (R) D223(R) | NONE | (SAME AS PRI) REMARKS |
| | SEC COOL PUMP B | DETECTORS (REED SW) (SEE REMARKS) | | | | | | | | | | | | | | | | | 230 LBS/HR | N/A | D225 (R) D223(R) | NONE | |
| | SEC COOL PUMP C | DETECTORS (REED SW) (SEE REMARKS) | | | | | | | | | | | | | | | | | 230 LBS/HR (1 PUMP) | N/A | D225 (R) D223(R) | NONE | |
| PRI COOL TEMP HIGH (CAUTION) | PRI COOL TEMP HIGH | DETECTOR 1 | | | X | | | | | | X | X | | | | | X | | 60 TO 100°F | $T \geq 120 \pm 5.8$°F | C225 (R) | NONE | DETECTORS ACTIVE WHEN C&W SUBSYSTEM IS ENABLED |
| | | DETECTOR 2 | | | | | | X | | | | | | X | X | | | X | | | | | |
| SEC COOL TEMP HIGH (CAUTION) | SEC COOL TEMP HIGH | DETECTOR 1 | | | X | | | | | | X | X | | | | | X | | 60 TO 100°F | $T \geq 120 \pm 5.8$°F | C226 (R) | NONE | DETECTORS ACTIVE WHEN C&W SUBSYSTEM IS ENABLED |
| | | DETECTOR 2 | | | | | | X | | | | | | X | X | | | X | | | | | |
| PRI COOL TEMP LOW (CAUTION) | PRI COOL TEMP LOW | DETECTOR 1 | | | X | | | | | | X | X | | | | | X | | 45 TO 49°F | $T \leq 40 \pm 2.9$°F | C209(R) C217(R) | NONE | DETECTORS ACTIVE WHEN C&W SUBSYSTEM IS ENABLED |
| | | DETECTOR 2 | | | | | | X | | | | | | X | X | | | X | | | | | |
| SEC COOL TEMP LOW (CAUTION) | SEC COOL TEMP LOW | DETECTOR 1 | | | X | | | | | | X | X | | | | | X | | 45 TO 49°F | $T \leq 40 \pm 2.9$°F | C210(R) C218(R) | NONE | DETECTORS ACTIVE WHEN C&W SUBSYSTEM IS ENABLED |
| | | DETECTOR 2 | | | | | | X | | | | | | X | X | | | X | | | | | |
| $PPO_2$ LOW (WARNING) | $PPO_2$ MONITOR | MONITOR SENSOR (SEE REMARKS) | | | | | | | | | | | | | | | X | | 171 TO 202 MMHg | $PPO_2 \leq 157.4 \pm 18.8$ MMHg | D237 D239 D240 | METER (PNL 225) (S) | TWO OF THREE $PPO_2$ SENSORS IN THE ECS SYSTEM PROVIDE $PPO_2$ SIGNALS TO C&W DETECTORS. ANY ONE OF THE THREE SENSORS CAN BE SELECTED BY THE $O_2/N_2$ CONTROLLER SW OR BY THE $O_2/N_2$ MONITOR SW (PNL 225). |
| | $PPO_2$ CONTROL | CONTROL SENSOR (SEE REMARKS) | | | | | | | | | | | | | | | | X | 171 TO 202 MMHg | $PPO_2 \leq 157.4 \pm 18.8$ MMHg | D237 D239 D240 | METER (PNL 225) (S) | |

Figure 2.8.9-1 C&W Parameters (Sheet 2)

8083-3

| C & W DISPLAY TITLE (PNL 207 &*616) | C & W INHIBIT SWITCH TITLE (PNL 207) | C&W DETECTORS | C & W SENSOR PWR $V_{C\&W1+24}$ | $V_{C\&W1-24}$ | $V_{C\&W1+5}$ | $V_{C\&W2+24}$ | $V_{C\&W2-24}$ | $V_{C\&W2+5}$ | $V_{ECS1}$ | $V_{ECS2}$ | C&W DETECTION MODULE POWER $V_{C\&W1+24}$ | $V_{C\&W1-24}$ | $V_{C\&W1+5}$ | $V_{C\&W2+24}$ | $V_{C\&W2-24}$ | $V_{C\&W2+5}$ | $V_{C\&W1+28}$ | $V_{C\&W2+28}$ | NOMINAL RANGE | TRIGGER LIMITS | CORRESPONDING INDICATORS (R) TM SENSOR REDUNDANT TO C&W (S) M SENSOR SAME AS TM: TM MEASUREMENTS | ON DISPLAY BOARDS | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SIEVE OUT $PPCO_2$ HIGH (CAUTION) | SIEVE A $PPCO_2$ | DETECTOR 1 | X | X | | | | | | | X | X | | | | | X | | 1.7 TO 3.1 MMHg | $PPCO_2 \geq 4.4 \pm 1.5$ MMHg | D210 | METER (PNL 203) (S) | 2 $PPCO_2$ SENSORS AT EACH MOL SIEVE OUTLET (A AND B) PROVIDE $PPCO_2$ MONITORING. DETECTORS (INCLUDING SENSORS) ARE ACTIVE WHEN C&W SUBSYSTEM IS ENABLED. |
| | | DETECTOR 2 | | | | X | X | | | | | | | X | X | | | X | | | | | |
| | SIEVE B $PPCO_2$ | DETECTOR 1 | X | X | | | | | | | X | X | | | | | X | | 1.7 TO 3.1 MMHg | $PPCO_2 \geq 4.4 \pm 1.5$ MMHg | D214 | METER (PNL 203) (S) | |
| | | DETECTOR 2 | | | | X | X | | | | | | | X | X | | | X | | | | | |
| SIEVE FLOW (CAUTION) | SIEVE A GAS FLOW | DETECTOR 1 (SEE REMARKS) | | | | | | | X OR | X | | | | | | | | | F ≈ 33 CFM | $F \leq 21.1 \pm 3.8$ CFM | F210 | NONE | ONE DETECTOR (FLOW SENSOR) IN EACH MOL SIEVE OUTLET PROVIDES A TRIGGER SIGNAL TO BOTH C&W SUB-UNITS. PWR IS SUPPLIED BY SIEVE A OR B FANS PWR SW (PNL 204). PRI SELECTS $V_{ECS}$ 1 AND SEC SELECTS $V_{ECS}$ 2. |
| | SIEVE B GAS FLOW | DETECTOR 1 (SEE REMARKS) | | | | | | | X OR | X | | | | | | | | | F ≈ 33 CFM | $F \leq 21.1 \pm 3.8$ CFM | F211 | NONE | |
| OWS GAS INTER CHG (CAUTION) | OWS GAS INTERCHG | DETECTOR 1 (SEE REMARKS) | | | | | | | X | | | | | | | | | | F ≈ 112-155 CFM PLV FAN ON HIGH | $F \leq 78 \pm 10.4$ CFM | F205 | NONE | DETECTOR (FLOW METER) ACTIVATES BY AM FANS DUCT SW. (PNL 204) |
| *CLUSTER PRESS LOW (WARNING) | CLUSTER PRESS | DETECTOR 1 | | | | | | | X | | | | | | | | | | 4.8 TO 5.2 PSIA | $P \leq 4.6 \pm .1$ PSIA | D207 (R) | METERS (PNL 225, 316,617) R | DETECTORS ACTIVE WHEN C&W SUBSYSTEM ACTIVATED. DETECTOR RETURNS TO NORMAL @ $P \geq 4.7$ PSIO |
| | | DETECTOR 2 | | | | | | | | X | | | | | | | | | | | | | |
| CNDST TANK ΔP (CAUTION) | CNDSATE TANK ΔP | DETECTOR 1 (SEE REMARKS) | | | | | | | X | | | | | | | | | | 0.5 TO 5.2 PSIA BELOW CLUSTER AMBIENT | $\Delta P \leq 0.4 {}^{+0.4}_{-0.1}$ PSID | D208 (R) | METER (PNL 216) | DETECTOR ACTIVE WHEN C&W SUBSYSTEM ACTIVATED. DETECTOR RETURNS TO NORMAL AT $\Delta P \geq 0.8$ PSIO |
| SIEVE TIMER (CAUTION) | SIEVE A TIMER | DETECTOR (SEE REMARKS) | | | | | | | | | | | | | | | | | N/A | TIMER POWER INTERRUPTS ≤20 ± 12 ms | NONE | NONE | EACH MOL SIEVE CYCLE TIMER PROVIDES A CONTACT CLOSURE TO THE C&W UPON POWER INTERRUPTS. CONTROL OF THE RESPECTIVE CYCLE TIMER IS PROVIDED BY MOL SIEVE SIEVE A OR B TIMERS SWS (PNL 203). |
| | | DETECTOR (SEE REMARKS) | | | | | | | | | | | | | | | | | N/A | TIMER POWER INTERRUPTS ≤20 ± 12 ms | NONE | NONE | |
| | SIEVE B TIMER | DETECTOR (SEE REMARKS) | | | | | | | | | | | | | | | | | N/A | TIMER POWER INTERRUPTS ≤20 ± 12 ms | NONE | NONE | |
| | | DETECTOR (SEE REMARKS) | | | | | | | | | | | | | | | | | N/A | TIMER POWER INTERRUPTS 20 ± 12 ms | NONE | NONE | |
| CLUSTER ATT (WARNING) | CLSTR ATT HI RATE | DETECTOR (LOCATED IN ATM) SEE REMARKS | | | | | | | | | | | | | | | | | * | K * | K 382-702 (50 BIT ATM WDRD) | PNL 130 DAS | ATM PROVIDES CONTACT CLOSURES TO THE C&W *ATM COMPUTER SOFTWARE FUNCTIONS (FOR DETAILS REF ATM AOH) |
| | CLSTR ATT THRUSTER STUCK | DETECTOR (LOCATED IN ATM) SEE REMARKS | | | | | | | | | | | | | | | | | N/A * | K * | K 382-702 | PNL 130 DAS | |
| ACS MALF (CAUTION) | ACS MALF CMG SAT | DETECTOR (LOCATED IN ATM) SEE REMARKS | | | | | | | | | | | | | | | | | N/A * | K * | K 382-702 | PNL 130 DAS | |
| | ACS MALF TACS ONLY | DETECTOR (LOCATED IN ATM) SEE REMARKS | | | | | | | | | | | | | | | | | N/A * | K N/A * | K 382-702 | PNL 130 DAS | |
| | ACS MALF RATE GYRO | DETECTOR (LOCATED IN ATM) SEE REMARKS | | | | | | | | | | | | | | | | | N/A * | K N/A * | K 382-702 | PNL 130 DAS | |
| COMPUTER MALF (CAUTION) | COMPUTER XOVER | DETECTOR (LOCATED IN ATM) SEE REMARKS | | | | | | | | | | | | | | | | | N/A * | K N/A * | K 382-702 | NONE | ATM COMPUTER SWITCHING SIGNAL FUNCTION |
| | COMPUTER SELF TEST | DETECTOR (LOCATED IN ATM) SEE REMARKS | | | | | | | | | | | | | | | | | N/A * | N/A * | K 382-702 | PNL 130 DAS | ATM COMPUTER SOFTWARE FUNCTION |

Figure 2.8.9-1 C&W Parameters (Sheet 3)

8083 -4

| C & W DISPLAY TITLE (PNL 207 & * 616) | C & W INHIBIT SWITCH TITLE (PNL 207) | C&W DETECTORS | C & W SENSOR PWR | | | | | | | | | C&W DETECTION MODULE POWER | | | | | | | | | NOMINAL RANGE | TRIGGER LIMITS | CORRESPONDING INDICATORS (R) TM SENSOR REDUNDANT TO C&W (S) M SENSOR SAME AS TM | | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | $V_{C\&W\ 1+24}$ | $V_{C\&W\ 1-24}$ | $V_{C\&W\ 1+5}$ | $V_{C\&W\ 2+24}$ | $V_{C\&W\ 2-24}$ | $V_{C\&W\ 2+5}$ | $V_{ECS\ 1}$ | $V_{ECS\ 2}$ | | $V_{C\&W\ 1+24}$ | $V_{C\&W\ 1-24}$ | $V_{C\&W\ 1+5}$ | $V_{C\&W\ 2+24}$ | $V_{C\&W\ 2-24}$ | $V_{C\&W\ 2+5}$ | $V_{C\&W\ 1+28}$ | $V_{C\&W\ 2+28}$ | | | | TM MEASURE-MENTS | ON BOARD DISPLAYS | |
| ATM BUS 1 LOW (WARNING) | ATM BUS 1 LOW | DETECTOR (LOCATED IN ATM) SEE REMARKS | | | | | | | | | | | | | | | | | | | 28 TO 30 VDC | V ≤25 ± .5 VDC | M019 (R) | METER PNL 130 | ATM PROVIDES CONTACT CLOSURES TO C&W (FOR DETAILS SEE ATM SOH) |
| ATM BUS 2 LOW (WARNING) | ATM BUS 2 LOW | DETECTOR (LOCATED IN ATM) SEE REMARKS | | | | | | | | | | | | | | | | | | | 28 TO 30 VDC | V ≤ 25 ± .5 VDC | M020 (R) | METER PNL 130 | " |
| ATM CNST THERM (CAUTION) | ATM CNST PUMP ΔP | DETECTOR (LOCATED IN ATM) SEE REMARKS | | | | | | | | | | | | | | | | | | | 31 PSID | ΔP ≤ 26 ± 1 PSID | D006 (R) | METER PNL 130 (S) | ATM PROVIDES CONTACT CLOSURE TO C&W (FOR DETAILS SEE ATM SOH) |
| | ATM CNST COOLANT TEMP | DETECTOR (LOCATED IN ATM) SEE REMARKS | | | | | | | | | | | | | | | | | | | 49 TO 51°F | 45 ≥ T ≥ 55°F ± .1 °F | C286 (R) | ATM C&D (S) | |
| | ATM CNST HEATER TEMP | DETECTOR (LOCATED IN ATM) SEE REMARKS | | | | | | | | | | | | | | | | | | | 40 TO 60°F | T ≥ 150 ± .36°F | C295 (R) | ATM C&D | |
| EVA 1 (WARNING) | EVA 1 PUMP ΔP | DETECTOR (MECHANICAL ΔP SWITCH) (SEE REMARKS) | | | | | | | | | | | | | | | | | | | 15 TO 22 PSID | ΔP ≤ 4±1 PSID | D201 R | NONE | ΔP SW RETURNS TO NORMAL @ ΔP ≥ 5.0 PSID ΔP SW IS ARMED VIA SUIT UMB SYS 1 PUMP SW PNL 317 |
| | EVA 1 $H_2O$ IN TEMP | DETECTOR 1 | | | X | | | | | | | X | X | | | | | X | | | -41 TO 49°F | T ≤ 33.5 ± 1.5°F | C407 R | NONE | |
| | | DETECTOR 2 | | | | | | X | | | | | | | X | X | | | X | | | | | | |
| EVA 2 (WARNING) | EVA 2 PUMP ΔP | DETECTOR (MECHANICAL ΔP sw) SEE REMARKS | | | | | | | | | | | | | | | | | | | 15 TO 22 PSID | ΔP ≤ 4±1 PSID | 0202 R | NONE | ΔP SW RETURNS TO NORMAL @ ΔP ≥ 5.0 PSID ΔP SW IS ARMED VIA SUIT UMB SYS 2 PUMP SW PNL 317 |
| | EVA 2 $H_2O$ IN TEMP | DETECTOR 1 | | | X | | | | | | | X | X | | | | | X | | | 41 TO 49°F | T ≤ 33.5 ± 1.5°F | C408 R | NONE | |
| | | DETECTOR 2 | | | | | | X | | | | | | | X | X | | | X | | | | | | |
| * CREW ALERT (WARNING) | CREW ALERT 1 | RELAY IN CREW ALERT MODULE 1 | | | | | | | | | | | | | | | | | | | N/A | DISCRETE VIA CRDU | K301 TO K311 | NONE | CREW ALERT 1 AND ALERT 2 SIGNALS ARE PROVIDED BY GROUNO COMMAND VIA THE AM DCS SYSTEM |
| | CREW ALERT 2 | RELAY IN CREW ALERT MODULE 2 | | | | | | | | | | | | | | | | | | | N/A | DISCRETE VIA CRDU | K301 TO K311 | NONE | |
| CSM (WARNING) | CSM 1 | DETECTOR (NONE) RELAY CLOSURE IN CSM C&WS | | | | | | | | | | | | | | | | | | | N/A | N/A | | CSM C&W DISPLAYS | CSM C&W SYSTEM UPON DETECTING ANY OUT-OF-LIMIT CONDITION PROVIDES REDUNDANT CSM 1 & CSM 2 CONTACT CLOSURES TO THE C&W. |
| | CSM 2 | DETECTOR (NONE) RELAY CLOSURE IN CSM C&WS | | | | | | | | | | | | | | | | | | | N/A | N/A | | CSM C&W DISPLAYS | |

Figure 2.8.9-1 C&W Parameters (Sheet 4)

8107

| FIRE DETECTOR NAME | FIRE DETECTOR PANEL | | INHIBIT SW TITLES PNL 207 | GROUP INDICATOR TITLE PNL 207, 616 |
|---|---|---|---|---|
| MDA FIRE SENSOR 1 | SENSOR 1 | PNL 120 | MDA/STS FIRE 1 | MDA/STS FIRE |
| MDA FIRE SENSOR 2 | SENSOR 2 | | | |
| MOLE SIEVE A FIRE SENSOR 1 | SENSOR 1 | PNL 236 | MDA/STS FIRE 2 | |
| MOL SIEVE A FIRE SENSOR 2 | SENSOR 2 | | | |
| MOLE SIEVE B FIRE SENSOR 1 | SENSOR 1 | PNL 237 | | |
| MOLE SIEVE B FIRE SENSOR 2 | SENSOR 2 | | | |
| STS HT EXC MOD FIRE SENSOR 1 | SENSOR 1 | PNL 238 | | |
| STS HT EXC MOD FIRE SENSOR 2 | SENSOR 2 | | | |
| OWS COOLING MOD FIRE SENSOR 1 | SENSOR 1 | PNL 392 | AM AFT FIRE 1 | AM AFT FIRE |
| OWS COOLING MOD FIRE SENSOR 2 | SENSOR 2 | | AM AFT FIRE 2 | |
| OWS FWD FIRE SENSOR 1 | SENSOR 1 | PNL 529 | OWS FWD FIRE 1 | OWS FWD FIRE |
| OWS FWD FIRE SENSOR 2 | SENSOR 2 | | | |
| OWS FWD FIRE SENSOR 3 | SENSOR 1 | PNL 530 | OWS FWD FIRE 2 | |
| NOT USED | NOT USED | | | |
| EXP COMP FIRE SENSOR 1 | SENSOR 1 | PNL 618 | OWS EXP FIRE 1 | OWS EXP FIRE |
| EXP COMP FIRE SENSOR 2 | SENSOR 2 | | | |
| EXP COMP FIRE SENSOR 3 | SENSOR 1 | PNL 619 | OWS EXP FIRE 2 | |
| NOT USED | NOT USED | | | |
| WARD ROOM FIRE SENSOR 1 | SENSOR 1 | PNL 633 | OWS QTRS FIRE 1 | OWS CREW QTRS FIRE |
| WARD ROOM FIRE SENSOR 2 | SENSOR 2 | | | |
| WASTE MGMT AREA FIRE SENSOR | SENSOR 1 | PNL 638 | OWS QTRS FIRE 2 | |
| SLEEP COMPARTMENT FIRE SENSOR 1 | SENSOR 2 | | | |
| SLEEP COMPARTMENT FIRE SENSOR 2 | SENSOR 1 | PNL 639 | | |
| SLEEP COMPARTMENT FIRE SENSOR 3 | SENSOR 2 | | | |

| RAPID ΔP DETECTOR | INHIBIT SW TITLES PNL 207 | INDICATOR TITLE (PNL 207, 616) |
|---|---|---|
| ΔP DETECTOR 1 | RAPID ΔP 1 | RAPID ΔP |
| ΔP DETECTOR 2 | RAPID ΔP 2 | |

Figure 2.8.9-2 Emergency Parameters

SUBSECTION 2.9

DOCKING AND CREW TRANSFER

2.9.1 INTRODUCTION

This section identifies the physical rendezvous and docking provisions of the SWS and the operations associated with rendezvous, docking, and crew transfer.

2.9.2 RENDEZVOUS

The SWS rendezvous functions consist of positioning the SWS so that the DA-mounted VHF ranging antenna and tracking lights can be acquired by the CSM during rendezvous maneuvers. The VHF antenna and tracking lights are turned when the CSM is 300 NM from the SWS. Approximately four orbits prior to docking, the SWS is placed in a retrograde attitude with a constant pitch rate, with the -Z coordinate toward the earth (Z-local vertical X in orbit plane - retrograde). This is the rendezvous attitude for VHF tracking. Approximately two orbits prior to docking, the SWS is re-positioned to an attitude called solar inertial; the CSM at this time will be close enough to the SWS so that the VHF ranging antenna will not be needed.

2.9.3 DOCKING

The CSM maneuvers to the axial docking port of the MDA. Normally, the axial port is used since power, communication, and ventilation are available only at this port. CSM maneuvering is aided from a range of approximately 200 feet to a distance of 50 feet by running lights located on the cone of the MDA and on the forward end of the FAS. The white lights locate the +Z coordinate; the amber lights, the -Z; the red lights, the +Y; and the green lights, the -Y coordinate (figure 2.9-1). From 50 feet to capture, the docking target on the axial port is used. To sight on the target, the CSM crewman uses the CSM-mounted crewman optical alignment sight (COAS) (figure 2.9-2).

On initial contact of the probe and drogue, three capture latches are released that engage the probe and drogue. The probe retraction system is then activated, compressing the probe while simultaneously mating the docking ring to the docking tunnel for a pressure-tight seal. When the mating is complete, 12 docking latches automatically secure this connection (figure 2.9-3). Pressure is then equalized between the CSM and the tunnel,

9858

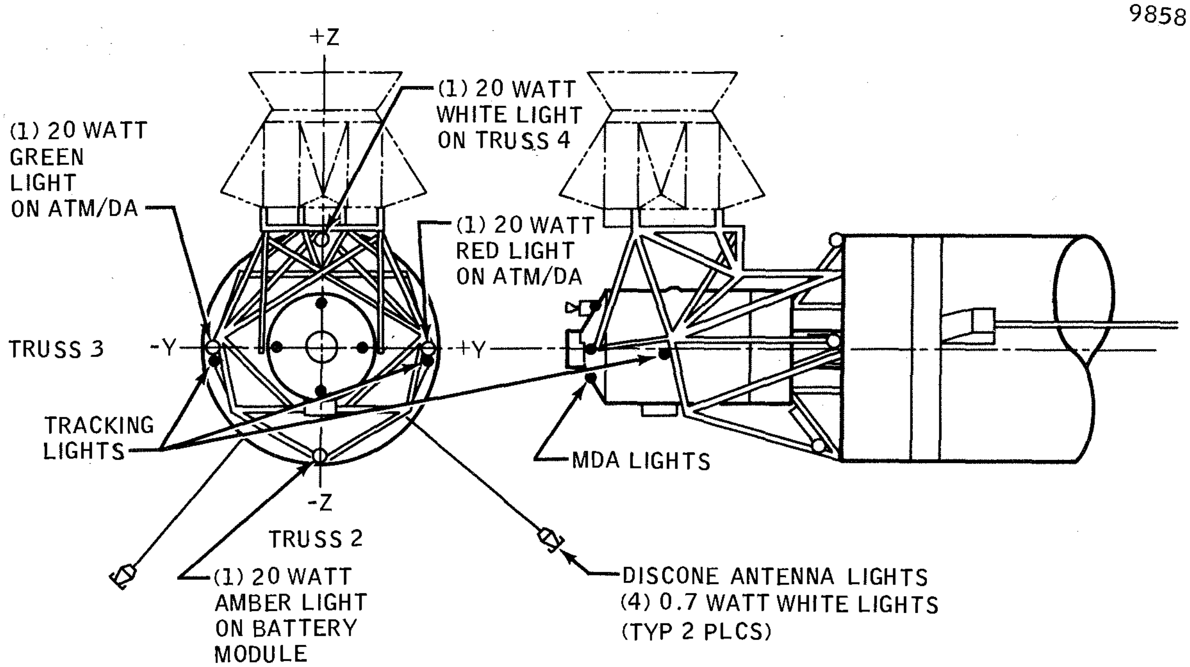



Figure 2.9-1 Tracking and Docking Lights

9943

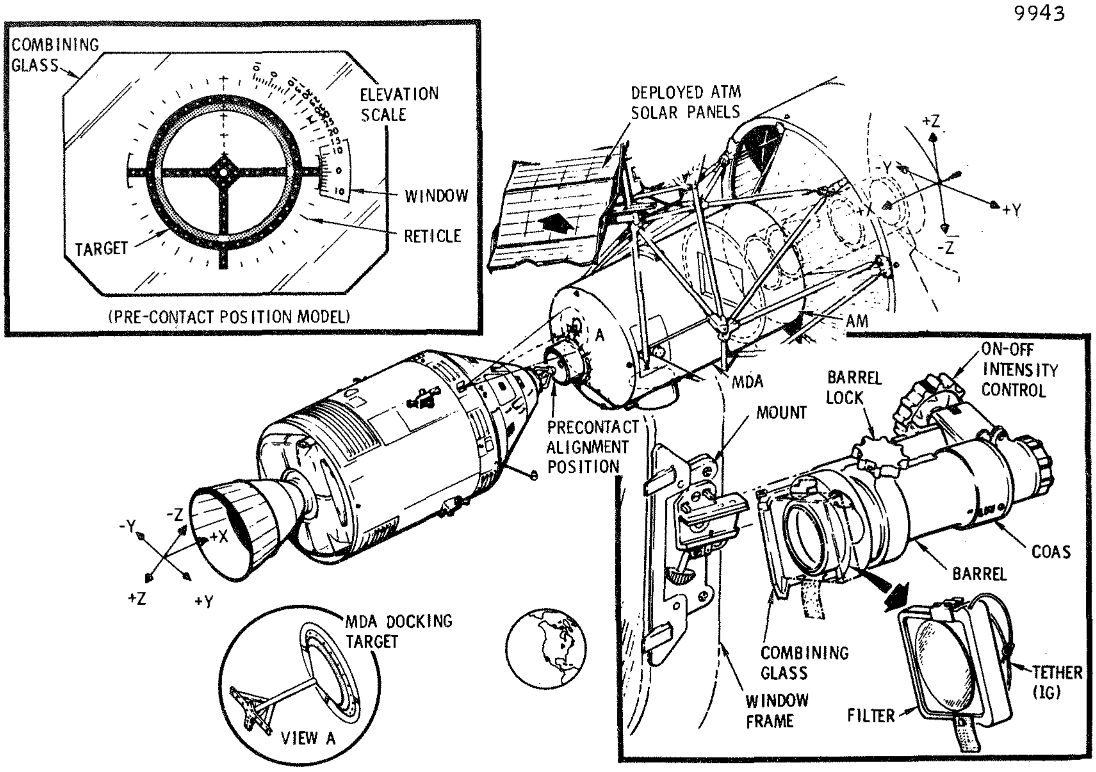



Figure 2.9-2 Crewman Optical Alignment Sight (COAS)

9095

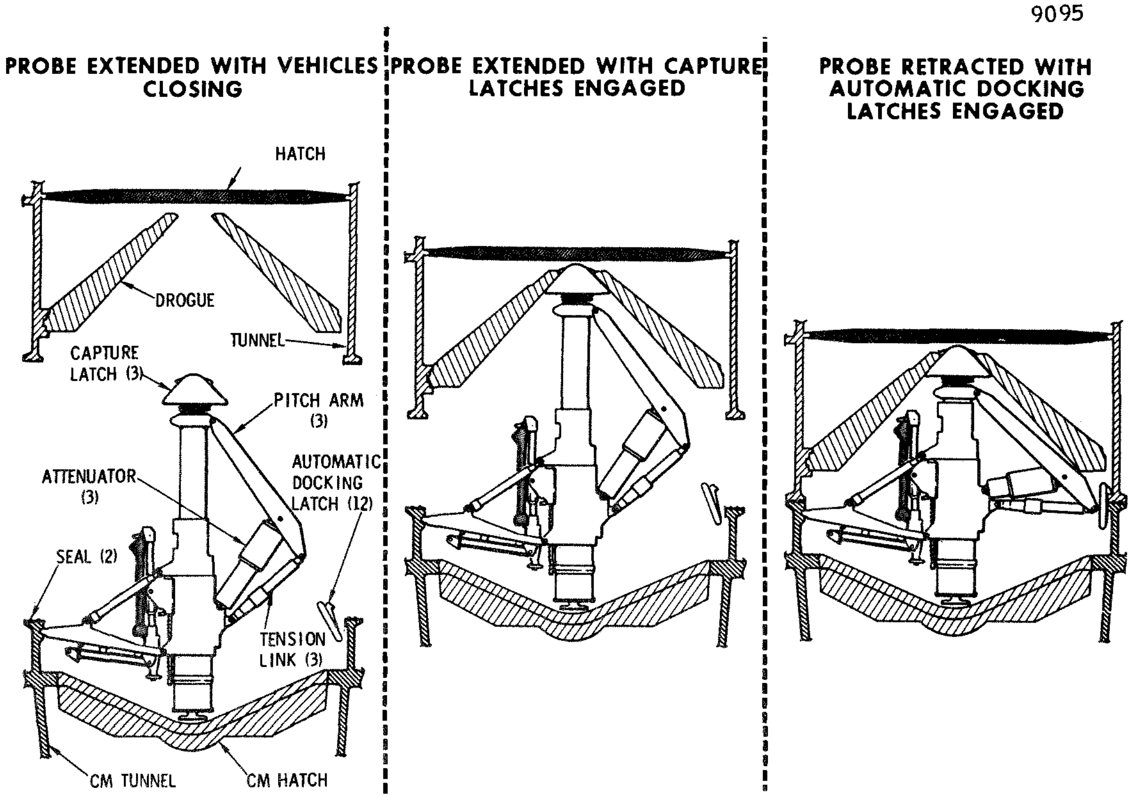



Figure 2.9-3 MDA Docking Sequence

the CSM hatch is removed, and the 12 latches are verified. The probe and drogue (figure 2.9-4) are removed and temporarily stowed in the CSM. Pressure is equalized through the equalization valve in the MDA hatch, which is then opened into the MDA.

2.9.4 CREW TRANSFER

With the CSM docked to the MDA, the latches securely fastened to the tunnel rings; the probe, drogue, and CSM hatch removed and stowed (figure 2.9-5), and the MDA hatch opened, the crew crawls through the tunnels from the CSM to the MDA. The umbilicals are retrieved from the MDA and connected to their respective connectors in the CM docking ring. A CM/MDA interchange duct, used to provide ventilation from the MDA into the CM, is also installed at this time. The crew then continues activation of the SWS.

2.9.5 DEACTIVATION

To undock, the entire sequence of docking is reversed:

- The umbilicals and the interchange duct are removed.
- The MDA hatch is closed.
- The drogue is installed.
- The probe is installed.
  - a. The capture latches are latched to the drogue.
  - b. The probe is mounted on the docking ring.
  - c. The probe is held retracted by the extension latch assembly.
  - d. It is verified that nitrogen pressure has previously been relieved off the probe.
  - e. The probe electrical control is reconnected.
- The 12 docking latches are released.
- The CM tunnel hatch is installed to seal the CM cabin.
- The tunnel pressure is vented overboard.
- The probe extension latch and capture latches are electrically released.
- The probe spring extends the probe separating the CSM and the MDA.

2.9.6 SUBSYSTEM AND MAJOR COMPONENT DESCRIPTION

2.9.6.1 VHF RANGING SYSTEM

(Refer to paragraph 2.2.3.4)

2.9.6.2 TRACKING LIGHTS

(Refer to paragraph 2.5.4)

2.9.6.3 DOCKING LIGHTS

(Refer to paragraph 2.5.4)

2.9.6.4 DOCKING ALIGNMENT TARGETS

(Refer to paragraph 2.0.7.3.3)

2.9.6.5 DOCKING PORTS AND MECHANISMS

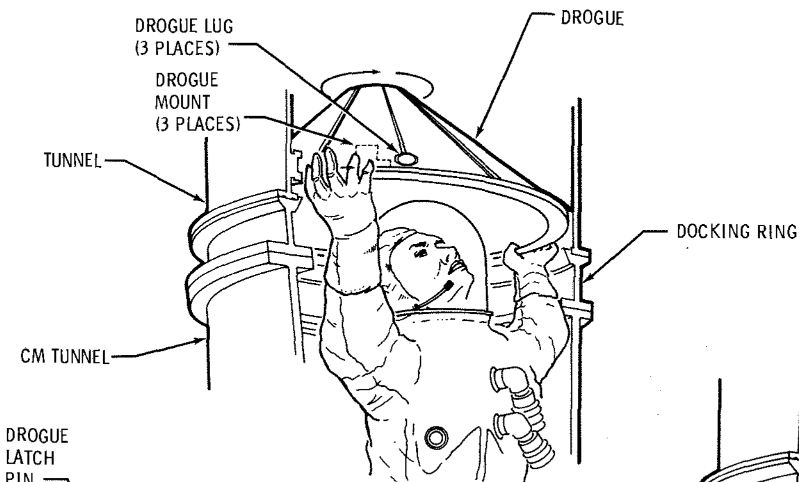
(Refer to paragraph 2.0.7.3.4)

2.9.6.6 PROBE

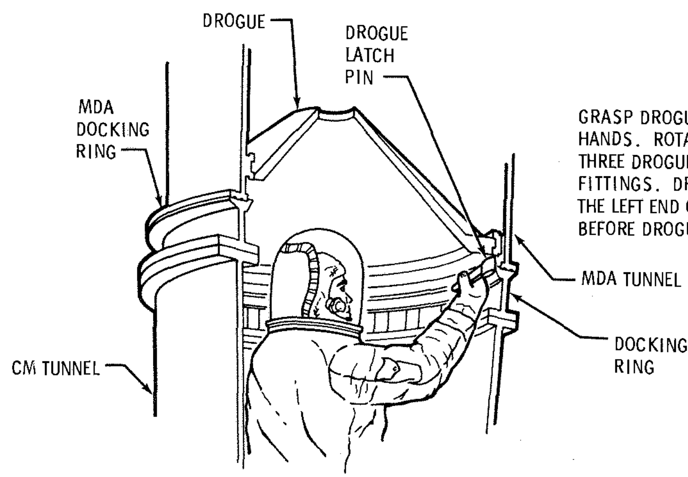
(Refer to CSM-SLOH Volume I)

2.9.6.7 DOCKING RING AND LATCHES

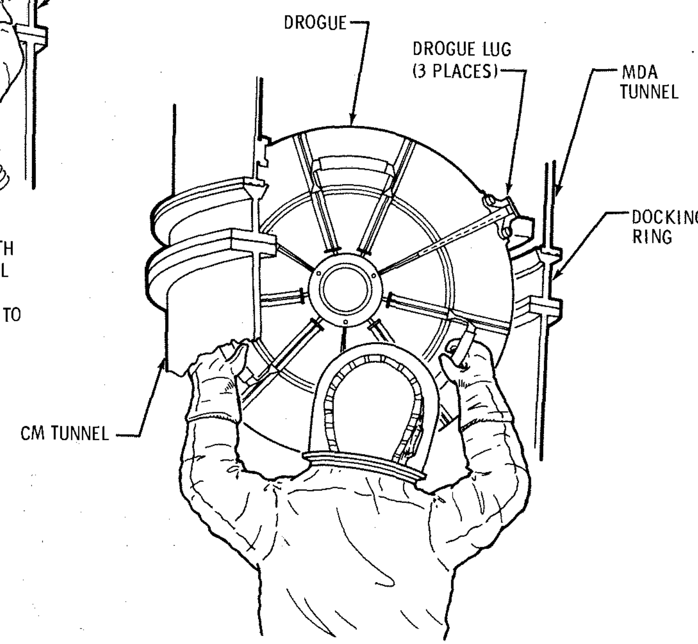
(Refer to CSM-SLOH Volume I)




STEP 2
GRASP DROGUE OUTER RING WITH BOTH HANDS. ROTATE (CW) AND PUSH UNTIL THREE DROGUE LUGS CLEAR SUPPORT FITTINGS. DROGUE LUGS MUST MOVE TO THE LEFT END OF SUPPORT FITTING BEFORE DROGUE CAN BE PUSHED FREE




STEP 1
PULL AND ROTATE (CCW) DROGUE LOCK LEVER UNTIL FLUSH AGAINST TUNNEL WALL




STEP 3 AND 4
ROTATE DROGUE TOWARD CM AND GRASP ANY TWO HANDLES TAKING CARE NOT TO STRIKE MDA HATCH. MANEUVER DROGUE PAST SUPPORT FITTINGS AND STOW IN CM UNDER RIGHT HAND COUCH. (DROGUE WILL LATER STOW ON FORWARD CONE OF MDA)

Figure 2.9-4 Drogue Removal

9094

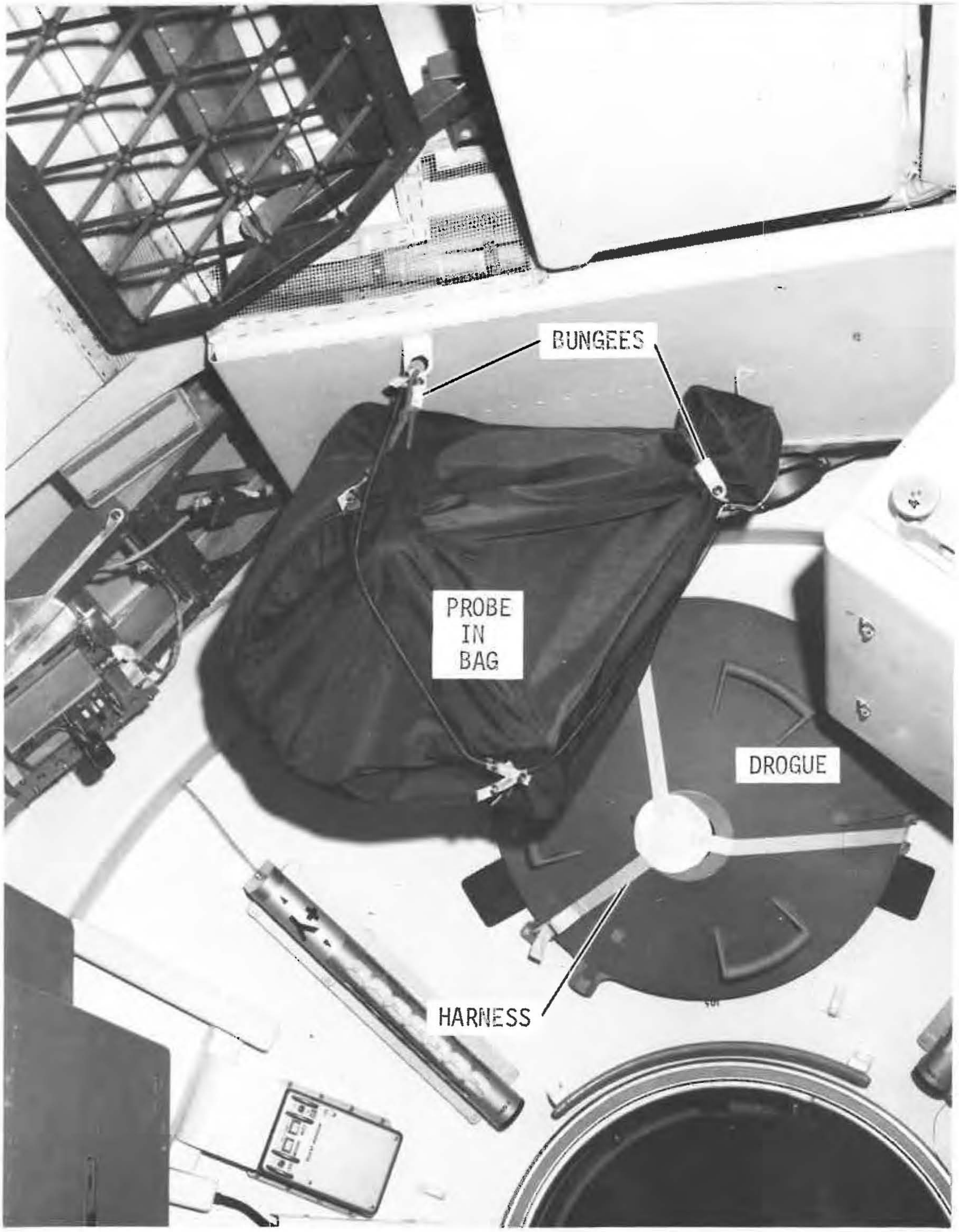



Figure 2.9-5 Drogue and Probe Stowage

SUBSECTION 2.10

EXPERIMENTS

## 2.10.1 GENERAL

The Skylab program represents a major step towards the practical utilization of space for man's benefit and knowledge. The primary objectives of the Skylab program are to study the effects of long-duration space flights on men and systems and to perform a wide spectrum of scientific and technological investigations.

An extensive series of medical experiments will be performed during and after each mission to:

- o Determine physiological and psychological responses of men exposed to extended periods in space
- o Establish predictable limits for future mission duration
- o Determine post mission readaption to earth environment

Scientific investigation will be conducted during the missions in several areas:

| | |
|---|---|
| o Astronomy | - Observation of solar activities and phenomena to gain a better understanding of the sun, its atmosphere, and its effects |
| o Geographics and Earth Resources | - Evaluation of remote sensing techniques designed to scan the earth's surface and record radiation patterns in various wavelengths |
| o Technological/Scientific Phenomena | - Evaluation of engineering developments and demonstration of various scientific phenomena through engineering and technological experiments |

Table 2.10-1 lists all the experiments to be performed during the Skylab program. For detailed information on the ATM Experiments, refer to the SLOH-ATM, Volume I (MSC 04728). All other experiments are covered in detail in the SLOH-Experiments, Volume I (MSC 00924).

TABLE 2.10-1 SKYLAB EXPERIMENTS

7000

| NO. | EXPERIMENT NAME | MISSION ASSIGNMENT | STOWED IN / IN OPERATED | POWER | INTERFACES FOR OR SOURCES OF: INST | NITROGEN | VACUUM | OTHER | EXPERIMENT OPERATION: FREQUENCY | TIME | CREWMEN REQ'D | SCHEDULING CONSTRAINTS | AGENCY | P I / ORGANIZATION | REMARKS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DOD | | | | | | | | | | | | | | | |
| D008 | RADIATION IN SPACECRAFT | SL-1/2 | CSM/CSM | MN A & B | CM DSE | | | | 2 IN SAA & 2 IN N. LAT | 45 MIN | 1 | NO RADIATION SOURCES ALLOWED IN CM AFTER INSTALLATION | AF/MSC | CAPT. M. F. SCHNEIDER/USAF | ADDITIONAL SURVEY DURING SOLAR FLARE | # |
| D024 | THERMAL CONTROL COATINGS | SL-1/2 & 3 | AM/AM | | | | | | | | 2 | EVA REQ'D DURING BOTH MISSIONS | AF/MSC | CARL BOEBEL/WPAFB | | |
| | | | | | | | | | 1 | | | | | | | |
| | MEDICAL | | | | | | | | | | | | | | | |
| M071 | MINERAL BALANCE | ALL | OWS/OWS | | | | | | EACH CM-EVERY DAY | 90 MIN | 1 | USES EQUIP. OF M074 AND M172 | MSC | DR. G. D. WHEDON/ | BLUE & CARMINE DYE MARKERS INGESTED; ALT 6 DAY INTERVALS | |
| M073 | BIO-ASSAY OF BODY FLUIDS | ALL | OWS/OWS | | | | | | EACH CM-EVERY DAY | | 1 | PERFORMED DURING M071 | MSC | DR. C. LEACH/MSC | | |
| M074 | SPECIMEN MASS MEASUREMENT | ALL | OWS/OWS | OWS BUS 1 OR 2 | | | | | EACH CM-AS REQ'D | 30 MIN | 1 | AIR MOTION MUST BE LESS THAN 70 FT/MIN; NOT DURING PLANNED MANEUVERS | MSC | COL. JOHN ORD/BROOKS AFB | CALIBRATED 3 TIMES DURING A MISSION | |
| M078 | BONE MINERAL MEASUREMENT | A | | | | | | | | | | NO HIGH CALCIUM FOODS INGESTED PRIOR TO X-RAYS | MSC | | | |
| M092 | IN-FLIGHT LOWER BODY NEGATIVE PRESSURE | ALL | OWS/OWS | ESS | ESS | ESS | OWS | NOTE B | EACH CM-EVERY 3 DAYS | 1 HR. | 2 | M093, M131, M171, S073 & T027; NOT WITHIN 3 HOURS AFTER MEAL | MSC | DR. R. JOHNSON/MSC | LBNPD MAINTAINED AT 67-78°F | |
| M093 | VECTORCARDIOGRAM | ALL | OWS/OWS | ESS | ESS | | | | EACH CM-EVERY 3 DAYS | 45 MIN | 2 | M092, M131, S073 & T027; NOT WITHIN 3 HOURS AFTER MEAL | MSC | CAPT. N. W. ALLEBACH/USN BOMED & SUR | EQUIP. USED DURING M092 & M171 | |
| M111 | CYTOGENETIC STUDIES OF THE BLOOD | A | | | | | | | | | | | MSC | DR. M. SHAW/U OF TEX | | |
| M112 | MAN'S IMMUNITY - IN VITRO ASPECTS | A | | | | | | | | | | | MSC | DR. S. RITZMAN/SHRINERS BURNS | | |
| M113 | BLOOD VOLUME AND RED CELL LIFE SPAN | A | | | | | | | | | | | MSC | DR. P. JOHNSON/BAYLOR | | |
| M114 | RED BLOOD CELL METABOLISM | A | | | | | | | | | | | MSC | C. MENGEL/U OF MO. | | |
| M115 | SPECIAL HEMATOLOGIC EFFECTS | A | | | | | | | | | | | MSC | DR. C. L. FISCHER | | |
| M131 | HUMAN VESTIBULAR FUNCTION | SL-1/2 & 3 | OWS/OWS | OWS BUS 1 OR 2 | ESS | E | | | EACH CM-6 TIMES | 93 MIN | 2 | NOT WITHIN ONE HOUR AFTER MEAL | MSC | DR. A GRAYDIEL/USN AV. MED | | # |
| M133 | SLEEP MONITORING | SL-1/2 &3 | OWS/OWS | | | | | | 21 TIMES | 8 HRS | 1 | | MSC | DR. J. D. FROST JR./ | | |
| M151 | TIME AND MOTION STUDY | ALL | OWS/OWS | | | | | | | | | | MSC | DR. J. F. KUBIS/FORDAM US | | # |
| M171 | METABOLIC ACTIVITY | ALL | OWS/OWS | ESS | ESS | OWS | OWS | NOTE C | EACH CM-3 TIMES | 128 MIN | 2 | M093 | MSC | DR. E. MICHEL/MSC | CM BREATHE OWS ATMOSPHERE | |
| M172 | BODY MASS MEASUREMENT | ALL | OWS/OWS | OWS BUS 1 | | | | | EACH CM-EVERY DAY | 15 MIN | 1 | SAME AS M074 | MSC | COL. JOHN ORD/BROOKS AFB | CALIBRATED 3 TIMES DURING A MISSION | |
| ESS | MEDICAL EXPERIMENTS SUPPORT SYSTEM | ALL | OWS/OWS | OWS BUS 1 OR 2 | HLJ MULTI | | | | | | N/A | | | | | |
| | ENGINEERING | | | | | | | | | | | | | | | |
| M415 | THERMAL CONTROL COATINGS | SL-2 | IU/IU | | | | | | 1 | | NONE | CSM MUST BE CLEAR OF EJECTED COVER TRAJECTORY | MSFC | E. C. MCKANNAN/MSFC | | |
| M479 | ZERO GRAVITY FLAMMABILITY | SL-3 | MDA/MDA | (M512) | | | (M512) | NOTE D | | | 1 | ALL PHASES OF M512 MUST BE COMPLETED | MSFC | H. KIMZEY/MSC | | # |
| M487 | HABITABILITY/CREW QUARTERS | ALL | OWS/OWS | | | | | | | | 1 | | MSFC | DR. C. JOHNSON/MSC | | # |
| M509 | ASTRONAUT MANEUVERING EQUIPMENT | SL-1/2 & 3 | OWS/OWS | OWS BUS 2 | | NRS | | | EACH CM-2 TIMES | 15 HRS | 2 | M092, M093, S063, S073, S019 & T027 | MSC | MAJ. C. E. WHITSETT/USAF | | # |
| M512 | MATERIALS PROCESSING FACILITY | SL-1/2 | MDA/MDA | AM BUS 1 | | | MDA | NOTE D | 1 | 214 HRS | 1 | | MSFC | P. G. PARKS/USAF | | # |
| M516 | CREW ACTIVITIES/MAINTENANCE STUDY | | | | | | | | | | | | | | | |
| M551 | METALS MELTING | | (M512) | | | | | | | | | | | | | |
| M552 | EXOTHERMIC BRAZING | | (M512) | | | | | | | | | | | | | |
| M553 | SPHERE FORMING | | (M512) | | | | | | | | | | | | | |
| M554 | COMPOSITE CASTING | | (M512) | | | | | | | | | | | | | |
| M555 | GALLIUM ARSENSIDE CRYSTAL GROWTH | | (M512) | | | | | | | | | | | | | |
| | SCIENTIFIC | | | | | | | | | | | | | | | |
| S009 | NUCLEAR EMULSION | SL-1/2 | MDA, OWS/MDA | AM BUS 2 | | | | | 1 | | 1 | | MSFC | DR. M. M. SHAPIRO/NRL | | |
| S015 | EFFECT OF ZERO GRAVITY ON SINGLE HUMAN CELLS | SL-1/2 | CSM/CSM | MN A & B | | | | | 1 | | 1 | TEMP MAINTAINED BETWEEN 50° & 95°F | MSC | DR. P. O. MONTGOMERY/DALLAS CO. HOS | MONITOR TWICE DAILY (SIX MINUTES) | |
| S019 | ULTRAVIOLET STELLAR ASTRONOMY | SL-1/2 & 3 | OWS/-Z SAL | OWS BUS 1 OR 2 | | | SAL | | 1 | 9 HRS | 1 | M509, S063, S073, S149, S183 T013 T020 T027 & (LIGHTING) | MSC | DRS. HENIZE & WRAY/N.W.U | | # |
| S020 | X-RAY/ULTRAVIOLET SOLAR PHOTOGRAPHY | SL-1/2 & 3 | OWS/+Z SAL | OWS BUS 1 OR 2 | | | SAL | | 1 | 9 HRS | 1 | M509, S063, S073, T020, T025 & T027 | MSC | DR. R. TOUSEY/NRL | | # |
| S052 | WHITE LIGHT CORONAGRAPH | ALL | ATM, MDA/ATM | | | | | | | | 1 | | MSFC | DR. G. NEWKIRK/HAO | | # |
| S054 | X-RAY SPECTROGRAPHIC TELESCOPE | ALL | ATM, MDA/ATM | | | | | | | | 1 | | MSFC | DR. M. ZOMBECK/AS&E | | # |
| S055A | UV SCANNING POLYCHOMATOR-SPECTROHELIOMETER | ALL | ATM/ATM | | | | | | | | 1 | | MSFC | DR. E. REEVES/HCO | | # |
| S056 | X-RAY TELESCOPE | ALL | ATM, MDA/ATM | | | | | | | | 1 | | MSFC | J. MILLIGAN/MSFC | | # |
| S063 | ULTRAVIOLET AIRGLOW HORIZON PHOTOGRAPHY | SL-3 | OWS/±Z SALs | | | | | | 1 | | 2 | S019, S020, S073, S149, T025. T027 S183 & (LIGHTING | MSC | DR. D. PACKER/NRL | | # |
| S071/S072 | CIRCADIAN RHYTHM - POCKET MICE AND VINEGAR GNATS | SL-3 | CSM/CSM | MN A & B | | | | | 1 | | NONE | | ARC | DR. C. S. PITTENDRIGH/PRINCETON | | |
| S073 | GEGENSCHEIN/ZODIACAL LIGHT | SL-1/2 | OWS/±Z SAL | (T027) | (T027) | | | | | | 2 | M092, M093, M509, S019, S020, S063, S149, S183, T013, T020, T025, T027 & EREP (LIGHTING) | MSFC | DR. J. WEINBERG/DUDLEY OBS. | | # |
| S082A | EXTREME ULTRAVIOLET CORONAL SPECTROHELIOGRAPH | ALL | ATM, MDA/ATM | | | | | | | | 1 | | MSFC | DR. J. D. PURCELL/NRL | | # |
| S082B | CHROMOSPHERIC EXTREME ULTRAVIOLET SPECTROGRAPH | ALL | ATM, MDA/ATM | | | | | | | | 1 | | MSFC | DR. J. D. PURCELL/NRL | | # |
| S149 | PARTICLE COLLECTION | ALL | OWS/-Z SAL | T027 | T027 | | | | 1 | | 1 | M509, S019, S063, S073, S183 & T027 | MSC | DR. HEMMENWAY/DUDLY OBS. | | |
| S150 | X-RAY ASTRONOMY | SL-3 | IU/IU | | | | | | | | NONE | | MSFC | DR. W. KRAUSHAAR/U OF WIS | | |
| S183 | ULTRAVIOLET PANORAMA | SL-1/2 | OWS/-Z SAL | | | | | | 1 | 8 HRS | 2 | S019, S063, S073, M5D9. S149, T025 & T027 | MSFC | DR. G. COURTES/LAB.D' ASTRO | | # |
| S190 | MULTISPECTRAL PHOTOGRAPHIC FACILITY | ALL | MDA/MDA | AM BUS 2 | | | | | | | 2 | LIGHTING | MSC | A. GRANDFIELD/MSC | | # |
| S191 | INFRARED SPECTROMETER | ALL | MDA/MDA | AM BUS 1 | | | | | | | 2 | SUN ANGLE - ZENITH & 20° B ≤ 50° | MSC | DR. T. BARNETT/MSC | | # |
| S192 | MULTISPECTRAL SCANNER | ALL | MDA/MDA | AM BUS 1 | | | | | | | 2 | SUN ANGLE > 0° | MSC | DR. C. KORB/MSC | | |
| S193 | MICROWAVE RADIOMETER/SCATTEROMETER AND ALTIMETER | ALL | ATM/DA/MDA | AM BUS 2 | | | | | | | 2 | | MSC | DR. R. MOORE/U OF KAN | | |
| S194 | L-BAND RADIOMETER | ALL | MDA/MDA | AM BUS 1 | | | | | | | 2 | | MSC | DR. W. PEAKE/OHIO STATE U. | | |
| | TECHNOLOGICAL | | | | | | | | | | | | | | | |
| T002 | MANUAL NAVIGATION SIGHTINGS | SL-3 & 4 | | | | | | | | | | (LIGHTING) | | | | |
| T003 | IN-FLIGHT AEROSOL ANALYSIS | SL-1/2 | OWS/OA | SCB | | | | | | | | | ERC | DR. W. LEAVITT/ERC | | |
| T013 | CREW VEHICLE DISTURBANCES | SL-1/2 | OWS/OWS, MDA | OWS BUS 2 | | | | | 1 | 58 MIN | 3 | S019, S063, S073, S149 & T027 | LARC | B. CONWAY/LARC | | |
| T018 | PRECISION OPTICAL TRACKING | ALL | IU/IU | | | | | | | | NONE | | MSFC | J. GOULD/MSFC | | # |
| TD20 | FOOT-CONTROLLED MANEUVERING UNIT | SL-3 | OWS/OWS | SCB | (M509) | M509 | | | 1 | 10 HRS. | 2 | S019, S063, S073, S149 T027 & (LIGHTING) | LARC | D. HEWES/LARC | | # |
| T025 | CORONAGRAPH CONTAMINATION MEASUREMENTS | SL-1/2 | OWS/±Z SAL | OWS BUS 1 & 2 | | | | | 1 | 280 MIN | | S020, S063, S073 T027 & (LIGHTING) | MSC | DR. G. BONNER/MSC | | # |
| T027 | CONTAMINATION MEASUREMENT | ALL | OWS/±Z SAL | OWS BUS 1 OR 2 | HLK MULTI | | | | 4 | 190 MIN | | M092, M093, S019, S020, S063, S073, S149, S183, T013, T020 & T025 & EREP | MSFC | DR. J. MUSCAN/MMC | | # |
| | | | | | | | | | | | | | ARC | F. G. EDWARDS/ARC | | |

A - THESE EXPERIMENTS ARE PERFORMED PRE- AND POST-FLIGHT ONLY
B - M092 VENTS OWS ATMOSPHERE TO SPACE
C - M171 VENTS METHANE ($CH_4$) THRU THE OWS WALL TO SPACE
D - VENTS ATMOSPHERE TO SPACE AND RECEIVES H2O FROM OWS WATER SUPPLY
E - SELF CONTAINED N2 SUPPLY TO MOTOR HOUSING
* ITEMS IN PARENTHESES ARE NOT INTERFACES BUT DO INDICATE A REQUIREMENT

SCB - SELF-CONTAINED BATTERIES
NRS - NITROGEN RECHARGE STATION

FILM RETURNED IN CSM #

SUBSECTION 2.11

SEQUENTIAL

2.11.1 INTRODUCTION

This section describes the SWS flight sequence of events required to convert the SWS from the launch to orbital configuration. The descriptions begin with launch of Skylab 1 and end with CSM docking on Skylab 2. Events associated with each SWS module are identified, but reference should be made to the respective Skylab Operations Handbook Sections for detailed systems hardware information, and to the Flight Sequence Requirements Control documents for expanded command sequences.

2.11.2 INTERFACES

The system interfaces associated with the sequential events are as follows:

- EPS - Provides electrical power to sequential functions
  - Sequential Bus 1 and 2
    - Radiator Shield Jettison
    - Payload Shroud Jettison
    - ATM Deployment
  - Deploy Bus 1 and 2
    - Discone Antenna Deploy
    - ATM SAS Deploy
    - OWS SAS Deploy
    - OWS Meteroid Shield Deploy
  - AM Bus 1 and 2
  - OWS Bus 1 and 2
- AM Instrumentation - Telemeters information of SWS event occurance and systems status
- AM DCS - Ground commanded event control
- IU - Automatic event sequencing and attitude control of the SWS
- IU Instrumentation - Telemeters IU system status and vehicle attitude information
- ATM APCS - Attitude control of the SWS after IU/ATM APCS switch over
- ATM DCS - Ground commanded ATM event control and SWS navigation updates
- ATM Instrumentation - Telemeters ATM systems status and vehicle attitude information

2.11.3 SEQUENTIAL CONTROL

Sequential control of the SWS is provided by the IU, the AM DCS, the ATM APCS, and the ATM DCS (figure 2.11.3-1).

2.11.3.1 IU

The IU provides guidance, navigation and event sequencing capability to the SWS and booster vehicle from liftoff through approximately 7.5 hours. The IU functional components are the Launch Vehicle Digital Computer (LVDC). Launch Vehicle Data Adapter (LVDA), Command Receiver and Decoder, Stabilized Platform, Control Computer, and switch selectors located in the IU, S-IC, S-II, and OWS. The LVDC is a general purpose computer that provides guidance, navigation attitude control, event sequencing, and ground command processing under control of a stored flight program. The three-gimbal stabilized platform (ST-124) provides a space-fixed coordinate reference frame for attitude control and navigation measurements. These measurements are combined in the LVDC with the computed gravitational acceleration to obtain velocity and position of the vehicle. The LVDA is the input/output device for the LVDC. It performs the signal processing required to make the signals acceptable to the LVDC or the other interfacing hardware. Automatic event sequencing is accomplished by the four switch selectors under control of the LVDC. The switch selectors decode digital flight sequence commands from the LVDC/LVDA and activate the proper control circuit to execute the commands. The OWS switch selector provides control commands to the payload shroud, AM, MDA, ATM, and OWS systems. The IU, S-IC, and S-II switch selectors provide control to those respective modules.

Attitude control during boost is provided by commands through the control computer to the S-IC and S-II engine actuators. Attitude control after orbital insertion and for the next 4.5 hours is provided by the IU the thruster attitude control system and then by the ATM attitude pointing and control system through the SL-4 mission.

The IU command receiver and decoder (part of the IU command and communications system) provides capability of updating information in the LVDC such as guidance, navigation and event sequencing.

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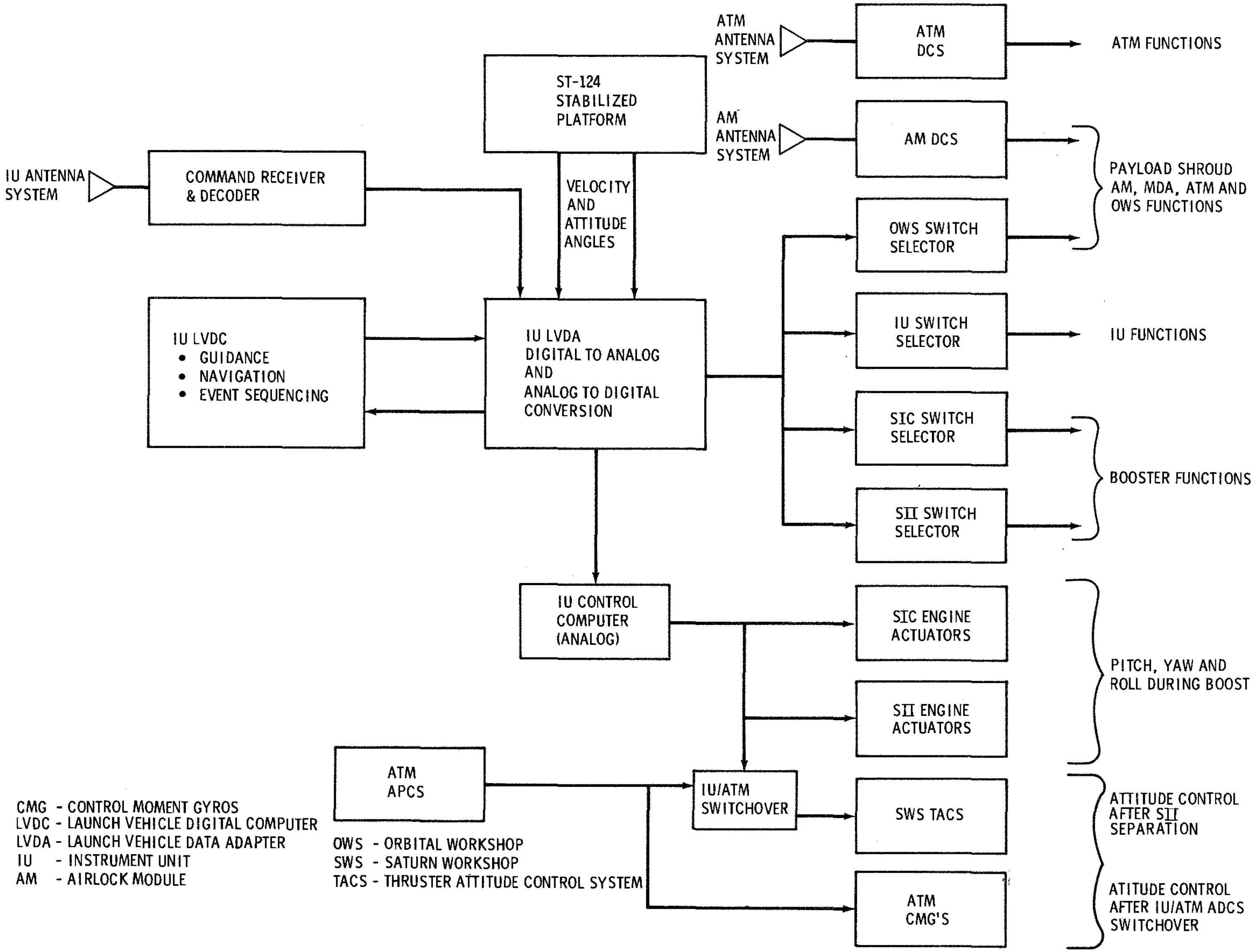



CMG - CONTROL MOMENT GYROS
LVDC - LAUNCH VEHICLE DIGITAL COMPUTER
LVDA - LAUNCH VEHICLE DATA ADAPTER
IU - INSTRUMENT UNIT
AM - AIRLOCK MODULE

OWS - ORBITAL WORKSHOP
SWS - SATURN WORKSHOP
TACS - THRUSTER ATTITUDE CONTROL SYSTEM

Figure 2.11.3-1 SWS Sequential Control

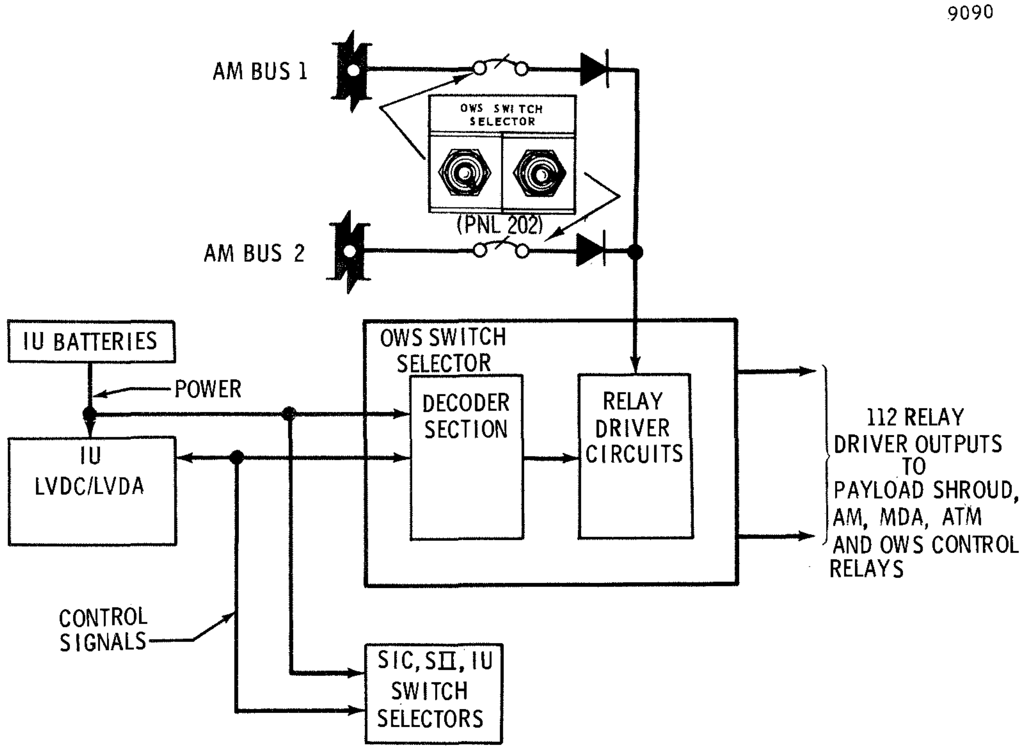



Figure 2.11.3-2 OWS Switch Selector Power

The IU flight program for event sequencing is divided into four primary time bases and one alternate time base.

- TB 1 - Initiated by a liftoff signal at umbilical disconnect
- TB 2 - Initiated at S-IC inboard engine cutoff
- TB 3 - Initiated at S-IC outboard engines cutoff
- TB 4 - Initiated at cutoff of the S-II engines
- TB 4b - Provide IU to ATM APCS TACS switch over if the IU guidance reference fails between TB4+53 min and TB4+6:21:10.6, hr:min:sec

TB 4 is used for automatic activation of SWS systems from S-II cutoff to end of IU lifetime at 7.5 hours into the mission. Ground commands through the IU are inhibited until TB4+0 sec by LVDC software lockout.

Electrical power to the OWS switch selector relay driver circuits is provided by AM Bus 1 and 2 through OWS switch selector circuit breakers 1 and 2 on panel 202 (figure 2.11.3-2).

2.11.3.2 AM DCS

The AM DCS provides backup control of critical functions controlled by the IU and prime control of many functions not assigned to the IU. All commands processed by the AM DCS must be initiated and sequenced by the ground controllers. No automatic sequencing is available through the AM DCS, and due to range safety requirements AM DCS commands are not used until orbital insertion.

2.11.3.3 ATM DCS

The ATM DCS provides control to ATM functions through switch selectors located in the ATM module, and update capability to the ATM APCS primary (secondary) computer. ATM DCS is activated during the ATM APCS initialization sequence at 01:05:56 Hr:Min:Sec Ground Elapsed Time (G.E.T).

2.11.3.4 ATM APCS

The ATM APCS provides attitude control from approximately 4.65 hours G.E.T until the termination of SL-4. Attitude control is provided by the control moment gyros (CMG) and supplemented by the TACS as required. Initialization of the APCS to the standby mode occurs at 01:05:56 Hr:Min:Sec G.E.T. Initialization includes turn on of the ATM primary computer, rate gyros, control moment gyros, and sun sensors. Switchover from IU to APCS enables APCS control of the TACS and places the CMG's in the active control mode, CMG spinup will be approximately 25 to 30 percent of the nominal rotational velocity at switchover.

## 2.11.4 SEQUENTIAL EVENTS

The following section describes the sequence of events, sequence categories, interlocks, and SL-2 launch commit criteria as a function of SWS status.

### 2.11.4.1 SEQUENCE EVENT CATEGORIES

The sequential events are divided into three basic event categories:

SC-I - Time Critical Functions
SC-II - Sequence Critical Functions
SC-III - Not time or sequence critical

### 2.11.4.2 INTERLOCKS

Event interlocks are associated with the IU automatic control sequence in the following table:

| EVENT | INTERLOCKED EVENT | REMARKS |
|---|---|---|
| S-II Separation | IU Control of TACS | Enabled by breakwire between S-II and Payload Interface |
| Payload Shroud Jettison | ATM Deploy | Enabled by separation of lanyard connectors on each PS segment |
| ATM Deploy | ATM SAS Deploy | Enabled by limit (toggle) switches actuated when ATM is deployed and locked |
| OWS SAS Beam Fairings Deploy | OWS SAS Wing Deploy<br>OWS Meteoroid Shield Deploy | Enabled by 2 of 3 voting limit switches actuated when both beam fairings are deployed and locked |

The interlocked functions are implemented in the relay control circuits and not in the LVDC program logic. If the IU control circuits fail, AM DCS commands must be used to complete the event and enable IU control of the succeeding interlocked event. No event interlocks are associated with either the prime or backup AM DCS controlled events.

### 2.11.4.3 SL-2 CSM LAUNCH COMMIT CRITERIA AS A FUNCTION OF SWS STATUS

- o Payload Shroud jettisoned and positioned to preclude contact with the CSM during ascent
- o S-II stage separated, safed, and positioned to preclude contact with the CSM during ascent
- o ATM deployed
- o Manned Space Flight Network/SWS Instrumentation and Communications established
- o Pressure integrity of the SWS verified
- o ATM APCS activated, operating, and solar inertial attitude maintained
- o OWS and ATM solar ar·ays deployed and operating
- o SWS Environmental Control, Electrical Power, Attitude Control, Communications, and Data Systems operating within limits required for successful manned habitation

### 2.11.4.4 SWS LIFTOFF CONFIGURATION

IU ACTIVE

ATM
TCS - OFF
EPS - BATTERIES ON
APCS - OFF
EXPERIMENT CANISTER - LAUNCH LOCKED CONFIGURATION

AM/MDA/OWS
EPS - BATTERIES ON
SEQUENTIAL BUS 1 and 2 - OFF
DEPLOY BUS 1 and 2 - OFF
REG BUS 1 and 2 - ON
OWS BUS 1 and 2 - ON
AM/ATM EPS OPERATING INDEPENDENTLY

COMMUNICATIONS
VHF RANGING - OFF
2 WATT LAUNCH XMITTER - ON
RF LINK VIA LAUNCH and CMD STUBS

ECS
MDA VENT VLVS - OPEN
OWS REFRIGERATION SYSTEM - OFF
OWS HABITATION AND WASTE TANKS PRESSURIZED TO 25±1 PSIA
AM PRI COOLANT LOOP IN RADIATOR BYPASS MODE
AM SEC COOLANT LOOP - OFF
OWS RADIANT HEATERS - OFF
AM/MDA WALL HEATERS - OFF
OWS RADIATOR SHIELD - SECURED

CREW SYSTEMS
TRACKING LIGHTS - OFF
DOCKING LIGHTS - OFF

2.11.4.4 SWS LIFTOFF CONFIGURATION (cont'd)

INSTRUMENTATION
REAL TIME - ON
TAPE RECORDERS - OFF

DCS/TRS
PRI and SECONDARY RECEIVER DECODERS - ON
PRI ELECTRONIC TIMER - ON

STRUCTURAL
PAYLOAD SHROUD (Launch Configuration)
ATM (stowed)
ATM SAS (stowed)
DISCONE ANTENNAS (stowed)
OWS SAS (stowed)
METEOROID SHIELD (stowed)

2.11.4.5 SEQUENTIAL EVENTS FROM LIFTOFF TO SL-2 CSM DOCKING

| FUNCTION | EVENT CATEGORY | SEQUENCE TIME | REMARKS |
|---|---|---|---|
| SL-1 SWS Launch | SC-1 | TB1 + 0.0 sec | SL-1 launch is assumed to occur at 1230 hours Eastern Standard Time (EST) on 30 April 1973 (Preliminary Attitude and Event Timeline) TB1 = IU umbilical disconnect. |
| Close Multiple Docking Adapter (MDA) Vent Valves | SC-II | TB1 + 272 sec | MDA Vent Valves are open at SL-1 liftoff to vent the MDA during boost. MDA vent valves are closed during ascent to maintain internal pressure of nitrogen at 0.5 psia. Maximum valve closing time of 16 sec is assumed. Valves must be fully closed by TB1 + 288 sec. Initiated by IU automatic sequencing (two commands, one for each of two series-arranged valves) Time based upon blowdown to 0.5 psia. |
| S-II Outboard Engine Cutoff (OECO) | SC-II | TB1 +578 sec = TB4 + 0.0 sec | Initiated by LVDC command based on velocity sensing. LVDC will reissue the OECO command as a backup. OECO time can vary $\pm$10 sec depending on flight performance. IU CCS enabled at TB4+0 sec. |
| S-II/Payload Separation and Thruster Attitude Control System (TACS) Activation | SC-I | TB4 + 2.0 sec | IU LVDC issues S-II/payload separation signal at TB4 +2 sec. Separation will occur immediately after completion of S-II engine thrust decay to preclude S-II recontact with the SWS. Initiated by IU automatic sequencing with IU Command and Communication System (CCS) backup. TACS will provide attitude control from S-II separation until transfer of control to CMG's, and thereafter to supplement CMG's as required. TACS activated by wire disconnect across separation interface. |
| Activate AM Data Recorders (Data 1 and Data 2) | SC-III | TB4 + 5 sec | Recorders are not qualified to be active in the boost environment. Initiated by AM DCS. |
| Activate AM Sequential Buses 1 and 2 | SC-II | TB4 + 5 sec | Sequential buses are supplied power by AM buses. Sequential bus power required for refrigeration system radiator protective shield jettison, Payload Shroud (PS) jettison, and ATM deployment. Initiated by IU automatic sequencing (AM DCS backup). Buses can only be deactivated manually. |
| Jettison Orbital Workshop (OWS) Refrigeration System Radiator Protective Shield | SC-II | TB4 + 8 sec | Cover is required during S-II stage separation for radiator protection from retrorockets. Jettison required for radiator operation. Initiated by IU automatic sequencing (AM DCS backup). |
| SWS Orbital Insertion | SC-II | TB4 + 10 sec | Time is based on OECO + 10 sec. |
| Pitch to Retrograde through Gravity Gradient Attitude | | TB4 + 10 sec, $\Delta$T = 11.7 min | Required for PS jettison and Solar Inertial Attitude acquisition. Initiated by IU automatic sequencing (IU CCS backup). |

2.11.4.5 SEQUENTIAL EVENTS FROM LIFTOFF TO SL-2 CSM DOCKING (cont'd)

| FUNCTION | EVENT CATEGORY | SEQUENCE TIME | REMARKS |
|---|---|---|---|
| Activate OWS Refrigeration System | SC-I | TB4 + 20 sec | Refrigeration system activation follows radiator protective shield jettison. Must be activated early to reacquire chilldown condition for food storage and to freeze urine samples collected during first 24 hours of manned mission. Initiated by IU automatic sequencing (AM DCS backup). |
| Open OWS Habitation Area Pneumatic Vent Valves (2) and Waste Tank Vents (2) | SC-II | TB4 + 30 sec | Initiated by IU automatic sequencing (IU CCS backup). |
| Jettison Payload Shroud | SC-II | TB4 + 5 min 30 sec | PS jettison at gravity gradient $\pm 10°$ is required for mission continuation. Initiated by IU automatic sequencing (AM DCS backup). |
| Activate AM Deploy Buses 1 and 2 | SC-II | TB4 + 5 min 45 sec | Deploy bus switch must be in CMD position at SL-1 liftoff. Deploy buses are required to provide power for deployment of AM discone antennas, ATM and OWS solar arrays, and OWS meteoroid shield. Initiated by IU automatic sequencing (AM DCS backup). Deactivated after OWS meteoroid shield deployment sequence (ref TB4+90 min). |
| Deploy AM Discone Antennas | SC-II | TB4 + 6 min 15 sec $\Delta T$ = 32 sec nominal and 42 sec maximum | AM deploy buses must have been activated to supply power for this function. PS must have been jettisoned prior to antenna deployment because of structural interference. Initiated by AM DCS command (prime and backup). |
| Initiate ATM Deployment Sequence | SC-II | TB4 + 6 min 30 sec $\Delta T$ = 4 min nominal and 8 min maximum | ATM deployment is required for CSM docking, ATM experiment operations, and ATM solar array deployment. AM sequential buses must be activated to supply ATM deployment power. PS must have been jettisoned. Initiated by IU automatic sequencing (AM DCS backup). ATM deployment motors are cut off 18 sec after latching, by timers actuated by limit switches on ATM latching mechanism. |
| Deactivate AM Real Time Telemetry System | SC-II | TB4 + 6 min 57 sec | Deactivated prior to switching antennas and transmitters to prevent arcing in coax switches. Venting adequate to preclude arcing is not ensured for 24 hours. This deactivates the 2-watt launch transmitter. Initiated by AM DCS command (on-board control backup). |
| Transfer Telemetry Transmission and Command Launch Capability from launch Stub to Discone Antennas | SC-II | TB4 + 6 min 58 sec | Antenna switch (Discone/Stub/CMD) must be in CMD position at SL-1 liftoff. Transfer will be accomplished as soon as discones are deployed. Required to optimize SWS to Manned Space Flight Network (MSFN) communications. Initiated by AM DCS command. |
| Switch from AM 2-watt Transmitter A to AM 10-watt Transmitter A | SC-II | TB4 + 6 min 59 sec | Required to optimize SWS/MSFN communications. Switching will be performed after discone antenna deployment. Initiated by AM DCS command. No switching backup. |
| Activate AM Real Time Telemetry System | SC-II | TB4 + 7 min | This activates 10-watt transmitter. Initiated by AM DCS command. |
| Switch AM Primary Coolant Loop Radiator Flow from BYPASS to NORMAL, and activate AM secondary loop | SC-II | TB4 + 7 min 15 sec | Radiator flow switches for primary and secondary AM coolant loops must be in CMD position at SL-1 liftoff. Radiator bypass selector valve is switched to NORMAL after PS jettison to route coolant flow through radiator rather than through ground cooling heat exchanger, Initiated by AM DCS command (one command for each loop). |

2.11.4.5 SEQUENTIAL EVENTS FROM LIFTOFF TO SL-2 CSM DOCKING (cont'd)

| FUNCTION | EVENT CATEGORY | SEQUENCE TIME | REMARKS |
|---|---|---|---|
| Terminate Maneuver to Retrograde Attitude | SC-II | TB4 + 11 min 54 sec | Maneuver is terminated automatically by attitude sensing in IU. |
| Initiate ATM Solar Arrays Deployment Sequence | SC-II | TB4 +15 min ( ΔT = 3 min nominal, 10 min maximum) | Initiated by IU automatic sequencing (AM DCS backup). AM Deploy Buses must have been activated to supply power for solar array deployment. Deployment motors will be shut off at 12:17 min:sec into sequence by IU automatic sequencing if not shut off previously by switches on slider locks. |
| Close OWS Habitation Area Pneumatic Latching Vent Valve | | TB4 + 15 min | Latching vent valve is sequenced closed by IU automatic sequencing (IU CCS backup) prior to time predicted for pneumatic vent valve closure. |
| Activate ATM Telemetry System | SC-II | TB4 + 27 min | ATM telemetry system is required after ATM solar array deployment for transmission of ATM status. Initiated by IU automatic sequencing (prime and backup). |
| Close OWS Habitation Area Pneumatic Vent Valve | SC-II | TB4 + 30 min 38.5 ± 58.5 sec | Vent valve will be closed when habitation area pressure drops to 0.5 psia. Time shown is based on nominal venting rates to 0.5 psia. Initiated by IU automatic sequencing (IU CCS backup). |
| Acquire Solar Inertial Attitude | SC-I | TB4 + 34 min 30 sec ( ΔT = 9.6 min) | Maneuver to acquire solar inertial attitude will begin shortly prior to orbital midnight and will be completed shortly after orbital midnight. Solar inertial attitude is required prior to CSM rendezvous and to maximize power generating capabilities of solar arrays during sunlit portion of orbit. Initiated by IU automatic sequencing (IU CCS backup) |
| Deploy OWS Solar Arrays | SC-II | TB4 + 40 min 27 sec ΔT = 8 min | Initiated by IU automatic sequencing (AM DCS backup). Solar array beam/fairings are released deployed, and locked in deployed position. Solar panels are then released simultaneously from each beam/fairing. |
| Activate ATM Thermal Control System (TCS) | SC-I | TB4 + 43 min 40 sec | ATM TCS controls are configured at SL-1 liftoff as follows:<br>o PUMP switch -- PRIMARY<br>o CONTROLLER switch -- PRIMARY<br>o HEATER POWER switch -- AUTO<br>ATM solar arrays must have been deployed. ATM TCS and electronic equipment must be activated not later than 8 hours and 2 hours, respectively, after launch, and remain on continuously during all orbital mission phases. Initiated by IU automatic sequencing (ATM DCS backup available after ATM APCS activation at TB4 + 56 min 18 sec). |
| Activate OWS Radiant Heaters | SC-II | TB4 + 56 min | OWS radiant heater switches must be in CMD position at SL-1 liftoff. Required to raise OWS wall temperature for manned habitation. OWS radiant heaters must be energized within 1 hr after orbital insertion. Radiant heaters will be deenergized if OWS food containers or film vault temperatures exceed 75°F. Two commands required: one for each set of four heaters, on-board control backup. |

2.11.4.5 SEQUENTIAL EVENTS FROM LIFTOFF TO SL-2 CSM DOCKING (cont'd)

| FUNCTION | EVENT CATEGORY | SEQUENCE TIME | REMARKS |
|---|---|---|---|
| Activate ATM Attitude and Pointing Control System (APCS) | SC-II | TB4 + 56 min 18 sec | CMG spin vectors are in launch orientation at at SL-1 liftoff. APCS will be activated by by applying power to APCS buses (ATM EPS buses 7D12 and 7D22). Activation of APCS buses automatically activates ATM Digital Computers (DC's), associated Workshop Computer Interface Units (WCIU's), and ATM DCS. The ATM DC will automatically sequence activation of the CMG subsystem (including spinup), acquisition sun sensor, APCS rate gyros, and automatic checkout of APCS status. Initiated by IU automatic sequencing (AM DCS backup). |
| Initiate Meteoroid Shield Deployment Sequence | SC-II | TB4 + 86 min 10 sec $\Delta T$ = 3 sec | Power required for meteoroid shield deployment supplied from AM deploy buses. OWS meteoroid shield must be deployed prior to crew entry into OWS to provide OWS thermal control capability. Initiated by IU automatic sequencing (AM DCS backup). |
| Activate MDA Wall and Tunnel Heaters | SC-III | TB4 + 86 min 20 sec | MDA wall heaters are required to raise MDA wall temperature for manned habitation. MDA tunnel heaters are required to provide minimum temperature of MDA docking ring and MDA docking drogue of +50°F and -100°F, respectively, prior to CSM docking. MDA wall and tunnel heaters are both activated by same AM DCS command (backup) |
| Activate MDA Port Heaters | SC-III | TB4 + 86 min 21 sec | MDA port heaters are required to replace heat lost from MDA through major skin penetrations at two docking ports. Initiated by AM DCS (backup). |
| Pressurize OWS Habitation Area with Oxygen | SC-II | TB4 + 87 min, $\Delta T$ = 9 hr 22 min | O2 and N2 latching solenoid valves must be closed at SL-1 liftoff to prevent excessive gas loss in case of regulator failure during ascent. On-board control switches for O2 fill, N2 fill, and OWS fill valves must be in CMD position at SL-1 liftoff. OWS nominal pressure will be 5.0 $\pm$ 0.2 psia. OWS partial pressures are 3.7 $\pm$ + 0.2 psia of O2 and 1.3 psia of N2 as required. Primary and secondary fill valves are controlled by separate AM DCS commands. Pressurization is terminated by pressure switch (AM DCS backup). |
| Deactivate AM Deploy Buses | SC-II | TB4 + 90 min | AM deploy buses not required after meteoroid shield deployment. If AM deploy buses are activated by IU or AM DCS, they must be deactivated by IU or AM DCS, respectively. Initiated by IU automatic sequencing followed by AM DCS if required (on-board control backup). |
| Dump OWS Pneumatic System Bottle | SC-II | TB4 + 3 hr $\Delta T$ = 3 hr 45 min | Required to prevent loss of OWS habitation area pressure due to inadvertent opening of OWS habitation area pneumatic vent valves. Initiated after OWS venting and terminated during IU lifetime. Initiated by IU automatic sequencing (no backup). |
| Parallel ATM and MDA/AM/OWS Electrical Power Systems (EPS) | SC-II | TB4 + 4 hr 30 min $\Delta T$ = 3 min | ATM and MDA/AM OWS power systems will be paralleled to provide power sharing capabilities during peak loads. Initiated by AM DCS. (on-board backup) |

2.11.4.5 SEQUENTIAL EVENTS FROM LIFTOFF TO SL-2 CSM DOCKING (cont'd)

| FUNCTION | EVENT CATEGORY | SEQUENCE TIME | REMARKS |
|---|---|---|---|
| Transfer SWS Attitude Control from IU to APCS | SC-I | TB4 + 4 hr 30 min | IU provides guidance and navigation for SWS launch vehicle from launch until APCS takeover, which cannot be longer than 7.5 hr after SL-1 launch. Initiated by IU automatic sequencing (AM DCS backup). Capability to switch back from ATM to IU is available for 7.5 hrs through the AM DCS only. IU to SWS sequential control through the OWS switch selector is not affected by attitude control switchover. |
| End of IU Guaranteed Life | SC-I | TB4 + 7 hr 20 min | The IU is capable of operating for 7.5 hr after launch of SL-1. |
| Pressurize MDA/AM with Oxygen | SC-II | TB1 + 11 hr 25 min<br>$\Delta T$ = 1 hr 40 min | On-board control switches for O2 fill, N2 fill, and AM fill valves must be in CMD position at SL-1 liftoff. MDA/AM nominal pressure is 5.0 $\pm$0.2 psia. MDA/AM nominal partial pressures are 3.7 psia of O2 and 1.3 psia of N2, as required. Primary and secondary fill valves controlled by separate AM DCS commands. Terminated by pressure switch (AM DCS backup) control of both valves. |
| SL-2 CSM Launch | SC-I | TB1 + 23 hr 30 min | Compliance with launch commit criteria in the mission requirements document (MRD) will be a prerequisite to CSM launch. |
| Turn off OWS Radiant Heaters | SC-II | *TBS | OWS radiant heaters will be turned off prior to acquiring Z-LV(R) to conserve electrical power during two orbits in Z-LV(R). Initiated by AM DCS command (no backup). |
| SWS acquire and maintain Z-LV(R) Attitude | SC-I | *TBS<br>$\Delta T$ = 3 hr 6 min | Z-LV(R) attitude maneuver will be initiated at approximately orbital midnight and maintained for two orbits to optimize very high frequency (VHF) angular ranging capability and tracking light visibility. Initiated by ATM DCS command (no backup). |
| Turn on SWS Acquisition (Tracking) Lights | SC-I | *TBS | Flashing lights are required for CSM visual tracking and provide continuous coverage from 300 nm to 1 nm. Initiated by AM DCS command (primary and backup). |
| Activate SWS VHF Ranging | SC-I | *TBS | VHF ranging required from a maximum distance of 300 nm to a minimum distance of 500 ft. Initiated by AM DCS command (primary and backup). |
| SWS reacquire Solar Inertial Attitude | SC-I | *TBS | Docking will be accomplished in solar inertial attitude. Initiated automatically by ATM APCS at approximately at orbital midnight. (ATM DCS backup). |
| Switch MDA Wall Heaters to 70° thermostat | SC-II | *TBS | Required to raise MDA wall temperature for manned habitation. Switched to higher temperature mode after SWS reacquires solar inertial attitude. Switched by AM DCS command (no backup). |
| Turn on OWS Radiant Heaters | SC-II | *TBS | OWS radiant heaters are turned off to conserve power while in Z-LV(R) Attitude. Heaters are turned on to raise OWS wall temperature for manned habitation. Activated by AM DCS command. |
| Turn on SWS Docking (running) Lights (Rendezvous dependent) | SC-II | *TBS | Docking lights provide vehicle gross attitude reference determination. Initiated by AM DCS command (lights divided into two groups, one command for each group; one group is sufficient for docking). |

2.11.4.5 SEQUENTIAL EVENTS FROM LIFTOFF TO SL2 CSM DOCKING (cont'd)

| FUNCTION | EVENT CATEGORY | SEQUENCE TIME | REMARKS |
|---|---|---|---|
| Turn off SWS Acquisition (Tracking) Lights (Rendezvous dependent) | SC-II | *TBS | Acquisition (tracking lights will be turned off prior to docking when CSM is approximately 1 nm. from the SWS. Turned off by AM electronic timer Tx function (AM DCS backup). |
| Deactivate SWS VHF Ranging Transponder (Rendezvous dependent) | SC-II | *TBS | VHF ranging no longer required when CSM is less than 500 ft from SWS. Deactivated by AM DCS command (primary and backup). |
| CSM dock to Axial Port of MDA | SC-III | *TBS | CSM will dock to MDA axial docking port. SWS must be in solar inertial (Z-IOP/Z) attitude for docking. |
| Turn off SWS Docking (Running) Lights | SC-III | *TBS | Docking (running) lights are not required after CSM docking. Turned off by AM DCS (one command for each group, on-board control backup). |
| Change ATM APCS control gains to docked configuration | SC-III | *TBS | APCS control gains must be changed within one revolution after CSM docking (changed by ATM DCS command) |

* Sequence time is a function of the number of CSM orbits prior to docking. The orbit number varies as a function of the CSM launch time, with nominal being 5 orbits, and maximum being 8 orbits.

# SECTION 3.0

## CONTROLS AND DISPLAYS

### INTRODUCTION

This section contains detailed descriptions of all SWS controls and displays, with the exception of those for the ATM and Experiments, which are referenced to the applicable SLOH. A table of cross-references for quick and easy reference to any control or display, is provided in Appendix C. This table lists each item alphabetically by system, the panel that contains the item, and the page number on which the item is to be found.

Panel numbers in this section are those numbers printed on each panel and on the panel illustration preceding each tabulated list. Crew station/panel designations are presented in figure 3.0-1. Column headings for the tabular presentation, and the description of the entries made under each, are as follows:

o Location. Notes the location, by panel number, of a particular control or display in the SWS, and lists the crew station designation.

CREW STATION DESIGNATORS

| | |
|---|---|
| CM | Command Module |
| M | MDA; Forward and Aft Compartment |
| ST | Structural Transition Section |
| A | AM; Forward, Lock and Aft Compartment |
| VF | FAS Workstation |
| VR | Replacement Workstation |
| D024 | D024 Sample Panels |
| VC | ATM Center Workstation |
| VT | ATM Workstation Transfer |
| VS | ATM Sun End Workstation |
| D | OWS Forward Dome |
| E | OWS Experiment Compartment |
| F | OWS Forward Compartment |
| S | OWS Sleep Compartment |
| W | OWS Wardroom |
| H | OWS Waste Management Compartment |
| P | OWS Aft Compartment (Plenum Area) |

o Item. Notes the type of control or display. The abbreviations utilized for the type of control or display are listed below.

TYPE OF CONTROL OR DISPLAY

| | |
|---|---|
| cb | Circuit Breaker |
| conn | Connector |
| ht | Hatch |
| hndl | Handle |
| ind | Indicator (meter) |
| knob | Knob |
| lt | Light |
| pot | Potentiometer |
| qd | Quick Disconnect |
| sel | Selector Switch (rotary) |
| sw | Switch |
| tgl | Toggle |
| vlv | Valve |
| pb | Pushbutton |

o Name and Position. Gives the placarded nomenclature of the control or display and the control positions exactly as placarded on the panel. In the absence of placards, a functional name is assigned, and control positions are described.

o Function. Describes the function of each control position.

o Circuit Breaker. Gives the nomenclature and location of the circuit breaker(s) for circuit protection and electrical power control to each display or control component.

o Power Source. Identifies the immediate bus or source supplying power to each control or display.

o DCS Chnl. Gives the DCS octal word to execute the function from ground command.

o Remarks. Supplies additional data and information pertinent to the control or display.

7512

| ORBITAL ASSEMBLY CREW STATIONS | PANEL NUMBERS | STOWAGE NUMBERS |
|---|---|---|
| CM - COMMAND MODULE | - | - |
| M - MDA | 100 SERIES | M100 SERIES |
| ST - STS | 200 SERIES | M200 SERIES |
| A - AM; FWD, LOCK & AFT COMPT | 300 SERIES | A300 SERIES |
| VF - FASS | - | - |
| VC - ATM CWS | - | - |
| VT - ATM SUN END TRFR | - | - |
| VS - ATM SUN END WS | - | - |
| D - OWS DOME | 400 SERIES | D400 |
| E - OWS EXP | 600 SERIES | E600 |
| F - OWS FWD | 500 SERIES | F500 |
| S - OWS SLEEP | 900 SERIES | S900 |
| W - OWS WARD | 700 SERIES | W700 |
| H - OWS WMC | 800 SERIES | H800 |
| P - OWS PLENUM | 1000 SERIES | |

PANEL

| NO. | NAME |
|---|---|
| 100 | AXIAL HATCH |
| 101 | INT LIGHT PNL |
| 102 | INTERCOM BOX |
| 103 | VENT PNL |
| 104 | UTILITY OUT 3 |
| 105 | M512 EXP |
| 106 | S190 EXP |
| 107 | WINDOW COVER LATCH |
| 108 | WINDW COVER CRANK |
| 109 | S191 EXP O&C PNL |
| 110 | EREP PNL |
| 111 | S009 EXP |
| 112 | UTILITY OUT 1 |
| 113 | M512 CHBR VENT VLV |
| 114 | M512 BLKHD VENT VLV |
| 115 | HIGH PWR ACCY OUT 1 |
| 116 | INTERCOM BOX |
| 117 | WINDW HTR PNL |
| 118 | RADIAL HATCH |
| 120 | FIRE SENSOR CNTL PNL |
| 121 | DAS |
| 128 | RADIO NOISE BURST MON |
| 129 | RADIO NOISE BURST MON |
| 130 | ATM O&C PNL |
| 131 | INTERCOM BOX |
| 132 | VIDEO PNL |
| 133 | TV STATION |
| 134 | UTILITY OUT 2 |
| 135 | EREP COOL VLV |
| 136 | S192 EXP |
| 139 | HIGH PWR ACCY OUT 2 |
| 140 | UTILITY OUT 4 |
| 160 | ATM EXT CNST ROLL |

PANEL

| NO. | NAME |
|---|---|
| 200 | CB PNL (ECS/I&C) |
| 201 | CB PNL (EPS) |
| 202 | CB PNL (MISC) |
| 203 | CNTL PNL (ECS) |
| 204 | CNTL PNL (I&C) |
| 205 | CNTL PNL (EPS) |
| 206 | CNTL PNL (EPS, C&W) |
| 207 | CNTL PNL (LTG, C&W) |
| 208 | CNTL PNL (PROT SPECT) |
| 209 | CNTL PNL (TELEPRINT) |
| 210 | PCG CNTL SCH |
| 211 | BUS DISTR. SCH |
| 212 | CLOCK |
| 213 | UTILITY OUT 1 |
| 214 | UTILITY OUT 2 |
| 216 | CNTL PNL (CNDSATE) |
| 217 | CNTL PNL (IVA) |
| 218 | MOL SV B VENT VLV |
| 219 | UTILITY OUT 3 (MOL SV B BED $N_2$ VLV) |
| 220 | MOL SV A VENT VLV |
| 221 | UTILITY OUT 4 (MOL SV A BED $N_2$ VLV) |
| 223 | SYS 1 LCG RES PRESS VLV |
| 224 | SYS 2 LCG RES PRESS VLV |
| 225 | $O_2/N_2$ CNTL SYS PNL |
| 226 | MOL SV A VLV CNTL |
| 227 | MOL SV B VLV CNTL |
| 228 | MOL SV A BED VLVS |
| 229 | MOL SV B BED VLVS |
| 230 | MOL SV A HT EXCH CNTL PNL |
| 232 | MOL SV B HT EXCH CNTL PNL |
| 233 | MOL SV A AIRFLOW VLV PNL |
| 234 | MDA/OWS AIR SEL VLV |
| 235 | ATM CLNT RES PRESS VLV |
| 236 | FIRE SENSOR CNTL PNL |
| 237 | FIRE SENSOR CNTL PNL |
| 238 | FIRE SENSOR CNTL PNL |
| 239 | MOL SV B AIRFLOW VLV PNL |
| 241 | STS WINDOW CRANK +Z |
| 242 | STS WINDOW CRANK +Y |
| 243 | STS WINDOW CRANK -Z |
| 244 | STS WINDOW CRANK -Y |

PANEL

| NO. | NAME |
|---|---|
| 390 | CNTL PNL (OWS, LTG, TCS) |
| 391 | CABIN PRESS RELIEF VLV |
| 392 | FIRE SENSOR CNTL PNL |
| 393 | CONDENSATE DUMP PORT |

PANEL

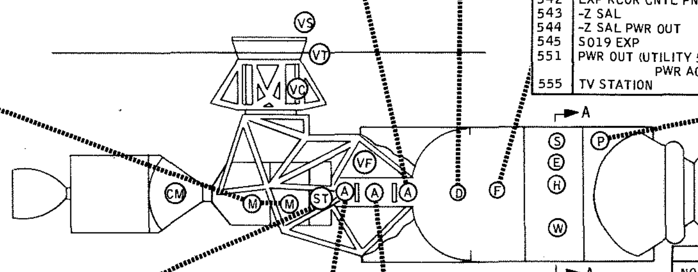
| NO. | NAME |
|---|---|
| 400 | OWS HATCH, PRESS EQ VLV |
| 401 | INTERCOM BOX |
| 402 | PWR OUT (UTILITY 1&2 HIGH PWR ACCY 1&2) |
| 403 | SOLENOID VENT PORT |
| 404 | TV STATION |
| 405 | PNEUMATIC VENT PORT |

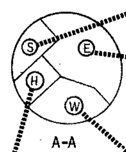
PANEL

| NO. | NAME |
|---|---|
| 500 | WATER SYS PRESS PNL |
| 517 | +Z SAL |
| 518 | +Z SAL PWR OUT |
| 520 | INTERCOM BOX |
| 521 | PWR OUT (UTILITY 1&2 HIGH PWR ACCY 1&2) |
| 522 | T020 EXP |
| 523 | M509 EXP |
| 524 | T027 EXP |
| 525 | S020 EXP |
| 527 | M172EXP |
| 530 | FIRE SENSOR CNTL PNL |
| 531 | FIRE SENSOR CNTL PNL |
| 531 | PWR OUT (UTILITY 3&4, HIGH PWR ACCY 3&4) |
| 534 | T013 EXP |
| 540 | INTERCOM BOX |
| 542 | EXP RCDR CNTL PNL |
| 543 | -Z SAL |
| 544 | -Z SAL PWR OUT |
| 545 | S019 EXP |
| 551 | PWR OUT (UTILITY 5&6 HIGH PWR ACCY 5&6) |
| 555 | TV STATION |

PANEL

| NO. | NAME |
|---|---|
| 1001 | REFR PUMP PKG VAC VENT VLV |




PANEL

| NO. | NAME |
|---|---|
| 300 | CABIN PRESS RELIEF VLV |

PANEL

| NO. | NAME |
|---|---|
| 311 | FWD HATCH |
| 312 | FWD HATCH HANDLE |
| 313 | CABIN PRESS RELIEF VLV |
| 316 | EVA SUPPORT CNTL PNL |
| 317 | EVA PNL 1 |
| 318 | LOCK DEPRESS VLV |
| 319 | EVA HATCH HANDLE |
| 320 | TV STATION |
| 321 | EXTENDIBLE BOOM PNL |
| 323 | EVA PNL 2 |
| 325 | AFT HATCH |
| 326 | AFT HATCH HANDLE |

PANEL

| NO. | NAME |
|---|---|
| 600 | INTERCOM BOX |
| 601 | UTILITY OUT 1&2 |
| 607 | FLARE ALERT PNL |
| 610 | CLOCK |
| 611 | CB PNL REFRIG |
| 612 | CB PNL HI PWR & UTIL OUT, TV |
| 613 | CB PNL LTG, EXP, C&W |
| 614 | CB PNL HSS TCS |
| 615 | CB PNL EPS |
| 616 | CB PNL LTG, REFRIG, C&W |
| 617 | CB PNL EPS, INSTR, TCS |
| 618 | FIRE SENSOR CNTL PNL |
| 619 | FIRE SENSOR CNTL PNL |
| 620 | ESS/M171 $N_2$ SUPPLY PNL |
| 621 | M092 EXP |
| 622 | METABOLIC ANALYZER |
| 623 | ESS |
| 624 | M171 EXP |
| 625 | M092 VAC VENT VLV |
| 627 | INTERCOM BOX |
| 628 | UTILITY OUT 3&4 |
| 630 | CNTL PNL WARDRM/WMC LTGS |
| 631 | PWR OUT (UTILITY 5&6, HIGH PWR ACCY 1&2) |
| 632 | M131 EXP |
| 633 | FIRE SENSOR CNTL PNL |
| 634 | TRASH AIRLOCK |
| 638 | FIRE SENSOR CNTL PNL |
| 639 | FIRE SENSOR CNTL PNL |
| 640 | VAN ALLEN BELT DOSIMETER |
| 642 | TV STATION |

PANEL

| NO. | NAME |
|---|---|
| 901 | INTERCOM BOX |
| 902 | INTERCOM BOX |
| 903 | INTERCOM BOX |
| 904 | M133 EXP |

PANEL

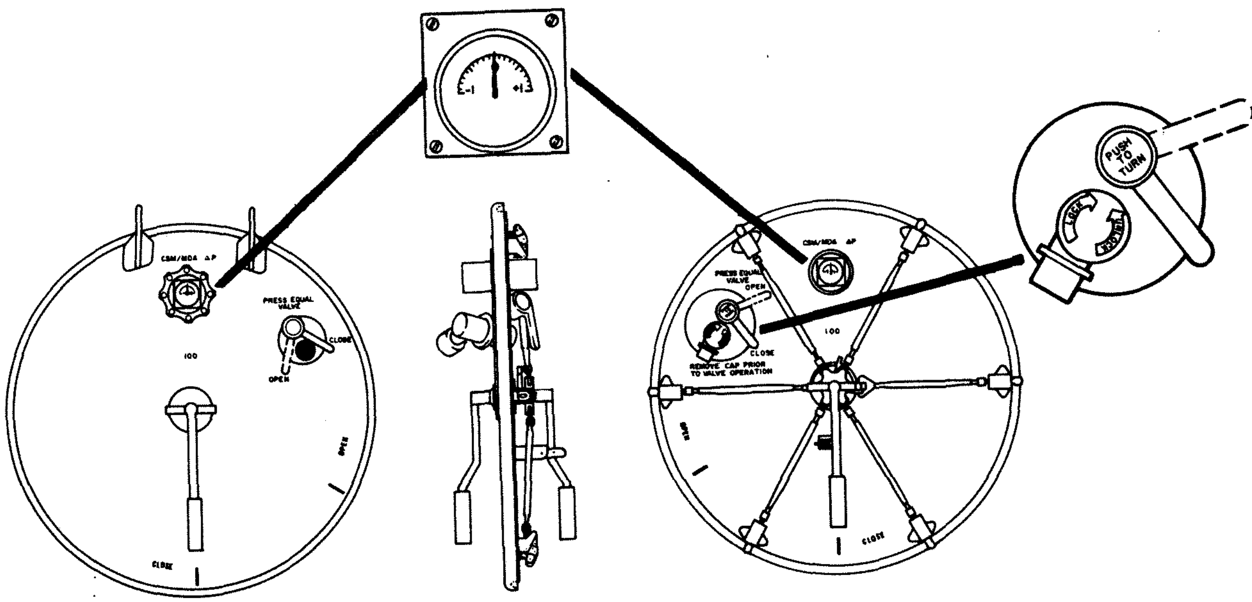
| NO. | NAME |
|---|---|
| 700 | CNTL PNL $H_2O$ DUMP/ WINDW HTR |
| 701 | S063 UV SYNC |
| 702 | INTERCOM BOX |
| 703 | M074 EXP |
| 705 | FOOD PREP TABLE |
| 706 | WATER DUMP VLV |
| 707 | FOOD TRAY 1 OUTLET |
| 708 | FOOD TRAY 2 OUTLET |
| 709 | FOOD TRAY 3 OUTLET |
| 711 | PWR OUT (UTILITY 1 & 2) |

PANEL

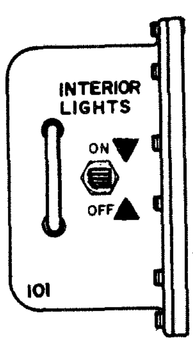
| NO. | NAME |
|---|---|
| 800 | CNTL PNL WMC |
| 801 | INTERCOM BOX |
| 803 | PWR OUT (UTILITY 1&2 HIGH PWR ACCY 1&2) |
| 817 | CB PNL WASTE PROCESSOR |
| 818 | PROCESSOR VENT / URINE DUMP |
| 822 | M074 EXP |
| 825 | FECAL/URINE COLLECTOR |
| 831 | WATER DUMP VLV |

Figure 3.0-1 Crew Station/Panel Designation

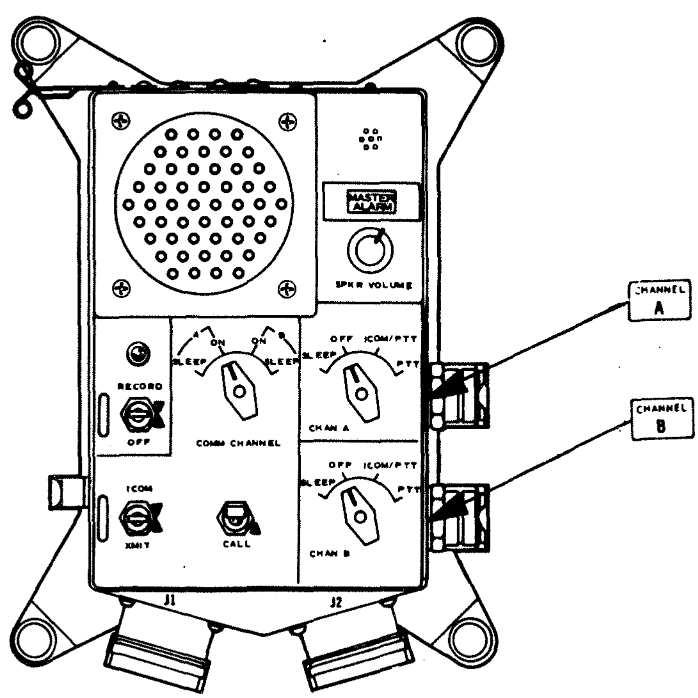
P1




100 SHOWN (AXIAL)




101




102

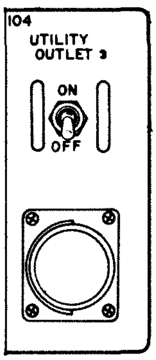
| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | ht | AXIAL HATCH | | | | | Unless noted, these controls and displays are typical for both the CSM and MDA sides |
| 100 | M | gage | CM/MDA $\Delta$P | Differential pressure gage (+1 to -1 psia); displays a direct reading of any differential pressure between the CM and MDA at time of entry | | | | Typical for panel 118 |
| 100 | M | vlv | PRESS EQUALIZATION VALVE | | | | | |
| | | | OPEN | Opens hatch (PRESSURE EQUALIZATION VALVE) to relieve any CM/MDA differential pressure; butterfly type valve is mounted in hatch | | | | |
| | | | CLOSE | Closes (PRESSURE EQUALIZATION VALVE) | | | | |
| | | | cap | Protects valve from dirt or debris | | | | CM side only; secured with chain lanyard |
| 100 | M | hndl | RELEASE HANDLE | | | | | |
| | | | OPEN | Retracts hatch latches to open hatch | | | | Hatches and latching bars are CM side only |
| | | | CLOSE | Engages hatch latches to lock and secure hatch | | | | |
| | | | INTERIOR LIGHTS | | | | | |
| 101 | M | sw | ON | Turns on all MDA floodlights | COMPARTMENT LIGHT MDA 1 & 2 (pnl 202) | AM BUS 1&2 | | OFF-LO-HI integral light sw is contained within all MDA lights and controls their intensity<br>These lights can also be controlled by the MDA FWD 1 & 2 and MDA AFT 1 & 2 light switches (pnl 207) |
| | | | (ctr) | Normal position of switch | | | | |
| | | | OFF | Turns above off | | | | Momentary switch which returns to center position |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | INTERCOM BOX | | | | | |
| 102 | M | lt | MASTER ALARM | Illuminates when a caution, warning or emergency parameter exceeds the operating limits | MASTER ALARM STATUS LTS 1 (pnl 202) | AM BUS 1 | | Typical for panels 116, 131, 401, 520, 540, 600, 627, 702, 801, 901, 902 and 903 |
| | | | | | MASTER ALARM STATUS LTS 2 | AM BUS 2 | | Master alarm lt contains dual lamps |
| 102 | M | pot | SPKR VOLUME | Adjusts the speaker output volume | INTERCOM A INTERCOM B (pnl 200) | AM BUS 1 AM BUS 2 | | Affects voice signals only. C&W tones bypass speaker volume control |
| 102 | M | lt | RECORD | Illuminates when voice recording is initiated and the DATA recorder is recording | VOICE RCDR LTS (pnl 200) | AM BUS 1 | | NOTE: If light extinguishes (typically due to ground initiated recorder dump) while recording on EXP 1 or 2 recorders, voice will be recorded on these recorders |
| 102 | M | sw | [RECORD/OFF] | | | | | |
| | | | RECORD | Initiates voice and data recording on the DATA recorder. Also enables EXP 1 and EXP 2 recorders to record voice if they are in record mode | AUDIO SYS INTERCOM A (pnl 200) | AM BUS 1 | | Selected channel must correspond with INST SYS RCDR AUDIO sw (pnl 204) for proper voice recording |
| | | | (ctr) | Normal position of switch | | | | Momentary switch with return to the center position |
| | | | OFF | Disables voice recording | | | | |
| 102 | M | sel | COMM CHANNEL | | | | | |
| | | | A-SLEEP | Deactivates the intercom box electronics and C&W tones except when overridden by a CALL or CREW ALERT signal | | | | |
| | | | A-ON | Activates the intercom box electronics and enables channel A voice and C&W tone interfaces | AUDIO SYS INTERCOM A (pnl 200) | AM BUS 1 | | |
| | | | B-ON | Activates the intercom box electronics and enables channel A voice and C&W tone interfaces | AUDIO SYS INTERCOM A (pnl 200) | AM BUS 1 | | |
| | | | B-SLEEP | Deactivates the intercom box electronics and C&W tones except when overridden by a CALL or CREW ALERT signal | | | | |

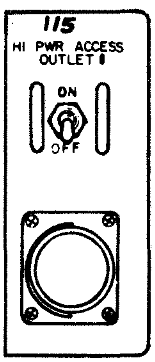
| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 102 | M | sel | CHAN A | | | | | |
| | | | SLEEP | Disables the CCU headset earphone output, microphone input, and C&W tones except when overridden by a CALL or CREW ALERT signal. Enables bio-med | AUDIO SYS CCU A (pnl 200) | AM BUS 1 | | |
| | | | OFF | Disables all outputs and inputs at the CCU A connector | | | | |
| | | | ICOM/PTT | Enables "hot mike" communication through the intercom "loop" on channel A without activation of the CCU [ICOM/XMIT] sw. | | | | |
| | | | | Enables CSM transmitter control logic to downlink the channel A audio signal to MSFN when the CCU switch is activated to XMIT | | | | |
| | | | | Enables bio-med, and C&W tones | | | | |
| | | | PTT | Enables the channel A intercom "loop" when the CCU sw is activated to ICOM and enables downlinking of the channel A audio signal when the CCU sw is activated to the XMIT position | | | | |
| | | | | Enables bio-med, and C&W tones | | | | |
| 102 | M | sel | CHAN B | Provides same functions on channel B as CHAN A sw provides on channel A | AUDIO SYS CCU B (pnl 200) | AM BUS 2 | | |
| 102 | M | sw | [ICOM/XMIT] | | | | | |
| | | | ICOM | Activates the respective intercom box microphone amplifier and disables the respective intercom box speaker amplifier (enables the intercom "loop") | AUDIO SYS INTERCOM A, B (pnl 200) | AM BUS 1,2 | | Enables respective intercom box microphone and disables the speaker |
| | | | (ctr) | Normal position of switch | | | | Momentary switch which returns to the center position |
| | | | XMIT | Enables the intercom "loop" and activates CSM transmitter control logic to downlink the R/T audio signal | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 102 | M | sw | [CALL] | | | | | |
| | | | (up) | Normal off position of switch | AUDIO SYS INTERCOM A, B (pnl 200) | AM BUS 1,2 | | Momentary switch which returns to the up position |
| | | | CALL | Enables the intercom "loop" on both channels simultaneously, and overrides the SLEEP mode on all switches | | | | AM bus 1 & 2 provide redundant power for call signal |

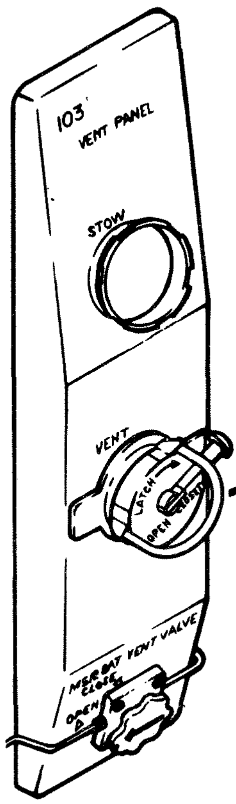
P2

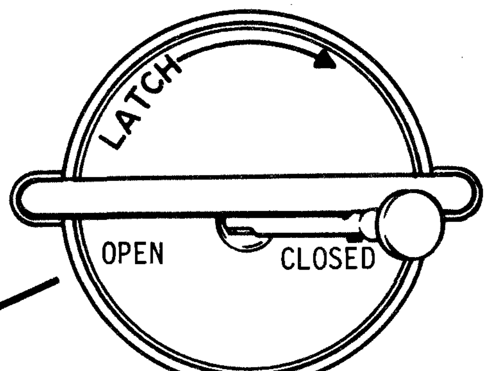



104

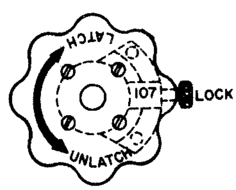



115

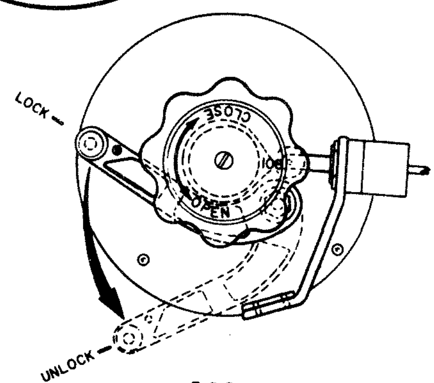



103



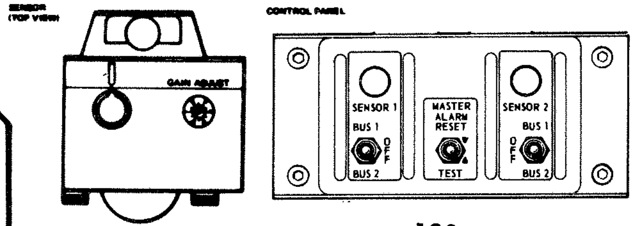

107



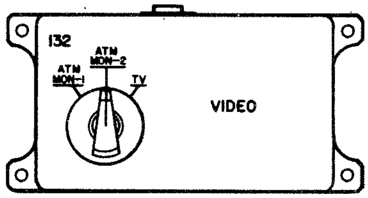

108

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | VENT PANEL | | | | | |
| 103 | M | conn | STOW | Prehabitation stowage location of the vent valve plug | | | | |
| | | conn | VENT | Vent line for the MDA/AM compartments | | | | |
| 103 | M | plug | [LATCH/OPEN/CLOSE] | | | | | |
| | | | OPEN | Allows vent plug to be removed from mating receptical | | | | Installed during activation Plugs the vent valve orifice in MDA |
| | | | CLOSE | Secures vent plug to be removed from mating receptical and provide seal | | | | |
| 103 | M | vlv | M512 BAT VENT VALVE | | | | | |
| | | | OPEN | Vents M512 battery case to space | | | | |
| | | | CLOSED | Seals M512 battery case from space | | | | Closed only after battery is discharged |
| | | | UTILITY OUTLET | | | | | |
| 104 | M | sw | UTIL OUTLET 2 | | | | | |
| | | | ON | Turns UTILITY OUTLET #2 on | UTIL PWR MDA 2 4 (pnl 202) | AM BUS 2 | | Typical for panels 104, 112, 134, 140, 213 and 390 |
| | | | OFF | Turns UTILITY OUTLET #2 off | | | | |
| 104 | M | conn | [connector] | Zero-G receptacle provides electrical power interface for a portable equipment plug | | | | |
| 105 | M | | Experiment M512 | --------------- Ref SLEOH --------------- | | | | |
| 106 | M | | Experiment S190 | --------------- Ref SLEOH --------------- | | | | |
| | | | WINDOW COVER LATCH | | | | | |
| 107 | M | knob | [LATCH/UNLATCH] | | | | | |
| | | | LATCH | Holds S190 window cover closed | | | | |
| | | | UNLATCH | Releases S190 window cover | | | | Rotate counterclockwise to UNLATCH |
| | | xnob | [LOCK] | | | | | |
| | | | LOCK | Thumb screw lock on window cover latch handle | | | | Pull and turn to UNLOCK |

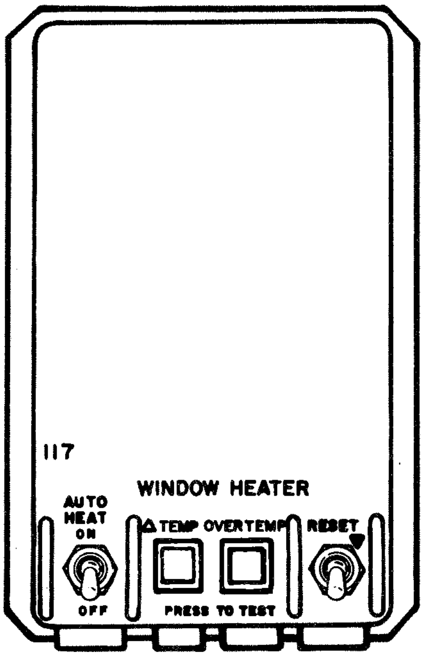
| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | WINDOW COVER CRANK | | | | | |
| 108 | M | knob | [OPEN/CLOSE] | | | | | |
| | | | OPEN | Opens MDA window cover | | | | Counterclockwise rotation of 292 degrees to open |
| | | | CLOSE | Closes MDA window cover | | | | Clockwise rotation of 292 degrees to close |
| 108 | M | hndl | [LOCK/UNLOCK] | | | | | |
| | | | LOCK | Locks window cover crank to closed position | | | | |
| | | | UNLOCK | Unlocks window cover crank to allow crank to be operated | | | | |
| 109 | M | | Experiment S191 C&D | --------------- Ref SLEOH --------------- | | | | |
| 110 | M | | EREP C&D | --------------- Ref SLEOH --------------- | | | | |
| 111 | M | | Experiment S009 | --------------- Ref SLEOH --------------- | | | | |
| 112 | M | | UTILITY OUTLET #1 | ------------- See Panel 104 ------------- | | | | |
| 113 | M | hndl | M512 WORK CHAMBER VENT VALVE | --------------- Ref SLEOH --------------- | | | | |
| 114 | M | | M512 BULKHEAD VENT VALVE | --------------- Ref SLEOH --------------- | | | | |
| | | | HI POWER ACCESSORY OUTLET 1 | | | | | |
| 115 | M | sw | | | | | | |
| | | | ON | Turns HI PWR ACCESS OUTLET #1 on | HI PWR ACC OUTLETS 1 (pnl 202) | AM BUS 1 | | Typical for panel 115, and 139 |
| | | | OFF | Turns HI PWR ACCESS OUTLET #1 off | | | | |
| 115 | M | conn | [connector] | Zero-G receptacle provides electrical power interface for a portable equipment plug | | | | |
| 116 | M | | INTERCOM BOX | ------------- See Panel 102 ------------- | | | | |



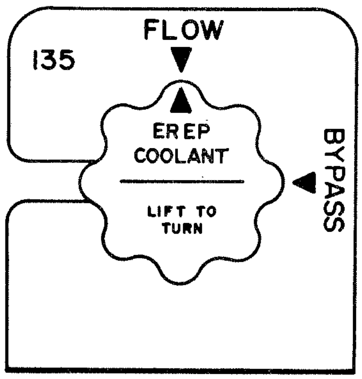

120



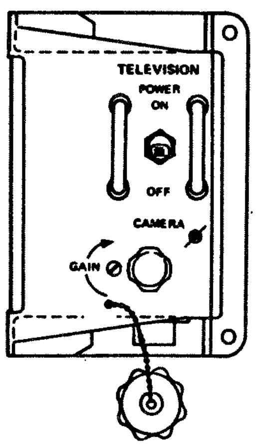

132




117




135



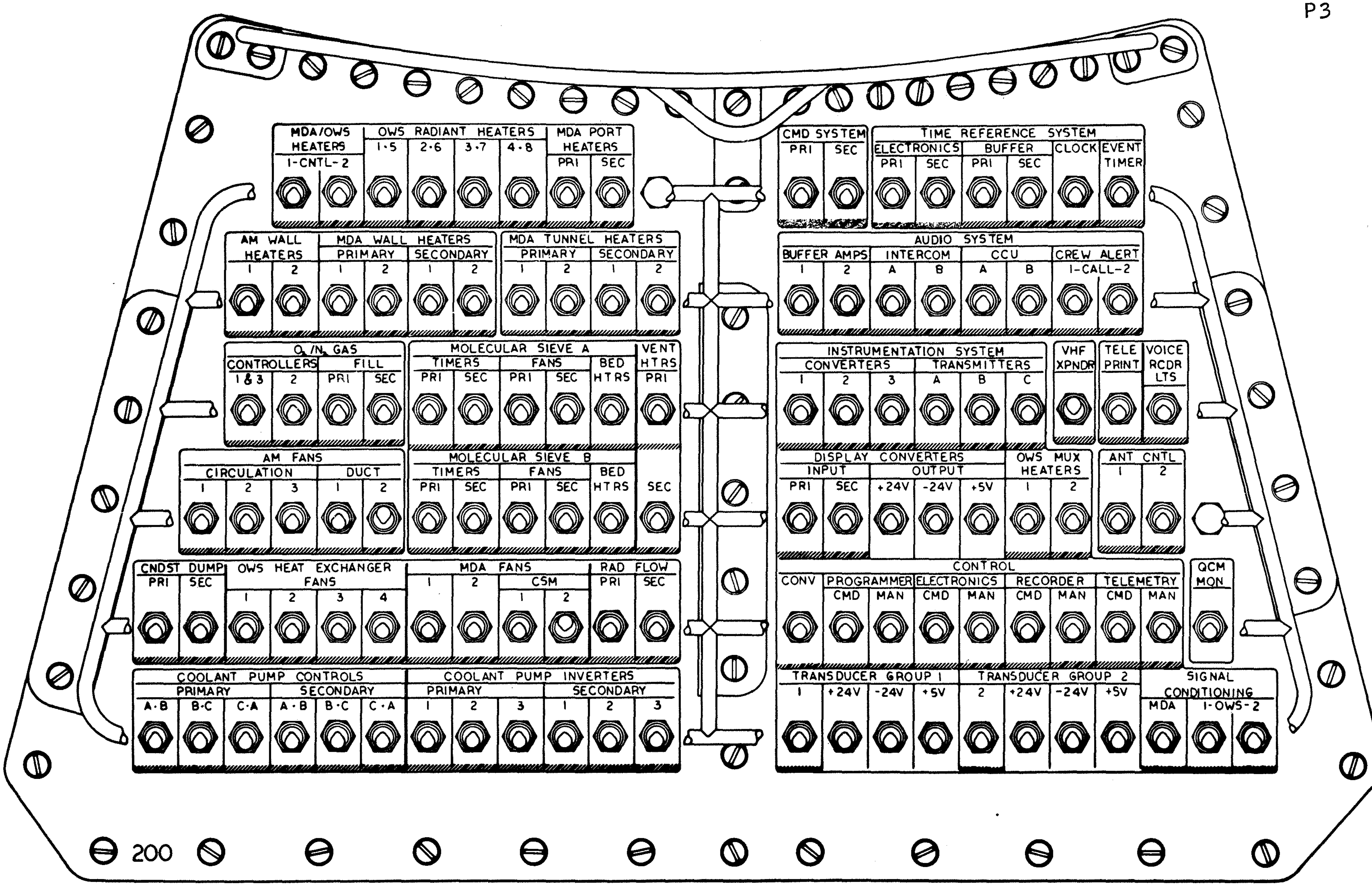

133

| LOCATION | | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| PNL | STA# | | | | | | | |
| | | | WINDOW HEATER CONTROL | | | | | |
| 117 | M | sw | AUTO HEAT | | | | | |
| | | | ON | Turns window heaters on | MDA WINDOW HTR (pnl 202) | AM BUS 1 & 2 | | |
| | | | OFF | Turns window heaters off | | | | |
| 117 | M | lt | TEMP | Indicates if either frame to glass $\Delta$ T is $\pm 4°F$ or if glass to ambient $\Delta$ T is $\pm 17°F$ | | | | |
| 117 | M | lt | OVERTEMP | Indicates sensors on window and frames have sensed that the temperature of the window and/or frames has exceeded 103 degrees F and that overtemp relay has removed power from heaters | | | | |
| 117 | M | sw | [RESET] | | | | | |
| | | | RESET | Closes overtemp sensing system relay if the sensor temps are below 91°F resulting in: (1) power being returned to heater elements, and (2) the OVERTEMP light being extinguished | | | | Momentary switch returns to down position |
| | | | (down) | Normal position of switch | | | | |
| 118 | M | ht | RADIAL HATCH | ------------- See Panel 100 ------------- | | | | |
| | | | FIRE SENSOR CONTROL | | | | | |
| 120 | M | lt | SENSOR 1 | Illuminates when fire sensor 1 is activated by a fire or a sensor test from panel 120 | C&W SNSRS EMER 1, 2 (pnl 202) | EPS CONTROL BUS 1,2 | | Typical for panels 120, 236, 237, 238, 392, 529, 530, 618, 619, 633, 638, 639 |
| 120 | M | sw | SENSOR 1 | | | | | |
| | | | BUS 1 | Powers fire sensor 120-1 and enables fire sensor 120-1 test capability | C&W SNSRS EMER 1 (pnl 202) | EPS CONTROL BUS 1 | | |
| | | | OFF | Turns fire sensor 120-1 off | | | | |
| | | | BUS 2 | Powers fire sensor 120-1 and enables fire sensor 120-1 test capability | C&W SNSRS EMER 2 (pnl 202) | EPS CONTROL BUS 2 | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 120 | M | sw | [MASTER ALARM RESET/ TEST] | | | | | |
| | | | RESET | Turns off master alarm lights, audible tones, and TM closures | C&W SNSRS EMER 1, 2 (pnl 202) | EPS CONTROL BUS 1,2 | | |
| | | | (ctr) | Normal position of switch | | | | |
| | | | TEST | Illuminates internal UV test lamps for fire sensors 120-1 & 2 | | * EPS CONTROL BUS 1,2 | | * Test power to sensor 120-1 & 2 selected by the respective BUS 1/OFF/BUS 2 switch |
| 120 | M | lt | SENSOR 2 | Illuminates when fire sensor 120-2 is activated by a fire or a sensor test from panel 120 | C&W SNSRS EMER 1, 2 (pnl 202) | EPS CONTROL BUS 1,2 | | |
| 120 | M | sw | SENSOR 2 | | | | | |
| | | | BUS 1 | Powers fire sensor 120-2 and enables fire sensor 120-2 test capability | C&W SNSRS EMER 1 (pnl 202) | EPS CONTROL BUS 1 | | |
| | | | OFF | Turns fire sensor 120-2 off | | | | |
| | | | BUS 2 | Powers fire sensor 120-2 and enables fire sensor 120-2 test capability | C&W SNSRS EMER 2 (pnl 202) | EPS CONTROL BUS 2 | | |
| 121 | M | | DIGITAL ADDRESS SYSTEM | ------------- Ref SLOH/ATM -------------- | | | | |
| 128 | M | | RADIO NOISE BURST MON (BACKUP) | ------------- Ref SLOH/ATM -------------- | | | | |
| 129 | M | | RADIO NOISE BURST MON | ------------- Ref SLOH/ATM -------------- | | | | |
| 130 | M | | ATM DISPLAYED CONTROL CONSOLE | ------------- Ref SLOH/ATM -------------- | | | | |
| 131 | M | | INTERCOM BOX | ------------- See Panel 102 ------------- | | | | Voice recording from this panel also uses AUDIO SYS INTERCOM B cb (pnl 200) and AM bus 2 power for redundant control logic |
| | | | VIDEO SELECTOR | | | | | |
| 132 | M | sel | VIDEO | | | | | |
| | | | ATM MON-1 | Enables downlink of ATM monitor 1 video | TV ATM VIDEO (pnl 202) | AM BUS 2 | | Video signals are routed through this switch to the CSM video system and sent to MSFN by the CSM USB transmitter |
| | | | ATM MON-2 | Enables downlink of ATM monitor 2 video | | | | |
| | | | TV | Enables downlink of portable TV camera video from one of five TV input stations | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | TELEVISION STATION | | | | | |
| | | | TELEVISION | | | | | |
| 133 | M | sw | POWER | | | | | |
| | | | ON | Powers television camera | TV PWR MDA (pnl 202) | AM BUS 2 | | Typical for panels 133,320,404,505,642 |
| | | | OFF | Deactivates the above | | | | |
| 133 | M | pot | GAIN | Rotary trim potentiometer that allows adjustment of video signal from camera | | | | Potentiometer provided with screwdriver slot. Rotate clockwise to increase amplification |
| 133 | M | conn | CAMERA (connector) | Zero-G connector for portable TV camera | | | | provides power to and receiver signal from the portable TV camera |
| 134 | M | | UTILITY OUTLET #3 | ------------- See Panel 104 ------------- | | | | |
| 135 | M | vlv | EREP COOLANT | | | | | |
| | | | FLOW | Allows ATM/EREP coolant water to flow through EREP electronics package | | | | |
| | | | BYPASS | Bypasses ATM/EREP coolant water around the EREP and ties a relief valve between the EREP and coolant water loop preventing overpressurization of the EREP loop due to thermal expansion. Relief valve opens, full flow and closes 10-30 psid | | | | |
| 136 | M | | Experiment S192 | --------------- Ref SLEOH --------------- | | | | |
| 139 | M | | HI PWR ACC OUTLET #2 | ------------- See Panel 115 ------------- | | | | |
| 140 | M | | UTILITY OUTLET #4 | ------------- See Panel 104 ------------- | | | | |

P3


MDA/OWS HEATERS
1-CNTL-2
OWS RADIANT HEATERS
1·5
2·6
3·7
4·8
MDA PORT HEATERS
PRI
SEC
CMD SYSTEM
PRI
SEC
TIME REFERENCE SYSTEM
ELECTRONICS
PRI
SEC
BUFFER
PRI
SEC
CLOCK
EVENT TIMER
AM WALL HEATERS
1
2
MDA WALL HEATERS
PRIMARY
1
2
SECONDARY
1
2
MDA TUNNEL HEATERS
PRIMARY
1
2
SECONDARY
1
2
AUDIO SYSTEM
BUFFER AMPS
1
2
INTERCOM
A
B
CCU
A
B
CREW ALERT
1-CALL-2
$O_2/N_2$ GAS
CONTROLLERS
1 & 3
2
FILL
PRI
SEC
MOLECULAR SIEVE A
TIMERS
PRI
SEC
FANS
PRI
SEC
BED HTRS
VENT HTRS
PRI
INSTRUMENTATION SYSTEM
CONVERTERS
1
2
3
TRANSMITTERS
A
B
C
VHF XPNDR
TELE PRINT
VOICE RCDR LTS
AM FANS
CIRCULATION
1
2
3
DUCT
1
2
MOLECULAR SIEVE B
TIMERS
PRI
SEC
FANS
PRI
SEC
BED HTRS
SEC
DISPLAY CONVERTERS
INPUT
PRI
SEC
OUTPUT
+24V
-24V
+5V
OWS MUX HEATERS
1
2
ANT CNTL
1
2
CNDST DUMP
PRI
SEC
OWS HEAT EXCHANGER FANS
1
2
3
4
MDA FANS
1
2
CSM
1
2
RAD FLOW
PRI
SEC
CONTROL
CONV
PROGRAMMER
CMD
MAN
ELECTRONICS
CMD
MAN
RECORDER
CMD
MAN
TELEMETRY
CMD
MAN
QCM MON
COOLANT PUMP CONTROLS
PRIMARY
A·B
B·C
C·A
SECONDARY
A·B
B·C
C·A
COOLANT PUMP INVERTERS
PRIMARY
1
2
3
SECONDARY
1
2
3
TRANSDUCER GROUP 1
1
+24V
-24V
+5V
TRANSDUCER GROUP 2
2
+24V
-24V
+5V
SIGNAL CONDITIONING
MDA
1-OWS-2
200

200

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | Panel 200 | | | | | |
| | | | Circuit Breaker Panel | | | | | |
| | | | MDA/OWS HEATERS | | | | | |
| 200 | ST | cb | CNTL-1 (3.9A) | Provides power to control switches and relays of MDA heaters and OWS radiant heaters 1 | | AM BUS 1 | | |
| 200 | ST | cb | CNTL-2 (3.9A) | Provides power to control switches and relays of MDA heaters and OWS radiant heaters 2 | | AM BUS 2 | | |
| | | | OWS RADIANT HEATERS | | | | | |
| 200 | ST | cb | 1 5 (18.4A) | Provides power thru control relays to OWS radiant heaters #1 and #5 | | AM BUS 1 | | 125 watt heaters |
| 200 | ST | cb | 2 6 (18.4A) | Provides power thru control relays to OWS radiant heaters #2 and #6 | | AM BUS 2 | | 125 watt heaters |
| 200 | ST | cb | 3 7 (18.4A) | Provides power thru control relays to OWS radiant heaters #3 and #7 | | AM BUS 1 | | 125 watt heaters |
| 200 | ST | cb | 4 8 (18.4A) | Provides power thru control relays to OWS radiant heaters #4 and #8 | | AM BUS 2 | | 125 watt heaters |
| | | | MDA PORT HEATERS | | | | | |
| 200 | ST | cb | PRI (5.4A) | Provides power to primary MDA CSM port heater and MDA spare port heater thru control relays or the MDA HEATERS PORT CSM and MDA HEATERS PORT SPARE sws (Panel 203) | | AM BUS 1 | | 15 watt heaters |
| 200 | ST | cb | SEC (5.4A) | Provides power secondary MDA CSM port heater and MDA spare port heater thru control relays or the MDA HEATERS PORT CSM and MDA HEATERS PORT SPARE sws (Panel 203) | | AM BUS 2 | | 15 watt heaters |
| | | | AM WALL HEATERS | | | | | |
| 200 | ST | cb | 1 (5.4A) | Provides power to AM wall heaters: STS 1, 3, 5 & 7 and lock tunnel 2, 4, 6, & 8 thru AM WALL HEATERS sws (Panel 203) | | AM BUS 1 | | 15 watt heaters |
| 200 | ST | cb | 2 (5.4A) | Provides power to AM wall heaters: STS 2, 4, 6 & 8 and lock tunnel 3, 5 & 7 thru AM WALL HEATERS sws (Panel 203) | | AM BUS 2 | | 15 watt heaters |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | MDA WALL HEATERS | | | | | |
| | | | PRIMARY | | | | | |
| 200 | ST | cb | 1 (12.0A) | Provides power thru control relays to upper MDA wall heaters 1, 2, 3 & 4 and lower MDA wall heaters 13, 14, 15 & 16 primary element | | AM BUS 1 | | 20 watt upper wall heaters<br>40 watt lower wall heaters |
| 200 | ST | cb | 2 (12.0A) | Provides power thru control relays to upper MDA wall heaters 5, 6, 7 & 8 and lower MDA wall heaters 9, 10, 11 & 12 primary element | | AM BUS 2 | | 20 watt upper wall heaters<br>40 watt lower wall heaters |
| | | | SECONDARY | | | | | |
| 200 | ST | cb | 1 (12.0A) | Provides power thru control relays to upper MDA wall heaters 5, 6, 7 & 8 and lower MDA wall heaters 9, 10, 11 & 12 secondary element | | AM BUS 1 | | 20 watt upper wall heaters<br>40 watt lower wall heaters |
| 200 | ST | cb | 2 (12.0A) | Provides power thru control relays to upper MDA wall heaters 1, 2, 3 & 4 and lower MDA wall heaters 13, 14, 15 & 16 secondary element | | AM BUS 2 | | 20 watt upper wall heaters<br>40 watt lower wall heaters |
| | | | MDA TUNNEL HEATERS | | | | | |
| | | | PRIMARY | | | | | |
| 200 | ST | cb | 1 (5.4A) | Provides power to MDA tunnel heater #1 primary element thru MDA HEATERS TUNNEL sw (Panel 203) or control relays | | AM BUS 1 | | 80 watt heater |
| 200 | ST | cb | 2 (5.4A) | Provides power to MDA tunnel heater #2 primary element thru MDA HEATERS TUNNEL sw (Panel 203) or control relays | | AM BUS 2 | | 80 watt heater |
| | | | SECONDARY | | | | | |
| 200 | ST | cb | 1 (5.4A) | Provides power to MDA tunnel heater #1 secondary element thru MDA HEATERS TUNNEL sw (Panel 203) or control relays | | AM BUS 1 | | 80 watt heater |
| 200 | ST | cb | 2 (5.4A) | Provides power to MDA tunnel heater #2 secondary element thru MDA HEATERS TUNNEL sw (Panel 203) or control relays | | AM BUS 2 | | 80 watt heaters |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | O2/N2 GAS | | | | | |
| | | | CONTROLLERS | | | | | |
| 200 | ST | cb | 1 3 (3.9A) | Provides power to No. 1 & 3 PPO2 sensor amplifiers and No. 1 & 3 N2 solenoid valve controllers thru the O2/N2 CONTR MON sel and O2/N2 CONTR sel (panel 225) | | AM BUS 1 | | |
| 200 | ST | cb | 2 (3.9A) | Provides power to No. 2 PPO2 sensor amplifier and No. 2 N2 solenoid valve controller thru the O2/N2 CONTR MON sel and O2/N2 CONTR sel (panel 225) | | AM BUS 2 | | |
| | | | FILL | | | | | |
| 200 | ST | cb | PRI (5.4A) | Provides power to O2, N2 fill primary solenoid valves thru O2, N2 FILL PRI sws & to AM, OWS fill primary solenoid valves thru AM, OWS FILL PRI sws & to pri O2, N2 supply solenoid (panel 225) vlvs thru O2, N2 BOTTLES PRI sws | | AM BUS 1 | | |
| 200 | ST | cb | SEC (5.4A) | Provides power to O2, N2 fill secondary solenoid valves thru O2, N2 FILL SEC sws & to AM, OWS fill secondary solenoid valves thru AM, OWS FILL SEC sws & to secondary O2, N2 supply solenoids thru O2, N2 BOTTLES SEC sws (panel 225) | | AM BUS 2 | | |
| | | | MOLECULAR SIEVE A | | | | | |
| | | | TIMERS | | | | | |
| 200 | ST | cb | PRI (3.9A) | Provides power to molecular sieve A solenoid valves 2, 3 thru S2, S3 sws (Panel 226), and cycle timer #1 for operation or #2 for reset capability thru MOL SV A TIMERS | BUS 1 | AM | | Cycle timer #1 is primary |
| 200 | ST | cb | SEC (3.9A) | Provides power to molecular sieve A solenoid valves 1, 4 thru S1, S4 sws (panel 226) and cycle timer #1 for operation or #2 for reset capability thru MOL SV A TIMERS | BUS 2 | AM | | Cycle timer #2 is secondary |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | MOLECULAR SIEVE A (cont'd) | | | | | |
| | | | FANS | | | | | |
| 200 | ST | cb | PRI (5.4A) | Provides power to molecular sieve A fan #1 power inverter thru MOL SV A FANS PWR sw (panel 203) and MOL SV A FANS DISCONNECT sw (panel 203) | | AM BUS 1 | | |
| 200 | ST | cb | SEC (5.4A) | Provides power to molecular sieve A fan #2 power inverter thru MOL SV A FANS PWR sw (panel 203) and MOL SV A FANS DISCONNECT sw (panel 203) | | AM BUS 2 | | |
| 200 | ST | | BED HTRS (26.4A) | Provides power to molecular sieve A temperature controller bed 1 or 2 thru MOL SV A BAKEOUT HTRS sw (panel 203) | | AM BUS 1 | | |
| | | | VENT HEATERS | | | | | |
| 200 | ST | cb | PRI (3.9A) | Provides power to molecular sieve A vent heaters (primary) 9, 11, 13, 15 & 17 and mol sieve B heater (primary) 1, 3, 5 & 7 thru MOL SV A & B VENT HEATERS sw (panel 203) | | AM BUS 1 | | 5.2 watt #9 M.S.-A, #1 M.S.-B htr<br>7.8 watt #13, 11 M.S.-A, #3, #5, #7 M.S.-B htr<br>6.0 watt #15, 17 M.S.-A htr |
| 200 | ST | cb | SEC (3.9A) | Provides power to molecular sieve A vent heaters (secondary) 10, 12, 14, 16, & 18 and mol sieve B heater (secondary) 2, 4, 6 & 8 thru MOL SV A & B VENT HEATERS sws (panel 203) | | AM BUS 2 | | 5.2 watt #10 M.S.-A, #2 M.S.-B htr<br>7.8 watt #12, 14 M.S.-A, #4, 6, 8 M.S.-B htr 6.0 watt #16, 18 M.S.-A htr |
| | | | AM FANS | | | | | |
| | | | CIRCULATION | | | | | |
| 200 | ST | cb | 1 (3.9A) | Provides power to AM circulation fan #1 thru AM FANS CIRCULATION 1 sw (panel 203) | | AM BUS 1 | | |
| 200 | ST | cb | 2 (3.9A) | Provides power to AM circulation fan #2 thru AM FANS CIRCULATION 1 sw (panel 203) | | AM BUS 2 | | |
| 200 | ST | cb | 3 (3.9A) | Provides power to AM circulation fan #3 thru AM FANS CIRCULATION 3 sw (panel 203) | | AM BUS 1 | | |
| | | | DUCT | | | | | |
| 200 | ST | cb | 1 (3.9A) | Provides power to AM circulation fan duct-1 outlet thru AM FANS DUCT sw (panel 203) | | AM BUS 1 | | Two electrical outlets are provided #1 and #2, the fan may be connected to either |
| 200 | ST | cb | 2 (3.9A) | Provides power to AM circulation fan duct-2 outlet thru AM FANS DUCT sw (panel 203) | | AM BUS 2 | | Two electrical outlets are provided #1 and #2, the fan may be connected to either |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | MOLECULAR SIEVE B | | | | | |
| | | | TIMERS | | | | | |
| 200 | ST | cb | PRI (3.9A) | Provides power to molecular sieve B solenoid valves 2, 3 thru S2, S3 sws (panel 227), and cycle timer #1 for operation or #2 for reset capability thru MOL SV B TIMERS sw (panel 203) | BUS 1 | AM | | |
| 200 | ST | cb | SEC (3.9A) | Provides power to molecular sieve B solenoid valves 4, 1 thru S4, S1 sws(panel 227), and cycle timer #1 for operation or #2 for reset capability thru MOL SV B TIMERS sw (panel 203) | BUS 2 | AM | | |
| | | | FANS | | | | | |
| 200 | ST | cb | PRI (5.4A) | Provides power to molecular sieve B fan #1 power inverter thru MOL SV B FANS PWR sw (panel 203) and MOL SV B FANS DISCONNECT sw (panel 203) | | AM BUS 1 | | |
| 200 | ST | cb | SEC (5.4A) | Provides power to molecular sieve B fan #2 power inverter thru MOL SV B FANS PWR sw (panel 203) and MOL SV B FANS DISCONNECT sw (panel 203) | | AM BUS 2 | | |
| 200 | ST | cb | BED HTRS (26.4A) | Provides power to molecular sieve B temperature controller bed 1 or 2 thru MOL SV B BAKEOUT HEATERS sw (panel 203) | | AM BUS 2 | | |
| | | | CNDST DUMP | | | | | |
| 200 | ST | cb | PRI (3.9A) | Provides power to condensate control system primary vent valve and heater thru CNDST CONT SYS VENT HTRS and CNDST CONT SYS VENT VLV sws (panel 216) | | AM BUS 1 | | 40 watt heater |
| 200 | ST | cb | SEC (3.9A) | Provides power to condensate control system secondary vent valve and heater thru CONDST CONT SYS VENT HTRS and CNDST CONT SYS VENT VLV sws (panel 216) | | AM BUS 2 | | 40 watt heater |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | OWS HEAT EXCHANGER FANS | | | | | |
| 200 | ST | cb | 1 (5.4A) | Provides power to OWS heat exchanger fan #1 and shutoff valve #1 thru control control relays, and control relays thru OWS HT EXCH FANS 1 sw (panel 614) | | AM BUS 1 | | |
| 200 | ST | cb | 2 (5.4A) | Provides power to OWS heat exchanger fan #2 and shutoff valve #2 thru control relays, and control relays thru OWS HT EXCH FANS 2 sw (panel 614) | | AM BUS 2 | | |
| 200 | ST | cb | 3 (5.4A) | Provides power to OWS heat exchanger fan #3 and fan shutoff valve #3 thru control relays, and control relays thru OWS HT EXCH FANS 3 sw (panel 614) | | AM BUS 1 | | |
| 200 | ST | cb | 4 (5.4A) | Provides power to OWS heat exchanger fan #4 and shutoff valve #4 thru control relays, and control relays thru OWS HT EXCH FANS 4 sw (panel 614) | | AM BUS 2 | | |
| | | | MDA FANS | | | | | |
| 200 | ST | cb | 1 (3.9A) | Provides power to MDA fan #1 thru MDA FANS 1 sw (panel 203) | | AM BUS 1 | | |
| 200 | ST | cb | 2 (3.9A) | Provides power to MDA fan #2 thru MDA FANS 2 sw (panel 203) | | AM BUS 2 | | |
| | | | CSM | | | | | |
| 200 | ST | cb | 1 (3.9A) | Provides power to MDA CSM fan electrical outlet #1 thru MDA FANS CSM sw (panel 203) | | AM BUS 1 | | Two electrical outlets are provided #1 and #2. The fan may be connected to either |
| 200 | ST | cb | 2 (3.9A) | Provides power to MDA CSM fan electrical outlet #2 thru MDA FANS CSM sw (panel 203) | | AM BUS 2 | | Two electrical outlets are provided #1 and #2. The fan may be connected to either |
| | | | RAD FLOW | | | | | |
| 200 | ST | cb | PRI (3.9A) | Provides power to radiator bypass primary valve thru RAD FLOW PRI sw (panel 203) and to suit umbilical system 1 HX coolant flow, solenoid valve thru SUS 1 HX COOLANT FLOW sw (panel 217) | | AM BUS 1 | | |
| 200 | ST | cb | SEC (3.9A) | Provides power to radiator bypass secondary valve thru RAD FLOW SEC sw (panel 203) and to suit umbilical system 1 HX coolant flow solenoid valve thru SUS 2 HX COOLANT FLOW sw (panel 217) | | AM BUS 2 | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | COOLANT PUMP CONTROLS | | | | | |
| | | | PRIMARY | | | | | |
| 200 | ST | cb | A B (3.9A) | Provides power to primary coolant loop pump A & B controls thru PRI CLNT LOOP INVERTERS sel (panel 203) | | AM BUS 1 | | |
| 200 | ST | cb | B C (3.9A) | Provides power to primary coolant loop Pump B & C controls thru PRI CLNT LOOP INVERTERS sel (panel 203) | | AM BUS 2 | | |
| 200 | ST | cb | C A (3.9A) | Provides power to primary coolant loop pump C & A controls thru PRI CLNT LOOP INVERTERS sel (panel 203) | | AM BUS 1 | | |
| | | | SECONDARY | | | | | |
| 200 | ST | cb | A B (3.9A) | Provides power to secondary coolant loop pump A & B controls thru SEC CLNT LOOP INVERTERS sel (panel 203) | | AM BUS 2 | | |
| 200 | ST | cb | B C (3.9A) | Provides power to secondary coolant loop pump B & C controls thru SEC CLNT LOOP INVERTERS sel (panel 203) | | AM BUS 1 | | |
| 200 | ST | cb | C A (3.9A) | Provides power to secondary coolant loop pump C & A controls thru SEC CLNT LOOP INVERTERS sel (panel 203) | | AM BUS 2 | | |
| | | | COOLANT PUMP INVERTERS | | | | | |
| | | | PRIMARY | | | | | |
| 200 | ST | cb | 1 (12.0A) | Provides power to primary -1 coolant pump power inverter thru control relays | | AM BUS 1 | | |
| 200 | ST | cb | 2 (12.0A) | Provides power to primary -2 coolant pump power inverter thru control relays | | AM BUS 2 | | |
| 200 | ST | cb | 3 (12.0A) | Provides power to primary -3 coolant pump power inverter thru control relays | | AM BUS 1 | | |
| | | | SECONDARY | | | | | |
| 200 | ST | cb | 1 (12.0A) | Provides power to secondary -1 coolant pump power inverter thru control relays | | AM BUS 2 | | |
| 200 | ST | cb | 2 (12.0A) | Provides power to secondary -2 coolant pump power inverter thru control relays | | AM BUS 1 | | |
| 200 | ST | cb | 3 (12.0A) | Provides power to secondary -3 coolant pump power inverter thru control relays | | AM BUS 2 | | |

| LOCATION | | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| PNL | STA# | | | | | | | |
| | | | CMD SYSTEM | | | | | |
| 200 | ST | cb | PRI (3.9A) | Provides power to DCS:<br>Command relay driver unit primary electronics<br>Primary receiver/decoder<br>Primary receiver/decoder control rlys thru the CMD SYS sw (panel 204) | | EPS CONTROL BUS 1 | | |
| 200 | ST | cb | SEC (3.9A) | Provides power to DCS:<br>Command relay driver unit secondary electronics<br>Secondary receiver/decoder<br>Secondary receiver/decoder control rlys thru the CMD SYS sw (panel 204) | | EPS CONTROL BUS 2 | | |
| | | | TIME REFERENCE SYSTEM | | | | | |
| | | | ELECTRONICS | | | | | |
| 200 | ST | cb | PRI (3.9A) | Provides power to the primary electronic timer | | EPS CONTROL BUS 2 | | |
| 200 | ST | cb | SEC (3.9A) | Provides power to the secondary electronic | | EPS CONTROL BUS 1 | | |
| | | | BUFFER | | | | | |
| 200 | ST | cb | PRI (3.9A) | Provides power to the primary time correlation buffer thru the TIME REF SYS BUFFER sw (panel 212) | | AM BUS 1 | | |
| 200 | ST | cb | SEC (3.9A) | Provides power to the secondary time correlation buffer thru the TIME REF SYS BUFFER sw (panel 212) | | AM BUS 2 | | |
| 200 | ST | cb | CLOCK (3.9A) | Provides power to one of the GMT clocks (pnl 212) | | AM BUS 2 | | |
| 200 | ST | cb | EVENT TIMER (3.9A) | Provides power to the event timer (panel 206) | | AM BUS 1 | | |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | AUDIO SYSTEM | | | | | |
| | | | BUFFER AMPS | | | | | |
| 200 | ST | cb | 1 (3.9A) | Provides power to ALC A primary electronics and tape recorder amplifier and ALC B secondary electronics | | AM BUS 1 | | |
| 200 | ST | cb | 2 (3.9A) | Provides power to ALC B primary electronics and tape recorder amplifier and ALC A secondary electronics | | AM BUS 2 | | |
| | | | INTERCOM | | | | | |
| 200 | ST | cb | A (5.4A) | Provides power to intercom boxes and VOICE sw (panel 316) | | AM BUS 1 | | Provides voice recording control logic power |
| 200 | ST | cb | B (5.4A) | Provides power to intercom boxes and VOICE sw (panel 316) | | AM BUS 2 | | Provides redundant voice recording control logic power on intercom box pnl 131 and 316 |
| | | | CCU | | | | | |
| 200 | ST | cb | A (3.9A) | Provides power to channel A CCU on each ntercom box through the respective CHAN A sw | | AM BUS 1 | | |
| 200 | ST | cb | B (3.9A) | Provides power to channel B CCU on each intercom box through the respective CHAN B sw | | AM BUS 2 | | |
| | | | CREW ALERT | | | | | |
| 200 | ST | cb | CALL-1 (3.9A) | Provides power to the CSM call logic and the caution & warning system | | AM BUS 1 | | |
| 200 | ST | cb | CALL-2 (3.9A) | Provides power to the CSM call logic and the caution & warning system | | AM BUS 2 | | |
| | | | INSTRUMENTATION SYSTEM | | | | | |
| | | | CONVERTERS | | | | | |
| 200 | ST | cb | 1 (9.3A) | Provides power to the AM DC-DC converter #1 | | AM BUS 1 | | |
| 200 | ST | cb | 2 (9.3A) | Provides power to the AM DC-DC converter #2 | | AM BUS 2 | | |
| 200 | ST | cb | 3 (9.3A) | Provides power to the AM DC-DC converter #3 | | AM BUS 2 | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | INSTRUMENTATION SYSTEM (cont'd) | | | | | |
| | | | TRANSMITTERS | | | | | |
| 200 | ST | cb | A (3.9A) | Provides power to transmitter A and the launch/orbit transmitter select logic | | AM BUS 1 | | Provides power to either of two transmitters, a sealed 2 watt, for launch and early orbital phase, and a vented 10 watt for subsequent orbital phase |
| 200 | ST | cb | B (3.9A) | Provides power to transmitter B | | AM BUS 2 | | |
| 200 | ST | cb | C (3.9A) | Provides power to transmitter C | | AM BUS 2 | | |
| 200 | ST | cb | VHF XPNDR (3.9A) | Provides power to ranging tone transfer assembly and VHF transceiver assembly | | AM BUS 1 | | |
| 200 | ST | cb | TELEPRINT (3.9A) | Provides power to the IEU and teleprinter | | AM BUS 1 | | |
| 200 | ST | cb | VOICE RCDR LTS (3.9A) | Provides power to the Voice recording lights on each intercom box and the VOICE light (panel 316) | | AM BUS 1 | | |
| | | | DISPLAY CONVERTERS | | | | | |
| | | | INPUT | | | | | |
| 200 | ST | cb | PRI (3.9A) | Provides power to the primary display converter thru the INSTR SYS DISPLAY CONV sw (panel 204) and to selected transducers and display logic | | AM BUS 1 | | |
| 200 | ST | cb | SEC (3.9A) | Provides power to the secondary display converter thru the INSTR SYS DISPLAY CONVS sw (panel 204) and to selected transducers and display logic | | AM BUS 2 | | |

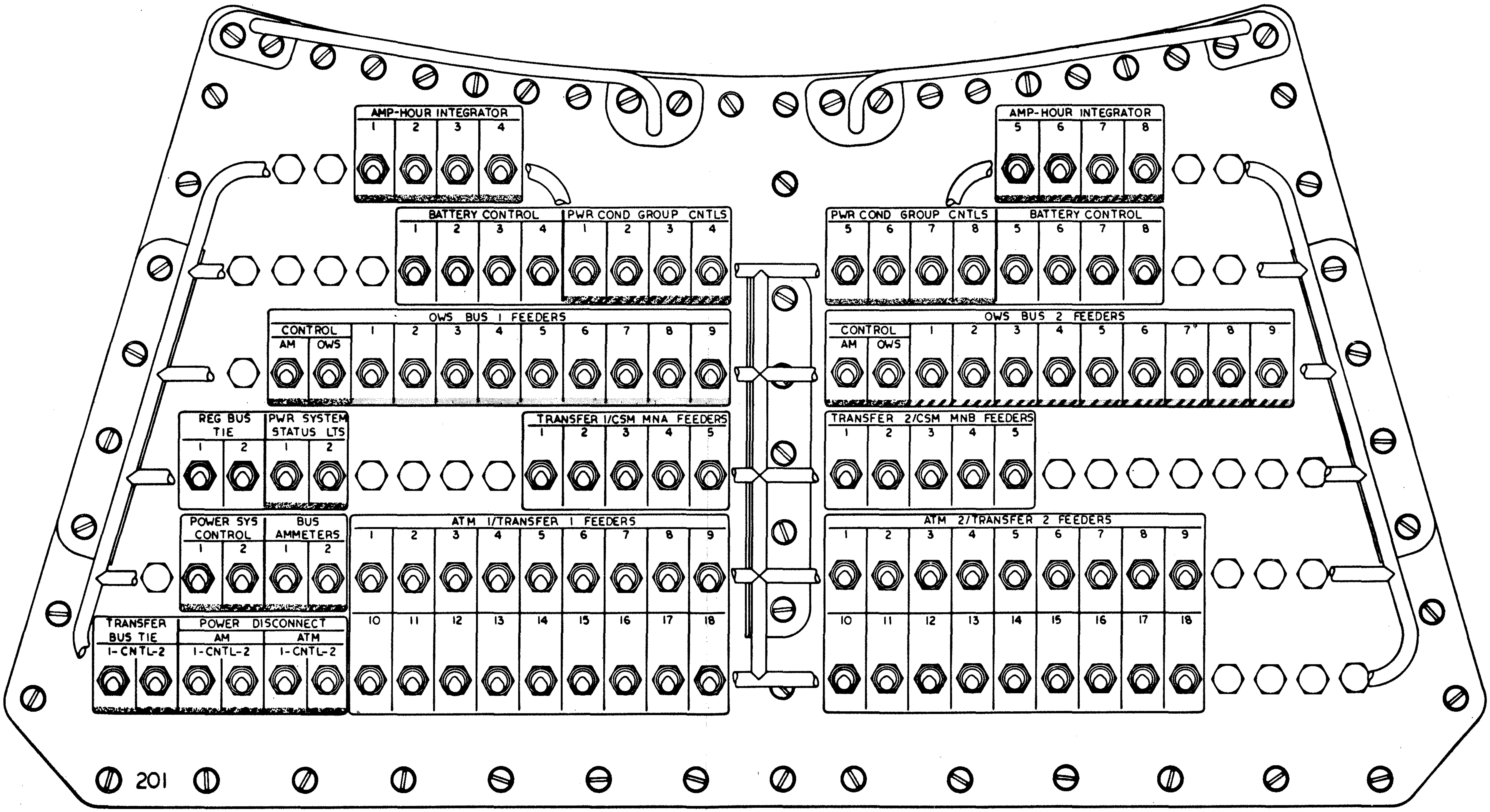
| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | DISPLAY CONVERTERS (cont'd) | | | | | |
| | | | OUTPUT | | | | | |
| 200 | ST | cb | +24V (3.9A) | Provides +24 vdc power to the AM display transducers | | PRI, SEC DISPLAY CONVERTER OR +24VDC INST BUS A, B | | |
| 200 | ST | cb | -24V (3.9A) | Provides -24 vdc power to the AM display transducers | | PRI, SEC DISPLAY CONVERTER OR -24VDC INST BUS A, B | | |
| 200 | ST | cb | +5V (3.9A) | Provides +5vdc power to the AM display transducers | | PRI,SEC DISPLAY CONVERTER OR +5VDC INST BUS A, B | | |
| | | | OWS MUX HEATERS | | | | | |
| 200 | ST | cb | 1 (9.3A) | Provides power to heaters for the OWS multiplexers LL - M,B,L,Q and HL - E,K | | AM BUS 1 | | |
| 200 | ST | cb | 2 (9.3A) | Provides power to heaters for the multiplexers LL - H,J,D and HL - J,D,T | | AM BUS 2 | | |
| | | | ANT CNTL | | | | | |
| 200 | ST | cb | 1 (3.9A) | Provides power to the discone antenna coax switch (panel 204) thru ANTENNA DISCONE sw | | AM BUS 1 | | |
| 200 | ST | cb | 2 (3.9A) | Provides power to launch/orbit antenna coax switch thru the ANTENNA-[DISCONE/STUB/CMD] sw | | AM BUS 2 | | |
| | | | CONTROL | | | | | |
| 200 | ST | cb | CONV (3.9A) | Provides control power to the manual AM converter select logic and AM display converter power logic | | AM BUS 2 | | |

| LOCATION | | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| PNL | STA# | | | | | | | |
| | | | CONTROL (cont'd) | | | | | |
| | | | PROGRAMMER | | | | | |
| 200 | ST | cb | CMD (3.9A) | Provides control power to the programmers DCS select and mode control logic thru INSTR SYS PROG sw (panel 204) | | AM BUS 1 | | |
| 200 | ST | cb | MAN (3.9A) | Provides control power to the programmers manual select and mode control logic thru INSTR SYS PROG sw (panel 204) | | AM BUS 2 | | |
| | | | ELECTRONICS | | | | | |
| 200 | ST | cb | CMD (3.9A) | Provides control power to the PCM interface box mode control logic enabling DCS selection thru INSTR SYS ELECT sw (panel 204) | | AM BUS 1 | | |
| 200 | ST | cb | MAN (3.9A) | Provides control power to the PCM interface box manual select and mode control logic thru INSTR SYS ELECT sw (panel 204) | | AM BUS 2 | | |
| | | | RECORDER | | | | | |
| 200 | ST | cb | CMD (3.9A) | Provides control power to the tape recorders mode control logic, rcdr audio select logic and tape recording logic | | AM BUS 1 | | |
| 200 | ST | cb | MAN (3.9A) | Provides control power to the tape recorders manual select and mode control logic, rcdr audio select logic and tape recording logic | | AM BUS 2 | | |
| | | | TELEMETRY | | | | | |
| 200 | ST | cb | CMD (3.9A) | Provides control power to the transmission DCS select and mode control logic and the DCS AM DC-DC converter select logic | | AM BUS 1 | | |
| 200 | ST | cb | MAN (3.9A) | Provides control power to the transmission manual select and mode control logic and the PCM bus select logic | | AM BUS 2 | | |
| 200 | ST | cb | QCM MON (3.9A) | Provides +24 vdc regulated power to the DA QCM/CM electronics | | INST BUS A | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | INSTRUMENTATION SYSTEM | | | | | |
| | | | TRANSDUCER GROUP 1 | | | | | |
| 200 | ST | cb | 1 (3.9A) | Provides +28 vdc power to group 1 transducers | | AM BUS 1 | | |
| 200 | ST | cb | +24V (3.9A) | Provides +24 vdc power to group 1 transducers | | INST BUS A OR BUS B | | |
| 200 | ST | cb | -24V (3.9A) | Provides -24 vdc power to group 1 transducers | | INST BUS A OR BUS B | | |
| 200 | ST | cb | +5V (3.9A) | Provides +5vdc power to group 1 transducers | | INST BUS A OR BUS B | | |
| | | | TRANSDUCER GROUP 2 | | | | | |
| 200 | ST | cb | 2 (3.9A) | Provides +28 vdc power to group 2 transducers | | AM BUS 2 | | |
| 200 | ST | cb | +24V (3.9A) | Provides +24 vdc power to group 2 transducers | | INST BUS A OR BUS B | | |
| 200 | ST | cb | -24V (3.9A) | Provides -24 vdc power to group 2 transducers | | INST BUS A OR BUS B | | |
| 200 | ST | cb | +5V (3.9A) | Provides +5vdc power to group 2 transducers | | INST BUS A OR BUS B | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | SIGNAL CONDITIONING | | | | | |
| 200 | ST | cb | MDA (3.9A) | Provides power to MDA signal conditioning | | AM BUS 2 | | |
| 200 | ST | cb | OWS-1 (9.3A) | Provides power to OWS transducers and signal conditioning equipment | | AM BUS 1 | | |
| 200 | ST | cb | OWS-2 (9.3A) | Provides power to OWS transducers and signal conditioning equipment | | AM BUS 2 | | |

P4


AMP-HOUR INTEGRATOR
1 2 3 4
AMP-HOUR INTEGRATOR
5 6 7 8
BATTERY CONTROL
1 2 3 4
PWR COND GROUP CNTLS
1 2 3 4
PWR COND GROUP CNTLS
5 6 7 8
BATTERY CONTROL
5 6 7 8
OWS BUS 1 FEEDERS
CONTROL
AM OWS
1 2 3 4 5 6 7 8 9
OWS BUS 2 FEEDERS
CONTROL
AM OWS
1 2 3 4 5 6 7 8 9
REG BUS TIE
1 2
PWR SYSTEM STATUS LTS
1 2
TRANSFER 1/CSM MNA FEEDERS
1 2 3 4 5
TRANSFER 2/CSM MNB FEEDERS
1 2 3 4 5
POWER SYS CONTROL
1 2
BUS AMMETERS
1 2
ATM 1/TRANSFER 1 FEEDERS
1 2 3 4 5 6 7 8 9
10 11 12 13 14 15 16 17 18
ATM 2/TRANSFER 2 FEEDERS
1 2 3 4 5 6 7 8 9
10 11 12 13 14 15 16 17 18
TRANSFER BUS TIE
1-CNTL-2
POWER DISCONNECT
AM
1-CNTL-2
ATM
1-CNTL-2
201

201

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | AMP-HOUR INTEGRATOR | | | | | |
| 201 | ST | cb | 1 (3.9A) | Provides power to battery charger 1 primary and secondary amp-hour meters | | EPS CONTROL BUS 1 | | Loss of power to the amp-hour meter resets the meter to zero resulting in a loss of battery state-of-charge. AH integrator also receives power from BAT |
| 201 | ST | cb | 2,3,4 (3.9A) | Same as AMP-HOUR INTEGRATOR cb #1 for systems 2, 3 and 4 | | EPS CONTROL BUS 1 | | |
| | | | BATTERY CONTROL | | | | | |
| 201 | ST | cb | 1 (3.9A) | Provides power to No. 1 battery control relays and battery charger 1 primary and secondary amp-hour meters | | BAT 1 | | |
| 201 | ST | cb | 2,3,4 (3.9A) | Same as BATTERY CONTROL cb #1 for system 2, 3 and 4 | | BAT 2,3&4 | | |
| | | | PWR COND GROUP CNTL | | | | | |
| 201 | ST | cb | 1 (3.9A) | Provides power to the power conditioning group 1 control relays<br>a. Amp-hour integrator select<br>b. Charge rate control<br>c. Battery control<br>d. Power conditioning group output<br>e. Power conditioning group bus select<br>f. Charge mode<br>g. Charger bypass power<br>h. Solar array output<br>i. Discharge limit inhibit<br>thru the related sws on (panel 205) | | EPS CONTROL BUS 2 | | Power is inhibited by the PWR SYS CONT sw in the CMD position |
| 201 | ST | cb | 2,3,4 (3.9A) | Same as PWR COND GROUP CNTL cb 1 for system 2, 3 and 4 | | EPS CONTROL BUS 2 | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | OWS BUS 1 FEEDERS | | | | | |
| | | | CONTROL | | | | | |
| 201 | ST | cb | AM (3.9A) | Provides control power to OWS power feed relays 1, 2, 3 & 13 thru OWS BUS 1 sw (panel 206) | | EPS CONTROL BUS 1 | | The power relays enable power from REG bus 1 to OWS bus 1 |
| 201 | ST | cb | OWS (3.9A) | Provides control power to OWS power feed relays 1, 2, 3 & 13 thru OWS BUS 1 sw (panel 617) | | EPS CONTROL BUS 1 | | |
| 201 | ST | cb | 1 (12.0A) | Protects feeder wiring for one of nine circuits which feed OWS bus 1 | | REG BUS 1 | | |
| 201 | ST | cb | 2 thru 9 (12.0A) | Same as OWS BUS 1 FEEDER cb 1 | | REG BUS 1 | | |
| | | | REG BUS TIE | | | | | |
| 201 | ST | cb | 1 (26.4A) | Connects REG bus 1 to REG bus 2 allowing a one bus operation | | REG BUS 1 to REG BUS 2 | | Buses are tied together to optimize power generating capability of the 8 PCG's |
| 201 | ST | cb | 2 (26.4A) | Same as REG BUS TIE 1 cb | | REG BUS 1 to REG BUS 2 | | |
| | | | PWR SYSTEM STATUS LTS | | | | | |
| 201 | ST | cb | 1 (3.9A) | Provides power to PCG 1-4 status lts, AM bus 2, OWS bus 1, ATM/xfer to bus 1, reg/trnsfr the bus 1, EPS bus 2 shunt reg & elec gnd status lts thru PWR SYS LTS BUS 1, 2 sw (panel 206) | | EPS CONTROL BUS 1 | | |
| 201 | ST | cb | 2 (3.9A) | Provides power to PCG 5-8 status lts, AM bus 1, OWS bus 2, ATM trnfr tie bus 2, reg/trnfr tie bus 2, EPS bus 1 shunt reg status lts thru PWR SYS LTS BUS 1, 2 sw (panel 206) | | EPS CONTROL BUS 2 | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | TRANSFER 1/CSM MNA FEEDERS | | | | | |
| 201 | ST | cb | 1 (18.4A) | Protects circuit between TRANSFER BUS 1 and CSM MN MNA | | TRANSFER BUS 1 | | |
| 201 | ST | cb | 2 thru 5 (18.4A) | Same as TRANSFER 1/CSM MNA FEEDERS cb 1 | | TRANSFER BUS 1 | | |
| | | | POWER SYS CONTROL | | | | | |
| 201 | ST | cb | 1 (3.9A) | Provides power to power system control relays:<br>No. 1 single point ground<br>AM bus 1 power<br>AM bus 2 power<br>Bus 2 shunt regulator<br>Bus 1 No. 1, 2, 3, 4 CRDU and enable thru PWR SYS CONT sw (panel 205) | | EPS CONTROL BUS 1 | | Power is inhibited by the PWR SYS CONT sw in the CMD position to each circuit except the shunt regulator and single point ground control |
| 201 | ST | cb | 2 (3.9A) | Provides power to power system control relays:<br>No. 2 single point ground<br>AM bus 2 power<br>AM bus 1 power<br>Bus 1 shunt regulator<br>Bus 2, No. 5, 6, 7, 8 CRDU and enable thru PWR SYS CONT sw (panel 205) | | EPS CONTROL BUS 2 | | |
| | | | BUS AMMETERS | | | | | |
| 201 | ST | cb | 1 (3.9A) | Provides power to 4 current sensors for bus 1 | | EPS CONTROL BUS 1 | | |
| 201 | ST | cb | 2 (3.9A) | Provides power to 4 current sensors for bus 2 | | EPS CONTROL BUS 2 | | |
| | | | TRANSFER BUS TIE | | | | | |
| 201 | ST | cb | CNTL-1 (3.9A) | Provides control power to bus 1, 2 reg transfer tie power relays and bus 1, 2 ATM transfer tie POWER relays thru REG/XFER TIE BUS 1, 2 and ATM/XFER TIE BUS 1, 2 sw (panel 206) | | EPS CONTROL BUS 1 | | |
| 201 | ST | cb | CNTL-2 (3.9A) | Provides control power to bus 1, 2 reg transfer tie power relays and bus 1, 2 ATM transfer tie power relays thru REG/XFER TIE BUS 1, 2 sw and ATM/XFER TIE BUS 1, 2 sw (panel 206) | | EPS CONTROL BUS 2 | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | POWER DISCONNECT | | | | | |
| | | | AM | | | | | |
| 201 | ST | cb | CNTL-1 (3.9A) | Provides control power to PWR DISCON 1, 2 sw (panel 205) | | EPS CONTROL BUS 1 | | Switches control<br>a. 1-8 PCG group output power reset relays<br>b. BUS 1, 2 power disconnect control relays |
| 201 | ST | cb | CNTL-2 (3.9A) | Provides control power to PWR DISCON 1, 2 sw (panel 205) | | EPS CONTROL BUS 2 | | c. BUS 1, 2 reg transfer tie power relays open condition |
| | | | ATM | | | | | |
| 201 | ST | cb | CNTL-1 (3.9A) | Provides power to ATM relay to disconnect bus 1, 2 ATM transfer tie power | | EPS CONTROL BUS 1 | | Provides redundant power to ATM CNTL-2 |
| 201 | ST | cb | CNTL-2 (3.9A) | Provides power to ATM relay to disconnect bus 1, 2 ATM transfer tie power | | EPS CONTROL BUS 2 | | Provides redundant power to ATM CNTL-1 |
| | | | ATM 1/TRANSFER 1 FEEDERS | | | | | |
| 201 | ST | cb | 1 (12.0A) | Protects feeder wiring for one of eighteen circuits which feed ATM main bus 1 | | TRANSFER BUS 1 | | |
| 201 | ST | cb | 2 thru 18 (12.0A) | Same as ATM 1/TRANSFER 1 FEEDERS cb 1 | | TRANSFER BUS 1 | | |
| | | | AMP-HOUR INTEGRATOR | | | | | |
| 201 | ST | cb | 5 thru 8 (3.9A) | Same as AMP-HOUR INTEGRATOR cb 1 for systems 1-4 | | EPS CONTROL BUS 2 | | |
| | | | PWR COND GROUP CNTL | | | | | |
| 201 | ST | cb | 5 thru 8 (3.9A) | Same as PWR COND GROUP CNTL cb 1 for systems 1-4 | | EPS CONTROL BUS 1 | | |
| | | | BATTERY CONTROL | | | | | |
| 201 | ST | cb | 5 thru 8 | Same as BATTERY CONTROL cb 1 for systems 1-4 | | BAT 5-8 | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | OWS BUS 2 FEEDERS | | | | | |
| | | | CONTROLS | | | | | |
| 201 | ST | cb | AM (3.9A) | Provides power to OWS power relays 4, 5 6 and 14 thru OWS BUS 2 sw (panel 206) | | EPS CONTROL BUS 2 | | The power relays control power from reg bus 2 to OWS bus 2 |
| 201 | ST | cb | OWS (3.9A) | Provides power to OWS power relays 4, 5, 6 & 14 thru OWS BUS 1 sw (panel 617) | | EPS CONTROL BUS 2 | | Provides redundant power through control switch in OWS (pnl 617) |
| 201 | ST | cb | 1 (12.0A) | Protects feeder wiring for one of eighteen circuits which feed OWS distribution bus 2 | | REG BUS 2 | | |
| 201 | ST | cb | 2 thru 9 (12.0A) | Same as OWS BUS 2 FEEDER cb 1 | | REG BUS 2 | | |
| | | | TRANSFER 2/CSM MNB FEEDERS | | | | | |
| 201 | ST | cb | 1 (18.4A) | Protects power transfer circuit between TRANSFER bus 2 and CSM MNB | | TRANSFER BUS 2 | | |
| 201 | ST | cb | 2 thru 5 (18.4A) | Same as TRANSFER 2/CSM MNB FEEDER cb 1 | | TRANSFER BUS 2 | | |
| | | | ATM 2/TRANSFER 2 FEEDERS | | | | | |
| 201 | ST | cb | 1 (12.0A) | Protects feeder wiring for one of eighteen circuits which feed ATM main bus 1 | | TRANSFER BUS 2 | | |
| 201 | ST | cb | 2 thru 18 (12.0A) | Same as ATM 2/TRANSFER 2 FEEDER cb 1 | | TRANSFER BUS 2 | | |

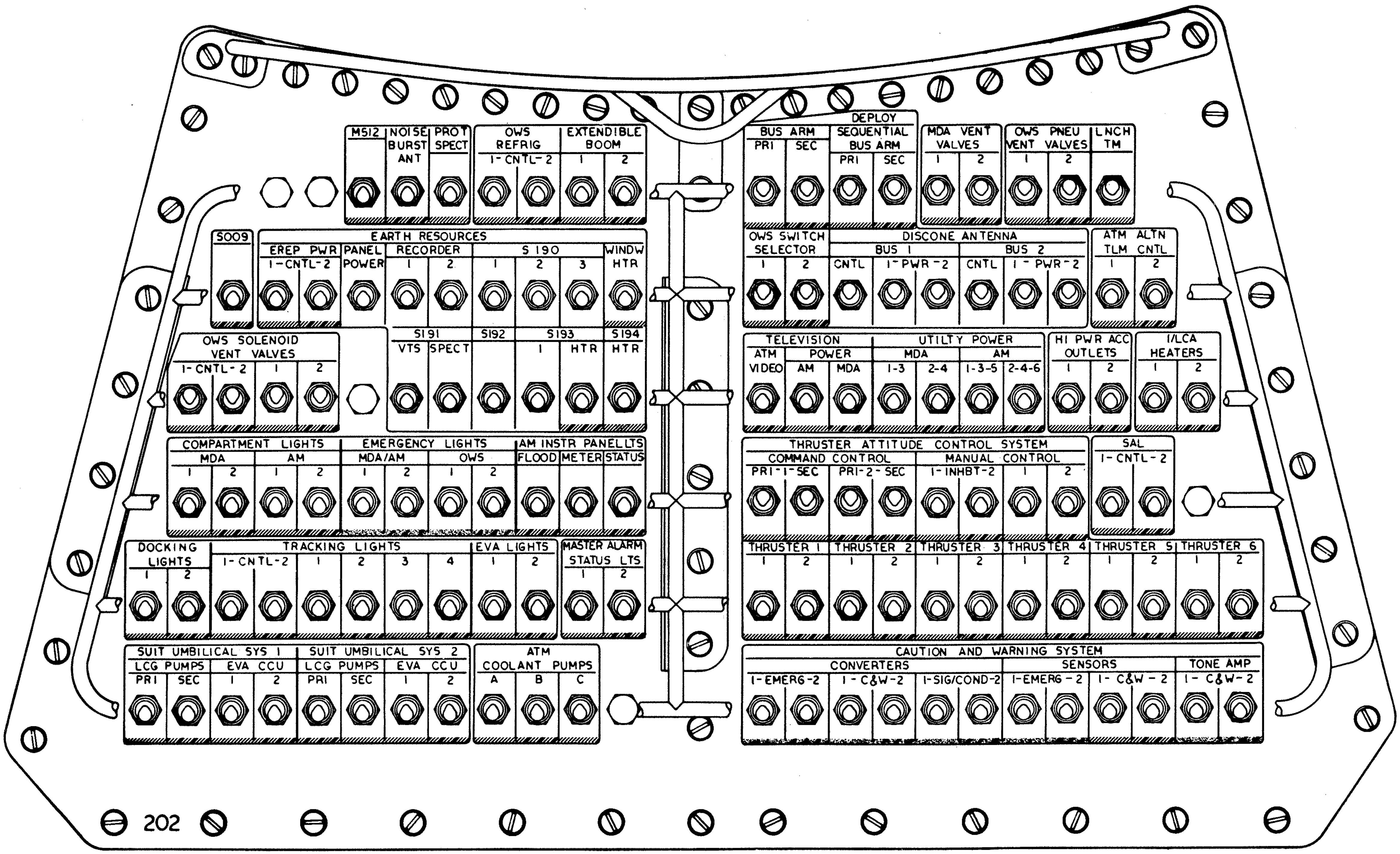






(Page 3.0-42 is BLANK)

P5


M512
NOISE BURST ANT
PROT SPECT
OWS REFRIG
1 - CNTL - 2
EXTENDIBLE BOOM
1
2
DEPLOY
BUS ARM
PRI
SEC
SEQUENTIAL BUS ARM
PRI
SEC
MDA VENT VALVES
1
2
OWS PNEU VENT VALVES
1
2
LNCH TM
S009
EARTH RESOURCES
EREP PWR
1 - CNTL - 2
PANEL POWER
RECORDER
1
2
S 190
1
2
3
WINDW HTR
OWS SWITCH SELECTOR
1
2
DISCONE ANTENNA
BUS 1
CNTL
1 - PWR - 2
BUS 2
CNTL
1 - PWR - 2
ATM ALTN TLM CNTL
1
2
OWS SOLENOID VENT VALVES
1 - CNTL - 2
1
2
S191
VTS
SPECT
S192
S193
1
HTR
S194
HTR
TELEVISION
ATM VIDEO
POWER
AM
MDA
UTILITY POWER
MDA
1-3
2-4
AM
1-3-5
2-4-6
HI PWR ACC OUTLETS
1
2
I/LCA HEATERS
1
2
COMPARTMENT LIGHTS
MDA
1
2
AM
1
2
EMERGENCY LIGHTS
MDA/AM
1
2
OWS
1
2
AM INSTR PANEL LTS
FLOOD
METER
STATUS
THRUSTER ATTITUDE CONTROL SYSTEM
COMMAND CONTROL
PRI - 1 - SEC
PRI - 2 - SEC
MANUAL CONTROL
1 - INHBT - 2
1
2
SAL
1 - CNTL - 2
DOCKING LIGHTS
1
2
TRACKING LIGHTS
1 - CNTL - 2
1
2
3
4
EVA LIGHTS
1
2
MASTER ALARM STATUS LTS
1
2
THRUSTER 1
1
2
THRUSTER 2
1
2
THRUSTER 3
1
2
THRUSTER 4
1
2
THRUSTER 5
1
2
THRUSTER 6
1
2
SUIT UMBILICAL SYS 1
LCG PUMPS
PRI
SEC
EVA CCU
1
2
SUIT UMBILICAL SYS 2
LCG PUMPS
PRI
SEC
EVA CCU
1
2
ATM COOLANT PUMPS
A
B
C
CAUTION AND WARNING SYSTEM
CONVERTERS
1 - EMERG - 2
1 - C&W - 2
1 - SIG/COND - 2
SENSORS
1 - EMERG - 2
1 - C&W - 2
TONE AMP
1 - C&W - 2
202

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 202 | ST | cb | M512 (12.0A) | Provides power to experiment M512 | | AM BUS 1 | | Ref SLEOH |
| 202 | ST | cb | NOISE BURST ANT (3.9A) | Provides power to the radio noise burst monitor (panel 128) | | AM BUS 2 | | Ref SLEOH |
| 202 | ST | cb | PROT SPECT (3.9A) | Provides power to the proton spectrometer | | AM BUS 1 | | |
| | | | OWS REFRIG | | | | | |
| 202 | ST | cb | CNTL-1 (3.9A) | Provides signal power to the refrigeration system primary loop control logic (enable-disable) thru control relays | | AM BUS 1 | | |
| 202 | ST | cb | CNTL-2 (3.9A) | Provides signal power to the refrigeration system secondary loop control logic (enable-disable) thru control relays | | AM BUS 2 | | |
| | | | EXTENDIBLE BOOM | | | | | |
| 202 | ST | cb | 1 (5.4A) | Provides power to the sun end extendible boom outlet and the center extendible boom redundant outlet thru EXTNDBL COOM CTR & SUN END sw (panel 321) | | AM BUS 1 | | |
| 202 | ST | cb | 2 (5.4A) | Provides power to the center extendible boom outlet and the sun end extendible boom redundant outlet thru EXTNDBL BOOM CTR & SUN END sw (panel 321) | | AM BUS 2 | | |
| 202 | ST | cb | S009 (3.9A) | Provides power to experiment S009 thru S009 CONT sw (panel 111) | | AM BUS 2 | | Ref SLEOH |
| | | | EARTH RESOURCES | | | | | |
| | | | EREP PWR | | | | | |
| 202 | ST | cb | CNTL-1 (3.9A) | Provides power to the EREP BUS 1 power control switch (panel 110) | | AM BUS 1 | | Ref SLEOH |
| 202 | ST | cb | CNTL-2 (3.9A) | Provides power to the EREP BUS 2 power control switch (panel 110) | | AM BUS 2 | | Ref SLEOH |
| 202 | ST | cb | PANEL POWER (18.4A) | Provides power to the EREP panel 110 | | EREP BUS 1 | | Ref SLEOH |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | RECORDER | | | | | |
| 202 | ST | cb | 1 (12.0A) | Provides power to earth resources recorder and coolant pump | | EREP BUS 1 | | Ref SLEOH |
| 202 | ST | cb | 2 (12.0A) | Provides power to earth resources recorder #2 | | EREP | | Ref SLEOH |
| | | | S190 | | | | | |
| 202 | ST | cb | 1 (18.4A) | Provides power to S190 experiment multispectral cameras (panel 106) | | EREP BUS 2 | | Ref SLEOH |
| 202 | ST | cb | 2 (18.4A) | Provides power to S190 experiment multispectral cameras (panel 106) | | EREP BUS 2 | | Ref SLEOH |
| 202 | ST | cb | 3 (9.3A) | Provides power to S190 experiment multispectral cameras (panel 106) | | EREP BUS 2 | | Ref SLEOH |
| 202 | ST | cb | WINDOW HTR (18.4A) | Provides power to the S190 window heaters thru WINDOW HEATER AUTO HEAT sw (panel 117) | | AM BUS 2 | | |
| | | | S191 | | | | | |
| 202 | ST | cb | VTS (18.4A) | Provides power to the S191 viewfinder tracking system (panel 109) | | EREP BUS 1 | | Ref SLEOH |
| 202 | ST | cb | SPECT (12.0A) | Provides power to the S191 EREP spectrometer (panel 109) | | EREP BUS 1 | | Ref SLEOH |
| 202 | ST | cb | S192 (18.4A) | Provides power to experiment S192 10 band scanner (panel 136) | | EREP BUS 1 | | Ref SLEOH |
| | | | S193 | | | | | |
| 202 | ST | cb | 1 (18.4A) | Provides power to the S193 microwave radiometer scatterometer | | EREP BUS 2 | | Ref SLEOH |
| 202 | ST | cb | HTR (3.9A) | Provides power to the S193 microwave radiometer scatterometer heater | | AM BUS 2 | | Ref SLEOH |
| 202 | ST | cb | S194 HTR | Provides power to the Exp S194 L-Band antenna heater | | AM BUS 1 | | Ref SLEOH |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | OWS SOLENOID VENT VALVES | | | | | |
| 202 | ST | cb | CNTL-1 (3.9A) | Provides power to OWS vent valves 1,2&3 control relays | | AM BUS 1 | | |
| 202 | ST | cb | CNTL-2 (3.9A) | Provides power to OWS vent valves 2,3&4 control relays | | AM BUS 2 | | |
| 202 | ST | cb | 1 (9.3A) | Provides power to open OWS vent valves #1 & 2 and close OWS vent valves #1 & 3 thru control relays | | AM BUS 1 | | |
| 202 | ST | cb | 2 (9.3A) | Provides power to open OWS vent valves #3 & 4 and close OWS vent valves #2 & 4 thru control relays | | AM BUS 2 | | |
| | | | COMPARTMENT LIGHTS | | | | | |
| | | | MDA | | | | | |
| 202 | ST | cb | 1 (3.9A) | Provides power to the MDA forward 1 & 3 and aft 1 & 3 lights thru LTG MDA FWD 1•3 & LTG MDA AFT 1•3 sw respectively (panel 207) or INTERIOR LTS sw (panel 101) | | AM BUS 1 | | |
| 202 | ST | cb | 2 (3.9A) | Provides power to the MDA forward 2 & 4, and aft 2 & 4 lights thru LTG MDA FWD 2•4 & LTG MDA AFT 2•4 sw respectively (panel 207) or INTERIOR LTS sw (panel 101) | | AM BUS 2 | | |
| | | | AM | | | | | |
| 202 | ST | cb | 1 (5.4A) | Provides power to all (4) STS fwd lights thru LTG STS FWD sel (panel 207) (2) lock compt lights thru LTG LOCK sw (panel 316) & (3) aft compt lights thru LTS AFT sw | | AM BUS 1 | | |
| 202 | ST | cb | 2 (5.4A) | Provides power to all (4) STS fwd lights thru LTG STS FWD sel (panel 207) (2) lock compt lights thru LTG LOCK sw (panel 316) & (3) aft compt lights thru LTS AFT sw (panel 390) | | AM BUS 2 | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | EMERGENCY LIGHTS | | | | | |
| | | | MDA/AM | | | | | |
| 202 | ST | cb | 1 (3.9A) | Provides emergency power to MDA aft light #3 and to one STS instrument panel light | | EPS CONTROL BUS 2 | | |
| 202 | ST | cb | 2 (3.9A) | Provides emergency power to MDA forward light #2, to one STS instrument panel light and to one lock compartment | | EPS CONTROL BUS 2 | | |
| | | | OWS | | | | | |
| 202 | ST | cb | 1 (3.9A) | Provides emergency power to OWS emergency lights dome 1, upper wall 3, experiment compartment 7 & 13 thru emergency lights control logic & thru LTS OWS ENTRY sw (pnl 390) | | EPS CONTROL BUS 1 | | |
| 202 | ST | cb | 2 (3.9A) | Provides emergency power to OWS emergency lights dome 4, upper wall 8, experiment compartment 6 & 14 thru emergency lights control logic & thru LTS OWS ENTRY sw (panel 390) | | EPS CONTROL BUS 2 | | |
| | | | AM INSTR PANEL LTS | | | | | |
| 202 | ST | cb | FLOOD (3.9A) | Provides power to (6) STS instrument panel lights thru LTG PNL sel (panel 207) | | AM BUS 2 | | |
| 202 | ST | cb | METER (3.9A) | Provides power to (62) STS meter lights thru LTG METER sel (panel 207) and (4) lock compartment meter lights thru LTG, LOCK METER sw (panel 316) | | AM BUS 1 | | Each meter has two meter lights |
| 202 | ST | cb | STATUS (3.9A) | Provides power to AM instrument panel status lights | | AM BUS 2 | | |
| | | | DOCKING LIGHTS | | | | | |
| 202 | ST | cb | 1 (5.4A) | Provides power to docking lights 1 control relays, to MDA & AM amber & white docking lights & (2) docking lights on each discone antenna thru LTG DKG sw (panel 207) | | AM BUS 1 | | |
| 202 | ST | cb | 2 (5.4A) | Provides power to docking lights 2 control relays, to MDA & AM green & red docking lights & (2) docking lights on each discone antenna thru LTG DKG sw (panel 207) | | AM BUS 2 | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | TRACKING LIGHTS | | | | | |
| 202 | ST | cb | CNTL-1 (3.9A) | Provides power to operate primary tracking lights control relays thru LTG TRACKING sw (panel 207) | | AM BUS 1 | | |
| 202 | ST | cb | CNTL-2 (3.9A) | Provides power to operate secondary tracking lights control relays thru LTG TRACKING sw (panel 207) | | AM BUS 2 | | |
| 202 | ST | cb | 1 (9.3A) | Provides power to primary tracking light unit no. 1 electronics assembly to illuminate the +Y primary tracking light | | AM BUS 1 | | |
| 202 | ST | cb | 2 (9.3A) | Provides power to secondary tracking light unit no. 2 electronics assembly to illuminate the -Y secondary tracking light | | AM BUS 2 | | |
| 202 | ST | cb | 3 (9.3A) | Provides power to primary tracking light unit no. 3 electronics assembly to illuminate the -Y primary tracking light | | AM BUS 1 | | |
| 202 | ST | cb | 4 (9.3A) | Provides power to secondary tracking lights unit no. 4 electronics assembly to illuminate the +Y secondary tracking light | | AM BUS 2 | | |
| | | | EVA LIGHTS | | | | | |
| 202 | ST | cb | 1 (5.4A) | Provides power to (3) AM EVA lights, thru LTG EVA AM sw & to (4) DA EVA lights thru LTG EVA DA sw and to ATM EVA lights control logic thru LTG EVA ATM sw (panel 316) | | AM BUS 1 | | The white AM docking light is utilized as one of the three AM EVA lights |
| 202 | ST | cb | 2 (5.4A) | Provides power to (2) AM EVA lights thru LTG EVA AM sw and to DA EVA lights thru LTG EVA DA sw (panel 316) | | AM BUS 2 | | |
| | | | MASTER ALARM STATUS LTS | | | | | |
| 202 | ST | cb | 1 (3.9A) | Provides 28vdc power to illuminate the primary light bulb in the master alarm lights at each speaker intercom station | | AM BUS 1 | | |
| 202 | ST | cb | 2 (3.9A) | Provides 28vdc power to illuminate the secondary light bulb in the master alarm lights at each speaker intercom station | | AM BUS 2 | | Provides redundant power to the master alarm lights |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | SUIT UMBILICAL SYSTEM 1 | | | | | |
| | | | LCG PUMPS | | | | | |
| 202 | ST | cb | PRI (3.9A) | Provides power to the primary suit coolant pump umbilical system 1 thru SUS 1 PUMP sws (IVA, EVA panels 317, 217) | | AM BUS 1 | | |
| 202 | ST | cb | SEC (3.9A) | Provides power to the secondary suit coolant pump umbilical system 1 thru SUS 1 PUMP sws (IVA, EVA panels 317, 217) | | AM BUS 2 | | |
| | | | EVA CCU | | | | | |
| 202 | ST | cb | 1 (5.4A) | Provides power to SUIT UMB SYS 1 - LSU POWER switches (panels 217, 317, 323) | | AM BUS 1 | | Provides power to biomed, headset microphone and ALSA thru EVA CCU AUDIO CHAN A connector |
| 202 | ST | cb | 2 (5.4A) | Provides power to SUIT UMB SYS 1 - LSU POWER switches (panels 217, 317, 323) | | AM BUS 2 | | Provides redundant power to above compone components |
| | | | SUIT UMBILICAL SYSTEM 2 | | | | | |
| | | | LCG PUMPS | | | | | |
| 202 | ST | cb | PRI (3.9A) | Provides power to the primary suit coolant pump umbilical system 2 thru SUS 2 PUMP sws (IVA,EVA panels 217, 323) | | AM BUS 2 | | |
| 202 | ST | cb | SEC (3.9A) | Provides power to the secondary suit coolant pump umbilical system 2 thru SUS 2 PUMP sws (IVA, EVA panels 217, 323) | | AM BUS 1 | | |
| | | | EVA CCU | | | | | |
| 202 | ST | cb | 1 (5.4A) | Provides power to SUIT UMB SYS 2-LSU POWER switches (panels 217, 317, 323) | | AM BUS 1 | | Provides power to biomed, headset microphone and ALSA thru EVA CCU AUDIO CHAN B connector |
| 202 | ST | cb | 2 (5.4A) | Provides power to SUIT UMB SYS 2-LSU POWER switches (panels 217, 317, 323) | | AM BUS 2 | | Provides redundant power to above components |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | ATM COOLANT PUMPS | | | | | |
| 202 | ST | cb | A (3.9A) | Provides power to ATM coolant pump A thru ATM CLNT PUMPS A sw (panel 203) | | AM BUS 1 | | |
| 202 | ST | cb | B (3.9A) | Provides power to ATM coolant pump B thru ATM CLNT PUMPS B sw (panel 203) | | AM BUS 2 | | |
| 202 | ST | cb | C (3.9A) | Provides power to ATM coolant pump C thru ATM CLNT PUMPS C sw (panel 203) | | AM BUS 1 | | |
| | | | DEPLOY | | | | | |
| | | | BUS ARM | | | | | |
| 202 | ST | cb | PRI (3.9A) | Provides power to No. 1 deploy bus arm control relays thru DPLY BUS sw (panel 205) | | AM BUS 1 | | PRI CONT RELAYS arm/disarm both primary and secondary buses |
| 202 | ST | cb | SEC (3.9A) | Provides power to No. 2 deploy bus arm control relays thru DPLY BUS sw (panel 205) | | AM BUS 2 | | SEC CONT RELAYS arm/disarm both secondary and primary buses |
| | | | SEQUENTIAL BUS ARM | | | | | |
| 202 | ST | cb | PRI (3.9A) | Provides power to No. 1 sequential bus arm control relays thru SEQ BUS sw (panel 205) | | AM BUS 1 | | See Deploy bus |
| 202 | ST | cb | SEC (3.9A) | Provides power to No. 2 sequential bus arm thru SEQ BUS sw (panel 205) | | AM BUS 2 | | See Deploy bus |
| | | | MDA VENT VALVES | | | | | |
| 202 | ST | cb | 1 (3.9A) | Provides power to MDA vent valve #1 thru control relays | | AM BUS 1 | | |
| 202 | ST | cb | 2 (3.9A) | Provides power to MDA vent valve #2 thru control relays | | AM BUS 2 | | |
| | | | OWS PNEU VENT VALVES | | | | | |
| 202 | ST | cb | 1 (9.3A) | Provides power to primary waste tank vent actuation control module solenoids and habitation area bypass vent valve actuation control module solenoids thru control relays | | AM BUS 1 | | |
| 202 | ST | cb | 2 (9.3A) | Provides power to secondary waste tank vent actuation control module solenoids and habitation area bypass vent valve actuation control module solenoids thru control relays | | AM BUS 2 | | |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 202 | ST | cb | LNCH TM (3.9A) | Provides power to power-down, liftoff, and plug supervision monitor circuits and to selected measurements required only prior to initial habitation | | AM BUS 1 | | cb opened on SL - 1/2 activation for duration of mission |
| | | | OWS SWITCH SELECTOR | | | | | |
| 202 | ST | cb | 1 (3.9A) | Provides power to OWS switch selector | | AM BUS 1 | | Relay driver power |
| 202 | ST | cb | 2 (3.9A) | Provides power to OWS switch selector | | AM BUS 2 | | Provides redundant relay driver power |
| | | | DISCONE ANTENNA | | | | | |
| | | | BUS 1 | | | | | |
| 202 | ST | cb | CNTL (3.9A) | Provides control power for discone antennas release actuators #1 thru ANT sw (panel 205) | | DEPLOY BUS 1 | | Provides control power only when ANT sw is positioned to DEPLOY |
| 202 | ST | cb | PWR-1 (5.4A) | Provides power to discone antenna #1 release actuator #1 | | DEPLOY BUS 1 | | Primary control power provided by CRDU |
| 202 | ST | cb | PWR-2 (5.4A) | Provides power to discone antenna #2 release actuator #1 | | DEPLOY BUS 1 | | |
| | | | BUS 2 | | | | | |
| 202 | ST | cb | CNTL (3.9A) | Provides control power for discone antennas release actuators #2 thru ANT sw (panel 205) | | DEPLOY BUS 2 | | Provides control power only when ANT sw is positioned to DEPLOY |
| 202 | ST | cb | PWR-1 (5.4A) | Provides power to discone antenna #1 release actuator #2 | | DEPLOY BUS 2 | | Primary control power provided by CRDU |
| 202 | ST | cb | PWR-2 (5.4A) | Provides power to discone antenna #2 release actuator #2 | | DEPLOY BUS 2 | | |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | ATM ALTN TLM CNTL | | | | | |
| 202 | ST | cb | 1 (3.9A) | Provides power to ATM Cannister Vent #1 and power through the CRDU isolation relays to ATM to perform functions listed on remarks column | | AM BUS 1 | | S370-ATM Tape Recorder #1-Record<br>S329-ATM Tape Recorder #1-Playback<br>S371-ATM Tape Recorder #1-Stop<br>S359-ATM Transmitter #1 ON-Forward Antenna<br>S351-ATM Transmitter #1 ON-Aft Antenna<br>S375 ATM Transmitter #2 ON-Forward Antenna<br>S374-ATM Transmitter #2 ON-Aft Antenna |
| 202 | ST | cb | 2 (3.9A) | Provides power to ATM Cannister Vent #2 and power through the CRDU isolation relays to the ATM to perform functions | | AM BUS 2 | | S298-ATM Tape Recorder #2-Record<br>S310-ATM Tape Recorder #2-Playback<br>S299-ATM Tape Recorder #2-Stop<br>S301-ATM Transmitter #1 input-Tape Recorder<br>S300-ATM Transmitter #1 input-Real Time<br>S303-ATM Transmitter #2 input-Tape Recorder<br>S302-ATM Transmitter #2 input-Real Time |
| | | | TELEVISION | | | | | |
| 202 | ST | cb | ATM VIDEO (3.9A) | Provides power to VIDEO sel sw (panel 132) | | AM BUS 2 | | |
| | | | POWER | | | | | |
| 202 | ST | cb | AM (3.9A) | Provides power to AM TM input station (panel 320) | | AM BUS 1 | | |
| 202 | ST | cb | MDA (3.9A) | Provides power to MDA TV input station (panel 133) | | AM BUS 2 | | |
| | | | UTILITY POWER | | | | | |
| | | | MDA | | | | | |
| 202 | ST | cb | 1-3 (5.4A) | Provides power to MDA UTILITY OUTLET 1 and 3 (panels 112, 134) | | AM BUS 1 | | |
| 202 | ST | cb | 2-4 (5.4A) | Provides power to MDA UTILITY OUTLET 2 and 4 (panels 104, 140) | | AM BUS 2 | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | UTILITY POWER | | | | | |
| | | | AM | | | | | |
| 202 | ST | cb | 1-3-5 (5.4A) | Provides power to AM UTILITY POWER outlets 1, 3, and 5 (panels 213, 219, 390) | | AM BUS 1 | | |
| 202 | ST | cb | 2-4-6 (5.4A) | Provides power to AM UTILITY POWER outlets 2, 4, and 6 (panels 214, 221, 316) | | AM BUS 2 | | |
| | | | HI PWR ACC OUTLETS | | | | | |
| 202 | ST | cb | 1 (12.0A) | Provides power to HI PWR ACCESS outlet 1 in the MDA (panel 115) | | AM BUS 1 | | |
| 202 | ST | cb | 2 (12.0A) | Provides power to HI PWR ACCESS outlet 2 in the MDA (panel 139) | | AM BUS 2 | | |
| | | | I/LCA HEATERS | | | | | |
| 202 | ST | cb | 1 (5.4A) | Provides power to MDA I/LCA heater 1 | | AM BUS 1 | | 90 watt heater element (primary circuit) |
| 202 | ST | cb | 2 (5.4A) | Provides power to MDA I/LCA heater 2 | | AM BUS 2 | | 90 watt heater element (primary circuit) |
| | | | THRUSTER ATTITUDE CONTROL SYSTEM | | | | | |
| | | | COMMAND CONTROL | | | | | |
| 202 | ST | cb | PRI-1 (3.9A) | Provides power to command control bus 1 and IU/ATM control transfer 1, command control bus 1 on, off and TACS bus 1 on, off relays | | AM BUS 1 | | |
| 202 | ST | cb | SEC-1 (3.9A) | Provides power to command control bus 1 and IU/ATM control transfer 1, command control bus 1 on, off and TACS bus 1 on, off relays | | AM BUS 1 | | Provides redundant power to command control bus 1 and command control Bus 1 on, off relays |
| 202 | ST | cb | PRI-2 (3.9A) | Provides power to command control bus 2 and command control bus 2 on, off relays | | AM BUS 2 | | |
| 202 | ST | cb | SEC-2 (3.9A) | Provides power to command control bus 2 and command control bus 2 on, off relays | | AM BUS 2 | | Provides redundant power to command control bus 2 and command control bus 2 on, off relays |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | MANUAL CONTROL | | | | | |
| 202 | ST | cb | INHBT-1 (3.9A) | Provides power to manual control inhibit switches for TACS buses-1 (panel 130) | | AM BUS 1 | | |
| 202 | ST | cb | INHBT-2 (3.9A) | Provides power to manual control inhibit switches for TACS buses-2 (panel 130) | | AM BUS 2 | | |
| 202 | ST | cb | 1 (3.9A) | Provides power to TACS buses-1 enable relay timer modules and to TACS-1 chamber pressure switches | | AM BUS 1 | | |
| 202 | ST | cb | 2 (3.9A) | Provides 28 VDC power to TACS buses-2 enable relay timer modules and to TACS-2 chamber pressure switches | | AM BUS 2 | | |
| | | | THRUSTER 1 | | | | | |
| 202 | ST | cb | 1 (9.3A) | Provides power to TACS bus 1-2A | | AM BUS 1 | | |
| 202 | ST | cb | 2 (9.3A) | Provides power to TACS bus 1-2B | | AM BUS 2 | | Redundant power to Thruster 1 control valve solenoids |
| | | | THRUSTER 2 | | | | | |
| 202 | ST | cb | 1 (9.3A) | Provides power to TACS bus 1-3A | | AM BUS 1 | | |
| 202 | ST | cb | 2 (9.3A) | Provides power to TACS bus 1-3B | | AM BUS 2 | | Redundant power to Thruster 2 control valve solenoids |
| | | | THRUSTER 3 | | | | | |
| 202 | ST | cb | 1 (9.3A) | Provides power to TACS bus 1-1A | | AM BUS 1 | | |
| 202 | ST | cb | 2 (9.3A) | Provides power to TACS bus 1-1B | | AM BUS 2 | | Redundant power to Thruster 3 control valve solenoids |
| | | | THRUSTER 4 | | | | | |
| 202 | ST | cb | 1 (9.3A) | Provides power to TACS bus 2-2A | | AM BUS 1 | | |
| 202 | ST | cb | 2 (9.3A) | Provides power to TACS bus 2-2B | | AM BUS 2 | | Redundant power to Thruster 4 control valve solenoids |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | THRUSTER 5 | | | | | |
| 202 | ST | cb | 1 (9.3A) | Provides power to TACS bus 2-1A | | AM BUS 1 | | |
| 202 | ST | cb | 2 (9.3A) | Provides power to TACS bus 2-1B | | AM BUS 2 | | Redundant power to Thruster 5 control valve solenoids |
| | | | THRUSTER 6 | | | | | |
| 202 | ST | cb | 1 (9.3A) | Provides power to TACS bus 2-3A | | AM BUS 1 | | |
| 202 | ST | cb | 2 (9.3A) | Provides power to TACS bus 2-3B | | AM BUS 2 | | Redundant power to Thruster 6 control valve solenoids |
| | | | SAL | | | | | |
| 202 | ST | cb | CNTL-1 (3.9A) | Provides power to the scientific airlock experiment control logic through the +Z SAL OUTLET (panel 518) | | AM BUS 1 | | S149 utilizes the INST connector on panel 518 |
| 202 | ST | cb | CNTL-2 (3.9A) | Provides power to the scientific airlock experiment control logic through the -Z SAL OUTLET (panel 544) | | AM BUS 2 | | S149 utilizes the INST connector on panel 544 |
| | | | CAUTION AND WARNING SYSTEM | | | | | |
| | | | CONVERTERS | | | | | |
| 202 | ST | cb | EMERG-1 (5.4A) | Provides power to emergency subunit 1 DC/DC converter #1 | | EPS CONTROL BUS 1 | | |
| 202 | ST | cb | EMERG-2 (5.4A) | Provides power to emergency subunit 2 DC/DC converter #2 | | EPS CONTROL BUS 2 | | |
| 202 | ST | cb | C&W-1 (5.4A) | Provides power to C&W subunit 1 DC/DC converter #1 | | EPS CONTROL BUS 1 | | |
| 202 | ST | cb | C&W-2 (5.4A) | Provides power to C&W subunit 2 DC/DC converter #2 | | EPS CONTROL BUS 2 | | |

| LOCATION | | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| PNL | STA# | | | | | | | |
| 202 | ST | cb | SIG/COND-1 (5.4A) | Provides power to primary C&W signal conditioning primary display converter and C&W detection module #1 detectors and relay drivers | | EPS CONTROL BUS 1 | | |
| 202 | ST | cb | SIG/COND-2 (5.4A) | Provides power to secondary C&W signal conditioning secondary display converter and C&W detection module #2 detectors and relay drivers | | EPS CONTROL BUS 2 | | |
| | | | SENSORS | | | | | |
| 202 | ST | cb | EMER-1 (5.4A) | Provides +28VDC emergency sensor (VES 1) power to rapid P sensor 1 and to each fire sensor control panel (BUS 1) | | EPS CONTROL BUS 1 | | SENSOR 1 and 2 control switches on each Fire Sensor Control Panel can detect either VES 1 (BUS 1) or VES 2 (BUS 2) power |
| 202 | ST | cb | EMER-2 (5.4A) | Provides 28VDC emergency sensor 2 (VES 2) power to rapid P sensor 2 and to each fire sensor control panel (BUS 2) | | EPS CONTROL BUS 2 | | |
| 202 | ST | cb | C&W 1 (3.9A) | Provides +28VDC power (VECS 1) to caution & warning sensors in the ECS | | AM CONTROL BUS 1 | | Sieve A or B gas flow, OWS gas interchange, condensate tank P cluster pressure low |
| 202 | ST | cb | C&W-2 (3.9A) | Provides +28VDC power (VECS 2) to caution & warning sensors in the ECS | | AM CONTROL BUS 2 | | Sieve A or B gas flow, cluster pressure low (redundant) |
| | | | TONE AMPS | | | | | |
| 202 | ST | cb | C&W-1 (3.9A) | Provides power to C&W High level audio amplifier #1 | | EPS CONTROL BUS 1 | | |
| 202 | ST | cb | C&W-2 (3.9A) | Provides power to C&W high level audio amplifier #2 | | EPS CONTROL BUS 2 | | |



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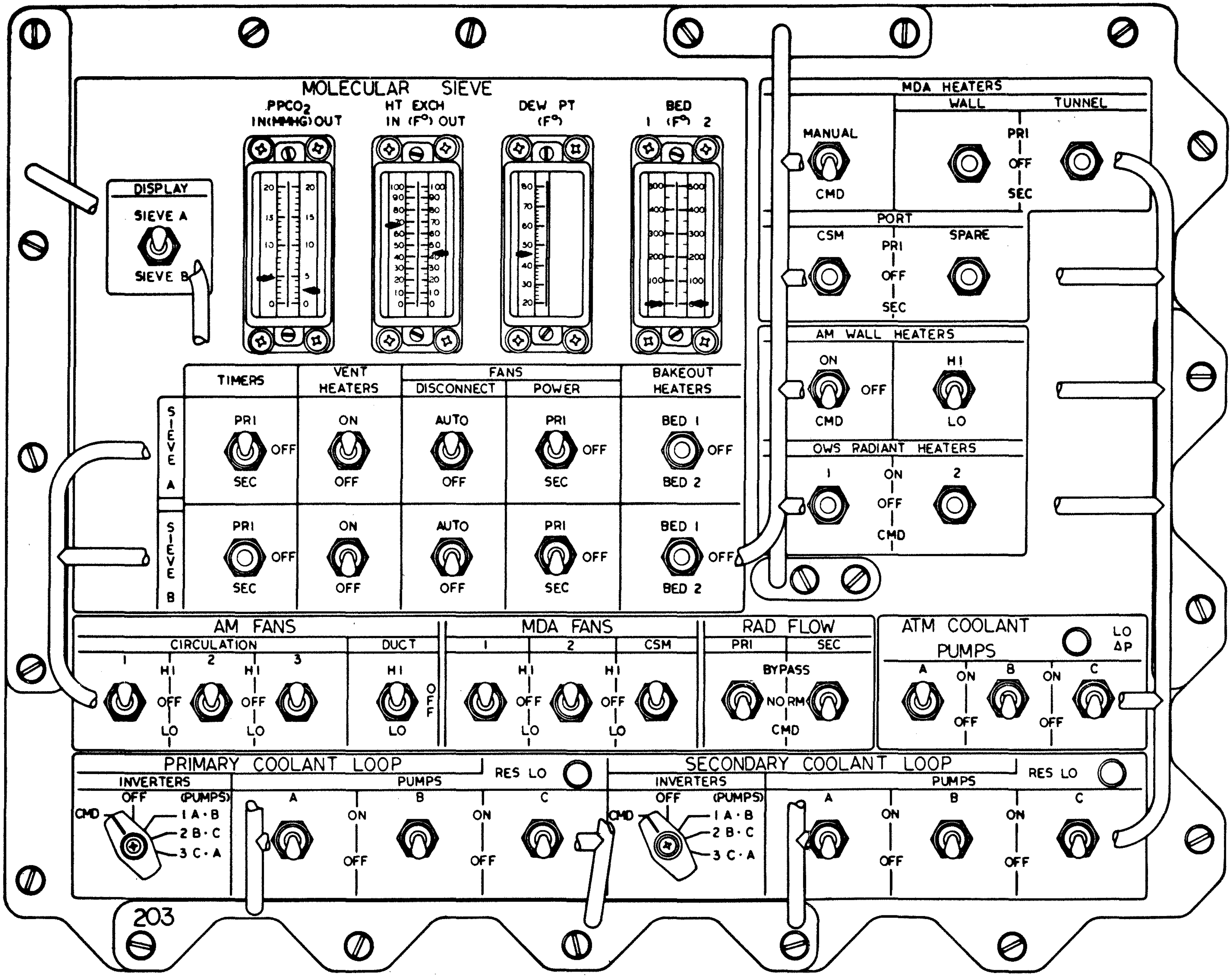
P8


MOLECULAR SIEVE
PPCO2 IN (MMHG) OUT
HT EXCH IN (F°) OUT
DEW PT (F°)
BED 1 (F°) 2
DISPLAY
SIEVE A
SIEVE B
TIMERS
VENT HEATERS
FANS
DISCONNECT
POWER
BAKEOUT HEATERS
SIEVE A
SIEVE B
PRI
SEC
OFF
ON
AUTO
BED 1
BED 2
MDA HEATERS
WALL
TUNNEL
MANUAL
CMD
PORT
CSM
SPARE
AM WALL HEATERS
HI
LO
OWS RADIANT HEATERS
AM FANS
CIRCULATION
DUCT
MDA FANS
RAD FLOW
BYPASS
NORM
ATM COOLANT PUMPS
LO ΔP
PRIMARY COOLANT LOOP
SECONDARY COOLANT LOOP
RES LO
INVERTERS
(PUMPS)
1 A·B
2 B·C
3 C·A
PUMPS
203

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | MOLECULAR SIEVE | | | | | |
| 203 | ST | sw | DISPLAY | | | | | |
| | | | SIEVE A | Selects mol sieve A transducer outputs to indicators | DISP CONV INPUT PRI (pnl 200) | AM BUS 1 | | |
| | | | SIEVE B | Selects mol sieve B transducer outputs to indicators | DISP CONV INPUT SEC (pnl 200) | AM BUS 2 | | |
| 203 | ST | ind | PPCO2 | | | | | |
| | | | IN | Indicates partial pressure of CO2 in the atmosphere gas entering the mol sieve | DISP CONV OUTPUT +24V & -24V (pnl 200) | INST BUS A or B or DISP CONV | | Range 0 to 20 mmHg |
| | | | OUT | Indicates partial pressure of CO2 in the atmosphere gas leaving the mol sieve sorbent canister | C&W CONV | | | Range 0 to 20 mmHg |
| 203 | ST | ind | HEAT EXCH | | | | | |
| | | | IN | Indicates temperature of mol sieve condensing heat exchanger module inlet gas temp | DISP CONV OUTPUT +24V (pnl 200) | INST BUS A or B or DISP CONV | | Range 0 to 100°F |
| | | | OUT | Indicates temperature of mol sieve condensing heat exchanger module outlet gas temp | DISP CONV OUTPUT +24V (pnl 200) | INST BUS A or B or DISP CONV | | Range 0 to 100°F |
| 203 | ST | ind | DEW PT | Indicates dew point of mol sieve condensing heat exchanger inlet gas | DISP CONV INPUT PRI FOR SV A & SEC FOR SV B | AM BUS 1 for SV A & AM BUS 2 for SV B | | Range 20 to 80°F |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | MOLECULAR SIEVE A | | | | | |
| 203 | ST | ind | BED | | | | | |
| | | | 1 | Indicates temperature of mol sieve sorbent canister 1 | MOL SV A BED HTRS FOR SIEVE A and MOL SV B BED HTRS FOR SIEVE B | AM BUS 1 for SV A and AM BUS 2 FOR SV B | | Range 0 to 500°F |
| | | | 2 | Indicates temperature of mol sieve sorbent canister 2 | | | | Range 0 to 500°F |
| | | | SIEVE A | | | | | |
| 203 | ST | sw | TIMERS | | | | | |
| | | | PRI | Turns on mol sieve A cycle timer #1 (PRI) | MOL SV A TMRS PRI & SEC (pnl 200) | AM BUS 1&2 | | |
| | | | OFF | Turns off mol sieve A cycle timers | | | | |
| | | | SEC | Turns on mol sieve A cycle timer #2 (SEC) | | | | |
| 203 | ST | sw | VENT HEATERS | | | | | |
| | | | ON | Turns on mol sieve A vent heaters #9, 10, 11, 12, 13, 14, 15, 16, 17, 18 and mol sieve B vent htrs #7, 8 | VENT HTRS PRI & SEC (pnl 200) | AM BUS 1&2 | | HTRS 7,9,11,13,15,& 17 PRI (AM BUS 1) HTRS 8,10,12,14,16& 18 SEC (AM BUS 2) |
| | | | OFF | Turns off above | | | | |
| | | | FANS | | | | | |
| 203 | ST | sw | DISCONNECT | | | | | |
| | | | AUTO | Enables turn off control of mol sieve A fans by mol sieve A bed 1, 2 gas valve limit switches | MOL SV A FANS PRI & SEC | AM BUS 1&2 | | Fans are turned off if both adsorbent assemblies are in the adsorb mode |
| | | | OFF | Deactivates above | | | | |
| 203 | ST | sw | POWER | | | | | |
| | | | PRI | Enables power thru the DISCONNECT sw to mol sieve A fans #1 inverter | MOL SV A FANS PRI (pnl 200) | AM BUS 1 | | |
| | | | OFF | Turns off power to fan inverters #1 & 2 | | | | |
| | | | SEC | Enables power thru the DISCONNECT sw to mol sieve A fan #2 inverter | MOL SV A FANS SEC (pnl 200) | AM BUS 2 | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | MOLECULAR SIEVE A (cont'd) | | | | | |
| 203 | ST | sw | BAKEOUT HEATERS | | | | | |
| | | | BED 1 | Turns on mol sieve A bakeout heaters in bed 1 and provides power to sieve A bed 1 temp transducer | MOL SV A BED HTRS | AM BUS 1 | | |
| | | | OFF | Turns off mol sieve A bakeout htrs | | | | |
| | | | BED 2 | Turns on mol sieve A bakeout heaters in bed 2 and provides power to sieve A bed 2 temp transducer | MOL SV A BED HTRS | AM BUS 1 | | |
| | | | SIEVE B | | | | | |
| 203 | ST | sw | TIMERS | | | | | |
| | | | PRI | Turns on molecular sieve B cycle timer #1 (PRI) | MOL SV B TMRS PRI & SEC (pnl 200) | AM BUS 1&2 | | |
| | | | OFF | Turns off mol | | | | |
| | | | OFF | Turns off molecular sieve B cycle timers | | | | |
| | | | SEC | Turns on molecular sieve B cycle timer #2 (SEC) | | | | |
| 203 | ST | sw | VENT HEATERS | | | | | |
| | | | ON | Turns on molecular sieve B vent heaters #1, 2, 3, 4, 5, 6, 7, 8 and molecular sieve A vent heaters #9-18 | VENT HTRS PRI & SEC (pnl 200) | AM BUS 1&2 | | ODD # HTRS 1-18 PRI (AM BUS 1)<br>EVEN # HTRS 1-18 SEC (AM BUS 2) |
| | | | OFF | Turns off above | | | | |
| | | | FANS | | | | | |
| 203 | ST | sw | DISCONNECT | | | | | |
| | | | AUTO | Enables turn off control of molecular sieve B fans by molecular sieve B bed 1, 2 gas valve limit switches | MOL SV B FANS PRI & SEC (pnl 200) | AM BUS 1&2 | | Fans are turned off if both absorbent assemblies are in the absorb mode |
| | | | OFF | Turns off above | | | | |
| 203 | ST | sw | POWER | | | | | |
| | | | PRI | Enables power thru the DISCONNECT sw to molecular sieve B fan #1 inverter | MOL SV B FANS PRI (pnl 200) | AM BUS 1 | | |
| | | | OFF | Turns off power to fans | | | | |
| | | | SEC | Enables power thru the DISCONNECT sw to molecular sieve B fan #2 inverter | MOL SV B FANS SEC (pnl 200) | AM BUS 2 | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | MOLECULAR SIEVE B (cont'd) | | | | | |
| 203 | ST | sw | BAKEOUT HEATERS | | | | | |
| | | | BED 1 | Turns on molecular sieve B bakeout heaters in bed 1 and provides power to sieve B bed 1 temp transducer | MOL SV B BED HTRS (pnl 200) | AM BUS 2 | | |
| | | | OFF | Turns off molecular sieve B bakeout heaters | | | | |
| | | | BED 2 | Turns on molecular sieve B bakeout heaters in bed 2 and provides power to sieve B bed 2 temp transducer | MOL SV B BED HTRS | AM BUS 2 | | |
| | | | MDA HEATERS | | | | | |
| 203 | ST | sw | [MANUAL/CMD] | | | | | |
| | | | MANUAL | Enables manual control of MDA wall, tunnel and port heaters | MDA/OWS HTRS CNTL 1,2 (pnl 200) | AM BUS 1&2 | | |
| | | | CMD | Enables DCS control of MDA wall tunnel and port heaters | | | | |
| 203 | ST | sw | WALL | | | | | |
| | | | PRI | Turns on MDA wall heaters primary elements | MDA/OWS HTRS PRI 1, 2 | AM BUS 1&2 | 44624<br>40124<br>45724<br>43064 | MDA WL/TNL 1 HTRS ON<br>PRI MDA WL 1 HTRS<br>MDA WL/TNL 2 HTRS ON<br>PRI MDA WL 2 HTRS |
| | | | OFF | Turns off MDA wall heaters | | | 42624<br>44064 | MDA WL/TNL 1 HTRS OFF<br>MDA WL/TNL 2 HTRS OFF |
| | | | SEC | Turns on MDA wall heaters secondary elements | MDA/OWS HTRS SEC 1, 2 | AM BUS 1&2 | 44624<br>43624<br>45724<br>41064 | MDA WL/TNL 1 HTRS ON<br>SEC MDA WL 1 HTRS<br>MDA WL/TNL 2 HTRS ON<br>SEC MDA WL 2 HTRS |
| 203 | ST | sw | TUNNEL | | | | | |
| | | | PRI | Turns on primary MDA tunnel heaters 1&2 | MDA TUNL HTR PRI 1, 2 (pnl 200) | AM BUS 1 | 44624<br>45724<br>44660 | MDA WL/TNL 1 HTRS ON<br>MDA WL/TNL 2 HTRS ON<br>PRI MDA TNL 1-2 |
| | | | OFF | Turns off MDA tunnel heaters | | | 42624<br>44064 | MDA WL/TNL 1 HTRS OFF<br>MDA WL/TNL 2 HTRS OFF |
| | | | SEC | Turns on secondary MDA tunnel heaters 1&2 | MDA TUNL HTRS SEL 1, 2 (pnl 200) | AM BUS 2 | 44624<br>45724<br>40660 | MDA WL/TNL 1 HTRS ON<br>MDA WL/TNL 2 HTRS ON<br>SEC MDA TNL 1-2 |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | PORT | | | | | |
| 203 | ST | sw | CSM | | | | | |
| | | | PRI | Turns on primary MDA CSM port heater | MDA PORT HTRS PRI (pnl 200) | AM BUS 1 | 41204<br>44604 | MDA PRT HTRS ON<br>PRI MDA/CSM PRI HTR |
| | | | OFF | Turns off MDA CSM port heaters | | | 45204 | MDA PRT HTRS OFF |
| | | | SEC | Turns on secondary MDA CSM port heater | MDA PORT HTRS SEL (pnl 200) | AM BUS 2 | 41204<br>40604 | MDA PRT HTRS ON<br>SEC MDA/CSM PRT HTR |
| 203 | ST | sw | SPARE | | | | | |
| | | | PRI | Turns on primary MDA spare port heater | MDA PORT HTRS PRI (pnl 200) | AM BUS 1 | 41204<br>46460 | MDA PRT HTRS ON<br>PRI MDA SPR PRT HTR |
| | | | OFF | Turns off MDA spare port heaters | | | 45204 | MDA PRT HTRS OFF |
| | | | SEC | Turns on secondary MDA spare port heater | MDA PORT HTRS SEL (pnl 200) | AM BUS 2 | 41204<br>42460 | MDA PRT HTRS ON<br>SEC MDA SPR PRT HTR |
| | | | AM WALL HEATERS | | | | | |
| 203 | ST | sw | [ON/OFF/CMD] | | | | | |
| | | | ON | Turns on STS wall heaters 1-8, lock tunnel wall heaters 2-8 | AM WALL HTRS 1&2 (pnl 200) | AM BUS 1&2 | <br>40260<br>43620 | STS wall HTRS 1,3,5,7 and lock tunnel wall HTRS 2,4,6,8 (AM WALL HTRS 1) AM BUS 1. STS wall HTRS 2,4,6,8 and lock tunnel wall htrs 3,5,7 (AM WALL HTRS 2) AM BUS 2<br>AM 60 HTRS ON<br>AM 40 HTRS ON |
| | | | OFF | Turns off above | | | 44260<br>47620 | AM 60 HTRS OFF<br>AM 40 HTRS OFF |
| | | | CMD | Enables DCS control of above | | | | |
| 203 | ST | sw | [HI/LO] | | | | | |
| | | | HI | Enables 85°F thermostat for AM wall heater control | AM WALL HTRS 1&2 (pnl 200) | AM BUS 1&2 | | |
| | | | LO | Enables 62°F thermostat for AM wall heater control | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | OWS RADIANT HEATERS | | | | | |
| 203 | ST | sw | 1 ON | Turns on radiant heaters 1, 3, 5 & 7 | OWS RDNT HTRS 1-5 AND 3-7 | AM BUS 1 | 41060 | OWS RDNT HTRS 1 ON |
| | | | OFF | Turns off radiant heaters 1, 3, 5 & 7 | | | 45060 | OWS RDNT HTRS 1 OFF |
| | | | CMD | Enables DCS control of above | | | | |
| 203 | ST | sw | 2 ON | Turns on radiant heaters 2, 4, 6 & 8 | OWS RDNT HTRS 2-6 AND 4-8 | AM BUS 2 | 41560 | OWS RDNT HTRS 2 ON |
| | | | OFF | Turns off radiant heaters 2, 4, 6 & 8 | | | 45560 | OWS RDNT HTRS 2 OFF |
| | | | CMD | Enables DCS control of above | | | | |
| | | | AM FANS | | | | | |
| | | | CIRCULATION | | | | | |
| 203 | ST | sw | 1 | | | | | |
| | | | HI | Turns AM circulation fan #1 on high speed | AM FANS CIRC 1 (pnl 200) | AM BUS 1 | | |
| | | | OFF | Turns off AM circulation fan #1 | | | | |
| | | | LO | Turns AM circulation fan #1 on low speed | | | | |
| 203 | ST | sw | 2 | | | | | |
| | | | HI | Turns AM circulation fan #2 on high speed | AM FANS CIRC 2 (pnl 200) | AM BUS 2 | | |
| | | | OFF | Turns off AM circulation fan #2 | | | | |
| | | | LO | Turns AM circulation fan #2 on low speed | | | | |
| 203 | ST | sw | 3 | | | | | |
| | | | HI | Turns AM circulation fan #3 on high speed | AM FANS CIRC 3 (pnl 200) | AM BUS 1 | | |
| | | | OFF | Turns off AM circulation fan #3 | | | | |
| | | | LO | Turns AM circulation fan #3 on low speed | | | | |
| | | | DUCT | | | | | |
| 203 | ST | sw | HI | Provides power to high speed contacts on AM circulation fan duct electrical outlets 1 & 2 | AM FANS DUCT 1&2 (pnl 200) | AM BUS 1&2 | | |
| | | | OFF | Provides no power to AM circulation fan duct electrical outlets 1, 2 | | | | |
| | | | LO | Provides power to low speed contacts on AM circulation fan duct electrical outlets 1 & 2 | | | | |

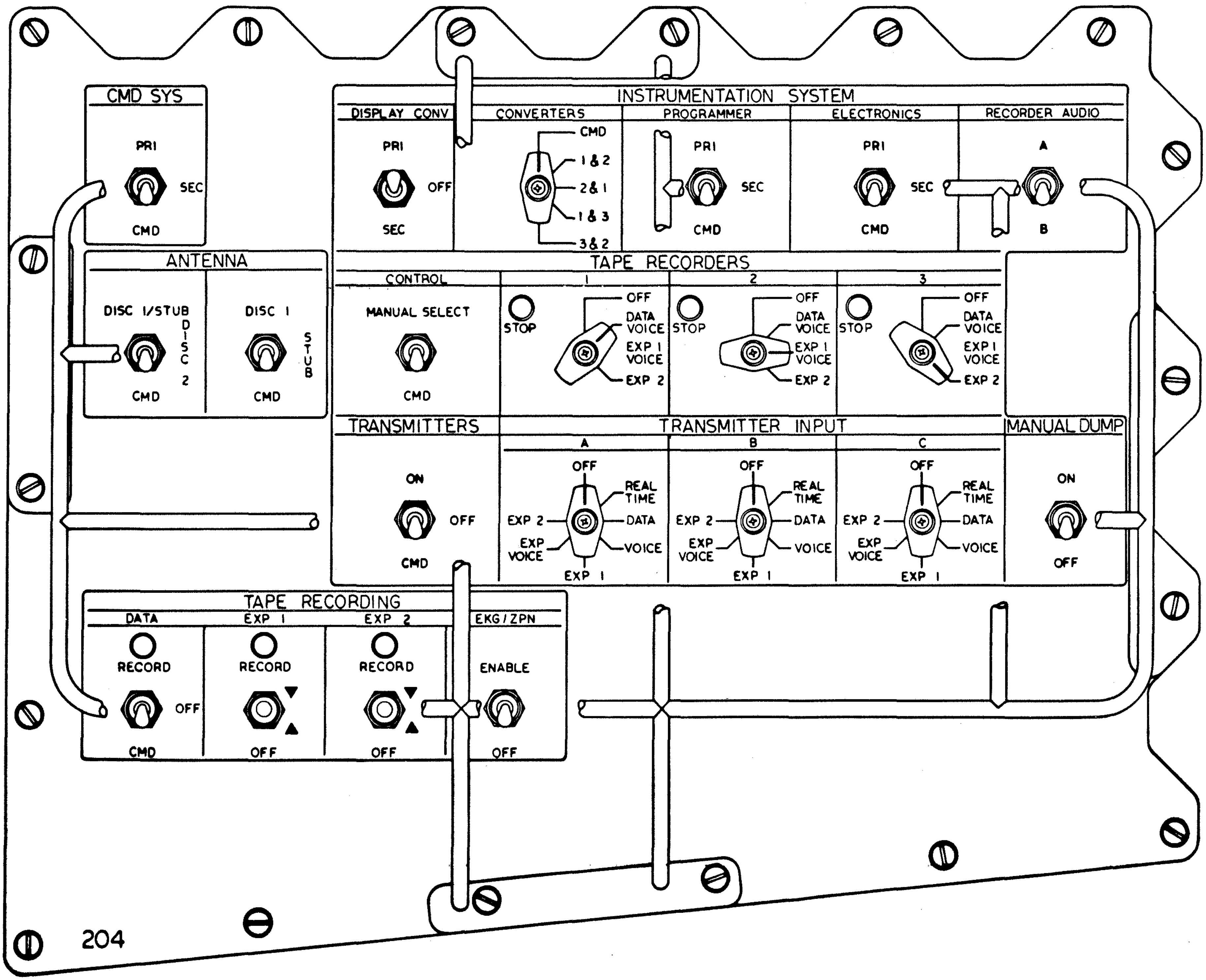
| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | MDA FANS | | | | | |
| 203 | ST | sw | 1 | | | | | |
| | | | HI | Turns MDA fan #1 on high speed | MDA FANS 1 (pnl 200) | AM BUS 1 | | |
| | | | OFF | Turns off MDA fan #1 | | | | |
| | | | LO | Turns MDA fan #1 on low speed | | | | |
| 203 | ST | sw | 2 | | | | | |
| | | | HI | Turns MDA fan #2 on high speed | MDA FANS 2 (pnl 200) | AM BUS 2 | | |
| | | | OFF | Turns off MDA fan #2 | | | | |
| | | | LO | Turns MDA fan #2 on low speed | | | | |
| 203 | ST | sw | CSM | | | | | |
| | | | HI | Provides power to high speed contacts on MDA CSM fan electrical outlets 1, 2 | MDA FANS CSM 1, 2 (pnl 200) | AM BUS 1&2 | | |
| | | | OFF | Provides no power to MDA CSM fan electrical outlets 1, 2 | | | | |
| | | | LO | Provides power to low speed contacts on MDA CSM fan electrical outlets 1, 2 | | | | |
| | | | RAD FLOW | | | | | |
| 203 | ST | sw | PRI | | | | | |
| | | | BYPASS | Activates primary coolant loop radiator bypass valve | RAD FLOW PRI (pnl 200) | AM BUS 1 | 47464 | Coolant bypasses radiator PRI RAD FLO BYP |
| | | | NORM | Deactivates primary coolant loop radiator bypass valve | | | 40264 | Coolant flow thru radiator PRI RAD FLO NORM |
| | | | CMD | Enables DCS control of primary coolant loop radiator bypass valve | | | | |
| 203 | ST | sw | SEC | | | | | |
| | | | BYPASS | Activates secondary coolant loop radiator bypass valve | RAD FLOW SEC (pnl 200) | AM BUS 2 | 43260 | Coolant bypasses radiator SEC RAD FLO BYP |
| | | | NORM | Deactivates secondary coolant loop radiator bypass valve | | | 47260 | Coolant flow thru radiator SEC RAD FLO NORM |
| | | | CMD | Enables DCS control of secondary coolant loop radiator bypass valve | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | ATM COOLANT PUMPS | | | | | |
| 203 | ST | lt | [LOΔP] | Illuminates when a low pressure is sensed in the ATM cool loop | AM INSTR PNL LTS STATUS | AM BUS 2 | | LowΔP switch is activated when pressure across a pump is less than or equal to 4 ± 1 PSID. Power thru a closedΔP switch for illumination of the LoΔP light is provided from any of the three COOLANT PUMPS A, B or C sws when in the ON position |
| 203 | ST | sw | A | | | | | |
| | | | ON | Turns on ATM coolant pump A, and enablesΔP switch | ATM CLNT PUMPS A (pnl 202) | AM BUS 1 | | |
| | | | OFF | Turns off above | | | | |
| 203 | ST | sw | B | | | | | |
| | | | ON | Turns on ATM coolant pump B, and enablesΔP switch | ATM CLNT PUMPS B (pnl 202) | AM BUS 2 | | |
| | | | OFF | Turns off above | | | | |
| 203 | ST | sw | C | | | | | |
| | | | ON | Turns on ATM coolant pump C, and enablesΔP switch | ATM CLNT PUMPS C (pnl 202) | AM BUS 1 | | |
| | | | OFF | Turns off above | | | | |
| | | | PRIMARY COOLANT LOOP | | | | | |
| 203 | ST | sel | INVERTERS | | | | | |
| | | | CMD | Enables DCS control of primary coolant pump power inverters 1, 2 & 3 and coolant pumps A, B & C | CLNT PUMP CONTS PRI A B, B C & C A (pnl 200) | AM BUS 1&2 | | |
| | | | OFF | Turns primary coolant pump power inverters 1, 2 & 3 off | | | 47744<br>47560<br>46320 | PRI COOL INV 1 OFF<br>PRI COOL INV 2 OFF<br>PRI COOL INV 3 OFF |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | PRIMARY COOLANT LOOP | | | | | |
| | | | INVERTERS (cont'd) | | | | | |
| | | | 1 A•B | Enables primary coolant pump power inverter 1 to power pri coolant pump A and/or B | CLNT PUMP INVS PRI 1 (pnl 200) | AM BUS 1 | 43744 | PRI COOL INV 1 ON |
| | | | 2 B•C | Enables primary coolant pump power inverter 2 to power pri coolant pump B and/or C | CLNT PUMP INVS PRI 2 (pnl 200) | AM BUS 2 | 43560 | PRI COOL INV 2 ON |
| | | | 3 C•A | Enables primary coolant pump power inverter 3 to power pri coolant pump C and/or A | CLNT PUMP INVS PRI 3 (pnl 200) | AM BUS 1 | 42329 | PRI COOL INV 3 ON |
| | | | PUMPS | | | | | |
| 203 | ST | sw | A | | | | | |
| | | | ON | Turns primary coolant pump A on | CLNT PUMP CONTS PRI A B or C A (pnl 200) | AM BUS 1 | 41720 | Pump A is powered from inverter 1 or 3 PRI COOL PMP A ON |
| | | | OFF | Turns above off | | | 45720 | PRI COOL PMP A OFF |
| 203 | ST | sw | B | | | | | |
| | | | ON | Turns primary coolant pump B on | CLNT PUMP CONTS PRI A B or B C (pnl 200) | AM BUS 1&2 | 43104 | Pump B is powered from inverter 1 or 2 PRI COOL PMP B ON |
| | | | OFF | Turns above off | | | 47104 | PRI COOL PMP B OFF |
| 203 | ST | sw | C | | | | | |
| | | | ON | Turns primary coolant pump C on | CLNT PUMP CONTS PRI C A or B C (pnl 200) | AM BUS 1&2 | 43720 | Pump C is powered from inverter 2 or 3 PRI COOL PMP C ON |
| | | | OFF | Turns above off | | | 47720 | PRI COOL PMP C OFF |
| 203 | ST | lt | RES LO | Illuminates when a primary coolant loop pump reservoir, upstream of an operating pump in the loop, becomes empty of fluid | AM INSTR PNL LTS STATUS (pnl 202) | AM BUS 2 | | Resets with 5 cu in of fluid in reservoir |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | SECONDARY COOLANT LOOP | | | | | |
| 203 | ST | sel | INVERTERS | | | | | |
| | | | CMD | Enables DCS control of secondary coolant pump power inverters 1, 2 & 3 and coolant pumps A, B, & C | CLNT PUMP CONTS SEC A B, B C & C A (pnl 200) | AM BUS 1&2 | | |
| | | | OFF | Turns secondary coolant pump power inverters 1, 2, & 3 off | | | 45260<br>44620<br>47404 | SEC COOL INV 1 OFF<br>SEC COOL INV 2 OFF<br>SEC COOL INV 3 OFF |
| | | | 1 A•B | Enables secondary coolant pump power inverter 1 to power sec coolant pump A and/or B | CLNT PUMP INVS SEC 1 (pnl 200) | AM BUS 2 | 41260 | SEC COOL INV 1 ON |
| | | | 2 B•C | Enables secondary coolant pump power inverter 2 to power secondary coolant pump B and/or C | CLNT PUMP INVS SEC 2 (pnl 200) | AM BUS 1 | 40620 | SEC COOL INV 2 ON |
| | | | 3 C•A | Enables secondary coolant pump power inverter 3 to power secondary coolant pump C and/or A | CLNT PUMP INVS SEC 3 (pnl 200) | AM BUS 2 | 43404 | SEC COOL INV 3 ON |
| | | | PUMPS | | | | | |
| 203 | ST | sw | A | | | | | |
| | | | ON | Turns secondary coolant pump A on | CLNT PUMP CONTS SEC A B or C A (pnl 200) | AM BUS 2 | 41444 | Pump A is powered from inverter 1 or 3<br>SEC COOL PMP A ON |
| | | | OFF | Turns above off | | | 45444 | SEC COOL PMP A OFF |
| 203 | ST | sw | B | | | | | |
| | | | ON | Turns secondary coolant pump B on | CLNT PUMP CONTS PRI A B or B C (pnl 200) | AM BUS 1&2 | 40344 | Pump B is powered from inverter 1 or 2<br>SEC COOL PMP B ON |
| | | | OFF | Turns above off | | | 44344 | SEC COOL PMP B OFF |
| 203 | ST | sw | C | | | | | |
| | | | ON | Turns secondary coolant pump C on | CLNT PUMP CONTS SEC C A or B C (pnl 200) | AM BUS 1&2 | 43444 | Pump C is powered from inverter 2 or 3<br>SEC COOL PMP C ON |
| | | | OFF | Turns above off | | | 47444 | SEC COOL PMP C OFF |
| 203 | ST | lt | RES LO | Illuminates when a secondary coolant loop pump reservoir, upstream of an operating pump in the loop, becomes empty of fluid | AM INSTR PNL LTS STATUS (pnl 202) | AM BUS 2 | | Resets with 5 cu in of fluid in reservoir |

P7


CMD SYS
PRI
SEC
CMD
INSTRUMENTATION SYSTEM
DISPLAY CONV
PRI
OFF
SEC
CONVERTERS
CMD
1 & 2
2 & 1
1 & 3
3 & 2
PROGRAMMER
PRI
SEC
CMD
ELECTRONICS
PRI
SEC
CMD
RECORDER AUDIO
A
B
ANTENNA
DISC 1/STUB
DISC 2
CMD
DISC 1
STUB
CMD
TAPE RECORDERS
CONTROL
MANUAL SELECT
CMD
1
2
3
STOP
OFF
DATA VOICE
EXP 1 VOICE
EXP 2
TRANSMITTERS
ON
OFF
CMD
TRANSMITTER INPUT
A
B
C
OFF
REAL TIME
DATA
VOICE
EXP 1
EXP VOICE
EXP 2
MANUAL DUMP
ON
OFF
TAPE RECORDING
DATA
RECORD
OFF
CMD
EXP 1
RECORD
OFF
EXP 2
RECORD
OFF
EKG/ZPN
ENABLE
OFF
204

204

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 204 | ST | sw | CMD SYS | | | | | |
| | | | PRI | Activates the primary RCVR/DCDR and primary CRDU electronics and enables the interface between the primary RCVR/ DCDR and the selected electronic timer | CMD SYS PRI & SEC (pnl 200) | EPS CONTROL BUS 1&2 | | |
| | | | SEC | Activates the secondary RCVR/DCDR and secondary CRDU electronics and enables the interface between the secondary RCVR/ and the selected electronic timer | | | | |
| | | | CMD | Enables DCS control for selection of the above | | | 714<br>715<br>726<br>727 | PRI OFF<br>PRI ON<br>SEC OFF<br>SEC ON |
| | | | ANTENNA | | | | | |
| 204 | ST | sw | [(DISC 1/STUB)/DISC 2/ CMD] | | | | | |
| | | | DISC 1/STUB | Enables ANT [DISC 1/STUB/CMD] sw (pnl 204) to select discone 1 or launch stub antenna for DCS/TM reception/transmission | ANT CNTL 1 (pnl 200) | AM BUS 1 | | |
| | | | DISC 2 | Selects discone antenna No. 2 for DCS/TM reception/transmission | | | | |
| | | | CMD | Enables DCS control selection of the above functions | | | 47660<br>43660 | |
| 204 | ST | sw | [DISC 1/STUB/CMD] | | | | | |
| | | | DISC 1 | Selects discone antenna No. 1 for DCS/TM reception/transmission | ANT CNTL 2 (pnl 200) | AM BUS 2 | | The above ANT-DISC sw must be in the DISC 1/STUB position to enable DISC 1 or STUB selection by this switch |
| | | | STUB | Selects launch stub antenna for DCS/TM reception/transmission | | | | |
| | | | CMD | Enables DCS control selection of the above functions | | | 40160<br>44160 | |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | INSTRUMENTATION SYSTEM | | | | | |
| 204 | ST | sw | DISPLAY CONV | | | | | |
| | | | PRI | Selects the primary AM panel indicator DC-DC converter | INST SYS DISP CONVS INPUT PRI (pnl 200) | AM BUS 1 | | Nominal position during manned mission |
| | | | OFF | Disables both the primary and secondary converters | | | | Nominal position during launch and storage phases |
| | | | SEC | Selects the secondary AM panel indicator DC-DC converter | INST SYS DISP CONVS INPUT SEC (pnl 200) | AM BUS 2 | | Redundant power supply |
| 204 | ST | sel | CONVERTERS | | | | | |
| | | | CMD | Enables DCS selection of the AM DC-DC converters | INST SYS CONT TM CMD (pnl 200) | AM BUS 1 | 41624 45624 46624 47624 | Normal position during entire mission |
| | | | 1&2 | Selects converter 1 to power INST bus A and converter 2 to power INST bus B | INST SYS CONT CONV (pnl 200) | AM BUS 2 | | |
| | | | 2&1 | Selects converter 2 to power INST bus A and converter 1 to power INST bus B | INST SYS CONT CONV (pnl 200) | AM BUS 2 | | |
| | | | 1&3 | Selects converter 1 to power INST bus A and converter 3 to power INST bus B | INST SYS CONT CONV (pnl 200) | AM BUS 2 | | |
| | | | 3&2 | Selects converter 3 to power INST bus A and converter 2 to power INST bus B | INST SYS CONT CONV (pnl 200) | AM BUS 2 | | |
| 204 | ST | sw | PROGRAMMER | | | | | |
| | | | PRI | Selects the PCM subsystem primary programmer | INST SYS CONT PROG MAN (pnl 200) | AM BUS 2 | | |
| | | | SEC | Selects the PCM subsystem secondary programmer | INST SYS CONT PROG MAN (pnl 200) | AM BUS 2 | | |
| | | | CMD | Enables DCS selection of the programmers | INST SYS PROG CMD (pnl 200) | AM BUS 1 | 40220 44220 | Nominal position during entire mission |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 204 | ST | sw | ELECTRONICS | | | | | |
| | | | PRI | Selects the PCM subsystem interface box primary electronics | INST SYS CONT ELECT MAN (pnl 200) | AM BUS 2 | | |
| | | | SEC | Selects the PCM subsystem interface box secondary electronics | INST SYS CONT ELECT MAN (pnl 200) | AM BUS 2 | | |
| | | | CMD | Enables DCS selection of the interface box electronics | INST SYS CONT ELECT CMD (pnl 200) | AM BUS 1 | 41644 45644 | Nominal position during entire mission |
| 204 | ST | sw | RECORDER AUDIO | | | | | |
| | | | A | Selects audio channel A for voice recording | INST SYS CONT RCDR CMD (pnl 200) | AM BUS 1 | | Nominal position during launch phase to activation |
| | | | B | Selects audio channel B for voice recording | INST SYS CONT RCDR MAN (pnl 200) | AM BUS 2 | | Nominal position subsequent to activation, for entire remaining mission |
| | | | TAPE RECORDERS | | | | | |
| 204 | ST | sw | CONTROL | | | | | |
| | | | MANUAL SELECT | Enables manual selection of the tape recorders | INST SYS CONT RCDR MAN (pnl 200) | AM BUS 2 | | |
| | | | CMD | Enables DCS selection of the tape recorders | INST SYS CONT RCDR CMD (pnl 200) | AM BUS 1 | 42520 42620 46520 46620 | Nominal position during entire mission |
| | | | 1 | | | | | |
| 204 | ST | lt | STOP | Illuminates when recorder #1 ceases motion with power applied | AM INSTR PNL LTS STATUS (pnl 202) | AM BUS 2 | | Nominally indicates end-of-tape |
| 240 | ST | sel | OFF | Disables recorder No. 1 | INST SYS CONT RCDR MAN (pnl 200) | AM BUS 2 | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | TAPE RECORDERS | | | | | |
| | | | 1 (cont'd) | | | | | |
| | | | DATA/VOICE | Establishes the interface selecting tape recorder No. 1 Tracks A and B for recording and transmitting DATA and VOICE respectively | INST SYS CONT RCDR MAN (pnl 200) | AM BUS 2 | | |
| | | | EXP 1/VOICE | Establishes the interface selecting tape recorder No. 1 Tracks A and B for recording and transmitting EXP 1 and EXP VOICE respectively | INST SYS CONT RCDR MAN (pnl 200) | AM BUS 2 | | |
| | | | EXP 2 | Establishes the interface selecting tape recorder No. 1 track A for recording and transmitting EXP 2 or DATA 2 | INST SYS CONT RCDR MAN (pnl 200) | AM BUS 2 | | |
| | | | 2&3 | | | | | |
| 204 | ST | lt | STOP | Same as TAPE RECORDERS 1 STOP light for TAPE RECORDERS 2 & 3 STOP lights | AM INSTR PNL LTS STATUS (pnl 202) | AM BUS 2 | | |
| 204 | ST | sel | OFF | Same as TAPE RECORDERS 1 selector switch for TAPE RECORDERS 2 and 3 | INST SYS CONT RCDR MAN (pnl 200) | AM BUS 2 | | |
| | | | DATA/VOICE | Same as TAPE RECORDERS 1 selector switch for TAPE RECORDERS 2 and 3 | INST SYS CONT RCDR MAN (pnl 200) | AM BUS 2 | | |
| | | | EXP 1/VOICE | Same as TAPE RECORDERS 1 selector switch for TAPE RECORDERS 2 and 3 | INST SYS CONT RCDR MAN (pnl 200) | AM BUS 2 | | |
| | | | EXP 2 | Same as TAPE RECORDERS 1 selector switch for TAPE RECORDERS 2 and 3 | INST SYS CONT RCDR MAN (pnl 200) | AM BUS 2 | | |

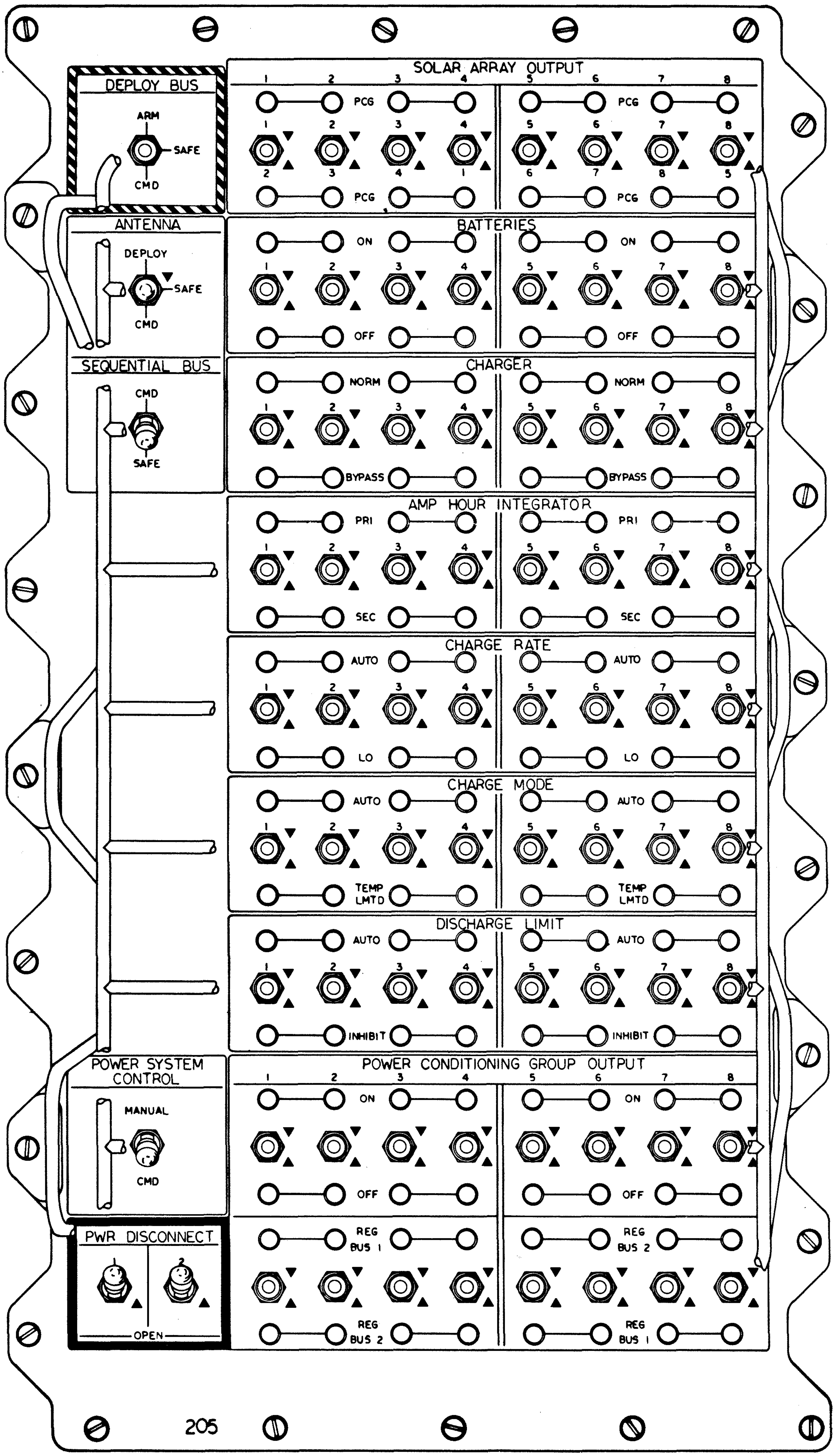
CONTROLS AND DISPLAYS

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 204 | ST | sw | TRANSMITTERS | | | | | |
| | | | ON | Activates transmission of telemetry and/ or D/T voice as selected by transmitter input A, B, & C sel & manual dump sw | INST SYS CONT TM MAN (pnl 200) | AM BUS 2 | | |
| | | | OFF | Disables transmission of telemetry & D/T voice | INST SYS CONT TM MAN (pnl 200) | AM BUS 2 | | |
| | | | CMD | Enables DCS control of the above transmissions | INST SYS CONT TM CMD (pnl 200) | AM BUS 1 | See Re-marks | Nominal position during entire mission 740,741,750,751,744,745,724,725,764, 765,734,735,774,775,722,723,746,747, 736,737,776,777,43220,47220,41604, 45604,41264,46264,43264,45264 |
| | | | TRANSMITTER INPUT | | | | | |
| 204 | ST | sel | A | | | | | |
| | | | OFF | Disables transmission on transmitter A | INST SYS CONT TM MAN (pnl 200) | AM BUS 2 | | |
| | | | REAL TIME | Selects R/T TM transmission | INST SYS CONT TM MAN (pnl 200) | AM BUS 2 | | |
| | | | DATA | Selects DATA rcdr track A transmission | INST SYS CONT TM MAN (pnl 200) | AM BUS 2 | | |
| | | | VOICE | Selects DATA rcdr track B transmission | INST SYS CONT TM MAN (pnl 200) | AM BUS 2 | | |
| | | | EXP 1 | Selects EXP 1 rcdr track A transmission | INST SYS CONT TM MAN (pnl 200) | AM BUS 2 | | |
| | | | EXP VOICE | Selects EXP 1 rcdr track B transmission | INST SYS CONT TM MAN (pnl 200) | AM BUS 2 | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | TRANSMITTER INPUT (cont'd) | | | | | |
| | | | EXP 2 | Selects EXP 2 rcdr track A transmission | INST SYS CONT TM MAN (pnl 200) | AM BUS 2 | | |
| 204 | ST | sel | B&C OFF | Same as TRANSMITTER INPUT A selector switch for transmitters B&C | INST SYS CONT TM MAN (pnl 200) | AM BUS 2 | | |
| | | | REAL TIME | Same as TRANSMITTER INPUT A selector switch for transmitters B&C | INST SYS CONT TM MAN (pnl 200) | AM BUS 2 | | |
| | | | DATA | Same as TRANSMITTER INPUT A selector switch for transmitters B&C | INST SYS CONT TM MAN (pnl 200) | AM BUS 2 | | |
| | | | VOICE | Same as TRANSMITTER INPUT A selector switch for transmitters B&C | INST SYS CONT TM MAN (pnl 200) | AM BUS 2 | | |
| | | | EXP 1 | Same as TRANSMITTER INPUT A selector switch for transmitters B&C | INST SYS CONT TM MAN (pnl 200) | AM BUS 2 | | |
| | | | EXP VOICE | Same as TRANSMITTER INPUT A selector switch for transmitters B&C | INST SYS CONT TM MAN (pnl 200) | AM BUS 2 | | |
| | | | EXP 2 | Same as TRANSMITTERS INPUT A selector switch for transmitters B&C | INST SYS CONT TM MAN (pnl 200) | AM BUS 2 | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 204 | ST | sw | MANUAL DUMP | | | | | |
| | | | ON | Provides the playback discrete to the tape recorder(s) selected for transmission by TRANSMITTER INPUT A, B, & C sel | INST SYS CONT TM MAN (pnl 200) | AM BUS 2 | | Used with a crew initiated transmission only |
| | | | OFF | Removes the playback discrete | | | | Nominal position during entire mission |
| | | | TAPE RECORDING | | | | | |
| | | | DATA | | | | | |
| 204 | ST | lt | [RECORD] | Illuminates when the DATA recorder is in motion and the TAPE RECORDING-DATA switch is in the RECORD position | AM INSTR PNL LTS STATUS (pnl 202) | AM BUS 2 | | |
| 204 | ST | sw | RECORD | Activates DATA recording & enables DCS control of DATA 2 recording | INST SYS CONT RCDR MAN (pnl 200) | AM BUS 2 | | |
| | | | OFF | Deactivates DATA 2 and DATA recording except in support of VOICE recording | INST SYS CONT RCDR MAN (pnl 200) | AM BUS 2 | | |
| | | | CMD | Enables DCS control of DATA & DATA 2 recording | INST SYS CONT RCDR CMD,MAN (pnl 200) | AM BUS 1,2 | 40424 44424 42644 46644 | Nominal position during entire mission |
| | | | EXP 1 | | | | | |
| 204 | ST | lt | [RECORD] | Illuminates when the EXP 1 recorder is in motion and EXP 1 recording has been initiated | AM INSTR PNL LTS STATUS (pnl 202) | AM BUS 2 | | |
| 204 | ST | sw | RECORD | Activates EXP 1 recording | INST SYS CONT RCDR CMD, MAN (pnl 202) | AM BUS 1,2 | | |
| | | | (ctr) | | | | | Momentary switch return to center |
| | | | OFF | Turns off EXP 1 recording originally initiated by this switch | INST SYS CONT RCDR CMD, MAN (pnl 202) | AM BUS 1,2 | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | TAPE RECORDING (cont'd) | | | | | |
| | | | EXP 2 | | | | | |
| 204 | ST | lt | [RECORD] | Illuminates when the EXP 2 recorder is in motion and EXP 2 recording has been initiated | AM INSTR PNL LTS STATUS (pnl 202) | AM BUS 2 | | |
| 204 | ST | sw | RECORD | Activates EXP 2 recording & inhibits DCS control of DATA 2 recording | INST SYS CONT RCDR CMD, MAN (pnl 200) | AM BUS 1,2 | | |
| | | | (ctr) | | | | | Momentary switch return to center |
| | | | OFF | Turns off EXP 2 recording originally initiated by this switch and enables DCS control of DATA 2 recording | INST SYS CONT RCDR CMD, MAN (pnl 200) | AM BUS 1,2 | | |
| 204 | ST | sw | EKG/ZPN | | | | | |
| | | | ENABLE | Enables recording of EKG/ZPN for OBS channel A and B on EXP 1 and 2 rcdrs respectively | INST SYS CONT RCDR MAN, CMD (pnl 200) | AM BUS 1,2 | | Nominal position for EVA and IVA operations. Prohibits running exps M509, T013, M092, M093, M171, T027 and S073 |
| | | | OFF | Disables the above | INST SYS CONT RCDR MAN, CMD (pnl 200) | AM BUS 1,2 | | |


DEPLOY BUS
ARM
SAFE
CMD
ANTENNA
DEPLOY
SAFE
CMD
SEQUENTIAL BUS
CMD
SAFE
POWER SYSTEM CONTROL
MANUAL
CMD
PWR DISCONNECT
1
2
OPEN
SOLAR ARRAY OUTPUT
1 2 3 4 5 6 7 8
PCG
BATTERIES
ON
OFF
CHARGER
NORM
BYPASS
AMP HOUR INTEGRATOR
PRI
SEC
CHARGE RATE
AUTO
LO
CHARGE MODE
AUTO
TEMP LMTD
DISCHARGE LIMIT
AUTO
INHIBIT
POWER CONDITIONING GROUP OUTPUT
ON
OFF
REG BUS 1
REG BUS 2
205

P9

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 205 | ST | sw | DEPLOY BUS | | | | | |
| | | | ARM | Activates arm relays to connect AM bus 1, 2 to deploy bus 1, 2 | DPLY BUS ARM PRI & SEC (pnl 202) | AM BUS 1,2 | | |
| | | | SAFE | Disables deploy bus 1, 2 | | | | |
| | | | CMD | Enables DCS control of the above | | | 720<br>721<br>770<br>771 | Permission OFF<br>Permission ON<br>SAFE<br>ARM |
| 205 | ST | sw | ANTENNA | | | | | |
| | | | DEPLOY | Activates discone antennas 1, 2 release actuators | DPLY DISCONE ANT BUS 1, 2 CNTL (pnl 202) | DEPLOY BUS 1,2 | | |
| | | | SAFE | Inhibits the above | | | | |
| | | | CMD | Enables DCS control of the above | | | 40600<br>43740 | DEPLOY Bus 1<br>DEPLOY Bus 2 |
| 205 | ST | sw | SEQUENTIAL BUS | | | | | |
| | | | CMD | Enables DCS control to connect AM bus 1, 2 to sequential bus 1, 2 | DPLY SEQ BUS ARM PRI, SEC (pnl 202) | AM BUS 1,2 | 40644 | No DCS capability for disarming |
| | | | SAFE | Disables sequential bus 1, 2 | | | | Only means of disarming the sequential buses |
| 205 | ST | sw | POWER SYSTEM CONTROL | | | | | |
| | | | MANUAL | Enables manual control of the power system control functions and inhibits ground control except for ELEC GND sw | PWR SYS CONT 1&2 (pnl 201) | EPS CONTROL BUS 1&2 | | NOTE: All EPS switches are operative (enables) only when the POWER SYSTEM CONTROL switch is in the MANUAL position |
| | | | CMD | Enables only DCS control of the power system control functions and inhibits manual control except for ELEC GND sw | | | | |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | PWR DISCONNECT | | | | | |
| 205 | ST | sw | 1 | | | | | |
| | | | (up) | Normal position, no effect on AM power | PWR DISCON AM 1&2 (pnl 201) | EPS CONTROL BUS 1&2 | | |
| | | | OPEN | Disconnects PCG's 1-4 from reg bus and opens reg bus 1 ckt to transfer bus 1 | | | | Switch is momentary with return to the (up) position |
| 205 | ST | sw | 2 | | | | | |
| | | | (up) | Normal position, no effect on AM power | PWR DISCON AM 1&2 (pnl 201) | EPS CONTROL BUS 1&2 | | |
| | | | OPEN | Disconnects PCG's 5-8 from reg bus and opens reg bus 2 to transfer bus 2 | | | | Switch is momentary with return to the (up) position |
| | | | SOLAR ARRAY OUTPUT | | | | | |
| 205 | ST | sw | 1 | | | | | |
| | | | PCG-1 | Connects array #1 to charger #1 | PCG CNTLS 1 (pnl 201) | EPS CONTROL BUS 2 | 44000 | NOTE: All solar array output switches are momentary switches in the up or down position and return to center |
| | | | PCG-2 | Connects array #1 to charger #2 | | | 40000 | |
| 205 | ST | lt | 1 | | | | | |
| | | | PCG-1 | Indicates array #1 connected to charger #1 | PWR SYS STATUS LTS 1 (pnl 201) | EPS CONTROL BUS 1 | | |
| | | | PCG-2 | Indicates array #1 connected to charger #2 | | | | |
| 205 | ST | sw | 2 | | | | | |
| | | | PCG-2 | Connects array #2 to charger #2 | PCG CNTLS 2 (pnl 201) | EPS CONTROL BUS 2 | 44200 | |
| | | | PCG-3 | Connects array #2 to charger #3 | | | 40200 | |
| 205 | ST | lt | 2 | | | | | |
| | | | PCG-2 | Indicates array #2 connected to charger #2 | PWR SYS STATUS LTS 1 (pnl 201) | EPS CONTROL BUS 1 | | |
| | | | PCG-3 | Indicates array #2 connected to charger #3 | | | | |

CONTROLS AND DISPLAYS

| LOCATION | | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| PNL | STA# | | | | | | | |
| | | | SOLAR ARRAY OUTPUT (cont'd) | | | | | |
| 205 | ST | sw | 3 | | | | | |
| | | | PCG-3 | Connects array #3 to charger #3 | PCG CNTLS 3 (pnl 201) | EPS CONTROL BUS 2 | 44040 | |
| | | | PCG-4 | Connects array #3 to charger #4 | | | 40040 | |
| 205 | ST | lt | 3 | | | | | |
| | | | PCG-3 | Indicates array #3 connected to charger #3 | PWR SYS STATUS LTS 1 (pnl 201) | EPS CONTROL BUS 1 | | |
| | | | PCG-4 | Indicates array #3 connected to charger #4 | | | | |
| 205 | ST | sw | 4 | | | | | |
| | | | PCG-4 | Connects array #4 to charger #4 | PCG CNTLS 4 (pnl 201) | EPS CONTROL BUS 2 | 47240 | |
| | | | PCG-1 | Connects array #4 to charger #1 | | | 43240 | |
| 205 | ST | lt | 4 | | | | | |
| | | | PCG-4 | Indicates array #4 connected to charger #4 | PWR SYS STATUS LTS 1 (pnl 201) | EPS CONTROL BUS 1 | | |
| | | | PCG-1 | Indicates array #4 connected to charger #1 | | | | |
| 205 | ST | sw | 5 | | | | | |
| | | | PCG-5 | Connects array #5 to charger #5 | PCG CNTLS 5 (pnl 201) | EPS CONTROL BUS 1 | 44100 | |
| | | | PCG-6 | Connects array #5 to charger #6 | | | 40100 | |
| 205 | ST | lt | 5 | | | | | |
| | | | PCG-5 | Indicates array #5 connected to charger #5 | PWR SYS STATUS LTS 2 (pnl 201) | EPS CONTROL BUS 2 | | |
| | | | PCG-6 | Indicates array #5 connected to charger #6 | | | | |
| 205 | ST | sw | 6 | | | | | |
| | | | PCG-6 | Connects array #6 to charger #6 | PCG CNTLS 6 (pnl 201) | EPS CONTROL BUS 1 | 47500 | |
| | | | PCG-7 | Connects array #6 to charger #7 | | | 43500 | |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | SOLAR ARRAY OUTPUT (cont'd) | | | | | |
| 205 | ST | lt | 6 | | | | | |
| | | | PCG-6 | Indicates array #6 connected to charger #6 | PWR SYS STATUS LTS 2 (pnl 201) | EPS CONTROL BUS 2 | | |
| | | | PCG-7 | Indicates array #6 connected to charger #7 | | | | |
| 205 | ST | sw | 7 | | | | | |
| | | | PCG-7 | Connects array #7 to charger #7 | PCG CNTLS 7 (pnl 201) | EPS CONTROL BUS 1 | 44140 | |
| | | | PCG-8 | Connects array #7 to charger #8 | | | 40140 | |
| 205 | ST | lt | 7 | | | | | |
| | | | PCG-7 | Indicates array #7 connected to charger #7 | PWR SYS STATUS LTS 2 (pnl 201) | EPS CONTROL BUS 2 | | |
| | | | PCG-8 | Indicates array #7 connected to charger #8 | | | | |
| 205 | ST | sw | 8 | | | | | |
| | | | PCG-8 | Connects array #8 to charger #8 | PCG CNTLS 8 (pnl 201) | EPS CONTROL BUS 1 | 44340 | |
| | | | PCG-5 | Connects array #8 to charger #5 | | | 40340 | |
| 205 | ST | lt | 8 | | | | | |
| | | | PCG-8 | Indicates array #8 connected to charger #8 | PWR SYS STATUS LTS 2 (pnl 201) | EPS CONTROL BUS 2 | | |
| | | | PCG-5 | Indicates array #8 connected to charger #5 | | | | |
| | | | BATTERIES | | | | | |
| 205 | ST | sw | 1 | | | | | |
| | | | ON | Connects #1 battery power & voltage sense leads to #1 charger | BAT CONT 1 PCG CNTLS 1 (pnl 201) | EPS CONTROL BUS 2 | 41400 | NOTE: Batteries switches are momentary and return to the center position |
| | | | OFF | Disconnects the above | | BAT 1 | 45400 | |
| 205 | ST | lt | 1 | | | | | |
| | | | ON | Indicates #1 battery power & voltage sense leads to #1 charger are connected | PWR SYS STATUS LTS 1 (pnl 201) | EPS CONTROL BUS 1 | | |
| | | | OFF | Indicates the above are off | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | BATTERIES (cont'd) | | | | | |
| 205 | ST | sw | 2 thru 4 | | | | | |
| | | | ON | Same as BATTERY sw 1 for system 2 thru 4 | BAT CONT 2 thru 4 & PCG CNTLS 2 thru 4 (pnl 201) | BAT 2 thru 4, EPS CONTROL BUS 2 | | NOTE: 41600,42440, and 43640 are DCS CHNL numbers appearing in remarks column for space reasons |
| | | | OFF | Disconnects the above | | | | NOTE: 45600, 46440, and 47640 |
| 205 | ST | lt | 2 thru 4 | | | | | |
| | | | ON | Same as BATTERY lights 1 for systems 2 thru 4 | PWR SYS STATUS LTS 1 (pnl 201) | EPS CONTROL BUS 1 | | |
| | | | OFF | Indicates the above are off | | | | |
| 205 | ST | sw | 5 thru 8 | | | | | |
| | | | ON | Same as BATTERY lights 1 for system 5 thru 8 | BAT CONT 5 thru 8 PCG CNTLS 5 thru 8 (pnl 201) | EPS CONTROL BUS 1, BAT 5 thru 8 | | NOTE: 42500, 40700, 42540, and 42740 |
| | | | OFF | Indicates the above are off | | | | NOTE: 46500, 44700, 46540, and 46740 |
| 205 | ST | lt | 5 thru 8 | | | | | |
| | | | ON | Same as BATTERY lights 1 for system 5 thru 8 | PWR SYS STATUS LTS 2 (pnl 201) | EPS CONTROL BUS 2 | | |
| | | | OFF | Disconnects the above | | | | |
| | | | CHARGER | | | | | |
| 205 | ST | sw | 1 | | | | | |
| | | | NORM | Connects array output to charger #1 | PCG CNTLS 1 (pnl 201) | EPS CONTROL BUS 2 | 46400 | NOTE: Charger switches are momentary and return to the center position |
| | | | BYPASS | Connects array output to regulator #1 | | | 42400 | |
| 205 | ST | lt | 1 | | | | | |
| | | | NORM | Indicates array output connected to charger #1 | PWR SYS STATUS LTS 1 (pnl 201) | EPS CONTROL BUS 1 | | |
| | | | BYPASS | Indicates array output connected to regulator #1 | | | | |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | CHARGER (cont'd) | | | | | |
| 205 | ST | sw | 2 thru 4 | | | | | |
| | | | NORM | Same as CHARGER sw 1 for systems 2 thru 4 | PCG CNTLS 2 thru 4 (pnl 201) | EPS CONTROL BUS 2 | | NOTE: 46600, 47440, and 44640 |
| | | | BYPASS | Connects array output to regulator 2 thru 4 | | | | NOTE: 42600, 43440, and 40640 |
| 205 | ST | lt | 2 thru 4 | | | | | |
| | | | NORM | Same as CHARGER lts 1 for systems 2 thru 4 | PWR SYS STATUS LTS 1 (pnl 201) | EPS CONTROL BUS 1 | | |
| | | | BYPASS | Indicates array output connected to regulator 2 thru 4 | | | | |
| 205 | ST | sw | 5 thru 8 | | | | | |
| | | | NORM | Same as CHARGER sw 1 for systems 5 thru 8 | PCG CNTLS 5 thru 8 (pnl 201) | EPS CONTROL BUS 1 | | NOTE: 44500, 47300, and 44740 |
| | | | BYPASS | Connects array output to regulator 5 thru 8 | | | | NOTE: 40500, 43300, and 40740 |
| 205 | ST | lt | 5 thru 8 | | | | | |
| | | | NORM | Same as CHARGER lts 1 for system 5 thru 8 | PWR SYS STATUS LTS 2 (pnl 201) | EPS CONTROL BUS 2 | | |
| | | | BYPASS | Indicates array output connected to regulator 5 thru 8 | | | | |
| | | | AMP HOUR INTEGRATOR | | | | | |
| 205 | ST | sw | 1 | | | | | |
| | | | PRI | Selects the primary amp-hour meter to control PCG #1 charger control logic | PCG CNTL 1 | EPS CONTROL BUS 2 | 42264 | NOTE: Amp-hour integrator switches are momentary and return to the center position |
| | | | SEC | Selects the secondary amp-hour meter to control PCG #1 charger control logic | | | 44264 | |
| 205 | ST | lt | 1 | | | | | |
| | | | PRI | Indicates the charge of battery #1 | PWR SYS STATUS LTS 1 (pnl 201) | EPS CONTROL BUS 1 | | |
| | | | SEC | Indicates the charge of battery #1 | | | | |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | AMP HOUR INTEGRATOR (cont'd) | | | | | |
| 205 | ST | sw | 2 thru 4 | | | | | |
| | | | PRI | Same as amp hour integrator sw 1 for systems 2 thru 4 | PCG CNTLS 2 thru 4 (pnl 201) | EPS CONTROL BUS 2 | | NOTE: 45220, 47160, and 44560 |
| | | | SEC | Indicates the charge of battery 2 thru 4 | | | | NOTE: 41220, 43160, and 40560 |
| 205 | ST | lt | 2 thru 4 | | | | | |
| | | | PRI | Same as AMP HOUR INTEGRATOR lights 1 for system 2 thru 4 | PWR SYS STATUS LIGHTS 1 (pnl 201) | EPS CONTROL BUS 1 | | |
| | | | SEC | Indicates the change of battery 2 thru 4 | | | | |
| 205 | ST | sw | 5 thru 8 | | | | | |
| | | | PRI | Same as AMP HOUR INTEGRATOR sw 1 for systems 5 thru 8 | PCG CNTLS 5 thru 8 (pnl 201) | EPS CONTROL BUS 2 | | NOTE: 45120, 47120, 46004, and 45004 |
| | | | SEC | Selects the secondary amp-hour meter to control PCG 5 thru 8 charger control logic | | | | NOTE: 41120, 43120, 42004, and 41004 |
| | | | CHARGE RATE | | | | | |
| 205 | ST | sw | 1 | | | | | |
| | | | AUTO | Allows PCG 1 to be in automatic control of charger current output | PCG CNTLS 1 (pnl 201) | EPS CONTROL BUS 2 | 47400 | NOTE: Charge rate switches are momentary and return to the center position |
| | | | LO | Allows for a constant current charge mode of .75 ± .5 amps | | | 43400 | |
| 205 | ST | lt | 1 | | | | | |
| | | | AUTO | Indicates automatic control of PCG 1 | PWR SYS STATUS LIGHTS 1 (pnl 201) | EPS CONTROL BUS 1 | | |
| | | | LO | Indicates constant current charge mode for PCG 1 | | | | |
| 205 | ST | sw | 2 thru 4 | | | | | |
| | | | AUTO | Same as CHARGE RATE sw 1 for systems 2 thru 4 | PCG CNTLS 2 thru 4 (pnl 201) | EPS CONTROL BUS 2 | | NOTE: 47600, 45440, and 45640 |
| | | | LO | Allows for a constant current charge mode of .75 ± .5 amps | | | | NOTE: 43600, 41440, and 41640 |

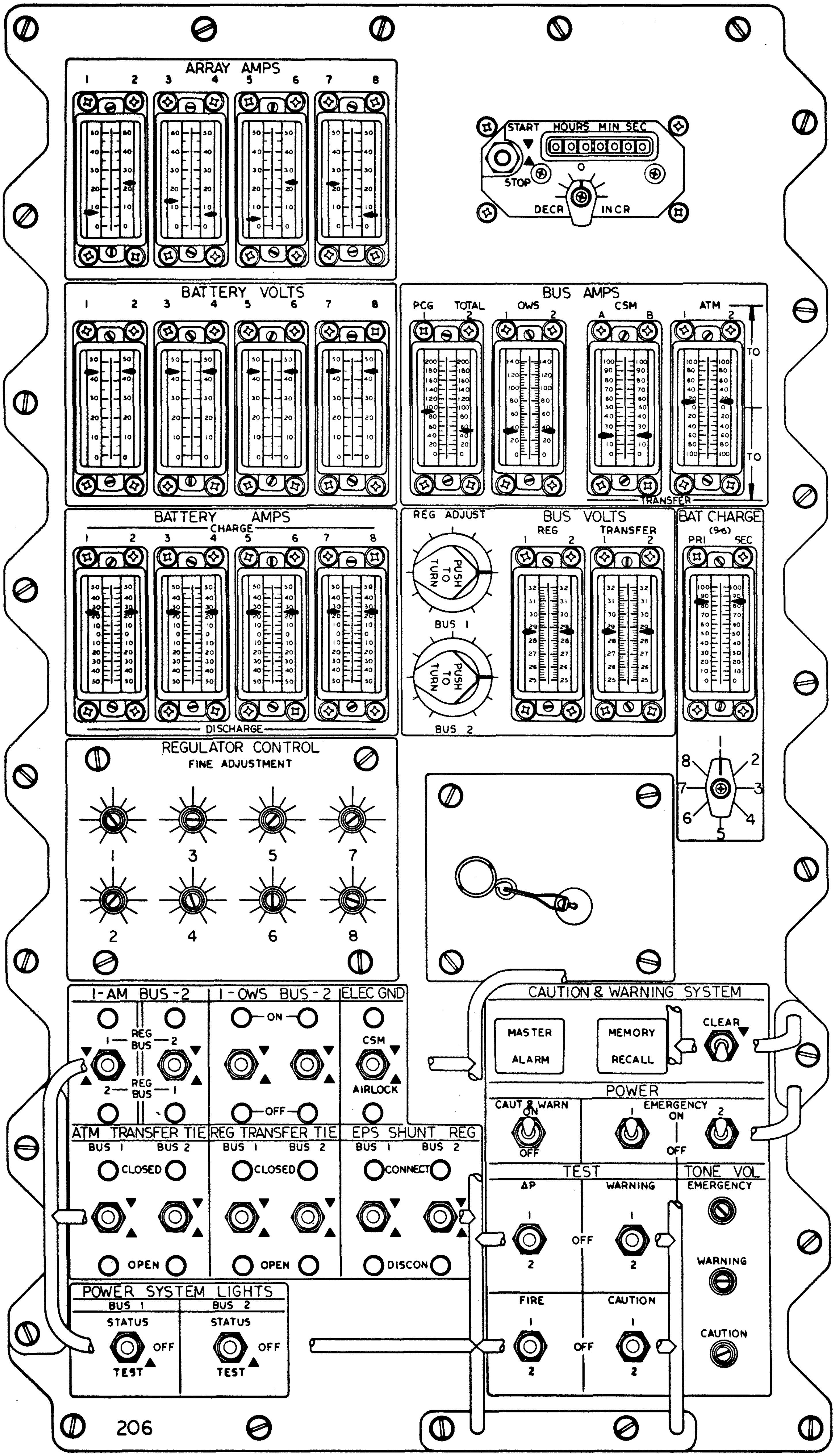
| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | CHARGE RATE (cont'd) | | | | | |
| 205 | ST | lt | 2 thru 4 | | | | | |
| | | | AUTO | Same as CHARGE RATE lts 1 for systems 2 thru 4 | PWR SYS STATUS LIGHTS 1 (pnl 201) | EPS CONTROL BUS 1 | | |
| | | | LO | Indicates constant current charge mode mode for PCG 1 | | | | |
| 205 | ST | sw | 5 thru 8 | | | | | |
| | | | AUTO | Same as CHARGE RATE sw 1 for systems 5 thru 8 | PWR COND GROUP CNTLS 5 thru 8 (pnl 201) | EPS CONTROL BUS 1 | | NOTE: 45500, 46700, 45540, and 45740 |
| | | | LO | Allows for a constant current charge mode of .75 ± .5 amps | | | | NOTE: 41500, 42700, 41540, and 41740 |
| 205 | ST | lt | 5 thru 8 | | | | | |
| | | | AUTO | Same as CHARGE RATE lts 1 for systems 5 thru 8 | PWR SYS STATUS LIGHTS 2 (pnl 201) | EPS CONTROL BUS 2 | | |
| | | | LO | Indicates automatic control of PCG 5 thru 8 | | | | |
| | | | CHARGE MODE | | | | | |
| 205 | ST | sw | 1 | | | | | |
| | | | AUTO | Switches the amp hour meter 100% state-of-charge signal to the PCG 1 | PWR COND GROUP CNTLS 1 (pnl 201) | EPS CONTROL BUS 2 | | 100% state of charge signal causes charger to switch to constant current mode<br>NOTE: Charge mode switches are momentary with return to the center position |
| | | | TEMP LMTD | Disconnects 100% state-of-charge signal and allows rate of charge to be temp limited | | | | |
| 205 | ST | lt | 1 | | | | | |
| | | | AUTO | Indicates auto mode of 100% state-of-charge signal of PCG 1 | PWR SYS STATUS LIGHTS 1 (pnl 201) | EPS CONTROL BUS 1 | | |
| | | | TEMP LMTD | Indicates state-of-charge is temp limited | | | | |
| 205 | ST | sw | 2 thru 4 | | | | | |
| | | | AUTO | Same as CHARGE MODE sw 1 for systems 2 thru 4 | PCG CNTLS 2 thru 4 (pnl 201) | EPS CONTROL BUS 2 | | |
| | | | TEMP LMTD | Same as TEMP LMTD sw 1 for systems 2 thru 4 | | | | |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | CHARGE MODE (cont'd) | | | | | |
| 205 | ST | lt | 2 thru 4 | | | | | |
| | | | AUTO | Same as CHARGE MODE lts 1 for system 2 thru 4 | PWR SYS STATUS LIGHTS 1 (pnl 201) | EPS CONTROL BUS 1 | | |
| | | | TEMP LMTD | Indicates state-of-charge is temp limited | | | | |
| 205 | ST | sw | 5 thru 8 | | | | | |
| | | | AUTO | Same as CHARGE MODE sw 1 for system 5 thru 8 | PCG CNTLS 5 thru 8 (pnl 201) | EPS CONTROL BUS 1 | | |
| | | | TEMP LMTD | Same as CHARGE MODE sw 1 ffor systems 5 thru 8 | | | | |
| 205 | ST | lt | 5 thru 8 | | | | | |
| | | | AUTO | Same as CHARGE MODE lts 1 for systems 5 thru 8 | PWR SYS STATUS LIGHTS 2 (pnl 201) | EPS CONTROL BUS 2 | | |
| | | | TEMP LMTD | Same as CHARGE MODE lts 1 for system 5 thru 8 | | | | |
| | | | DISCHARGE LIMIT | | | | | |
| 205 | ST | sw | 1 | | | | | |
| | | | AUTO | Controls 30% state of charge signal from charger 1 to regulator 1 | PCG CNTLS 1 (pnl 201) | EPS CONTROL BUS 2 | 47000 | 30% signal causes regulator to lower voltage output by 2 volts which effectively removes PCG from AM loads allowing battery to be recharged faster. Returning to 50% state-of-charge allows normal operation |
| | | | INHIBIT | Disconnects 30% signal allowing regulator to continue normal operation | | | 43000 | NOTE: Discharge limit switches are momentary with return to the center position |
| 205 | ST | lt | 1 | | | | | |
| | | | AUTO | Indicates 30% state-of-charge signal from charger 1 to regulator is as enabled | PWR SYS STATUS LIGHTS 1 (pnl 201) | EPS CONTROL BUS 1 | | |
| | | | INHIBIT | Indicates 30% state-of-charge signal is disabled | | | | |
| 205 | ST | sw | 2 thru 4 | | | | | |
| | | | AUTO | Same as DISCHARGE LIMIT sw 1 for systems 2 thru 4 | PCG CNTLS 2 thru 4 (pnl 201) | EPS CONTROL BUS 2 | | NOTE: 47200, 47040, and 45240 |
| | | | INHIBIT | Disconnects 30% signal allowing the regulator to continue normal operation | | | | NOTE: 43200, 43040, and 41240 |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | DISCHARGE LIMIT (cont'd) | | | | | |
| 205 | ST | lt | 2 thru 4 | | | | | |
| | | | AUTO | Same as DISCHARGE LIMIT lts 1 for systems 2 thru 4 | PWR SYS STATUS LIGHTS 1 (pnl 201) | EPS CONTROL BUS 1 | | |
| | | | INHIBIT | Indicates 30% state-of-charge signal is disabled | | | | |
| 205 | ST | sw | 5 thru 8 | | | | | |
| | | | AUTO | Same as DISCHARGE LIMIT sw 1 for systems 5 thru 8 | PCG CNTLS 5 thru 8 (pnl 201) | EPS CONTROL BUS 1 | | NOTE: 47100, 45300, 47140, and 47340 |
| | | | INHIBIT | Disconnects 30% signal allowing the regulator to continue normal operation | | | | NOTE: 43100, 41300, 43140, and 43340 |
| 205 | ST | lt | 5 thru 8 | | | | | |
| | | | AUTO | Same as DISCHARGE LIMIT lts 1 for systems 5 thru 8 | PWR SYS STATUS LIGHTS 2 (pnl 201) | EPS CONTROL BUS 2 | | |
| | | | INHIBIT | Indicates 30% state-of-charge signal is disabled | | | | |
| | | | POWER CONDITIONING GROUP OUTPUT | | | | | |
| 205 | ST | sw | 1 | | | | | |
| | | | ON | Connects #1 PCG voltage regulated output to #1 regulator power select relay | PCG CNTLS 1 (pnl 201) | EPS CONTROL BUS 2 | 42000 | NOTE: PCG output switches are momentary with return to the center position |
| | | | OFF | Disconnects the above | | | 46000 | |
| 205 | ST | lt | 1 | | | | | |
| | | | ON | Indicates #1 PCG voltage regulator output connected to #1 regulator power select relay | PWR SYS STATUS LIGHTS 1 (pnl 201) | EPS CONTROL BUS 1 | | |
| | | | OFF | Indicates the above is disconnected | | | | |
| 205 | ST | sw | 1 | | | | | |
| | | | REG BUS 1 | Connects #1 PCG voltage regulated power to reg bus 1 | PCG CNTLS 1 (pnl 201) | EPS CONTROL BUS 2 | 45000 | |
| | | | REG BUS 2 | Connects #1 PCG voltage regulated power to reg bus 2 | | | 41000 | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | POWER CONDITIONING GROUP OUTPUT (cont'd) | | | | | |
| 205 | ST | lt | 1 | | | | | |
| | | | REG BUS 1 | Indicates #1 PCG voltage regulated power connected to reg bus 1 | PWR SYS STATUS LIGHTS 1 (pnl 201) | EPS CONTROL BUS 1 | | |
| | | | REG BUS 2 | Indicates #1 PCG voltage regulated power connected to reg bus 2 | | | | |
| 205 | ST | sw | 2 thru 4 | | | | | |
| | | | ON | Same as PCG OUTPUT ON/OFF sw 1 for systems 2 thru 4 | PCG CNTLS 2 thru 4 (pnl 201) | EPS CONTROL BUS 2 | | NOTE: 42200, 42040, and 40240 |
| | | | OFF | Disconnects the above | | | | NOTE: 46200, 46040, and 44240 |
| 205 | ST | lt | 2 thru 4 | | | | | |
| | | | ON | Same as PCG OUTPUT ON/OFF lts 1 for systems 2 thru 4 | PWR SYS STATUS LIGHTS 1 (pnl 201) | EPS CONTROL BUS 1 | | |
| | | | OFF | Indicates the above is disconnected | | | | |
| 205 | ST | sw | 2 thru 4 | | | | | |
| | | | REG BUS 1 | Same as PCG OUTPUT REG BUS sw 1 for systems 2 thru 4 | PCG CNTLS 2 thru 4 (pnl 201) | EPS CONTROL BUS 2 | | NOTE: 45200, 45040, and 46240 |
| | | | REG BUS 2 | Same as PCG OUTPUT REG BUS sw 2 for systems 2 thru 4 | | | | NOTE: 41200, 41040, and 42240 |
| 205 | ST | lt | 2 thru 4 | | | | | |
| | | | REG BUS 1 | Same as PCG OUTPUT REG BUS lts 1 for systems 2 thru 4 | PWR SYS STATUS LIGHTS 1 (pnl 201) | EPS CONTROL BUS 1 | | |
| | | | REG BUS 2 | Same as PCG OUTPUT REG BUS lts 2 for systems 2 thru 4 | | | | |
| 205 | ST | sw | 5 thru 8 | | | | | |
| | | | ON | Same as PCG OUTPUT ON/OFF sw 1 for systems 5 thru 8 | PCG CNTLS 5 thru 8 (pnl 201) | EPS CONTROL BUS 1 | | NOTE: 42100, 40300, 42140, and 42340 |
| | | | OFF | Disconnects the above | | | | NOTE: 46100, 44300, 46140, and 46340 |
| 205 | ST | lt | 5 thru 8 | | | | | |
| | | | ON | Same as PCG OUTPUT ON/OFF lts 1 for systems 5 thru 8 | PWR SYS STATUS LIGHTS 2 (pnl 201) | EPS CONTROL BUS 2 | | |
| | | | OFF | Indicates the above is disconnected | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | POWER CONDITIONING GROUP OUTPUT (cont'd) | | | | | |
| 205 | ST | sw | 5 thru 8 | | | | | |
| | | | REG BUS 2 | Same as PCG OUTPUT REG BUS sw 1 for systems 5 thru 8 | PCG CNTLS 5 thru 8 (pnl 201) | EPS CONTROL BUS 1 | | NOTE: 45100, 46300, 45140, and 45340 |
| | | | REG BUS 1 | Same as PCG OUTPUT REG BUS sw 1 for systems 5 thru 8 | | | | NOTE: 41100, 42300, 41140, and 41340 |
| 205 | ST | lt | 5 thru 8 | | | | | |
| | | | REG BUS 2 | Same as PCG OUTPUT REG BUS lts for systems 5 thru 8 | PWR SYS STATUS LIGHTS 1 (pnl 201) | EPS CONTROL BUS 2 | | |
| | | | REG BUS 1 | Same as PCG OUTPUT REG BUS lts for systems 5 thru 8 | | | | |


ARRAY AMPS
BATTERY VOLTS
BUS AMPS
PCG
TOTAL
OWS
CSM
ATM
TO
TRANSFER
START
HOURS MIN SEC
STOP
DECR
INCR
BATTERY AMPS
CHARGE
DISCHARGE
REG ADJUST
PUSH TO TURN
BUS 1
BUS 2
BUS VOLTS
REG
TRANSFER
BAT CHARGE
PRI
SEC
REGULATOR CONTROL
FINE ADJUSTMENT
I-AM BUS-2
I-OWS BUS-2
ELEC GND
REG BUS
ON
OFF
CSM
AIRLOCK
ATM TRANSFER TIE
REG TRANSFER TIE
EPS SHUNT REG
CLOSED
OPEN
CONNECT
DISCON
CAUTION & WARNING SYSTEM
MASTER ALARM
MEMORY RECALL
CLEAR
POWER
CAUT & WARN
EMERGENCY
TEST
ΔP
WARNING
FIRE
CAUTION
TONE VOL
POWER SYSTEM LIGHTS
STATUS
TEST
206

P10

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | ARRAY AMPS | | | | | |
| 206 | ST | ind | 1 | Provides OWS solar array group 1 current indication | | SAS GROUP 1 | | Range 0 to 50 amps |
| 206 | ST | ind | 2 thru 8 | Same as array amps ind 1 for solar groups 2 thru 8 | | SAS GROUP 2 thru 8 | | |
| 206 | ST | sw | EVENT TIMER | | | | | |
| | | | START | Activates event timer | TIME REF SYS EVENT TMR (pnl 200) | AM BUS 1 | | Momentary switch with return to the center position |
| | | | STOP | Deactivates event timer | | | | |
| 206 | ST | ind | [HOUR MIN SEC] | Provides elapsed time | TIME REF SYS EVENT TMR (pnl 200) | AM BUS 1 | | |
| 206 | ST | sw | [DECR/INCR] | | | | | |
| | | | DECR [X25] | Clock will indicate decreasing time at a rate 25 times that of std time | TIME REF SYS EVENT TMR (pnl 200) | AM BUS 1 | | Furthermost position counterclockwise (ccw) from straight up position |
| | | | [X4] | Clock will indicate decreasing time at a rate 4 times that of std time | | | | Second position ccw from straight up position |
| | | | [X.3] | Clock will indicate decreasing time at a rate .3 times that of std time | | | | First position ccw from straight up position |
| | | | [std] | Clock will indicate increasing time at the standard rate | | | | Center or straight up position |
| | | | INCR | | | | | |
| | | | [X.3] | Clock will indicate increasing time at a rate .3 times that of std time | | | | First position clockwise (cw) from straight up position |
| | | | [X4] | Clock will indicate increasing time at a rate 4 times that of std time | | | | Second position cw from straight up position |
| | | | [X25] | Clock will indicate increasing time at a rate 25 times that of std time | | | | Furthermost position cw from straight up position |
| | | | BATTERY VOLTS | | | | | |
| 206 | ST | ind | 1 | Provides BATTERY 1 output voltage indication | | BAT 1 | | Range 0 to 50 volts |
| 206 | ST | ind | 2 thru 8 | Same BATTERY battery volts ind 1 for batteries 2 thru 8 | | BAT 2 thru 8 | | |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | BUS AMPS | | | | | |
| | | | PCG TOTAL | | | | | |
| 206 | ST | ind | 1 | Provides algebraic sum of currents from all PCG's tied to reg bus 1 | | ALL PCG's tied to REG BUS 1 | | Range 0 to 200 amps |
| 206 | ST | ind | 2 | Provides algebraic sum of currents from all PCG's tied to reg bus 2 | | ALL PCG's tied to REG BUS 2 | | Range 0 to 200 amps |
| | | | OWS | | | | | |
| 206 | ST | ind | 1 | Indicates current to OWS bus 1 from reg bus 1 in AM | | REG BUS 1 | | Range 0 to 140 amps |
| 206 | ST | ind | 2 | Indicates current to OWS bus 2 from reg bus 2 in AM | | REG BUS 2 | | Range 0 to 140 amps |
| | | | CSM | | | | | |
| 206 | ST | ind | A | Indicates current to CSM bus A from transfer bus 1 | | TRANS BUS 1 | | Range 0 to 100 amps |
| 206 | ST | ind | B | Indicates current to CSM bus B from transfer bus 2 | | TRANS BUS 2 | | Range 0 to 100 amps |
| | | | ATM | | | | | |
| 206 | ST | ind | 1 | Indicates current to ATM main bus 1 from transfer bus 1 | | TRANS BUS 1 | | Range - 100 to + 100 amp + reading indicates pwr xfer to ATM from AM |
| 206 | ST | ind | 2 | Indicates current to AM/ATM bus 2 from transfer bus 2 | | TRANS BUS 2 | | Range - 100 to +100 amp + reading indicates pwr xfer to ATM from AM |
| | | | BATTERY AMPS | | | | | |
| | | | CHARGE/DISCHARGE | | | | | |
| 206 | ST | ind | 1 | Provides battery #1 current measured between battery #1 and charger #1 | | BAT 1 | | Range -50 to +50 amp + reading indicates charging |
| 206 | ST | ind | 2 thru 8 | Same as BATTERY AMPS CHARGE/DISCHARGE ind #1 for systems 2 thru 8 | | BAT 2 thru 8 | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | REG ADJUST | | | | | |
| 206 | ST | pot | BUS 1 | Adjust reg bus 1 voltage level by adjusting the output voltage level of the regulators attached to reg bus 1 | | REG BUS 1 | | Reg output open circuit voltage is adjustable from 26 to 30 volts and adjusts all regulators tied to that bus |
| 206 | ST | pot | BUS 2 | Same as REG ADJUST BUS 1 except for reg bus 2 | | REG BUS 2 | | |
| | | | BUS VOLTS | | | | | |
| | | | REG | | | | | |
| 206 | ST | ind | 1 | Provides reg bus 1 voltage indication | | REG BUS 1 | | Range 25 to 32 volts |
| 206 | ST | ind | 2 | Provides reg bus 2 voltage indication | | REG BUS 2 | | Range 25 to 32 volts |
| | | | TRANSFER | | | | | |
| 206 | ST | ind | 1 | Provides transfer bus 1 voltage indication | | TRANS BUS 1 | | Range 25 to 32 volts |
| 206 | ST | ind | 2 | Provides transfer bus 2 voltage indication | | TRANS BUS 2 | | Range 25 to 32 volts |
| | | | BAT CHARGE % | | | | | |
| 206 | ST | ind | PRI | Displays battery state-of-charge for primary amp-hour meters as selected by the BAT CHARGE selector switch | | | | Range 0 to 100% |
| 206 | ST | ind | SEC | Displays battery state-of-charge for secondary amp-hour meters as selected by the BAT CHARGE selector switch | | | | Range 0 to 100% |
| 206 | ST | sel | 1 thru 8 | Connects primary and secondary amp-hour meters 1 thru 8 to bat charge % primary and secondary indicators as selected | | BATTERY CHARGER AH METER 1 thru 8 | | |
| | | | REGULATOR CONTROL | | | | | |
| | | | FINE ADJUSTMENT | | | | | |
| 206 | ST | pot | 1 | Fine adjustment of voltage regulator 1 output to insure proper load sharing with respect to other PCG's | | REG BUS 1 | | |
| 206 | ST | pot | 2 thru 8 | Same as FINE ADJUSTMENT potentiometer 1 for systems 2 thru 8 | | REG BUS 2 thru 8 | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | AM BUS | | | | | |
| 206 | ST | sw | 1 | | | | | |
| | | | REG BUS 1 | Connects reg bus 1 power output to AM bus 1 | PWR SYS CONT 1&2 (pnl 201) | EPS CONTROL BUS 1&2 | 44400 | Momentary switches with return to the center position |
| | | | REG BUS 2 | Connects reg bus 2 power output to AM bus 1 | | | 40400 | |
| 206 | ST | lt | 1 | | | | | |
| | | | REG BUS 1 | Indicates reg bus 1 connected to AM bus 1 | PWR SYS STATUS LTS 1 (pnl 201) | EPS CONTROL BUS 1 | | |
| | | | REG BUS 2 | Indicates reg bus 2 connected to AM bus 1 | | | | |
| 206 | ST | sw | 2 | | | | | |
| | | | REG BUS 2 | Connects reg bus 2 power output to AM bus 2 | PWR SYS CONT 1&2 (pnl 201) | EPS CONTROL BUS 1&2 | 47540 | |
| | | | REG BUS 1 | Connects reg bus 1 power output to AM bus 2 | | | 43540 | |
| 206 | ST | lt | 2 | | | | | |
| | | | REG BUS 2 | Indicates reg bus 2 connected to AM bus 2 | PWR SYS STATUS LTS 2 (pnl 201) | EPS CONTROL BUS 2 | | |
| | | | REG BUS 1 | Indicates reg bus 1 connected to AM bus 2 | | | | |
| | | | OWS BUS | | | | | |
| 206 | ST | sw | 1 | | | | | |
| | | | ON | Connects reg bus 1 output to OWS bus 1 | OWS BUS 1 FEEDERS CONT AM (pnl 201) | EPS CONTROL BUS 1 | 43460 | Momentary switches with return to the center position. Similar sw function on OWS pnl 617 |
| | | | OFF | Disconnects the above | | | 47460 | |
| 206 | ST | lt | 1 | | | | | |
| | | | ON | Indicates the above | PWR SYS STATUS LTS 1 | EPS CONTROL BUS 1 | | Similar lt function on OWS pnl 617 |
| | | | OFF | Indicates the above | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | OWS BUS (cont'd) | | | | | |
| 206 | ST | sw | 2 | | | | | |
| | | | ON | Connects reg bus 2 output to OWS bus 2 | OWS BUS 2 FEEDERS CONT AM (pnl 201) | EPS CONTROL BUS 2 | 43004 | |
| | | | OFF | Disconnects the above | | | 47004 | |
| 206 | ST | lt | 2 | | | | | |
| | | | ON | Indicates the above | PWR SYS STATUS LTS 2 | EPS CONTROL BUS 2 | | |
| | | | OFF | Indicates the above | | | | |
| | | | ELEC GND | | | | | |
| 206 | ST | sw | CSM | Connects AM return buses to CSM single point ground | PWR SYS CONT 1&2 | EPS CONTROL BUS 1&2 | 46220 45660 | Normal condition with CSM umbilical connected NOTE: Momentary switch with return to the center position |
| | | | AIRLOCK | Provides AM single point ground prior to CSM hookup and dual point ground after hookup | | | 42220 41660 | |
| 206 | ST | lt | CSM | Indicates a CSM ground | PWR SYS STATUS LTS 1 | EPS CONTROL BUS 1 | | |
| | | | AIRLOCK | Indicates a dual ground with both AM and CSM ground when CSM docked | | | | |
| | | | ATM TRANSFER TIE | | | | | |
| 206 | ST | sw | BUS 1 | | | | | |
| | | | CLOSED | Connects transfer bus 1 output power to ATM main bus 1 | XFER BUS TIE CNTL 1 & 2 (pnl 201) | EPS CONTROL BUS 1&2 | 43700 | Momentary switches with return to the center position |
| | | | OPEN | Disconnects transfer bus 1 from ATM main bus 1 | | | 47700 | |
| 206 | ST | lt | BUS 1 | | | | | |
| | | | CLOSED | Indicates transfer bus 1 connected to ATM main bus 1 | PWR SYS STATUS LTS 1 (pnl 201) | EPS CONTROL BUS 1&2 | | |
| | | | OPEN | Indicates transfer bus 1 disconnected from ATM main bus 1 | | | | |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | ATM TRANSFER TIE (cont'd) | | | | | |
| 206 | ST | sw | BUS 2 | | | | | |
| | | | CLOSED | Connects transfer bus 2 output power to ATM main bus 2 | XFER BUS TIE CNTL 1 & 2 | EPS CONTROL BUS 1&2 | 40440 | |
| | | | OPEN | Disconnects transfer bus 2 from ATM main bus 2 | | | 44440 | |
| 206 | ST | lt | BUS 2 | | | | | |
| | | | CLOSED | Indicates transfer bus 2 connected to ATM main bus 2 | PWR SYS STATUS LTS (pnl 201) | EPS CONTROL BUS 2 | | |
| | | | OPEN | Indicates transfer bus 2 disconnected from ATM main bus 2 | | | | |
| | | | REG TRANSFER TIE | | | | | |
| 206 | ST | sw | BUS 1 | | | | | |
| | | | CLOSED | Connects reg bus 1 output power to transfer bus 1 | XFER BUS TIE CNTL 1 & 2 (pnl 201) | EPS CONTROL BUS 1&2 | 41700 | |
| | | | OPEN | Disconnects reg bus 1 output power from transfer bus 1 | | | 45700 | |
| 206 | ST | lt | BUS 1 | | | | | |
| | | | CLOSED | Indicates reg bus 1 connected to transfer bus 1 | PWR SYS STATUS LTS 1 (pnl 201) | EPS CONTROL BUS 1 | | |
| | | | OPEN | Indicates reg bus 1 disconnected from transfer bus 1 | | | | |
| 206 | ST | sw | BUS 2 | | | | | |
| | | | CLOSED | Connects reg bus 2 output power to transfer bus 2 | XFER BUS TIE CNTL 1 & 2 (pnl 201) | EPS CONTROL BUS 1&2 | 42640 | |
| | | | OPEN | Disconnects reg bus 2 from transfer bus 2 | | | 46640 | |
| 206 | ST | lt | BUS 2 | | | | | |
| | | | CLOSED | Indicates reg bus 2 connected to transfer bus 2 | PWR SYS STATUS LTS 2 (pnl 201) | EPS CONTROL BUS 2 | | |
| | | | OPEN | Indicates reg bus 2 disconnected to transfer bus 2 | | | | |

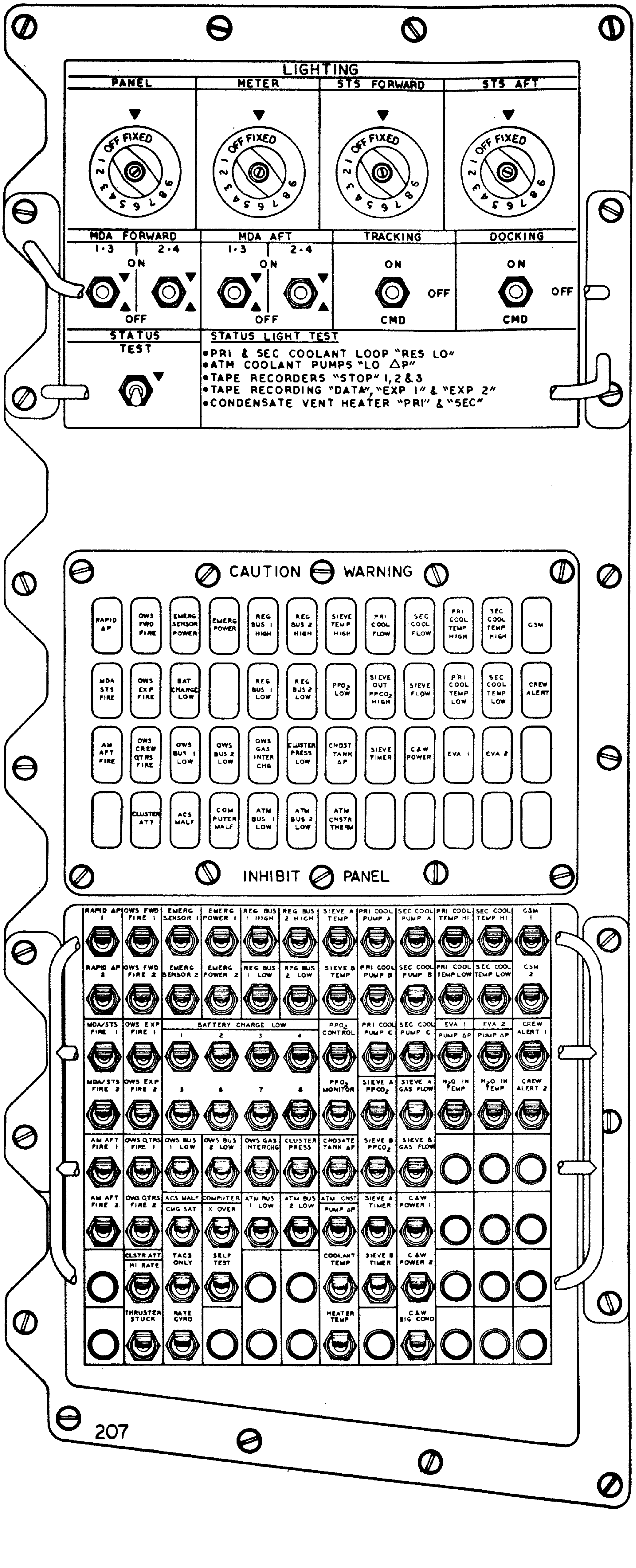
| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | EPS SHUNT REG | | | | | |
| 206 | ST | sw | BUS 1 | | | | | |
| | | | CONNECT | Connects EPS control bus 1 to the EPS bus 1 shunt regulator | PWR SYS CONT 2 (pnl 201) | EPS CONTROL BUS 2 | | Momentary switches with return to the center position |
| | | | DISCON | Disconnects EPS control bus 1 from EPS bus 1 shunt regulator | | | | |
| 206 | ST | lt | BUS 1 | | | | | |
| | | | CONNECT | Indicates EPS control bus 1 connected to EPS bus 1 shunt regulator | PWR SYS STATUS LTS 1 | EPS CONTROL BUS 1 | | |
| | | | DISCON | Indicates EPS control bus 1 disconnected from EPS Bus 1 shunt regulator | | | | |
| 206 | ST | sw | BUS 2 | | | | | |
| | | | CONNECT | Connects EPS control bus 2 to the EPS bus 2 shunt regulator | PWR SYS CONT 1 (pnl 201) | EPS CONTROL BUS 1 | | |
| | | | DISCON | Disconnects EPS control bus 2 from EPS bus 2 shunt regulator | | | | |
| 206 | ST | lt | BUS 2 | | | | | |
| | | | CONNECT | Indicates EPS control bus 2 connected to EPS bus 2 shunt regulator | PWR SYS STATUS LTS 2 (pnl 201) | EPS CONTROL BUS 2 | | |
| | | | DISCON | Indicates EPS control bus 2 disconnected from EPS bus 2 shunt regulator | | | | |
| | | | POWER SYSTEM LIGHTS | | | | | |
| 206 | ST | sw | BUS 1 | | | | | |
| | | | STATUS | Connects the power system 1 status lights relay contacts with power source to test status lights | PWR SYS STATUS LTG 1&2 (pnl 201) | EPS CONTROL BUS 1 | | |
| | | | OFF | Disconnects the power system 1 status lights | | | | |
| | | | TEST | Illuminates the power system 1 status lights regardless of relay position | | | | Switch position is momentary which returns to the OFF position after actuation |
| 206 | ST | sw | BUS 2 | | | | | |
| | | | STATUS | Connects the power system 2 status lights relay contacts with the power source to test status lights | PWR SYS STATUS LTS 1&2 (pnl 201) | EPS CONTROL BUS 2 | | |
| | | | OFF | Disconnects the power system 2 status lights | | | | |
| | | | TEST | Illuminates the power system 2 status lights regardless of relay position | | | | Switch position is momentary which returns to the OFF position after actuation |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | CAUTION & WARNING SYSTEM | | | | | |
| | | | MASTER ALARM | | | | | |
| 206 | ST | lt | | Illuminates when a caution, warning or emergency parameter exceeds the operating limits | | C&W SUB UNIT LAMP DRIVERS | | |
| 206 | ST | pb | | Turns off the audible tones, the T/M closure signals and all master alarm lights | C&WS CONVS C&W 1&2 EMER 1&2 (pnl 202) | EPS CONTROL BUS 1&2 | | |
| | | | MEMORY RECALL | | | | | |
| 206 | ST | lt | | Illuminates when a caution, or warning parameter exceeds the operating limits | | C&W SUB UNIT LAMP DRIVERS | | |
| 206 | ST | pb | | Provides memory recall to caution & warning subunits 1 & 2 which illuminates the caution (warning) system status lt (pnl 207) associated with a caution (warning) condition | C&WS CONVS C&W 1&2 (pnl 202) | EPS CONTROL BUS 1&2 | | |
| 206 | ST | sw | [CLEAR] | | | | | |
| | | | CLEAR | clears caution and warning subunits 1 and 2 memory | C&WS CONVS C&W 1&2 (pnl 202) | EPS CONTROL BUS 1&2 | | |
| | | | (down) | Normal switch position | | | | Switch is a momentary which returns to the down position after actuation |
| | | | POWER | | | | | |
| 206 | ST | sw | CAUT & WARN | | | | | |
| | | | ON | Turns on power to caution and warning subsystem 1 and 2 | C&WS CONVS C&W 1&2 (pnl 202) | EPS CONTROL BUS 1&2 | | |
| | | | | | 1-SIG/ COND-2 | EPS CONTROL BUS 1&2 | | |
| | | | | | C&WS SENSORS 1-C&W-2 | AM BUS 1&2 | | |
| | | | | | C&WS TONE AMP 1-C&W-2 (pnl 202) | EPS CONTROL BUS 1&2 | | |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | POWER (cont'd) | | | | | |
| | | | CAUT & WARN (cont'd) | | | | | |
| | | | OFF | Turns off caution and warning subsystem 1 and 2 | | | | |
| 206 | ST | sw | EMERGENCY - 1 | | | | | |
| | | | ON | Turns on power to emergency subsystem 1 | C&WS CONVS EMERG 1 (pnl 202) | EPS CONTROL BUS 1 | | |
| | | | | | C&WS SENSORS EMERG-1 (pnl 202) | EPS CONTROL BUS 1 | | |
| | | | OFF | Turns off emergency subsystem 1 | | | | |
| 206 | ST | sw | EMERGENCY - 2 | | | | | |
| | | | ON | Turns on power to emergency subsystem 2 | C&WS CONVS EMERG 2 (pnl 202) | EPS CONTROL BUS 2 | | |
| | | | | | C&WS SENSORS EMERG 2 (pnl 202) | EPS CONTROL BUS 2 | | |
| | | | OFF | Turns off emergency subsystem 2 | | | | |
| | | | TEST | | | | | |
| 206 | ST | sw | $\Delta$ P | | | | | |
| | | | 1 | Turns off emergency subunit 2 and simultaneously applies a $\Delta$ P test signal to the rapid $\Delta$ P sensors 1 & 2 | C&WS CONVS EMERG 1 (pnl 202) | EPS CONTROL BUS 1 | | |
| | | | | | C&WS SENSORS 1-EMERG-2 (pnl 202) | EPS CONTROL BUS 1,2 | | |
| | | | OFF | Normal systems operation position | C&W CONVS EMERG 1 & 2 (pnl 202) | EPS CONTROL BUS 1,2 | | |
| | | | | | C&WS SENSORS 1-EMERG-2 (pnl 202) | EPS CONTROL BUS 1,2 | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | POWER (cont'd) TEST (cont'd) Δ P (cont'd) | | | | | |
| | | | 2 | Turns off emergency subunit 1 and simultaneously applies a Δ P test signal to the rapid Δ P sensors 1 & 2 | C&W CONVS EMERG 2 (pnl 202) | EPS CONTROL BUS 2 | | |
| | | | | | C&WS SENSORS 1-EMERG-2 (pnl 202) | EPS CONTROL BUS 1,2 | | |
| 206 | ST | sw | WARNING | | | | | |
| | | | 1 | Turns off caution and warning subunit 2 and applies a test signal to caution and warning subunit 1 warning parameter input channels | C&W CONVS C&W 1 (pnl 202) | EPS CONTROL BUS 1 | | The test signal is 28 vdc supplied by the +28 vdc control converter in C&W subunit #1 |
| | | | OFF | Normal systems operating position | C&W CONVS C&W 1, 2 (pnl 202) | EPS CONTROL BUS 1,2 | | |
| | | | 2 | Turns off caution and warning subunit 1 and applies a test signal to caution and warning subunit 2 warning parameter input channels | C&W CONVS C&W 2 (pnl 202) | EPS CONTROL BUS 2 | | The test signal is 28 vdc supplied by the +28 vdc control converter in C&W subunit #2 |
| 206 | ST | sw | FIRE | | | | | |
| | | | 1 | Applies a fire test signal to emergency subunit 1 fire parameter input channels, and turns off emergency subunit 2 | C&W CONVS EMERG 1 (pnl 202) | EPS CONTROL BUS 1 | | The test signal is 28 vdc supplied by the +28 vdc control converter in emergency subunit 1 |
| | | | OFF | Normal system operation position | C&W CONVS EMERG 1&2 (pnl 202) | EPS CONTROL BUS 1,2 | | |
| | | | 2 | Applies a fire test signal to emergency subunit 2 fire parameter input channels and turns off emergency subunit 1 | C&W CONVS EMERG 2 (pnl 202) | EPS CONTROL BUS 2 | | The test signal is 28 vdc supplied by the +28 vdc control converter in emergency subunit 2 |
| 206 | ST | sw | CAUTION | | | | | |
| | | | 1 | Turns off caution and warning subunit 2 and applies a test signal to caution and warning subunit 1 caution input channels | C&W CONVS C&W 1 (pnl 202) | EPS CONTROL BUS 1 | | Test signal is 28 vdc supplied by the +28 vdc control converter in C&W subunit 1 |
| | | | OFF | Normal systems operating position | C&W CONVS C&W 1&2 | EPS CONTROL BUS 1,2 | | |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | POWER (cont'd) | | | | | |
| | | | TEST (cont'd) | | | | | |
| | | | CAUTION (cont'd) | | | | | |
| | | | 2 | Turns off caution and warning subunit 1 and applies a test signal to caution and warning subunit 2 caution input channels | C&W CONVS C&W 2 (pnl 202) | EPS CONTROL BUS 2 | | Test signal is 28 vdc supplied by the +28 vdc control converter in C&W subunit 2 |
| | | | TONE VOL | | | | | |
| 206 | ST | pot | EMERGENCY | Provides volume control of the emergency, rapid $\Delta$P and fire tones | | | | Requires use of the screwdriver located on panel 206 |
| 206 | ST | pot | WARNING | Provides volume control of the warning tone | | | | |
| 206 | ST | pot | CAUTION | Provides volume control of the caution tone | | | | |


LIGHTING
PANEL
METER
STS FORWARD
STS AFT
OFF FIXED
MDA FORWARD
MDA AFT
TRACKING
DOCKING
1-3
2-4
ON
OFF
CMD
STATUS
TEST
STATUS LIGHT TEST
•PRI & SEC COOLANT LOOP "RES LO"
•ATM COOLANT PUMPS "LO ΔP"
•TAPE RECORDERS "STOP" 1,2 & 3
•TAPE RECORDING "DATA", "EXP 1" & "EXP 2"
•CONDENSATE VENT HEATER "PRI" & "SEC"
CAUTION
WARNING
RAPID ΔP
OWS FWD FIRE
EMERG SENSOR POWER
EMERG POWER
REG BUS 1 HIGH
REG BUS 2 HIGH
SIEVE TEMP HIGH
PRI COOL FLOW
SEC COOL FLOW
PRI COOL TEMP HIGH
SEC COOL TEMP HIGH
CSM
MDA STS FIRE
OWS EXP FIRE
BAT CHARGE LOW
REG BUS 1 LOW
REG BUS 2 LOW
PPO2 LOW
SIEVE OUT PPCO2 HIGH
SIEVE FLOW
PRI COOL TEMP LOW
SEC COOL TEMP LOW
CREW ALERT
AM AFT FIRE
OWS CREW QTRS FIRE
OWS BUS 1 LOW
OWS BUS 2 LOW
OWS GAS INTER CHG
CLUSTER PRESS LOW
CNDST TANK ΔP
SIEVE TIMER
C&W POWER
EVA 1
EVA 2
CLUSTER ATT
ACS MALF
COMPUTER MALF
ATM BUS 1 LOW
ATM BUS 2 LOW
ATM CNSTR THERM
INHIBIT
PANEL
RAPID ΔP 1
OWS FWD FIRE 1
EMERG SENSOR 1
EMERG POWER 1
REG BUS 1 HIGH
REG BUS 2 HIGH
SIEVE A TEMP
PRI COOL PUMP A
SEC COOL PUMP A
PRI COOL TEMP HI
SEC COOL TEMP HI
CSM 1
RAPID ΔP 2
OWS FWD FIRE 2
EMERG SENSOR 2
EMERG POWER 2
REG BUS 1 LOW
REG BUS 2 LOW
SIEVE B TEMP
PRI COOL PUMP B
SEC COOL PUMP B
PRI COOL TEMP LOW
SEC COOL TEMP LOW
CSM 2
MDA/STS FIRE 1
OWS EXP FIRE 1
BATTERY CHARGE LOW
1
2
3
4
PPO2 CONTROL
PRI COOL PUMP C
SEC COOL PUMP C
EVA 1 PUMP ΔP
EVA 2 PUMP ΔP
CREW ALERT 1
MDA/STS FIRE 2
OWS EXP FIRE 2
5
6
7
8
PPO2 MONITOR
SIEVE A PPCO2
SIEVE A GAS FLOW
H2O IN TEMP
H2O IN TEMP
CREW ALERT 2
AM AFT FIRE 1
OWS QTRS FIRE 1
OWS BUS 1 LOW
OWS BUS 2 LOW
OWS GAS INTERCHG
CLUSTER PRESS
CNDSATE TANK ΔP
SIEVE B PPCO2
SIEVE B GAS FLOW
AM AFT FIRE 2
OWS QTRS FIRE 2
ACS MALF
CMG SAT
COMPUTER
X OVER
ATM BUS 1 LOW
ATM BUS 2 LOW
ATM CNST PUMP ΔP
SIEVE A TIMER
C&W POWER 1
CLSTR ATT
HI RATE
TACS ONLY
SELF TEST
COOLANT TEMP
SIEVE B TIMER
C&W POWER 2
THRUSTER STUCK
RATE GYRO
HEATER TEMP
C&W SIG COND
207

207

P11

| LOCATION | | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| PNL | STA# | | | | | | | |
| | | | LIGHTING | | | | | |
| 207 | ST | sel | PANEL | | | | | |
| | | | OFF | Turns off six STS inst panel lights | AM INSTR PANEL LTS FLOOD (pnl 202) | AM BUS 2 | | |
| | | | FIXED | Turns on six STS inst panel lights, full brilliance | | | | |
| | | | 1-9 | Varies six STS inst panel lights intensity | | | | (1 = minimum intensity) |
| 207 | ST | sel | METER | | | | | |
| | | | OFF | STS meter lights off, provides no power | AM INSTR PANEL LTS METER (pnl 202) | AM BUS 1 | | Each meter contains 2 lights |
| | | | FIXED | STS meter lights on, full brilliance | | | | |
| | | | 1-9 | Varies STS meter lights intensity | | | | |
| 207 | ST | sel | STS FORWARD | | | | | |
| | | | OFF | Four STS forward lights off, provides no power | COMPT LTS AM 1 (pnl 202) | AM BUS 1 | | |
| | | | FIXED | Four STS forward lights on, full brilliance | | | | |
| | | | 1-9 | Varies STS forward lights intensity | | | | |
| 207 | ST | sel | STS AFT | | | | | |
| | | | OFF | Four STS off lights off, provides no power | COMPT LTS AM 2 (pnl 202) | AM BUS 2 | | |
| | | | FIXED | Four STS aft lights on, full brilliance | | | | |
| | | | 1-9 | Varies STS aft lights intensity | | | | |
| | | | MDA FORWARD | | | | | |
| 207 | ST | sw | 1•3 | | | | | |
| | | | ON | Turns on forward MDA lights 1 & 3 | COMPT LTS MDA 1 (pnl 202) | AM BUS 1 | | Momentary switches with return to the center position |
| | | | OFF | Turns off above | | | | |
| 207 | ST | sw | 2•4 | | | | | |
| | | | ON | Turns on forward MDA lights 2 & 4 | COMPT LTS MDA 2 (pnl 202) | AM BUS 2 | | |
| | | | OFF | Turns off above | | | | |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | MDA AFT | | | | | |
| 207 | ST | sw | 1•3 | | | | | |
| | | | ON | Turns on aft MDA lights 1 & 3 | COMPT LTS MDA 1 (pnl 202) | AM BUS 1 | | Momentary switches with return to the center position |
| | | | OFF | Turns off above | | | | |
| 207 | ST | sw | 2•4 | | | | | |
| | | | ON | Turns on aft MDA lights 2 & 4 | COMPT LTS MDA 2 (pnl 202) | AM BUS 2 | | |
| | | | OFF | Turns off above | | | | |
| 207 | ST | sw | TRACKING | | | | | |
| | | | ON | Turns on primary and secondary tracking lights | TRACKING LTS CNTL 1 & 2 (pnl 202) | AM BUS 1&2 | | |
| | | | OFF | Turns above off | | | | |
| | | | CMD | Enables ground control of above | | | | |
| 207 | ST | sw | DOCKING | | | | | |
| | | | ON | Turns (16) docking lights on | DOCKING LTS 1&2 (pnl 202) | AM BUS 1&2 | | |
| | | | OFF | Turns (16) docking lights off | | | | |
| | | | CMD | Enables DCS command of docking lights | | | | |
| 207 | ST | sw | STATUS TEST | Illuminates:<br>a) Pri & sec cool loop "RES LO" lights<br>b) ATM cool pump "LO P" lights<br>c) Tape recorders "STOP" 1, 2 & 3 lights<br>d) Tape recording "DATA", EXP 1", "EXP 2" lights<br>e) Condensate vent htr "PRI" & "SEC" | AM INSTR PNL LTS STATUS (pnl 202) | AM BUS 2 | | Momentary position with return to the down position |
| | | | (down) | Turns above off | | | | |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | CAUTION & WARNING | | | | | |
| 207 | ST | 1t | RAPID ΔP | Illuminates when a decrease in OA internal pressure greater than or equal to 0.1 psia min is sensed by either of redundant rapid ΔP detectors | | EMERGENCY SUBUNIT 1&2 LAMP DRIVERS | | |
| 207 | ST | 1t | OWS FWD FIRE | Illuminates when a fire condition is detected in the OWS forward area | | EMERGENCY SUBUNIT 1&2 LAMP DRIVERS | | 3 Fire sensors in OWS FWD COMP |
| 207 | ST | 1t | EMERG SENSOR POWER | Illuminates when Emergency Sensor 1 or 2 voltage falls to less than or equal to 25 ± .5 vdc | | C&W SUBUNIT 1&2 LAMP DRIVERS | | Nominal range 26 to 30 vdc |
| 207 | ST | 1t | EMERG POWER | Illuminates when either the emergency control bus voltage or the emergency logic power falls to less than or equal to 24 ± 1.0 vdc or 4 ± .3 vdc respectively | | C&W SUBUNIT LAMP DRIVERS | | Nominal range 26 to 30 vdc |
| 207 | ST | 1t | REG BUS 1 HIGH | Illuminates when regulated bus 1 voltage is greater than or equal to 31.0 ± .62 vdc | | C&W SUBUNIT LAMP DRIVERS | | Nominal range 26 to 30 vdc |
| 207 | ST | 1t | REG BUS 2 HIGH | Illuminates when regulated bus 2 voltage is greater than or equal to 31.0 ± .62 vdc | | C&W SUB UNIT LAMP DRIVERS | | Nominal range 26 to 30 vdc |
| 207 | ST | 1t | SIEVE TEMP HIGH | Illuminates when mol sieve A or B temperature is greater than or equal to 440±10°F | | C&W SUBUNIT LAMP DRIVERS | | Nominal range 375 to 410°F |
| 207 | ST | 1t | PRI COOL FLOW | Illuminates when the flow from primary coolant pumps A, B, or C is less than or equal to 50 lbs/hr | | C&W SUBUNIT LAMP DRIVERS | | Normal flow 240 lbs/hr per pump |
| 207 | ST | 1t | SEC COOL FLOW | Illuminates when the flow from secondary coolant pump A, B, or C is less than or equal to 50 lbs/hr | | C&W SUBUNIT LAMP DRIVERS | | Normal flow 240 lbs/hr per pump |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | CAUTION & WARNING (cont'd | | | | | |
| 207 | ST | 1t | PRI COOL TEMP HIGH | Illuminates when the primary coolant temperature is greater than or equal to 120°F±3.8°F | | C&W SUBUNIT LAMP DRIVERS | | Nominal range 60 to 100°F |
| 207 | ST | 1t | SEC COOL TEMP HIGH | Illuminates when the primary coolant temperature is greater than or equal to 120°F±3.8°F | | C&W SUBUNIT DRIVERS | | Nominal range 60 to 100°F |
| 207 | ST | 1t | CSM | Illuminates when the CSM C&WS is triggered by a CSM C&WS parameter | | C&W SUBUNIT LAMP DRIVERS | | Nominal N/A |
| 207 | ST | 1t | MDA/STS FIRE | Illuminates when a fire is detected in the MDA/STS area | | EMERGENCY SUBUNIT LAMP DRIVERS | | 2 Fire sensors in MDA, 2 in mol sieve A, 2 in mol sieve B, and 2 in cabin heat exchanger |
| 207 | ST | 1t | OWS EXP FIRE | Illuminates when a fire is detected in the OWS experimental compartment | | EMERGENCY SUBUNIT LAMP DRIVERS | | |
| 207 | ST | 1t | BAT CHARGE LOW | Illuminates when anyone of the eight AM EPS batteries is less than or equal to 30% SOC | | C&W SUBUNIT LAMP DRIVERS | | Nominal range 0 to 50% depth of discharge |
| 207 | ST | 1t | | Spare | | | | |
| 207 | ST | 1t | REG BUS 1 LOW | Illuminates when the regulated bus 1 voltage is 25.0±.5 vdc | | C&W SUBUNIT LAMP DRIVERS | | Nominal range 26 to 30 vdc |
| 207 | ST | 1t | REG BUS 2 LOW | Illuminates when the regulated bus 2 voltage is 25.0 ± .5 vdc | | C&W SUBUNIT LAMP DRIVERS | | Nominal range 26 to 30 vdc |
| 207 | ST | 1t | PPO2 LOW | Illuminates when PPO2 drops to 157.4 ± 18.8 mmHg | | C&W SUBUNIT DRIVERS | | Nominal range 171 to 202 mmHg |
| 207 | ST | 1t | SIEVE OUT PPCO2 HIGH | Illuminates when PPCO2 increases to 4.4 ± 1.5 mmHg | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | CAUTION & WARNING (cont'd) | | | | | |
| 207 | ST | lt | SIEVE FLOW | Illuminates when the flow in molecular sieve A or B is 20 $\pm$ 3.8 cfm | | C&W SUBUNIT LAMP DRIVERS | | Nominal range approximately 33 cfm |
| 207 | ST | lt | PRI COOL TEMP LOW | Illuminates when the temperature in the primary coolant 47° loop is 40°F $\pm$ 2.4°F | | C&W SUBUNIT LAMP DRIVERS | | Nominal range 44° to 50°F |
| 207 | ST | lt | SEC COOL TEMP LOW | Illuminates when the temperature in the secondary coolant 47° loop is 40°F $\pm$ 2.4°F | | C&W SUBUNIT LAMP DRIVERS | | Nominal range 44° to 50°F |
| 207 | ST | lt | CREW ALERT | Illuminates when either ground commanded crew alert 1 or 2 is initiated via AM DCS | | C&W SUBUNIT LAMP DRIVERS | | |
| 207 | ST | lt | AM AFT FIRE | Illuminates when a fire is detected in the AM aft area | | EMERGENCY SUBUNIT LAMP DRIVERS | | 2 Fire sensors in OWS heat exchanger |
| 207 | ST | lt | OWS CREW QTRS FIRE | Illuminates when a fire condition is detected in the crew quarters area | | EMERGENCY SUBUNIT LAMP DRIVERS | | 2 Fire sensors in wardroom, 1 in waste management compartment, and 3 in sleep compartment |
| 207 | ST | lt | OWS BUS 1 LOW | Illuminates when OWS bus 1 voltage is 23.5 $\pm$ .47 vdc | | C&W SUBUNIT LAMP DRIVERS | | Nominal range 25 to 30 vdc |
| 207 | ST | lt | OWS BUS 2 LOW | Illuminates when OWS bus 2 voltage is 23.5 $\pm$ .47 vdc | | C&W SUBUNIT LAMP DRIVERS | | Nominal range 25 to 30 vdc |
| 207 | ST | lt | OWS GAS INTERCHG | Illuminates when the OWS gas flow 78.0 $\pm$ 10.4 vdc | | C&W SUBUNIT LAMP DRIVERS | | Nominal range approximately 112 to 155 cfm |
| 207 | ST | lt | CLUSTER PRESS LOW | Illuminates when either sensor in the OA detects a cabin pressure 4.7 +0 psia | | C&W SUBUNIT LAMP DRIVERS | | Nominal range 4.8 to 5.2 psia |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | CAUTION & WARNING (cont'd) | | | | | |
| 207 | ST | 1t | CNDST TANK $\Delta P$ | Illuminates when the $\Delta P$ between the cabin and condensate tank is $0.4^{+0.4}_{-0.1}$ psid | | C&W SUBUNIT LAMP DRIVERS | | Nominal range .5 to 5.2 psia below cluster ambient |
| 207 | ST | 1t | SIEVE TIMER | Illuminates when power is interrupted 30 ms to either cycle timer in molecular sieve A or B | | C&W SUBUNIT LAMP DRIVERS | | |
| 207 | ST | 1t | C&W POWER | Illuminates when the C&W control power or C&W logic power is less than or equal to $24 \pm 1.0$ vdc or $4 \pm .3$ vdc respectively for either C&W subunit 1 or 2 or the output from either C&W signal conditioning display converter 1 or 2 exceeds the following criteria<br>+24V: $>26$ or $<22$ vdc<br>-24V: $<-26$ or $>-22$ vdc<br>+5V: $<4.8$ or $>5.2$ vdc | | C&W SUBUNIT LAMP DRIVERS | | Nominal C&W subunit range 26 to 30 vdc and 4.8 to 5.4 vdc respectively<br>Nominal signal conditioning display converter range<br>+24: $+24\pm.3$ vdc<br>-24: $-24\mp.3$ vdc<br>+ 5: $+5\mp.075$ vdc |
| 207 | ST | 1t | EVA 1 | Illuminates when EVA LCG 1 $H_2O$ inlet temp is $< 33.5\pm1.2$°F or the EVA coolant loop pump $\Delta P$ $4\mp1.0$ psid | | C&W SUBUNIT LAMP DRIVERS | | Nominal range temp, 41 to 49°F<br>Nominal range $\Delta P$, 10 to 22 psid<br>$\Delta P$ switch opens, $\Delta P = 5.0$ psid |
| 207 | ST | 1t | EVA 2 | Illuminates when EVA LCG 2 $H_2O$ inlet temp is $< 33.5\pm1.2$°F or the EVA coolant loop pump $\Delta P$ $4\pm1.0$ psid | | C&W SUBUNIT LAMP DRIVERS | | Nominal range temp, 41 to 49°F<br>Nominal range $\Delta P$, 10.7 to 13.3 psid<br>$\Delta P$ switch opens, $\Delta P = 5.0$ psid |
| 207 | ST | 1t | | Spare | | | | |
| 207 | ST | 1t | | Spare | | | | |
| 207 | ST | 1t | CLUSTER ATT | Reference SLOH-ATM | | | | |
| 207 | ST | 1t | ACS MALF | Reference SLOH-ATM | | | | |
| 207 | ST | 1t | COMPUTER MALF | Reference SLOH-ATM | | | | |
| 207 | ST | 1t | ATM BUS 1 LOW | Reference SLOH-ATM | | | | |
| 207 | ST | 1t | ATM BUS 2 LOW | Reference SLOH-ATM | | | | |
| 207 | ST | 1t | ATM CNST THERM | Reference SLOH-ATM | | | | |
| 207 | ST | 1t | | Spare | | | | |
| 207 | ST | 1t | | Spare | | | | |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 207 | ST | lt | | Spare | | | | |
| 207 | ST | lt | | Spare | | | | |
| 207 | ST | lt | | Spare | | | | |
| | | | INHIBIT PANEL | | | | | |
| 207 | ST | sw | RAPID $\Delta$ P 1 | | | | | |
| | | | (up) | Enables rapid $\Delta$ P sensor #1 output signal to emergency subunits 1&2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | RAPID $\Delta$ P 2 | | | | | |
| | | | (up) | Enables rapid $\Delta$ P sensor #2 output signal to emergency subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | OWS FWD FIRE 1 | | | | | |
| | | | (up) | Enables OWS forward detection fire groups output signal to emergency subunit 1 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | OWS FWD FIRE 2 | | | | | |
| | | | (up) | Enables OWS forward detection fire groups output signal to emergency subunit 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | EMERG SENSOR 1 | | | | | |
| | | | (up) | Enables emergency sensor power 1 detector 1 & 2 output signal to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | EMERG SENSOR 2 | | | | | |
| | | | (up) | Enables emergency sensor power 2 detector 1 & 2 output signal to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 207 | ST | sw | EMERG POWER 1 | | | | | |
| | | | (up) | Enables emergency subunit 1 voltage detector output signal to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | EMERG POWER 2 | | | | | |
| | | | (up) | Enables emergency subunit 2 voltage detector output signal to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | REG BUS 1 HIGH | | | | | |
| | | | (up) | Enables regulator bus 1 high voltage detectors output signals to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | REG BUS 2 HIGH | | | | | |
| | | | (up) | Enables regulator bus 2 high voltage detectors output signals to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | REG BUS 1 LOW | | | | | |
| | | | (up) | Enables regulator bus 1 low voltage detectors output signals to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | REG BUS 2 LOW | | | | | |
| | | | (up) | Enables regulator bus 2 low voltage detectors output signals to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | SIEVE A TEMP | | | | | |
| | | | (up) | Enables molecular sieve A temp controller over temp output signal to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 207 | ST | sw | SIEVE B TEMP | | | | | |
| | | | (up) | Enables molecular sieve B temp controller over temp output signal to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | PRI COOL PUMP A | | | | | |
| | | | (up) | Enables primary coolant pump A flow detector signal output to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | PRI COOL PUMP B | | | | | |
| | | | (up) | Enables primary coolant pump B flow detector signal output to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | PRI COOL PUMP C | | | | | |
| | | | (up) | Enables primary coolant pump C flow detector signal output to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | SEC COOL PUMP A | | | | | |
| | | | (up) | Enables secondary coolant pump A flow detector signal output to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | SEC COOL PUMP B | | | | | |
| | | | (up) | Enables secondary coolant pump B flow detector signal output to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | SEC COOL PUMP C | | | | | |
| | | | (up) | Enables secondary coolant pump C flow detector signal output to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 207 | ST | sw | PRI COOL TEMP HI | | | | | |
| | | | (up) | Enables primary coolant temp high detectors output signal to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | SEC COOL TEMP HI | | | | | |
| | | | (up) | Enables secondary coolant temp high detectors output signal to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | PRI COOL TEMP LOW | | | | | |
| | | | (up) | Enables primary coolant temp low detectors output signal to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | SEC COOL TEMP LOW | | | | | |
| | | | (up) | Enables secondary coolant temp low detectors output signal to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | CSM 1 | | | | | |
| | | | (up) | Enables the CSM 1 relay contact closure to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | CSM 2 | | | | | |
| | | | (up) | Enables the CSM 2 relay contact closure to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | MDA/STS FIRE 1 | | | | | |
| | | | (up) | Enables MDA/STS fire detection groups output signal to emergency subunit 1 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | MDA/STS FIRE 2 | | | | | |
| | | | (up) | Enables MDA/STS fire detection groups output signal to emergency subunit 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 207 | ST | sw | OWS EXP FIRE 1 | | | | | |
| | | | (up) | Enables the OWS experiment fire detection groups output signal to emergency subunit 1 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | OWS EXP FIRE 2 | | | | | |
| | | | (up) | Enables the OWS experiment fire detection groups output signal to emergency subunit 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| | | | BATTERY CHARGE LOW | | | | | |
| 207 | ST | sw | 1 | | | | | |
| | | | (up) | Enables battery charger #1 low level detectors output signals to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | 2 | | | | | |
| | | | (up) | Enables battery charger #2 low level detectors output signals to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | 3 | | | | | |
| | | | (up) | Enables battery charger #3 low level detectors output signals to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | 4 | | | | | |
| | | | (up) | Enables battery charger #4 low level detectors output signals to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | 5 | | | | | |
| | | | (up) | Enables battery charger #5 low level detectors output signals to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | BATTERY CHARGE LOW (cont'd) | | | | | |
| 207 | ST | sw | 6 | | | | | |
| | | | (up) | Enables battery charger #6 low level detectors output signals to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | 7 | | | | | |
| | | | (up) | Enables battery charger #7 low level detectors output signals to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | 8 | | | | | |
| | | | (up) | Enables battery charger #8 low level detectors output signals to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | PPO2 CONTROL | | | | | |
| | | | (up) | Enables the controller PPO2 level detector output signal to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | PPO2 MONITOR | | | | | |
| | | | (up) | Enables the monitor PPO2 level detector output signal to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | SIEVE A PPCO2 | | | | | |
| | | | (up) | Enables molecular sieve A PPCO2 1 & 2 level detectors output signals to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 207 | ST | sw | SIEVE B PPCO2 | | | | | |
| | | | (up) | Enables molecular sieve B PPCO2 1 & 2 level detectors output signals to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | SIEVE A GAS FLOW | | | | | |
| | | | (up) | Enables molecular sieve A gas flow detector output signal to the caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | SIEVE B GAS FLOW | | | | | |
| | | | (up) | Enables molecular sieve B gas flow detector output signal to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| | | | EVA 1 | | | | | |
| 207 | ST | sw | PUMP $\Delta$ P | | | | | |
| | | | (up) | Enables EVA LCG 1 pump $\Delta$ P sensor output signal to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | H2O IN TEMP | | | | | |
| | | | (up) | Enables EVA LCG 1 H2O inlet temp level detectors output signals to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| | | | EVA 2 | | | | | |
| 207 | ST | sw | PUMP $\Delta$ P | | | | | |
| | | | (up) | Enables EVA LCG 2 pump $\Delta$ P sensor output signal to the caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | H2O IN TEMP (up) | Enables the EVA LCG 2 H2O inlet temperature level detectors output signals to caution and warning units 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |

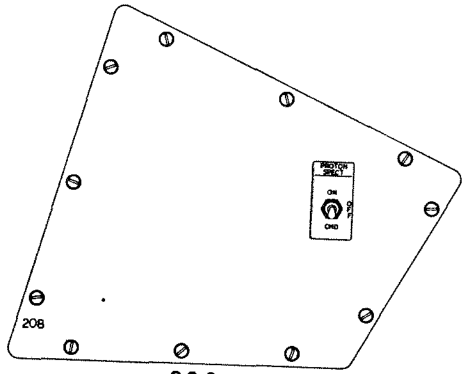
| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 207 | ST | sw | CREW ALERT 1 | | | | | |
| | | | (up) | Enables the crew alert 1 output signal to caution and warning units 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | CREW ALERT 2 | | | | | |
| | | | (up) | Enables the crew alert 2 output signal to caution and warning units 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | AM AFT FIRE 1 | | | | | |
| | | | (up) | Enables AM aft fire detection groups output signal to emergency subunit 1 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | AM AFT FIRE 2 | | | | | |
| | | | (up) | Enables AM aft fire detection groups output signal to emergency subunit 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | OWS QTRS FIRE 1 | | | | | |
| | | | (up) | Enables the OWS crew quarters fire detection groups output signal to the emergency subunit 1 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | OWS QTRS FIRE 2 | | | | | |
| | | | (up) | Enables the OWS crew quarters fire detection groups output signal to the emergency subunit 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | OWS BUS 1 LOW | | | | | |
| | | | (up) | Enables OWS bus 1 voltage level detectors output signals to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | OWS BUS 2 LOW | | | | | |
| | | | (up) | Enables OWS bus 2 voltage level detectors output signals to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 207 | ST | sw | OWS GAS INTERCHNG | | | | | |
| | | | (up) | Enables the OWS gas flow meter level detector output signal to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | CLUSTER PRESS | | | | | |
| | | | (up) | Enables the cluster pressure low sensors 1 & 2 output signals to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | CNDSATE TANK $\Delta$P | | | | | |
| | | | (up) | Enables condensate tank $\Delta$P sensor output signals to caution and warning subunits 1 & 2 | NONE | | | |
| | | | CLUSTER ATT | | | | | |
| 207 | ST | sw | HI RATE | | | | | |
| | | | (up) | Enables cluster high rate signal from the ATM to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | THRUSTER STUCK | | | | | |
| | | | (up) | Enables thruster stuck signal from the ATM to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| | | | ACS MALF | | | | | |
| 207 | ST | sw | CMG SAT | | | | | |
| | | | (up) | Enables the control moment gyro saturated signal from the ATM to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | TACS ONLY | | | | | |
| | | | (up) | Enables the TACS only control mode signal from the ATM to caution and warning sub-units 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |

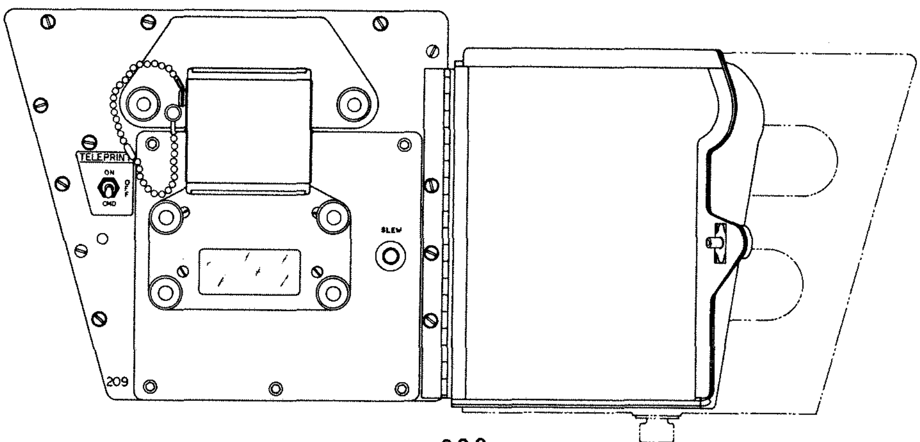
| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | ACS MALF (cont'd) | | | | | |
| 207 | ST | sw | RATE GYRO | | | | | |
| | | | (up) | Enables the rate gyro malfunction signal from the ATM to the caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| | | | COMPUTER | | | | | |
| 207 | ST | sw | XOVER | | | | | |
| | | | (up) | Enables the ATM computer crossover signal from the ATM to caution and warning sub-units 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | SELF TEST | | | | | |
| | | | (up) | Enables the ATM computer self test EVA signal from the ATM to caution and warn-ing subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | ATM BUS 1 LOW | | | | | |
| | | | (up) | Enables the ATM bus 1 voltage low signal from the ATM to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | ATM BUS 2 LOW | | | | | |
| | | | (up) | Enables the ATM bus 2 voltage low signal from the ATM to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| | | | ATM CNST | | | | | |
| 207 | ST | sw | PUMP$\Delta$P | | | | | |
| | | | (up) | Enables the ATM TCS pump P low signal from the ATM to caution and warning sub-units 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | ATM CNST (cont'd) | | | | | |
| 207 | ST | sw | COOLANT TEMP | | | | | |
| | | | (up) | Enables the ATM TCS coolant temp high and/or low signal from the ATM to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | HEATER TEMP | | | | | |
| | | | (up) | Enables the ATM canister heater temp high signal from the ATM to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | SIEVE A TIMER | | | | | |
| | | | (up) | Enables molecular sieve A timers 1(2) power interrupt output signals to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | SIEVE B TIMER | | | | | |
| | | | (up) | Enables molecular sieve B timers 1(2) power interrupt output signals to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | C&W POWER 1 | | | | | |
| | | | (up) | Enables C&W subunit 1 voltage level detectors output signals to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | C&W POWER 2 | | | | | |
| | | | (up) | Enables C&W subunit 2 voltage level detectors output signals to caution and warning subunits 1 & 2 | NONE | | | |
| | | | (down) | Inhibits the above | | | | |
| 207 | ST | sw | C&W SIG COND | | | | | |
| | | | (up) | Enables C&W signal conditioning primary & secondary display converters voltage level detectors output signals to the caution and warning subunits 1 & 2 | C&W CONVS C&W 1&2 (pnl 202) | EPS CONTROL BUS 1,2 | | |
| | | | (down) | Inhibits the above | | | | |

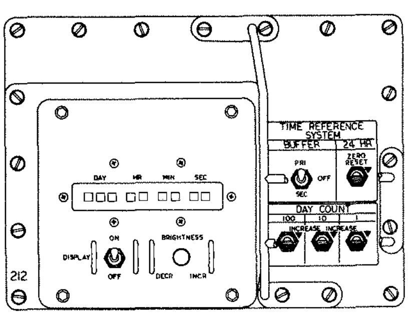
P12



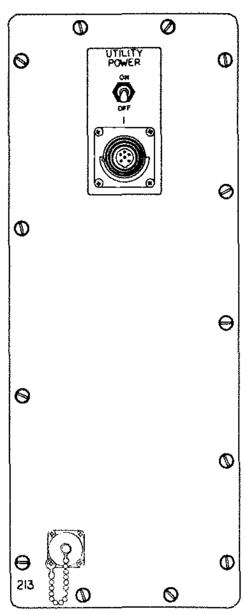

208



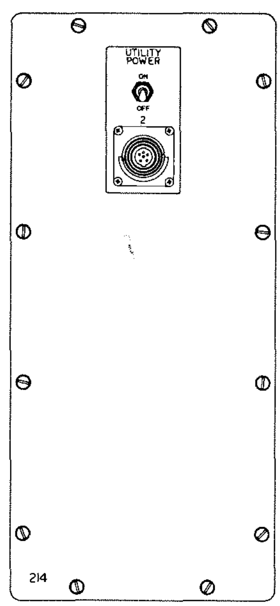

209




212




213

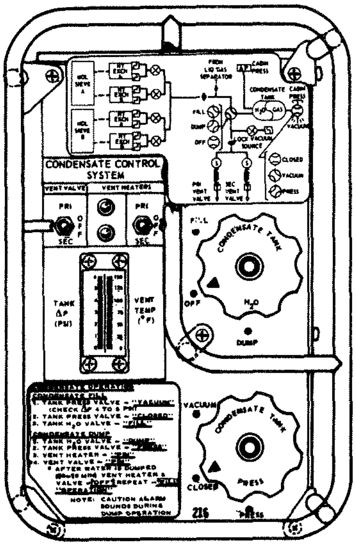



214

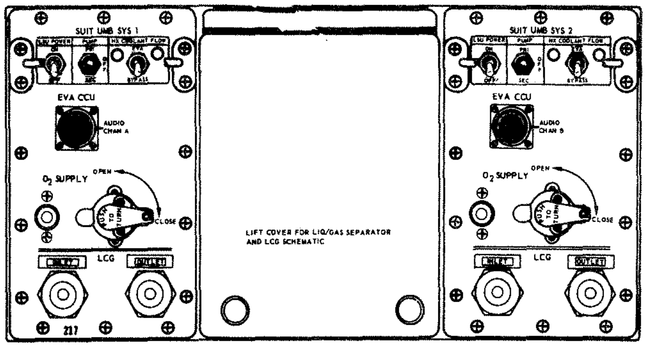
| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 208 | ST | sw | PROTON SPECT | | | | | |
| | | | ON | Turns the proton spectrometer on | PROT SPECT (pnl 202) | AM BUS 1 | | DCS Channel 43344 is ALSO active to change the threshold setting in a manual control mode |
| | | | OFF | Turns the above off | PROT SPECT (pnl 202) | AM BUS 1 | 45344 | |
| | | | CMD | Enables DCS control of the above | | | 41344<br>43344 | |
| 209 | ST | sw | TELEPRINT | | | | | |
| | | | ON | Turns on power to teleprinter and IEU | TELEPRINT (pnl 200) | AM BUS 1 | | |
| | | | OFF | Deactivates the above | | | | |
| | | | CMD | Allows DCS control of power to teleprinter | | | 707<br>706 | ON<br>OFF |
| 209 | ST | pb | SLEW | Causes teleprinter to advance paper | TELEPRINT (pnl 200) | AM BUS 1 | | Paper is fed as long as switch is depressed |
| | | | GMT CLOCK | | | | | |
| 212 | ST | ind | [DAY/HR/MIN/SEC] | Displays elapsed time from start of clock | | | | Typical for panel 610 |
| 212 | ST | sw | DISPLAY ON | Activates clock | | | | |
| | | | OFF | Deactivates clock | | | | |
| 212 | ST | pot | BRIGHTNESS DECR | Decreases brightness of elapsed time display | | | | Turn ccw to decrease brightness |
| | | | INCR | Increases brightness of elapsed time display | | | | Turn cw to increase brightness |
| | | | TIME REFERENCE SYSTEM | | | | | |
| 212 | ST | sw | BUFFER PRI | Activates primary time correlation buffer | | | | |
| | | | OFF | Deactivates both time correlation buffers | | | | |
| | | | SEC | Activates secondary time correlation buffer | | | | |
| 212 | ST | sw | 24 HR ZERO RESET | Resets the active electronic timer Te RGSTR which causes the GMT clock display to indicate zero hours, minutes, and seconds | | | | Momentary switch which returns to the center position |
| | | | (ctr) | Normal position of switch | | | | |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | TIME REFERENCE SYSTEM (cont'd) | | | | | |
| | | | DAY COUNT | | | | | |
| 212 | ST | sw | 100 INCREASE | Increases day count by 100 | | | | Momentary switch which returns to the center position |
| | | | (ctr) | Normal position of switch | | | | |
| 212 | ST | sw | 10 INCREASE | Increases day count by 10 | | | | |
| | | | (ctr) | Normal position of switch | | | | |
| 212 | ST | sw | 1 INCREASE | Increases day count by 1 | | | | |
| | | | (ctr) | Normal position of switch | | | | |
| | | | UTILITY POWER | | | | | |
| 213 | ST | sw | ON | Turns AM UTILITY POWER outlet #1 on | UTIL PWR AM 1 3 5 (pnl 202) | AM BUS 1 | | |
| | | | OFF | Turns above off | | | | |
| 213 | ST | conn | 1 | Zero-G receptacle provides electrical power interface with portable equipment plug | | | | |
| | | | UTILITY POWER | | | | | |
| 214 | ST | sw | | | | | | |
| | | | ON | Turns AM UTILITY POWER outlet #2 on | UTIL PWR AM 2 4 6 (pnl 202) | AM BUS 2 | | |
| | | | OFF | Turns above off | | | | |
| 214 | ST | conn | | Zero-G receptacle provides electrical power interface with portable equipment plug | | | | |

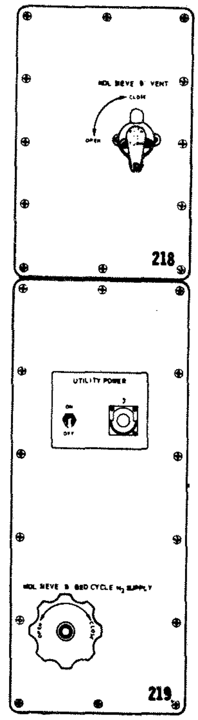
P13

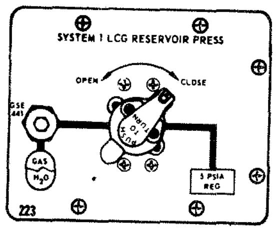



216



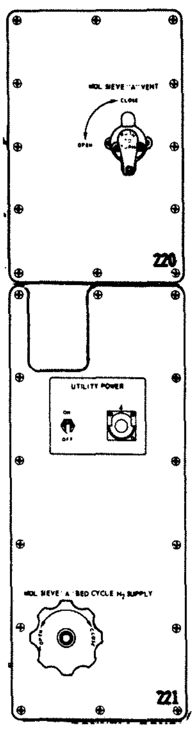

217



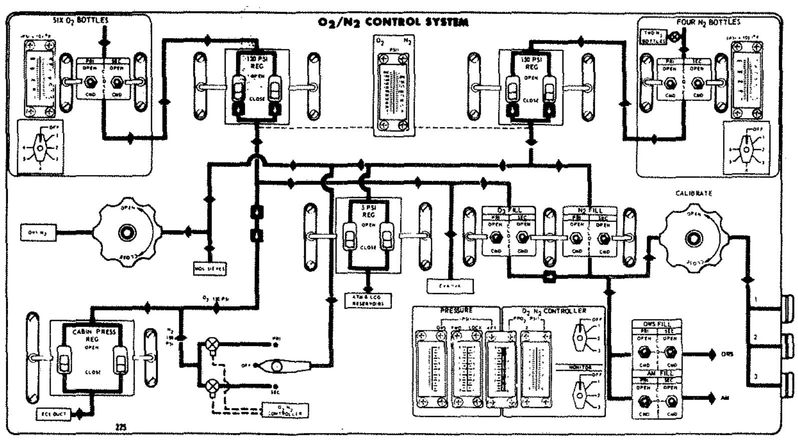




223

218, 219




220, 221




225

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | CONDENSATE CONTROL SYSTEM | | | | | |
| 216 | ST | sw | VENT VALVE | | | | | |
| | | | PRI | Opens primary condensate control system vent valve | CNDST DUMP PRI & SEC (pnl 200) | AM BUS 1&2 | | |
| | | | OFF | Closes condensate control system vent valves | | | | |
| | | | SEC | Opens secondary condensate control system vent valve | | | | |
| | | | VENT HEATERS | | | | | |
| 216 | ST | lt | [PRI] | Illuminates when primary condensate control system vent heater is on | CNDST DUMP PRI (pnl 200) | AM BUS 1 | | |
| 216 | ST | lt | [SEC] | Illuminates when secondary condensate control system vent heater is on | CNDST DUMP SEC (pnl 200) | AM BUS 2 | | |
| 216 | ST | sw | PRI | Turns primary condensate control system vent heater on, selects primary vent temperature display | CNDST DUMP PRI& DISP CONV INPUT PRI | AM BUS 1 | | |
| | | | OFF | Turns condensate control system vent heaters off | | | | |
| | | | SEC | Turns secondary condensate cont system vent heater on, selects secondary vent temperature display | CNDST DUMP PRI & DISP CONV INPUT SEC (pnl 200) | AM BUS 2 | | |
| 216 | ST | ind | TANK $\Delta$P (PSI) | Indicates pressure differential between cabin pressure and condensate tank pressure | DISP CONV OUTPUT +24V (pnl 200) | INST BUS A or B DISP CONV PRI or SEC | | Range 0 to 6 psi |
| 216 | ST | ind | VENT TEMP (°F) | Indicates temperature of the selected (PRI or SEC) condensate control system vent line | DISP CONV OUTPUT +24V (pnl 200) | INST BUS A or B DISP CONV PRI or SEC | | Range 0 to 150°F |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | CONDENSATE TANK | | | | | |
| 216 | ST | vlv | H2O | | | | | |
| | | | FILL | Connects the condensate tank water line to the condensing heat exchangers and water separator water line | | | | |
| | | | OFF | Disconnects the condensate tank from the condensate system | | | | |
| | | | DUMP | Connects the condensate tank water line to condensate system overboard vent lines | | | | |
| 216 | ST | vlv | PRESS | | | | | |
| | | | VACUUM | Connects the condensate tank gas side pressure line to vent lines | | | | |
| | | | CLOSED | Disconnects the condensate tank gas side pressure line from the condensate system | | | | |
| | | | PRESS | Connects the condensate tank gas side pressure line to cabin pressure | | | | |
| | | | SUIT UMB SYS 1 | | | | | |
| 217 | ST | sw | LSU POWER | | | | | |
| | | | ON | Activates suit umbilical system 1 | SUS 1 EVA CCU 1&2 (pnl 202) | AM BUS 1&2 | | Provides power to the EVA CCU AUDIO CHAN A connector |
| | | | OFF | Turns off the above | | | | |
| 217 | ST | sw | PUMP | | | | | |
| | | | PRI | Turns suit umbilical system 1 primary coolant pump on | SUS 1 LCG PUMPS PRI (pnl 202) | AM BUS 1 | | |
| | | | OFF | Turns suit umbilical system 1 coolant pumps off | | | | |
| | | | SEC | Turns suit umbilical system 1 secondary coolant pump on | SUS 1 LCG PUMPS SEC (pnl 202) | AM BUS 2 | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | EVA CCU | | | | | |
| 217 | ST | conn | AUDIO CHAN A | Provides the connector interface for the ALSA, EVA communication, and biomed | | | | OBS Channel A |
| 217 | ST | conn | O2 SUPPLY | Provides the connector interface for the #1 suit O2 umbilical and the 120 psi O2 regulator output | | | | |
| 217 | ST | vlv | | | | | | |
| | | | OPEN | Opens a path from the 120 psi O2 regulator output to the suit umbilical system 1 O2 supply QD | | | | Push to turn valve |
| | | | CLOSE | Closes the above | | | | |
| 217 | ST | conn | LCG INLET | Provides an interface connect point for the #1 suit umbilical LCG Inlet and the suit cooling system #1 outlet | | | | |
| 217 | ST | conn | LCG OUTLET | Provides an interface connect point for the #1 suit umbilical LCG outlet and the suit cooling system #1 inlet | | | | |
| | | | SUIT UMB SYS 2 | | | | | |
| 217 | ST | sw | LSU POWER | | | | | |
| | | | ON | Activates suit umbilical system 2 | SUS 2 EVA CCU 1 & 2 (pnl 202) | AM BUS 1&2 1 or 2 | | Provides power to the EVA CCU AUIDO CHAN B connector |
| | | | OFF | Deactivates the above | | | | |
| 217 | ST | sw | PUMP | | | | | |
| | | | PRI | Turns suit umbilical system 2 primary coolant pump on | SUS 2 LCG PUMP PRI (pnl 202) | AM BUS 2 | | |
| | | | OFF | Turns suit umbilical system 2 coolant pumps off | | | | |
| | | | SEC | Turns suit umbilical system 2 secondary coolant pump on | SUS 2 LCG PUMP SEC (pnl 202) | AM BUS 1 | | |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | EVA CCU | | | | | |
| 217 | ST | conn | AUDIO CHAN B | Provides the connector interface for the ALSA, EVA communication and biomed | | | | OBS Channel B |
| 217 | ST | conn | 02 SUPPLY | Provides the connector interface for the #2 suit 02 umbilical and the 120 psi 02 regulator output | | | | |
| 217 | ST | vlv | OPEN | Opens a path from 120 psi 02 regulator output to the suit umbilical system 2 02 supply QD | | | | |
| | | | CLOSE | Closes the above | | | | |
| 217 | ST | conn | LCG INLET | Provides interface connect point for the #2 suit umbilical LCG inlet and the suit cooling system #2 outlet | | | | |
| 217 | ST | conn | LCG OUTLET | Provides an interface connect point for the #2 suit umbilical LCG outlet and the suit cooling system #2 inlet | | | | |
| 218 | ST | vlv | MOL SIEVE "B" VENT | | | | | |
| | | | OPEN | Opens the path from mol sieve B overboard vent duct to vacuum | | | | |
| | | | CLOSE | Closes the above | | | | |
| | | | UTILITY POWER | | | | | |
| 219 | ST | sw | ON | Turns on AM utility power outlet #3 | UTIL PWR AM 1•3•5 (pnl 202) | AM BUS 1 | | |
| | | | OFF | Turns above off | | | | |
| 219 | ST | conn | 3 | Zero-G receptacle provides electrical power interface with portable equipment plug | | | | |
| 219 | ST | vlv | MOL SIEVE "B" BED CYCLE N2 SUPPLY | Controls the pneumatic supply from the 150 PSIG N2 supply line to the mol sieve "B" automatic cycle adsorb/desorb solenoid valves | | | | Counterclockwise rotation opens valve Clockwise rotation closes valve |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 220 | ST | vlv | MOL SIEVE "A" VENT | | | | | |
| | | | OPEN | Opens the path from mol sieve A overboard vent duct to the vacuum of space | | | | |
| | | | CLOSE | Closes the above | | | | |
| | | | UTILITY POWER | | | | | |
| 221 | ST | sw | | | | | | |
| | | | ON | Turns on AM utility power outlet #4 | UTIL PWR AM 2 4 6 (pnl 202) | AM BUS 2 | | |
| | | | OFF | Turns above off | | | | |
| 221 | ST | conn | 4 | Zero-G receptacle provides electrical power interface with portable equipment plug | | | | |
| 221 | ST | vlv | MOL SIEVE "A" BED CYCLE N2 SUPPLY | Controls the pneumatic supply from the 150 psig N2 supply line to the mol sieve "A" automatic cycle adsorb/desorb solenoid valves | | | | Counterclockwise rotation opens<br>Clockwise rotation closes valve |
| | | | SYSTEM 1 LCG RESERVOIR PRESS | | | | | Typical for panel 224 (system 2) |
| 223 | ST | vlv | | | | | | |
| | | | OPEN | Opens the path from the 5 PSIA gas regulator output to the gas side of the suit system #1 water tank | | | | |
| | | | CLOSE | Closes the above | | | | |
| 224 | ST | vlv | OPEN | Opens the path from the 5 PSID gas regulator output to the gas side of the suit system #2 water tank | | | | |
| | | | CLOSE | Closes the above | | | | |
| | | | O2/N2 CONTROL SYSTEM | | | | | |
| | | | SIX O2 BOTTLES | | | | | |
| 225 | ST | ind | | | | | | |
| | | | (PSI X 10) | Indicates pressure in the O2 bottle selected by the selector | DISP CONV OUTPUT +5V (pnl 200) | INST BUS A OR B OR DISP CONV | | Range 0 to 400 X10 psi |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 225 | ST | ind | (°F) | Indicates the temperature in the 02 bottle selected by the selector | DISP CONV OUTPUT +24V (pnl 200) | INST BUS A OR B OR DISP CONV | | Range 0 to 125°F |
| 225 | ST | sel | OFF | Disconnects temperature, pressure transducers from indicator | NONE | NONE | | |
| | | | 1-6 | Connects 02 bottle 1-6 temperature, pressure transducers with the indicator | NONE | NONE | | |
| 225 | ST | sw | PRI | | | | | |
| | | | OPEN | Opens primary 02 supply valve | 02/N2 GAS FILL PRI (pnl 200) | AM BUS 1 | | Supplies 02 gas from the 02 supply to two 02 120 PSI regulators |
| | | | CLOSE | Closes the above | | | | |
| | | | CMD | Enables DCS control of the above | | | 41744<br>45744 | PRI 02 SUP VLV CLS<br>PRI 02 SUP VLV OPN |
| 225 | ST | sw | SEC | | | | | |
| | | | OPEN | Opens the secondary 02 supply valve | 02/N2 GAS FILL SEC (pnl 200) | AM BUS 2 | | Redundant valve in parallel |
| | | | CLOSE | Closes the above | | | | |
| | | | CMD | Enables DCS control of the above | | | 40724<br>44724 | SEC 02 SUP VLV CLS<br>SEC 02 SUP VLV OPN |
| | | | 120 PSI REG | | | | | |
| 225 | ST | vlv | A OPEN | Opens a path from the 02 supply to 120 psi regulator A inlet | | | | Toggle valve |
| | | | CLOSE | Closes the above | | | | |
| 225 | ST | vlv | B OPEN | Opens a path from the 02 supply to 120 psi regulator B inlet | | | | Toggle<br>Either of two regulators can supply 02 required |
| | | | CLOSE | Closes the above | | | | |

| LOCATION | | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| PNL | STA# | | | | | | | |
| 225 | ST | ind | O2 (PSI) | Indicates the 120 psi O2 regulator output pressure | DISP CONV OUTPUT +5V (pnl 200) | INST BUS A OR B OR DISP CONV | | Range 0 to 200 psi |
| 225 | ST | ind | N2 (PSI) | Indicates the 150 psi N2 regulator output pressure | DISP CONV OUTPUT +5 V (pnl 200) | INST BUS A OR B OR DISP CONV | | Range 0 to 250 psi |
| | | | 150 PSI REG | | | | | |
| 225 | ST | vlv | A | | | | | |
| | | | OPEN | Opens a path from the N2 supply to 150 psi reg A inlet | | | | Toggle valve |
| | | | CLOSE | Closes the above | | | | |
| 225 | ST | vlv | B | | | | | |
| | | | OPEN | Opens a path from the N2 supply to 150 psi reg B inlet | | | | Toggle valve<br>Either of two regulators can supply N2 required |
| | | | CLOSE | Closes the above | | | | |
| | | | FOUR N2 BOTTLES | | | | | |
| 225 | ST | sw | PRI | | | | | |
| | | | OPEN | Opens the primary N2 supply valve | O2/N2 GAS FILL PRI (pnl 200) | AM BUS 1 | | Supplies N2 gas from N2 supply to two N2 150 PSI regulators |
| | | | CLOSE | Closes the above | | | | |
| | | | CMD | Enables DCS control of tthe above | | | 40224<br>44224 | PRI N2 SUP VLV CLS<br>PRI N2 SUP VLV OPN |
| 225 | ST | sw | SEC | | | | | |
| | | | OPEN | Opens the secondary O2 supply valve | O2/N2 GAS FILL SEC (pnl 200) | AM BUS 2 | | Redundant valve in parallel |
| | | | CLOSE | Closes the above | | | | |
| | | | CMD | Enables DCS control of the above | | | 42724<br>46724 | SEC N2 SUP VLV CLS<br>SEC N2 SUP VLV OPN |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 225 | ST | ind | (PSI X 10) | Indicates the pressure in the N2 bottle selected by the selector | DISP CONV OUTPUT +5V (pnl 200) | INST BUS A OR B OR DISP CONV | | Range 0 to 400 X 10 psi |
| 225 | ST | ind | (°F) | Indicates the temperature in the N2 bottle selected by the selector | DISP CONV OUTPUT +24V (pnl 200) | INST BUS A OR B OR DISP CONV | | Range -25 to 125°F |
| 225 | ST | sel | OFF | Disconnects temperature, pressure transducers from indicator | NONE | NONE | | |
| 225 | ST | sel | 1-6 | Connects N2 bottle 1-6 temperature, pressure transducers to the indicator | NONE | NONE | | |
| 225 | ST | vlv | OWS N2 OPEN | Controls the flow from 150 psi N2 supply to the OWS N2 supply line | | | | Counterclockwise rotation opens valve |
| | | | CLOSE | Closes the above | | | | Clockwise rotation closes valve |
| | | | 5 PSI REG | | | | | |
| 225 | ST | vlv | A | | | | | |
| | | | OPEN | Opens a path from the 150 psig N2 supply line to 5 psia regulator A | | | | Toggle valve<br>Regulators supply N2 to EVA, IVA, ATM cooling reservoirs |
| | | | CLOSE | Closes the above | | | | |
| 225 | ST | vlv | B | | | | | |
| | | | OPEN | Opens a path from the 150 psig N2 supply line to 5 psia regulator B | | | | Toggle valve |
| | | | CLOSE | Closes the above | | | | |
| | | | O2 FILL | | | | | |
| 225 | ST | sw | PRI | | | | | |
| | | | OPEN | Opens primary O2 fill solenoid valve | O2/N2 GAS FILL PRI (pnl 200) | AM BUS 1 | | Supplies O2 gas for AM/MDA/OWS pressurization |
| | | | CLOSE | Closes the above | | | | |
| | | | CMD | Enables DCS control of the above | | | 40120<br>44120 | PRI O2 FIL VLV OPN<br>PRI O2 FIL VLV CLSD |

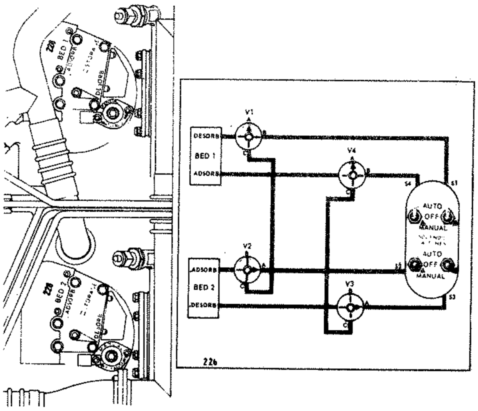
| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | O2 FILL (cont'd) | | | | | |
| 225 | ST | sw | SEC | | | | | |
| | | | OPEN | Opens secondary O2 fill solenoid valve | O2/N2 GAS FILL SEC (pnl 200) | AM BUS 2 | | Redundant valve in parallel |
| | | | CLOSE | Closes the above | | | | |
| | | | CMD | Enables DCS control of the above | | | 42660<br>46660 | SEC O2 FIL VLV OPN<br>SEC O2 FIL VLV CLSD |
| | | | N2 FILL | | | | | |
| 225 | ST | sw | PRI | | | | | |
| | | | OPEN | Opens primary N2 fill solenoid valve | O2/N2 GAS FILL PRI (pnl 200) | | | Provides N2 gas for AM/MDA/OWS pressurization |
| | | | CLOSE | Closes the above | | | | |
| | | | CMD | Enables DCS control of the above | | | 43520<br>47520 | PRI N2 FIL VLV OPN<br>PRI N2 FIL VLV CLSD |
| 225 | ST | sw | SEC | | | | | |
| | | | OPEN | Opens secondary N2 fill solenoid valve | O2/N2 GAS FILL SEC (pnl 200) | | | Redundant valve in parallel |
| | | | CLOSE | Closes the above | | | | |
| | | | CMD | Enables DCS control of tthe above | | | 41160<br>45160 | SEC N2 FIL VLV OPN<br>SEC N2 FIL VLV CLSD |
| 225 | ST | vlv | CALIBRATE | | | | | |
| | | | OPEN | Controls flow of gas from O2,N2 gas fill line to PPO2 calibration outlets | | | | Counterclockwise rotation opens valves |
| | | | CLOSE | Closes the above | | | | Clockwise rotation closes valve |
| | | | CABIN PRESS REG | | | | | |
| 225 | ST | vlv | A OPEN | Opens a path from the O2/N2 gas supply to 5 psia cabin pressure regulator A | | | | Toggle valve<br>Cabin pressure regulator supplies controlled mixture of O2N2 gas to the cabin |
| | | | CLOSE | Closes the above | | | | |
| 225 | ST | vlv | B OPEN | Opens a path from the O2/N2 gas supply to 5 psia cabin pressure regulator B | | | | Toggle valve |
| | | | CLOSE | Closes the above | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 225 | ST | vlv/sel | [PRI/OFF/SEC] | | | | | |
| | | | PRI | Opens a path from the 150 psi N2 supply line to the primary N2 solenoid valve and connects the #1, 2, 3 N2 solenoid valve controllers with the primary N2 solenoid valve | | | | N2 solenoid valves are controlled by one of the partial pressure 02 controller circuits |
| | | | OFF | Closes the paths between the N2 supply line and the primary and secondary solenoid valves and disconnects the circuit between the #1, 2,3 N2 solenoid valve controllers via the primary and secondary solenoid valves | | | | |
| | | | SEC | Opens a path from the 150 PSI N2 supply line to the secondary N2 solenoid valve and connects the #1, 2, 3 N2 solenoid valve controllers with the SEC N2 solenoid valve | | | | |
| | | | PRESSURE | | | | | |
| 225 | ST | ind | OWS (PSI) | Indicates OWS cabin pressure | DISP CONV INPUT PRI (pnl 200) | AM BUS 1 | | Range 0 to 8 psi |
| 225 | ST | ind | FWD (PSI) | Indicates AM forward compartment cabin pressure | DISP CONV OUTPUT +5V (pnl 200) | INST BUS A OR B OR DISP CONV | | Range 0 to 8 psi |
| 225 | ST | ind | LOCK (PSI) | Indicates AM lock compartment cabin pressure | DISP CONV OUTPUT +5V (pnl 200) | INST BUS A OR B OR DISP CONV | | Range 0 to 8 psi |
| 225 | ST | ind | AFT (PSI) | Indicates AM aft compartment cabin pressure | DISP CONV OUTPUT +5V (pnl 200) | INST BUS A OR B OR DISP CONV | | Range 0 to 8 psi |

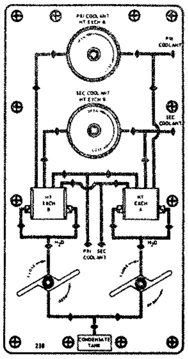
| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | 02/N2 CONTROLLER | | | | | |
| | | | PP02 (PSI) | | | | | |
| 225 | ST | ind | 1 | Indicates the partial pressure of 02 sensed by the #1 PP02 sensor | 02/N2 GAS CONTRS 1 3 (pnl 200) | AM BUS 1 | | Range 0 to 6 psi |
| 225 | ST | ind | 2 | Indicates the partial pressure of 02 sensed by the #2 PP02 sensor | 02/N2 GAS CONTRS 2 (pnl 200) | AM BUS 2 | | Range 0 to 6 psi |
| 225 | ST | ind | 3 | Indicates the partial pressure of 02 sensed by the #3 PP02 sensor | 02/N2 GAS CONTRS 1 3 (pnl 200) | AM BUS 1 | | Range 0 to 6 psi |
| 225 | ST | sel | OFF | Deadfaces the 02N2 controller selector | | | | |
| | | | 1 | Selects the #1 02/N2 controller circuit | 02/N2 GAS CONTRS 1 3 (pnl 200) | AM BUS 1 | | A controller circuit consists of a PP02 sensor, an amplifier and a N2 solenoid valve controller |
| | | | 2 | Selects the #2 02/N2 controller circuit | 02/N2 GAS CONTRS 2 (pnl 200) | AM BUS 2 | | |
| | | | 3 | Selects the #3 02/N2 controller circuit | 02/N2 GAS CONTRS 1 3 (pnl 200) | AM BUS 1 | | |
| 225 | ST | sel | MONITOR | | | | | |
| | | | OFF | Deadfaces 02N2 controller monitor selector | | | | |
| | | | 1 | Selects #1 02/N2 monitor circuit | 02/N2 GAS CONTRS 1 3 (pnl 200) | AM BUS 1 | | A monitor circuit consists of a PP02 sensor and amplifier |
| | | | 2 | Selects #2 02/N2 monitor circuit | 02/N2 GAS CONTRS 2 (pnl 200) | AM BUS 2 | | |
| | | | 3 | Selects #3 02/N2 monitor circuit | 02/N2 GAS CONTRS 1 3 (pnl 200) | AM BUS 1 | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | OWS FILL | | | | | |
| 225 | ST | sw | PRI | | | | | |
| | | | OPEN | Opens the OWS primary fill solenoid valve | 02/N2 GAS FILL PRI (pnl 200) | AM BUS 1 | | |
| | | | CLOSE | Closes the above | | | | |
| | | | CMD | Enables DCS control of the OWS primary fill solenoid valve | | | 41620<br>45620 | DCS control is thru a pressure switch<br>PRI OWS FIL VLV OPN<br>PRI OWS FIL VLV CLSD |
| 225 | ST | sw | SEC | | | | | |
| | | | OPEN | Opens OWS secondary fill solenoid valve | 02/N2 GAS FILL SEC (pnl 200) | AM BUS 2 | | |
| | | | CLOSE | Closes the above | | | | |
| | | | CMD | Enables DCS control of the OWS secondary fill solenoid valve | | | 42204<br>46204 | DCS control is thru a pressure switch<br>SEC OWS FIL VLV OPN<br>SEC OWS FIL VLV CLSD |
| | | | AM FILL | | | | | |
| 225 | ST | sw | PRI | | | | | |
| | | | OPEN | Opens the AM primary fill solenoid valve | 02/N2 GAS FILL PRI (pnl 200) | AM BUS 1 | | |
| | | | CLOSE | Closes the above | | | | |
| | | | CMD | Enables DCS control of the AM primary fill solenoid valve | | | 41320<br>45320 | DCS control is thru a pressure switch<br>PRI AM FIL VLV OPN<br>PRI AM FIL VLV CLSD |
| 225 | ST | sw | SEC | | | | | |
| | | | OPEN | Opens the AM secondary fill solenoid | 02/N2 GAS FILL SEC (pnl 200) | AM BUS 2 | | |
| | | | CLOSE | Closes the above | | | | |
| | | | CMD | Enables DCS control of the AM secondary fill solenoid valve | | | 42160<br>46160 | DCS control is thru a pressure switch<br>SEC AM FIL VLV OPN<br>SEC AM FIL VLV CLSD |

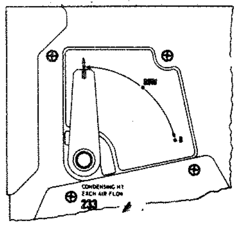
P18



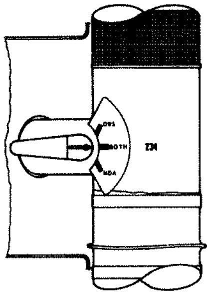

226,228



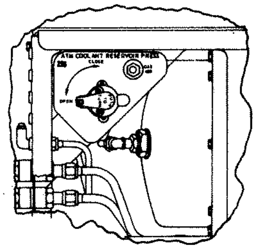

230



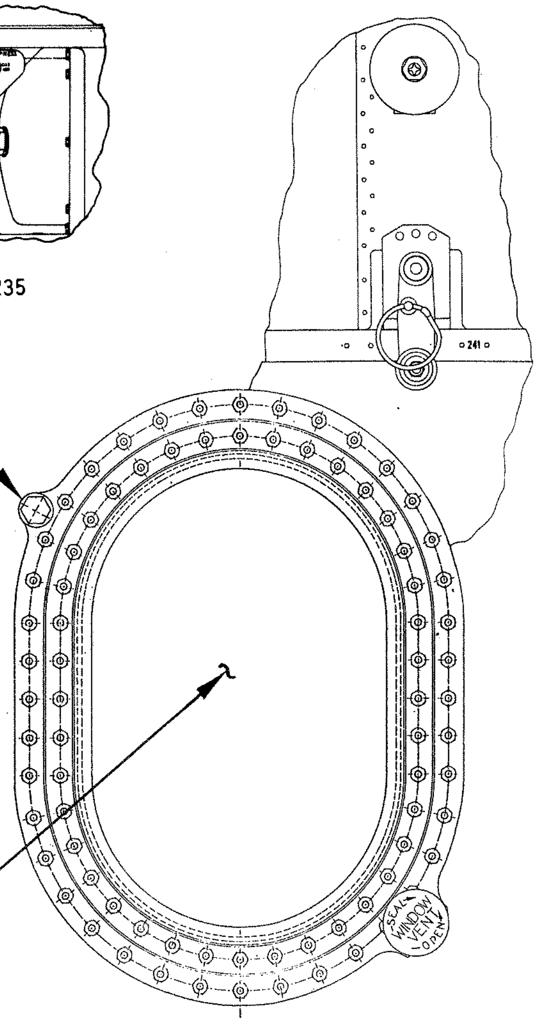
233




234




235




241

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 226 | ST | vlv | V1 | | | | | |
| | | | A | Connects together:<br>a) The desorb side of bed 1 pneumatic actuator<br>b) The outlet of solenoid valve S1<br>c) Interconnect valve V2 | | | | Enables solenoid valve S1 to position bed 1 to desorb and provide pressure to selector valve V2 |
| | | | B | Connects together:<br>a) The desorb side of bed 1 pneumatic actuator<br>b) Interconnect valve V2 | | | | Enables solenoid valve S2 to position bed 1 to desorb |
| | | | C | Connects together:<br>a) The desorb side of bed 1 pneumatic actuator<br>b) The outlet of solenoid valve S1 | | | | Enables solenoid valve S1 to position bed 1 to desorb |
| 226 | ST | vlv | V2 | | | | | |
| | | | A | Connects together:<br>a) The adsorb side of bed 2 pneumatic actuator<br>b) Interconnect valve V1 | | | | Enables solenoid valve S1 to position bed 2 to adsorb |
| | | | B | Connects together:<br>a) The adsorb side of bed 2 pneumatic actuator<br>b) The outlet solenoid valve S2<br>c) Interconnect valve V1 | | | | Enables solenoid valve S2 to position bed 2 to adsorb and provide pressure to selector valve V1 |
| | | | C | Connects together:<br>a) The adsorb side of bed 2 pneumatic actuator<br>b) The outlet of solenoid | | | | Enables solenoid valve S2 to position bed 2 to adsorb |
| 226 | ST | vlv | V3 | | | | | |
| | | | A | Connects together:<br>a) The desorb side of bed 2 penumatic actuator<br>b) Interconnect valve V4 | | | | Enables solenoid valve S4 to position bed 2 to desorb |
| | | | B | Connects together:<br>a) The desorb side of bed 2 penumatic actuator<br>b) The outlet of solenoid valve S3<br>c) Interconnect valve V4 | | | | Enables solenoid valve S3 to position bed 2 to desorb and provide pressure to selector valve V4 |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | V3 (cont'd) | | | | | |
| | | | C | Connects together:<br>a) The desorb side of bed 2 pneumatic actuator<br>b) The outlet of solenoid valve S3 | | | | Enables solenoid valve S3 to position bed 2 to desorb |
| 226 | ST | vlv | V4 | | | | | |
| | | | A | Connects together:<br>a) The adsorb side of bed 1 pneumatic actuator<br>b) The outlet of solenoid valve S4<br>c) Interconnect valve V3 | | | | Enables solenoid valve S4 to position bed 1 to adsorb and provide pressure to selector valve V3 |
| | | | B | Connects together:<br>a) The adsorb side of bed 1 pneumatic actuator<br>b) Interconnect valve V3 | | | | Enables solenoid valve S3 to position bed 1 to adsorb |
| | | | C | Connects together:<br>a) The adsorb side of bed 1 pneumatic actuator<br>b) The outlet of solenoid valve S4 | | | | Enables solenoid valve S4 to position bed 1 to adsorb |
| | | | SOLENOID SWITCHES | | | | | |
| 226 | ST | sw | S4 | | | | | |
| | | | AUTO | Enables control of solenoid valve S4 by mol sieve A cycle timers | MOL SV A TMRS PRI & SEC (pnl 200) | AM BUS 1&2 | | |
| | | | OFF | Deadfaces solenoid valve, no power, closes valve | | | | |
| | | | MANUAL | Powers solenoid valve, open valve | MOL SV A TMRS SEC (pnl 200) | AM BUS 2 | | |
| 226 | ST | sw | S1 | | | | | |
| | | | AUTO | Enables control of solenoid valve S1 by mol sieve A cycle timers | MOL SV A TMRS PRI & SEC (pnl 200) | AM BUS 1&2 | | |
| | | | OFF | Deadfaces solenoid valve, no power, closes valve | | | | |
| | | | MANUAL | Powers solenoid valve, opens valve | MOL SV A TMRS SEC (pnl 200) | AM BUS 2 | | |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | SOLENOID SWITCHES (cont'd) | | | | | |
| 226 | ST | sw | S2 | | | | | |
| | | | AUTO | Enables control of solenoid valve S2 by mol sieve A cycle timers | MOL SV A TMRS PRI & SEC (pnl 200) | AM BUS 1&2 | | |
| | | | OFF | Deadfaces solenoid valve, no power, closes valve | | | | |
| | | | MANUAL | Powers solenoid valve, opens valve | MOL SV A TMRS SEC (pnl 200) | AM BUS 1 | | |
| 226 | ST | sw | S3 | | | | | |
| | | | AUTO | Enables control of solenoid valve S3 by mol sieve A cycle timers | MOL SV A TMRS PRI & SEC (pnl 200) | AM BUS 1&2 | | |
| | | | OFF | Deadfaces solenoid valve, no power, closes valve | | | | |
| | | | MANUAL | Powers solenoid valve, opens valve | MOL SV A TMRS SEC (pnl 200) | AM BUS 1 | | |
| 227 | ST | vlv | V1 A | Connects together: a) The desorb side of bed 1 pneumatic actuator b) The outlet of solenoid valve S1 c) Interconnect valve V2 | | | | Enables solenoid valve S1 to position bed 1 to desorb and provide pressure to selector valve V2 |
| | | | B | Connects together: a) The desorb side of bed 1 pneumatic actuator b) Interconnect valve V2 | | | | Enables solenoid valve S2 to position bed 1 to desorb |
| | | | C | Connects together: a) The desorb side of bed 1 pneumatic actuator b) The outlet of solenoid valve S1 | | | | Enables solenoid valve S1 to position bed 1 to desorb |

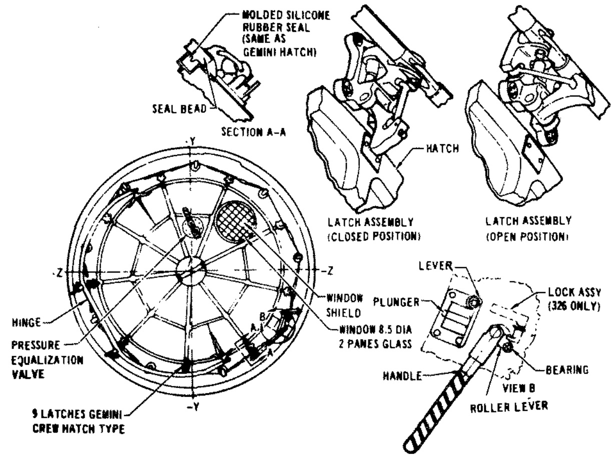
| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 227 | ST | vlv | V2 | | | | | |
| | | | A | Connects together:<br>a) The adsorb side of bed 2 pneumatic<br>b) Interconnect valve V1 | | | | Enables solenoid valve S1 to position bed 2 to adsorb |
| | | | B | Connects together:<br>a) The adsorb side of bed 2 pneumatic actuator<br>b) The outlet of solenoid valve S2<br>c) Interconnect valve V1 | | | | Enables solenoid valve S2 to position bed 2 to adsorb and provide pressure to selector valve V1 |
| | | | C | Connects together:<br>a) The adsorb side of bed 2 pneumatic actuator<br>b) The outlet of solenoid valve S2 | | | | Enables solenoid valve S2 to position bed 2 to adsorb |
| 227 | ST | vlv | V3 A | Connects together:<br>a) The desorb side of bed 2 pneumatic actuator<br>b) Interconnect valve V4 | | | | Enables solenoid valve S4 to position bed 2 to desorb |
| | | | B | Connects together:<br>a) The desorb side of bed 2 pneumatic actuator<br>b) The outlet of solenoid valve S3<br>c) Interconnect valve V4 | | | | Enables solenoid valve S3 to position bed 2 to desorb and provide pressure to selector valve V4 |
| | | | C | Connects together:<br>a) The desorb side of bed 2 pneumatic actuator<br>b) The outlet of solenoid valve S3 | | | | Enables solenoid valve S3 to position bed 2 to desorb |
| 227 | ST | vlv | V4 A | Connects together:<br>a) The adsorb side of bed 1 pneumatic actuation<br>b) The outlet of solenoid valve S4<br>c) Interconnect valve V3 | | | | Enables solenoid valve S4 to position bed 1 to adsorb and provide pressure to selector valve V3 |
| | | | B | Connects together:<br>a) The adsorb side of bed 1 pneumatic actuator<br>b) Interconnect valve V3 | | | | Enables solenoid valve S3 to position bed 1 to adsorb |
| | | | C | Connects together:<br>a) The adsorb side of bed 1 pneumatic actuator<br>b) The outlet of solenoid solenoid valve S4 | | | | Enables solenoid valve S4 to position bed 1 to adsorb |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | SOLENOID SWITCHES | | | | | |
| 227 | ST | sw | S4 | | | | | |
| | | | AUTO | Enables control of solenoid valve S4 by mol sieve B cycle timers | MOL SV B TMRS PRI & SEC (pnl 200) | AM BUS 1&2 | | |
| | | | OFF | Deadfaces solenoid valve, no power, closes valve | | | | |
| | | | MANUAL | Powers solenoid valve, opens valve | MOL SV B TMRS SEC (pnl 200) | AM BUS 2 | | |
| 227 | ST | sw | S1 | | | | | |
| | | | AUTO | Enables control of solenoid valve S1 by mol sieve B cycle timers | MOL SV B TMRS PRI & SEC (pnl 200) | AM BUS 1&2 | | |
| | | | OFF | Deadfaces solenoid valve, no power, closes valve | | | | |
| | | | MANUAL | Powers solenoid valve, opens valve | MOL SV B TMRS SEC (pnl 200) | AM BUS 2 | | |
| 227 | ST | sw | S2 | | | | | |
| | | | AUTO | Enables control of solenoid valve S2 by mol sieve B cycle timers | MOL SV B TMRS PRI & SEC (pnl 200) | AM BUS 1&2 | | |
| | | | OFF | Deadfaces solenoid valve, no power, closes valve | | | | |
| | | | MANUAL | Powers solenoid valve, opens valve | MOL SV B TMRS SEC (pnl 200) | AM BUS 1 | | |
| 227 | ST | sw | S3 | | | | | |
| | | | AUTO | Enables control of solenoid valve S3 by mol sieve B cycle timers | MOL SV B TMRS PRI & SEC (pnl 200) | AM BUS 1&2 | | |
| | | | OFF | Deadfaces solenoid valve, no power, closes valve | | | | |
| | | | MANUAL | Powers solenoid valve, opens valve | MOL SV B TMRS SEC (pnl 200) | AM BUS 1 | | |

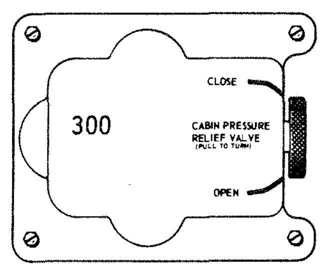
| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | BED 1 | | | | | |
| 228 | ST | ind | ADSORB | Indicates the molecular sieve A gas selector valve 1 is in the adsorb position | | | | The gas selector valve directs cabin gas through bed 1 for H2O and CO2 removal and then back to cabin |
| | | | STORAGE | Indicates the molecular sieve A gas selector valve 1 is in the storage position | | | | The gas selector valve prevents flow from cabin to bed 1. Bed 1 to cabin or bed 1 to vacuum |
| | | | DESORB | Indicates the molecular sieve A gas selector valve 1 is in the desorb position | | | | The gas selector valve directs flow from bed 1 to the vacuum of space |
| 228 | ST | vlv | MANUAL TO ADSORB | Counterclockwise rotation manually sets the molcular sieve A gas selector valve 1 from the adsorb to storage to desorb positions | | | | Clockwise rotation will set valve from the desorb to storage to adsorb position |
| | | | BED 2 | | | | | |
| 228 | ST | ind | ADSORB | Indicates the molecular sieve A gas selector valve 2 is in the adsorb position | | | | The gas selector valve directs cabin gas through bed 2 for H2O and CO2 removal and then back to cabin |
| | | | STORAGE | Indicates the molecular sieve A gas selector valve 2 is in the storage position | | | | The gas selector valve prevents flow from cabin to bed 2, bed 2 to cabin or bed 2 to vacuum |
| | | | DESORB | Indicates the molecular sieve A gas selector valve 2 is in the desorb position | | | | The gas selector valves directs flow from bed 2 to the vacuum of space |
| 228 | ST | vlv | MANUAL TO ADSORB | Counterclockwise rotation manually sets the molecular sieve A gas selector valve 2 from the adsorb to storage to desorb positions | | | | Clockwise rotation will set the valve from the desorb to storage to adsorb position |
| 229 | ST | | | -------------SEE PANEL 228------------- | | | | Same as panel 228 only for mol sv B |
| 230 | ST | vlv | PRI COOLANT HT EXCH B | Controls coolant flow from the primary coolant loop through the molecular sieve A condensing heat exchanger B | | | | Counterclockwise rotation opens the valve<br>Clockwise rotation closes the valve |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 230 | ST | vlv | SEC COOLANT HT EXCH B | Controls coolant flow from the secondary coolant loop through the molecular sieve A condensing heat exchanger B | | | | Counterclockwise rotation opens the valve<br>Clockwise rotation closes the valve |
| 230 | ST | vlv | HT EXCH B H20 | Controls H20 flow from molecular sieve A condensing heat exchanger B to condensate tank | | | | Clockwise rotation closes the valve<br>Counterclockwise rotation opens the valve |
| 230 | ST | vlv | HT EXCH A H20 | Controls H20 flow from molecular sieve A condensing heat exchanger A to condensate tank | | | | Clockwise rotation closes the valve<br>Counterclockwise rotation opens the valve |
| 232 | ST | | | -------------SEE PANEL 230------------- | | | | Same as panel 230 only for Mol Sv B |
| 233 | ST | vlv | CONDENSING HT EXCH AIR FLOW | | | | | |
| | | | A | Connects condensing heat exchanger A outlet air flow to molecular sieve A inlet | | | | Typical for panel 239 |
| | | | BOTH | Connects condensing heat exchanger A&B outlet air flow to molecular sieve A inlet | | | | |
| | | | B | Connects condensing heat exchanger B outlet air flow to molecular sieve A inlet | | | | |
| 234 | ST | vlv | [OWS/BOTH/MDA] | | | | | |
| | | | OWS | Connects molecular sieve A & B gas outlets to the OWS gas distribution system | | | | |
| | | | BOTH | Connects molecular sieve A & B gas outlets to the OWS/MDA gas distribution systems | | | | |
| | | | MDA | Connects molecular sieve A & B gas outlets to the MDA gas distribution system | | | | |
| 235 | ST | vlv | ATM COOLANT RESERVOIR PRESS | | | | | |
| | | | OPEN | Opens a path from the 5 PSIA N2 gas regulator to the gas side of ATM H20 reservoir | | | | Push to turn valve |
| | | | CLOSE | Closes the above | | | | |

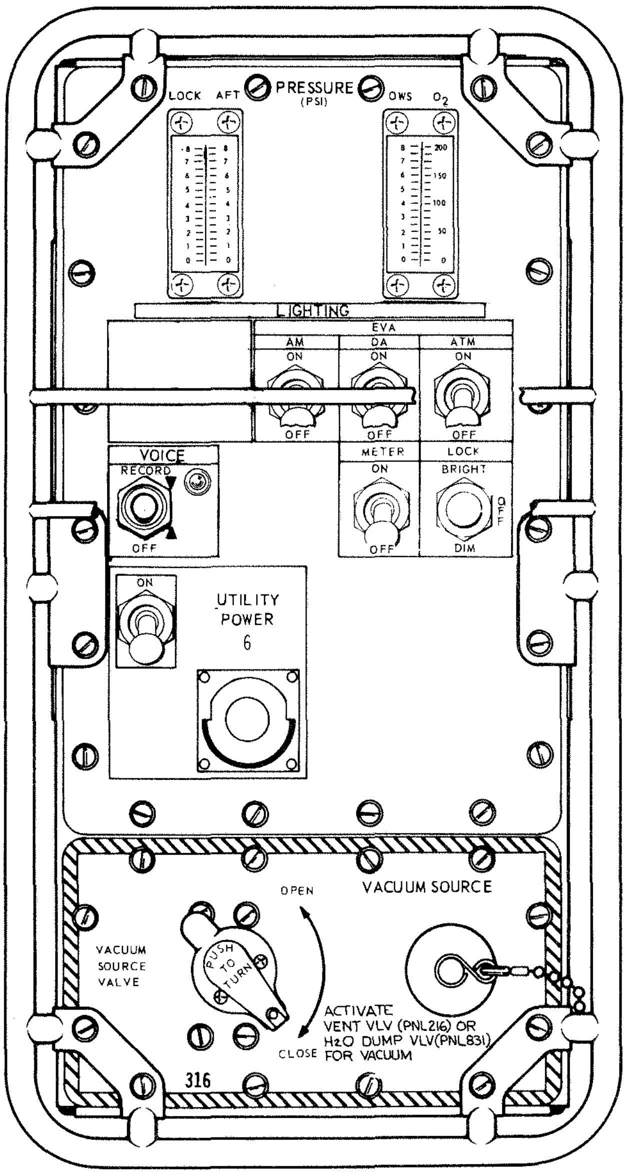
| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 236 | ST | | FIRE SENSOR CONTROL | ---------------- See Panel 120 ----------- | | | | |
| 237 | ST | | FIRE SENSOR CONTROL | ---------------- See Panel 120 ----------- | | | | |
| 238 | ST | | FIRE SENSOR CONTROL | ---------------- See Panel 120 ----------- | | | | |
| 239 | ST | vlv | CONDENSING HT EXCH AIR FLOW | ---------------- See Panel 233 ----------- | | | | Same as panel 233 only for Mol Sv B |
| | | | STS +Z WINDOW | | | | | |
| 241 | ST | hndl | WINDOW CRANK | | | | | |
| | | | (cw) | Full cw closes the +Z STS window cover | | | | Typical for panels 242 (+Y), 243 (-Z), and 244 (-Y) |
| | | | (ccw) | Full ccw opens the +Z STS window cover | | | | Handle rotates 2 1/4 turns to full open |
| 241 | ST | knob | WINDOW VENT | | | | | |
| | | | OPEN | Vents the space between the STS window panes during the activation | | | | Rotate knob 2 turns counterclockwise to open. This valve is provided to release vapor trapped between the two panes of the window during launch |
| | | | SEAL | Seals the volume between the two STS window panes | | | | Rotate knob 2 turns clockwise to seal (This space left permanently sealed after activation) |
| 242 | ST | | STS +Y WINDOW | ---------------- See Panel 241 ----------- | | | | |
| 243 | ST | | STS -Z WINDOW | ---------------- See Panel 241 ----------- | | | | |
| 244 | ST | | STS -Y WINDOW | ---------------- See Panel 241 ----------- | | | | |



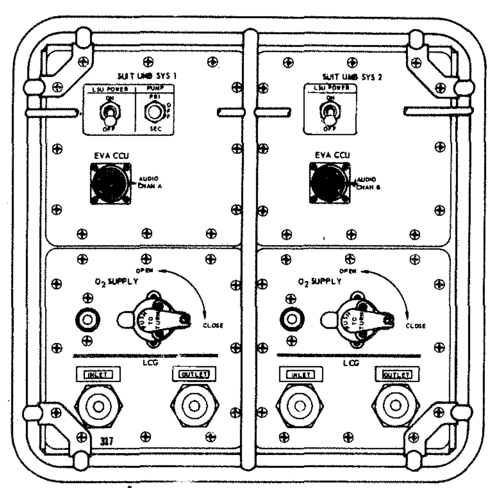

311, 312




300




316




317

| LOCATION | | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| PNL | STA# | | | | | | | |
| 300 | A | vlv | CABIN PRESSURE RELIEF VALVE | | | | | Typical for panels 300 (forward), 313 (lock), 391 (aft) |
| | | | OPEN | Enables the AM forward compartment cabin pressure relief valve to act as a relief valve | | | | $5.5 + 0.5 \atop -0$ psid (cabin to ambient) cracking pressure |
| | | | CLOSE | Inhibits the AM forward compartment relief valve | | | | |
| | | | PRESSURE EQUALIZATION | | | | | Typical for panel 325 (Aft Hatch) |
| 311 | A | vlv | [FWD] | | | | | |
| | | | OPEN | Opens a vent between AM forward compartment and the airlock compartment | | | | |
| | | | CLOSE | Closes the above | | | | |
| 311 | A | cap | [LOCK/UNLOCK] | Provides additional seal when valve is in the closed position | | | | Cap has no stowage location but is secured to panel by chain |
| | | | FORWARD HATCH HANDLE | | | | | Typical for panel 326 (Aft Hatch) |
| 312 | A | vlv | (open) | Allows retraction of latch assemblies which enables hatch to be opened | | | | |
| | | | (close) | Engages latch assemblies which secure hatch to interfacing structure | | | | |
| 313 | A | vlv | CABIN PRESSURE RELIEF VALVE | ------------- See Panel 300 ------------- | | | | This valve is the lock compartment relief valve |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | PRESSURE (PSI) | | | | | |
| 316 | A | ind | LOCK | Displays cabin pressure in AM lock compartment | DISP CONV OUTPUT +5 (pnl 200) | INST BUS A or B or DISP CONV | | Range 0 to 8 psi |
| 316 | A | ind | AFT | Displays cabin pressure in AM aft compartment | DISP CONV OUTPUT +5 (pnl 200) | INST BUS A or B or DISP CONV | | Range 0 to 8 psi |
| 316 | A | ind | OWS | Displays cabin pressure in OWS | DISP CONV INPUT PRI (pnl 200) | AM BUS 1 | | Range 0 to 8 psi |
| 316 | A | ind | O2 | Displays the O2 120 psi regulator output pressure | DISP CONV OUTPUT +5 (pnl 200) | INST BUS A or B or DISP CONV | | Range 0 to 200 psi |
| | | | LIGHTING | | | | | |
| | | | EVA | | | | | |
| 316 | A | sw | AM | | | | | |
| | | | ON | Turns on all (5) AM EVA lights | EVA LTS 1&2 (pnl 202) | AM BUS 1&2 | | |
| | | | OFF | Turns off above | | | | |
| 316 | A | sw | DA | | | | | |
| | | | ON | Turns on all (8) DA EVA lights | EVA LTS 1&2 (pnl 202) | AM BUS 1&2 | | |
| | | | OFF | Turns off above | | | | |
| 316 | A | sw | ATM | | | | | |
| | | | ON | Enables DCS control of all 12 ATM EVA lights | EVA LTS 1 (pnl 202) | AM BUS 1 | | |
| | | | OFF | Disables DCS control of ATM EVA lights | | | | |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 316 | A | sw | METER | | | | | |
| | | | ON | Turns on (4) meter lights LOCK/AFT and OWS/O2 on panel 316 | AM INSTR PNL LTS METER (pnl 202) | AM BUS 1 | | Each meter contains two lights |
| | | | OFF | Turns off above | | | | |
| 316 | A | sw | LOCK | | | | | |
| | | | BRIGHT | Turns on all (4) lock compartment lights | COMPT LTS AM 1&2 (pnl 202) | AM BUS 1&2 | | |
| | | | OFF | Turns off all (4) lock compartment lights | | | | |
| | | | DIM | Turns on (2) lock compartment lights and leaves (2) off | | | | |
| 316 | A | sw | VOICE | | | | | |
| | | | RECORD | Initiates voice and DATA recording on the DATA recorder, also enables EXP 1 and 2 recorders to record voice if they are in the record mode | AUDIO SYS INTERCOM A, B (pnl 200) | AM BUS 1&2 | | Selected channel must correspond with INST SYS RCDR AUDIO switch for proper recording |
| | | | (ctr) | Normal position of switch | AUDIO SYS INTERCOM A, B (pnl 200) | AM BUS 1&2 | | Switch is momentary and returns to center position |
| | | | OFF | Disables voice recording | | | | |
| 316 | A | lt | | Illuminates when voice recording is initiated and the DATA recorder is recording | VOICE RCDR LTS (pnl 200) | AM BUS 1 | | NOTE: If light extinguishes (typically due to ground initiated recorder dump) while recording on EXP 1 or 2 recorders, voice will be recorded on these recorders |
| | | | UTILITY POWER | | | | | |
| 316 | A | sw | ON | Turns lock tunnel utility power #6 on | UTIL PWR ATM 2•4•6 (pnl 202) | AM BUS 2 | | |
| | | | OFF | Turns above off | | | | |
| 316 | A | conn | 6 | Zero-G receptacle, provides electrical power interface with portable equipment plug | | | | |
| 316 | A | vlv | VACUUM SOURCE VALVE | | | | | |
| | | | OPEN | Opens a path from vacuum source connector to the condensate tank overboard dump line | | | | |
| | | | CLOSE | Closes the above | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | VACUUM SOURCE | | | | | |
| 316 | A | conn | | Quick disconnect connector, provides interface with condensate tank overboard dump line | | | | |
| 316 | A | cap | | Covers the vacuum quick disconnect when the vacuum is not in use | | | | |
| | | | SUIT UMB SYS 1 | | | | | |
| 317 | A | sw | LSU POWER | | | | | |
| | | | ON | Activates suit umbilical system 1 | SUS 1 EVA CCU 1&2 (pnl 202) | AM BUS 1&2 | | Provides power to the EVA CCU AUDIO CHAN A connector |
| | | | OFF | Deactivates the above | | | | |
| 317 | A | sw | PUMP | | | | | |
| | | | PRI | Turns umbilical system 1 primary suit coolant pump on | SUS 1 LCG PUMPS PRI (pnl 202) | AM BUS 1 | | |
| | | | OFF | Turns umbilical system 1 suit coolant pumps off | | | | |
| | | | SEC | Turns umbilical system 1 secondary suit coolant pump on | SUS 1 LCG PUMPS SEC (pnl 202) | AM BUS 2 | | |
| | | | EVA CCU | | | | | |
| 317 | A | conn | AUDIO CHAN A | Provides the connector interface for the ALSA EVA communications, and biomed | | | | OBS channel A |
| | | | 02 SUPPLY | | | | | |
| 317 | A | conn | | Provides the connect interface for the #1 suit 02 umbilical and the 120 psi 02 regulator supply | | | | |
| 317 | A | vlv | | | | | | |
| | | | OPEN | Opens a path between the 120 psi 02 regulator output to the suit umbilical system 1 02 supply Q. D. | | | | Push to turn |
| | | | CLOSE | Closes the above | | | | |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 317 | A | conn | LCG INLET | Provides an interface connect point for the #1 umbilical suit inlet 1 and the suit cooling system #1 outlet | | | | |
| 317 | A | conn | LCG OUTLET | Provides an interface connect point for the #1 umbilical suit outlet and the suit cooling system #1 inlet | | | | |
| | | | SUIT UMB SYS 2 | | | | | |
| 317 | A | sw | LSU POWER | | | | | |
| | | | ON | Activates suit umbilical system 2 | SUS 2 EVA CCU 1&2 (pnl 202) | AM BUS 1&2 | | Provides power to the EVA CCU AUDIO CHAN B connector |
| | | | OFF | Deactivates the above | | | | |
| | | | EVA CCU | | | | | |
| 317 | A | conn | AUDIO CHAN B | Provides the connector interface for the ALSA, EVA communication, and biomed | | | | OBS channel A |
| | | | 02 SUPPLY | | | | | |
| 317 | A | conn | | Provides the connect interface for the #1 suit 02 umbilical and the 120 psi 02 regulator supply | | | | |
| 317 | A | vlv | | | | | | |
| | | | OPEN | Opens a path between the 120 psi 02 regulator output and the suit umbilical system 1 02 supply Q. D. | | | | |
| | | | CLOSE | Closes the above | | | | |
| 317 | A | conn | LCG INLET | Provides an interface connect point for the #1 umbilical suit inlet and the suit cooling system #2 outlet | | | | |
| 317 | A | conn | LCG OUTLET | Provides an interface connect point for the #1 umbilical suit outlet and the suit cooling system #2 inlet | | | | |

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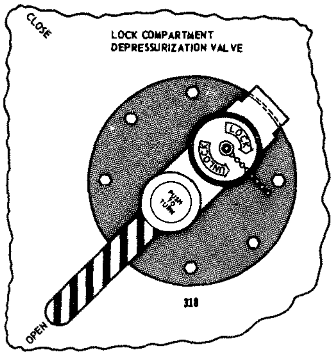
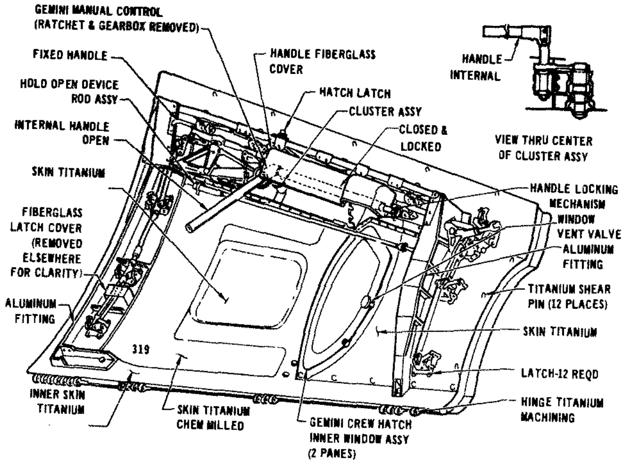
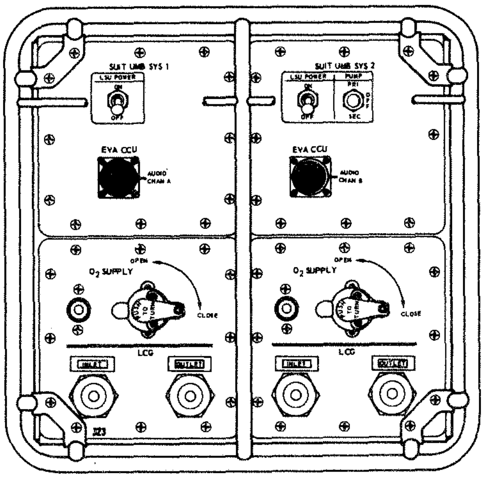


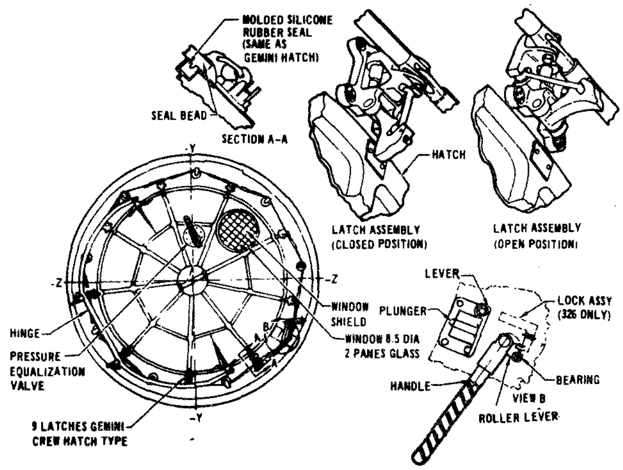

318



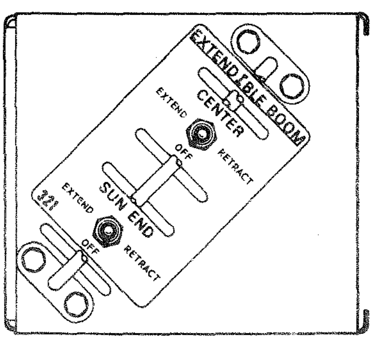

319



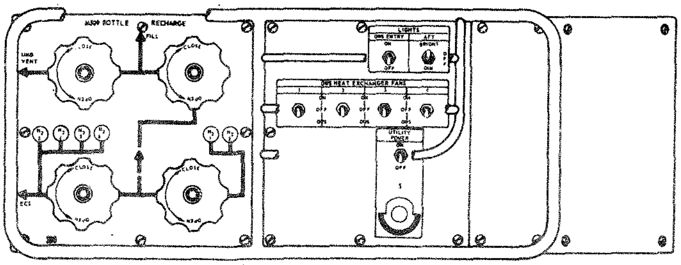

323




325, 326 SHOWN (AFT)




321




390

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | LOCK COMPARTMENT DEPRESSURIZATION VALVE | | | | | |
| 318 | A | vlv | OPEN | Opens a vent between AM lock compartment and vacuum for depressurization | | | | |
| | | | CLOSE | Closes the above | | | | |
| 318 | A | cap | [LOCK/UNLOCK] | Provide additional seal when value is in closed position | | | | Cap has no stowage location but is secured to panel by chain |
| | | | EVA HATCH | | | | | |
| 319 | A | hndl | [Internal Handle] | | | | | |
| | | | OPEN | Allows retraction of latch assemblies which enables hatch to be opened | | | | |
| | | | CLOSE | Engages latch assemblies which secure hatch to interfacing structure | | | | |
| 319 | A | knob | WINDOW VENT | | | | | |
| | | | OPEN | Vents the space between the EVA hatch window panes during activation | | | | Rotate knob 2 turns counterclockwise to open |
| | | | SEAL | Seals the volume between the two EVA hatch window panes | | | | Rotate knob 2 turns clockwise to seal (this space left permanently sealed after activation) |
| | | | TELEVISION STATION | | | | | |
| 320 | A | sw | TELEVISION POWER | | | | | |
| | | | ON | Powers television camera | TV PWR AM (pnl 202) | AM BUS 1 | | See figure for panel 133 |
| | | | OFF | Deactivates the above | | | | |
| 320 | A | pot | GAIN | Rotary trim potentiometer that allows adjustment of video signal gain from camera | | | | Potentiometer provided with screwdriver slot. Rotate clockwise to increase amplification |
| 320 | A | conn | CAMERA (connector) | Zero-G connector for portable TV camera | | | | Power to and signal from the camera |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | EXTENDIBLE BOOM | | | | | |
| 321 | A | sw | CENTER | | | | | |
| | | | EXTEND | Provides power to extend the center extendible boom thru the limit switch | EXTENDIBLE BOOM 1,2 (pnl 202) | AM BUS 1,2 | | |
| | | | OFF | Deadfaces the center extendible boom sw | | | | |
| | | | RETRACT | Provides power to retract the center extendible boom thru the limit switch | EXTENDIBLE BOOM 1,2 (pnl (202) | AM BUS 1,2 | | |
| 321 | A | sw | SUN END | | | | | |
| | | | EXTEND | Provides power to extend the sun end extendible boom | EXTENDIBLE BOOM 2,1 (pnl 202) | AM BUS 2,1 | | |
| | | | OFF | Deadfaces the sun end extendible boom sw | | | | |
| | | | RETRACT | Provides power to retract the sun end extendible boom | EXTENDIBLE BOOM 2.1 (pnl 202) | AM BUS 2,1 | | |
| | | | SUIT UMB SYS 1 | | | | | |
| 323 | A | sw | LSU POWER | | | | | |
| | | | ON | Activates suit umbilical system 1 | SUS 1 EVA CCU 1&2 (pnl 202) | AM BUS 1&2 | | Provides power to the EVA CCU AUDIO CHAN A connector |
| | | | OFF | Deactivates the above | | | | |
| | | | EVA CCU | | | | | |
| 323 | A | conn | AUDIO CHAN A | Provides the connector interface for the ALSA, EVA communications, and biomed | | | | OBS channel B |

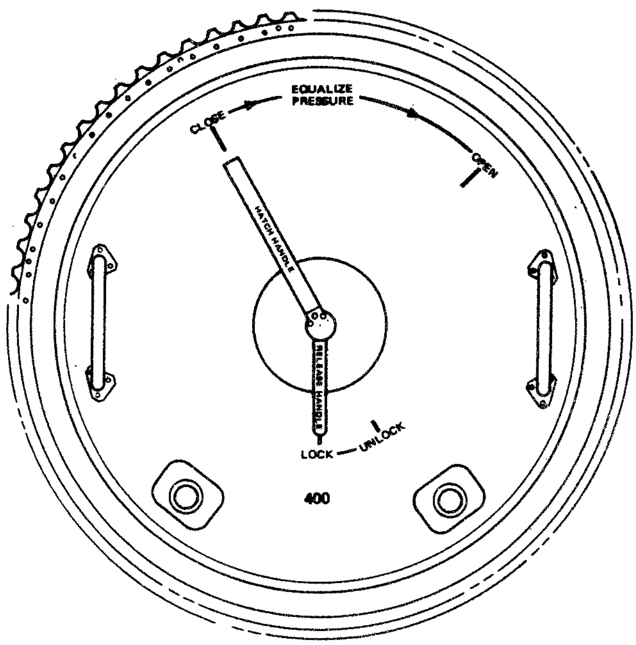
| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | O2 SUPPLY | | | | | |
| 323 | A | conn | | Provides the connect interface for the #2 suit O2 umbilical and the 120 psi O2 regulator supply | | | | |
| 323 | A | vlv | | | | | | |
| | | | OPEN | Opens a path between the 120 psi O2 regulator output and the suit umbilical sys #2 O2 supply Q.D. | | | | |
| | | | CLOSE | Closes the above | | | | |
| 323 | A | conn | LCG INLET | Provides an interface connect point for the #2 umbilical suit inlet and the suit cooling sys #1 outlet | | | | |
| 323 | A | conn | LCG OUTLET | Provides an interface connect point for the #2 umbilical suit outlet and the suit cooling sys #1 inlet | | | | |
| | | | SUIT UMB SYS 2 | | | | | |
| 323 | A | sw | LSU POWER | | | | | |
| | | | ON | Activates suit umbilical system 1 | SUS 2 EVA CCU 1&2 (pnl 202) | AM BUS 1&2 | | Provides power to the EVA CCU AUDIO CHAN B connector |
| | | | OFF | Deactivates the above | | | | |
| 323 | A | sw | PUMP | | | | | |
| | | | PRI | Turns umb sys 2 primary suit coolant pump on | SUS 2 LCG PUMPS PRI (pnl 202) | AM BUS 2 | | |
| | | | OFF | Turns umb sys 2 suit coolant pumps off | | | | |
| | | | SEC | Turns umb sys 2 secondary suit coolant pump on | SUS 2 LCG PUMPS SEC (pnl 202) | AM BUS 1 | | |
| | | | EVA CCU | | | | | |
| 323 | A | conn | AUDIO CHAN B | Provides the connector interface for the ALSA, EVA communications, and biomed | | | | OBS channel B |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | O2 SUPPLY | | | | | |
| 323 | A | conn | | Provides the connector interface for the #2 suit O2 umbilical and the 120 psi O2 regulator supply | | | | |
| 323 | A | vlv | | | | | | |
| | | | OPEN | Opens a path between the 120 psi O2 regulator output and the suit umbilical sys #2 O2 supply Q.D. | | | | |
| | | | CLOSE | Disconnects the above | | | | |
| 323 | A | conn | LCG INLET | Provides an interface connect point for the #2 umbilical suit inlet and the suit cooling sys #2 outlet | | | | |
| 323 | A | conn | LCG OUTLET | Provides an interface connect point for the #2 umbilical suit outlet and the suit cooling sys #2 inlet | | | | |
| 325 | A | vlv | PRESSURE EQUALIZATION | ------------- See Panel 311 ------------- | | | | Aft Hatch |
| 326 | A | hndl | FORWARD HATCH HANDLE | ------------- See Panel 312 ------------- | | | | Aft Hatch |
| | | | M509 BOTTLE RECHARGE | | | | | |
| 390 | A | vlv | UMB VENT OPEN | Controls M509 recharge fill line vent to the AM aft compartment | | | | Counterclockwise rotation opens the valve |
| | | | CLOSE | | | | | Clockwise rotation closes the valve |
| 390 | A | vlv | FILL OPEN | Controls N2 gas supply to recharge the M509 bottle through the recharge station | | | | Counterclockwise rotation opens the valve |
| | | | CLOSE | | | | | Clockwise rotation closes the valve |
| 390 | A | vlv | ECS/N2 3,4,5,6 OPEN | Controls the flow of N2 gas from the N2 3, 4, 5 & 6 bottles to the M509 recharge station | | | | Counterclockwise rotation opens the valve |
| | | | CLOSE | | | | | Clockwise rotation closes the valve |
| 390 | A | vlv | N2 1, N2 2 OPEN | Controls the flow of N2 gas from the N2 1, 2 bottles to the M509 recharge station | | | | Counterclockwise rotation opens the valve |
| | | | CLOSE | | | | | Clockwise rotation closes the valve |

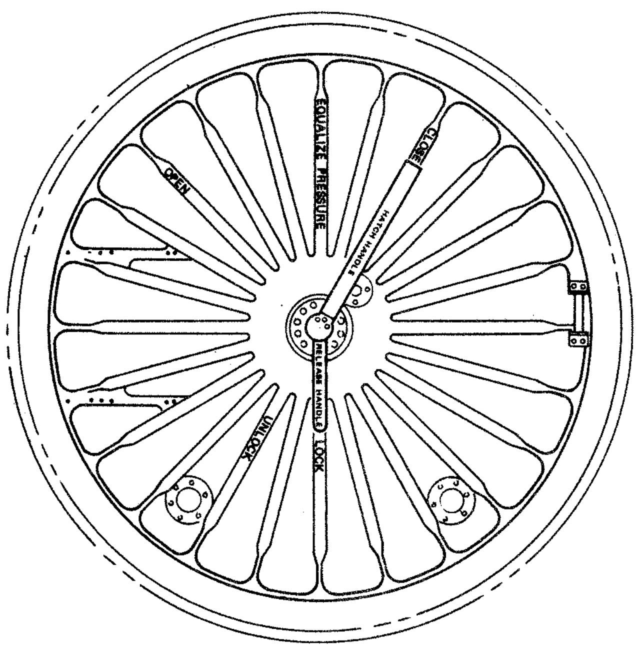
| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | LIGHTS | | | | | |
| 390 | A | sw | OWS ENTRY | | | | | |
| | | | ON | Turns on all OWS entry/emerg lights | EMER LTS OWS 1&2 (pnl 202) | EPS CONTROL BUS 1&2 | | Dome lts 1 & 4<br>Upper wall lts 3 & 8<br>Exp compt lts 6, 7, 13 & 14 |
| | | | OFF | Turns off above | | | | |
| 390 | A | sw | AFT | | | | | |
| | | | BRIGHT | Turns on all six AM aft compartment lights | COMPT LTS AM 1&2 (pnl 202) | AM BUS 1&2 | | |
| | | | OFF | Turns off all six AM aft compartment lights | | | | |
| | | | DIM | Turns on three of six AM aft compt lights | | | | |
| | | | OWS HEAT EXCHANGER FANS | | | | | |
| 390 | A | sw | 1 | | | | | |
| | | | ON | Turns OWS heat exchanger fan #1 on and opens the OWS circulation valve #1 | OWS HT EXCH FANS 1 (pnl 200) | AM BUS 1 | | |
| | | | OFF | Turns the fan off and closes the valve | | | | |
| | | | OWS | Enables manual or auto OWS control of heat exchanger fan #1 and OWS circulation valve #1 | | | | |
| 390 | A | sw | 2 | | | | | |
| | | | ON | Turns OWS heat exchanger fan #2 on and opens the OWS circulation valve #2 | OWS HT EXCH FANS 2 (pnl 200) | AM BUS 2 | | |
| | | | OFF | Turns the fan off and closes the valve | | | | |
| | | | OWS | Enables manual or auto OWS control of heat exchanger fan #2 and OWS circulation valve #2 | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | OWS HEAT EXCHANGER FANS (cont'd) | | | | | |
| 390 | A | sw | 3 | | | | | |
| | | | ON | Turns OWS heat exchanger fan #3 on and opens the OWS circulation valve #3 | OWS HT EXCH FANS 3 (pnl 200) | AM BUS 1 | | |
| | | | OFF | Turns the fan off and closes the valve | | | | |
| | | | OWS | Enables manual or auto OWS control of the fan and valve | | | | |
| 390 | A | sw | 4 | | | | | |
| | | | ON | Turns OWS heat exchanger fan #4 on and opens the OWS circulation valve #4 | OWS HT EXCH FANS 4 (pnl 200) | AM BUS 2 | | |
| | | | OFF | Turns the fan off and closes the valve | | | | |
| | | | OWS | Enables manual or auto OWS control of the fan and valve | | | | |
| | | | UTILITY POWER | | | | | |
| 390 | A | sw | | | | | | |
| | | | ON | Turns aft tunnel utility power #5 on | UTIL PWR AM 1•3•5 (pnl 202) | AM BUS 1 | | |
| | | | OFF | Turns the above off | | | | |
| 390 | A | conn | 5 | Zero-G receptacle, provides electrical power interface with portable equipment plug | | | | |
| 391 | A | vlv | CABIN PRESSURE RELIEF VALVE | ------------- See Panel 300 ------------- | | | | This valve provides pressure relief for the aft compartment |
| 392 | A | | FIRE SENSOR CONTROL | ------------- See Panel 120 ------------- | | | | |

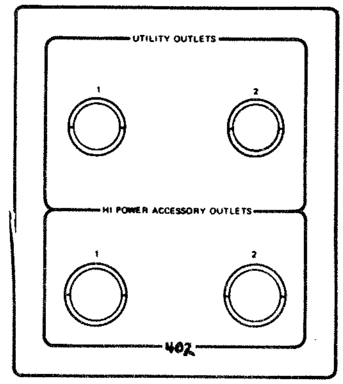
P24



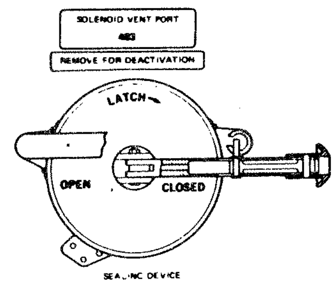

FORWARD SIDE



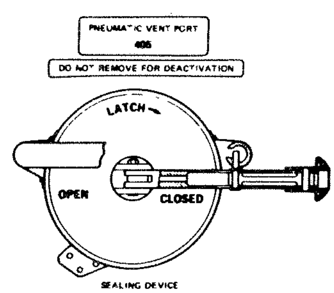

AFT SIDE




402




403

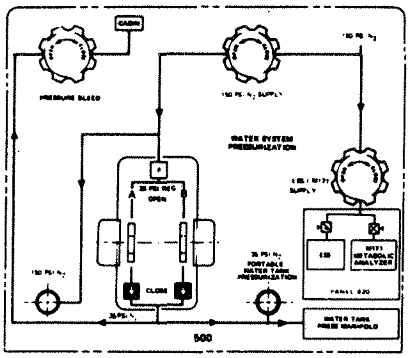



405

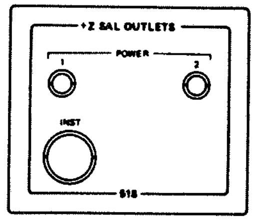
PANEL 400

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | OWS HATCH | | | | | |
| 400 | D | vlv | HATCH HANDLE CLOSE | Latches the OWS hatch | | | | |
| | | | EQUALIZE PRESSURE | Equalizes pressure across the hatch | | | | |
| | | | OPEN | Releases OWS hatch latches | | | | |
| 400 | D | hndl | RELEASE HANDLE LOCK | Secures OWS hatch handle from operating | | | | |
| | | | UNLOCK | Enables OWS hatch handle to be positioned to open | | | | |
| 401 | D | lt | INTERCOM BOX | -------------See Panel 102------------- | | | | |
| | | | UTILITY OUTLETS | | | | | |
| 402 | D | conn | 1 | Zero-G receptacle, provides electrical power interface with portable equipment plug | UTIL OUTLETS DOME 1 (pnl 612) | OWS BUS 1 | | Typical for panels 402,521,531,551 and 803 |
| 402 | D | conn | 2 | Zero-G receptacle, provides electrical power interface with portable equipment plug | UTIL OUTLETS DOME 2 (pnl 612) | OWS BUS 2 | | |
| | | | HI POWER ACCESSORY OUTLETS | | | | | |
| 402 | D | conn | 1 | Zero-G receptacle, provides electrical power interface with portable equipment plug | HI PWR ACC OUTLETS DOME 1 (pnl 612) | OWS BUS 1 | | |
| 402 | D | conn | 2 | Zero-G receptacle, provides electrical power interface with portable equipment plug | HI PWR ACC OUTLETS DOME 2 (pnl 612) | OWS BUS 2 | | |

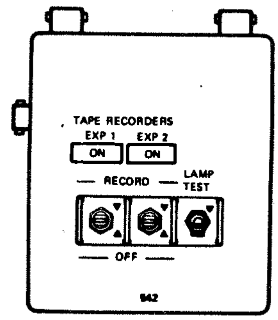
| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | SOLENOID VENT PORT | | | | | |
| 403 | D | vlv | OPEN | Handle position, opens solenoid vent port sealing device | | | | |
| | | | CLOSED | Handle position closes solenoid vent port sealing device | | | | |
| | | | (latch) | Clockwise rotation latches port sealing device (plug) | | | | |
| | | | (unlatch) | Counterclockwise rotation unlatches port sealing device (plug) | | | | |
| | | | TELEVISION STATION | | | | | |
| 404 | D | SW | TELEVISION POWER ON | Power to television camera | TV OUTLETS DOME (pnl 612) | OWS BUS 2 | | See figure for panel 133 |
| | | | OFF | Deactivates the above | | | | |
| 404 | D | pot | GAIN | Rotary trim potentiometer that allows adjustment of video signal gain from camera | | | | Potentiometer provided with screwdriver slot. Rotate clockwise to increase amplification |
| 404 | D | conn | CAMERA (connector) | Zero-G connector for portable TV camera | | | | Power to and signal from the camera |
| | | | PNEUMATIC VENT PORT | | | | | |
| 405 | D | vlv | OPEN | Handle position, opens pneumatic vent port sealing device | | | | |
| | | | CLOSED | Handle position closes pneumatic vent port sealing device | | | | |
| 405 | D | plug | (latch) | Clockwise rotation latches port sealing device | | | | |
| | | | (unlatch) | Counterclockwise rotation latches port sealing device | | | | |



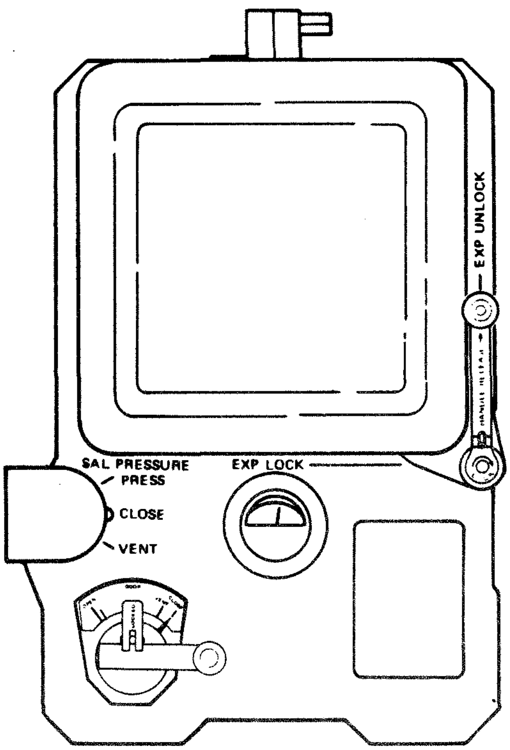

500



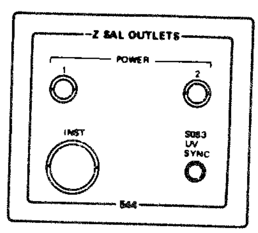

518




542.




517




544

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 500 | F | vlv | PRESSURE BLEED | | | | | |
| | | | OPEN | Controls 35 psi N2 gas bleedoff to cabin from water pressurization system line | | | | Counterclockwise rotation opens valve<br>Clockwise rotation closes valve |
| | | | CLOSE | Closes the above | | | | |
| 500 | F | vlv | 150 PSI N2 SUPPLY | | | | | |
| | | | OPEN | Controls flow of N2 gas from the 150 PSI N2 supply line to the water pressurization system | | | | Counterclockwise rotation opens valve<br>Clockwise rotation closes valve |
| | | | CLOSE | Closes the above | | | | |
| | | | 35 PSI REG | | | | | |
| 500 | F | vlv | A | | | | | |
| | | | OPEN | Opens the path from the 150 PSI N2 feeder supply line to the (A) 35 PSI regulator | | | | Toggle valve |
| | | | CLOSE | Closes the above | | | | |
| 500 | F | vlv | B | | | | | |
| | | | OPEN | Opens the path from the 150 PSI N2 feeder supply line to the (B) 35 PSI regulator | | | | Toggle valve |
| | | | CLOSE | Closes the above | | | | |
| 500 | F | vlv | M171/ESS SUPPLY | | | | | |
| | | | OPEN | Controls 150 PSI N2 supply to the experiment support system and the M171 metabolic analyzer | | | | Counterclockwise rotation opens valve<br>Clockwise rotation closes valve |
| | | | CLOSE | Closes the above | | | | |
| 500 | F | conn | 150 PSI N2 | Provides a connect point interface for 150 PSI N2 gas, quick disconnect connector | | | | |
| 500 | F | conn | 35 PSI N2 PORTABLE WATER TANK PRESSURIZATION | Provides a connect point interface for 35 PSI N2 gas to pressurize the portable water tank | | | | |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | SCIENTIFIC AIRLOCK (+Z) | | | | | |
| 517 | F | conn | VACUUM SOURCE | Quick disconnect connector provides interface point for venting experiment canisters to vacuum | | | | |
| 517 | F | vlv | SAL PRESSURE | | | | | |
| | | | PRESS | Connects SAL to cabin pressure for pressurization | | | | |
| | | | CLOSE | Isolates SAL | | | | |
| | | | VENT | Connects SAL to vacuum for venting | | | | |
| 517 | F | ind | | Indicates the pressure in the SAL experiment lock compartment | | | | Range 0 to 30 psia |
| 517 | F | hndl | HANDLE RELEASE | | | | | |
| | | | EXP UNLOCK | Releases locking dogs so that experiment can be removed from SAL | | | | |
| | | | EXP LOCK | Sets locking dogs to hold experiments into to SAL seal flange | | | | Clockwise rotation locks dogs |
| 517 | F | hndl | DOOR | | | | | |
| | | | OPEN | Opens SAL outer door | | | | |
| | | | VENT | Vents SAL to vacuum by releasing seal at outer door | | | | |
| | | | CLOSE | Closes SAL outer door | | | | |
| | | knob | [LOCKED/UNLOCKED] | | | | | |
| | | | LOCKED | Prevents door crank from being inadvertantly moved | | | | |
| | | | UNLOCKED | Releases door crank | | | | |
| | | | +Z SAL OUTLETS | | | | | |
| | | | POWER | | | | | |
| 518 | F | conn | 1 | Zero-G receptacle provides electrical power interface for a portable equipment plug | EXPS SAL +Z OUTLET 1 (pnl 613) | OWS BUS 1 | | |
| 518 | F | conn | 2 | Zero-G receptacle provides electrical power interface for a portable equipment plug | EXPS SAL +Z OUTLET 2 (pnl 613) | OWS BUS 2 | | |

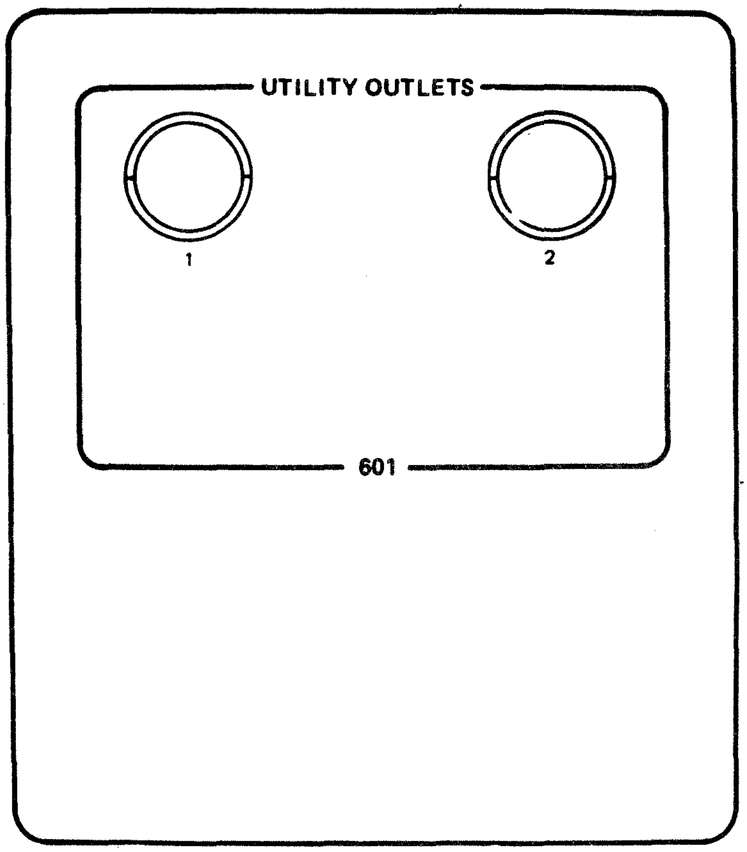
| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 518 | F | conn | INST | Provides interface connect point for input to instrumentation system | | | | |
| 520 | F | | INTERCOM BOX | -------------- See Panel 102 -------------- | | | | |
| | | | UTILITY OUTLETS | | | | | |
| 521 | F | conn | 1 | Zero-G receptacle, provides electrical power interface with portable equipment plug | UTIL OUTLETS UPPER WALL 1 (pnl 612) | OWS BUS 1 | | Typical for panels 402,521,531,551, and 803 |
| 521 | F | conn | 2 | Zero-G receptacle, provides electrical power interface with portable equipment plug | UTIL OUTLETS UPPER WALL 2 (pnl 612) | OWS BUS 2 | | |
| | | | HI POWER ACCESSORY OUTLETS | | | | | |
| 521 | F | conn | 1 | Zero-G receptacle, provides electrical power interface with portable equipment plug | HI PWR ACC OUTLETS UPPER WALL 1 (pnl 612) | OWS BUS 1 | | |
| 521 | F | conn | 2 | Zero-G receptacle, provides electrical power interface with portable equipment plug | HI PWR ACC OUTLETS UPPER WALL 2 (pnl 612) | OWS BUS 2 | | |
| 529 | F | | FIRE SENSOR CONTROL | -------------- See Panel 120 -------------- | | | | |
| 530 | F | | FIRE SENSOR CONTROL | -------------- See Panel 120 -------------- | | | | |
| | | | UTILITY OUTLETS | | | | | |
| 531 | F | conn | 3 | Zero-G receptacle, provides electrical power interface with portable equipment plug | UTIL OUTLETS UPPER WALL 3 (pnl 612) | OWS BUS 1 | | Typical for panels 402,521,531,551 and 803 |
| 531 | F | conn | 4 | Zero-G receptacle, provides electrical power interface with portable equipment plug | UTIL OUTLETS UPPER WALL 4 (pnl 612) | OWS BUS 2 | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | HI POWER ACCESSORY OUTLETS | | | | | |
| 531 | F | conn | 3 | Zero-G receptacle, provides electrical power interface with portable equipment plug | HI PWR ACC OUTLETS UPPER WALL 3 (pnl 612) | OWS BUS 1 | | |
| 531 | F | conn | 4 | Zero-G receptacle, provides electrical power interface with portable equipment plug | HI PWR ACC OUTLETS UPPER WALL 4 (pnl 612) | OWS BUS 2 | | |
| 540 | F | | INTERCOM BOX | ------------- See Panel 102 ------------- | | | | |
| | | | TAPE RECORDERS | | | | | |
| | | | EXP 1 | | | | | |
| 542 | F | lt | ON | Illuminates when the EXP 1 recorder is in motion and EXP 1 recording has been initiated | AM INSTR PNL LTS STATUS (pnl 202) | AM BUS 2 | | Extinguished when the EKG/ZPN sw (pnl 204) is enabled |
| 542 | F | sw | [RECORD/OFF] | | | | | |
| | | | RECORD | Activates EXP 1 recording | DISP PWR/RCDR CONT (pnl 613) | OWS BUS 1&2 | | |
| | | | (ctr) | | | | | Momentary switch which returns to the center position |
| | | | OFF | Turns off EXP 1 recording if originally initiated from the OWS (pnl 542 or 617) | DISP PWR/RCDR CONT (pnl 613) | OWS BUS 1&2 | | |
| | | | EXP 2 | | | | | |
| 542 | F | lt | ON | Illuminates when the EXP 2 recorder is in motion and EXP 2 recording has been initiated | AM INSTR PNL LTS STATUS (pnl 202) | AM BUS 2 | | Extinguished when the EKG/ZPN sw (pnl 204) is enabled or if DCS control of DATA 2 is enabled |

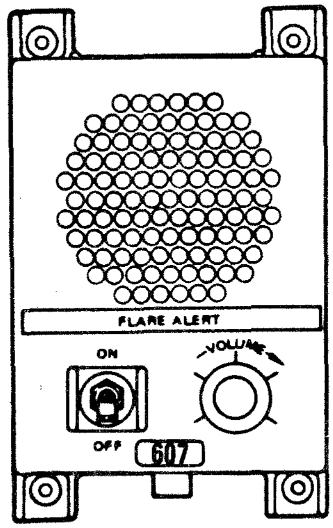
| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 542 | F | sw | [RECORD/OFF] | | | | | |
| | | | RECORD | Activates EXP 2 recording and inhibits DCS control of DATA 2 recording | DISP PWR/RCDR CONT (pnl 613) | OWS BUS 1&2 | | |
| | | | (ctr) | | | | | Momentary switch which returns to the center position |
| | | | OFF | Turns off EXP 2 recording originally initiated from the OWS and enables DCS control of DATA 2 recording | DISP PWR/RCDR CONT (pnl 613) | OWS BUS 1&2 | | |
| 542 | F | sw | LAMP TEST | | | | | |
| | | | LAMP TEST | Illuminates TAPE RECORDERS EXP 1 & 2 ON lights for test purposes | DISP LAMP TEST (pnl 613) | OWS BUS 2 | | Momentary switch which returns to the down position |
| | | | (down) | | | | | |
| 543 | F | | SCIENTIFIC AIRLOCK (-Z) | ------------- See Panel 517 ------------- | | | | |
| | | | -Z SAL OUTLETS | | | | | |
| | | | POWER | | | | | |
| 544 | F | conn | 1 | Zero-G receptacle provides electrical power interface for a portable equipment plug | EXPS SAL -Z OUTLET 1 | OWS BUS 1 | | |
| 544 | F | conn | 2 | Zero-G receptacle provides electrical power interface for a portable equipment plug | EXPS SAL -Z OUTLET 2 | OWS BUS 2 | | |
| 544 | F | conn | INST | Provides interface connect point for input to instrumentation system | | | | |
| 544 | F | conn | S063 UV SYNC | Provides connect point for S063 camera synchronization | | | | |
| | | | UTILITY OUTLETS | | | | | |
| 551 | F | conn | 5 | Zero-G receptacle, provides electrical power interface with portable equipment plug | UTIL OUTLETS UPPER WALL 5 (pnl 612) | OWS BUS 1 | | Typical for panels 402,521,531,551 and 803 |
| 551 | F | conn | 6 | Zero-G receptacle, provides electrical power interface with portable equipment plug | UTIL OUTLETS UPPER WALL 6 (pnl 612) | OWS BUS 2 | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | HI POWER ACCESSORY OUTLETS | | | | | |
| 551 | F | conn | 5 | Zero-G receptacle, provides electrical power interface with portable equipment plug | HI PWR ACC OUTLETS WALL 5 (pnl 612) | OWS BUS 1 | | |
| 551 | F | conn | 6 | Zero-G receptacle, provides electrical power interface with portable equipment plug | HI PWR ACC OUTLETS UPPER WALL 6 (pnl 612) | OWS BUS 2 | | |
| | | | TELEVISION STATION | | | | | |
| 555 | F | sw | TELEVISION POWER | | | | | |
| | | | ON | Power to television camera | TV OUTLETS FWD COMPT (pnl 612) | OWS BUS 1 | | See figure for panel 133 |
| | | | OFF | Deactivates the above | | | | |
| 555 | F | pot | GAIN | Rotary trim potentiometer that allows allows adjustment of video signal gain from camera | | | | Potentiometer provided with screwdriver slot. Rotate clockwise to increase amplification |
| 555 | F | conn | CAMERA (connector) | Zero-G connector for portable TV camera | | | | Power to and signal from the camera |

P26




601




607

| LOCATION | | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| PNL | STA# | | | | | | | |
| 600 | E | | INTERCOM BOX | -------------- See Panel 102 ------------- | | | | |
| | | | UTILITY OUTLETS | | | | | |
| 601 | E | conn | 1 | Zero-G receptacle provides electrical power interface with portable equipment plug | UTIL OUTLETS EXP COMPT 1 (pnl 612) | OWS BUS 1 | | Typical for panels 601 and 628 |
| 601 | E | conn | 2 | Zero-G receptacle provides electrical power interface with portable equipment plug | UTIL OUTLETS EXP COMPT 2 (pnl 612) | OWS BUS 2 | | |
| | | | FLARE ALERT | | | | | |
| 607 | E | sw | ON | Enables flare alert notification box | DISP FLARE ALERT (pnl 613) | OWS BUS 2 | | Activated by contact closure from the ATM C&D panel. Contact closure driven by X-Ray threshold level detector (S054) or radio noise burst monitor (RNBM) |
| | | | OFF | Inhibits the above | | | | |
| 607 | E | pot | VOLUME | Controls the volume of the audible tone output of the solar flare notification box | | | | Clockwise rotation increases the volume |
| 610 | E | | GMT CLOCK | ------------- See Panel 212 -------------- | | | | |

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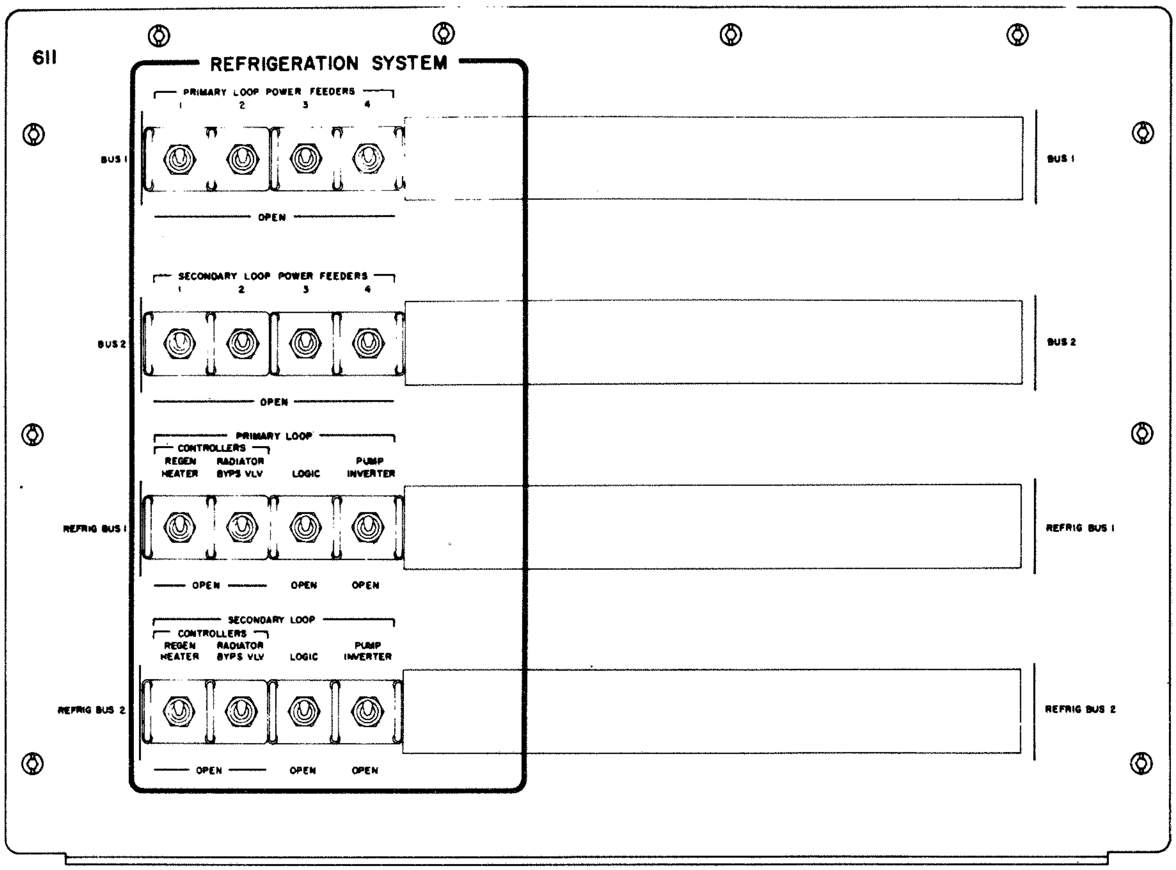
P14


611
REFRIGERATION SYSTEM
PRIMARY LOOP POWER FEEDERS
1 2 3 4
BUS 1
OPEN
SECONDARY LOOP POWER FEEDERS
1 2 3 4
BUS 2
OPEN
PRIMARY LOOP
CONTROLLERS
REGEN HEATER
RADIATOR BYPS VLV
LOGIC
PUMP INVERTER
REFRIG BUS 1
OPEN
OPEN
OPEN
SECONDARY LOOP
CONTROLLERS
REGEN HEATER
RADIATOR BYPS VLV
LOGIC
PUMP INVERTER
REFRIG BUS 2
OPEN
OPEN
OPEN
BUS 1
BUS 2
REFRIG BUS 1
REFRIG BUS 2

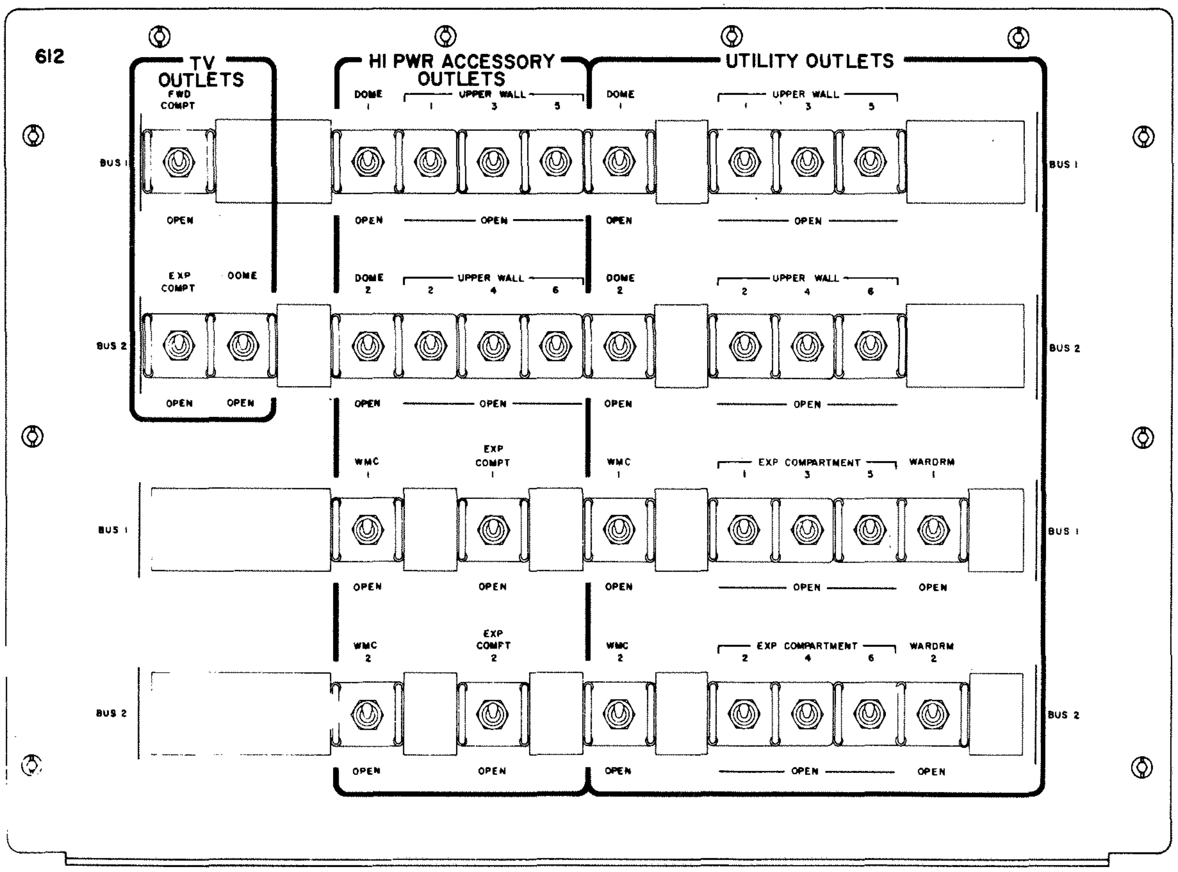
611

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | REFRIGERATION SYSTEM | | | | | |
| | | | PRIMARY LOOP POWER FEEDERS | | | | | |
| | | | BUS 1 | | | | | |
| 611 | E | cb | 1 (20.0A) (up) | Connects OWS bus 1 power feeder 1 to refrigeration system bus 1 | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| 611 | E | cb | 2,3,4 (20.0A) (up) | Same as primary loop power feeder bus 1 circuit breaker 1 for power feeders 2,3,4 | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | SECONDARY LOOP POWER FEEDERS | | | | | |
| | | | BUS 2 | | | | | |
| 611 | E | cb | 1 (20.0A) (up) | Connects OWS bus 2 power feeder 1 to refrigeration system bus 2 | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 611 | E | cb | 2,3,4 (20.0A)(up) | Same as secondary loop power feeder bus 2 circuit breaker 1 for power feeders 2,3,4 | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| | | | PRIMARY LOOP | | | | | |
| | | | REFRIG BUS 1 | | | | | |
| | | | CONTROLLERS | | | | | |
| 611 | E | cb | REGEN HEATER(up) (6.0A) | Provides power to the refrigeration system primary loop regenerator heater controller | | RS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| 611 | E | cb | RADIATOR BYPASS VLV (6.0A) (up) | Provides power to the refrigeration system primary loop radiator bypass valve controller | | RS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| 611 | E | cb | LOGIC (6.0A) (up) | Provides power to the refrigeration system primary loop control logic unit | | RS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| 611 | E | cb | PUMP INVERTER (up) (6.0A) | Provides power to the refrigeration system primary loop coolant pump inverter | | RS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | SECONDARY LOOP | | | | | |
| | | | REFRIG BUS 2 | | | | | |
| | | | CONTROLLERS | | | | | |
| 611 | E | cb | REGEN HEATER(up) (6.0A) | Provides power to the refrigeration system secondary loop regenerator heater controller | | RS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 611 | E | cb | RADIATOR BYPASS VLV (6.0A) (up) | Provides power to the refrigeration system secondary loop radiator bypass valve Controller | | RS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 611 | E | cb | LOGIC (6.0A) (up) | Provides power to the refrigeration system secondary loop control logic unit | | RS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 611 | E | cb | PUMP INVERTER (up) (6.0A) | Provides power to the refrigeration system secondary loop coolant pump inverter | | RS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |

P15


612
TV OUTLETS
FWD COMPT
EXP COMPT
DOME
HI PWR ACCESSORY OUTLETS
UTILITY OUTLETS
DOME 1
UPPER WALL
DOME 2
WMC 1
WMC 2
EXP COMPT 1
EXP COMPT 2
EXP COMPARTMENT
WARDRM 1
WARDRM 2
BUS 1
BUS 2
OPEN

612

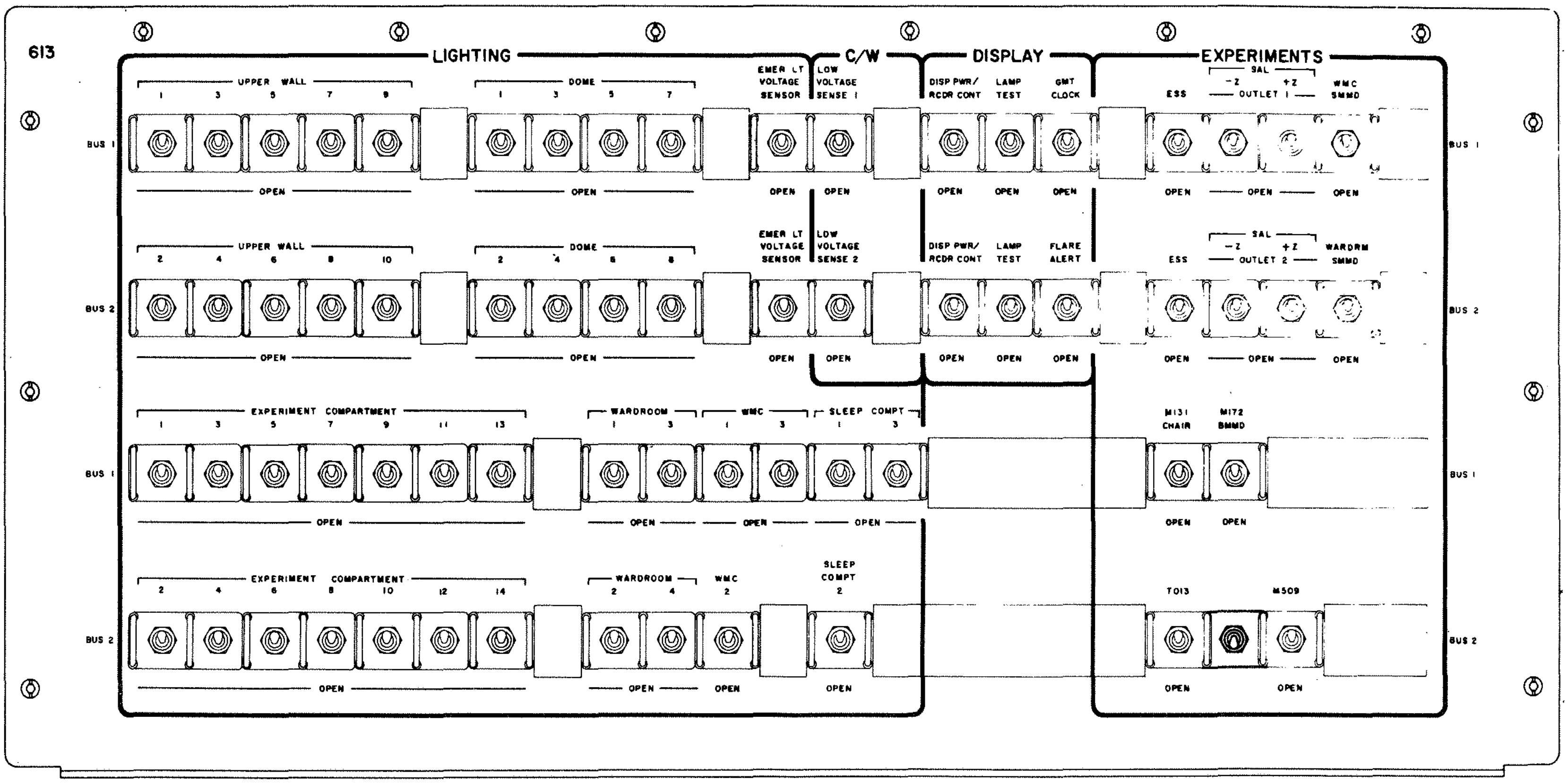
| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | TV OUTLETS | | | | | |
| | | | BUS 1 | | | | | |
| 612 | E | cb | FWD COMPT (6.0A) (up) | Provides power to the forward compartment TV input station (panel 555) | | OWS BUS 1 | | |
| | | | OPEN | Opens the above circuit | | | | |
| | | | BUS 2 | | | | | |
| 612 | E | cb | EXP COMPT (6.0A) (up) | Provides power to the experiment compartment TV inputs station (panel 642) | | OWS BUS 2 | | |
| | | | OPEN | Opens the above circuit | | | | |
| 612 | E | cb | DOME (6.0A) (up) | Provides power to the dome TV input station (panel 404) | | OWS BUS 2 | | |
| | | | OPEN | Opens the above circuit | | | | |
| | | | HI PWR ACCESSORY OUTLETS | | | | | |
| | | | BUS 1 | | | | | |
| 612 | E | cb | DOME 1 (12.0A) (up) | Closes circuit providing power to high power #1 dome utility outlet | | OWS BUS 1 | | |
| | | | OPEN | Opens above circuit | | | | |
| | | | UPPER WALL | | | | | |
| 612 | E | cb | 1 (12.0A) (up) | Closes circuit providing power to high power #1 upper wall utility outlet | | OWS BUS 1 | | |
| | | | OPEN | Opens above circuit | | | | |
| 612 | E | cb | 3 (12.0A) (up) | Closes circuit providing power to high power #3 upper wall utility outlet | | OWS BUS 1 | | |
| | | | OPEN | Opens above circuit | | | | |
| 612 | E | cb | 5 (12.0A) (up) | Closes circuit providing power to high power #5 upper wall utility outlet | | OWS BUS 1 | | |
| | | | OPEN | Opens above circuit | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | BUS 2 | | | | | |
| 612 | E | cb | DOME 2 (12.0A) (up) | Closes circuit providing power to high power #2 dome utility outlet | | OWS BUS 2 | | |
| | | | OPEN | Opens above circuit | | | | |
| | | | UPPER WALL (12.0A) | | | | | |
| 612 | E | cb | 2 (12.0A) (up) | Closes circuit providing power to high power #2 upper wall utility outlet | | OWS BUS 2 | | |
| | | | OPEN | Opens above circuit | | | | |
| 612 | E | cb | 4 (12.0A) (up) | Closes circuit providing power to high power #4 upper wall utility outlet | | OWS BUS 2 | | |
| | | | OPEN | Opens above circuit | | | | |
| 612 | E | cb | 6 (12.0A) (up) | Closes circuit providing power to high power #6 upper wall utility outlet | | OWS BUS 2 | | |
| | | | OPEN | Opens above circuit | | | | |
| | | | BUS 1 | | | | | |
| 612 | E | cb | WMC 1 (12.0A) (up) | Closes circuit providing power to high power #1 WMC utility outlet | | OWS BUS 1 | | |
| | | | OPEN | Opens above circuit | | | | |
| 612 | E | cb | EXP COMPT 1 (12.0A) (up) | Closes circuit providing power to high power #1 experiment compartment utility outlet | | OWS BUS 1 | | |
| | | | OPEN | Opens above circuit | | | | |
| | | | BUS 2 | | | | | |
| 612 | E | cb | WMC 2 (12.0A) (up) | Closes circuit providing power to high power #2 WMC utility outlet | | OWS BUS 2 | | |
| | | | OPEN | Opens above circuit | | | | |
| 612 | E | cb | EXP COMPT 2 (12.0A) (up) | Closes circuit providing power to high power #2 experiment compartment utility outlet | | OWS BUS 2 | | |
| | | | OPEN | Opens above circuit | | | | |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | UTILITY OUTLETS | | | | | |
| | | | BUS 1 | | | | | |
| 612 | E | cb | DOME 1 (6.0A) (up) | Closes circuit providing power to #1 dome utility outlet | | OWS BUS 1 | | |
| | | | OPEN | Opens above circuit | | | | |
| | | | UPPER WALL | | | | | |
| 612 | E | cb | 1 (6.0A) (up) | Closes circuit providing power to upper wall utility outlet 1 | | OWS BUS 1 | | |
| | | | OPEN | Opens above circuit | | | | |
| 612 | E | cb | 3 (6.0A) (up) | Closes circuit providing power to upper wall utility outlet 3 | | OWS BUS 1 | | |
| | | | OPEN | Opens above circuit | | | | |
| 612 | E | cb | 5 (6.0A) (up) | Closes circuit providing power to upper wall utility outlet 5 | | OWS BUS 1 | | |
| | | | OPEN | Opens above circuit | | | | |
| | | | BUS 2 | | | | | |
| 612 | E | cb | DOME 2 (6.0A) (up) | Closes circuit providing power to dome utility outlet 2 | | OWS BUS 2 | | |
| | | | OPEN | Opens above circuit | | | | |
| | | | UPPER WALL | | | | | |
| 612 | E | cb | 2 (6.0A) (up) | Closes circuit providing power to upper wall utility outlet 2 | | OWS BUS 2 | | |
| | | | OPEN | Opens above circuit | | | | |
| 612 | E | cb | 4 (6.0A) (up) | Closes circuit providing power to upper wall utility outlet 4 | | OWS BUS 2 | | |
| | | | OPEN | Opens above circuit | | | | |
| 612 | E | cb | 6 (6.0A) (up) | Closes circuit providing power to upper wall utility outlet 6 | | OWS BUS 2 | | |
| | | | OPEN | Opens above circuit | | | | |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | BUS 1 | | | | | |
| 612 | E | cb | WMC 1 (6.0A) (up) | Closes circuit providing power to WMC utility outlet 1 | | OWS BUS 1 | | |
| | | | OPEN | Opens above circuit | | | | |
| | | | EXP COMPARTMENT | | | | | |
| 612 | E | cb | 1 (6.0A) (up) | Closes circuit providing power to experiment compartment utility outlet 1 | | OWS BUS 1 | | |
| | | | OPEN | Opens above circuit | | | | |
| 612 | E | cb | 3 (6.0A) (up) | Closes circuit providing power to experiment compartment utility outlet 3 | | OWS BUS 1 | | |
| | | | OPEN | Opens above circuit | | | | |
| 612 | E | cb | 5 (6.0A) (up) | Closes circuit providing power to experiment compartment utility outlet 5 | | OWS BUS 1 | | |
| | | | OPEN | Opens above circuit | | | | |
| 612 | E | cb | WARDRM 1 (6.0A)(up) | Closes circuit providing power to wardroom utility outlet 1 | | OWS BUS 1 | | |
| | | | OPEN | Opens above circuit | | | | |
| | | | BUS 2 | | | | | |
| 612 | E | cb | WMC 2 (6.0A) (up) | Closes circuit providing power to WMC Utility outlet 2 | | OWS BUS 2 | | |
| | | | OPEN | Opens above circuit | | | | |
| | | | EXP COMPARTMENT | | | | | |
| 612 | E | cb | 2 (6.0A) (up) | Closes circuit providing power to experiment compartment utility outlet 2 | | OWS BUS 2 | | |
| | | | OPEN | Opens above circuit | | | | |
| 612 | E | cb | 4 (6.0A) (up) | Closes circuit providing power to experiment compartment utility outlet 4 | | OWS BUS 2 | | |
| | | | OPEN | Opens above circuit | | | | |
| 612 | E | cb | 6 (6.0A) (up) | Closes circuit providing power to experiment compartment utility outlet 6 | | OWS BUS 2 | | |
| | | | OPEN | Opens above circuit | | | | |
| 612 | E | cb | WARDRM 2 (6.0A)(up) | Closes circuit providing power to wardroom utility outlet 2 | | OWS BUS 2 | | |
| | | | OPEN | Opens above circuit | | | | |

P16


613
LIGHTING
C/W
DISPLAY
EXPERIMENTS
UPPER WALL
DOME
EMER LT VOLTAGE SENSOR
LOW VOLTAGE SENSE 1
LOW VOLTAGE SENSE 2
DISP PWR/ RCDR CONT
LAMP TEST
GMT CLOCK
FLARE ALERT
ESS
SAL
OUTLET 1
OUTLET 2
WMC SMMD
WARDRM SMMD
BUS 1
BUS 2
OPEN
EXPERIMENT COMPARTMENT
WARDROOM
WMC
SLEEP COMPT
M131 CHAIR
M172 BMMD
T013
M509

613

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | LIGHTING | | | | | |
| | | | BUS 1 | | | | | |
| | | | UPPER WALL | | | | | |
| 613 | E | cb | 1 (3.0A) (up) | Provides power to OWS upper wall light #1 thru LTG UPPER WALL +Z SAL [1•2•10] sw | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | 3(3.0A) (up) | Provides power to OWS upper wall light #3 thru LTG UPPER WALL +Y [3•4]sw | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | 5 (3.0A) (up) | Provides power to OWS upper wall light #5 thru LTG UPPER WALL -Z SAL [5•6•7] sw | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | 7 (3.0A) (up) | Provides power to OWS upper wall light #7 thru LTG UPPER WALL -Z SAL [5•6•7] sw | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | 9 (3.0A) (up) | Provides power to OWS upper wall light #9 thru LTG UPPER WALL -Y [8•9] sw | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| | | | DOME | | | | | |
| 613 | E | cb | 1 (3.0A) (up) | Provides power to OWS dome light #1 thru LTG DOME [1•3•5] sw | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | 3 (3.0A) (up) | Provides power to OWS dome light #3 thru LTG DOME [1•3•5] sw | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | 5 (3.0A) (up) | Provides power to OWS dome light #5 thru LTG DOME [1•3•5] sw | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | 7 (3.0A) (up) | Provides power to OWS dome light #7 thru LTG DOME [7•8] sw | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 613 | E | cb | EMER LT VOLTAGE (up) SENSOR (3.0A) | Provides voltage monitoring signal of OWS bus 1 to emergency lighting low voltage sensor | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| | | | BUS 2 | | | | | |
| | | | UPPER WALL | | | | | |
| 613 | E | cb | 2 (3.0A) (up) | Provides power to OWS upper wall light #2 thru LTG UPPER WALL +Z SAL [1•2•10] sw | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | 4 (3.0A) (up) | Provides power to OWS upper wall light #4 thru LTG UPPER WALL +Y [3•4] sw | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | 6 (3.0A) (up) | Provides power to OWS upper wall light #6 thru LTG UPPER WALL -Z SAL [5•6•7] sw | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | 8 (3.0A) (up) | Provides power to OWS upper wall light #8 thru LTG UPPER WALL -Y [8•9] sw | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | 10 (3.0A) (up) | Provides power to OWS upper wall light #10 thru LTG UPPER WALL +Z SAL [1•2•10] sw | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| | | | DOME | | | | | |
| 613 | E | cb | 2 (3.0A) (up) | Provides power to OWS dome light #2 thru LTG DOME [2•4•6] sw | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | 4 (3.0A) (up) | Provides power to OWS dome light #4 thru LTG DOME [2•4•6] sw | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | 6 (3.0A) (up) | Provides power to OWS dome light #6 thru LTG DOME [2•4•6] sw | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | BUS 2 (cont'd) | | | | | |
| | | | DOME (cont'd) | | | | | |
| 613 | E | cb | 8 (3.0A) (up) | Provides power to OWS dome light #8 thru LTG DOME [7•8] sw | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | EMER LT VOLTAGE (up) SENSOR (3.0A) | Provides voltage monitoring signal of OWS bus 2 to emergency lighting low voltage sensor | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| | | | BUS 1 | | | | | |
| | | | EXP COMPARTMENT | | | | | |
| 613 | E | cb | 1 (3.0A) (up) | Provides power to OWS experiment compartment light #1 thru LTG EXP COMPT [1•3•5] sw | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | 3 (3.0A) (up) | Provides power to OWS experiment compartment light #3 thru LTG EXP COMPT [1•3•5] sw | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | 5 (3.0A) (up) | Provides power to OWS experiment compartment light #5 thru LTG EXP COMPT [1•3•5] sw | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | 7 (3.0A) (up) | Provides power to OWS experiment compartment light #7 thru LTG EXP COMPT [7•9•11] sw | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | 9 (3.0A) (up) | Provides power to OWS experiment compartment light #9 thru LTG EXP COMPT [7•9•11] sw | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | BUS 1 (cont'd) | | | | | |
| | | | EXP COMPARTMENT(cont'd) | | | | | |
| 613 | E | cb | 11 (3.0A) (up) | Provides power to OWS experiment compartment light #11 thru LTG EXP COMPT [7•9•11] sw | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | 13 (3.0A) (up) | Provides power to OWS experiment compartment light #13 thru LTG EXP COMPT [13•14] | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| | | | WARDROOM | | | | | |
| 613 | E | cb | 1 (3.0A) (up) | Provides power to OWS wardroom light #1 thru LTS WARDRM [1•3] sw | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | 3 (3.0A) (up) | Provides power to OWS wardroom light #3 thru LTS WARDRM [1•3] sw | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| | | | WMC | | | | | |
| 613 | E | cb | 1 (3.0A) (up) | Provides power to OWS WMC light #1 thru LTS [WMC] sw | | OWS BUS 1 | | |
| | | | OPEN | Disconnect the above | | | | |
| 613 | E | cb | 3 (3.0A) (up) | Provides power to OWS WMC light #3 thru LTS [WMC] sw | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| | | | SLEEP COMPARTMENT | | | | | |
| 613 | E | cb | 1 (3.0A) (up) | Provides power to OWS sleep compartment light #1 thru LTG [SLEEP COMPT] sw | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | | | 3 (3.0A) (up) | Provides power to OWS sleep compartment light #3 thru LTG [SLEEP COMPT] sw | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | BUS 2 | | | | | |
| | | | EXP COMPARTMENT | | | | | |
| 613 | E | cb | 2 (3.0A) (up) | Provides power to OWS experiment compartment light #2 thru LTG EXP COMPT [2•4•6] sw | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | 4 (3.0A) (up) | Provides power to OWS experiment compartment light #4 thru LTG EXP COMPT [2•4•6] sw | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | 6 (3.0A) (up) | Provides power to OWS experiment compartment light #6 thru LTG EXP COMPT [2•4•6] sw | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | 8 (3.0A) (up) | Provides power to OWS experiment compartment light #8 thru LTG EXP COMPT [8•10•12] sw | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | 10 (3.0A) (up) | Provides power to OWS experiment compartment light #10 thru LTG EXP COMPT[8•10•12] sw | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | 12 (3.0A) (up) | Provides power to OWS experiment compartment light #12 thru LTG EXP COMPT [8•10•12] sw | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | 14 (3.0A) (up) | Provides power to OWS experiment compartment light #14 thru LTG EXP COMPT [13•14] sw | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |

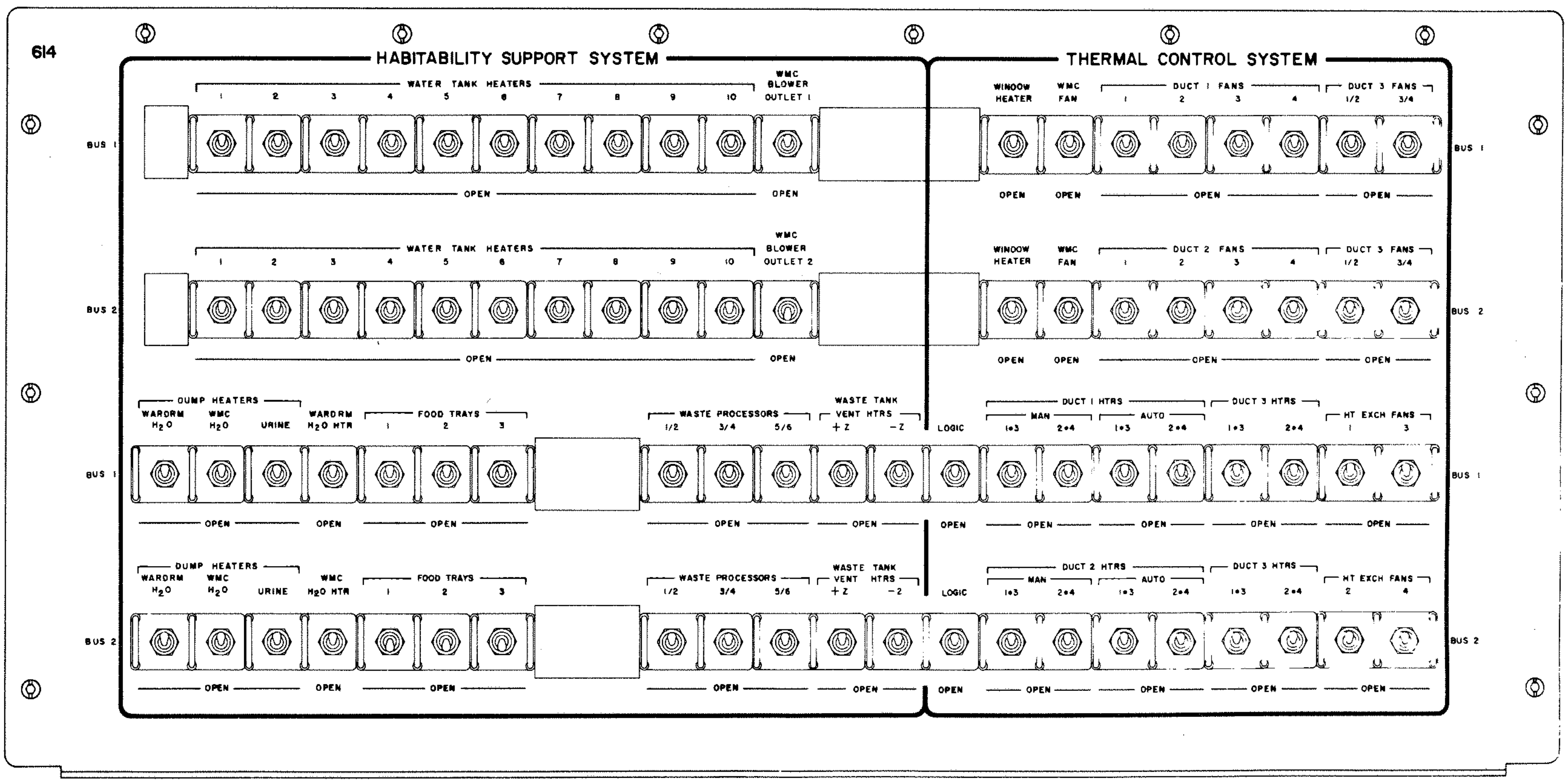
| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | WARDROOM | | | | | |
| 613 | E | cb | 2 (3.0A) (up) | Provides power to OWS wardroom light #2 thru LTS WARDRM [2•4] sw | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | 4 (3.0A) (up) | Provides power to OWS wardroom light #4 thru LTS WARDRM [2•4] sw | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| | | | WMC | | | | | |
| 613 | E | cb | 2 (3.0A) (up) | Provides power to OWS WMC light #2 thru LTS [WMC] sw | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| | | | SLEEP COMPARTMENT | | | | | |
| 613 | E | cb | 2 (3.0A) (up) | Provides power to OWS sleep compartment light #2 thru LTG [SLEEP COMPT] sw | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| | | | C/W | | | | | |
| | | | BUS 1 | | | | | |
| 613 | E | cb | LOW VOLTAGE SENSE 1 (6.0A) (up) | Provides OWS bus 1 signal to caution and warning subsystem low voltage level detectors 1 and 2 | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| | | | BUS 2 | | | | | |
| 613 | E | cb | LOW VOLTAGE SENSE 2 (6.0A) (up) | Provides OWS bus 2 signal to caution and warning subsystem low voltage level detectors 1 and 2 | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |

| LOCATION | | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| PNL | STA# | | | | | | | |
| | | | DISPLAY | | | | | |
| | | | BUS 1 | | | | | |
| 613 | E | cb | DISPLAY PWR/ RCDR CONT (3.0A) (up) | Provides power to the experiment recorders control logic and OWS meters and indicator lights | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | LAMP TEST(6.0A)(up) | Provides power to test all OWS indicator lights except C/W | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | GMT CLOCK(3.0A)(up) | Provides power to the GMT clock (panel 610) | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| | | | BUS 2 | | | | | |
| 613 | E | cb | DISPLAY PWR/ RCDR CONT (3.0A) (up) | Provides power to the experiment recorders control and EXP 1 mode select logic and OWS meters and indicator lights | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | LAMP TEST (6.0A)(up) | Provides power to test all OWS indicator lights except C/W | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | FLARE ALERT (3.0A) (up) | Provides power to the flare alert box | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| | | | EXPERIMENTS | | | | | |
| | | | BUS 1 | | | | | |
| 613 | E | cb | ESS (20.0A) (up) | Provides power to the experiment support system console | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | EXPERIMENTS (cont'd) | | | | | |
| | | | BUS 1 (cont'd) | | | | | |
| | | | SAL | | | | | |
| 613 | E | cb | -Z OUTLET 1 (20.0A) (up) | Provides power to the -Z SAL utility outlet #1 | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | +Z OUTLET 1 (20.0A) (up) | Provides power to the +Z SAL utility outlet #1 | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | WMC SMMD (6.0A) (up) | Provides power to the WMC M074 experiment specimen mass measurement device | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| | | | BUS 2 | | | | | |
| 613 | E | cb | ESS (20.0A) (up) | Provides power to the experiment support system console | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| | | | SAL | | | | | |
| 613 | E | cb | -Z OUTLET 2 (20.0A) (up) | Provides power to the -Z SAL utility outlet #2 | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | +Z OUTLET 2 (20.0A) (up) | Provides power to the +Z SAL utility outlet #2 | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | WARDRM SMMD (6.0A) (up) | Provides power to the wardroom M074 experiment specimen mass measurement device | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| | | | BUS 1 | | | | | |
| 613 | E | cb | M131 CHAIR (20.0A) (up) | Provides power to the M131 rotating litter chair control console | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | EXPERIMENTS (cont'd) | | | | | |
| | | | BUS 1 (cont'd) | | | | | |
| 613 | E | cb | M172 BMMD (6.0A)(up) | Provides power to the experiment M172 body mass measurement device | | OWS BUS 1 | | |
| | | | OPEN | Disconnect the above | | | | |
| | | | BUS 2 | | | | | |
| 613 | E | cb | T013 (6.0A) (up) | Provides power to the experiment T013 crew vehicle disturbances | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 613 | E | cb | M509 (12.0A) (up) | Provides power to the experiment M509 astronaut maneuvering equipment | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |

P17


614
HABITABILITY SUPPORT SYSTEM
THERMAL CONTROL SYSTEM
WATER TANK HEATERS
1 2 3 4 5 6 7 8 9 10
WMC BLOWER OUTLET 1
WMC BLOWER OUTLET 2
WINDOW HEATER
WMC FAN
DUCT 1 FANS
DUCT 2 FANS
DUCT 3 FANS
1/2 3/4
BUS 1
BUS 2
OPEN
DUMP HEATERS
WARDRM $H_2O$
WMC $H_2O$
URINE
WARDRM $H_2O$ HTR
WMC $H_2O$ HTR
FOOD TRAYS
WASTE PROCESSORS
1/2 3/4 5/6
WASTE TANK VENT HTRS
+Z −Z
LOGIC
DUCT 1 HTRS
DUCT 2 HTRS
DUCT 3 HTRS
MAN
AUTO
1+3 2+4
HT EXCH FANS
1 3
2 4

614

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | HABITABILITY SUPPORT SYSTEM | | | | | |
| | | | BUS 1 | | | | | |
| | | | WATER TANK HEATERS | | | | | |
| 614 | E | cb | 1 (6.0A) | Provides power to bus 1 water tank 1 heater blanket | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| 614 | E | cb | 2-10 (6.0A) | Same as bus 1 WATER TANK HEATER cb 1 for water tanks 2-10 | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| 614 | E | cb | WMC BLOWER OUTLET 1 (6.0A) | Provides power to fecal/urine collector blower unit & urine separators | | OWS BUS 1 | | Power is supplied to a circuit breaker in the blower unit & in each urine separator |
| | | | OPEN | Disconnects the above | | | | |
| | | | BUS 2 | | | | | |
| | | | WATER TANK HEATERS | | | | | |
| 614 | E | cb | 1 (6.0A) | Provides power to bus 2 water tank 1 heater blanket | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 614 | E | cb | 2-10 (6.0A) | Same as bus 2 WATER TANK HEATER cb 1 for water tanks 2-10 | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 614 | E | cb | WMC BLOWER OUTLET 2 (6.0A) | Provides power to fecal/urine collector blower unit & urine separators | | OWS BUS 2 | | Provides redundant power. Connectors are stowed until required for use |
| | | | OPEN | Disconnects the above | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | BUS 1 | | | | | |
| 614 | E | cb | DUMP HEATERS | | | | | |
| | | | WARDROOM H2O (6.0A) | Provides power to wardroom water dump heater probe bus 1 heater element thru the H2O DUMP HTR sw | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| 614 | E | cb | WMC H2O (6.0A) | Provides power to WMC water dump heater probe bus 1 heater element thru the DUMP HTRS H2O sw | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| 614 | E | cb | URINE (6.0A) | Provides power to urine dump heater probe bus 1 heater element thru the DUMP HTRS URINE sw | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| 614 | E | cb | WARDROOM H2O HTR (6.0A) | Provides power to wardroom H2O heater | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| | | | FOOD TRAYS | | | | | |
| 614 | E | cb | 1 (15.0A) | Provides power to bus 1 FOOD TRAY 1 OUTLET | | OWS BUS 1 | | Food tray 1 connects to the outlet using a high power accessory adaptor cable |
| | | | OPEN | Disconnect the above | | | | |
| 614 | E | cb | 2 (15.0A) | Provides power to bus 1 FOOD TRAY 2 OUTLET | | OWS BUS 1 | | Food tray 2 connects to the outlet using a high power accessory adaptor cable |
| | | | OPEN | Disconnects the above | | | | |
| 614 | E | cb | 3 (15.0A) | Provides power to bus 1 FOOD TRAY 3 OUTLET | | OWS BUS 1 | | Food tray 3 connects to the outlet using a high power accessory adaptor cable |
| | | | OPEN | Disconnects the above | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | WASTE PROCESSORS | | | | | |
| 614 | E | cb | 1/2 (15.0A) | Provides power to processors 1 and 2 thru WASTE PROCESSORS BUS SEL 1 and 2 switches and thru PROCESSOR 1 and 2 cbs (panel 817) | | OWS BUS 1 | | Provides redundant power to processor 2. Power is routed to the processor circuit breakers on panel 817 |
| | | | OPEN | Disconnects the above | | | | |
| 614 | E | cb | 3/4 (15.0A) | Provides power to processors 3 and 4 thru WASTE PROCESSORS BUS SEL 3 and 4 switches and thru PROCESSOR 3 and 4 cbs (panel 817) | | OWS BUS 1 | | Provides redundant power to processor 4. Power is routed to the processor circuit breakers on panel 817 |
| | | | OPEN | Disconnects the above | | | | |
| 614 | E | cb | 5/6 (15.0A) | Provides power to processors 5 and 6 thru WASTE PROCESSORS BUS SEL 5 and 6 switches and thru PROCESSOR 5 and 6 cbs (panel 817) | | OWS BUS 1 | | Provides redundant power to processor 6. Power is routed to the processor circuit breakers on panel 817 |
| | | | OPEN | Disconnects the above | | | | |
| | | | BUS 2 | | | | | |
| | | | DUMP HEATERS | | | | | |
| 614 | E | cb | WARDROOM H20 (6.0A) | Provides power to wardroom water dump heater probe bus 2 heater element thru the H20 DUMP HTR sw | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 614 | E | cb | WMC H20 (6.0A) | Provides power to WMC water dump heater probe bus 2 heater element thru the DUMP HTRS H20 sw | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 614 | E | cb | URINE (6.0A) | Provides power to urine dump heater probe bus 2 htr element thru the DUMP HTRS URINE sw | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 614 | E | cb | WMC H20 HTR (6.0A) | Provides power to WMC H20 heater | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | FOOD TRAYS | | | | | |
| 614 | E | cb | 1 (15.0A) | Provides power to bus 2 FOOD TRAY 1 OUTLET | | OWS BUS 2 | | Provides redundant power |
| | | | OPEN | Disconnects the above | | | | |
| 614 | E | cb | 2 (15.0A) | Provides power to bus 2 FOOD TRAY 2 OUTLET | | OWS BUS 2 | | Provides redundant power |
| | | | OPEN | Disconnects the above | | | | |
| 614 | E | cb | 3 (15.0A) | Provides power to bus 2 FOOD TRAY 3 OUTLET | | OWS BUS 2 | | Provides redundant power |
| | | | OPEN | Disconnects the above | | | | |
| | | | WASTE PROCESSORS | | | | | |
| 614 | E | cb | 1/2 (15.0A) | Provides power to processors 1 and 2 thru WASTE PROCESSOR BUS SEL 1 and 2 switches thru PROCESSOR 1 and 2 cbs (panel 817) | | OWS BUS 2 | | Provides redundant power to processor 1. Power is routed to the processor circuit breakers on panel 817 |
| | | | OPEN | Disconnects the above | | | | |
| 614 | E | cb | 3/4 (15.0A) | Provides power to processors 3 and 4 thru WASTE PROCESSORS BUS SEL 3 and 4 switches thru PROCESSOR 3 and 4 cbs (panel 817) | | OWS BUS 2 | | Provides redundant power to processor 3. Power is routed to the processor circuit breakers on panel 817 |
| | | | OPEN | Disconnects the above | | | | |
| 614 | E | cb | 5/6 (15.0A) | Provides power to processors 5 and 6 thru WASTE PROCESSORS BUS SEL 5 and 6 switches thru PROCESSOR 5 and 6 cbs (panel 817) | | OWS BUS 2 | | Provides redundant power to processor 5. Power is routed to the processor circuit breakers on panel 817 |
| | | | OPEN | Disconnects the above | | | | |
| | | | THERMAL CONTROL SYSTEM | | | | | |
| | | | BUS 1 | | | | | |
| 614 | E | cb | WINDOW HEATER (12.0A) | Provides power to the wardroom window assembly heater thru the WINDOW HTR sw | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| 614 | E | cb | WMC FAN (6.0A) | Provides power to the waste management compartment ventilation fan thru the FAN sw | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | THERMAL CONTROL SYSTEM (cont'd) | | | | | |
| | | | BUS 1 (cont'd) | | | | | |
| | | | DUCT 1 FANS | | | | | |
| 614 | E | cb | 1 (6.0A) | Provides direct power to the duct 1 fan #1 turning fan on | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above, turning fan off | | | | |
| 614 | E | cb | 2,3,4 (6.0A) | Same as DUCT 1 FAN #1 cb for duct 1 fans 2,3,4 | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| | | | DUCT 3 FANS | | | | | |
| 614 | E | cb | 1/2 (6.0A) | Provides power to the duct 3 fans 1 and 2 thru the DUCT 3 FANS BUS SEL 1 and 2 sws | | OWS BUS 1 | | Provides redundant power |
| | | | OPEN | Disconnect the above | | | | |
| 614 | E | cb | 3/4 (6.0A) | Provides power to the duct 3 fans 3 and 4 thru the DUCT 3 FANS BUS SEL 3 and 4 sws | | OWS BUS 1 | | Provides redundant power |
| | | | OPEN | Disconnects the above | | | | |
| | | | BUS 2 | | | | | |
| 614 | E | cb | WINDOW HEATER (12.0A) | Provides power to the wardroom window assembly heater thru the WINDOW HTR sw | | OWS BUS 2 | | Provides redundant power to window heater sw |
| | | | OPEN | Disconnects the above | | | | |
| 614 | E | cb | WMC FAN (6.0A) | Provides power to the waste management compartment ventilation fan thru the FAN sw | | OWS BUS 2 | | Provides redundant power to the WMC fan sw |
| | | | OPEN | Disconnects the above | | | | |
| | | | DUCT 2 FANS | | | | | |
| 614 | E | cb | 1 (6.0A) | Provides direct power to the duct 2 fan #1, turning fan on | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above, turning fan off | | | | |
| 614 | E | cb | 2-4 (6.0A) | Same as DUCT 2 FAN 1 cb for fans 2-4 | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |

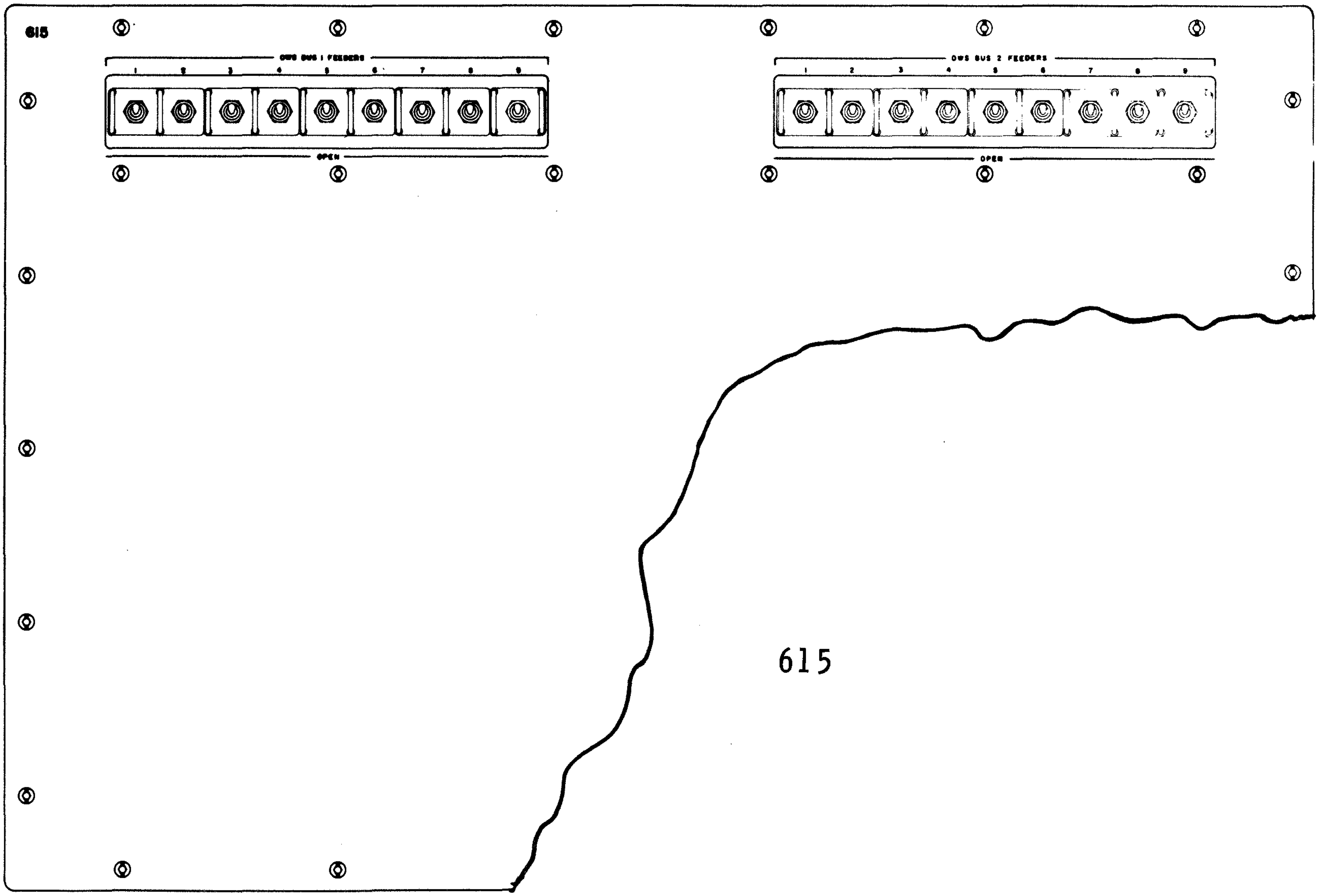
| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | THERMAL CONTROL SYSTEM (cont'd) | | | | | |
| | | | BUS 2 (cont'd) | | | | | |
| | | | DUCT 3 FANS | | | | | |
| 614 | E | cb | 1/2 (6.0A) | Provides power to the duct 3 fans 1 and 2 thru the DUCT 3 FANS BUS SEL 1 and 2 sws | | OWS BUS 2 | | Provides redundant power |
| | | | OPEN | Disconnects the above | | | | |
| 614 | E | cb | 3/4 (6.0A) | Provides power to the duct 3 fans 3 and 4 thru the DUCT 3 FANS BUS SEL 3 and 4 sws | | OWS BUS 2 | | Provides redundant power |
| | | | OPEN | Disconnects the above | | | | |
| | | | BUS 1 | | | | | |
| 614 | E | cb | LOGIC (3.0A) | Provides power to the thermal control system control logic module | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| | | | DUCT 1 HTRS | | | | | |
| 614 | E | cb | MAN 1•3 (20.0A) | Provides power for manual operation of duct 1 heaters 1 and 3 thru TCS HTRS DUCT 1 1•3 sw | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| 614 | E | cb | MAN 2•4 (20.0A) | Provides power for manual operation of duct 1 heaters 2 and 4 thru TCS HTRS DUCT 1 2•4 sw | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| 614 | E | cb | AUTO 1•3 (20.0A) | Provides power for automatic operation of duct 1 heaters 1 and 3 by the heater control logic thru TCS HTRS DUCT 1 1•3 sw | | OWS BUS 1 | | |
| 614 | E | cb | AUTO 2•4 (20.0A) | Provides power for automatic operation of the duct 1 heaters 2 and 4 by the heater control logic thru TCS HTRS DUCT 1 2•4 sw | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | THERMAL CONTROL SYSTEM (cont'd) | | | | | |
| | | | BUS 1 (cont'd) | | | | | |
| | | | DUCT 3 HTRS | | | | | |
| 614 | E | cb | 1•3 (20.0A) | Provides power to duct 3 heaters 1 and 3 thru TCS HTRS DUCT 3 1•3 sw | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| 614 | E | cb | 2•4 (20.0A) | Provides power to duct 3 heaters 2 and 4 thru TCS HTRS DUCT 3 2•4 sw | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| | | | HT EXCH FANS | | | | | |
| 614 | E | cb | 1 (3.0A) | Provides power to the heat exchanger #1 fan thru TCS HT EXCH FANS 1 sw and to OWS circulation solenoid valve 1 | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| 614 | E | cb | 3 (3.0A) | Provides power to the heat exchanger #3 fan thru TCS HT EXCH FANS 3 sw and to OWS circulation solenoid valve 3 | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| | | | BUS 2 | | | | | |
| 614 | E | cb | LOGIC (3.0A) | Provides power to the thermal control system logic module | | OWS BUS 2 | | Provides redundant power |
| | | | OPEN | Disconnects the above | | | | |
| | | | DUCT 2 HTRS | | | | | |
| 614 | E | cb | MAN 1•3 (20.0A) | Provides power for manual operation of duct 2 heaters 1 and 3 thru TCS HTRS DUCT 2 1•3 sw | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 614 | E | cb | MAN 2•4 (20.0A) | Provides power for manual operation of duct 2 heaters 2 and 4 thru TCS HTRS DUCT 2 2•4 sw | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | THERMAL CONTROL SYSTEM (cont'd) | | | | | |
| | | | BUS 2 (cont'd) | | | | | |
| | | | DUCT 2 HTRS (cont'd) | | | | | |
| 614 | E | cb | AUTO 1•3 (20.0A) | Provides power for automatic operation of the duct 2 heaters 1 and 3 by the heater control logic thru TCS HTRS DUCT 2 1•3 sw | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 614 | E | cb | AUTO 2•4 (20.0A) | Provides power for automatic operation of the duct 2 heaters 2 and 4 by the heater control logic thru TCS HTRS DUCT 2 2•4 sw | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| | | | DUCT 3 HTRS | | | | | |
| 614 | E | cb | 1•3 (20.0A) | Provides power to duct 3 heaters 1 and 3 thru TCS HTRS DUCT 3 1•3 sw | | OWS BUS 2 | | Provides redundant power |
| | | | OPEN | Disconnects the above | | | | |
| 614 | E | cb | 2•4 (20.0A) | Provides power to duct 3 heaters 2 and 4 thru TCS HTRS DUCT 3 2•4 sw | | OWS BUS 2 | | Provides redundant power |
| | | | OPEN | Disconnects the above | | | | |
| | | | HT EXCH FANS | | | | | |
| 614 | E | cb | 2 (3.0A) | Provides power to the heat exchanger #2 fan thru TCS HT EXCH FANS 2 sw and to OWS circulation valve #2 | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 614 | E | cb | 4 (3.0A) | Provides power to the heat exchanger #4 fan thru TCS HT EXCH FANS 4 sw and to OWS circulation valve #4 | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | WASTE TANK VENT HTRS | | | | | |
| 614 | E | cb | +Z (3.0A) | Provides power to the primary +Z waste tank vent heater | | OWS BUS 1 | | The primary waste tank vent heater is rated at 13 watts and is controlled by a thermal switch which closes at 47°F and opens at 97°F |
| | | | OPEN | Disconnects the above | | | | |
| 614 | E | cb | -Z (3.0A) | Provides power to the primary -Z waste tank vent heater | | OWS BUS 1 | | The primary waste tank vent heater is rated at 13 watts and is controlled by a thermal switch which closes at 47°F and opens at 97°F |
| | | | OPEN | Disconnects the above | | | | |
| | | | WASTE TANK VENT HTRS | | | | | |
| 614 | E | cb | +Z (3.0A) | Provides power to the secondary +Z waste tank vent heater | | OWS BUS 2 | | The secondary waste tank vent heater is rated at 13 watts and is controlled by a thermal switch which closes at 37°F and opens at 52°F |
| 614 | E | cb | -Z (3.0A) | Provides power to the secondary -Z waste tank vent heater | | OWS BUS 2 | | The secondary waste tank vent heater is rated at 13 watts and is controlled by a thermal switch which closes at 37°F and opens at 52°F |
| | | | OPEN | Disconnects the above | | | | |

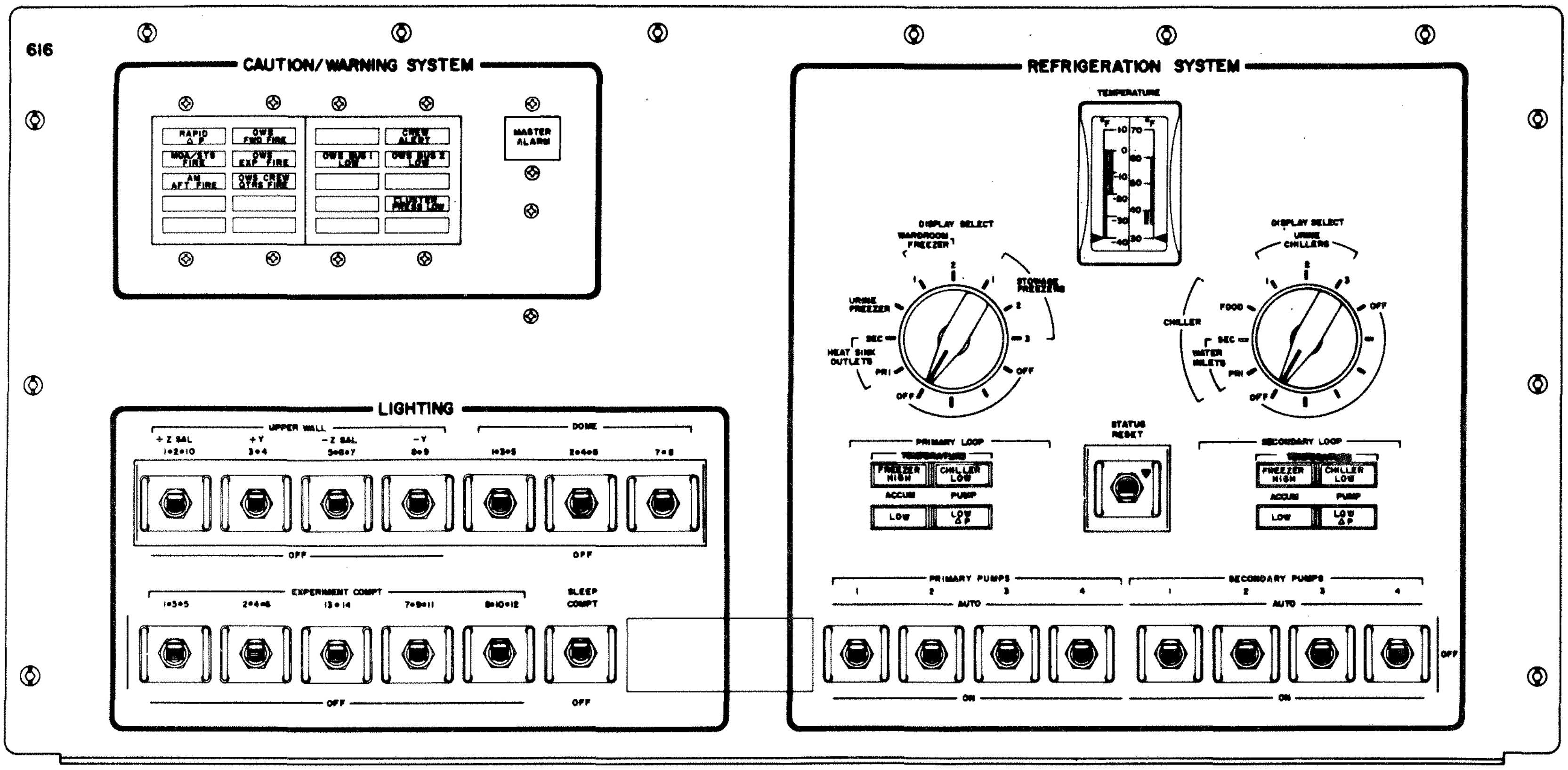
P19


615
OWS BUS 1 FEEDERS
1 2 3 4 5 6 7 8 9
OPEN
OWS BUS 2 FEEDERS
1 2 3 4 5 6 7 8 9
OPEN
615

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | OWS BUS 1 FEEDERS | | | | | |
| 615 | E | cb | 1 (12.0A) | Provides power to the power feeder 1 between OWS BUS 1 and REG BUS 1 | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| 615 | E | cb | 2-9 (12.0A) | Same as OWS BUS 1 feeders cb 1 for feeders 2-9 | | OWS BUS 1 | | |
| | | | OPEN | Disconnects the above | | | | |
| | | | OWS BUS 2 FEEDERS | | | | | |
| 615 | E | cb | 1 (12.0A) | Provides power to the power feeder 1 between OWS bus 2 and REG bus 2 | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 615 | E | cb | 2-9 (12.0A) | Same as OWS bus 2 feeders cb 1 for feeders 2-9 | | OWS BUS 2 | | |
| | | | OPEN | Disconnects the above | | | | |

(Page 3.0-226 is BLANK)

P20


616
CAUTION/WARNING SYSTEM
RAPID ΔP
OWS FWD FIRE
MDA/STS FIRE
OWS EXP FIRE
AM AFT FIRE
OWS CREW QTRS FIRE
CREW ALERT
OWS BUS 1 LOW
OWS BUS 2 LOW
CLUSTER PRESS LOW
MASTER ALARM
LIGHTING
UPPER WALL
+Z SAL
+Y
-Z SAL
-Y
DOME
OFF
EXPERIMENT COMPT
SLEEP COMPT
REFRIGERATION SYSTEM
TEMPERATURE
DISPLAY SELECT
WARDROOM FREEZER
STORAGE FREEZERS
URINE FREEZER
HEAT SINK OUTLETS
SEC
PRI
OFF
URINE CHILLERS
FOOD
CHILLER
WATER INLETS
PRIMARY LOOP
SECONDARY LOOP
FREEZER HIGH
CHILLER LOW
ACCUM
PUMP
LOW
LOW ΔP
STATUS RESET
PRIMARY PUMPS
SECONDARY PUMPS
AUTO
ON

616

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | CAUTION/WARNING SYSTEM | | | | | |
| 616 | E | lt | MASTER ALARM | Illuminates when a caution, warning, or emergency parameter exceeds the operating limits | | C&W SUBUNIT LAMP DRIVERS | | Red light |
| 616 | E | pb | | Turns off the audible warning tones, the T/M signals and all master alarm lights | CONVERTERS C&W 1 & 2 (pnl 202) | C&W CONTROL VOLTAGE | | |
| 616 | E | lt | RAPID Δ P | Illuminates when a decrease in OA internal pressure is greater than or equal to 0.1 psia/min sensed by either rapid Δ P detector | | EMER SUBUNIT LAMP DRIVERS | | Red emergency light |
| 616 | E | lt | OWS FWD FIRE | Illuminates when a fire is detected in the OWS forward area | | EMER SUBUNIT LAMP DRIVERS | | Red emergency light |
| 616 | E | lt | CLUSTER PRESS LOW | Illuminates when either cluster pressure low sensor in the STS detects a cabin pressure less than or equal to 4.6$\pm$.1 psia | | C&W SUBUNIT LAMP DRIVERS | | Nominal range 5.0$\pm$.2 psia<br>Red warning light |
| 616 | E | lt | CREW ALERT | Illuminates when either crew alert 1 or 2 is activated by a discrete input via the AM DCS | | C&W SUBUNIT LAMP DRIVERS | | Red warning light |
| 616 | E | lt | MDA/STS FIRE | Illuminates when a fire is detected in the MDA/STS area | | EMER SUBUNIT LAMP DRIVERS | | Red emergency light |
| 616 | E | lt | OWS EXP FIRE | Illuminates when a fire is detected in in the OWS experiment compartment | | EMER SUBUNIT LAMP DRIVERS | | Red emergency light |
| 616 | E | lt | AM AFT FIRE | Illuminates when a fire is detected in the AM aft area | | EMER SUBUNIT LAMP DRIVERS | | Red emergency light |
| 616 | E | lt | OWS CREW QTRS FIRE | Illuminates when a fire is detected in the OWS crew quarters | | EMER SUBUNIT LAMP DRIVERS | | Red emergency light |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 616 | E | lt | OWS BUS 1 LOW | Illuminates when the power to OWS BUS 1 is less than or equal to 23.5 ± .47 vdc | | C&W SUBUNIT LAMP DRIVERS | | Nominal range 25 to 30 vdc<br>Yellow caution light |
| 616 | E | lt | OWS BUS 2 LOW | Illuminates when the power to OWS BUS 2 is less than or equal to 23.5 ± .47 vdc | | C&W SUBUNIT LAMP DRIVERS | | Nominal range 25 to 30 vdc<br>Yellow caution light |
| | | | LIGHTING | | | | | |
| | | | UPPER WALL | | | | | |
| 616 | E | sw | +Z SAL 1•2•10 (up) | Turns on OWS upper wall lights 1, 2, and 10 | LTG UPPER WALL 1, 2, & 10 (pnl 613) | OWS BUS 1&2 | | OFF-LO-HI integral light switch is contained within all OWS lights and controls their intensity |
| | | | OFF | Turns off the above | | | | |
| 616 | E | sw | +Y 3•4 (up) | Turns on OWS upper wall lights 3 and 4 | LTG UPPER WALL 3 & 4 (pnl 613) | OWS BUS 1&2 | | |
| | | | OFF | Turns off the above | | | | |
| 616 | E | sw | -Z SAL 5•6•7 (up) | Turns on OWS upper wall lights 5, 6, and 7 | LTG UPPER WALL 5, 6, & 7 (pnl 613) | OWS BUS 1&2 | | |
| | | | OFF | Turns off the above | | | | |
| 616 | E | sw | -Y 8•9 (up) | Turns on OWS upper wall lights 8 and 9 | LTG UPPER WALL 8 & 9 (pnl 613) | OWS BUS 1&2 | | |
| | | | OFF | Turns off the above | | | | |
| | | | DOME | | | | | |
| 616 | E | sw | 1•3•5 (up) | Turns on OWS dome lights 1, 3, and 5 | LTG DOME 1, 3, & 5 (pnl 613) | OWS BUS 1 | | |
| | | | OFF | Turns off the above | | | | |
| 616 | E | sw | 2•4•6 (up) | Turns on OWS dome lights 2, 4, and 6 | LTG DOME 2, 4, & 6 (pnl 613) | OWS BUS 2 | | |
| | | | OFF | Turns off the above | | | | |
| 616 | E | sw | 7•8 (up) | Turns on OWS dome lights 7 and 8 | LTG DOME 7 & 8 (pnl 613) | OWS BUS 1&2 | | |
| | | | OFF | Turns off the above | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | EXPERIMENT COMPARTMENT | | | | | |
| 616 | E | sw | 1•3•5 (up) | Turns on OWS experiment compartment lights 1, 3, and 5 | LTG EXP COMPT 1, 3, & 5 (pnl 613) | OWS BUS 1 | | |
| | | | OFF | Turns off the above | | | | |
| 616 | E | sw | 2•4•6 (up) | Turns on OWS experiment compartment lights 2, 4, and 6 | LTG EXP COMPT 2, 4, & 6 (pnl 613) | OWS BUS 2 | | |
| | | | OFF | Turns off the above | | | | |
| 616 | E | sw | 13•14 (up) | Turns on OWS experiment compartment lights 13 and 14 | LTG EXP COMPT 13 & 14 (pnl 613) | OWS BUS 1&2 | | |
| | | | OFF | Turns off the above | | | | |
| 616 | E | sw | 7•9•11 (up) | Turns on OWS experiment compartment lights 7, 9, and 11 | LTG EXP COMPT 7, 9, & 11 (pnl 613) | OWS BUS 1 | | |
| | | | OFF | Turns off the above | | | | |
| 616 | E | sw | 8•10•12 (up) | Turns on OWS experiment compartment lights 8, 10, and 12 | LTG EXP COMPT 8, 10, & 12 (pnl 613) | OWS BUS 2 | | |
| | | | OFF | Turns off the above | | | | |
| 616 | E | sw | SLEEP COMPT (up) | Turns on sleep compartment lights 1, 2, and 3 | LTG SLEEP COMPT 1, 2, & 3 (pnl 613) | OWS BUS 1&2 | | |
| | | | OFF | Turns off the above | | | | |
| | | | REFRIGERATION SYSTEM | | | | | |
| | | | TEMPERATURE | | | | | |
| 616 | E | ind | °F | Displays temperature in the freezer section of the refrigeration loop at the point selected by the display selector | DISPLAY PWR/RCDR CONT. (pnl 613) | OWS BUS 1 | | Range -40° to 10°F |
| 616 | E | ind | °F | Displays temperature in the chiller section of the refrigeration loop at the point selected by the display selector | DISPLAY PWR/RCDR CONT. (pnl 613) | OWS BUS 2 | | Range 30° to 70°F |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | DISPLAY SELECT (1) | | | | | |
| 616 | E | sel | OFF | Connects indicator with OWS common return, dead facing meter | | | | |
| | | | HEAT SINK OUTLETS PRI | Displays temperature of the refrigeration system primary loop thermal capacitor coolant outlet | DISPLAY PWR/RCDR CONT. (pnl 613) | OWS BUS 1 | | Transducer range -40° to 10°F (-20° to -14° nominal) |
| | | | SEC | Displays temperature of the refrigeration system secondary loop thermal capacitor coolant outlet | DISPLAY PWR/RCDR CONT. (pnl 613) | OWS BUS 1 | | Transducer range -40° to 10°F (-20° to -14° nominal) |
| | | | URINE FREEZER | Displays temperature of the refrigeration system urine freezer | DISPLAY PWR/RCDR CONT. (pnl 613) | OWS BUS 1 | | Transducer range -40° to 10°F (-18° to -5° nominal) |
| | | | WARDROOM FREEZER 1 | Displays temperature of the wardroom food freezer compartment 1 | DISPLAY PWR/RCDR CONT. (pnl 613) | OWS BUS 1 | | Transducer Range -40° to 10°F (-20° to 1° nominal) |
| | | | 2 | Displays temperature of the wardroom food freezer compartment 2 | DISPLAY PWR/RCDR CONT (pnl 613) | OWS BUS 1 | | Transducer Range -40° to 10°F (-20 to 1° nominal) |
| | | | STOWAGE FREEZER 1 | Displays temperature of the food stowage freezer compartment 1 | DISPLAY PWR/RCDR CONT. (pnl 613) | OWS BUS 1 | | Transducer range -40° to 10°F (-20° to 1° nominal) |
| | | | 2 | Displays temperature of the food stowage freezer compartment 2 | DISPLAY PWR/RCDR CONT. (pnl 613) | OWS BUS 1 | | Transducer range -40° to 10°F (-20° to 1° nominal) |
| | | | 3 | Displays temperature of the food stowage freezer compartment 3 | DISPLAY PWR/RCDR CONT. (pnl 613) | OWS BUS 1 | | Transducer range -40° to 10°F (-20° to 1° nominal) |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | DISPLAY SELECT (2) | | | | | |
| 616 | E | sel | OFF | Connects indicator with OWS common return deadfacing meter | | | | |
| | | | CHILLER | | | | | |
| | | | WATER INLETS PRI | Displays temperature of the refrigeration system primary loop water chiller coolant inlet | DISPLAY PWR/RCDR CONT. (pnl 613) | OWS BUS 2 | | Transducer range 30° to 70°F (36° to 42° nominal) |
| | | | SEC | Displays temperature of the refrigeration system secondary loop water chiller coolant inlet | DISPLAY PWR/RCDR CONT. (pnl 613) | OWS BUS 2 | | Transducer range 30° to 70°F (36° to 42° nominal) |
| | | | FOOD | Displays temperature of the wardroom food chiller compartment | DISPLAY PWR/RCDR CONT. (pnl 613) | OWS BUS 2 | | Transducer range 30° to 70°F (36° to 42° nominal) |
| | | | URINE CHILLERS 1 | Displays temperature of the refrigeration system urine chiller #1 | DISPLAY PWR/RCDR CONT. (pnl 613) | OWS BUS 2 | | Transducer range 30° to 70°F (35° to 44° nominal) |
| | | | 2 | Displays temperature of the refrigeration system urine chiller #2 | DISPLAY PWR/RCDR CONT. (pnl 613) | OWS BUS 2 | | Transducer range 30° to 70°F (35° to 44° nominal) |
| | | | 3 | Displays temperature of the refrigeration system urine chiller #3 | DISPLAY PWR/RCDR CONT. (pnl 613) | OWS BUS 2 | | Transducer range 30° to 70°F (35° to 44° nominal) |
| | | | PRIMARY LOOP | | | | | |
| | | | INLET TEMP | | | | | |
| 616 | E | lt | FREEZER HIGH | Illuminates when the temperature in the wardroom food freezer primary coolant inlet is high | RS PRI LOOP LOGIC (pnl 611) | RS BUS 1 | | Switch closure T = 1.0 ± 1°F |
| 616 | E | lt | CHILLER LOW | Illuminates when the temperature in the wardroom table chiller primary coolant inlet is low | RS PRI LOOP LOGIC (pnl 611) | RS BUS 1 | | Switch closure T = 33.5 ± 1°F |
| 616 | E | lt | ACCUM LOW | Illuminates when the level in the primary coolant loop accumulator is low | RS PRI LOOP LOGIC (pnl 611) | RS BUS 1 | | Switch closure when 0 cu in fluid is detected and opens when 5 cu in fluid is added |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | PRIMARY LOOP (cont'd) | | | | | |
| | | | INLET TEMP (cont'd) | | | | | |
| 616 | E | lt | PUMP LOW Δ P | Illuminates when a low differential pressure between the pump inlet and outlet of the primary loop is detected | RS PRI LOOP LOGIC (pnl 611) | RS BUS 1 | | Switch closure Δ P = 35 psia |
| 616 | E | sw | STATUS RESET (up) | Turns off primary and secondary loop out-of-limit condition status lights | RS PRI,SEC LOOP LOGIC (pnl 611) | RS BUS 1,2 | | If out-of-limit condition still exists, lights will come back on when momentary sw released |
| | | | SECONDARY LOOP | | | | | |
| | | | INLET TEMP | | | | | |
| 616 | E | lt | FREEZER HIGH | Illuminates when the temperature in the wardroom food freezer secondary coolant inlet is high | RS SEC LOOP LOGIC (pnl 611) | RS BUS 2 | | Switch closure T = 1.0 ± 1°F |
| 616 | E | lt | CHILLER LOW | Illuminates when the temperature in the wardroom table chiller secondary coolant inlet is low | RS SEC LOOP LOGIC | RS BUS 2 | | Switch closure T = 33.5 ± 1°F |
| 616 | E | lt | ACCUM LOW | Illuminates when the level in the secondary coolant loop accumulator is low | RS SEC LOOP LOGIC (pnl 611) | RS BUS 2 | | Switch closure when 0 cu in fluid is detected and opens when 5 cu in fluid is added |
| 616 | E | lt | PUMP LOW Δ P | Illuminates when a low differential pressure between the pump inlet and outlet of the secondary loop is detected | RS SEC LOOP LOGIC (pnl 611) | RS BUS 2 | | Switch closure Δ P = 35 PSID |
| | | | PRIMARY PUMPS | | | | | |
| 616 | E | sw | 1 AUTO | Enables automatic control by primary logic unit | RS PRI LOOP LOGIC (pnl 611) | RS BUS 1 | | |
| | | | OFF | Turns primary pump 1 off | | | | |
| | | | ON | Turns primary pump 1 on through the primary coolant pump inverter | RS PRI LOOP LOGIC (pnl 611) | RS BUS 1 | | Manual command utilization logic unit, bypassing the AUTO control position |
| 616 | E | sw | 2 thru 4 AUTO | Enables automatic control by primary logic unit | RS PRI LOOP LOGIC (pnl 611) | RS BUS 1 | | |
| | | | OFF | Turns primary pump 2-4 off | | | | |
| | | | ON | Turns primary pumps 2-4 on through the primary coolant pump inverter | RS PRI LOOP LOGIC (pnl 611) | RS BUS 1 | | Manual command utilization logic unit, bypassing the AUTO control position |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | SECONDARY PUMPS | | | | | |
| 616 | E | sw | 1 AUTO | Enables automatic control by secondary logic unit | RS SEC LOOP LOGIC (pnl 611) | RS BUS 2 | | |
| | | | OFF | Turns secondary pump 1 off | | | | |
| | | | ON | Turns secondary pump 1 on through the secondary coolant pump inverter | RS SEC LOOP LOGIC (pnl 611) | RS BUS 2 | | Manual command utilization logic unit, bypassing the AUTO control position |
| 616 | E | sw | 2 thru 4 AUTO | Enables automatic control by secondary logic unit | RS SEC LOOP LOGIC (pnl 611) | RS BUS 2 | | |
| | | | OFF | Turns secondary pumps 2-4 off | | | | |
| | | | ON | Turns secondary pumps 2-4 on through the secondary coolant pump inverter | RS SEC LOOP LOGIC (pnl 611) | RS BUS 2 | | Manual command utilization logic unit, bypassing the AUTO control position |

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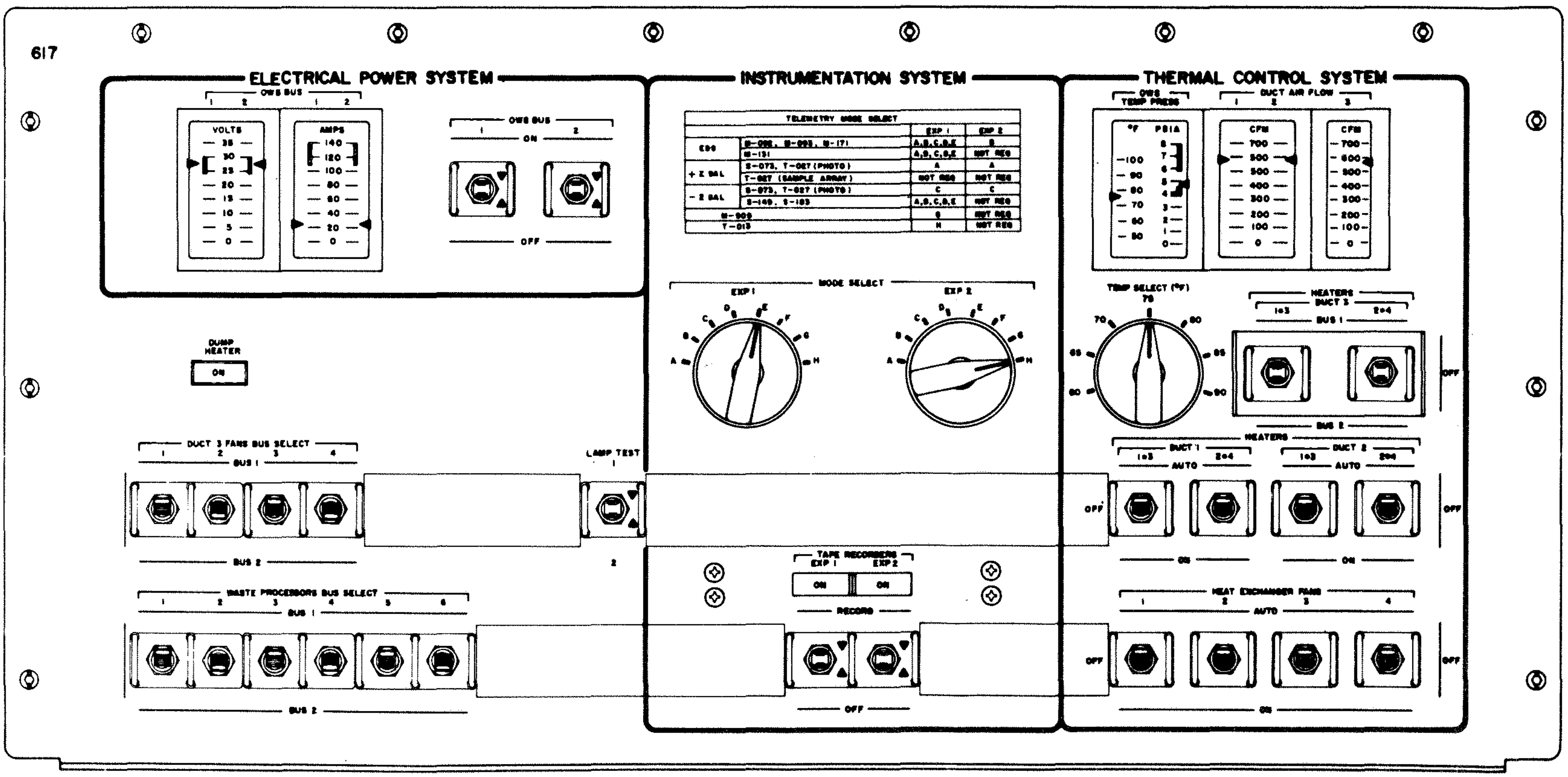
P21


617
ELECTRICAL POWER SYSTEM
INSTRUMENTATION SYSTEM
THERMAL CONTROL SYSTEM

617

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | ELECTRICAL POWER SYSTEM | | | | | |
| | | | OWS BUS | | | | | |
| 617 | E | ind | VOLTS | | | | | |
| | | | 1 | Provides OWS bus 1 voltage indication | | OWS BUS 1 | | Range 0 to 35 volts |
| | | | 2 | Provides OWS bus 2 voltage indication | | OWS BUS 2 | | Range 0 to 35 volts |
| 617 | E | ind | AMPS | | | | | |
| | | | 1 | Indicates current from REG bus 1 to OWS bus 1 | DISPLAY PWR/RCDR CONT. (pnl 613) | OWS BUS 1 | | Range 0 to 140 amps |
| | | | 2 | Indicates current from REG bus 2 to OWS bus 2 | DISPLAY PWR/RCDR CONT. (pnl 613) | OWS BUS 2 | | Range 0 to 140 amps |
| | | | OWS BUS | | | | | |
| 617 | E | sw | 1 | | | | | |
| | | | ON | Connects OWS bus 1 to REG bus 1 | OWS BUS 1 FEEDERS CONT OWS (pnl 201) | EPS CONTROL BUS 1 | | Similar sw function on AM panel 206 |
| | | | OFF | Disconnects the above | | | | |
| 617 | E | sw | 2 | | | | | |
| | | | ON | Connects OWS bus 2 to AREG bus 2 | OWS BUS 2 FEEDERS CONT OWS (pnl 201) | EPS CONTROL BUS 2 | | Similar sw function on AM panel 206 |
| | | | OFF | Disconnects the above | | | | |
| 617 | E | lt | DUMP HEATER ON | Illuminates when a waste tank dump heater probe is turned on | DISPLAY PWR/RCDR CONT. (pnl 613) | OWS BUS 1or 2 | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | DUCT 3 FANS BUS SELECT | | | | | |
| 617 | E | sw | 1 | | | | | |
| | | | BUS 1 | OWS BUS 1 powers duct 3 fan 1 on | TCS BUS 1, 2, DUCT 3 FANS 1/2 (pnl 614) | OWS BUS 1&2 | | |
| | | | BUS 2 | OWS BUS 2 powers duct 3 fan 1 on | | | | |
| 617 | E | sw | 2 | | | | | |
| | | | BUS 1 | OWS BUS 1 powers duct 3 fan 2 on | TCS BUS 1,2 DUCT 3 FANS 1/2 (pnl 614) | OWS BUS 1&2 | | |
| | | | BUS 2 | OWS BUS 2 powers duct 3 fan 2 on | | | | |
| 617 | E | sw | 3 | | | | | |
| | | | BUS 1 | OWS BUS 1 powers duct 3 fan 3 on | TCS BUS 1, 2 DUCT 3 FANS 3/4 (pnl 614) | OWS BUS 1&2 | | |
| | | | BUS 2 | OWS BUS 2 powers duct 3 fan 3 on | | | | |
| 617 | E | sw | 4 | | | | | |
| | | | BUS 1 | OWS BUS 1 powers duct 3 fan 4 on | TCS BUS 1, 2 DUCT 3 FANS 3/4 (pnl 614) | OWS BUS 1&2 | | |
| | | | BUS 2 | OWS BUS 2 power duct 3 fan 4 on | | | | |
| 617 | E | sw | LAMP TEST | | | | | |
| | | | 1 | Tests DUMP HEATER ON light #1 | DISPLAY LAMP TEST (pnl 613) | OWS BUS 1 | | Momentary switch with return to center position |
| | | | (ctr) | | | | | |
| | | | 2 | Tests DUMP HEATER ON light #2 and TAPE RECORDERS EXP 1 and 2 ON lights | DISPLAY LAMP TEST (pnl 613) | OWS BUS 2 | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | WASTE PROCESSORS BUS SELECT | | | | | |
| 617 | E | sw | 1 BUS 1 | Selects OWS bus 1 to power waste processor #1 | HSS BUS 1&2 WASTE PROCESSORS 1/2 (pnl 614) | OWS BUS 1 or 2 | | |
| | | | BUS 2 | Selects OWS bus 2 to power waste processor #1 | | | | |
| 617 | E | sw | 2 BUS 1 | Selects OWS bus 1 to power waste processor #2 | HSS BUS 1&2 WASTE PROCESSORS 1/2 (pnl 614) | OWS BUS 1 or 2 | | |
| | | | BUS 2 | Selects OWS bus 2 to power waste processor #2 | | | | |
| 617 | E | sw | 3 BUS 1 | Selects OWS bus 1 to power waste processor #3 | HSS BUS 1&2 WASTE PROCESSORS 3/4 (pnl 614) | OWS BUS 1 or 2 | | |
| | | | BUS 2 | Selects OWS bus 2 to power waste processor #3 | | | | |
| 617 | E | sw | 4 BUS 1 | Selects OWS bus 1 to power waste processor #4 | HSS BUS 1&2 WASTE PROCESSORS (pnl 614) | OWS BUS 1 or 2 | | |
| | | | BUS 2 | Selects OWS bus 2 to power waste processor #4 | | | | |
| 617 | E | sw | 5 BUS 1 | Selects OWS bus 1 to power waste processor #5 | HSS BUS 1&2 WASTE PROCESSORS 5/6 (pnl 614) | OWS BUS 1 or 2 | | |
| | | | BUS 2 | Selects OWS bus 2 to power waste processor #5 | | | | |
| 617 | E | sw | 6 BUS 1 | Selects OWS bus 1 to power waste processor #6 | HSS BUS 1&2 WASTE PROCESSORS 5/6 (pnl 614) | OWS BUS 1 or 2 | | |
| | | | BUS 2 | Selects OWS bus 2 to power waste processor #6 | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | INSTRUMENTATION SYSTEM | | | | | |
| | | | MODE SELECT | | | | | |
| 617 | E | sel | EXP 1 | | | | | |
| | | | A | Selects +Z SAL for instrumentation monitoring and enables subframe 2 recording | DISPLAY PWR/RCDR CONT (pnl 613) | OWS BUS 2 | | |
| | | | B | Selects ESS for monitoring and enables subframe 2 recording | DISPLAY PWR/RCDR CONT. (pnl 613) | OWS BUS 2 | | |
| | | | C | Selects -Z SAL for monitoring and enables subframe 2 recording | DISPLAY PWR/RCDR CONT (pnl 613) | OWS BUS 2 | | |
| | | | D | Open position (enables subframe 2 recording) | DISPLAY PWR/RCDR CONT (pnl 613) | OWS BUS 2 | | |
| | | | E | Open position (enables subframe 2 recording) | DISPLAY PWR/RCDR CONT (pnl 613) | OWS BUS 2 | | |
| | | | F | Disables subframe 2 recording | DISPLAY PWR/RCDR CONT (pnl 613) | OWS BUS 2 | | Overridden by the ENABLE position of the EKG/ZPN sw (panel 204) |
| | | | G | Disables subframe 2 and enables M509 PCM recording | DISPLAY PWR/RCDR CONT (pnl 613) | OWS BUS 2 | | Overridden by the ENABLE Position of the EKG/ZPN sw (panel 204) |
| | | | H | Disables subframe 2 and enables T013 PCM recording | DISPLAY PWR/RCDR CONT (pnl 613) | OWS BUS 2 | | Overridden by the ENABLE position of the EKG/ZPN sw (panel 204) |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 617 | E | sel | EXP 2 | | | | | |
| | | | A | Selects +Z SAL for monitoring | NONE | NONE | | |
| | | | B | Selects ESS for monitoring | NONE | NONE | | |
| | | | C | Selects -Z SAL for monitoring | NONE | NONE | | |
| | | | D | Open position | NONE | NONE | | |
| | | | E | Open position | NONE | NONE | | |
| | | | F | Open position | NONE | NONE | | |
| | | | G | Open position | NONE | NONE | | |
| | | | H | Open position | NONE | NONE | | |
| | | | TAPE RECORDERS | | | | | |
| | | | EXP 1 | | | | | |
| 617 | E | lt | ON | Illuminates when the EXP 1 recorder is in motion and EXP 1 recording has been initiated | AM INSTR PNL LTS STATUS (pnl 202) | AM BUS 2 | | Extinguished when the EKG/ZPN sw (panel 204) is enabled |
| 617 | E | sw | RECORD | Activates EXP 1 recording | DISPLAY PWR/RCDR CONT (pnl 613) | OWS BUS 1&2 | | Momentary switch with return to the center position |
| | | | (ctr) | | | | | |
| | | | OFF | Turns off EXP 1 recording if originally initiated from the OWS (pnl 542 or 617) | DISPLAY PWR/RCDR CONT (pnl 613) | OWS BUS 1&2 | | Momentary switch with return to the center position |
| | | | EXP 2 | | | | | |
| 617 | E | lt | ON | Illuminates when the EXP 2 recorder is in motion and EXP 2 recording has been initiated | AM INSTR PANEL LTS STATUS (pnl 202) | AM BUS 2 | | Extinguished when the EKG/ZPN sw (panel 204) is enabled or if DCS control of DATA 2 is enabled |
| 617 | E | sw | RECORD | Activates EXP 2 recording and inhibits DCS control of DATA 2 recording | DISPLAY PWR/RCDR CONT (pnl 613) | OWS BUS 1&2 | | Momentary switch with return to the center position |
| | | | (ctr) | | | | | |
| | | | OFF | Turns off EXP 2 recording originally initiated from the OWS and enables DCS control of DATA 2 recording | DISPLAY PWR/RCDR CONT (pnl 613) | OWS BUS 1&2 | | Momentary switch with return to the center position |

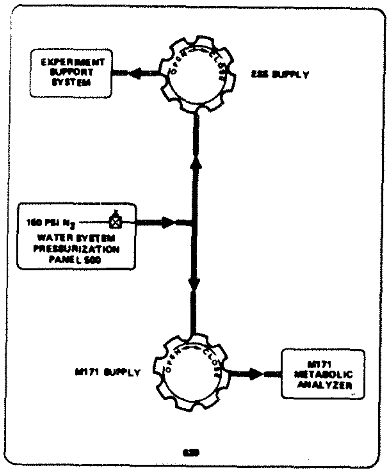
| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | THERMAL CONTROL SYSTEM | | | | | |
| 617 | E | ind | OWS | | | | | |
| | | | TEMP | Displays cabin temperature from 50° to 100°F sensed in the OWS wardroom | DISPLAY PWR/RCDR CONT (pnl 613) | OWS BUS 2 | | Transducer range 40° to 100°F |
| | | | PRESS | Displays OWS cabin pressure | DISPLAY PWR/RCDR CONT (pnl 613) | OWS BUS 2 | | Range 0 to 8 psia |
| | | | DUCT AIR FLOW | | | | | |
| 617 | E | ind | 1 | Displays duct 1 air flow | DISP PWR/ RCDR CONT (pnl 613) | OWS BUS 2 | | Range 0 to 700 cfm |
| | | | 2 | Displays duct 2 air flow | DISP PWR/ RCDR CONT (pnl 613) | OWS BUS 1 | | Range 0 to 700 cfm |
| | | | 3 | Displays duct 3 air flow | DISP PWR/ RCDR CONT (pnl 613) | OWS BUS 1 | | Range 0 to 700 cfm |
| 617 | E | sel | TEMP SELECT (°F) | Selects desired cabin temperature of OWS | | | | Range 60 to 90°F |
| | | | HEATERS DUCT 3 | | | | | |
| 617 | E | sw | 1•3 | | | | | |
| | | | BUS 1 | Turns duct 3 heaters 1 and 3 on | TCS BUS 1 DUCT 3 HTRS 1•3 (pnl 614) | OWS BUS 1 | | |
| | | | OFF | Turns duct 3 heaters 1 and 3 off | | | | |
| | | | BUS 2 | Turns duct 3 heaters 1 and 3 on | TCS BUS 2 DUCT 3 HTRS 1•3 (pnl 614) | OWS BUS 2 | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | HEATERS DUCT 3 (cont'd) | | | | | |
| 617 | E | sw | 2•4 | | | | | |
| | | | BUS 1 | Turns duct 3 heaters 2 and 4 on | TCS BUS 1 DUCT 3 HTRS 2•4 (pnl 614) | OWS BUS 1 | | |
| | | | OFF | Turns duct 3 heaters 2 and 4 off | | | | |
| | | | BUS 2 | Turns duct 3 heaters 2 and 4 on | TCS BUS 2 DUCT 3 HTRS 2•4 (pnl 614) | OWS BUS 2 | | |
| | | | HEATERS | | | | | |
| | | | DUCT 1 | | | | | |
| 617 | E | sw | 1•3 | | | | | |
| | | | AUTO | Enables automatic control of duct 1 htrs 1 and 3 by the thermal control system | TCS DUCT 1 HTRS AUTO 1•3 (pnl 614) | OWS BUS 1 | | |
| | | | OFF | Turns duct 1 htrs 1 and 3 off | | | | |
| | | | ON | Turns duct 1 htrs 1 and 3 on | TCS DUCT 1 HTRS MAN 1•3 (pnl 614) | OWS BUS 1 | | |
| 617 | E | sw | 2•4 | | | | | |
| | | | AUTO | Enables automatic control of duct 1 htrs 2 and 4 by the thermal control system | TCS DUCT 1 HTRS AUTO 2•4 (pnl 614) | OWS BUS 1 | | |
| | | | OFF | Turns duct 1 htrs 2 and 4 off | | | | |
| | | | ON | Turns duct 1 htrs 2 and 4 on | TCS DUCT 1 HTRS MAN 2•4 (pnl 614) | OWS BUS 1 | | |

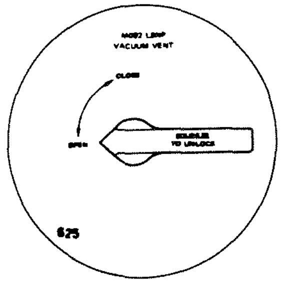
| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | HEATERS (cont'd) | | | | | |
| | | | DUCT 2 | | | | | |
| 617 | E | sw | 1•3 | | | | | |
| | | | AUTO | Enables automatic control of duct 2 htrs 1 and 3 by the thermal control system | TCS DUCT 2 HTRS AUTO 1•3 (pnl 614) | OWS BUS 2 | | |
| | | | OFF | Turns duct 2 htrs 1 and 3 off | | | | |
| | | | ON | Turns duct 2 htrs 1 and 3 on | | | | |
| 617 | E | sw | 2•4 | | | | | |
| | | | AUTO | Enables automatic control of duct 2 htrs 2 and 4 by the thermal control system | TCS DUCT 2 HTRS AUTO 2•4 (pnl 614) | OWS BUS 2 | | |
| | | | OFF | Turns duct 2 htrs 2 and 4 off | | | | |
| | | | ON | Turns duct 2 htrs 2 and 4 on | TCS DUCT 2 HTRS MAN 2•4 (pnl 614) | OWS BUS 2 | | |
| | | | HEAT EXCHANGER FANS | | | | | |
| 617 | E | sw | 1 | | | | | |
| | | | AUTO | Enables automatic control of heat exchanger fan and valve 1 by thermal control system | TCS HT EXCH FANS 1 (pnl 614) | OWS BUS 1 | | |
| | | | OFF | Turns heat exchanger fan and valve 1 off | | | | |
| | | | ON | Turns heat exchanger fan and valve 1 on | | | | |
| 617 | E | sw | 2 | | | | | |
| | | | AUTO | Enables automatic control of the heat exchanger fan and valve 2 by thermal control system | TCS HT EXCH FANS 2 (pnl 614) | OWS BUS 2 | | |
| | | | OFF | Turns heat exchanger fan and valve 2 off | | | | |
| | | | ON | Turns heat exchanger fan and valve 2 on | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | HEAT EXCHANGER FANS (cont'd) | | | | | |
| 617 | E | sw | 3 | | | | | |
| | | | AUTO | Enables automatic control of the heat exchanger fan and valve 3 by the thermal control system | TCS HT EXCH FANS 3 (pnl 614) | OWS BUS 1 | | |
| | | | OFF | Turns heat exchanger fan and valve 3 off | | | | |
| | | | ON | Turns heat exchanger fan and valve 3 on | | | | |
| 617 | E | sw | 4 | | | | | |
| | | | AUTO | Enables automatic control of the heat exchanger fan and valve 4 by the thermal control system | TCS HT EXCH FANS 4 (pnl 614) | OWS BUS 2 | | |
| | | | OFF | Turns heat exchanger fan and valve 4 off | | | | |
| | | | ON | Turns heat exchanger fan and valve 4 off | | | | |
| 618 | E | | FIRE SENSOR CONTROL | -------------- See Panel 120 -------------- | | | | |
| 619 | E | | FIRE SENSOR CONTROL | -------------- See Panel 120 -------------- | | | | |

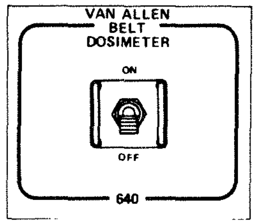
P29



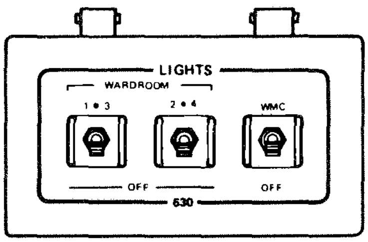

620




625




640

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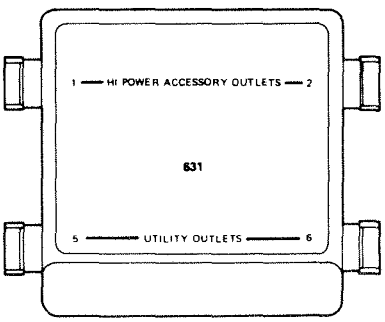
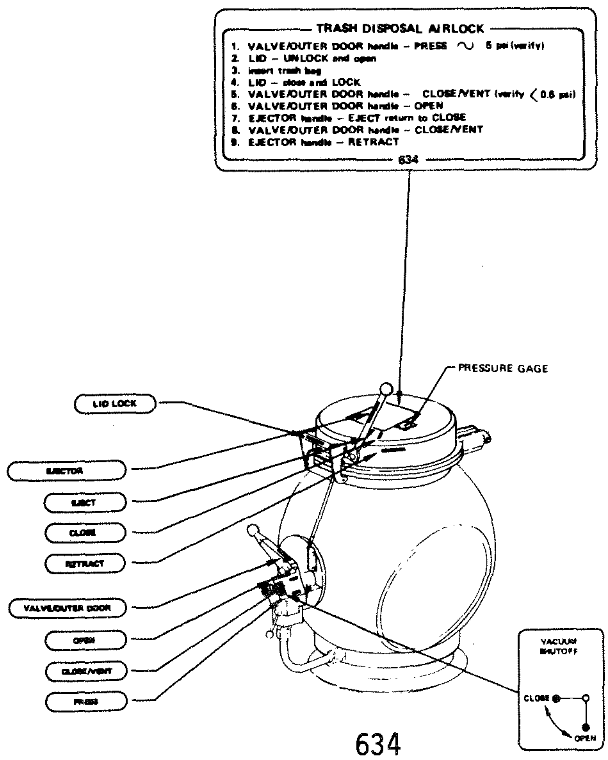



631




634

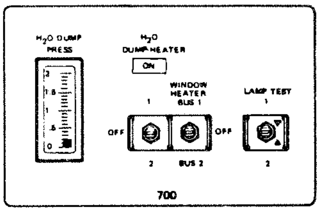
| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 620 | E | vlv | ESS SUPPLY | Controls 150 PSI N2 gas from N2 supply to experiment support system | | | | Counterclockwise rotation opens valve<br>Clockwise rotation closes valve |
| 620 | E | vlv | M171 SUPPLY | Controls 150 PSI N2 gas from N2 supply to the M171 metabolic analyzer | | | | Counterclockwise rotation opens valve<br>Clockwise rotation closes valve |
| 625 | E | vlv | M092 LBNP VACUUM VENT | | | | | |
| | | | OPEN | Vents M092 lower body negative pressure experiment to vacuum | | | | |
| | | | CLOSE | Closes the vent | | | | |
| 627 | E | | INTERCOM BOX | -------------- See Panel 102 -------------- | | | | |
| | | | UTILITY OUTLETS | | | | | |
| 628 | E | conn | 3 | Zero-G receptacle, provides electrical power interface with portable equipment plug | UTIL OUTLETS EXP COMPT 3 (pnl 612) | OWS BUS 1 | | Typical for panels 601 and 628 |
| 628 | E | conn | 4 | Zero-G receptacle, provides electrical power interface with portable equipment plug | UTIL OUTLETS EXP COMPT 4 (pnl 612) | OWS 8US 2 | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | LIGHTS | | | | | |
| | | | WARDROOM | | | | | |
| 630 | E | sw | 1•3 | Turns on OWS wardroom lights 1 and 3 | LTG WARDRM 1&3 (pnl 613) | OWS BUS 1 | | |
| | | | OFF | Turns off the above | | | | |
| 630 | E | sw | 2•4 | Turns on OWS wardroom lights 2 and 4 | LTG WARDRM 2&4 (pnl 613) | OWS BUS 2 | | |
| | | | OFF | Turns off the above | | | | |
| 630 | E | sw | WMC | Turns on OWS WMC lights 1, 2 and 3 | LTG WMC 1, 2 & 3 (pnl 613) | OWS BUS 1&2 | | |
| | | | OFF | Turns off the above | | | | |
| | | | HI POWER ACCESSORY OUTLETS | | | | | |
| 631 | E | conn | 1 | Zero-G receptacle provides electrical power interface with portable equipment plug | HI PWR ACC OUTLETS EXP COMPT 1 (pnl 612) | OWS BUS 1 | | |
| 631 | E | conn | 2 | Zero-g receptacle provides electrical power interface with portable equipment plug | HI PWR ACC OUTLETS EXP COMPT 2 | OWS BUS 2 | | |
| | | | UTILITY OUTLETS | | | | | |
| 631 | E | conn | 5 | Zero-G receptacle provides electrical power interface with portable equipment plug | UTIL OUTLETS EXP COMPT 5 (pnl 612) | OWS BUS 1 | | |
| 631 | E | conn | 6 | Zero-G receptacle provides electrical power interface with portable equipment plug | UTIL OUTLETS EXP COMPT 6 (pnl 612) | OWS BUS 2 | | |
| 633 | E | | FIRE SENSOR CONTROL | --------------- See Panel 120 ------------- | | | | |

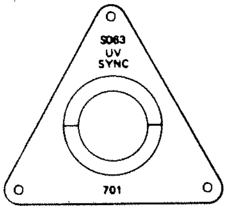
| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | TRASH DISPOSAL AIRLOCK | | | | | |
| 634 | E | hndl | EJECTOR | | | | | |
| | | | EJECT | Extends trash ejector mechanism | | | | |
| | | | CLOSE | Retracts ejector mechanism partially | | | | Handle returns to this position after ejector is released from EJECT |
| | | | RETRACT | Retracts trash ejector mechanism to stored position | | | | |
| 634 | E | ind | [Pressure Gage] | Indicates the trash airlock internal pressure | | | | Range 0 to 15 PSI |
| 634 | E | hndl | LID LOCK | | | | | |
| | | | (OPEN) | Releases lid and engages VALVE/OUTER DOOR handle interlock | | | | |
| | | | (CLOSE) | Locks lid in closed position | | | | |
| 634 | E | hndl | VALVE/OUTER DOOR | | | | | |
| | | | OPEN | Opens outer door for trash ejection | | | | |
| | | | CLOSE/VENT | Closes the outer door (if open), closes the trash disposal airlock pressurization valve, and vents the trash disposal airlock to vacuum of the waste tank | | | | |
| | | | PRESS | Closes the trash disposal airlock vent valve and connects trash disposal airlock to cabin for pressurization | | | | |
| 634 | E | vlv | VACUUM SHUTOFF | | | | | |
| | | | CLOSE | Seals off the trash disposal airlock vent line downstream of the vent valve and inhibits venting to the waste tank | | | | |
| | | | OPEN | Opens the trash disposal airlock vent line and enables venting | | | | |
| 638 | E | | FIRE SENSOR CONTROL | -------------- See Panel 120 ------------ | | | | |
| 639 | E | | FIRE SENSOR CONTROL | -------------- See Panel 120 ------------ | | | | |
| 640 | E | sw | VAN ALLEN BELT DOSIMETER | | | AM BUS 2 | | |
| | | | ON | Turns on Van Allen belt dosimeter | | | | |
| | | | OFF | Turns off the above | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | TELEVISION STATION | | | | | |
| 642 | E | sw | TELEVISION | | | | | |
| | | | POWER | | | | | |
| | | | ON | Powers televison camera | TV OUTLETS EXP COMPT (pnl 612) | OWS BUS 2 | | |
| | | | OFF | Deactivates above | | | | |
| 642 | E | pot | GAIN | Rotary trim potentiometer that allows adjustment of video signal from camera | | | | Potentiometer provided with screwdriver slot. Rotate clockwise to increase amplification |
| 642 | E | conn | CAMERA (connector) | Zero-G connector for portable TV camera | | | | Power to and signal from the camera |

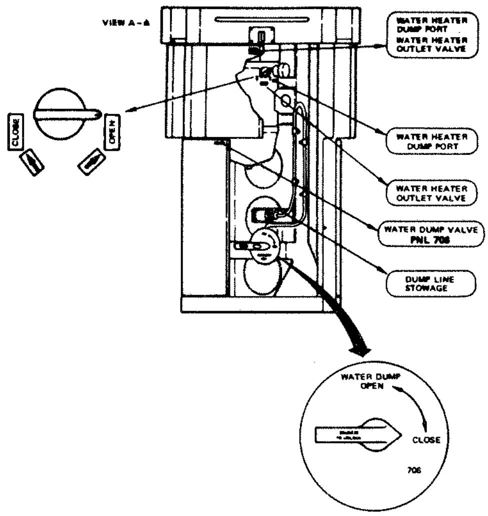
P27



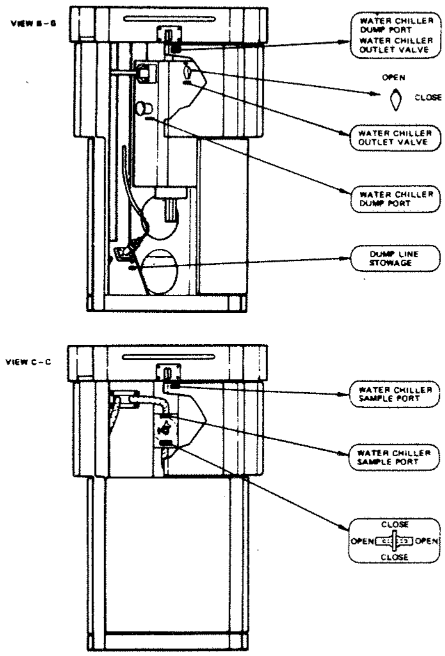

700

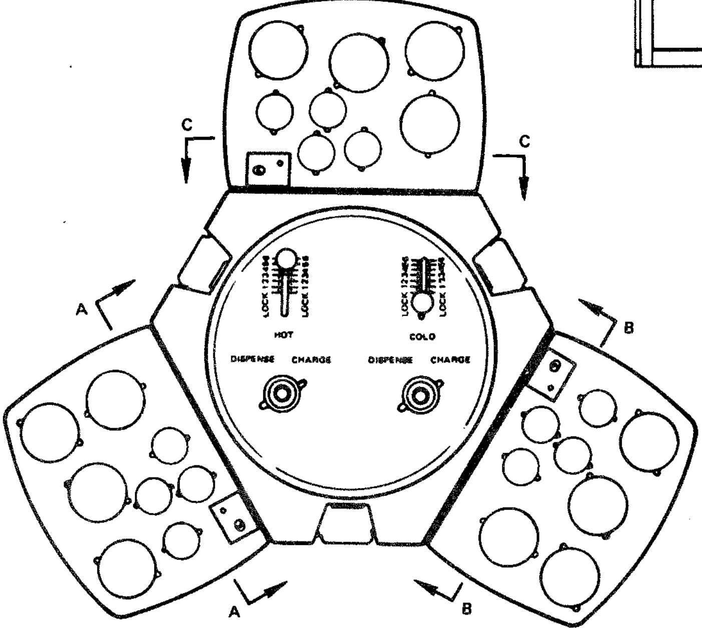



701




706



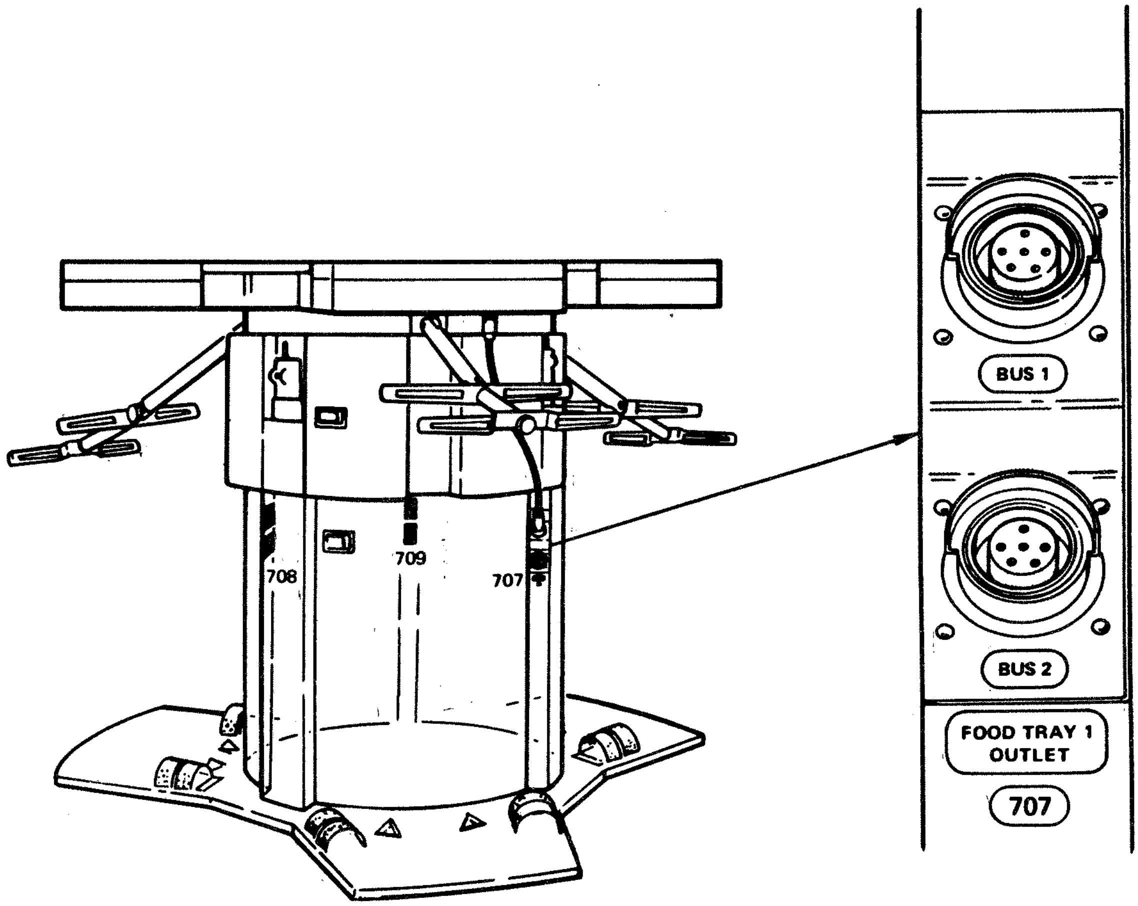




705

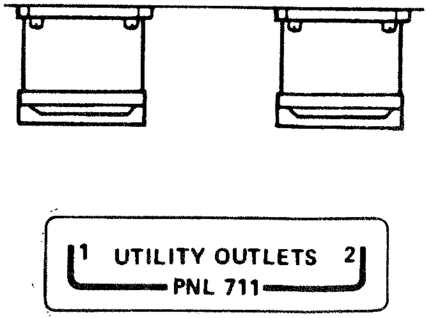
| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 700 | W | ind | H2O DUMP PRESS | Indicates the wardroom water dump line pressure | DISPLAY PWR/RCDR CONT. (pnl 613) | OWS BUS 2 | | Range 0 to 2 |
| 700 | W | lt | H2O DUMP HEATER | Illuminates when the wardroom water dump probe heater is on | DISPLAY PWR/RCDR CONT. (pnl 613) | OWS BUS 1 or 2 | | |
| 700 | W | sw | H2O DUMP HEATER | | | | | |
| | | | 1 | Turns on the wardroom water dump probe bus 1 heater element | HSS BUS 1 DUMP HTRS WARDRM H2O (pnl 614) | OWS BUS 1 | | |
| | | | OFF | Turns wardroom water dump probe heater off | | | | |
| | | | 2 | Turns on wardroom water dump probe bus 2 heater element | HSS BUS 2 DUMP HTRS WARDRM H2O (pnl 614) | OWS BUS 2 | | |
| 700 | W | sw | WINDOW HEATER | | | | | |
| | | | BUS 1 | Turns on wardroom window heater | TCS BUS 1 WINDW HTR (pnl 614) | OWS BUS 1 | | |
| | | | OFF | Turns wardroom window heater off | | | | |
| | | | BUS 2 | Turns on wardroom window heater | TCS BUS 2 WINDW HTR (pnl 614) | OWS BUS 2 | | |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 700 | W | sw | LAMP TEST | | | | | |
| | | | 1 | Illuminates lamp 1 of H2O DUMP HEATER ON light | DISP BUS 1 LAMP TEST (pnl 613) | OWS BUS 1 | | Momentary switch with return to the center position |
| | | | 2 | Illuminates lamp 2 of H2O DUMP HEATER ON light | DISP BUS 2 LAMP TEST (pnl 613) | OWS BUS 2 | | |
| 701 | W | conn | S063 UV SYNC | Provides connection point interface for S063 camera synchronization | | | | |
| 702 | W | | SPEAKER INTERCOM ASSEMBLY | ------------- See Panel 102 ------------- | | | | |
| | | | FOOD TABLE | | | | | |
| 705 | W | vlv | HOT | | | | | |
| | | | 1-6 | Selects amount of hot water (1-6 ounces) for food reconstitution | | | | |
| | | | LOCK | Locks selector in (0) ounce dispenser position | | | | |
| 705 | W | vlv | DISPENSE | Dispenses hot water through dispense port | | | | |
| | | | CHARGE | Fills accumulator with selected amount of hot water for dispensing | | | | |
| 705 | W | vlv | COLD | | | | | |
| | | | 1-6 | Selects amount of cold water (1-6 ounces) for food reconstitution | | | | |
| | | | LOCK | Locks selector in (0) ounce dispense position | | | | |
| 705 | W | vlv | DISPENSE | Dispenses cold water through dispense port | | | | |
| | | | CHARGE | Fills acuumulator with selected amount of cold water for dispensing | | | | |
| 705 | W | vlv | WATER HEATER OUTLET VALVE | | | | | |
| | | | OPEN | Connects the wardroom H2O heater with the hot food reconstitution dispenser | | | | |
| | | | CLOSE | Disconnects the above | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 705 | W | vlv | WATER CHILLER OUTLET VALVE | | | | | |
| | | | OPEN | Connects the water chiller with the cold food reconstitution dispenser | | | | |
| | | | CLOSE | Disconnects the above | | | | |
| 705 | W | vlv | WATER CHILLER SAMPLE PORT | | | | | |
| | | | OPEN | Connects the water chiller sample port with the water chiller water inlet line | | | | |
| | | | CLOSE | Disconnects the above | | | | |
| 706 | W | vlv | WATER DUMP | | | | | |
| | | | OPEN | Connects wardroom water network to wardroom water system dump to waste tank | | | | |
| | | | CLOSE | Disconnects the above | | | | |


708
709
707
BUS 1
BUS 2
FOOD TRAY 1
OUTLET
707

707


1 UTILITY OUTLETS 2
PNL 711

711

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 707 | W | conn | FOOD TRAY 1 OUTLET BUS 1 | Zero-G receptacle, provides electrical power interface with food tray 1 | HSS BUS 1 FOOD TRAYS 1 (pnl 614) | OWS BUS 1 | | |
| | | | FOOD TRAY 1 OUTLET BUS 2 | Zero-G receptacle, provides electrical power interface with food tray 1 | HSS BUS 2 FOOD TRAYS 1 (pnl 614) | OWS BUS 2 | | |
| 708 | W | conn | FOOD TRAY 2 OUTLET BUS 1 | Zero-G receptacle, provides electrical power interface with food tray 2 | HSS BUS 1 FOOD TRAYS 2 (pnl 614) | OWS BUS 1 | | |
| | | | FOOD TRAY 2 OUTLET BUS 2 | Zero-G receptacle, provides electrical power interface with food tray 2 | HSS BUS 2 FOOD TRAYS 2 (pnl 614) | OWS BUS 2 | | |
| 709 | W | conn | FOOD TRAY 3 OUTLET BUS 1 | Zero-G receptacle, provides electrical power interface with food tray 3 | HSS BUS 1 FOOD TRAYS 3 (pnl 614) | OWS BUS 1 | | |
| | | | FOOD TRAY 3 OUTLET BUS 2 | Zero-G receptacle, provides electrical power interface with food tray 3 | HSS BUS 2 FOOD TRAYS 3 (pnl 614) | OWS BUS 2 | | |
| | | | UTILITY OUTLETS | | | | | |
| 711 | W | conn | 1 | Zero-G receptacle, provides electrical power interface with portable equipment plug | UTIL OUTLETS OUTLETS WARDROOM 1 (pnl 612) | OWS BUS 1 | | |
| 711 | W | conn | 2 | Zero-G receptacle, provides electrical power interface with portable equipment plug | UTIL OUTLETS OUTLETS WARDROOM 2 (pnl 612) | OWS BUS 2 | | |

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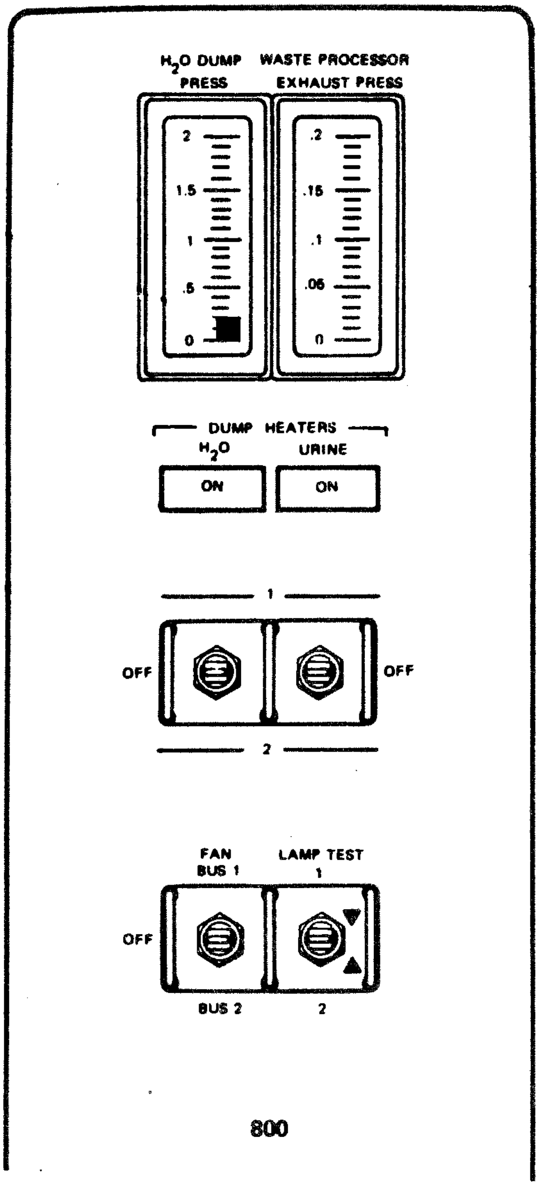
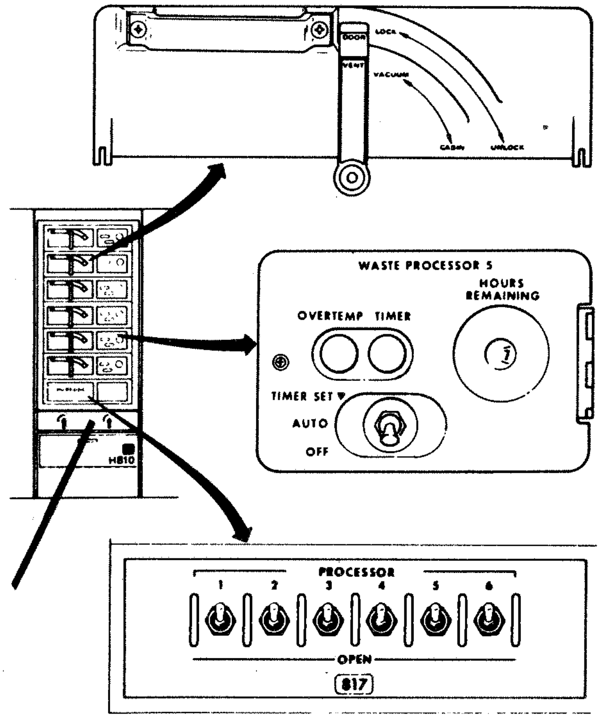
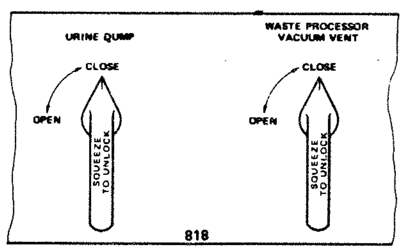

$H_2O$ DUMP PRESS
WASTE PROCESSOR EXHAUST PRESS
2
1.5
1
.5
0
.2
.15
.1
.05
0
DUMP HEATERS
$H_2O$
URINE
ON
ON
1
OFF
OFF
2
FAN BUS 1
LAMP TEST 1
OFF
BUS 2
2
800

P30


DOOR
VENT
LOCK
VACUUM
CABIN
UNLOCK
WASTE PROCESSOR 5
HOURS REMAINING
OVERTEMP
TIMER
TIMER SET
AUTO
OFF
H810
PROCESSOR
1
2
3
4
5
6
OPEN
817

817


URINE DUMP
WASTE PROCESSOR VACUUM VENT
CLOSE
OPEN
SQUEEZE TO UNLOCK
CLOSE
OPEN
SQUEEZE TO UNLOCK
818

818

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 800 | H | ind | H2O DUMP PRESS | Indicates the WMC water dump line pressure | DISPLAY PWR/RCDR CONT. (pnl 613) | OWS BUS 1 | | Range 0 to 2 psi |
| 800 | H | ind | WASTE PROCESSOR EXHAUST PRESS | Indicates the waste processor vacuum exhaust line pressure | DISPLAY PWR/RCDR CONT. (pnl 613) | OWS BUS 2 | | Range 0 to 0.2 psi |
| | | | DUMP H2O | | | | | |
| 800 | H | lt | ON | Illuminates when the WMC water dump probe heater is on | DISPLAY PWR/RCDR CONT. (pnl 613) | OWS BUS 1 or 2 | | |
| 800 | H | sw | 1 | Turns on WMC water dump probe BUS 1 heater element | HSS BUS 1 DUMP HTRS WMC H2O (pnl 614) | OWS BUS 1 | | |
| | | | OFF | Turns off WMC water dump probe heater elements | | | | |
| | | | 2 | Turns on WMC water dump probe bus 2 heater element | HSS BUS 1 DUMP HTRS URINE (pnl 614) | OWS BUS 2 | | |
| | | | HEATERS URINE | | | | | |
| 800 | H | lt | ON | Illuminates when the urine dump probe heater is on | DISPLAY PWR/RCDR CONT. (pnl 613) | OWS BUS 1 or 2 | | |
| 800 | H | sw | 1 | Turns on urine dump probe bus 1 heater element | HSS BUS 1 DUMP HTRS URINE (pnl 614) | OWS BUS 1 | | |
| | | | OFF | Turns off urine dump probe heater elements | | | | |
| | | | 2 | Turns on urine dump probe bus 2 heater element | HSS BUS 2 DUMP HTRS URINE (pnl 614) | OWS BUS 2 | | |

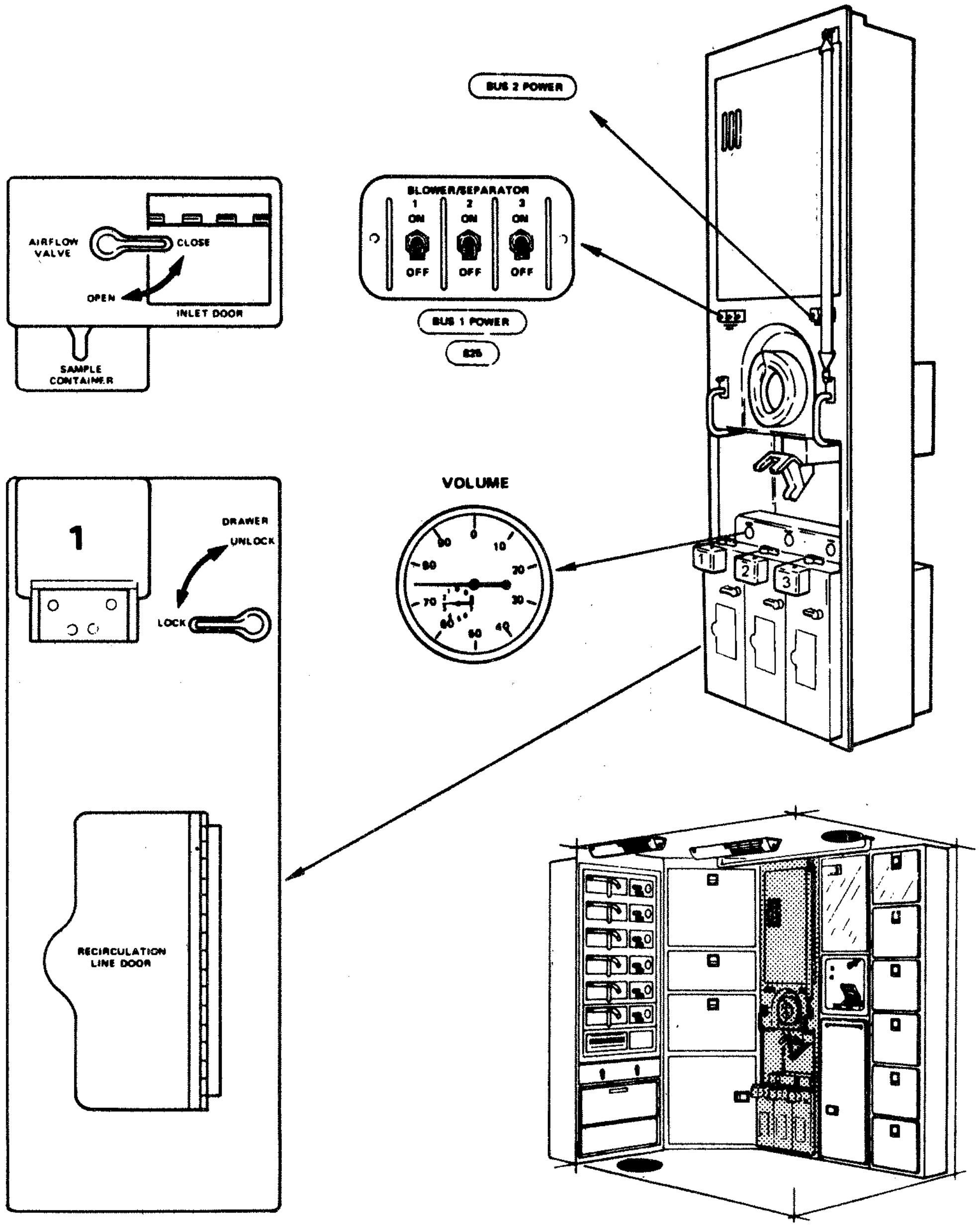
| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 800 | H | sw | FAN | | | | | |
| | | | BUS 1 | Turns on WMC Filter Fan | WMC FAN BUS 1 (pnl 614) | OWS BUS 1 | | |
| | | | OFF | Turns off WMC Filter Fan | | | | |
| | | | BUS 2 | Turns on WMC Filter Fan | WMC FAN BUS 2 (Pnl 614) | OWS BUS 2 | | |
| 800 | H | sw | LAMP TEST 1 | Illuminates lamp 1 of the DUMP H20 ON, URINE HEATERS on lights, and all OVER-TEMP and TIMER lights on waste processors | DISP BUS 1 LAMP TEST (pnl 613) | OWS BUS 1 | | Momentary switch with return to the center position |
| 800 | H | sw | LAMP TEST 2 | Illuminates lamp 2 of above and all OVERTEMP and TIMER lights on waste processors | DISP BUS 2 LAMP TEST (pnl 613) | OWS BUS 2 | | |
| 801 | H | | INTERCOM BOX | -------------See Panel 102------------- | | | | |
| | | | UTILITY OUTLETS | | | | | |
| 803 | H | conn | 1 | Zero-G receptacle, provides electrical power interface with portable equipment plug | UTIL OUTLETS WMC 1 (pnl 612) | OWS BUS 1 | | Typical for panel 402, 521, 531, 551, 803 |
| 803 | H | conn | 2 | Zero-G receptacle, provides electrical power interface with portable equipment plug | UTIL OUTLETS WMC 2 (pnl 612) | OWS BUS 2 | | |
| | | | HI POWER ACCESSORY OUTLETS | | | | | |
| 803 | H | conn | 1 | Zero-G receptacle, provides electrical power interface with portable equipment plug | HI PWR ACC OUTLETS WMC 1 (pnl 612) | OWS BUS 1 | | |
| 803 | H | conn | 2 | Zero-G receptacle, provides electrical power interface with portable equipment plug | HI PWR ACC OUTLETS WMC 2 (pnl 612) | OWS BUS 2 | | |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | WASTE PROCESSORS | | | | | |
| 817 | H | cb | 1 (10.0A) | Provides power to waste processor 1 from the bus select switch | HSS BUS 1&2 WASTE PROCESSORS 1/2 (pnl 614) | OWS BUS 1 or 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 817 | H | cb | 2 (10.0A) | Provides power to waste processor 2 from the bus select switch | HSS BUS 1&2 WASTE PROCESSORS 1/2 (pnl 614) | OWS BUS 1 or 2 | | |
| | | | OPEN | Disconnect the above | | | | |
| 817 | H | cb | 3 (10.0A) | Provides power to waste processor 3 from the bus select switch | HSS BUS 1&2 WASTE PROCESSORS 3/4 (pnl 614) | OWS BUS 1 or 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 817 | H | cb | 4 (10.0A) | Provides power to waste processor 4 from the bus select switch | HSS BUS 1&2 WASTE PROCESSORS 3/4 (pnl 614) | OWS BUS 1 or 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 817 | H | cb | 5 (10.0A) | Provides power to waste processor 5 from the bus select switch | HSS BUS 1&2 WASTE PROCESSORS 5/6 (pnl 614) | OWS BUS 1 or 2 | | |
| | | | OPEN | Disconnects the above | | | | |
| 817 | H | cb | 6 (10.0A) | Provides power to waste processor 6 from the bus select switch | HSS BUS 1&2 WASTE PROCESSORS 5/6 (pnl 614) | OWS BUS 1 or 2 | | |
| | | | OPEN | Disconnects the above | | | | |

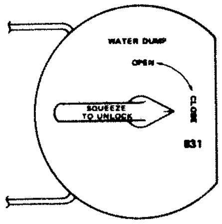
| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | WASTE PROCESSOR 1 | | | | | |
| 817 | H | sw | TIMER | | | | | |
| | | | SET | Powers HOURS REMAINING dial driver which sets timer and turns waste processor heater on | WASTE PROCESSORS 1 (pnl 817) | OWS BUS 1 or 2 | | |
| | | | AUTO | Enables timer control of waste processor | | | | |
| | | | OFF | Turns off waste processor | | | | |
| 817 | H | ind | HOURS REMAINING | Indicates hours remaining for waste processing | | | | Indicator is incremented in half-hours |
| 817 | H | lt | TIMER | Illuminates when waste processor is on timer control | WASTE PROCESSORS 1 (pnl 817) | OWS BUS 1 or 2 | | Green light |
| 817 | H | lt | OVERTEMP | Illuminates when an overtemp condition is sensed in the waste processor | WASTE PROCESSORS 1 (pnl 817) | OWS BUS 1 or 2 | | Overtemp condition when temp 160 $\pm$ 5°F Amber light |
| 817 | H | | WASTE PROCESSOR 2-6 | Same as waste processor 1 control and displays except for waste processor 2-6 | WASTE PROCESSORS 2-6 (pnl 817) | OWS BUS 1 or 2 | | |
| | | | WASTE PROCESSOR DOOR 1-6 | | | | | |
| 817 | H | hndl | DOOR | | | | | |
| | | | LOCK | Prohibits the opening of the waste processor door | | | | |
| | | | UNLOCK | Moves handle away from the waste processor door enabling its opening | | | | |
| 817 | H | vlv | VENT | | | | | |
| | | | VACUUM | Closes the waste processor pressurization valve and connects the waste processor with waste processor vacuum exhaust line | | | | |
| | | | CABIN | Closes the waste processor vent valve and connects the waste processor with the the cabin for pressurization | | | | |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 818 | H | vlv | URINE DUMP | | | | | |
| | | | OPEN | Connects the urine dump equipments with the urine dump line for dumping urine into the waste tank | | | | |
| | | | CLOSE | Disconnects the above | | | | |
| 818 | H | vlv | WASTE PROCESSOR VACUUM VENT | | | | | |
| | | | OPEN | Connects the waste processor vacuum exhaust line with the waste tank dump line for venting of the waste processors | | | | |
| | | | CLOSE | Disconnects the above | | | | |

P31


BUS 2 POWER
BLOWER/SEPARATOR
1
2
3
ON
OFF
BUS 1 POWER
825
AIRFLOW VALVE
CLOSE
OPEN
INLET DOOR
SAMPLE CONTAINER
VOLUME
1
DRAWER UNLOCK
LOCK
RECIRCULATION LINE DOOR

825


WATER DUMP
OPEN
CLOSE
SQUEEZE TO UNLOCK
831

831

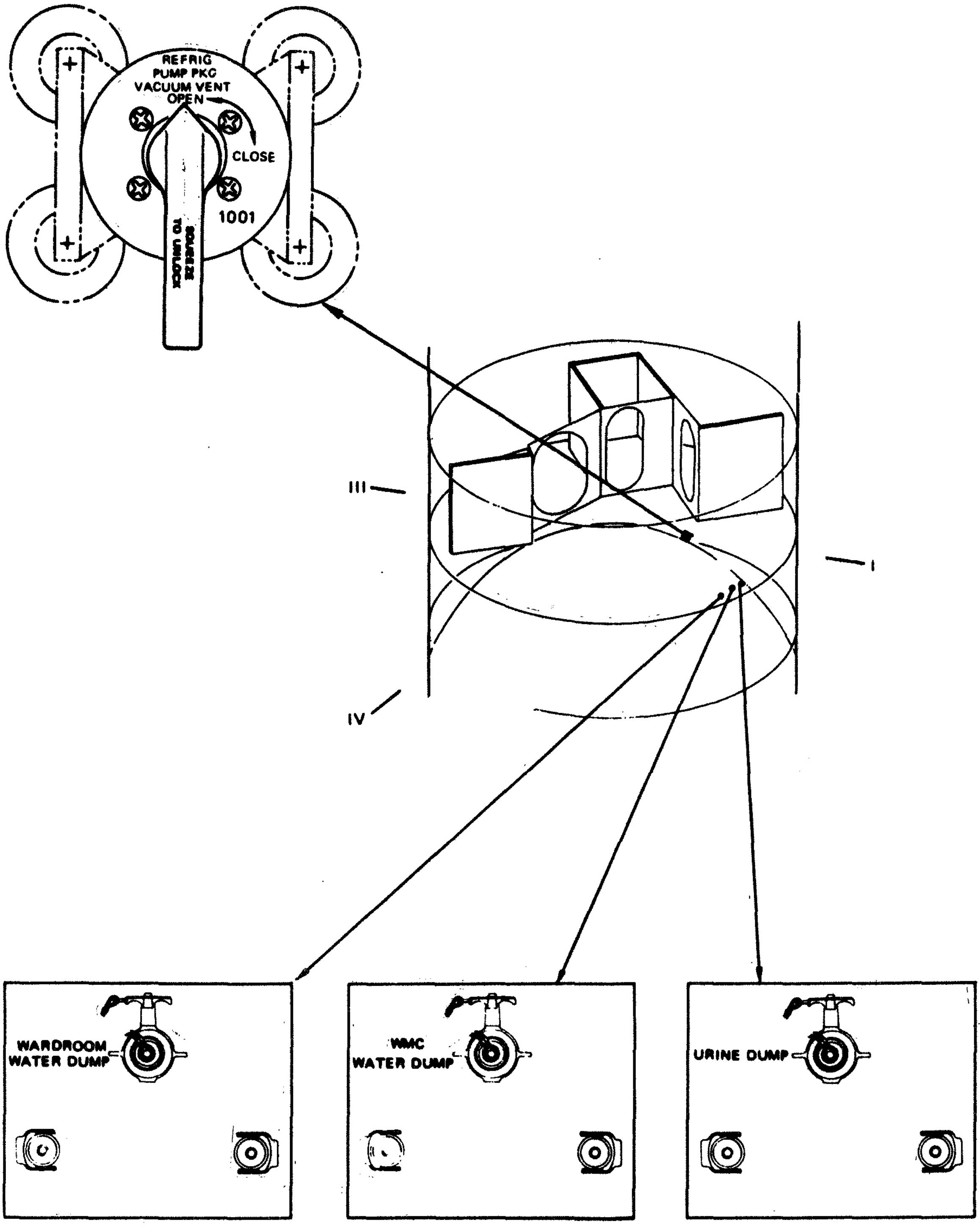
| LOCATION | | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| PNL | STA# | | | | | | | |
| | | | FECAL/URINE COLLECTOR | | | | | |
| 825 | H | sw | BLWR/SEPARATOR BUS 1 PWR - 1 ON | Turns on fecal/urine collector blower unit and urine drawer 1 urine separator for fecal or urine collection | HSS WMC BLWR OUTLET 1 (pnl 614) and bus 1 pwr 1 (behind fecal/urine collector access door) | OWS BUS 1 | | (A) Blower unit contains an integral power switch and circuit breaker |
| | | | OFF | Turns off the above | | | | (B) Urine separator continues to operate for 3 minutes using an interlock |
| 825 | H | sw | BLWR/SEPARATOR BUS 1 PWR - 2 ON | Turns on fecal/urine collector blower unit and urine drawer 3 urine separator for fecal or urine collection | HSS WMC BLWR OUTLET 1 (pnl 614) and bus 1 pwr-2 (behind fecal/urine collector access door) | OWS BUS 1 | | Same as (A) above |
| | | | OFF | Turns off the above | | | | Same as (B) above |
| 825 | H | sw | BLWR/SEPARATOR BUS 1 PWR - 3 ON | Turns on fecal/urine collector blower unit and urine drawer 2 urine separator for fecal or urine collection | HSS WMC BLWR OUTLET 1 (pnl 614) and bus 1 pwr-3 (behind fecal/urine collector access door) | OWS BUS 1 | | Same as (A) above |
| | | | OFF | Turns off the above | | | | Same as (B) above |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 825 | H | sw | BLWR/SEPARATOR BUS 2 PWR - 1 ON | Turns on fecal/urine collector blower unit and urine drawer 1 urine separator for fecal or urine collection | HSS WMC BLWR OUTLET 2 (pnl 614) and bus 2 pwr-1 (behind fecal/urine collector access door) | OWS BUS 2 | | Same as (A) above. Bus 2 connectors stowed until required for use |
| | | | OFF | Turns off the above | | | | Same as (B) above |
| 825 | H | sw | BLWR/SEPARATOR BUS 2 PWR - 2 ON | Turns on fecal/urine collector blower unit and urine drawer 2 urine separator for fecal or urine collection | HSS WMC BLWR OUTLET 2 (pnl 614) and bus 2 pwr - 2 (behind fecal/urine collector access door) | OWS BUS 2 | | Same as (A) above. Bus 2 connectors stowed until required for use |
| | | | OFF | Turns off the above | | | | Same as (B) above |
| 825 | H | sw | BLWR/SEPARATOR BUS 2 PWR - 3 ON | Turns on fecal/urine collector blower unit and urine drawer 3 urine separator for fecal or urine collection | HSS WMC BLWR OUTLET 2 (pnl 614) and bus 2 pwr-2 (behind fecal/urine collector access door) | OWS BUS 2 | | Same as (A) above. Bus 2 connectors stowed until required for use |
| | | | OFF | Turns off the above | | | | |
| 825 | H | ind | [drawer 1] VOLUME | Indicates the volume of accumulated urine in urine drawer 1 urine bag | | | | (C) When the drawer locking handle is in LOCK position, VOLUME indicates properly |
| 825 | H | ind | [drawer 2] VOLUME | Indicates the volume of accumulated urine in urine drawer 2 urine bag | | | | Same as (C) above |
| 825 | H | ind | [drawer 3] VOLUME | Indicates the volume of accumulated urine in urine drawer 3 urine bag | | | | Same as (C) above |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 825 | H | vlv | [drawer 1 locking handle] DRAWER | | | | | |
| | | | LOCK | Latches urine drawer 1 closed and applies the pressure plate to the urine bag | | | | |
| | | | UNLOCK | Unlatches urine drawer 1 for opening and removes the pressure plate from the urine bag | | | | |
| 825 | H | vlv | [drawer 2 locking handle] DRAWER | | | | | |
| | | | LOCK | Latches urine drawer 2 closed and applies the pressure plate to the urine bag | | | | |
| | | | UNLOCK | Unlatches urine drawer 2 for opening and removes the pressure plate from the urine bag | | | | |
| 825 | H | vlv | [drawer 3 locking handle] DRAWER | | | | | |
| | | | LOCK | Latches urine drawer 3 closed and applies the pressure plate to the urine bag | | | | |
| | | | UNLOCK | Unlatches urine drawer 3 for opening and removes the pressure plate from the urine bag | | | | |
| 825 | H | vlv | [drawer 1] AIRFLOW VALVE | | | | | |
| | | | OPEN | Connects urine separator 1 air outlet with the blower unit and filter and permits opening of the INLET DOOR for urine collection | | | | (D) The INLET DOOR stows the urine inlet line |
| | | | CLOSE | Disconnects the above and prevents opening of the INLET DOOR | | | | |
| 825 | H | vlv | [drawer 2] AIRFLOW VALVE | | | | | |
| | | | OPEN | Connects urine separator 2 air outlet with the blower unit and filter and permits opening of the INLET DOOR for urine collection | | | | Same as (D) above |
| | | | CLOSE | Disconnects the above and prevents opening of the INLET DOOR | | | | |
| 825 | H | vlv | [drawer 3] AIRFLOW VALVE | | | | | |
| | | | OPEN | Connects urine separator 3 air outlet with the blower unit and filter and permits opening of the INLET DOOR for urine collection | | | | Same as (D) above |
| | | | CLOSE | Disconnects the above and prevents opening of the INLET DOOR | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 831 | H | vlv | WATER DUMP | | | | | |
| | | | OPEN | Connects the WMC water network to the WMC water dump to the waste tank | | | | |
| | | | CLOSE | Disconnects the above | | | | |
| 901 | H | | INTERCOM BOX | -------------See Panel 102------------- | | | | |
| 902 | H | | INTERCOM BOX | -------------See Panel 102------------- | | | | |
| 903 | H | | INTERCOM BOX | -------------See Panel 102------------- | | | | |

P32


REFRIG
PUMP PKG
VACUUM VENT
OPEN
CLOSE
1001
SQUEEZE
TO UNLOCK
III
I
IV
WARDROOM
WATER DUMP
WMC
WATER DUMP
URINE DUMP

1001

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | REFRIG PUMP PKG VACUUM VENT | | | | | |
| 1001 | P | vlv | OPEN | Connects the refrigeration pump package to the waste tank for possible venting of leaking coolant | | | | |
| | | | CLOSE | Disconnects the above | | | | |

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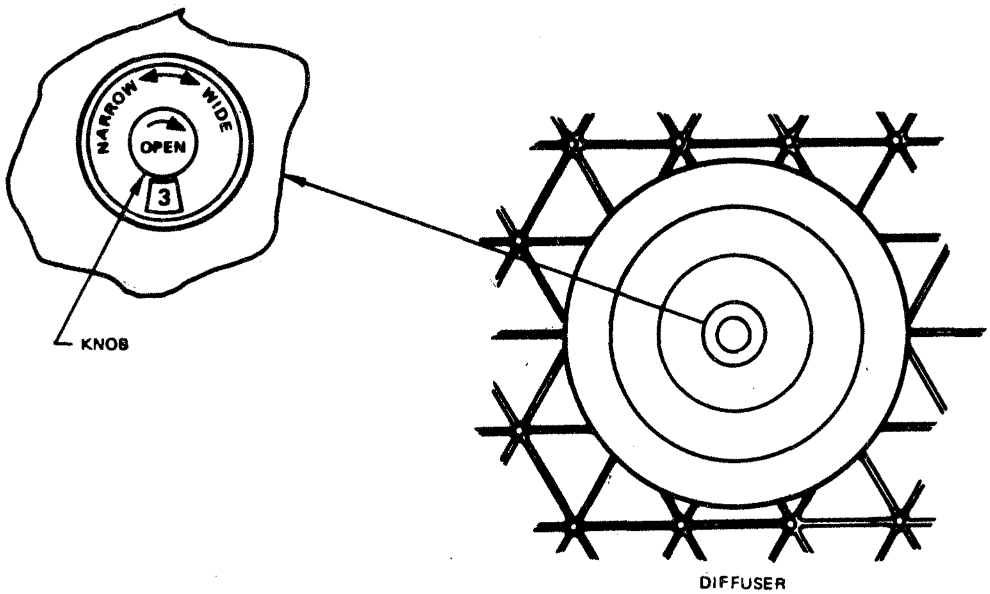
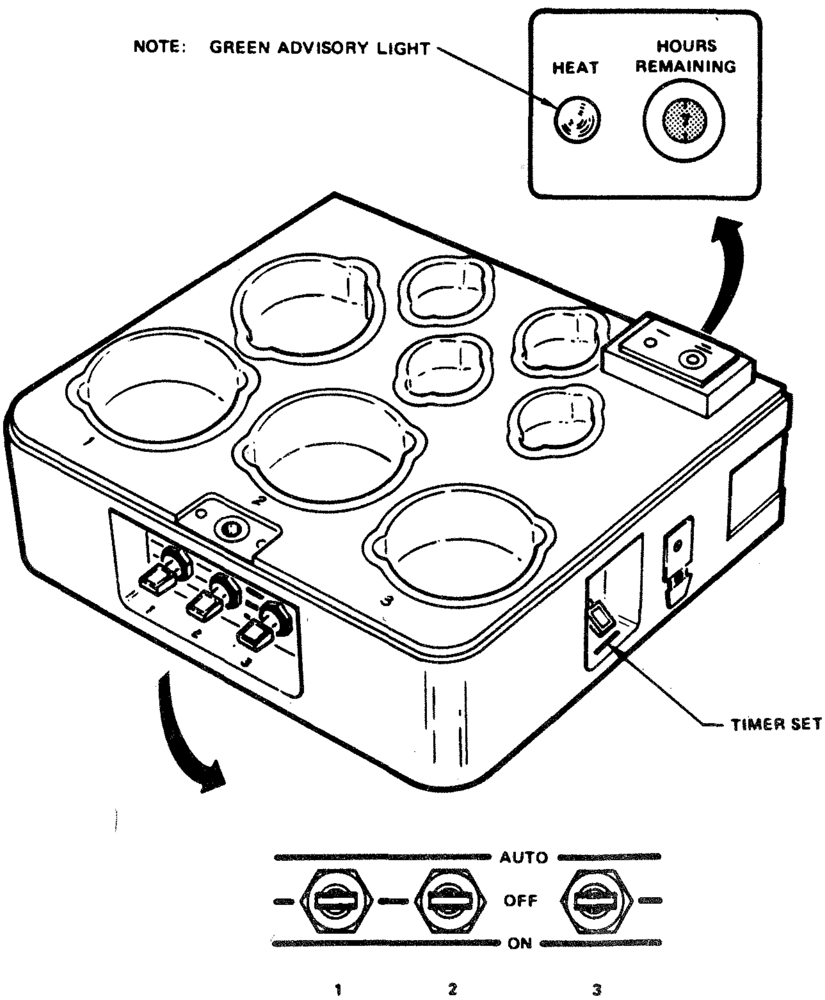



Diffuser




Food Tray

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | DIFFUSERS | | | | | |
| | | | [EXP comp diffusers 1-5] | | | | | |
| N/A | E | knob | OPEN | Opens damper to allow greater flow thru diffuser | | | | Rotate clockwise 8 turns to full open |
| N/A | E | knob | NARROW | Decreases area of dispersion | | | | Outer knob will rotate 8 turns from NARROW to WIDE |
| | | | WIDE | Increases area of dispersion | | | | |
| | | | [Wardrm diffusers 1-3] | | | | | |
| N/A | W | knob | OPEN | Opens damper to allow greater flow thru diffuser | | | | Rotate clockwise 8 turns to full open |
| N/A | W | knob | NARROW | Decreases area of dispersion | | | | Outer knob will rotate 8 turns from NARROW to WIDE |
| | | | WIDE | Increases area of dispersion | | | | |
| | | | [WMC diffuser] | | | | | |
| N/A | H | knob | OPEN | Opens damper to allow greater flow thru diffuser | | | | Rotate clockwise 8 turns to full open |
| N/A | H | knob | NARROW | Decreases area of dispersion | | | | Outer knob will rotate 8 turns from NARROW to WIDE |
| | | | WIDE | Increases area of dispersion | | | | |
| | | | FOOD TRAY 1 | | | | | |
| N/A | W | sw | [food cavity htr] 1 | | | | | |
| | | | AUTO | Turns on power to the TIMER SET switch and provides power to food cavity 1 heater after HOURS REMAINING timer expiration for automatic food heating | | OWS BUS 1 or BUS 2 | | (A) Food tray 1 connects to food tray outlet 1. The food cavity heater receives power when the HOURS REMAINING timer times out |
| | | | ON | Turns on power to operate food cavity 1 heater for manual food heating | | OWS BUS 1 or BUS 2 | | (B) Bypasses the HOURS REMAINING timer |
| | | | OFF | Turns off the above | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| N/A | W | sw | [food cavity htr] 2 | | | | | |
| | | | AUTO | Turns on power to the TIMER SET switch and provides power to food cavity 2 heater after HOURS REMAINING timer expiration for automatic food heating | | OWS BUS 1 or BUS 2 | | Same as (A) above |
| | | | ON | Turns on power to operate food cavity 2 heater for manual food heating | | OWS BUS 1 or BUS 2 | | Same as (B) above |
| | | | OFF | Turns off the above | | | | |
| N/A | W | sw | [food cavity htr] 3 | | | | | |
| | | | AUTO | Turns on power to the TIMER SET switch and provides power to food cavity 3 heater after HOURS REMAINING timer expiration for automatic food heating | | OWS BUS 1 or BUS 2 | | Same as (A) above |
| | | | ON | Turns on power to operate food cavity 3 heater for manual food heating | | OWS BUS 1 or BUS 2 | | Same as (B) above |
| | | | OFF | Turns off the above | | | | |
| N/A | W | ind | HOURS REMAINING | Indicates time-to-go to food cavity heater turn-on | | OWS BUS 1 or BUS 2 | | Timer range 0 to 12 hours. Provides power only to those food cavities whose switches are in AUTO |
| N/A | W | ind | HEAT | Illuminates when power is applied to any food cavity heater | | OWS BUS 1 or BUS 2 | | |
| N/A | W | sw | TIMER SET [up] | Drives HOURS REMAINING timer for selection of the desired time delay | | OWS BUS 1 or BUS 2 | | Momentary switch-returns to down position. Receives power from AUTO position of any food cavity heater switch |
| | | | [down] | Removes power from the above | | | | |

| LOCATION | | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| PNL | STA# | | | | | | | |
| | | | FOOD TRAY 2 & 3 | | | | | |
| N/A | W | sw | [food cavity htr] 1 | | | | | |
| | | | AUTO | Turns on power to the TIMER SET switch and provides power to food cavity 1 heater after HOURS REMAINING timer expiration for automatic food heating | | OWS BUS 1 or BUS 2 | | (A) Food tray 2 & 3 connects to food tray outlet 2 & 3. The food cavity heater receives power when the HOURS REMAINING timer times out |
| | | | ON | Turns on power to operate food cavity 1 heater for manual food heating | | OWS BUS 1 or BUS 2 | | (B) Bypasses the HOURS REMAINING timer |
| | | | OFF | Turns off the above | | | | |
| N/A | W | sw | [food cavity htr] 2 | | | | | |
| | | | AUTO | Turns on power to the TIMER SET switch and provides power to food cavity 2 heater after HOURS REMAINING timer expiration for automatic food heating | | OWS BUS 1 or BUS 2 | | Same as (A) above |
| | | | ON | Turns on power to operate food cavity 2 heater for manual food heating | | OWS BUS 1 or BUS 2 | | Same as (B) above |
| | | | OFF | Turns off the above | | | | |
| N/A | W | sw | [food cavity htr] 3 | | | | | |
| | | | AUTO | Turns on power to the TIMER SET switch and provides power to food cavity 3 heater after HOURS REMAINING timer expiration for automatic food heating | | OWS BUS 1 or BUS 2 | | Same as (A) above |
| | | | ON | Turns on power to operate food cavity heater for manual food heating | | OWS BUS 1 or BUS 2 | | Same as (B) above |
| | | | OFF | Turns off the above | | | | |
| N/A | W | ind | HOUPS REMAINING | Indicates time-to-go to food cavity heater turn-on | | OWS BUS 1 or BUS 2 | | Timer range 0 to 12 hours. Provides power only to those food cavities whose switches are in AUTO |
| N/A | W | ind | HEAT | Illuminates when power is applied to any food cavity heater | | OWS BUS 1 or BUS 2 | | |
| N/A | W | sw | TIMER SET [up] | Drives HOURS REMAINING timer for selection of the desired time delay | | OWS BUS 1 or BUS 2 | | Momentary switch- returns to down position. Receives power from AUTO position of any food cavity heater switch |
| | | | [down] | Removes power from the above | | | | |

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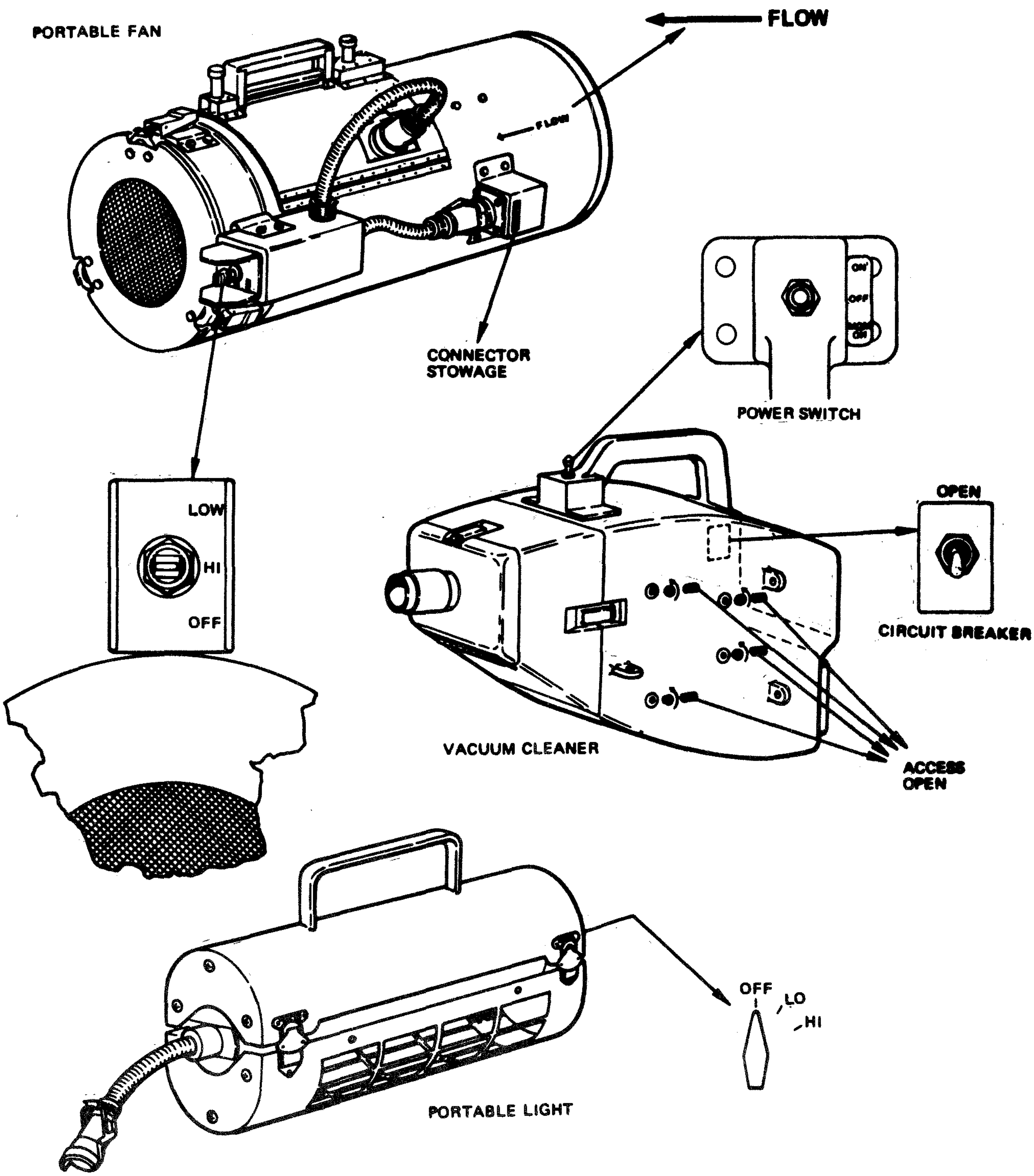
## PORTABLE FAN, VACUUM CLEANER AND PORTABLE LIGHT



| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | PORTABLE FAN | | | | | |
| N/A | N/A | sw | LOW | Turns on portable fan to the lowest speed | | BUS 1 or BUS 2 | | Portable fan connects to UTILITY OUTLET |
| | | | HI | Turns on portable fan to the highest speed | | BUS 1 or BUS 2 | | |
| | | | OFF | Turns off the portable fan | | | | |
| N/A | N/A | knob | DIFFUSER | | | | | |
| | | | NARROW | Decrease area of dispersion | | | | |
| | | | WIDE | Increase area of dispersion | | | | |
| | | | VACUUM CLEANER | | | | | |
| | | | CIRCUIT BREAKER [closed] | Provides power to the vacuum cleaner blower unit through the handle-mounted Switch | | BUS 1 or BUS 2 | | Vacuum cleaner connects to HI-POWER ASSESSORY OUTLET |
| | | | OPEN | Disconnects the above | | | | |
| N/A | N/A | sw | ON | Turns on the vacuum cleaner blower unit | CIRCUIT BREAKER (vacuum cleaner) | BUS 1 or BUS 2 | | Lever lock in the ON position. Switch mounted on handle |
| | | | MOM ON | Turns on the vacuum cleaner blower unit | CIRCUIT BREAKER (vacuum cleaner) | BUS 1 or BUS 2 | | Momentary switch in the MOM ON position-return to center |
| | | | OFF | Turns off the above | | | | |
| | | | PORTABLE LIGHT | | | | | |
| N/A | N/A | sw | HI | Turns on floodlight bulb to brightest illumination | | BUS 1 or BUS 2 | | Portable light connects to UTILITY OUTLET |
| | | | LO | Turns on floodlight bulb to the lowest illumination | | BUS 1 or BUS 2 | | |
| | | | OFF | Turns off the floodlight bulb | | | | |



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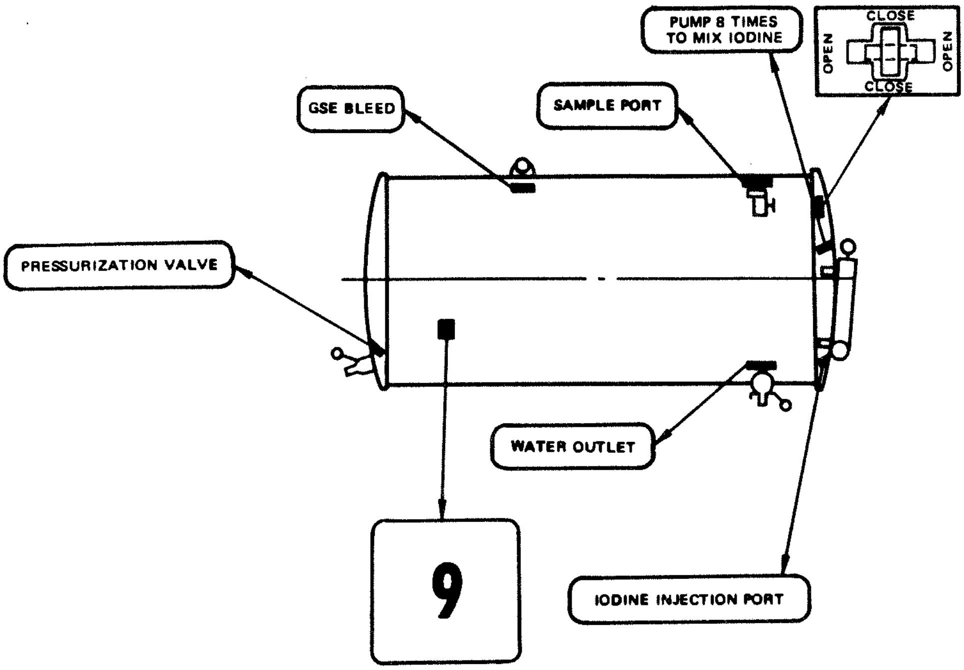
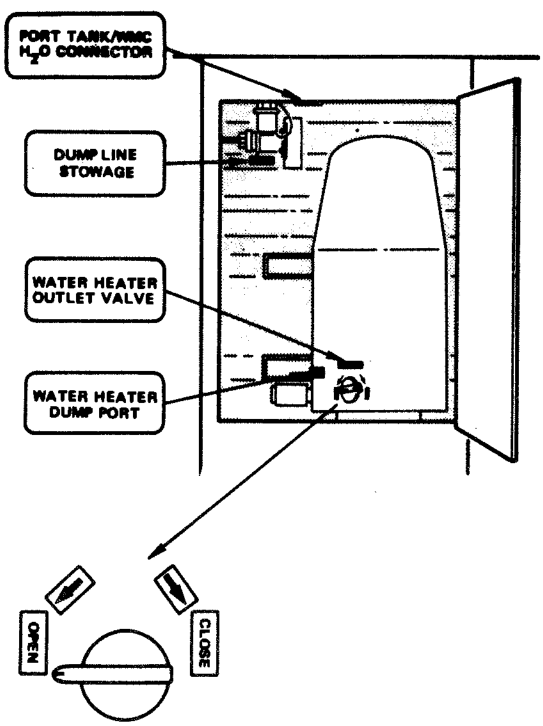
P35

WATER TANKS




WMC WATER HEATER

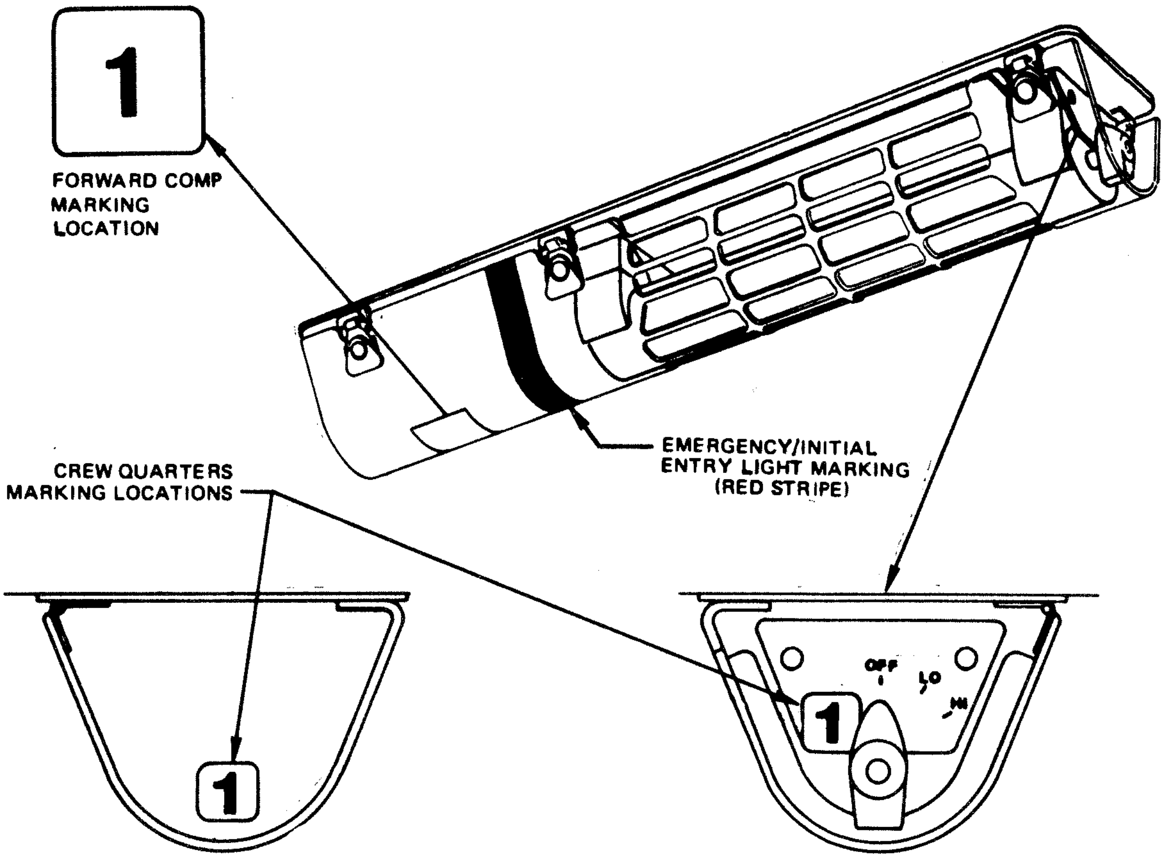


| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | WATER TANK 1 | | | | | |
| N/A | F | vlv | [water tank 1] PRESS | | | | | |
| | | | OPEN | Connects WT 1 N2 gas chamber with the 35 psi N2 supply for pressurization | | | | |
| | | | CLOSE | Disconnects the above | | | | |
| N/A | F | vlv | [water tank 1] WATER OUTLET | | | | | |
| | | | OPEN | Connects WT 1 water outlet port with the water tank's water chamber to provide a water supply | | | | Water outlet port connects to water hose |
| | | | CLOSE | Disconnects the above | | | | |
| N/A | F | vlv | [water tank 1] SAMPLE PORT | | | | | |
| | | | OPEN | Connects WT 1 sample port with the water tank's water chamber for water sampling | | | | Sample port is used with water sampler |
| | | | CLOSE | Disconnects the above | | | | |
| N/A | F | vlv | [water tank 1] IODINE INJ PORT | | | | | |
| | | | OPEN | Connects WT 1 iodine injection port with the water tank's water chamber for water purification | | | | Iodine injection port is used with the iodine injector |
| | | | CLOSE | Disconnects the above | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | WATER TANK 2-10 | | | | | |
| N/A | F | vlv | [water tank 2-10] PRESS | | | | | |
| | | | OPEN | Connects WT 2-10 N2 gas chamber with the 35 psi N2 supply for pressurization | | | | |
| | | | CLOSE | Disconnects the above | | | | |
| N/A | F | vlv | [water tank 2-10] WATER OUTLET | | | | | |
| | | | OPEN | Connects WT 2-10 water outlet port with the water tank's water chamber to provide a water supply | | | | Water outlet port connects to water hose |
| | | | CLOSE | Disconnects the above | | | | |
| N/A | F | vlv | [water tank 2-10] SAMPLE PORT | | | | | |
| | | | OPEN | Connects WT 2-10 sample port with the water tank's water chamber for water sampling | | | | Sample port is used with water sampler |
| | | | CLOSE | Disconnects the above | | | | |
| N/A | F | vlv | [water tank 2-10] IODINE INJ PORT | | | | | |
| | | | OPEN | Connects WT 2-10 iodine injection port with the water tank's water chamber for water purification | | | | Iodine injection port is used with the iodine injector |
| | | | CLOSE | Disconnects the above | | | | |
| | | | WMC H20 HEATER | | | | | |
| N/A | H | vlv | WATER HEATER OUTLET VALVE | | | | | |
| | | | OPEN | Connects the water heater with the WMC water dispenser valve | | | | |
| | | | CLOSE | Disconnects the above | | | | |

P36

## OWS LIGHTS



| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| | | | OWS LIGHTS | | | | | | |
| N/A | N/A | sw | [Integral light switch] | HI | Turns on light to brightest illumination | | Odd Numbers Bus 1 Even Numbers Bus 2 | | |
| | | | | LO | Turns on light to lowest illumination | | | | |
| | | | | OFF | Turns off the light | | | | |



(Page 3.0-300 is BLANK).

## WATER SAMPLE ANALYSIS

### OBTAINING WATER SAMPLE

1. Water tank SAMPLE PORT valve CLOSE (verify).
2. WATER SAMPLER screw onto water tank SAMPLE PORT.
3. WATER SAMPLER valve OPEN.
4. Water tank SAMPLE PORT valve OPEN.
5. WATER SAMPLER plunger withdraw until bottomed out.
6. Water tank SAMPLE PORT valve CLOSE.
7. WATER SAMPLER valve CLOSE.
8. WATER SAMPLER unscrew from water tank SAMPLE PORT.

### REAGENT INTRODUCTION

1. REAGENT CONTAINER PORT valve - CLOSE (verify).
2. WATER SAMPLER (with water sample) - screw onto REAGENT CONTAINER port.
3. WATER SAMPLER valve - OPEN.
4. REAGENT CONTAINER port valve - OPEN.
5. WATER SAMPLER plunger - pull to engage threads and turn CCW until bottomed out.
6. REAGENT CONTAINER port valve - CLOSE.
7. WATER SAMPLER valve - CLOSE.
8. WATER SAMPLER - wait 10 minutes before unscrewing from REAGENT CONTAINER.

### WATER SAMPLE COLOR COMPARISON

1. COLOR COMPARATOR - deploy from stowed position.
2. Make color comparison, record iodine concentration, determine if water tank requires iodine injection.
3. COLOR COMPARATOR - stow.
4. WASTE SAMPLE CONTAINER PORT valve - CLOSE (verify).
5. WATER SAMPLER - screw onto WASTE SAMPLE CONTAINER port.
6. WATER SAMPLER valve - OPEN.
7. WASTE SAMPLE CONTAINER port valve - OPEN.
8. WATER SAMPLER plunger - turn CW until thread disengagement, inject water/reagent into WASTE SAMPLE CONTAINER.
9. WASTE SAMPLE CONTAINER port valve - CLOSE.
10. WATER SAMPLER valve - CLOSE.
11. WATER SAMPLER - unscrew from WASTE SAMPLE CONTAINER port.

## IODINE INTRODUCTION

### INJECTOR FILLING

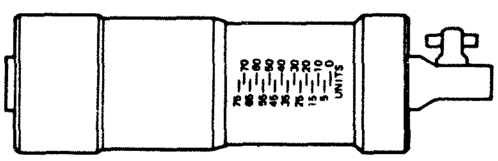
1. IODINE CONTAINER PORT A valve - CLOSE (verify).
2. IODINE INJECTOR - screw onto IODINE CONTAINER, PORT A - and verify iodine injector reads "0" units (fully CW).
3. IODINE INJECTOR valve - OPEN.
4. IODINE CONTAINER PORT A valve - OPEN.
5. IODINE INJECTOR rear cap - turn CCW to iodine units to be injected (see chart).
6. IODINE CONTAINER PORT A valve - CLOSE.
7. IODINE INJECTOR valve - CLOSE.
8. IODINE INJECTOR - unscrew from IODINE CONTAINER.

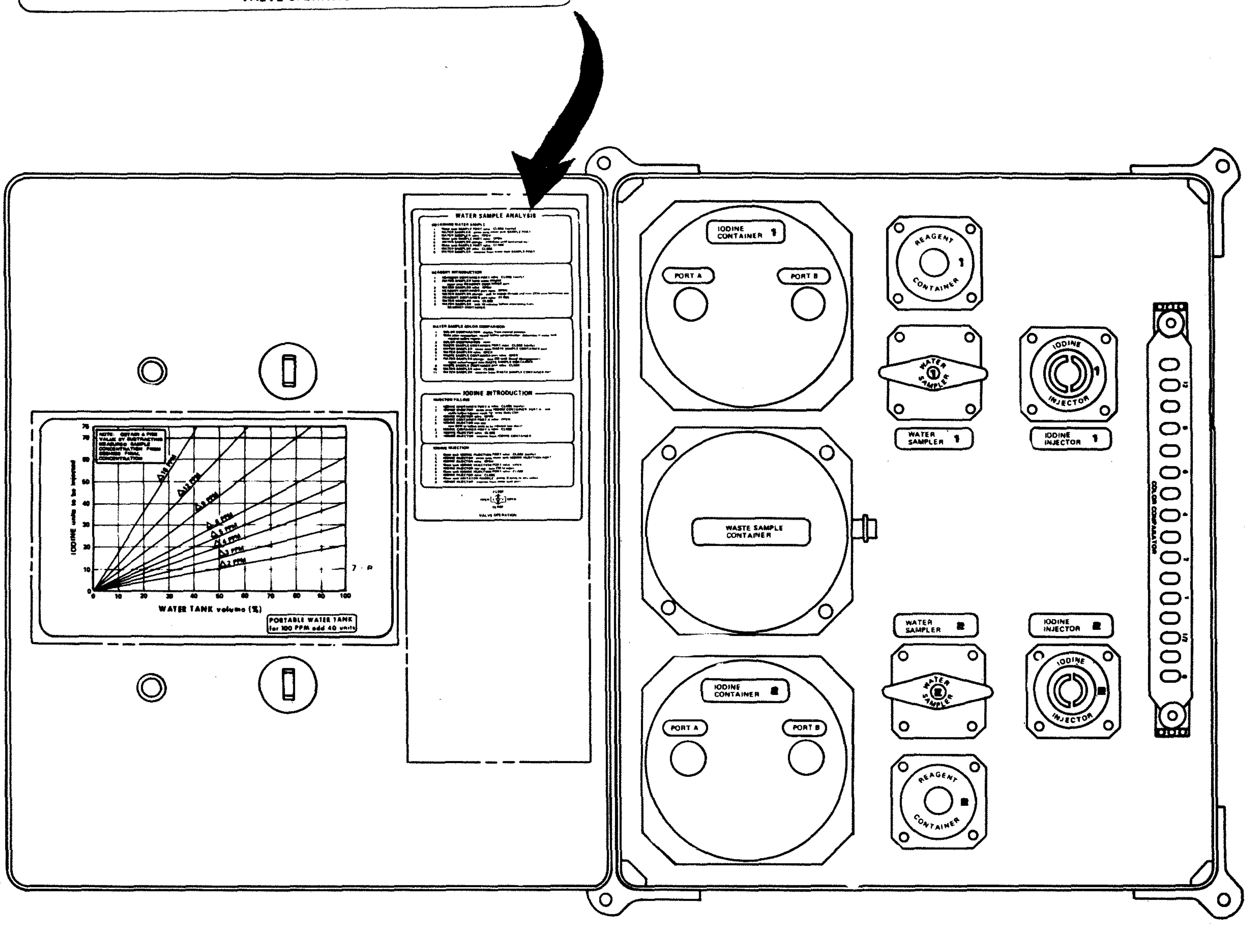
### IODINE INJECTION

1. Water tank IODINE INJECTION PORT valve CLOSE (verify)
2. IODINE INJECTOR - screw onto water tank IODINE INJECTION PORT.
3. IODINE INJECTOR valve - OPEN.
4. Water tank IODINE INJECTION PORT valve - OPEN.
5. IODINE INJECTOR rear cap - turn CW to inject.
6. Water tank IODINE INJECTION PORT valve - CLOSE.
7. IODINE INJECTOR valve - CLOSE.
8. Water tank AGITATOR HANDLE - pump 8 times to mix iodine.
9. IODINE INJECTOR - unscrew from water tank port.


VALVE OPERATION

IODINE INJECTOR



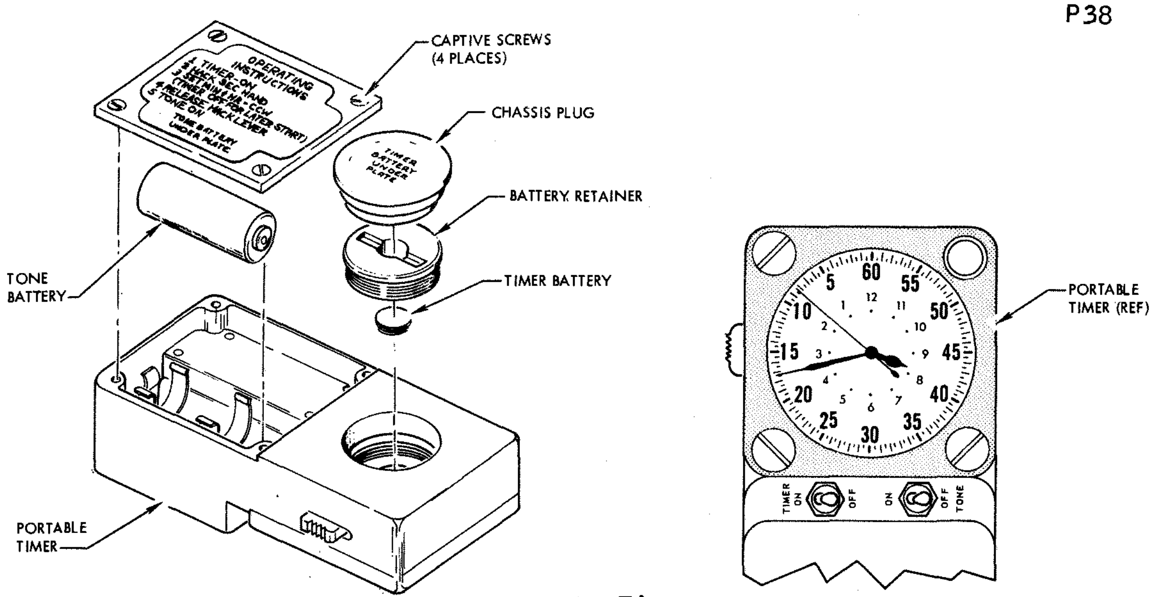




WATER PURIFICATION EQUIPMENT

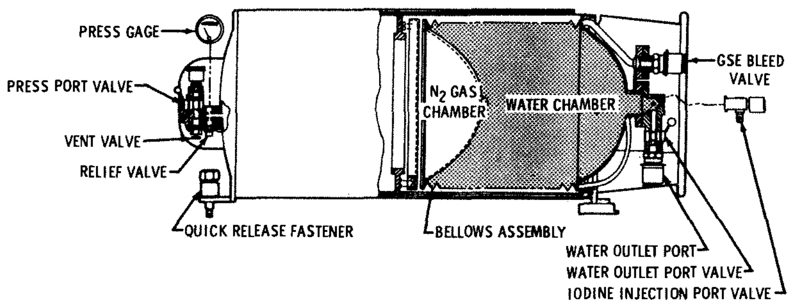
| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | WATER PURIFICATION EQUIPMENT | | | | | |
| N/A | F | vlv | WATER SAMPLER 1 OPEN | Connects WATER SAMPLER 1 outlet port with the water sampler accumulator for filling and expelling sampled water | | | | The water sampler is used in conjunction with the water tank, reagent container and waste sample container. WATER SAMPLER 1 is the prime unit |
| | | | CLOSE | Disconnects the above | | | | |
| N/A | F | vlv | WATER SAMPLER 2 OPEN | Connects WATER SAMPLER 2 outlet port with the water sampler accumulator for filling and expelling sampled water | | | | WATER SAMPLER 2 is the backup unit |
| | | | CLOSE | Disconnects the above | | | | |
| N/A | F | vlv | REAGENT CONTAINER 1 OPEN | Connects REAGENT CONTAINER 1 transfer port to the stored reagent for reagent withdrawal | | | | The reagent container is used in conjunction with the water sampler. REAGENT CONTAINER 1 is the prime unit. |
| | | | CLOSE | Disconnects the above | | | | |
| N/A | F | vlv | REAGENT CONTAINER 2 OPEN | Connects REAGENT CONTAINER 2 transfer port to the stored reagent for reagent withdrawal | | | | REAGENT CONTAINER 2 is the backup unit |
| | | | CLOSE | Disconnects the above | | | | |
| N/A | F | vlv | WASTE SAMPLE CONTAINER OPEN | Connects waste sample container transfer port to the waste water sample storage volume for water sample disposal | | | | The waste sample container is used in conjunction with the water sampler |
| | | | CLOSE | Disconnects the above | | | | |

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| N/A | F | vlv | IODINE CONTAINER 1 PORT A | | | | | |
| | | | OPEN | Connects IODINE CONTAINER 1 PORT A with the stored iodine for iodine withdrawal | | | | The iodine container is used in conjunction with the iodine injector. IODINE CONTAINER 1 is the prime unit. PORT A is a redundant iodine withdrawal port |
| | | | CLOSE | Disconnects the above | | | | |
| N/A | F | vlv | IODINE CONTAINER 1 PORT B | | | | | |
| | | | OPEN | Connects IODINE CONTAINER 1 PORT B with the stored iodine for iodine withdrawal | | | | PORT B is a redundant iodine withdrawal port |
| | | | CLOSE | Disconnects the above | | | | |
| N/A | F | vlv | IODINE CONTAINER 2 PORT A | | | | | |
| | | | OPEN | Connects IODINE CONTAINER 2 PORT A with the stored iodine for iodine withdrawal | | | | IODINE CONTAINER 2 is a backup unit. PORT A is a redundant iodine withdrawal port |
| | | | CLOSE | Disconnects the above | | | | |
| N/A | F | vlv | IODINE CONTAINER 2 PORT B | | | | | |
| | | | OPEN | Connects IODINE CONTAINER 2 PORT B with the stored iodine for iodine withdrawal | | | | PORT B is a redundant iodine withdrawal port |
| | | | CLOSE | Disconnects the above | | | | |
| N/A | F | vlv | IODINE INJECTOR 1 | | | | | |
| | | | OPEN | Connects IODINE INJECTOR 1 inlet port with the injector's iodine cylinder to withdraw and inject iodine | | | | The iodine injector is used in conjunction with the iodine container and the water tanks. IODINE INJECTOR 1 is the prime unit |
| | | | CLOSE | Disconnects the above | | | | |
| N/A | F | vlv | IODINE INJECTOR 2 | | | | | |
| | | | OPEN | Connects IODINE INJECTOR 2 inlet port with the injector's iodine cylinder to withdraw and inject iodine | | | | IODINE INJECTOR 2 is the backup unit |
| | | | CLOSE | Disconnects the above | | | | |

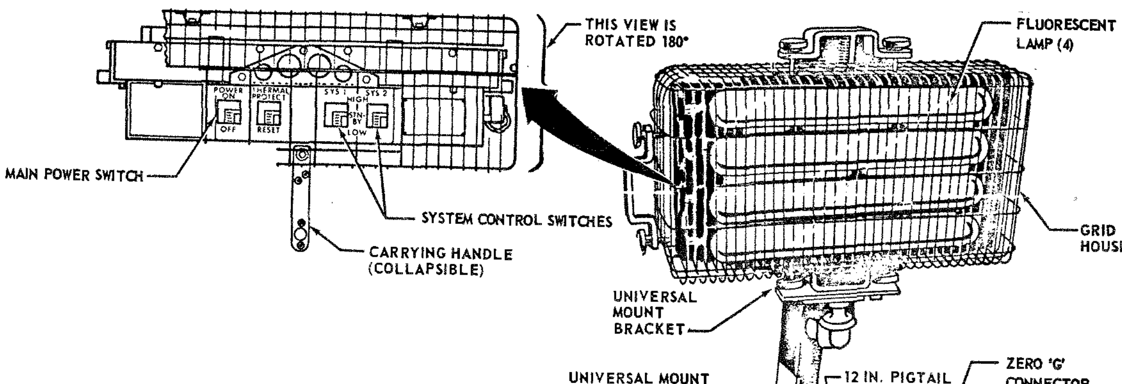
P38




Portable Timer




Portable Water Tank




High Intensity Light

| LOCATION PNL | STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | PORTABLE TIMER | | | | | Contains internal power source (Hg batteries) |
| N/A | N/A | sw | TIMER ON | Activates timing mechanism | | | | |
| | | | OFF | Deactivates timing mechanism | | | | |
| N/A | N/A | sw | TONE ON | Activates tone mechanism | | | | |
| | | | OFF | Deactivates tone mechanism | | | | |
| N/A | N/A | lvr | (CLUTCH) | Disconnects display hands from timing mechanism | | | | Spring loaded, must hold down to disconnect timing mechanism |
| N/A | N/A | knob | (Setting Knob) | Sets hour and minute hand | | | | Turn counterclockwise to set |
| | | | PORTABLE WATER TANK | | | | | |
| N/A | F | vlv | IODINE INJ PORT OPEN | Connects iodine injection port to the portable water tank's water chamber for water purification | | | | Iodine injection port is used with the iodine injector |
| | | | CLOSE | Disconnects the above | | | | |
| N/A | F | vlv | WATER OUTLET OPEN | Connects the water outlet port to the portable water tank's water chamber to provide for water filling and a water supply | | | | Water outlet port is used with a water hose |
| | | | CLOSE | Disconnects the above | | | | |
| N/A | F | vlv | PRESS VLV [open] | Connects the tank's pressurization port with the tank's N2 gas chamber | | | | Pressurization port is used with a GN2 hose |
| | | | [closed] | Disconnects the above | | | | |
| N/A | F | vlv | RELIEF VLV | Automatically relieves the N2 gas chamber into the cabin when an overpressure occurs | | | | Crack (51-58 psig) Reseat (45 psig) |
| N/A | F | ind | N2 PRESS | Indicates N2 gas chamber pressure continuously | | | | Range 0 to 80 psig |
| N/A | F | vlv | VENT [depressed] | Manually vents the N2 gas chamber to the cabin | | | | Push-button vent valve |
| | | | [released] | Disconnects the above | | | | |

| LOCATION PNL | LOCATION STA# | ITEM | NAME AND POSITION | FUNCTION | CIRCUIT BREAKER | POWER SOURCE | DCS CHNL | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | HIGH INTENSITY LIGHT | | | | | |
| N/A | | sw | POWER ON | Turns on power to 4 fluorescent lamps through SYS 1 and SYS 2 switches | | BUS 1 or BUS 2 | | High intensity light connects to HI-POWER ACCESSORY OUTLET. Two fluorescent lamps per system |
| | | | OFF | Turns off the above | | | | |
| N/A | | sw | SYS 1 HIGH | Turns on 2 - SYS 1 fluorescent lamps to bright illumination | | BUS 1 or BUS 2 | | |
| | | | LOW | Turns on 2 - SYS 1 fluorescent lamps to dim illumination | | BUS 1 or BUS 2 | | |
| | | | STNBY | Turns off the above | | | | |
| N/A | | sw | SYS 2 HIGH | Turns on 2 - SYS 2 fluorescent lamps to bright illumination | | BUS 1 or BUS 2 | | |
| | | | LOW | Turns on 2 - SYS 2 fluorescent lamps to dim illumination | | BUS 1 or BUS 2 | | |
| | | | STNBY | Turns off the above | | | | |
| N/A | | sw | THERMAL PROTECT RESET | Turns on reset power to reapply power to 2 - SYS 2 fluorescent lamps following SYS 2 shutdown due to overtemp circuit activation | | BUS 1 or BUS 2 | | Momentary switch - return to up position. Over temperature control cuts off power to SYS 2 fluorescent lamps when an over-temperature condition occurs |
| | | | [up] | Turns off reset power | | | | |

# APPENDIX A

## ABBREVIATIONS AND ACRONYMS

Abbreviations are used for all tenses, the possessive case, participle endings, the singular or plural, and the noun and modifying forms.

A° - Angstrom
ac - alternating current
A/C - Audio Center
A/D - Analog to Digital
adj - adjust
AGC - Automatic Gain Control
AH - ampere-hour
ALC - Audio Load Compensator
ALSA - Astronaut Life Support Assembly
AM - Airlock Module
amp - ampere
ampl - amplifier
ant - antenna
APCS - Attitude Pointing and Control System
ASMU - Automatically Stabilized Maneuvering Unit
assy - assembly
ATM - Apollo Telescope Mount
ATMDC - ATM Digital Computer
auto - automatic
aux - auxiliary
AVC - Automatic Volume Control
β angle - Beta angle
bat - battery
biomed - biomedical
B/A - bilevel
BLP - bilevel pulse
blwr - blower
BMMD - Body Mass Measurement Device
bps - bits per second
brt - bright
Btu - British thermal unit
CBRM - Charger Battery Regulator Module
cc - cubic centimeter
CCU - Crewman Communications Umbilical
ccw - counter clockwise
C&D - control and display
CDF - confined detonating fuse
Cdr - Commander
cfm - cubic feet per minute
chan - channel
ckt - circuit
CM - Command Module
CMD - command
CMG - Control Moment Gyros
Cmn - Crewman
CO2 - carbon dioxide
COAS - Crewman Optical Alignment Sight
coax - coaxial
COMM - Communications
compt - compartment
condr - conditioner
conn - connect
cont - control
conv - converter
CRDU - Command Relay Driver Unit
C&S - Configuration & Structures
CSM - Command and Service Module
cw - clockwise
C/W (C&W) - Caution and Warning
CWG - Constant Wear Garment
CWS - Center Work Station
C&WS - Caution and Warning System
DA - Deployment Assembly
db - decibel
dc - direct current
DCS - Digital Command System
decr - decrease
disch - discharge
disp - display
D/T - delayed time
EBW - Exploding Bridge Wire
ECS - Environmental Control System
EKG - electrocardiogram
emer - emergency
EMU - Extravehicular Mobility Unit
EPS - Electrical Power System
EREP - Earth Resources Experiment Package
ESS - Experiment Support System
EV - extravehicular
EVA - extravehicular activity
exp - experiment
°F - degrees Farenheit
FAS - Fixed Airlock Shroud
FC - fuel cell
FCC - Flight Control Computer
FCE - flight crew equipment
FDF - Flight Data File
flex - flexible
FM - frequency modulation
FMS - Food Management Subsystem
fps - feet per second
FSA - Fire Sensor Assembly
FSCP - Fire Sensor Control Panel
ft - foot
fwd - forward
gal - gallon
GET - Ground Elapsed Time
GMT - Greenwich Mean Time
GN2 - gaseous nitrogen
GSE - ground support equipment
HDC - Hasselblad Data Camera
H2O - water
H/L - highlevel
HPI - high performance insulation
hr - hour
HSS - Habitability Support Ssytem
htr - heater
Hz - Hertz
IB - Interface Box
icom - intercommunications
ID - identification
IH - Inertial Hold
IMSS - Inflight Medical Support Subsystem
in - inch
ind - indicator
inst - instrument, instrumentation
IOP - in-orbit plane
ips - inch per second
IR - Infra-red
IU - Instrument Unit

| | |
|---|---|
| IV | - intravehicular |
| IVA | - intravehicular activity |
| kbps | - Kilo bits per second |
| kHz | - Kilo-Hertz |
| KOH | - potassium hydroxide |
| KSC | - Kennedy Space Center |
| lb | - pound |
| LBNP | - Lower Body Negative Pressure |
| LCCU | - Light-weight Crewman Communication Umbilical |
| LCG | - Liquid Cooled Garment |
| LEA | - Launch Escape Assembly |
| LH | - left hand |
| LH2 | - liquid hydrogen |
| LiOH | - lithium hydroxide |
| L/L | - low level |
| LSB | - least significant bit |
| LSU | - Life Support Umbilical |
| lt | - light |
| ltg | - lighting |
| LVDA | - Launch Vehicle Data Adapter |
| LVDC | - Launch Vehicle Digital Computer |
| man | - manual |
| max | - maximum |
| MDA | - Multiple Docking Adpater |
| mgmt | - management |
| MHz | - mega-Hertz |
| min | - minimum, minute |
| ml | - millileters |
| mmHg | - millimeters of mercury |
| MN A | - Main Bus A |
| MN B | - Main Bus B |
| mol | - molecular |
| mom | - momentary |
| ms | - millisecond |
| MSB | - most significant bit |
| MSC | - Manned Spacecraft Center |
| MSFC | - George C. Marshall Space Flight Center |
| MSFN | - Manned Spaceflight Network |
| MUX | - multiplexer |
| mv | - millivolt |
| N2 | - nitrogen |
| NASA | - National Aeronautics and Space Administration |
| nm | - nautical miles |
| Ni-Cad | - nickel cadmium |
| NPV | - non-propulsive vent |
| NRZ | - non-return to zero |
| 02 | - oxygen |
| OA | - Orbital Assembly= (CSM/SWS)= (CSM/ATM/MDA/AM/OWS) |
| OBS | - Operational Biomedical System |
| OECO | - Outboard Engine Cutoff |
| OMNI | - omnidirectional |
| OWS | - Orbital Workshop |
| oz | - ounce |
| $\Delta$P | - differential pressure |
| PAM | - pulse amplitude modulation |
| PCG | - power conditioning group |
| PCM | - pulse code modulation |
| PCSA | - Power and Control Switching Assembly |
| pct | - percent |
| PCU | - Pressure Control Unit |
| PETN | - pentaerythritol tetranitrate |
| PGA | - Pressure Garment Assembly |
| PLV | - Post landing ventilation |
| Plt | - Pilot (crewman identification only) |
| pnl | - panel |
| PPCO2 | - partial pressure carbon dioxide |
| ppm | - parts per million |
| PPN2 | - partial pressure nitrogen |
| PPO2 | - partial pressure oxygen |
| pps | - pulse per second |
| PRD | - Personal Radiation Dosimeter |
| press | - pressure |
| pri | - primary |
| prog | - programmer |
| PS | - Payload Shroud |
| psi | - pounds per square inch |
| psia | - pounds per square inch absolute |
| psid | - pounds per square inch differential |
| psig | - pounds per square inch gauge |
| PTT | - push-to-talk |
| PVC | - polyvinylchloride (tubing) |
| PWM | - pulse width modulation |
| pwr | - power |
| QCM/CM | - Quartz Crystal Microbalance/Contamination Monitor |
| QD | - quick-disconnect |
| qtrs | - quarters |
| rad | - radiator |
| rcd (r) | - record (er) |
| rcv (r) | - receive (r) |
| RCVR/DCDR | - Receiver/Decoder |
| ref | - reference |
| reg | - regulator, regulated |
| RGSTR | - Register |
| req (d) | - require (d) |
| RF | - radio frequency |
| RH | - right hand |
| RS | - Refrigeration System |
| RMS | - Radiation Survey Meter |
| R/T | - real time |
| RZ | - return to zero |
| SAL | - Scientific Airlock |
| SAS | - Solar Array System |
| SC | - Sequential categories |
| sec | - second, secondary |
| SEVA | - Skylab Extravehicular Visor Assembly |
| SEWS | - Sun End Work Station |
| SF | - subframe |
| SI | - Solar Inertial |
| S-II | - Saturn II "Stage" |
| S-IVB | - Saturn IVB "Stage" |
| SL | - Skylab |
| SLOH | - Skylab Operations Handbook |
| SM | - Service Module |
| SMMD | - Specimen Mass Measurement Device |
| SOC | - state of charge |
| SOP | - Secondary Oxygen Pack |
| SPG | - single-point ground |
| Spt | - Scientist-Pilot |
| SPS | - samples per second, Service Propulsion System |
| std | - standard |
| STS | - Structural Transition Section |
| SUS | - Suit Umbilical System |
| sv | - sieve |
| sw | - switch |
| SWS | - Saturn Workshop (ATM/MDA/AM/OWS) |
| sync | - synchronize |
| sys | - system |
| TACS | - Thruster Attitude Control System |
| TB4 | - time base 4 |
| TBS | - to be supplied |
| TCB | - Time Correlation Buffer |
| TCS | - Thermal Control System |
| TCV | - Temperature Control Valve |
| Te | - elapsed time |
| temp | - temperature |
| TM | - telemetry |
| Tr | - time to go to redundant receiver/decoder |
| T/R | - transmit/receive |
| TRS | - Time Reference System |
| TV | - television |
| Tx | - time to go to equipment reset |
| typ | - typical |
| UCTA | - Urine Collection and Transfer Assembly |
| UHF | - ultra high frequency |

| | |
|---|---|
| umb | - umbilical |
| V | - Volt |
| VAB | - Vertical Assembly Building, Van Allen Belt |
| VABD | - Van Allen Belt Dosimeter |
| vac | - volts alternating current |
| vdc | - volts direct current |
| VCG | - vectorcardiogram |
| VCO | - Voltage Controlled Oscillator |
| VHF | - very high frequency |
| vlv | - valve |
| VOX | - voice-operated transmission |
| VRMS | - volts root-mean-square |
| W | - watt |
| WMC | - Waste Management Compartment |
| WMS | - Waste Management System |
| WT | - water tank |
| xmit | - transmit |
| xmtr | - transmitter |
| xpndr | - transponder |
| ZLV | - Z-local vertical |
| ZPN | - impedance pneumogram |

APPENDIX B

## SYMBOLS

LINE LEGEND . . . . . . . . . . . . . . . . . . . . . . . . . . . . . B-2

ELECTRICAL SYMBOLS. . . . . . . . . . . . . . . . . . . . . . . . . B-2

TELEMETRY SYMBOLS . . . . . . . . . . . . . . . . . . . . . . . . . B-10

PIPE LEGEND . . . . . . . . . . . . . . . . . . . . . . . . . . . . . B-11

MECHANICAL SYMBOLS. . . . . . . . . . . . . . . . . . . . . . . . . B-12

PYROTECHNICS SYMBOLS. . . . . . . . . . . . . . . . . . . . . . . . B-15

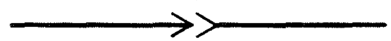
LINE LEGEND

Electrical Line, Power and Control

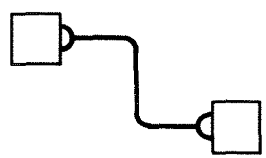
Electrical connected.-

Electrical crossover.-

Electrical connecter



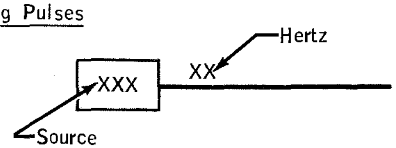
RF Cable



Mechanical Linkage



Timing Pulses

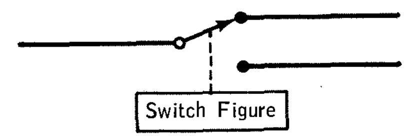



ELECTRICAL SYMBOLS

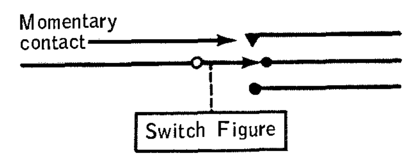
Switches

Where possible, all switches are shown in the de-energized position. If a switch gas momentary contacts (solid triangle), then the de-energized position will be the latching contacts (solid circle). C&D panel figure will accompany switch where possible.

Two-position switch.-

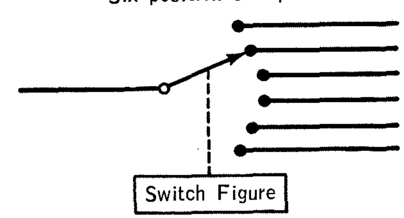



Three position switch.-



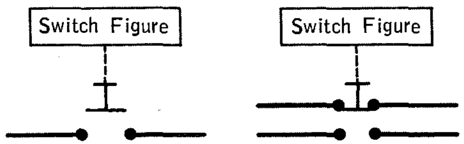

Rotary switches.-

Six-position example

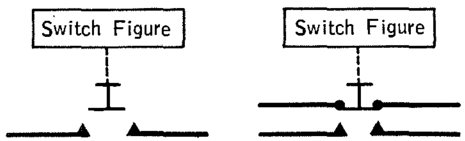


Pushbutton switches.-

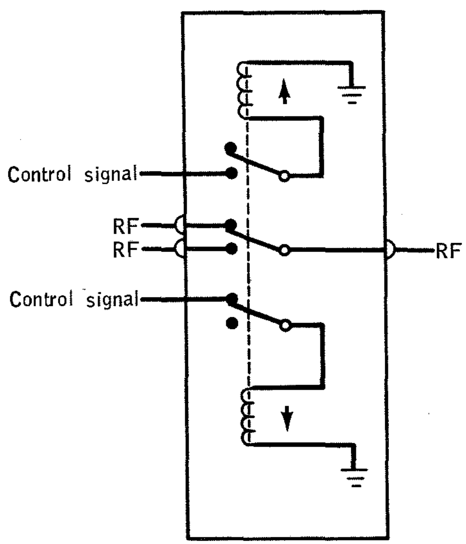
A. Latching



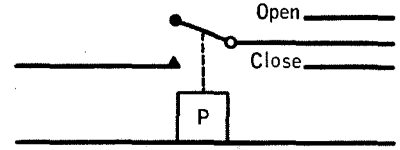

B. Momentary




Coax switch.-

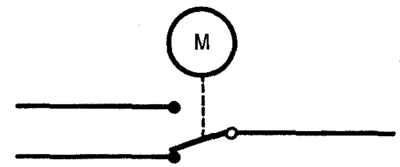



Pressure switch.-

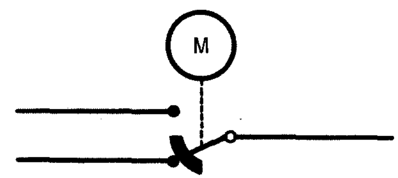



Motor switches.-

A. Break-before-make

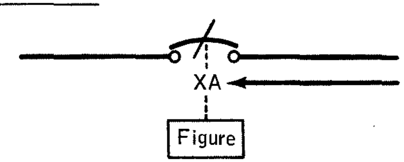



B. Make-before-break




Circuit Breakers

Toggle - SWS.-

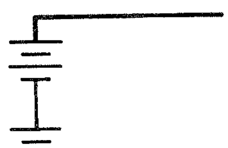


Fuses

General.-


Fusistor.-

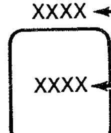

Batteries




Lights

Telelight.-

A. Caution and warning




Component or status light.-

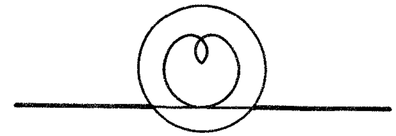
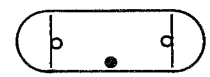


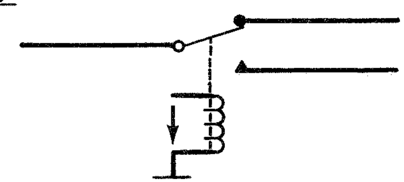

Figure (optional)

Note: In lieu of the light symbols, the actual artwork associated with a panel light may be used.

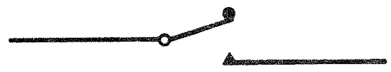
Flourscent Lamp



Relays

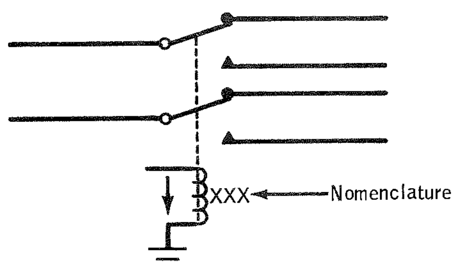


Momentary contact.-

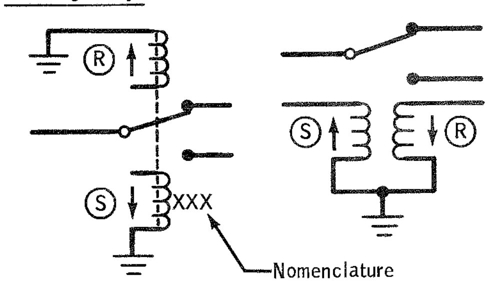


Latching contacts.-

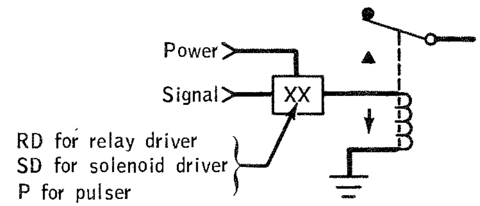
Non-latching relay.- Shown in de-energized position.



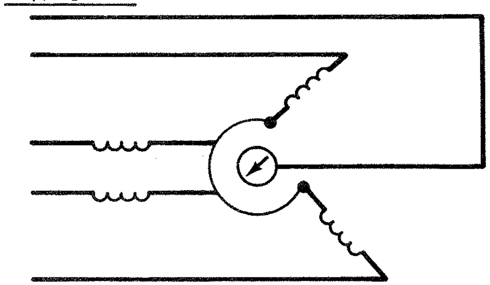

Latching relay.-



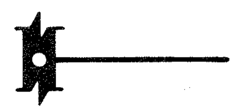

Relay or Solenoid Driver




Stepping motor



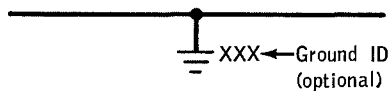
Buses



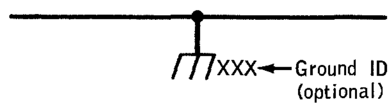
This symbol will be used for either a positive or a negative bus and will always be labeled with the appropriate bus ID.

Grounds

System.-




Frame or spacecraft structural ground.-



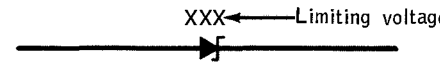

Common or return bus.-

Common or return bus symbol will always be labeled.

Diodes

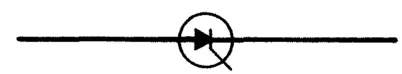
General.-

Zener.-

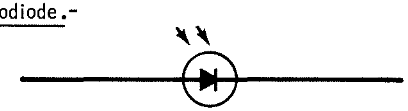



Tunnel.-

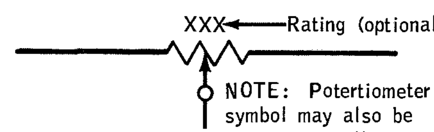
Control rectifier (SCR).-



Photodiode.-



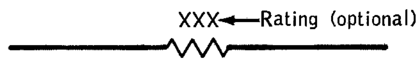
Potentiometer



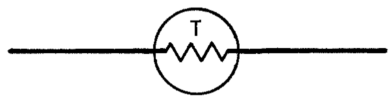

NOTE: Potertiometer symbol may also be shown vertically.

Resistors

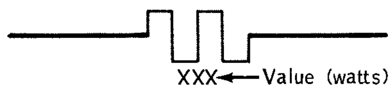
Fixed.-



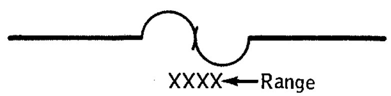

Thermistor or resistance thermometer.- Any element whose sensing resistance varies with temperature regardless of polarity.



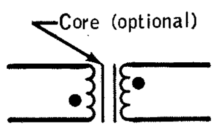

Heater




Thermostat

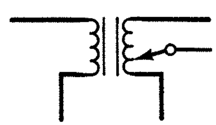



Transformers

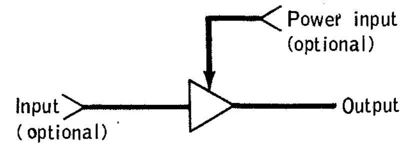



Dots indicate same phase

Variable transformer



Amplifier

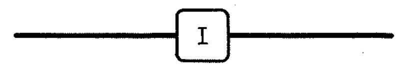



Capacitors

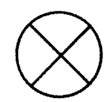
Fixed.-

Variable.-

Signal Inverter

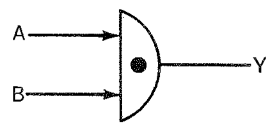



Summing Network (or dispenser)



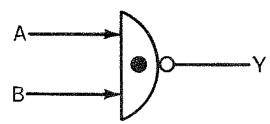
## Gates

And.-



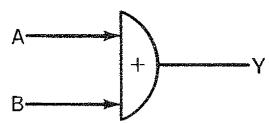

| A | B | Y |
|---|---|---|
| 1 | 1 | 1 |
| 1 | 0 | 0 |
| 0 | 1 | 0 |
| 0 | 0 | 0 |

Nand.-




| A | B | Y |
|---|---|---|
| 1 | 1 | 0 |
| 1 | 0 | 1 |
| 0 | 1 | 1 |
| 0 | 0 | 1 |

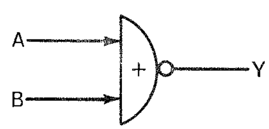
Or.-




| A | B | Y |
|---|---|---|
| 1 | 1 | 1 |
| 1 | 0 | 1 |
| 0 | 1 | 1 |
| 0 | 0 | 0 |

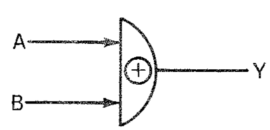
Truth table is optional

Nor.-




| A | B | Y |
|---|---|---|
| 1 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 1 | 0 |
| 0 | 0 | 1 |

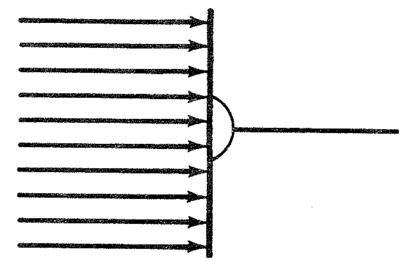
Exclusive or.-




| A | B | Y |
|---|---|---|
| 1 | 1 | 0 |
| 1 | 0 | 1 |
| 0 | 1 | 1 |
| 0 | 0 | 0 |

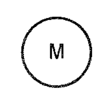
NOTE
Open circle indicates an inverter.

More than three input lines.-



Time Delay

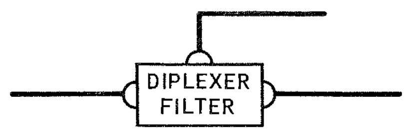

Motor



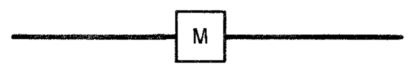

## Electrical Filters

Standard filter.-

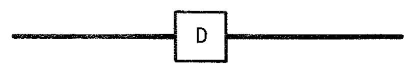
Diplexer filter.-




Modulator

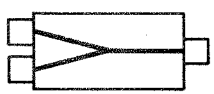



Demodulator

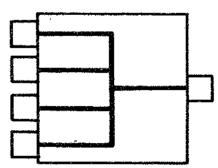



RF Connectors

Hybrid Ring

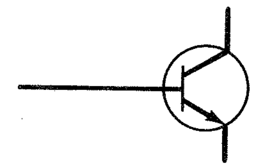


Quadriplexer

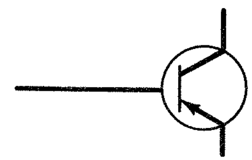


Transistors

NPN.-

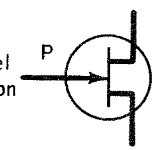


PNP transistor.-



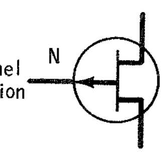
Field effect transistor (FET).-

P-channel
unijunction

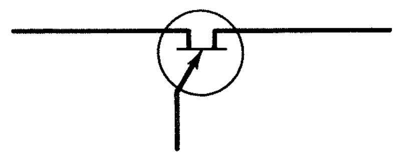



or

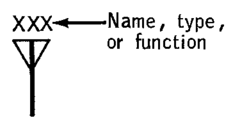
N-channel
unijunction



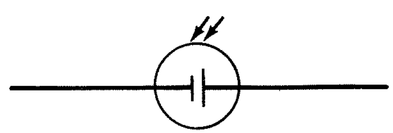
Unijunction transistor.-



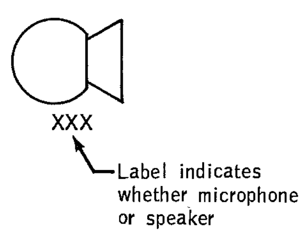
Antenna




Photoelectric Cell

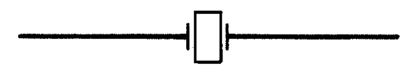


Microphone or Speaker




Headset

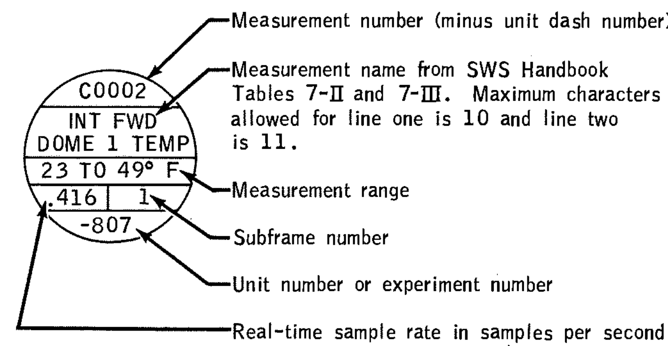
Crystal



TELEMETRY SYMBOLS

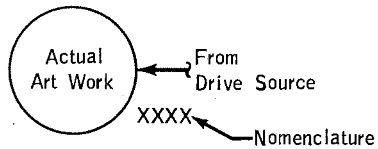
Measurements Telemetered

MDA/AM/OWS telemetry bubble.-

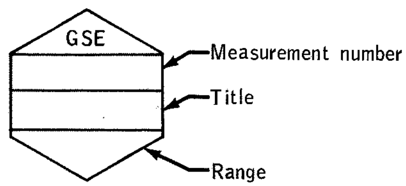


Onboard Meter (or gage)

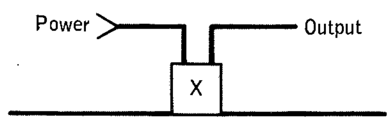
Artwork of the actual meter.




Measurements to GSE




Sensors

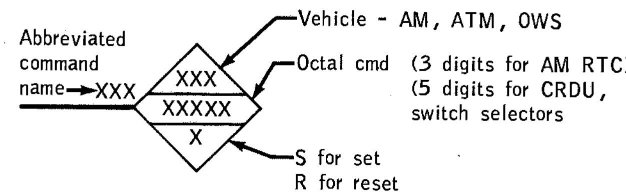



Letters indicate the type (i.e., P-pressure, T-temperature, F-flow, W-wetness, R-rate, V-voltage, I-amps, and D-dewpoint)

Biomedical Electrode

Ground Commands

SWS.-

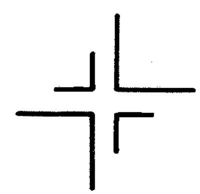



Command name will be adjacent to the diamond.

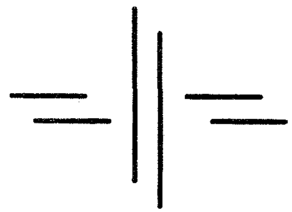
PIPE LEGEND

General

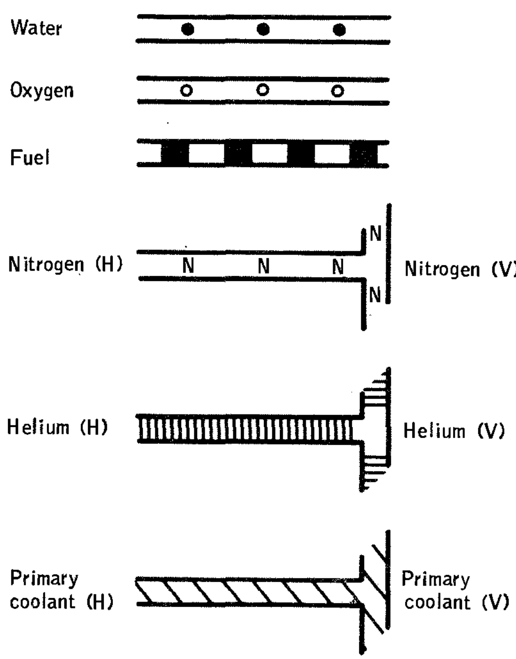
Plumbing connected.-

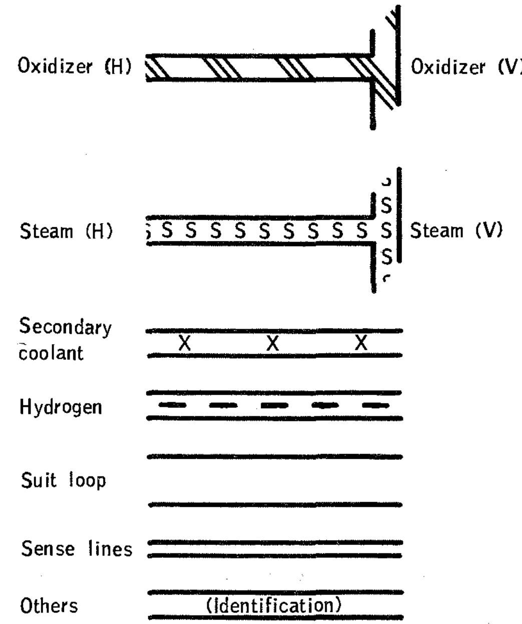


Plumbing crossover.-



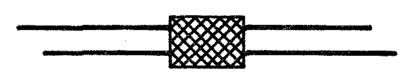
Line Designation



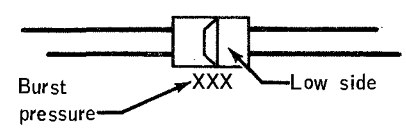




MECHANICAL SYMBOLS

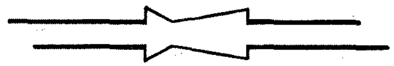
Mechanical Filter



Burst Diaphram

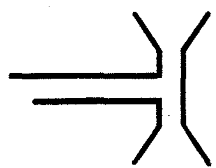


Venturi



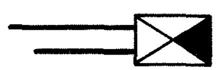
Vent

Thrust Neutralized Vent

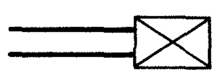


Disconnects

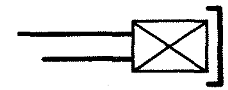
Self-sealing.-



Quick.-



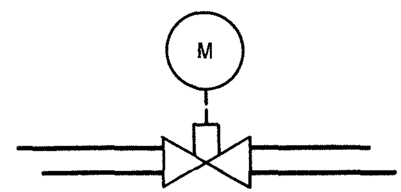
Quick-Disconnect Fill and Drain



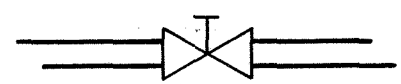
Fill and Drain or Test Point

Valves

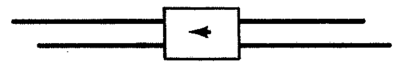
Motor controlled.-




Manual controlled.-

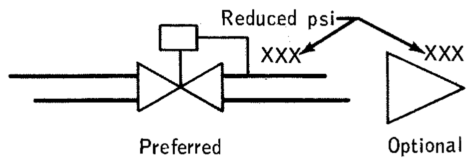


Check valve.-

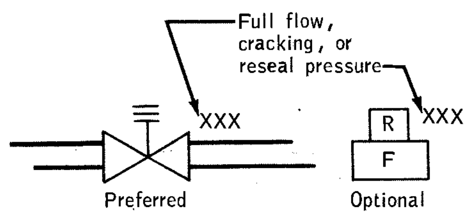


Orifice.-

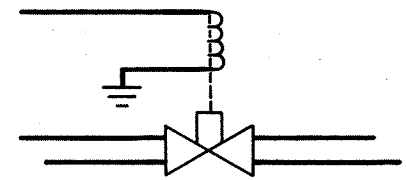

Pressure regulator.-




Relief valve.-

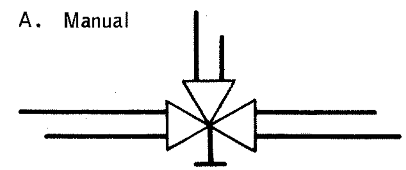



Solenoid valve.-

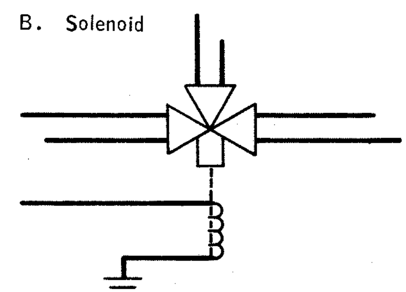


Three-way valves.-

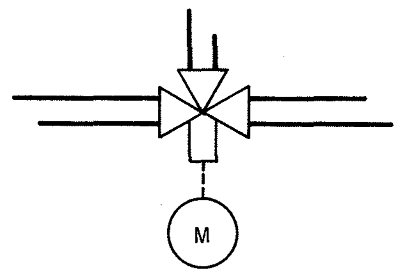
A. Manual



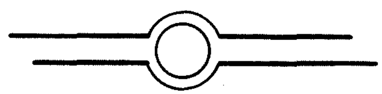
B. Solenoid



Motor controlled

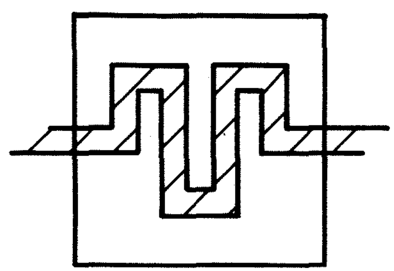



Ball valve.-



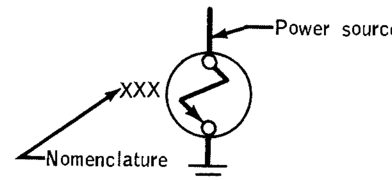
Cold Gas Thruster

Heat Exchanger

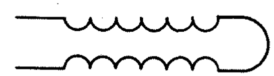


PYROTECHNIC SYMBOLS

Explosive Initiator

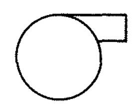



Bellows

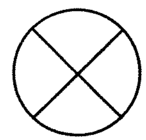


Manual Pump

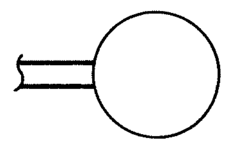
Blower Motor



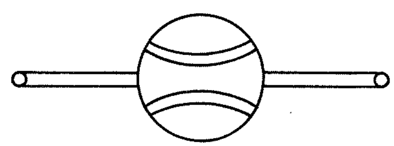
Dispenser



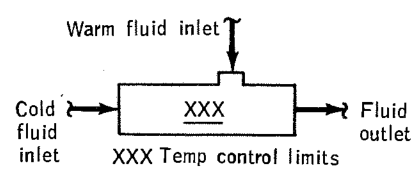
Gas Storage Sphere



Directional Valve



Vernatherm Temperature Control Valve



# APPENDIX C

## CONTROLS AND DISPLAYS LOCATOR INDEX

The locator index is a cross-reference system that permits quick and easy reference to any control or display. This table lists each switch, indicator, or control device alphabetically by system, the panel that contains the item, and the page number on which the item is to be found.

Column headings for the tabular presentation and the description of the entries made under each, are as follows:

- Control/Display Nomenclature. Gives the functional nomenclature of the item.
- Item. Describes the type of control or display.
- Panel Number. Identifies the number of the panel on which the item is located.
- Page Number. Notes the page of Section 3.0 where the function of the item is described.

| Control/Display Nomenclature | Item | Panel No. | Page No. |
|---|---|---|---|
| CAUTION AND WARNING SYSTEM | | | |
| CAUTION AND WARNING SYSTEM - CONVERTERS - C&W - 1, 2 | cb | 202 | 3.0-56 |
| CAUTION AND WARNING SYSTEM - CONVERTERS - EMERG - 1, 2 | cb | 202 | 3.0-56 |
| CAUTION AND WARNING SYSTEM - CONVERTERS - SIG/COND - 1, 2 | cb | 202 | 3.0-57 |
| CAUTION AND WARNING SYSTEM - SENSORS - C&W - 1, 2 | cb | 202 | 3.0-57 |
| CAUTION AND WARNING SYSTEM - SENSORS - EMERG - 1, 2 | cb | 202 | 3.0-57 |
| CAUTION AND WARNING SYSTEM - TONE AMPS C&W 1, 2 | cb | 202 | 3.0-57 |
| CAUTION & WARNING SYSTEM - CLEAR | sw | 206 | 3.0-104 |
| CAUTION & WARNING SYSTEM - MASTER ALARM | lt | 206 | 3.0-104 |
| CAUTION & WARNING SYSTEM - MASTER ALARM | pb | 206 | 3.0-104 |
| CAUTION & WARNING SYSTEM - MEMORY RECALL | lt | 206 | 3.0-104 |
| CAUTION & WARNING SYSTEM - MEMORY RECALL | pb | 206 | 3.0-104 |
| CAUTION & WARNING SYSTEM - POWER - CAUT & WARN | sw | 206 | 3.0-104 |
| CAUTION & WARNING SYSTEM - POWER - EMERGENCY - 1, 2 | sw | 206 | 3.0-105 |
| CAUTION & WARNING SYSTEM - TEST - CAUTION | sw | 206 | 3.0-106 |
| CAUTION & WARNING SYSTEM - TEST - FIRE | sw | 206 | 3.0-106 |
| CAUTION & WARNING SYSTEM - TEST - WARNING | sw | 206 | 3.0-106 |
| CAUTION & WARNING SYSTEM - TEST - $\Delta$P | sw | 206 | 3.0-105 |
| CAUTION & WARNING SYSTEM - TONE VOL - CAUTION | pot | 206 | 3.0-107 |
| CAUTION & WARNING SYSTEM - TONE VOL - EMERGENCY | pot | 206 | 3.0-107 |
| CAUTION & WARNING SYSTEM - TONE VOL - WARNING | pot | 206 | 3.0-107 |
| CAUTION WARNING - ACS MALF | lt | 207 | 3.0-116 |
| CAUTION WARNING - AM AFT FIRE | lt | 207 | 3.0-115 |
| CAUTION WARNING - ATM BUS 1 LOW | lt | 207 | 3.0-116 |
| CAUTION WARNING - ATM BUS 2 LOW | lt | 207 | 3.0-116 |
| CAUTION WARNING - ATM CNST THERM | lt | 207 | 3.0-116 |
| CAUTION WARNING - BAT CHG LO | lt | 207 | 3.0-114 |
| CAUTION WARNING - CLSTR ATT | lt | 207 | 3.0-116 |
| CAUTION WARNING - CLUSTER PRESS LOW | lt | 207 | 3.0-115 |
| CAUTION WARNING - CNDST TANK $\Delta$P | lt | 207 | 3.0-116 |
| CAUTION WARNING - COMPUTER MALF | lt | 207 | 3.0-116 |
| CAUTION WARNING - CREW ALERT | lt | 207 | 3.0-115 |
| CAUTION WARNING - CSM | lt | 207 | 3.0-114 |
| CAUTION WARNING - C&W POWER | lt | 207 | 3.0-116 |
| CAUTION WARNING - EMERG POWER | lt | 207 | 3.0-113 |
| CAUTION WARNING - EMERG SENSOR POWER | lt | 207 | 3.0-113 |
| CAUTION WARNING - EVA 1 | lt | 207 | 3.0-116 |
| CAUTION WARNING - EVA 2 | lt | 207 | 3.0-116 |
| CAUTION WARNING - OWS BUS 1 LOW | lt | 207 | 3.0-115 |
| CAUTION WARNING - OWS BUS 2 LOW | lt | 207 | 3.0-115 |
| CAUTION WARNING - OWS CREW QTRS FIRE | lt | 207 | 3.0-115 |
| CAUTION WARNING - OWS EXP FIRE | lt | 207 | 3.0-114 |
| CAUTION WARNING - OWS FWD FIRE | lt | 207 | 3.0-113 |
| CAUTION WARNING - OWS GAS INTERCHG | lt | 207 | 3.0-115 |
| CAUTION WARNING - MDA/STS FIRE | lt | 207 | 3.0-114 |

| Control/Display Nomenclature | Item | Panel No. | Page No. |
|---|---|---|---|
| CAUTION WARNING - PPO2 LOW. . . . . . . . . . . . . . . . . . . . . . . . . . | lt | 207 | 3.0-114 |
| CAUTION WARNING - PRI COOL FLOW . . . . . . . . . . . . . . . . . . . . . . . | lt | 207 | 3.0-113 |
| CAUTION WARNING - PRI COOL TEMP HIGH. . . . . . . . . . . . . . . . . . . . . | lt | 207 | 3.0-114 |
| CAUTION WARNING - PRI COOL TEMP LOW . . . . . . . . . . . . . . . . . . . . . | lt | 207 | 3.0-115 |
| CAUTION WARNING - RAPID$\Delta$P. . . . . . . . . . . . . . . . . . . . . . . . . . . | lt | 207 | 3.0-113 |
| CAUTION WARNING - REG BUS 1 HIGH, LO. . . . . . . . . . . . . . . . . . . . . | lt | 207 | 3.0-113, 114 |
| CAUTION WARNING - REG BUS 2 HIGH, LO. . . . . . . . . . . . . . . . . . . . . | lt | 207 | 3.0-113, 114 |
| CAUTION WARNING - SEC COOL FLOW . . . . . . . . . . . . . . . . . . . . . . . | lt | 207 | 3.0-113 |
| CAUTION WARNING - SEC COOL TEMP LOW . . . . . . . . . . . . . . . . . . . . . | lt | 207 | 3.0-115 |
| CAUTION WARNING - SEC COOL TEMP HI. . . . . . . . . . . . . . . . . . . . . . | lt | 207 | 3.0-114 |
| CAUTION WARNING - SIEVE FLOW. . . . . . . . . . . . . . . . . . . . . . . . . | lt | 207 | 3.0-115 |
| CAUTION WARNING - SIEVE OUT PPCO2 HIGH. . . . . . . . . . . . . . . . . . . . | lt | 207 | 3.0-114 |
| CAUTION WARNING - SIEVE TEMP HIGH . . . . . . . . . . . . . . . . . . . . . . | lt | 207 | 3.0-113 |
| CAUTION WARNING - SIEVE TIMER . . . . . . . . . . . . . . . . . . . . . . . . | lt | 207 | 3.0-116 |
| CAUTION/WARNING - AM AFT FIRE . . . . . . . . . . . . . . . . . . . . . . . . | lt | 616 | 3.0-229 |
| CAUTION/WARNING - CLUSTER PRESSURE LOW. . . . . . . . . . . . . . . . . . . . | lt | 616 | 3.0-229 |
| CAUTION/WARNING - CREW ALERT. . . . . . . . . . . . . . . . . . . . . . . . . | lt | 616 | 3.0-229 |
| CAUTION/WARNING - MASTER ALARM. . . . . . . . . . . . . . . . . . . . . . . . | lt | 616 | 3.0-229 |
| CAUTION/WARNING - MASTER ALARM. . . . . . . . . . . . . . . . . . . . . . . . | pb | 616 | 3.0-229 |
| CAUTION/WARNING - MDA/STS FIRE. . . . . . . . . . . . . . . . . . . . . . . . | lt | 616 | 3.0-229 |
| CAUTION/WARNING - OWS BUS 1 LOW . . . . . . . . . . . . . . . . . . . . . . . | lt | 616 | 3.0-230 |
| CAUTION/WARNING - OWS BUS 2 LOW . . . . . . . . . . . . . . . . . . . . . . . | lt | 616 | 2.0-230 |
| CAUTION/WARNING - OWS CREW QTRS FIRE. . . . . . . . . . . . . . . . . . . . . | lt | 616 | 2.0-229 |
| CAUTION/WARNING - OWS EXP FIRE. . . . . . . . . . . . . . . . . . . . . . . . | lt | 616 | 3.0-229 |
| CAUTION/WARNING - OWS FWD FIRE. . . . . . . . . . . . . . . . . . . . . . . . | lt | 616 | 3.0-229 |
| CAUTION/WARNING - RAPID$\Delta$P. . . . . . . . . . . . . . . . . . . . . . . . . . . | lt | 616 | 3.0-229 |
| C/W - LOW VOLTAGE SENSE - 1, 2. . . . . . . . . . . . . . . . . . . . . . . . | cb | 613 | 3.0-208 |
| DISPLAY - FLARE ALERT . . . . . . . . . . . . . . . . . . . . . . . . . . . . | cb | 613 | 3.0-209 |
| FLARE ALERT - [ON/OFF]. . . . . . . . . . . . . . . . . . . . . . . . . . . . | sw | 607 | 3.0-188 |
| FLARE ALERT VOLUME. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | pot | 607 | 3.0-188 |
| INHIBIT PANEL - ACS MALF - CMG SAT. . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-125 |
| INHIBIT PANEL - ACS MALF - RATE GYRO. . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-126 |
| INHIBIT PANEL - ACS MALF - TACS ONLY. . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-125 |
| INHIBIT PANEL - AM AFT FIRE - 1, 2. . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-124 |
| INHIBIT PANEL - ATM BUS 1 LOW . . . . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-126 |
| INHIBIT PANEL - ATM BUS 2 LOW . . . . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-126 |
| INHIBIT PANEL - ATM CNST - COOLANT TEMP . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-127 |
| INHIBIT PANEL - ATM CNST - HEATER TEMP. . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-127 |
| INHIBIT PANEL - ATM CNST - PUMP$\Delta$P. . . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-126 |
| INHIBIT PANEL - BATTERY CHARGE LOW - 1, 2, 3, 4, 5, 6, 7, 8 . . . . . . . . . | sw | 207 | 3.0-121, 122 |
| INHIBIT PANEL - CLSTR ATT - HI RATE . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-125 |
| INHIBIT PANEL - CLSTR ATT - THRUSTER STUCK. . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-125 |
| INHIBIT PANEL - CLUSTER PRESS . . . . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-125 |
| INHIBIT PANEL - CNDSATE TANK$\Delta$P . . . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-125 |
| INHIBIT PANEL - COMPUTER - SELF TEST. . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-126 |
| INHIBIT PANEL - COMPUTER - X OVER . . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-126 |
| INHIBIT PANEL - CREW ALERT - 1, 2 . . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-124 |
| INHIBIT PANEL - CSM - 1, 2. . . . . . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-120 |
| INHIBIT PANEL - C&W POWER - 1, 2. . . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-127 |
| INHIBIT PANEL - C&W SIG COND. . . . . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-127 |
| INHIBIT PANEL - EMERG POWER - 1, 2. . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-118 |
| INHIBIT PANEL - EMERG SENSOR - 1, 2 . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-117 |
| INHIBIT PANEL - EVA 1 - H2O IN TEMP . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-123 |
| INHIBIT PANEL - EVA 1 - PUMP$\Delta$P . . . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-123 |
| INHIBIT PANEL - EVA 2 - H2O IN TEMP . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-123 |
| INHIBIT PANEL - EVA 2 - PUMP$\Delta$P . . . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-123 |
| INHIBIT PANEL - MDA/STS FIRE - 1, 2 . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-120 |
| INHIBIT PANEL - OWS BUS 1 LOW . . . . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-124 |
| INHIBIT PANEL - OWS BUS 2 LOW . . . . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-124 |
| INHIBIT PANEL - OWS EXP FIRE - 1, 2 . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-121 |
| INHIBIT PANEL - OWS FWD FIRE - 1, 2 . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-117 |
| INHIBIT PANEL - OWS GAS INTERCHG. . . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-125 |
| INHIBIT PANEL - OWS QTRS FIRE - 1, 2. . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-124 |
| INHIBIT PANEL - PPO2 - CONTROL. . . . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-122 |
| INHIBIT PANEL - PPO2 - MONITOR. . . . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-122 |
| INHIBIT PANEL - PRI COOL PUMP A, B, C . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-119 |
| INHIBIT PANEL - PRI COOL TEMP - HI, LOW . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-120 |
| INHIBIT PANEL - RAPID$\Delta$P - 1, 2 . . . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-117 |
| INHIBIT PANEL - REG BUS 1 - HIGH, LOW . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-118 |
| INHIBIT PANEL - REG BUS 2 - HIGH, LOW . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-118 |

| Control/Display Nomenclature | Item | Panel No. | Page No. |
|---|---|---|---|
| INHIBIT PANEL - SEC COOL PUMP A, B, C | sw | 207 | 3.0-119 |
| INHIBIT PANEL - SEC COOL TEMP - HI, LOW | sw | 207 | 3.0-120 |
| INHIBIT PANEL - SIEVE A - GAS FLOW | sw | 207 | 3.0-123 |
| INHIBIT PANEL - SIEVE A - PPCO2 | sw | 207 | 3.0-122 |
| INHIBIT PANEL - SIEVE A - TEMP | sw | 207 | 3.0-118 |
| INHIBIT PANEL - SIEVE A - TIMER | sw | 207 | 3.0-127 |
| INHIBIT PANEL - SIEVE B - GAS FLOW | sw | 207 | 3.0-123 |
| INHIBIT PANEL - SIEVE B - PPCO2 | sw | 207 | 3.0-123 |
| INHIBIT PANEL - SIEVE B - TEMP | sw | 207 | 3.0-119 |
| INHIBIT PANEL - SIEVE B - TIMER | sw | 207 | 3.0-127 |
| MASTER ALARM - [RESET/TEST] | sw | 120,530,619 | 3.0-16, 181, 247 |
| MASTER ALARM - STATUS LTS - 1, 2 | cb | 202 | 3.0-49 |
| SENSOR 1 | lt | 120,530,619 | 3.0-15, 181, 247 |
| SENSOR 2 | lt | 120,530,619 | 3.0-16, 181, 247 |
| SENSOR 1 - [BUS 1/OFF/BUS 2] | sw | 120,530,619 | 3.0-15, 181, 247 |
| SENSOR 2 - [BUS 1/OFF/BUS 2] | sw | 120,530,619 | 3.0-16, 181, 247 |
| COMMUNICATIONS SYSTEM | | | |
| ANT CNTL 1, 2 | cb | 200 | 3.0-31 |
| ANTENNA - DISC 1/STUB/CMD | sw | 204 | 3.0-73 |
| ANTENNA - [(DISC 1/STUB)/DISC 2/CMD] | sw | 204 | 3.0-73 |
| AUDIO SYSTEM - BUFFER AMPS - 1, 2 | cb | 200 | 3.0-29 |
| AUDIO SYSTEM - CCU - A, B | cb | 200 | 3.0-29 |
| AUDIO SYSTEM - CREW ALERT - CALL - 1, 2 | cb | 200 | 3.0-29 |
| AUDIO SYSTEM - INTERCOM - A, B | cb | 200 | 3.0-29 |
| [CALL] | sw | 102 | 3.0-8 |
| CHAN A - SLEEP/OFF/(ICOM/PTT)/PTT | sel | 102 | 3.0-7 |
| CHAN B - SLEEP/OFF/(ICOM/PTT)/PTT | sel | 102 | 3.0-7 |
| COMM CHANNEL - A, B - SLEEP/ON | sel | 102 | 3.0-6 |
| [ICOM/XMIT] | sw | 102 | 3.0-7 |
| MASTER ALARM | lt | 102 | 3.0-6 |
| RECORD | lt | 102 | 3.0-6 |
| [RECORD/OFF] | sw | 102 | 3.0-6 |
| SPKR VOLUME | pot | 102 | 3.0-6 |
| SUIT UMBILICAL SYSTEM 1 - EVA CCU - 1, 2 | cb | 202 | 3.0-50 |
| SUIT UMBILICAL SYSTEM 1 - EVA CCU - AUDIO CHAN A | conn | 217 | 3.0-137 |
| SUIT UMBILICAL SYSTEM 1 - EVA CCU - AUDIO CHAN A | conn | 317 | 3.0-162 |
| SUIT UMBILICAL SYSTEM 1 - EVA CCU - AUDIO CHAN A | conn | 323 | 3.0-168 |
| SUIT UMBILICAL SYSTEM 2 - EVA CCU - 1, 2 | cb | 202 | 3.0-50 |
| SUIT UMBILICAL SYSTEM 2 - EVA CCU - AUDIO CHAN B | conn | 217 | 3.0-138 |
| SUIT UMBILICAL SYSTEM 2 - EVA CCU - AUDIO CHAN B | conn | 317 | 3.0-163 |
| SUIT UMBILICAL SYSTEM 2 - EVA CCU - AUDIO CHAN B | conn | 323 | 3.0-169 |
| TELEPRINT | cb | 200 | 3.0-30 |
| TELEPRINT - ON/OFF/CMD | sw | 209 | 3.0-131 |
| TELEPRINT - SLEW | pb | 209 | 3.0-131 |
| TV OUTLETS - DOME | cb | 612 | 3.0-197 |
| TV OUTLETS - EXP COMPT | cb | 612 | 3.0-197 |
| TV OUTLETS - FWD COMPT | cb | 612 | 3.0-197 |
| TELEVISION - CAMERA | conn | (133,320, | (3.0-17, 167, |
| TELEVISION - GAIN | pot | 404,555, | 176, 184, |
| TELEVISION - POWER - ON/OFF | sw | 642) | 254) |
| TELEVISION - POWER - AM | cb | 202 | 3.0-53 |
| TELEVISION - POWER - MDA | cb | 202 | 3.0-53 |
| TV ATM VIDEO | cb | 202 | 3.0-53 |
| VHF XPNDR | cb | 200 | 3.0-30 |
| VIDEO - ATM MON - 1/2/TV | sel | 132 | 3.0-16 |
| VOICE RCDR LTS | cb | 200 | 3.0-30 |
| VOICE - RECORD/OFF | lt | 316 | 3.0-161 |
| VOICE - RECORD/OFF | sw | 316 | 3.0-161 |

| Control/Display Nomenclature | Item | Panel No. | Page No. |
|---|---|---|---|
| CREW SYSTEMS | | | |
| AM INSTR PANEL LTS - FLOOD. | cb | 202 | 3.0-48 |
| AM INSTR PANEL LTS - METER. | cb | 202 | 3.0-48 |
| AM INSTR PANEL LTS - STATUS | cb | 202 | 3.0-48 |
| COLD 1-6/LOCK | sel | 705 | 3.0-258 |
| COLD - DISPENSE/CHARGE. | vlv | 705 | 3.0-258 |
| COMPARTMENT LIGHTS - AM - 1, 2. | cb | 202 | 3.0-47 |
| COMPARTMENT LIGHTS - MDA - 1, 2 | cb | 202 | 3.0-47 |
| DOCKING LIGHTS - 1, 2 | cb | 202 | 3.0-48 |
| DOOR - [LOCK/UNLOCK]. | hndl | 817 | 3.0-270 |
| DUMP HEATER - ON. | lt | 617 | 3.0-239 |
| DUMP H2O. | sw | 800 | 3.0-267 |
| DUMP H2O - ON | lt | 800 | 3.0-267 |
| EMERGENCY LIGHTS - MDA/AM - 1, 2. | cb | 202 | 3.0-48 |
| EMERGENCY LIGHTS - OWS - 1, 2 | cb | 202 | 3.0-48 |
| EVA LIGHTS - 1, 2 | cb | 202 | 3.0-49 |
| EXTENDABLE BOOM - CENTER. | sw | 321 | 3.0-168 |
| EXTENDABLE BOOM - SUN END | sw | 321 | 3.0-168 |
| EXTENDABLE BOOM - 1, 2. | cb | 202 | 3.0-45 |
| FAN | sw | 800 | 3.0-268 |
| FECAL/URINE COLLECTOR - drawer 1, 2, 3 - AIRFLOW VLV. | vlv | 825 | 3.0-277 |
| FECAL/URINE COLLECTOR - BLWR/SEPARATOR BUS 1 - PWR 1, 2, 3. | sw | 825 | 3.0-275 |
| FECAL/URINE COLLECTOR - BLWR/SEPARATOR BUS 2 - PWR 1, 2, 3. | sw | 825 | 3.0-276 |
| FECAL/URINE COLLECTOR - drawer 1, 2, 3 - DRAWER | hndl | 825 | 3.0-277 |
| FECAL/URINE COLLECTOR - drawer 1, 2, 3 - VOLUME | ind | 825 | 3.0-276 |
| [FOOD TRAY 1] - [food cavity htr] 1 | sw | N/A | 3.0-285 |
| [FOOD TRAY 1] - [food cavity htr] 2 | sw | N/A | 3.0-286 |
| [FOOD TRAY 1] - [food cavity htr] 3 | sw | N/A | 3.0-286 |
| [FOOD TRAY 1] - HOURS REMAINING | ind | N/A | 3.0-286 |
| [FOOD TRAY 1] - HEAT. | ind | N/A | 3.0-286 |
| [FOOD TRAY 1] - TIMER SET | sw | N/A | 3.0-286 |
| [FOOD TRAY 2] - [food cavity htr] 1 | sw | N/A | 3.0-287 |
| [FOOD TRAY 2] - [food cavity htr] 2 | sw | N/A | 3.0-287 |
| [FOOD TRAY 2] - [food cavity htr] 3 | sw | N/A | 3.0-287 |
| [FOOD TRAY 2] - HOURS REMAINING | ind | N/A | 3.0-287 |
| [FOOD TRAY 2] - HEAT. | ind | N/A | 3.0-287 |
| [FOOD TRAY 2] - TIMER SET | sw | N/A | 3.0-287 |
| [FOOD TRAY 3] - [food cavity htr] 1 | sw | N/A | 3.0-287 |
| [FOOD TRAY 3] - [food cavity htr] 2 | sw | N/A | 3.0-287 |
| [FOOD TRAY 3] - [food cavity htr] 3 | sw | N/A | 3.0-287 |
| [FOOD TRAY 3] - HOURS REMAINING | ind | N/A | 3.0-287 |
| [FOOD TRAY 3] - HEAT. | ind | N/A | 3.0-287 |
| [FOOD TRAY 3] - TIMER SET | sw | N/A | 3.0-287 |
| FOOD TRAY 1 OUTLET. | conn | 707 | 3.0-263 |
| FOOD TRAY 2 OUTLET | conn | 708 | 3.0-263 |
| FOOD TRAY 3 OUTLET. | conn | 709 | 3.0-263 |
| HABITABILITY SUPPORT SYSTEM - BUS 1 - DUMP HEATERS - URINE. | cb | 614 | 3.0-216 |
| HABITABILITY SUPPORT SYSTEM - BUS 1 - DUMP HEATERS - WARDROOM H2O | cb | 614 | 3.0-216 |
| HABITABILITY SUPPORT SYSTEM - BUS 1 - DUMP HEATERS - WMC H2O. | cb | 614 | 3.0-216 |
| HABITABILITY SUPPORT SYSTEM - BUS 1 - FOOD TRAYS - 1, 2, 3. | cb | 614 | 3.0-216 |
| HABITABILITY SUPPORT SYSTEM - BUS 1 - WARDRM H2O HTR. | cb | 614 | 3.0-216 |
| HABITABILITY SUPPORT SYSTEM - BUS 1 - WASTE PROCESSORS - 1/2, 3/4, 5/6. | cb | 614 | 3.0-217 |
| HABITABILITY SUPPORT SYSTEM - BUS 1 - WATER TANK HEATERS - 1 to 10. | cb | 614 | 3.0-215 |
| HABITABILITY SUPPORT SYSTEM - BUS 1 - WASTE TANK VENT HTRS - +Z, -Z | cb | 614 | 3.0-222A |
| HABITABILITY SUPPORT SYSTEM - BUS 1 - WMC BLOWER OUTLET 1 | cb | 614 | 3.0-215 |
| HABITABILITY SUPPORT SYSTEM - BUS 2 - DUMP HEATERS - URINE. | cb | 614 | 3.0-217 |
| HABITABILITY SUPPORT SYSTEM - BUS 2 - DUMP HEATERS - WARDRM H2O | cb | 614 | 3.0-217 |
| HABITABILITY SUPPORT SYSTEM - BUS 2 - DUMP HEATERS - WMC H2O. | cb | 614 | 3.0-217 |
| HABITABILITY SUPPORT SYSTEM - BUS 2 - FOOD TRAYS - 1, 2, 3. | cb | 614 | 3.0-218 |
| HABITABILITY SUPPORT SYSTEM - BUS 2 - WASTE PROCESSORS - 1/2, 3/4, 5/6. | cb | 614 | 3.0-218 |
| HABITABILITY SUPPORT SYSTEM - BUS 2 - WASTE TANK VENT HTRS - +Z, -Z | cb | 614 | 3.0-222A |
| HABITABILITY SUPPORT SYSTEM - BUS 2 - WATER TANK HEATERS 1 to 10. | cb | 614 | 3.0-215 |
| HABITABILITY SUPPORT SYSTEM - BUS 2 - WMC BLOWER OUTLET 2 | cb | 614 | 2.0-215 |
| HABITABILITY SUPPORT SYSTEM - BUS 2 - WMC H2O HTR | cb | 614 | 2.0-217 |
| HEATERS URINE | sw | 800 | 3.0-267 |
| HEATERS URINE - ON. | lt | 800 | 3.0-267 |
| [HIGH INTENSITY LIGHT] - POWER. | sw | N/A | 3.0-308 |
| [HIGH INTENSITY LIGHT] - SYS 1, 2 | sw | N/A | 3.0-308 |
| [HIGH INTENSITY LIGHT] - THERMAL PROTECT. | sw | N/A | 3.0-308 |
| HOT 1-6/LOCK. | sel | 705 | 3.0-258 |
| HOT - DISPENSE/CHARGE | vlv | 705 | 3.0-258 |

| Control/Display Nomenclature | Item | Panel No. | Page No. |
|---|---|---|---|
| H2O DUMP HEATER - ON. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | lt | 700 | 3.0-257 |
| H2O DUMP HEATER - [1/OFF/2] . . . . . . . . . . . . . . . . . . . . . . . . . . | sw | 700 | 3.0-257 |
| H2O DUMP PRESS. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | ind | 800 | 3.0-267 |
| H2O DUMP PRESS. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | ind | 700 | 3.0-257 |
| INTERIOR LIGHTS - ON/OFF. . . . . . . . . . . . . . . . . . . . . . . . . . . . | sw | 101 | 3.0-5 |
| LAMP TEST . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | sw | 617 | 3.0-240 |
| LAMP TEST 1. 2. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | sw | 800 | 3.0-268 |
| LIGHTING - BUS 1 - DOME - 1, 3, 5, 7. . . . . . . . . . . . . . . . . . . . . | cb | 613 | 3.0-203 |
| LIGHTING - BUS 1 - EMER LT VOLTAGE SENSOR . . . . . . . . . . . . . . . . . . | cb | 613 | 3.0-204 |
| LIGHTING - BUS 1 - EXPERIMENT COMPARTMENT - 1, 3, 5, 7, 9, 11, 13 . . . . . . . | cb | 613 | 3.0-205, 206 |
| LIGHTING - BUS 1 - SLEEP COMPT - 1, 3 . . . . . . . . . . . . . . . . . . . . | cb | 613 | 3.0-206 |
| LIGHTING - BUS 1 - UPPER WALL - 1, 3, 5, 7, & 9 . . . . . . . . . . . . . . . | cb | 613 | 3.0-203 |
| LIGHTING - BUS 1 - WARDROOM - 1, 3. . . . . . . . . . . . . . . . . . . . . . | cb | 613 | 3.0-206 |
| LIGHTING - BUS 1 - WMC - 1, 3 . . . . . . . . . . . . . . . . . . . . . . . . | cb | 613 | 3.0-206 |
| LIGHTING - BUS 2 - DOME - 2, 4, 6, 8. . . . . . . . . . . . . . . . . . . . . | cb | 613 | 3.0-204, 205 |
| LIGHTING - BUS 2 - EMER LT VOLTAGE SENSOR . . . . . . . . . . . . . . . . . . | cb | 613 | 3.0-205 |
| LIGHTING - BUS 2 - EXPERIMENT COMPARTMENT - 2, 4, 6, 8, 10, 12, 14. . . . . . . | cb | 613 | 3.0-207 |
| LIGHTING - BUS 2 - SLEEP COMPT - 2. . . . . . . . . . . . . . . . . . . . . . | cb | 613 | 3.0-208 |
| LIGHTING - BUS 2 - UPPERWALL - 2, 4, 6, 8, 10 . . . . . . . . . . . . . . . . | cb | 613 | 3.0-204 |
| LIGHTING - BUS 2 - WARDROOM - 2, 4. . . . . . . . . . . . . . . . . . . . . . | cb | 613 | 3.0-208 |
| LIGHTING - BUS 2 - WMC - 2. . . . . . . . . . . . . . . . . . . . . . . . . . | cb | 613 | 3.0-208 |
| LIGHTING - DOCKING. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-112 |
| LIGHTING - DOME - 1•3•5 . . . . . . . . . . . . . . . . . . . . . . . . . . . | sw | 616 | 3.0-230 |
| LIGHTING - DOME - 2•4•6 . . . . . . . . . . . . . . . . . . . . . . . . . . . | sw | 616 | 3.0-230 |
| LIGHTING - DOME - 7•8 . . . . . . . . . . . . . . . . . . . . . . . . . . . . | sw | 616 | 3.0-230 |
| LIGHTING - EVA - AM . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | sw | 316 | 3.0-160 |
| LIGHTING - EVA - ATM. . . . . . . . . . . . . . . . . . . . . . . . . . . . . | sw | 316 | 3.0-160 |
| LIGHTING - EVA - DA . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | sw | 316 | 3.0-160 |
| LIGHTING - EXPERIMENT COMPT - 1•3•5 . . . . . . . . . . . . . . . . . . . . . | sw | 616 | 3.0-231 |
| LIGHTING - EXPERIMENT COMPT - 2•4•6 . . . . . . . . . . . . . . . . . . . . . | sw | 616 | 3.0-231 |
| LIGHTING - EXPERIMENT COMPT - 13•14 . . . . . . . . . . . . . . . . . . . . . | sw | 616 | 3.0-231 |
| LIGHTING - EXPERIMENT COMPT - 7•9•11. . . . . . . . . . . . . . . . . . . . . | sw | 616 | 3.0-231 |
| LIGHTING - EXPERIMENT COMPT - 8•10•12 . . . . . . . . . . . . . . . . . . . . | sw | 616 | 3.0-231 |
| LIGHTING - LOCK . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | sw | 316 | 3.0-161 |
| LIGHTING - MDA - AFT - 1•3. . . . . . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-112 |
| LIGHTING - MDA - AFT - 2•4. . . . . . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-112 |
| LIGHTING - MDA FORWARD - 1•3. . . . . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-111 |
| LIGHTING - MDA FORWARD - 2•4. . . . . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-111 |
| LIGHTING - METER. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-111 |
| LIGHTING - METER. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | sw | 316 | 3.0-161 |
| LIGHTING - PANEL. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | sel | 207 | 3.0-111 |
| LIGHTING - SLEEP COMPT. . . . . . . . . . . . . . . . . . . . . . . . . . . . | sw | 616 | 3.0-231 |
| LIGHTING - STATUS . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-112 |
| LIGHTING - STS AFT. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-111 |
| LIGHTING - STS FORWARD. . . . . . . . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-111 |
| LIGHTING - TRACKING . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | sw | 207 | 3.0-112 |
| LIGHTING - UPPER WALL - +Y - 3•4. . . . . . . . . . . . . . . . . . . . . . . | sw | 616 | 3.0-230 |
| LIGHTING - UPPER WALL - -Y - 8•9. . . . . . . . . . . . . . . . . . . . . . . | sw | 616 | 3.0-230 |
| LIGHTING - UPPER WALL - +Z - 1•2•10 . . . . . . . . . . . . . . . . . . . . . | sw | 616 | 3.0-230 |
| LIGHTING - UPPER WALL - -Z - 5•6•7. . . . . . . . . . . . . . . . . . . . . . | sw | 616 | 3.0-230 |
| LIGHTS - AFT - [BRIGHT/OFF/DIM] . . . . . . . . . . . . . . . . . . . . . . . | sw | 390 | 3.0-171 |
| LIGHTS - OWS ENTRY - [ON/OFF] . . . . . . . . . . . . . . . . . . . . . . . . | sw | 390 | 3.0-171 |
| LIGHTS - WARDROOM - 1•3 . . . . . . . . . . . . . . . . . . . . . . . . . . . | sw | 630 | 3.0-252 |
| LIGHTS - WARDROOM - 2•4 . . . . . . . . . . . . . . . . . . . . . . . . . . . | sw | 630 | 3.0-252 |
| LIGHTS - WMC. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | sw | 630 | 3.0-252 |
| [OWS LIGHTS] - [HI/LO/OFF]. . . . . . . . . . . . . . . . . . . . . . . . . . | sw | N/A | 3.0-299 |
| [PORTABLE FAN] - [LOW/HI/OFF] . . . . . . . . . . . . . . . . . . . . . . . . | sw | N/A | 3.0-291 |
| [PORTABLE LIGHT] - [HI/LO/OFF]. . . . . . . . . . . . . . . . . . . . . . . . | sw | N/A | 3.0-291 |
| [PORTABLE TIMER] - [CLUTCH] . . . . . . . . . . . . . . . . . . . . . . . . . | lvr | N/A | 3.0-307 |
| [PORTABLE TIMER] - [setting knob] . . . . . . . . . . . . . . . . . . . . . . | knob | N/A | 3.0-307 |
| [PORTABLE TIMER] - TIMER. . . . . . . . . . . . . . . . . . . . . . . . . . . | sw | N/A | 3.0-307 |
| [PORTABLE TIMER] - TONE . . . . . . . . . . . . . . . . . . . . . . . . . . . | sw | N/A | 3.0-307 |
| [PORTABLE WATER TANK] - IODINE INJ PORT . . . . . . . . . . . . . . . . . . . | vlv | N/A | 3.0-307 |
| [PORTABLE WATER TANK] - N2 PRESS. . . . . . . . . . . . . . . . . . . . . . . | ind | N/A | 3.0-307 |
| [PORTABLE WATER TANK] - PRESS VLV . . . . . . . . . . . . . . . . . . . . . . | vlv | N/A | 3.0-307 |
| [PORTABLE WATER TANK] - RELIEF VLV. . . . . . . . . . . . . . . . . . . . . . | vlv | N/A | 3.0-307 |
| [PORTABLE WATER TANK] - VENT. . . . . . . . . . . . . . . . . . . . . . . . . | vlv | N/A | 3.0-307 |
| [PORTABLE WATER TANK] - WATER OUTLET. . . . . . . . . . . . . . . . . . . . . | vlv | N/A | 3.0-307 |
| REFRIGERATION PUMP PKG VACUUM VENT. . . . . . . . . . . . . . . . . . . . . . | vlv | 1001 | 3.0-281 |
| SUIT UMB SYS 1 - LSU POWER. . . . . . . . . . . . . . . . . . . . . . . . . . | sw | 217 | 3.0-136 |
| SUIT UMB SYS 1 - LSU POWER. . . . . . . . . . . . . . . . . . . . . . . . . . | sw | 317 | 3.0-162 |
| SUIT UMB SYS 1 - LSU POWER. . . . . . . . . . . . . . . . . . . . . . . . . . | sw | 323 | 3.0-168 |

| Control/Display Nomenclature | Item | Panel No. | Page No. |
|---|---|---|---|
| SUIT UMB SYS 2 - LSU POWER | sw | 217 | 3.0-137 |
| SUIT UMB SYS 2 - LSU POWER | sw | 317 | 3.0-163 |
| SUIT UMB SYS 2 - LSU POWER | sw | 323 | 3.0-169 |
| TRACKING LIGHTS - CNTL - 1, 2 | cb | 202 | 3.0-49 |
| TRACKING LIGHTS - 1, 2, 3, 4 | cb | 202 | 3.0-49 |
| TRASH AIRLOCK - EJECTOR | hndl | 634 | 3.0-253 |
| TRASH AIRLOCK - PRESSURE GAGE | ind | 634 | 3.0-253 |
| TRASH AIRLOCK - VACUUM SHUTOFF | vlv | 634 | 3.0-253 |
| TRASH AIRLOCK - VALVE/OUTER DOOR | vlv | 634 | 3.0-253 |
| URINE DUMP | vlv | 818 | 3.0-271 |
| [VACUUM CLEANER] - CIRCUIT BREAKER | cb | N/A | 3.0-291 |
| [VACUUM CLEANER] - [ON/MOM ON/OFF] | sw | N/A | 3.0-291 |
| VENT - [VACUUM/CABIN] | vlv | 817 | 3.0-270 |
| WASTE PROCESSORS BUS SELECT - 1, 2, 3, 4, 5, 6, | sw | 617 | 3.0-241 |
| WASTE PROCESSORS EXHAUST PRESS | ind | 800 | 3.0-267 |
| WASTE PROCESSOR - HOURS REMAINING | ind | 817 | 3.0-270 |
| WASTE PROCESSOR - OVER TEMP | lt | 817 | 3.0-270 |
| WASTE PROCESSOR - TIMER | lt | 817 | 3.0-270 |
| WASTE PROCESSOR - 1-6 | cb | 817 | 3.0-269 |
| WASTE PROCESSOR - 1 - TIMER - [SET/AUTO/OFF] | sw | 817 | 3.0-270 |
| WASTE PROCESSOR VACUUM VENT | vlv | 818 | 3.0-271 |
| WATER CHILLER OUTLET | vlv | 705 | 3.0-259 |
| WATER CHILLER SAMPLE PORT | vlv | 705 | 3.0-259 |
| WATER DUMP | vlv | 706,831 | 3.0-259, 278 |
| WATER HEATER OUTLET VALVE | vlv | 705 | 3.0-258 |
| [WATER PURIFICATION EQUIPMENT] - IODINE CONTAINER 1 PORT A, B | vlv | N/A | 3.0-304 |
| [WATER PURIFICATION EQUIPMENT] - IODINE CONTAINER 2 PORT A, B | vlv | N/A | 3.0-304 |
| [WATER PURIFICATION EQUIPMENT] - IODINE INJECTOR 1, 2 | vlv | N/A | 3.0-304 |
| [WATER PURIFICATION EQUIPMENT] - REAGENT CONTAINER 1, 2 | vlv | N/A | 3.0-303 |
| [WATER PURIFICATION EQUIPMENT] - WASTE SAMPLE CONTAINER | vlv | N/A | 3.0-303 |
| [WATER PURIFICATION EQUIPMENT] - WATER SAMPLER 1, 2 | vlv | N/A | 3.0-303 |
| [WATER TANK 1-10] - IODINE INJ PORT | vlv | N/A | 3.0-295, 296 |
| [WATER TANK 1-10] - PRESS | vlv | N/A | 3.0-295, 296 |
| [WATER TANK 1-10] - SAMPLE PORT | vlv | N/A | 3.0-295, 296 |
| [WATER TANK 1-10] - WATER OUTLET | vlv | N/A | 3.0-295, 296 |
| [WMC H20 HEATER] - WATER HEATER OUTLET VALVE | vlv | N/A | 3.0-296 |
| WINDOW HEATER [BUS 1/OFF/BUS 2] | sw | 700 | 3.0-257 |
| **DIGITAL COMMAND - TIME REFERENCE SYSTEM** | | | |
| BRIGHTNESS - [DECR/INCR] | pot | 212,610 | 3.0-131, 187 |
| CMD SYS | sw | 204 | 3.0-73 |
| CMD SYSTEM - PRI, SEC | cb | 200 | 3.0-28 |
| [DAY/HR/MIN/SEC] | ind | 212,610 | 3.0-131, 187 |
| [DECR/INCR] | sel | 206 | 3.0-97 |
| DISPLAY - GMT CLOCK | cb | 613 | 3.0-209 |
| DISPLAY - [ON/OFF] | sw | 212,610 | 3.0-131, 187 |
| [HOUR/MIN/SEC] | ind | 206 | 3.0-97 |
| [START/STOP] [EVENT TIMER] | sw | 206 | 3.0-97 |
| TIME REFERENCE SYSTEM - BUFFER - PRI, SEC | cb | 200 | 3.0-28 |
| TIME REFERENCE SYSTEM - BUFFER - [PRI/SEC] | sw | 212 | 3.0-131 |
| TIME REFERENCE SYSTEM - CLOCK | cb | 200 | 3.0-28 |
| TIME REFERENCE SYSTEM - DAY COUNT - 100 | sw | 212 | 3.0-132 |
| TIME REFERENCE SYSTEM - DAY COUNT - 10 | sw | 212 | 3.0-132 |
| TIME REFERENCE SYSTEM - DAY COUNT - 1 | sw | 212 | 3.0-132 |
| TIME REFERENCE SYSTEM - ELECTRONICS - PRI, SEC | cb | 200 | 3.0-28 |
| TIME REFERENCE SYSTEM - EVENT TIMER | cb | 200 | 3.0-28 |
| TIME REFERENCE SYSTEM - 24 HR - [ZERO RESET] | sw | 212 | 3.0-131 |
| **ELECTRICAL POWER SYSTEM** | | | |
| AM BUS 1 - [REG BUS 1/REG BUS 2] | sw,lt | 206 | 3.0-100 |
| AM BUS 2 - [REG BUS 1/REG BUS 2] | sw,lt | 206 | 3.0-100 |
| AMP - HOUR INTEGRATOR - 1 to 8 | cb | 201 | 3.0-37, 40 |
| AMP - HOUR INTEGRATOR - PRI/SEC - 1 to 8 | lt,sw | 205 | 3.0-88, 89 |
| ARRAY AMPS - 1 to 8 | ind | 206 | 3.0-97 |
| REGULATOR CONTROL - FINE ADJUSTMENT - 1 to 8 | pot | 206 | 3.0-99 |
| ATM 1/TRANSFER 1 FEEDERS - 1 to 18 | cb | 201 | 3.0-40 |
| ATM 2/TRANSFER 2 FEEDERS - 1 to 18 | cb | 201 | 3.0-41 |
| ATM/TRANSFER TIE - BUS 1 - [CLOSED/OPEN] | sw,lt | 206 | 3.0-101 |
| ATM/TRANSFER TIE - BUS 2 - [CLOSED/OPEN] | sw,lt | 206 | 3.0-102 |

| Control/Display Nomenclature | Item | Panel No. | Page No. |
|---|---|---|---|
| BAT CHARGE - [1 to 8] . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | sel | 206 | 3.0-99 |
| BAT CHARGE - (%) - PRI. . . . . . . . . . . . . . . . . . . . . . . . . . . | ind | 206 | 3.0-99 |
| BAT CHARGE - (%) - SEC. . . . . . . . . . . . . . . . . . . . . . . . . . . | ind | 206 | 3.0-99 |
| BATTERIES - ON/OFF -1 to 8. . . . . . . . . . . . . . . . . . . . . . . . | lt,sw | 205 | 3.0-86, 87 |
| BATTERY AMPS - 1 to 8 . . . . . . . . . . . . . . . . . . . . . . . . . . | ind | 206 | 3.0-98 |
| BATTERY CONTROL - 1 to 8. . . . . . . . . . . . . . . . . . . . . . . . . | cb | 201 | 3.0-37, 40 |
| BATTERY VOLTS - 1 to 8. . . . . . . . . . . . . . . . . . . . . . . . . . | ind | 206 | 3.0-97 |
| BUS AMPS - ATM - 1, 2 . . . . . . . . . . . . . . . . . . . . . . . . . . | ind | 206 | 3.0-98 |
| BUS AMPS - CSM - A, B . . . . . . . . . . . . . . . . . . . . . . . . . . | ind | 206 | 3.0-98 |
| BUS AMPS - OWS - 1, 2 . . . . . . . . . . . . . . . . . . . . . . . . . . | ind | 206 | 3.0-98 |
| BUS AMPS - PCG TOTAL - 1, 2 . . . . . . . . . . . . . . . . . . . . . . . | ind | 206 | 3.0-98 |
| BUS AMMETERS - 1, 2 . . . . . . . . . . . . . . . . . . . . . . . . . . . | cb | 201 | 3.0-39 |
| BUS VOLTS - REG - 1, 2. . . . . . . . . . . . . . . . . . . . . . . . . . | ind | 206 | 3.0-99 |
| BUS VOLTS - TRANSFER - 1, 2 . . . . . . . . . . . . . . . . . . . . . . . | ind | 206 | 3.0-99 |
| CHARGE MODE - AUTO/TEMP LMTD - 1 to 8 . . . . . . . . . . . . . . . . . . | lt,sw | 205 | 3.0-90, 91 |
| CHARGE RATE - AUTO/LO - 1 to 8. . . . . . . . . . . . . . . . . . . . . . | lt,sw | 205 | 3.0-89, 90 |
| CHARGER - NORM/BYPASS - 1 to 8. . . . . . . . . . . . . . . . . . . . . . | lt,sw | 205 | 3.0-87, 88 |
| DISCHARGE LIMIT - AUTO/INHIBIT - 1 to 8 . . . . . . . . . . . . . . . . . | lt,sw | 205 | 3.0-91, 92 |
| ELEC GND - [CSM/AIRLOCK]. . . . . . . . . . . . . . . . . . . . . . . . . | lt,sw | 206 | 3.0-101 |
| ELECTRICAL POWER SYSTEM - OWS BUS 1, 2 - AMPS . . . . . . . . . . . . . . | ind | 617 | 3.0-239 |
| ELECTRICAL POWER SYSTEM - OWS BUS 1 - [ON/OFF]. . . . . . . . . . . . . . | sw | 617 | 3.0-239 |
| ELECTRICAL POWER SYSTEM - OWS BUS 2 - [ON/OFF]. . . . . . . . . . . . . . | sw | 617 | 3.0-239 |
| ELECTRICAL POWER SYSTEM - OWS BUS 1, 2 - VOLTS. . . . . . . . . . . . . . | ind | 617 | 3.0-239 |
| EPS SHUNT REG BUS 1 . . . . . . . . . . . . . . . . . . . . . . . . . . . | sw | 206 | 3.0-103 |
| EPS SHUNT REG BUS 1 - DISCON. . . . . . . . . . . . . . . . . . . . . . . | lt | 206 | 3.0-103 |
| EPS SHUNT REG BUS 1 - CONN. . . . . . . . . . . . . . . . . . . . . . . . | lt | 206 | 3.0-103 |
| EPS SHUNT REG BUS 2 . . . . . . . . . . . . . . . . . . . . . . . . . . . | sw | 206 | 3.0-103 |
| EPS SHUNT REG BUS 2 - DISCON. . . . . . . . . . . . . . . . . . . . . . . | lt | 206 | 3.0-103 |
| EPS SHUNT REG BUS 2 - CONN. . . . . . . . . . . . . . . . . . . . . . . . | lt | 206 | 3.0-103 |
| HI POWER ACCESSORY OUTLETS - 1, 2 . . . . . . . . . . . . . . . . . . . . | sw | 139 | 3.0-17 |
| HI POWER ACCESSORY OUTLETS - 1, 2 . . . . . . . . . . . . . . . . . . . . | conn | 803 | 3.0-268 |
| HI POWER ACCESSORY OUTLETS - 1, 2 . . . . . . . . . . . . . . . . . . . . | conn | 521,631 | 3.0-181, 252 |
| HI POWER ACCESSORY OUTLETS - 3, 4 . . . . . . . . . . . . . . . . . . . . | conn | 531 | 3.0-182 |
| HI POWER ACCESSORY OUTLETS - 5, 6 . . . . . . . . . . . . . . . . . . . . | conn | 551 | 3.0-184 |
| HI PWR ACC OUTLETS - 1, 2 . . . . . . . . . . . . . . . . . . . . . . . . | cb | 202 | 3.0-54 |
| HI PWR ACCESS OUTLET - 1. . . . . . . . . . . . . . . . . . . . . . . . . | sw,conn | 115 | 3.0-12 |
| HI PWR ACCESS OUTLET - 1. . . . . . . . . . . . . . . . . . . . . . . . . | conn | 402 | 3.0-175 |
| HI PWR ACCESSORY OUTLETS - DOME - 1, 2. . . . . . . . . . . . . . . . . . | cb | 612 | 3.0-197, 198 |
| HI PWR ACCESSORY OUTLETS - EXP COMPT - 1, 2 . . . . . . . . . . . . . . . | cb | 612 | 3.0-198 |
| HI PWR ACCESSORY OUTLETS - UPPER WALL - 1 to 6. . . . . . . . . . . . . . | cb | 612 | 3.0-197, 198 |
| HI PWR ACCESSORY OUTLETS - WMC - 1, 2 . . . . . . . . . . . . . . . . . . | cb | 612 | 3.0-198 |
| OWS BUS 1 - [ON/OFF]. . . . . . . . . . . . . . . . . . . . . . . . . . . | lt,sw | 206 | 3.0-100 |
| OWS BUS 2 - [ON/OFF]. . . . . . . . . . . . . . . . . . . . . . . . . . . | lt,sw | 206 | 3.0-101 |
| OWS BUS 1 FEEDERS - 1 to 9. . . . . . . . . . . . . . . . . . . . . . . . | cb | 201 | 3.0-38 |
| OWS BUS 1 FEEDERS - 1 to 9. . . . . . . . . . . . . . . . . . . . . . . . | cb | 615 | 3.0-225 |
| OWS BUS 1 FEEDERS - CONTROL - AM. . . . . . . . . . . . . . . . . . . . . | cb | 201 | 3.0-38 |
| OWS BUS 1 FEEDERS - CONTROL - OWS . . . . . . . . . . . . . . . . . . . . | cb | 201 | 3.0-38 |
| OWS BUS 2 FEEDERS - 1 to 9. . . . . . . . . . . . . . . . . . . . . . . . | cb | 201 | 3.0-41 |
| OWS BUS 2 FEEDERS - 1 to 9. . . . . . . . . . . . . . . . . . . . . . . . | cb | 615 | 3.0-225 |
| OWS BUS 2 FEEDERS - CONTROL - AM. . . . . . . . . . . . . . . . . . . . . | cb | 201 | 3.0-41 |
| OWS BUS 2 FEEDERS - CONTROL - OWS . . . . . . . . . . . . . . . . . . . . | cb | 201 | 3.0-41 |
| POWER CONDITIONING GROUP OUTPUT - ON/OFF - 1 to 8 . . . . . . . . . . . . | lt,sw | 205 | 3.0-92,93,94 |
| POWER CONDITIONING GROUP OUTPUT - REG BUS 1/REG BUS 2 - 1 to 4. . . . . . | lt,sw | 205 | 3.0-92, 93 |
| POWER CONDITIONING GROUP OUTPUT - REG BUS 2/REG BUS 1 - 5 to 8. . . . . . | lt,sw | 205 | 3.0-93 94 |
| POWER DISCONNECT - AM - CNTL - 1, 2 . . . . . . . . . . . . . . . . . . . | cb | 201 | 3.0-40 |
| POWER DISCONNECT - ATM - CNTL - 1, 2. . . . . . . . . . . . . . . . . . . | cb | 201 | 3.0-40 |
| POWER SYSTEM CONTROL. . . . . . . . . . . . . . . . . . . . . . . . . . . | sw | 205 | 3.0-83 |
| POWER SYSTEM CONTROL - 1, 2 . . . . . . . . . . . . . . . . . . . . . . . | cb | 201 | 3.0-39 |
| POWER SYSTEM LIGHTS - BUS 1 . . . . . . . . . . . . . . . . . . . . . . . | sw | 206 | 3.0-103 |
| POWER SYSTEM LIGHTS - BUS 2 . . . . . . . . . . . . . . . . . . . . . . . | sw | 206 | 3.0-103 |
| PWR COND GROUP CNTLS - 1 to 8 . . . . . . . . . . . . . . . . . . . . . . | cb | 201 | 3.0-37, 40 |
| PWR DISCONNECT - 1, 2 . . . . . . . . . . . . . . . . . . . . . . . . . . | sw | 205 | 3.0-84 |
| PWR SYSTEM STATUS LTS - 1, 2. . . . . . . . . . . . . . . . . . . . . . . | cb | 201 | 3.0-38 |
| REG ADJUST - BUS 1. . . . . . . . . . . . . . . . . . . . . . . . . . . . | sel | 206 | 3.0-99 |
| REG ADJUST - BUS 2. . . . . . . . . . . . . . . . . . . . . . . . . . . . | sel | 206 | 3.0-99 |
| REG BUS TIE - 1, 2. . . . . . . . . . . . . . . . . . . . . . . . . . . . | cb | 201 | 3.0-38 |
| REG/TRANSFER TIE - BUS 1 - [CLOSED/OPEN]. . . . . . . . . . . . . . . . . | lt,sw | 206 | 3.0-102 |
| REG/TRANSFER TIE - BUS 2 - [CLOSED/OPEN]. . . . . . . . . . . . . . . . . | lt,sw | 206 | 3.0-102 |
| REGULATOR CONTROL - FINE ADJUSTMENT - 1 to 8. . . . . . . . . . . . . . . | pot | 206 | 3.0-99 |
| SOLAR ARRAY OUTPUT - PCG - 1 to 8 . . . . . . . . . . . . . . . . . . . . | lt,sw | 205 | 3.0-84,85, 86 |

| Control/Display Nomenclature | Item | Panel No. | Page No. |
|---|---|---|---|
| TRANSFER BUS TIE - CNTL - 1, 2. | cb | 201 | 3.0-39 |
| TRANSFER 1/CSM MNA FEEDERS - 1 to 5 | cb | 201 | 3.0-39 |
| TRANSFER 2/CSM MNB FEEDERS - 1 to 5 | cb | 201 | 3.0-41 |
| UTILITY OUTLETS - DOME - 1, 2 | conn | 402 | 3.0-176 |
| UTILITY OUTLETS - DOME - 1, 2 | cb | 612 | 3.0-199 |
| UTILITY OUTLETS - EXP COMPARTMENT - 1 to 6. | cb | 612 | 3.0-200 |
| UTILITY OUTLETS - UPPER WALL - 1 to 6 | cb | 612 | 3.0-199 |
| UTILITY OUTLETS - WARDRM - 1, 2 | cb | 612 | 3.0-200 |
| UTILITY OUTLETS - WMC - 1, 2. | cb | 612 | 3.0-200 |
| UTILITY OUTLETS - 1, 2. | sw,conn | 711,803 | 3.0-263, 268 |
| UTILITY OUTLETS - 1, 2. | conn | 521,601 | 3.0-181, 187 |
| UTILITY OUTLETS - 3, 4. | conn | 531,628 | 3.0-181, 251 |
| UTILITY OUTLETS - 5, 6. | conn | 551,631 | 3.0-83, 252 |
| UTILITY OUTLET - 2, 4 | sw,conn | 104,140 | 3.0-11, 17 |
| UTILITY OUTLET - 1, 3 | sw | 112,134 | 3.0-12, 17 |
| UTILITY POWER - AM - 1-3-5. | cb | 202 | 3.0-54 |
| UTILITY POWER - AM - 2-4-6. | cb | 202 | 3.0-54 |
| UTILITY POWER - MDA - 1-3 | cb | 202 | 3.0-53 |
| UTILITY POWER - MDA - 2-4 | cb | 202 | 3.0-53 |
| UTILITY POWER - 1 | sw,conn | 213 | 3.0-132 |
| UTILITY POWER - 2 | sw,conn | 214 | 3.0-132 |
| UTILITY POWER - 3 | sw,conn | 219 | 3.0-138 |
| UTILITY POWER - 4 | sw,conn | 221 | 3.0-139 |
| UTILITY POWER - 5 | sw,conn | 390 | 3.0-172 |
| UTILITY POWER - 6 | sw,conn | 316 | 3.0-161 |
| -Z SAL OUTLETS - POWER - 1, 2 | conn | 544 | 3.0-183 |
| +Z SAL OUTLETS - POWER - 1, 2 | conn | 518 | 3.0-180 |
| -Z SAL OUTLETS S063 UV SYNC | conn | 544 | 3.0-183 |
| ENVIRONMENTAL CONTROL SYSTEM | | | |
| AM FANS - CIRCULATION - 1, 2, 3 | cb | 200 | 3.0-24 |
| AM FANS - CIRCULATION - [HI/OFF/LO] - 1, 2, 3 | sw | 203 | 3.0-66 |
| AM FANS - DUCT - 1, 2 | cb | 200 | 3.0-24 |
| AM FANS - DUCT - [HI/OFF/LO]. | sw | 203 | 3.0-66 |
| AM WALL HEATERS - 1, 2. | cb | 200 | 3.0-21 |
| AM WALL HEATERS - [HI/LO] | sw | 203 | 3.0-65 |
| AM WALL HEATERS - [ON/OFF/CMD]. | sw | 203 | 3.0-65 |
| ATM COOLANT PUMPS - A, B, C | cb | 202 | 3.0-51 |
| ATM COOLANT PUMPS - LO P | lt | 203 | 3.0-68 |
| ATM COOLANT PUMPS - [ON/OFF] - A, B, C. | sw | 203 | 3.0-68 |
| ATM COOLANT RESERVOIR PRESS [OPEN/CLOSE]. | vlv | 235 | 3.0-155 |
| BED 1 - V1 - [A/B/C]. | ind,vlv | 226 | 3.0-149 |
| BED 1 - V4 - [A/B/C]. | ind,vlv | 226 | 3.0-150 |
| BED 2 - V2 - [A/B/C]. | ind,vlv | 226 | 3.0-149 |
| BED 2 - V3 - [A/B/C]. | ind,vlv | 226 | 3.0-149, 150 |
| BED 1 - [ADSORB/STORAGE/DESORB] | ind | 228,229 | 3.0-154 |
| BED 1 - [MANUAL /TO ADSORB] | vlv | 228,229 | 3.0-154 |
| BED 2 - [ADSORB/STORAGE/DESORB] | ind | 228,229 | 3.0-154 |
| BED 2 - [MANUAL/TO DESORB]. | vlv | 228,229 | 3.0-154 |
| CABIN PRESSURE RELIEF VALVE | vlv | 300 | 3.0-159 |
| [CLOSE/EQUALIZE PRESSURE/OPEN]. | vlv | 400 | 3.0-175 |
| CNDST DUMP - PRI, SEC | cb | 200 | 3.0-25 |
| CONDENSATE CONTROL SYSTEM - TANK $\Delta$P (PSI) | ind | 216 | 3.0-135 |
| CONDENSATE CONTROL SYSTEM - VENT HEATERS - [PRI]. | lt | 216 | 3.0-135 |
| CONDENSATE CONTROL SYSTEM - VENT HEATERS - [PRI/OFF/SEC]. | sw | 216 | 3.0-135 |
| CONDENSATE CONTROL SYSTEM - VENT HEATERS [SEC]. | lt | 216 | 3.0-135 |
| CONDENSATE CONTROL SYSTEM - VENT TEMP (°F). | ind | 216 | 3.0-135 |
| CONDENSATE CONTROL SYSTEM - VENT VALVE [PRI/OFF/SEC]. | sw | 216 | 3.0-135 |
| CONDENSATE TANK - H2O [DUMP/OFF/FILL] | vlv | 216 | 3.0-136 |
| CONDENSATE TANK - PRESS [VACUUM/CLOSED/PRESS] | vlv | 216 | 3.0-136 |
| CONDENSING HEAT EXCH AIR FLOW [A/BOTH/B]. | vlv | 233 | 3.0-155 |
| COOLANT PUMP CONTROLS - PRIMARY - A•B | cb | 200 | 3.0-27 |
| COOLANT PUMP CONTROLS - PRIMARY - B•C | cb | 200 | 3.0-27 |
| COOLANT PUMP CONTROLS - PRIMARY - C•A | cb | 200 | 3.0-27 |
| COOLANT PUMP CONTROLS - SECONDARY - A•B | cb | 200 | 3.0-27 |
| COOLANT PUMP CONTROLS - SECONDARY - B•C | cb | 200 | 3.0-27 |
| COOLANT PUMP CONTROLS - SECONDARY - C•A | cb | 200 | 3.0-27 |
| COOLANT PUMP INVERTERS - PRIMARY - 1, 2, 3. | cb | 200 | 3.0-27 |
| COOLANT PUMP INVERTERS - SECONDARY - 1, 2, 3. | cb | 200 | 3.0-27 |

| Control/Display Nomenclature | Item | Panel No. | Page No. |
|---|---|---|---|
| [DIFFUSERS] - [EXP compt diffusers 1-5] | knob | N/A | 3.0-285 |
| [DIFFUSERS] - [Sleep compt diffusers 1-3] | knob | N/A | 3.0-285 |
| [DIFFUSERS] - [Wardrm diffusers 1-3] | knob | N/A | 3.0-285 |
| [DIFFUSERS] - [WMC diffuser] | knob | N/A | 3.0-285 |
| DUCT 3 FANS BUS SELECT - 1, 2, 3, 4 | sw | 617 | 3.0-240 |
| I/LCA HEATERS - 1, 2 | cb | 202 | 3.0-54 |
| LOCK COMPARTMENT DEPRESSURIZATION VALVE | vlv | 318 | 3.0-167 |
| M512 BAT VENT | vlv | 103 | 3.0-11 |
| M171/ESS SUPPLY | vlv | 500 | 3.0-179 |
| [MDA/BOTH/OWS] | vlv | 234 | 3.0-155 |
| MDA FANS - 1, 2 | cb | 200 | 3.0-26 |
| MDA FANS - CSM - 1, 2 | cb | 200 | 3.0-26 |
| MDA FANS - CSM - [HI/OFF/LO] | sw | 203 | 3.0-67 |
| MDA FANS [HI/OFF/LO] - 1, 2 | sw | 203 | 3.0-67 |
| MDA HEATERS - [MANUAL/CMD] | sw | 203 | 3.0-64 |
| MDA HEATERS - PORT - CSM | sw | 203 | 3.0-65 |
| MDA HEATERS - PORT - SPARE | sw | 203 | 3.0-65 |
| MDA HEATERS - TUNNEL | sw | 203 | 3.0-64 |
| MDA HEATERS - WALL | sw | 203 | 3.0-64 |
| MDA/OWS HEATERS - CNTL - 1, 2 | cb | 200 | 3.0-21 |
| MDA/PORT HEATERS - PRI, SEC | cb | 200 | 3.0-21 |
| MDA VENT VALVES - 1, 2 | cb | 202 | 3.0-51 |
| MDA TUNNEL HEATERS - PRIMARY - 1, 2 | cb | 200 | 3.0-22 |
| MDA TUNNEL HEATERS - SECONDARY - 1, 2 | cb | 200 | 3.0-22 |
| MDA WALL HEATERS - PRIMARY - 1, 2 | cb | 200 | 3.0-22 |
| MDA WALL HEATERS - SECONDARY - 1, 2 | cb | 200 | 3.0-22 |
| MOL SIEVE "A" BED CYCLE N2 SUPPLY | vlv | 221 | 3.0-139 |
| MOL SIEVE A HT EXCH - HT EXCH A H20 | vlv | 230 | 3.0-155 |
| MOL SIEVE A HT EXCH - HT EXCH B H20 | vlv | 230 | 3.0-155 |
| MOL SIEVE A HT EXCH - PRI CLNT HT EXCH B | vlv | 230 | 3.0-154 |
| MOL SIEVE A HT EXCH - SEC CLNT HT EXCH B | vlv | 230 | 3.0-155 |
| MOL SIEVE A VENT | vlv | 220 | 3.0-139 |
| MOL SIEVE B HT EXCH - HT EXCH A H20 | vlv | 232 | 3.0-155 |
| MOL SIEVE B HT EXCH - HT EXCH B H20 | vlv | 232 | 3.0-155 |
| MOL SIEVE B HT EXCH - PRI CLNT HT EXCH B | vlv | 232 | 3.0-155 |
| MOL SIEVE B HT EXCH - SEC CLNT HT EXCH B | vlv | 232 | 3.0-155 |
| MOL SIEVE "B" VENT | vlv | 218 | 3.0-138 |
| MOL SIEVE "B" BED CYCLE N2 SUPPLY | vlv | 219 | 3.0-138 |
| MOLECULAR SIEVE A - BED HTRS | cb | 200 | 3.0-24 |
| MOLECULAR SIEVE A - FANS - PRI, SEC | cb | 200 | 3.0-24 |
| MOLECULAR SIEVE A - TIMERS - PRI, SEC | cb | 200 | 3.0-23 |
| MOLECULAR SIEVE B - BED HTRS | cb | 200 | 3.0-25 |
| MOLECULAR SIEVE B - FANS - PRI, SEC | cb | 200 | 3.0-25 |
| MOLECULAR SIEVE B - TIMERS - PRI, SEC | cb | 200 | 3.0-25 |
| MOLECULAR SIEVE - BED - 1, 2 (°F) | ind | 203 | 3.0-62 |
| MOLECULAR SIEVE - DEW PT (°F) | ind | 203 | 3.0-61 |
| MOLECULAR SIEVE - DISPLAY - [SIEVE A/SIEVE B] | sw | 203 | 3.0-61 |
| MOLECULAR SIEVE - HT EXCH - IN, OUT (°F) | ind | 203 | 3.0-61 |
| MOLECULAR SIEVE - PPCO2 - IN, OUT (mmHg) | ind | 203 | 3.0-61 |
| MOLECULAR SIEVE - SIEVE A - BAKEOUT HEATERS | sw | 203 | 3.0-63 |
| MOLECULAR SIEVE - SIEVE A - FANS - DISCONNECT | sw | 203 | 3.0-62 |
| MOLECULAR SIEVE - SIEVE A - FANS - POWER | sw | 203 | 3.0-62 |
| MOLECULAR SIEVE - SIEVE A - TIMERS | sw | 203 | 3.0-62 |
| MOLECULAR SIEVE - SIEVE A - VENT HEATERS | sw | 203 | 3.0-62 |
| MOLECULAR SIEVE - SIEVE B - BAKEOUT HEATERS | sw | 203 | 3.0-64 |
| MOLECULAR SIEVE - SIEVE B - FANS - DISCONNECT | sw | 203 | 3.0-63 |
| MOLECULAR SIEVE - SIEVE B - FANS - POWER | sw | 203 | 3.0-63 |
| MOLECULAR SIEVE - SIEVE B - TIMERS | sw | 203 | 3.0-63 |
| MOLECULAR SIEVE - SIEVE B - VENT HEATERS | sw | 203 | 3.0-63 |
| O2/N2 CONTROL SYSTEM - AM FILL - PRI [OPEN/CLOSE/CMD] | sw | 225 | 3.0-146 |
| O2/N2 CONTROL SYSTEM - AM FILL - SEC [OPEN/CLOSE/CMD] | sw | 225 | 3.0-146 |
| O2/N2 CONTROL SYSTEM - CABIN PRESS REG A [OPEN/CLOSE] | vlv | 225 | 3.0-143 |
| O2/N2 CONTROL SYSTEM - CABIN PRESS REG B [OPEN/CLOSE] | vlv | 225 | 3.0-143 |
| O2/N2 CONTROL SYSTEM - CALIBRATE [OPEN/CLOSE] | vlv | 225 | 3.0-143 |
| O2/N2 CONTROL SYSTEM - FOUR N2 BOTTLES - (°F) | ind | 225 | 3.0-142 |
| O2/N2 CONTROL SYSTEM - FOUR N2 BOTTLES - [OFF/1 to 6] | sel | 225 | 3.0-142 |
| O2/N2 CONTROL SYSTEM - FOUR N2 BOTTLES - PRI [OPEN/CLOSE/CMD] | sw | 225 | 3.0-141 |
| O2/N2 CONTROL SYSTEM - FOUR N2 BOTTLES - (PSI X 10) | ind | 225 | 3.0-142 |
| O2/N2 CONTROL SYSTEM - FOUR N2 BOTTLES - SEC [OPEN/CLOSE/CMD] | sw | 225 | 3.0-141 |
| O2/N2 CONTROL SYSTEM - N2 FILL - PRI [OPEN/CLOSE/CMD] | sw | 225 | 3.0-143 |
| O2/N2 CONTROL SYSTEM - N2 FILL - SEC [OPEN/CLOSE/CMD] | sw | 225 | 3.0-143 |
| O2/N2 CONTROL SYSTEM - N2 - [PRI/OFF/SEC] | vlv/sel | 225 | 3.0-144 |
| O2/N2 CONTROL SYSTEM - N2 - (PSI) | ind | 225 | 3.0-141 |

| Control/Display Nomenclature | Item | Panel No. | Page No. |
|---|---|---|---|
| O2/N2 CONTROL SYSTEM - O2 FILL - PRI [OPEN/CLOSE/CMD] | sw | 225 | 3.0-142 |
| O2/N2 CONTROL SYSTEM - O2 FILL - SEC [OPEN/CLOSE/CMD] | sw | 225 | 3.0-143 |
| O2/N2 CONTROL SYSTEM - O2 (PSI) | ind | 225 | 3.0-141 |
| O2/N2 CONTROL SYSTEM - O2/N2 CONTROLLER - MONITOR - OFF/1/2/3 | sel | 225 | 3.0-145 |
| O2/N2 CONTROL SYSTEM - O2/N2 CONTROLLER - OFF/1/2/3 | sel | 225 | 3.0-145 |
| O2/N2 CONTROL SYSTEM - O2/N2 CONTROLLER - PPO2 (PSI) - 1, 2, 3 | ind | 225 | 3.0-145 |
| O2/N2 CONTROL SYSTEM - OWS N2 [OPEN/CLOSE] | vlv | 225 | 3.0-142 |
| O2/N2 CONTROL SYSTEM - OWS FILL - PRI [OPEN/CLOSE/CMD] | sw | 225 | 3.0-146 |
| O2/N2 CONTROL SYSTEM - OWS FILL - SEC [OPEN/CLOSE/CMD] | sw | 225 | 3.0-146 |
| O2/N2 CONTROL SYSTEM - PRESSURE - AFT | ind | 225 | 3.0-144 |
| O2/N2 CONTROL SYSTEM - PRESSURE - FWD | ind | 225 | 3.0-144 |
| O2/N2 CONTROL SYSTEM - PRESSURE - LOCK | ind | 225 | 3.0-144 |
| O2/N2 CONTROL SYSTEM - PRESSURE - OWS | ind | 225 | 3.0-144 |
| O2/N2 CONTROL SYSTEM - SIX O2 BOTTLES - °F | ind | 225 | 3.0-140 |
| O2/N2 CONTROL SYSTEM - SIX O2 BOTTLES - [OFF/1 to 6] | sel | 225 | 3.0-140 |
| O2/N2 CONTROL SYSTEM - SIX O2 BOTTLES - PRI [OPEN/CLOSE/CMD] | sw | 225 | 3.0-140 |
| O2/N2 CONTROL SYSTEM - SIX O2 BOTTLES - (PSI X 10) | ind | 225 | 3.0-139 |
| O2/N2 CONTROL SYSTEM - SIX O2 BOTTLES - SEC [OPEN/CLOSE/CMD] | sw | 225 | 3.0-140 |
| O2/N2 CONTROL SYSTEM - 5 PSI REG A [OPEN/CLOSE] | vlv | 225 | 3.0-142 |
| O2/N2 CONTROL SYSTEM - 5 PSI REG B [OPEN/CLOSE] | vlv | 225 | 3.0-142 |
| O2/N2 CONTROL SYSTEM - 120 PSI REG A [OPEN/CLOSE] | vlv | 225 | 3.0-140 |
| O2/N2 CONTROL SYSTEM - 120 PSI REG B [OPEN/CLOSE] | vlv | 225 | 3.0-140 |
| O2/N2 CONTROL SYSTEM - 150 PSI REG A [OPEN/CLOSE] | vlv | 225 | 3.0-141 |
| O2/N2 CONTROL SYSTEM - 150 PSI REG B [OPEN/CLOSE] | vlv | 225 | 3.0-141 |
| O2/N2 GAS - CONTROLLERS - 1•3, 2 | cb | 200 | 3.0-23 |
| O2/N2 GAS - FILL - PRI, SEC | cb | 200 | 3.0-23 |
| OWS HEAT EXCHANGER FANS - 1, 2, 3, 4 | cb | 200 | 3.0-26 |
| OWS HEAT EXCHANGER FANS - 1, 2, 3, 4, - [ON/OFF/OWS] | sw | 390 | 3.0-171, 172 |
| OWS PNEU VENT VALVES - 1, 2 | cb | 202 | 3.0-51 |
| OWS RADIANT HEATERS - [ON/OFF/CMD] - 1, 2 | sw | 203 | 3.0-66 |
| OWS RADIANT HEATERS - 1 5, 2 6, 3 7, 4 8 | cb | 200 | 3.0-21 |
| OWS REFRIG - CNTL - 1, 2 | cb | 202 | 3.0-45 |
| OWS SOLENOID VENT VALVES - CNTL - 1, 2 | cb | 202 | 3.0-47 |
| OWS SOLENOID VENT VALVES - 1, 2 | cb | 202 | 3.0-47 |
| PRESSURE - AFT | ind | 316 | 3.0-160 |
| PRESSURE - LOCK | ind | 316 | 3.0-160 |
| PRESSURE - OWS | ind | 316 | 3.0-160 |
| PRESSURE - O2 | ind | 316 | 3.0-160 |
| PRESS BLEED | vlv | 500 | 3.0-179 |
| PRIMARY COOLANT LOOP - INVERTERS | sel | 203 | 3.0-68 |
| PRIMARY COOLANT LOOP - PUMPS - [ON/OFF] - A, B, C | sw | 203 | 3.0-69 |
| PRIMARY COOLANT LOOP - RES LO | lt | 203 | 3.0-69 |
| RAD FLOW - [BYPASS/NORM/CMD] - PRI, SEC | sw | 203 | 3.0-67 |
| RAD FLOW - PRI, SEC | cb | 200 | 3.0-26 |
| REFRIGERATION SYSTEM - DISPLAY SELECT 2 [CHILLER/URINE CHILLER 1, 2, 3] | sel | 616 | 3.0-233 |
| REFRIGERATION SYSTEM - DISPLAY SELECT 1 [HEAT SINK OUTLETS/URINE FREEZER/WARDRM FREEZER/STOWAGE FREEZER] | sel | 616 | 3.0-232 |
| REFRIGERATION SYSTEM - PRIMARY LOOP - CONTROLLERS - RADIATOR BYPASS VLV | cb | 611 | 3.0-192 |
| REFRIGERATION SYSTEM - PRIMARY LOOP - CONTROLLERS - REGEN HEATER | cb | 611 | 3.0-192 |
| REFRIGERATION SYSTEM - PRIMARY LOOP - INLET TEMP - ACCUM LOW | lt | 616 | 3.0-233 |
| REFRIGERATION SYSTEM - PRIMARY LOOP - INLET TEMP - CHILLER LO | lt | 616 | 3.0-233 |
| REFRIGERATION SYSTEM - PRIMARY LOOP - INLET TEMP - FREEZER HIGH | lt | 616 | 3.0-233 |
| REFRIGERATION SYSTEM - PRIMARY LOOP - INLET TEMP - PUMP LOW $\Delta$P | lt | 616 | 3.0-234 |
| REFRIGERATION SYSTEM - PRIMARY LOOP - LOGIC | cb | 611 | 3.0-192 |
| REFRIGERATION SYSTEM - PRIMARY LOOP POWER FEEDERS BUS 1 - 1, 2, 3, 4 | cb | 611 | 3.0-191 |
| REFRIGERATION SYSTEM - PRIMARY LOOP - PUMP INVERTERS | cb | 611 | 3.0-192 |
| REFRIGERATION SYSTEM - PRIMARY PUMPS - 1, 2, 3, 4 | sw | 616 | 3.0-234 |
| REFRIGERATION SYSTEM - SECONDARY LOOP - CONTROLLERS - RADIATOR BYPASS VLV | cb | 611 | 3.0-193 |
| REFRIGERATION SYSTEM - SECONDARY LOOP - CONTROLLERS - REGEN HEATER | cb | 611 | 3.0-193 |
| REFRIGERATION SYSTEM - SECONDARY LOOP - INLET TEMP - ACCUM LOW | lt | 616 | 3.0-234 |
| REFRIGERATION SYSTEM - SECONDARY LOOP - INLET TEMP - CHILLER LOW | lt | 616 | 3.0-234 |
| REFRIGERATION SYSTEM - SECONDARY LOOP - INLET TEMP - FREEZER HIGH | lt | 616 | 3.0-234 |
| REFRIGERATION SYSTEM - SECONDARY LOOP - INLET TEMP - PUMP LOW $\Delta$P | lt | 616 | 3.0-234 |
| REFRIGERATION SYSTEM - SECONDARY LOOP - LOGIC | cb | 611 | 3.0-193 |
| REFRIGERATION SYSTEM - SECONDARY LOOP POWER FEEDERS BUS 2 - 1, 2, 3, 4 | cb | 611 | 3.0-192 |
| REFRIGERATION SYSTEM - SECONDARY LOOP - PUMP INVERTER | cb | 611 | 3.0-193 |
| REFRIGERATION SYSTEM - SECONDARY PUMPS - 1, 2, 3, 4 | sw | 616 | 3.0-235 |
| REFRIGERATION SYSTEM - TEMPERATURE (°F) | ind | 616 | 3.0-231 |
| REFRIGERATION SYSTEM - TEMPERATURE (°F) | ind | 616 | 3.0-231 |
| SECONDARY COOLANT LOOP - INVERTERS | sel | 203 | 3.0-70 |
| SECONDARY COOLANT LOOP - PUMPS - [ON/OFF] - A, B, C | sw | 203 | 3.0-70 |
| SECONDARY COOLANT LOOP - RES LO | lt | 203 | 3.0-70 |

| Control/Display Nomenclature | Item | Panel No. | Page No. |
|---|---|---|---|
| SOLENOID SWITCHES - S1 [AUTO/OFF/MANUAL] | sw | 226,227 | 3.0-150, 153 |
| SOLENOID SWITCHES - S2 [AUTO/OFF/MANUAL] | sw | 226,227 | 3.0-151, 153 |
| SOLENOID SWITCHES - S3 [AUTO/OFF/MANUAL] | sw | 226,227 | 3.0-151, 153 |
| SOLENOID SWITCHES - S4 [AUTO/OFF/MANUAL] | sw | 226,227 | 3.0-150, 153 |
| SUIT UMBILICAL SYSTEM 1 - LCG - INLET | conn | 217 | 3.0-137 |
| SUIT UMBILICAL SYSTEM 1 - LCG - INLET | conn | 317 | 3.0-163 |
| SUIT UMBILICAL SYSTEM 1 - LCG - INLET | conn | 323 | 3.0-169 |
| SUIT UMBILICAL SYSTEM 1 - LCG - OUTLET | conn | 217 | 3.0-137 |
| SUIT UMBILICAL SYSTEM 1 - LCG - OUTLET | conn | 317 | 3.0-163 |
| SUIT UMBILICAL SYSTEM 1 - LCG - OUTLET | conn | 323 | 3.0-169 |
| SUIT UMBILICAL SYSTEM 1 - LCG PUMPS PRI,SEC | cb | 202 | 3.0-50 |
| SUIT UMBILICAL SYSTEM 1 - O2 SUPPLY | conn | 217 | 3.0-137 |
| SUIT UMBILICAL SYSTEM 1 - O2 SUPPLY | conn | 317 | 3.0-162 |
| SUIT UMBILICAL SYSTEM 1 - O2 SUPPLY | conn | 323 | 3.0-169 |
| SUIT UMBILICAL SYSTEM 1 - O2 SUPPLY [OPEN/CLOSE] | vlv | 217 | 3.0-137 |
| SUIT UMBILICAL SYSTEM 1 - O2 SUPPLY [OPEN/CLOSE] | vlv | 317 | 3.0-162 |
| SUIT UMBILICAL SYSTEM 1 - O2 SUPPLY [OPEN/CLOSE] | vlv | 323 | 3.0-169 |
| SUIT UMBILICAL SYSTEM 1 - PUMP - [PRI/OFF/SEC] | sw | 217 | 3.0-136 |
| SUIT UMBILICAL SYSTEM 1 - PUMP - [PRI/OFF/SEC] | sw | 317 | 3.0-162 |
| SUIT UMBILICAL SYSTEM 2 - LCG - INLET | conn | 217 | 3.0-138 |
| SUIT UMBILICAL SYSTEM 2 - LCG - INLET | conn | 317 | 3.0-163 |
| SUIT UMBILICAL SYSTEM 2 - LCG - INLET | conn | 323 | 3.0-170 |
| SUIT UMBILICAL SYSTEM 2 - LCG - OUTLET | conn | 217 | 3.0-138 |
| SUIT UMBILICAL SYSTEM 2 - LCG - OUTLET | conn | 317 | 3.0-163 |
| SUIT UMBILICAL SYSTEM 2 - LCG - OUTLET | conn | 323 | 3.0-170 |
| SUIT UMBILICAL SYSTEM 2 - LCG PUMPS PRI,SEC | cb | 202 | 3.0-50 |
| SUIT UMBILICAL SYSTEM 2 - O2 SUPPLY | conn | 217 | 3.0-138 |
| SUIT UMBILICAL SYSTEM 2 - O2 SUPPLY | conn | 317 | 3.0-163 |
| SUIT UMBILICAL SYSTEM 2 - O2 SUPPLY | conn | 323 | 3.0-170 |
| SUIT UMBILICAL SYSTEM 2 - O2 SUPPLY [OPEN/CLOSE] | vlv | 217 | 3.0-138 |
| SUIT UMBILICAL SYSTEM 2 - O2 SUPPLY [OPEN/CLOSE] | vlv | 317 | 3.0-163 |
| SUIT UMBILICAL SYSTEM 2 - O2 SUPPLY [OPEN/CLOSE] | vlv | 323 | 3.0-170 |
| SUIT UMBILICAL SYSTEM 2 - PUMP [PRI/OFF/SEC] | sw | 217 | 3.0-137 |
| SUIT UMBILICAL SYSTEM 2 - PUMP [PRI/OFF/SEC] | sw | 323 | 3.0-169 |
| SYSTEM 1 LCG RESERVOIR PRESS. | vlv | 223 | 3.0-139 |
| SYSTEM 2 LCG RESERVOIR PRESS. | vlv | 224 | 3.0-139 |
| THERMAL CONTROL SYSTEM - BUS 1 - DUCT 1 FANS - 1, 2, 3, 4 | cb | 614 | 3.0-219 |
| THERMAL CONTROL SYSTEM - BUS 1 - DUCT 3 FANS - 1/2, 3/4 | cb | 614 | 3.0-219 |
| THERMAL CONTROL SYSTEM - BUS 1 - DUCT 1 HTRS - AUTO - 1•3, 2•4 | cb | 614 | 3.0-220 |
| THERMAL CONTROL SYSTEM - BUS 1 - DUCT 1 HTRS - MAN - 1•3, 2•4 | cb | 614 | 3.0-220 |
| THERMAL CONTROL SYSTEM - BUS 1 - DUCT 3 HTRS - 1•3, 2•4 | cb | 614 | 3.0-221 |
| THERMAL CONTROL SYSTEM - BUS 1 - HT EXCH FANS - 1, 3. | cb | 614 | 3.0-221 |
| THERMAL CONTROL SYSTEM - BUS 1 - LOGIC. | cb | 614 | 3.0-220 |
| THERMAL CONTROL SYSTEM - BUS 1 - WINDOW HEATER. | cb | 614 | 3.0-218 |
| THERMAL CONTROL SYSTEM - BUS 1 - WMC FAN. | cb | 614 | 3.0-218 |
| THERMAL CONTROL SYSTEM - BUS 2 - DUCT 2 FANS - 1, 2, 3, 4 | cb | 614 | 3.0-219 |
| THERMAL CONTROL SYSTEM - BUS 2 - DUCT 3 FANS - 1/2, 3/4 | cb | 614 | 3.0-220 |
| THERMAL CONTROL SYSTEM - BUS 2 - DUCT 2 HTRS - AUTO - 1•3, 2•4 | cb | 614 | 3.0-222 |
| THERMAL CONTROL SYSTEM - BUS 2 - DUCT 2 HTRS - MAN - 1•3, 2•4 | cb | 614 | 3.0-221 |
| THERMAL CONTROL SYSTEM - BUS 2 - DUCT 3 HTRS - 1•3, 2•4 | cb | 614 | 3.0-222 |
| THERMAL CONTROL SYSTEM - BUS 2 - HT EXCH FANS - 2, 4. | cb | 614 | 3.0-222 |
| THERMAL CONTROL SYSTEM - BUS 2 - LOGIC. | cb | 614 | 3.0-221 |
| THERMAL CONTROL SYSTEM - BUS 2 - WINDOW HEATER. | cb | 614 | 3.0-219 |
| THERMAL CONTROL SYSTEM - BUS 2 - WMC FAN. | cb | 614 | 3.0-219 |
| THERMAL CONTROL SYSTEM - DUCT AIR FLOW - 1, 2, 3. | ind | 617 | 3.0-244 |
| THERMAL CONTROL SYSTEM - HT EXCHANGER FANS - 1, 2, 3, 4 | sw | 617 | 3.0-246, 247 |
| THERMAL CONTROL SYSTEM - HEATERS - DUCT 1 - 1•3, 2•4. | sw | 617 | 3.0-245 |
| THERMAL CONTROL SYSTEM - HEATERS - DUCT 2 - 1•3, 2•4. | sw | 617 | 3.0-246 |
| THERMAL CONTROL SYSTEM - HEATERS - DUCT 3 - 1•3, 2•4. | sw | 617 | 3.0-244, 245 |
| THERMAL CONTROL SYSTEM - OWS - PRESS. | ind | 617 | 3.0-244 |
| THERMAL CONTROL SYSTEM - OWS - TEMP | ind | 617 | 3.0-244 |
| THERMAL CONTROL SYSTEM - TEMP SELECT (°F) | sel | 617 | 3.0-244 |
| VACUUM SOURCE | conn | 316 | 3.0-162 |
| VACUUM SOURCE VALVE | vlv | 316 | 3.0-161 |
| VENT HTRS - PRI, SEC. | cb | 200 | 3.0-24 |
| VENT PLUG | plg | 103 | 3.0-11 |
| WINDOW HEATER CONTROL - AUTO HEAT | sw | 117 | 3.0-15 |
| WINDOW HEATER CONTROL - OVER TEMP | lt | 117 | 3.0-15 |
| WINDOW HEATER CONTROL - RESET | sw | 117 | 3.0-15 |
| WINDOW HEATER CONTROL - ΔTEMP. | lt | 117 | 3.0-15 |
| 150 PSI N2 SUPPLY | vlv | 500 | 3.0-179 |
| 150 PSI N2 PORTABLE WATER TANK PRESS. | vlv,conn | 500 | 3.0-179 |

| Control/Display Nomenclature | Item | Panel No. | Page No. |
|---|---|---|---|
| 35 PSI REG A. | vlv | 500 | 3.0-179 |
| 35 PSI REG B. | vlv | 500 | 3.0-179 |
| EXPERIMENT SYSTEM | | | |
| EARTH RESOURCES - EREP PWR - CNTL - 1, 2. | cb | 202 | 3.0-45 |
| EARTH RESOURCES - PANEL POWER | cb | 202 | 3.0-45 |
| EARTH RESOURCES - RECORDER - 1, 2 | cb | 202 | 3.0-46 |
| EARTH RESOURCES - S190 - 1, 2, 3. | cb | 202 | 3.0-46 |
| EARTH RESOURCES - S191 - SPECT. | cb | 202 | 3.0-46 |
| EARTH RESOURCES - S191 - VTS. | cb | 202 | 3.0-46 |
| EARTH RESOURCES - S192. | cb | 202 | 3.0-46 |
| EARTH RESOURCES - S193 - HTR. | cb | 202 | 3.0-46 |
| EARTH RESOURCES - S193 - 1. | cb | 202 | 3.0-46 |
| EARTH RESOURCES - S194 - HTR. | cb | 202 | 3.0-46 |
| EARTH RESOURCES - WINDOW HTR. | cb | 202 | 3.0-46 |
| ESS SUPPLY. | vlv | 620 | 3.0-251 |
| EXPERIMENT - BUS 1 - ESS. | cb | 613 | 3.0-209 |
| EXPERIMENT - BUS 1 - M131 CHAIR | cb | 613 | 3.0-210 |
| EXPERIMENT - BUS 1 - M172 BMMD. | cb | 613 | 3.0-211 |
| EXPERIMENT - BUS 1 - SAL - -Z - OUTLET 1. | cb | 613 | 3.0-210 |
| EXPERIMENT - BUS 1 - SAL - +Z - OUTLET 1. | cb | 613 | 3.0-210 |
| EXPERIMENT - BUS 1 - WMC SMMD | cb | 613 | 3.0-210 |
| EXPERIMENT - BUS 2 - ESS. | cb | 613 | 3.0-210 |
| EXPERIMENT - BUS 2 - M509 | cb | 613 | 3.0-211 |
| EXPERIMENT - BUS 2 - SAL - -Z - OUTLET 2. | cb | 613 | 3.0-210 |
| EXPERIMENT - BUS 2 - SAL - +Z - OUTLET 2. | cb | 613 | 3.0-210 |
| EXPERIMENT - BUS 2 - T013 | cb | 613 | 3.0-211 |
| EXPERIMENT - BUS 2 - WARDRM SMMD. | cb | 613 | 3.0-210 |
| [LATCH/UNLATCH] | knob | 107 | 3.0-11 |
| [LOCK]. | latch | 107 | 3.0-11 |
| [LOCK/UNLOCK] | hndl | 108 | 3.0-12 |
| M092 LBNP - VACUUM VENT | vlv | 625 | 3.0-251 |
| M171 SUPPLY | vlv | 620 | 3.0-251 |
| M509 BOTTLE RECHARGE - FILL | vlv | 390 | 3.0-170 |
| M509 BOTTLE RECHARGE - ECS/N2 3, 4, 5, 6. | vlv | 390 | 3.0-170 |
| M509 BOTTLE RECHARGE - N2 1, N2 2 | vlv | 390 | 3.0-170 |
| M509 BOTTLE RECHARGE - UMB VENT | vlv | 390 | 3.0-170 |
| M512. | cb | 202 | 3.0-45 |
| M512 BAT VENT VALVE | vlv | 103 | 3.0-11 |
| NOISE BURST ANTENNA | cb | 202 | 3.0-45 |
| [OPEN/CLOSE]. | knob | 108 | 3.0-12 |
| PROTON SPECT [ON/OFF/CMD] | sw | 208 | 3.0-131 |
| PROT SPECT. | cb | 202 | 3.0-45 |
| SAL - CNTL - 1, 2 | cb | 202 | 3.0-56 |
| S009. | cb | 202 | 3.0-45 |
| S063 UV SYNC. | conn | 544 | 3.0-183 |
| S063 UV SYNC. | conn | 701 | 3.0-258 |
| VAN ALLEN BELT DOSIMETER. | sw | 640 | 3.0-253 |
| INSTRUMENTATION SYSTEM | | | |
| DISPLAY - BUS 1 - DISP PWR/RCDR CONT. | cb | 613 | 3.0-209 |
| DISPLAY - BUS 1 - LAMP TEST | cb | 613 | 3.0-209 |
| DISPLAY - BUS 2 - DISP PWR/RCDR CONT. | cb | 613 | 3.0-209 |
| DISPLAY - BUS 2 - LAMP TEST | cb | 613 | 3.0-209 |
| INSTRUMENTATION SYSTEM - CONTROL - CONV | cb | 200 | 3.0-31 |
| INSTRUMENTATION SYSTEM - CONTROL - ELECTRONICS - CMD. | cb | 200 | 3.0-32 |
| INSTRUMENTATION SYSTEM - CONTROL - ELECTRONICS - MAN. | cb | 200 | 3.0-32 |
| INSTRUMENTATION SYSTEM - CONTROL - PROGRAMMER - CMD | cb | 200 | 3.0-32 |
| INSTRUMENTATION SYSTEM - CONTROL - PROGRAMMER - MAN | cb | 200 | 3.0-32 |
| INSTRUMENTATION SYSTEM - CONTROL - RECORDER - CMD | cb | 200 | 3.0-32 |
| INSTRUMENTATION SYSTEM - CONTROL - RECORDER - MAN | cb | 200 | 3.0-32 |
| INSTRUMENTATION SYSTEM - CONTROL - TELEMETRY - CMD. | cb | 200 | 3.0-32 |
| INSTRUMENTATION SYSTEM - CONTROL - TELEMETRY - MAN. | cb | 200 | 3.0-32 |
| INSTRUMENTATION SYSTEM - CONTROL - QCM MON. | cb | 200 | 3.0-32 |
| INSTRUMENTATION SYSTEM - CONVERTERS - 1, 2, 3 | cb | 200 | 3.0-29 |
| INSTRUMENTATION SYSTEM - CONVERTERS [CMD/1&2/2&1/1&3/3&2] | sel | 204 | 3.0-74 |
| INSTRUMENTATION SYSTEM - DISPLAY CONV - [PRI/OFF/SEC] | sw | 204 | 3.0-74 |
| INSTRUMENTATION SYSTEM - DISPLAY CONVERTERS - INPUT - PRI | cb | 200 | 3.0-30 |
| INSTRUMENTATION SYSTEM - DISPLAY CONVERTERS - INPUT - SEC | cb | 200 | 3.0-30 |

| Control/Display Nomenclature | Item | Panel No. | Page No. |
|---|---|---|---|
| INSTRUMENTATION SYSTEM - DISPLAY CONVERTERS - OUTPUT - +24V | cb | 200 | 3.0-31 |
| INSTRUMENTATION SYSTEM - DISPLAY CONVERTERS - OUTPUT - -24V | cb | 200 | 3.0-31 |
| INSTRUMENTATION SYSTEM - DISPLAY CONVERTERS - OUTPUT - +5V | cb | 200 | 3.0-31 |
| INSTRUMENTATION SYSTEM - ELECTRONICS [PRI/SEC/CMD] | sw | 204 | 3.0-75 |
| INSTRUMENTATION SYSTEM - MODE SELECT - EXP 1 | sel | 617 | 3.0-242 |
| INSTRUMENTATION SYSTEM - MODE SELECT - EXP 2 | sel | 617 | 3.0-243 |
| INSTRUMENTATION SYSTEM - OWS MUX HEATERS - 1, 2 | cb | 200 | 3.0-31 |
| INSTRUMENTATION SYSTEM - PROGRAMMER [PRI/SEC/CMD] | sw | 204 | 3.0-74 |
| INSTRUMENTATION SYSTEM - RECORDER AUDIO [A/B] | sw | 204 | 3.0-75 |
| INSTRUMENTATION SYSTEM - SIGNAL CONDITIONING - MDA | cb | 200 | 3.0-34 |
| INSTRUMENTATION SYSTEM - SIGNAL CONDITIONING - OWS - 1, 2 | cb | 200 | 3.0-34 |
| INSTRUMENTATION SYSTEM - TAPE RECORDERS - EXP 1 - ON | lt | 617 | 3.0-243 |
| INSTRUMENTATION SYSTEM - TAPE RECORDERS - EXP 1 - [RECORD/OFF] | sw | 617 | 3.0-243 |
| INSTRUMENTATION SYSTEM - TAPE RECORDERS - EXP 2 | lt | 617 | 3.0-243 |
| INSTRUMENTATION SYSTEM - TAPE RECORDERS - EXP 2 - [RECORD/OFF] | sw | 617 | 3.0-243 |
| INSTRUMENTATION SYSTEM - TRANSDUCER GROUP 1 - 1 | cb | 200 | 3.0-33 |
| INSTRUMENTATION SYSTEM - TRANSDUCER GROUP 1 - +24V | cb | 200 | 3.0-33 |
| INSTRUMENTATION SYSTEM - TRANSDUCER GROUP 1 - -24V | cb | 200 | 3.0-33 |
| INSTRUMENTATION SYSTEM - TRANSDUCER GROUP 1 - +5V | cb | 200 | 3.0-33 |
| INSTRUMENTATION SYSTEM - TRANSDUCER GROUP 2 - 2 | cb | 200 | 3.0-33 |
| INSTRUMENTATION SYSTEM - TRANSDUCER GROUP 2 - +24V | cb | 200 | 3.0-33 |
| INSTRUMENTATION SYSTEM - TRANSDUCER GROUP 2 - -24V | cb | 200 | 3.0-33 |
| INSTRUMENTATION SYSTEM - TRANSDUCER GROUP 2 - +5V | cb | 200 | 3.0-33 |
| INSTRUMENTATION SYSTEM - TRANSMITTERS - A, B, C | cb | 200 | 3.0-30 |
| MANUAL DUMP - [ON/OFF] | sw | 204 | 3.0-79 |
| TAPE RECORDERS - CONTROL [MANUAL SELECT/CMD] | sw | 204 | 3.0-75 |
| TAPE RECORDERS - EXP 1 - ON | lt | 542 | 3.0-182 |
| TAPE RECORDERS - EXP 1 - [RECORD/OFF] | sw | 542 | 3.0-182 |
| TAPE RECORDERS - EXP 2 - ON | lt | 542 | 3.0-182 |
| TAPE RECORDERS - EXP 2 - [RECORD/OFF] | sw | 542 | 3.0-183 |
| TAPE RECORDERS - LAMP TEST | sw | 542 | 3.0-183 |
| TAPE RECORDERS - 1 - STOP | lt | 204 | 3.0-75 |
| TAPE RECORDERS - 1 - [OFF/DATA VOICE/EXP 1 VOICE/EXP 2] | sel | 204 | 3.0-75, 76 |
| TAPE RECORDERS - 2 - STOP | lt | 204 | 3.0-76 |
| TAPE RECORDERS - 2 - [OFF/DATA VOICE/EXP 1 VOICE/EXP 2] | sel | 204 | 3.0-76 |
| TAPE RECORDERS - 3 - STOP | lt | 204 | 3.0-76 |
| TAPE RECORDERS - 3 - [OFF/DATA VOICE/EXP 1 VOICE/EXP 2] | sel | 204 | 3.0-76 |
| TAPE RECORDING - DATA | lt | 204 | 3.0-79 |
| TAPE RECORDING - DATA [RECORD/OFF/CMD] | sw | 204 | 3.0-79 |
| TAPE RECORDING - EKG/ZPN [ENABLE/OFF] | sw | 204 | 3.0-80 |
| TAPE RECORDING - EXP 1 | lt | 204 | 3.0-79 |
| TAPE RECORDING - EXP 1 [RECORD/OFF] | sw | 204 | 3.0-79 |
| TAPE RECORDING - EXP 2 | lt | 204 | 3.0-80 |
| TAPE RECORDING - EXP 2 [RECORD/OFF] | sw | 204 | 3.0-80 |
| TRANSMITTERS - [ON/OFF/CMD] | sw | 204 | 3.0-77 |
| TRANSMITTER INPUT - A [OFF/REAL TIME/DATA/VOICE/EXP 1/EXP VOICE/EXP 2] | sel | 204 | 3.0-77, 78 |
| TRANSMITTER INPUT - B [OFF/REAL TIME/DATA/VOICE/EXP 1/EXP VOICE/EXP 2] | sel | 204 | 3.0-78 |
| TRANSMITTER INPUT - C [OFF/REAL TIME/DATA/VOICE/EXP 1/EXP VOICE/EXP 2] | sel | 204 | 3.0-78 |
| -Z SAL OUTLETS - INST | conn | 544 | 3.0-183 |
| +Z SAL OUTLETS - INST | conn | 518 | 3.0-181 |


SEQUENTIAL SYSTEM


| | | | |
|---|---|---|---|
| ANTENNA - [DEPLOY/SAFE/CMD] | sw | 205 | 3.0-83 |
| ATM ALTN TLM CNTL - 1, 2 | cb | 202 | 3.0-53 |
| DEPLOY BUS - [ARM/SAFE/CMD] | sw | 205 | 3.0-83 |
| DEPLOY - BUS ARM - PRI, SEC | cb | 202 | 3.0-51 |
| DEPLOY - DISCONE ANTENNA - BUS 1 - CNTL | cb | 202 | 3.0-52 |
| DEPLOY - DISCONE ANTENNA - BUS 1 - PWR - 1, 2 | cb | 202 | 3.0-52 |
| DEPLOY - DISCONE ANTENNA - BUS 2 - CNTL | cb | 202 | 3.0-52 |
| DEPLOY - DISCONE ANTENNA - BUS 2 - PWR - 1, 2 | cb | 202 | 3.0-52 |
| DEPLOY - OWS SWITCH SELECTOR - 1, 2 | cb | 202 | 3.0-52 |
| DEPLOY - SEQUENTIAL BUS ARM - PRI, SEC | cb | 202 | 3.0-51 |
| LNCH TM | cb | 202 | 3.0-52 |
| SEQUENTIAL BUS - [CMD/SAFE] | sw | 205 | 3.0-83 |

| Control/Display Nomenclature | Item | Panel No. | Page No. |
|---|---|---|---|
| STRUCTURES | | | |
| CM/MDA ΔP | ind | 100,118 | 3.0-5, 15 |
| DOOR [OPEN/CLOSE] | crank | 517,543 | 3.0-180, 183 |
| RELEASE HANDLE | hndl | 100 | 3.0-5 |
| HANDLE RELEASE | hndl | 517,543 | 3.0-180, 183 |
| [INTERNAL HANDLE] | knob | 319 | 3.0-167 |
| [LATCH/UNLATCH] | knob | 107 | 3.0-11 |
| [LOCK/UNLOCK] | hndl | 108 | 3.0-12 |
| [OPEN/CLOSE] | crank | 108 | 3.0-12 |
| [OPEN/CLOSE] | hndl | 100,118 | 3.0-5, 15 |
| PNEUMATIC VENT PORT | plug | 405 | 3.0-176 |
| [PRESS EQUAL VALVE] | vlv | 311 | 3.0-159 |
| EQUALIZATION VALVE | vlv | 100,118 | 3.0-5, 15 |
| RELEASE HANDLE | hndl | 400 | 3.0-175 |
| SAL PRESSURE | vlv | 517,543 | 3.0-180, 183 |
| SAL PRESSURE | ind | 517,543 | 3.0-180, 183 |
| SOLENOID VENT PORT | plug | 403 | 3.0-176 |
| [STS WINDOW CRANK ASSEMBLY] | crank | 241,242, 243,244 | 3.0-156 |
| VENT PANEL - STOW | plug | 103 | 3.0-11 |
| VENT PANEL - VENT | plug | 103 | 3.0-11 |
| WINDOW VENT | knob | 319 | 3.0-167 |
| TACS | | | |
| TACS - COMMAND CONTROL - 1 - PRI, SEC | cb | 202 | 3.0-54 |
| TACS - COMMAND CONTROL - 2 - PRI, SEC | cb | 202 | 3.0-54 |
| TACS - MANUAL CONTROL - 1, 2 | cb | 202 | 3.0-55 |
| TACS - MANUAL CONTROL - INHIBIT - 1, 2 | cb | 202 | 3.0-55 |
| TACS - THRUSTER 1 - 1, 2 | cb | 202 | 3.0-55 |
| TACS - THRUSTER 2 - 1, 2 | cb | 202 | 3.0-55 |
| TACS - THRUSTER 3 - 1, 2 | cb | 202 | 3.0-55 |
| TACS - THRUSTER 4 - 1, 2 | cb | 202 | 3.0-55 |
| TACS - THRUSTER 5 - 1, 2 | cb | 202 | 3.0-56 |
| TACS - THRUSTER 6 - 1, 2 | cb | 202 | 3.0-56 |

APPENDIX D

ALPHABETICAL INDEX

The alphabetical index consists of subsystems, equipment and operations arranged in alphabetical order. This index includes material from sections 1.0 and 2.0 only.

TITLE ... PAGE NO.

A

Actuation Control Module.............2.4-22
Aft Compartment, AM..................2.0-66
Aft Interstage.......................2.0-106
Aft Skirt............................2.0-86
Airflow, Gravity Substitute
  Fecal..............................2.5-84
  Urine..............................2.5-86, 2.5-88
Airlock Module
  Failure............................2.0-66
  General............................2.0-50
  Structure..........................2.0-55
Airlock, Trash Disposal..............2.0-69
  Lid Seal...........................2.5-71, 2.5-144
  Vent Plug Seal.....................2.5-71, 2.5-144
ALSA.................................2.5-59
AM Bus
  Design Data........................2.1-48
  Functional.........................2.1-13
  Loads, General.....................2.1-4
Amp-Hour Integrator
  Component..........................2.1-35
  Design Data........................2.1-47
  Failure............................2.1-44
  Functional.........................2.1-9
AM Tunnel............................2.0-61
Angle of Incidence...................2.1-24
Antenna
  Discone............................2.2-8, 2.2-19
  Ranging............................2.0-26, 2.2-7, 2.2-19
  Stub...............................2.2-8, 2.2-19
APCS
  Pulse Control......................2.3-27
  Seq Control........................2.3-1, 2.11-3
  Thruster Control...................2.3-6, 2.3-14
Apollo Telescope Mount
  Deploy, Seq Interlocks.............2.11-4
  Experiment Canister................2.0-26
  General............................2.0-24
  Rack...............................2.0-26
  Solar Array........................2.0-26
ATM C&D Panel and EREP Cooling.......2.4-40
ATM Digital Computer
  General............................2.3-1
  TACS Modes.........................2.3-27
Atmosphere Control
  Component..........................2.4-67
  Design Data........................2.4-118
  Failure............................2.4-111
  Functional.........................2.4-7
  General............................2.4-1
  Limitations........................2.4-122
ATM Solar Array......................2.0-26
Attitude
  ATM Control Mode...................2.3-1
  ATM Mode Limitations...............2.3-28
  Hold Capability....................2.3-39
  IU Control Mode....................2.3-1
  IU Mode Limitations................2.3-27
  Propellant Budget..................2.3-23
Audio
  Components.........................2.2-11
  Functional.........................2.2-1
Audio Centers, CSM...................2.2-2
Audio Load Compensator
  Component..........................2.2-11
  Failure............................2.2-15
  Functional.........................2.2-2

B

Bag, Clothing........................2.5-49
  Contingency Fecal..................2.5-86
  Fecal..............................2.5-84
  Squeezer...........................2.5-122
  Trash..............................2.5-69
  Urine..............................2.5-87
  Vacuum Cleaner.....................2.5-88
Balls................................2.5-69
Battery
  ATM................................2.1-1
  CSM................................2.1-1
  IMSS Supply........................2.5-148
  Tape Player Supply.................2.5-67
Battery, AM PCG
  Component..........................2.1-37
  Design Data........................2.1-47
  Failure............................2.1-45
  Functional.........................2.1-9
  General............................2.1-1
Battery Charger, AM
  Component..........................2.1-32
  Design Data........................2.1-47
  Failure............................2.1-44
  Functional.........................2.1-9
  General............................2.1-1
  Operation..........................2.1-35
Battery Charger, ATM.................2.1-1
Battery Module.......................2.1-31
Bellows..............................2.0-66
Belt, Utility........................2.5-140
Beta Angle...........................2.1-24
Binoculars...........................2.5-67
Biocide, Iodine......................2.5-122, 2.5-127
Blower Unit
  Fecal/Urine Collector..............2.5-92
  Suit Dryer.........................2.5-64
  Vacuum Cleaner.....................2.5-100
Boom, Extendible.....................2.5-55
Bracket, Clothesline.................2.5-12, 2.5-56
Bungee...............................2.5-11

C

Cabin Heat Exchanger.................2.4-84
Cabin Pressure Regulator.............2.4-30
Cable, Urine Separator Power.........2.5-92, 2.5-144
Caddy, Tool..........................2.5-140
  Vacuum Cleaner.....................2.5-100

| TITLE | PAGE NO. |
|---|---|
| Cans, Food | 2.5-73, 2.5-77 |
| Disposal Wells | 2.5-77 |
| Drug | 2.5-147 |
| Cards, Playing | 2.5-67 |
| Cartridge, Cat Ion | 2.5-112 |
| Cassettes, Tape | 2.5-67 |
| Caution Condition | 2.8-5 |
| Charcoal Canister | 2.4-91 |
| Chart, Iodine Addition | 2.5-127 |
| Chiller | |
| Food | 2.5-77, 2.5-153 |
| Water | 2.5-83, 2.5-113 |
| Urine | 2.5-92 |
| Circuit Breakers | 2.1-42 |
| Clamp, LSU | 2.5-11, 2.5-51 |
| Clip, Clothesline | 2.5-12, 2.5-56 |
| Clothesline | 2.5-12, 2.5-56 |
| Clothing | 2.5-48, 2.5-49 |
| Color Coding, Crewman | 2.5-129 |
| Comparator, Color | 2.5-125 |
| Compartment, Slide Drying | 2.5-148 |
| Container, Reagent | 2.5-125 |
| Waste Sample | 2.5-127 |
| Iodine | 2.5-127 |
| Sample | 2.5-87, 2.5-96 |
| CO2 Partial Pressure Transducer | 2.6-22 |
| CO2 Removal | 2.4-79 |
| Coldplate | 2.4-62 |
| Communication | |
| See Audio | |
| Television | |
| Teleprinter | |
| RF | |
| Ranging | |
| Computer (ATMDC, FCC, LVDC) | 2.3-1 |
| Condensate | |
| Dump Solenoid Valve | 2.4-84 |
| Heater | 2.4-84 |
| System | 2.4-75 |
| Tank | 2.4-84 |
| Condensing Heat Exchanger | 2.4-84 |
| Contaminant Control | 2.4-82 |
| Control Moment Gyros | 2.3-1, 2.3-27 |
| Coolant Loop, AM | |
| Coldplate | 2.4-62 |
| Filter | 2.4-62 |
| Loop | 2.4-37 |
| Pump | 2.4-57 |
| Coolant Loop, Refrigeration | 2.4-101 |
| Crew Quarters | 2.0-75 |
| Crew Transfer | 2.9-3 |
| CRDU | |
| Component | 2.7-9 |
| Design Data | 2.7-16 |
| Failure | 2.7-15 |
| Functional | 2.7-1 |
| Limitations | 2.7-17 |
| CSM S-Band | 2.2-1 |
| Cuff, Contingency Urine | 2.5-88 |
| Current Monitoring | 2.1-21 |
| Current Transducer | 2.6-26 |
| C&W | |
| Converter | 2.8-20 |
| Design Data | 2.8-28 |
| Failure | 2.8-27 |
| High Level Audio Ampl | 2.8-26 |
| Indicator Lights | 2.8-13 |
| Klaxon | 2.8-26 |
| Parameters | 2.8-31 |
| Relay Module | 2.8-26 |
| Sensors & Detectors | 2.8-20 |
| Unit | 2.8-21 |
| Cycle Timer | 2.4-91 |

D

| TITLE | PAGE NO. |
|---|---|
| Darts | 2.5-67 |
| Data Adapter | 2.3-1 |
| DATA Recording | 2.6-8 |
| DATA 2 Recording | 2.6-8 |
| DC-DC CONVERTER | |
| Component | 2.6-15 |
| Failure & Design Data | 2.6-36 |
| Functional | 2.6-2 |
| Limitations | 2.6-38 |
| Thermal Control, OWS | 2.4-57 |
| TM | 2.6-38 |
| DCS | |
| AM Seq Control | 2.11-3 |
| ATM Seq Control | 2.11-3 |
| Component | 2.7-7 |
| Design Data | 2.7-15 |
| Failure | 2.7-14 |
| Functional | 2.7-1 |
| Limitations | 2.7-17 |
| Deactivation | 2.9-3 |
| Decal, "Snoopy" | 2.5-129 |
| Deploy Bus | |
| Functional | 2.1-19 |
| Loads, Gen | 2.1-4 |
| Deployment Assembly | |
| Components | 2.0-27 |
| Design Data | 2.0-39 |
| Failure | 2.0-34 |
| Functional | 2.0-27 |
| General | 2.0-26 |
| Limitations | 2.0-39 |
| Dew Point Temp Transduces | 2.6-20 |
| Digital Address System | 2.3-14 |
| Discone Antenna Booms | |
| Design Data | 2.0-24 |
| Failure | 2.0-23 |
| Functional | 2.0-19 |
| General | 2.0-18 |
| Limitations | 2.0-24 |
| Release Actuator | 2.0-20 |
| Rotary Joint | 2.0-20 |
| Dispenser (See H2O Gun) | |
| Dispenser | |
| Fecal Bag | 2.5-40, 2.5-84 |
| Tissue | 2.5-40, 2.5-133 |
| Towel | 2.5-40, 2.5-133 |
| Dispenser, Urine System Flush | 2.5-121, 2.5-144 |
| Disposal | |
| Liquids | 2.5-134 |
| Trash | 2.5-69 |
| Disposal Wells, Food Can | 2.5-77 |
| Docking | 2.9-1 |
| Docking Ports | 2.0-43 |
| Docking Targets | 2.0-43 |
| Dosimeter, Van Allen Belt | 2.5-153 |
| Drawer, Urine | 2.5-88 |
| Drogue | 2.0-49 |
| Drugs | 2.5-147 |
| Drying Area, Washcloth/Towel | 2.5-134 |

E

| TITLE | PAGE NO. |
|---|---|
| EBW | 2.0-5 |
| Elapsed Time | 2.7-1, 2.7-9 |
| Electronic Timer | |
| Component | 2.7-9 |
| Design Data | 2.7-16 |
| Failure | 2.7-15 |
| Functional | 2.7-1 |
| Emergency | 2.8-26 |

| TITLE | PAGE NO. |
|---|---|
| EPS Control | |
| AM/ATM/CSM Tie | 2.1-13 |
| AM Bus | 2.1-13 |
| Battery | 2.1-11 |
| Battery Overtemp | 2.1-11 |
| Charge Bypass | 2.1-11 |
| Charge Mode | 2.1-9 |
| Charge Rate | 2.1-11 |
| Deploy Bus | 2.1-19 |
| Discharge Limit | 2.1-9 |
| EREP Bus | 2.1-21 |
| Functional, Gen | 2.1-4 |
| OWS Bus | 2.1-13 |
| PCG Output | 2.1-13 |
| PWR Disconnect | 2.1-13 |
| PWR System Control | 2.1-4, 2.1-13 |
| Reg Bus Voltage | 2.1-11, 2.1-13, 2.1-48 |
| SAS PWR | 2.1-6 |
| SEQ Bus | 2.1-19 |
| Shunt Regulator | 2.1-13 |
| SOC | 2.1-9 |
| SPG | 2.1-21 |
| EPS Control Bus | |
| Design Data | 2.1-48 |
| Functional | 2.1-13 |
| Functional, Gen | 2.1-4 |
| Loads, Gen | 2.1-1 |
| Equipment, Urine Dump | 2.5-99, 2.5-136 |
| Water Purification | 2.5-122 |
| Water System | 2.5-108, 2.5-121 |
| Entertainment, Crewman | 2.5-66 |
| EREP Bus | |
| Functional | 2.1-21 |
| Loads, Gen | 2.1-4 |
| EREP Mounting | 2.0-26 |
| Escape Route | 2.5-147 |
| EVA | |
| Communication | 2.2-2, 2.2-11, 2.2-15 |
| Clothesline | 2.5-56 |
| Extendible Boom | 2.5.55 |
| Handrails | 2.5-6, 2.5-51 |
| Lighting | 2.5-17, 2.5-51 |
| Operations | 2.5-64 |
| Procedural Decals | 2.5-56 |
| Spacesuit | 2.5-56 |
| Tasks | 2.5-51 |
| Trail | 2.5-6, 2.5-51 |
| Workstations | 2.5-51 |
| Exerciser | |
| Exer-Gym | 2.5-67 |
| Hand | 2.5-67 |
| Experiment Canister | 2.0-26 |
| Experiment Compartment | 2.0-83 |
| Experiments | 2.10-1 |
| M092 LBNP Vacuum Vent | 2.5-138 |
| M171 Vacuum Vent | 2.5-138 |
| Extinguisher, Fire | 2.5-147 |
| EVA/IVA Support | |
| Component | 2.4-95 |
| Design Data | 2.4-119 |
| Failure | 2.4-111 |
| Functional | 2.4-7 |
| General | 2.4-1 |
| Limitations | 2.4-122 |
| Event Timer | |
| Component | 2.7-11 |
| Design Data | 2.7-17 |
| Failure | 2.7-15 |
| Functional | 2.7-1, 2.7-6 |
| EXP Pointing & Control | 2.3-1 |
| EXP 1 Recording | 2.6-8, 2.6-38 |
| EXP 2 Recording | 2.6-8, 2.6-38 |

| TITLE | PAGE NO. |
|---|---|
| F | |
| Fan | |
| PLV | 2.4-69, 2.4-82 |
| Portable | 2.4-72 |
| Molecular Sieve | 2.4-82 |
| Fecal/Urine Collector | 2.5-88 |
| Feces | |
| Collection | 2.5-84, 2.5-86 |
| Processing | 2.5-96 |
| Film Tree Receptacle | 2.5-13, 2.5-55 |
| Filter, Fecal Collector | 2.5-92, 2.5-144 |
| Filter | |
| Wardroom Water Network | 2.5-112 |
| Urine System Flush Water Network | 2.5-113 |
| Fire | |
| Detection | 2.8-9 |
| Sensor | 2.5-143, 2.8-21 |
| Test | 2.8-9 |
| Fire Fighting | 2.5-143 |
| Equipment | 2.5-143 |
| Operations | 2.5-147 |
| Ports | 2.5-143 |
| Firemans Pole | 2.5-6 |
| Fixed Airlock Shroud | 2.0-72 |
| Flexible Tunnel | 2.0-66 |
| Flight Control Computer | 2.3-1, 2.3-6 |
| Food | |
| Boxes | 2.5-45, 2.5-77 |
| Overcan | 2.5-73, 2.5-77 |
| Types | 2.5-73 |
| Food Freezer, Stowage | |
| Refrigeration | 2.4-105 |
| Storage | 2.5-45, 2.5-77 |
| Food Freezer, Wardroom | |
| Medical Drugs | 2.5-153 |
| Refrigeration | 2.4-105 |
| Storage | 2.5-45, 2.5-77 |
| Waste Management | 2.5-99 |
| Foot Restraint, Food Table | 2.5-4 |
| Foot Restraint, Light-Duty | 2.5-4, 2.5-88 |
| Foot Restraint, PGA | 2.5-4 |
| Fixed | 2.5-4 |
| Portable | 2.5-4 |
| Foot Restraint, Platform | 2.5-4 |
| Footwell | 2.5-4 |
| Formats | 2.6-12, 2.6-31 |
| PCM, TM | 2.6-12, 2.6-31 |
| DCS/TRS | 2.7-6 |
| Forward Compartment, AM | 2.0-61 |
| Forward Compartment, OWS | 2.0-74 |
| Forward Skirt | 2.0-85 |
| Fuel Cells | 2.1-1 |
| G | |
| Galley | 2.5-77 |
| Gas Flow Transducer | |
| C&W | 2.8-20 |
| Instrumentation | 2.6-22 |
| Gas Separator | 2.4-99 |
| Gimbal | 2.3-1 |
| Gloves, EVA | 2.5-59, 2.5-64 |
| Shirtsleeve | 2.5-49 |
| GMT Clock | |
| Component | 2.7-11 |
| Design Data | 2.7-17 |
| Failure | 2.7-15 |
| Functional | 2.7-1, 2.7-6 |
| Grid | 2.5-2 |
| Ground Cooling Hx | 2.4-60, 2.4-101 |
| Grounding | 2.1-21 |

TITLE PAGE NO.

H

Habitation Area.......................2.0-86
Handholds...........................2.5-6, 2,5-9
Handrails...........................2.5-6
Handwasher..........................2.5-121
Hanger, LCG.........................2.5-13, 2.5-64
Hat, Bump...........................2.5-49
Hatch
AM Tunnel.........................2.0-61
EVA...............................2.0-66
MDA...............................2.0-49
OWS...............................2.0-106
Heaters
Condensate Dump...................2.4-84
OWS Multiplexers..................2.6-2
Port..............................2.4-46
Tunnel............................2.4-46
Wall..............................2.4-46
Wardroom H20......................2.5-83, 2.5-113
Window............................2.4-46
WMC H20...........................2.5-83,2.5-118
Heat Exchanger
Cabin.............................2.4-84
Condensing........................2.4-84
Coolant Flow Bypass Vlv...........2.4-67
Ground Cooling, AM................2.4-60
Ground Cooling, RS................2.4-101
Oxygen............................2.4-62
Regenerative, AM..................2.4-62
Regenerative, RS..................2.4-105
Heat Pipes..........................2.4-40
Helmet, Pressure....................2.5-59
High Level Multiplexer (See Multiplexer)
H20 Gun.............................2.5-121, 2.5-122
Hook, Equipment.....................2.5-13, 2.5-51
Hose
Nitrogen Fill.....................2.5-107
Urine System Flush................2.5-113
Urine System Flush Dump...........2.5-138
Wardroom Water....................2.5-108
WMC Water.........................2.5-118
Housekeeping........................2.5-143
Hybrid Ring
Component.........................2.2-15
Failure...........................2.2-16
Functional........................2.2-8

I

I/LCA...............................2.5-25
Incubator...........................2.5-148
Injector, Iodine....................2.5-127
Instrument Unit.....................2.0-1
General...........................2.3-1
Thruster Control..................2.3-6
Insulation..........................2.4-49
Intercom Box
Component.........................2.2-11
Failure...........................2.2-15
Functional........................2.2-2
Limitations.......................2.2-20
Interface Box
Component.........................2.6-28
Design Data.......................2.6-37
Failure...........................2.6-36
Limitations.......................2.6-38
Select Logic......................2.6-5
Interface Electronics Unit..........2.2-16
Instrument Unit.....................2.11-1
IVA.................................2.2-11, 2.2-16

TITLE PAGE NO.

K

Kit, Hygiene........................2.5-129, 2.5-130
Kit, Label..........................2.5-33, 2.5-138
Card Deck Retainer................2.5-67
Card Retainer.....................2.5-67
Dart..............................2.5-67
Exer-Gym..........................2.5-67
Kit, Repair.........................2.5-140
Bandage...........................2.5-148
Catheterization...................2.5-148
Dental............................2.5-148
Diagnostic........................2.5-148
Hatch Tool........................2.5-140
Hematology/Urinalysis.............2.5-148
Microbiology......................2.5-148
Microscope........................2.5-148
Minor Surgery.....................2.5-148
Therapeutic.......................2.5-148
Tool..............................2.5-140

L

Launch Commit Criteria..............2.11-4
Launch/Orbit Transmitter Selection....2.2-8, 2.2-16, 2.6-8
Launch Vehicle Digital Computer.......2.3-1
Library.............................2.5-67
Liftoff Configuration...............2.11-4
Light Baffles.......................2.5-31
Light, Floodlight
MDA Application...................2.5-21
OWS Application...................2.5-27
Portable Light Application........2.5-33
Spares............................2.5-144
Light, High-Intensity...............2.5-33
Light, Portable.....................2.5-33
Light, 10 Watt
AM Aft Compt. Use.................2.5-25
Spare.............................2.5-144
STS Use...........................2.5-25
Light, 20 Watt......................2.5-27, 2.5-144
Lighting, AM Internal...............2.5-25
Lighting, Emergency.................2.5-30
Lighting, Entry.....................2.5-27
Lighting, External..................2.5-14
Docking Lights....................2.5-17
EVA Lights........................2.5-17
Tracking Lights...................2.5-14
Lighting, MDA Internal..............2.5-21
Lighting, OWS Internal..............2.5-27
Lights, AM EVA......................2.5-17
Lights, ATM EVA.....................2.5-17
Lights, DA EVA......................2.5-17
Lights, Docking.....................2.5-17
Lights, EVA.........................2.5-17, 2.5-51
Lights, Meter.......................2.5-27
Lights, Tracking....................2.5-14
Liquid Cooling Garment..............2.5-56, 2.5-64
Liquid Flow Transducer..............2.6-26
Lock Compartment, AM................2.0-61
Log Book, IMSS......................2.5-148
Low Level Multiplexer (See Multiplexer)

M

M509 Recharge Station...............2.4-33
Maintenance.........................2.5-138, 2.5-143
Manual Interconnect Valve...........2.4-91

| TITLE | PAGE NO. |
|---|---|
| MDA Signal Conditioner | |
| Component | 2.6-15 |
| Design Data | 2.6-37 |
| Functional | 2.6-2 |
| MDA Tunnels | 2.0-49 |
| Medical Kit | |
| Diagnostic/Treatment Equipment | 2.5-148 |
| Drug Supply | 2.5-147 |
| Laboratory Equipment | 2.5-148 |
| Resupply/Return | 2.5-153 |
| Treatment Equipment | 2.5-147 |
| Meteoroid Shield, OWS | 2.0-98 |
| Meteoroid Shield, TACS | 2.0-86 |
| Microscope | 2.5-148 |
| Mirrors | 2.5-134 |
| Missions | 1.1-1 |
| Moisture Removal | 2.4-72 |
| Molecular Sieve | |
| Charcoal Canister | 2.4-91 |
| CO2 Removal | 2.4-79 |
| Contaminant Control | 2.4-82 |
| Cycle Timer | 2.4-91 |
| Fan | 2.4-82 |
| Gas Selector Valve | 2.4-82 |
| Manual Interconnect Valve | 2.4-91 |
| Odor Removal | 2.4-82 |
| Solenoid Valve | 2.4-91 |
| Solids Trap | 2.4-91 |
| Sorbent Canister | 2.4-91 |
| Multiple Docking Adapter | |
| Components | 2.0-43 |
| Failure | 2.0-49 |
| General | 2.0-39 |
| Multiplexers | |
| Component | 2.6-28 |
| Design Data | 2.6-37 |
| Failure | 2.6-36 |
| Heaters, OWS | 2.6-2 |
| TM | 2.6-39 |
| **N** | |
| Nitrogen Distribution | |
| Component | 2.4-15 |
| **O** | |
| O2/N2 Storage | 2.4-15 |
| O2/N2 Two-Gas Control | 2.4-19 |
| O2 Partial Pressure Transducer | 2.6-22 |
| OBS Recording | 2.6-8 |
| Odor Removal | 2.4-82 |
| Off-Duty | 2.5-67 |
| Orbital Workshop, Structure | |
| Configuration | 2.0-74 |
| Failure | 2.0-110 |
| General | 2.0-74 |
| Overcan, Food | 2.5-73, 2.5-77 |
| Liner | 2.5-73, 2.5-77 |
| OWS Bus | |
| Design Data | 2.1-48 |
| Functional | 2.1-13 |
| Loads, Gen | 2.1-4 |
| OWS SAS Beam Fairings | |
| Deploy Seq. Interlock | 2.11-4 |
| Structure | 2.0-90 |
| Oxygen Distribution | 2.4-15 |
| Oxygen Heat Exchanger | 2.4-62 |

| TITLE | PAGE NO. |
|---|---|
| **P** | |
| Pack, Beverage | 2.5-73, 2.5-77 |
| Pad, Disinfectant | 2.5-133 |
| Paralleling, EPS | 2.1-1, 2.1-13 |
| Pattern, Snap | 2.5-13 |
| Payload Shroud | |
| Design Data | 2.0-17 |
| Failure | 2.0-13 |
| Functional | 2.0-1 |
| Jettison | 2.11-4 |
| Limitations | 2.0-17 |
| Mechanical | 2.0-5 |
| Pyrotechnics | 2.0-5 |
| PCM | |
| Components | 2.6-27 |
| Formats | 2.6-12 |
| PCM Bus Select Logic | 2.6-2 |
| Peak Power Tracker | |
| Component | 2.1-32 |
| Failure | 2.1-44 |
| Functional | 2.1-9 |
| Platform | 2.3-1 |
| Portable Timer | |
| Component | 2.7-14 |
| Design Data | 2.7-17 |
| Failure | 2.7-15 |
| Functional | 2.7-6 |
| Position Transducer | 2.6-26 |
| Power Conditioning Group, AM | |
| Component | 2.1-31 |
| Functional, Config | 2.1-6 |
| Functional, Gen | 2.1-4 |
| Power and Control Switching Assembly | |
| Component | 2.3-14 |
| General | 2.3-1 |
| Thruster Control | 2.3-6 |
| Power Transfer | 2.1-1 |
| PPO2 | 2.4-33 |
| Prelaunch Purge | 2.4-11 |
| Pressure Control Unit | 2.5-59, 2.5-61 |
| Pressure Garment Assembly | 2.5-56, 2.5-64 |
| Pressure Regulator (120 PSIG) | 2.4-23 |
| Pressure Transducer | |
| C&W | 2.8-20 |
| Instrumentation | 2.6-22 |
| Pressurization | 2.4-19 |
| Pressurization and Gas Distribution | |
| Component | 2.4-11 |
| Design Data | 2.4-115 |
| Failure | 2.4-111 |
| Functional | 2.4-4 |
| General | 2.4-1 |
| Limitations | 2.4-120 |
| Probe, Dump Heater | 2.5-134, 2.5-136 |
| Processor, Waste | 2.5-96 |
| Control Panel | 2.5-96, 2.5-144 |
| Door Seal | 2.5-96, 2.5-144 |
| Vacuum Vent | 2.5-96, 2.5-136 |
| Programmer | |
| Component | 2.6-28 |
| Design Data | 2.6-37 |
| Failure | 2.6-36 |
| Select Logic | 2.6-5 |
| TM | 2.6-39 |
| Propellant, TACS | |
| Budget | 2.3-23 |
| Design Data | 2.3-22 |
| Failure | 2.3-21 |
| General | 2.3-3 |
| Limitations | 2.3-27 |
| Malfunction | 2.3-14 |
| Storage Spheres | 2.3-16 |
| Thrust | 2.3-27 |

| TITLE | PAGE NO. |
|---|---|
| Proton Spectrometer | 2.6-15, 2.6-26 |
| PS Latch Actuator | 2.0-5 |
| Pump, Refrigeration | 2.4-101, 2.4-105 |
| Agitator | 2.5-103 |
| Purge | 2.4-11 |
| Fittings | 2.5-108, 2.5-113, 2.5-118 |
| Pyrotechnics | 2.0-5 |
| **Q** | |
| QCM/CM | 2.6-26, 2.6-39 |
| Quadriplexer | |
| Component | 2.2-15 |
| Design Data | 2.2-19 |
| Failure | 2.2-16 |
| Functional | 2.2-8 |
| Limitations | 2.2-20 |
| Quick Disconnect, Water Hose | 2.5-108, 2.5-113, 2.5-118, 2.5-144 |
| **R** | |
| Radiation | 2.5-153 |
| Radiator, AM/MDA | |
| Components | 2.4-37, 2.4-62 |
| Structure | 2.0-55 |
| Radiator, Refrigeration | |
| Component | 2.4-105 |
| Operation | 2.4-101 |
| Structure | 2.0-86 |
| Ranging | |
| Component | 2.2-15 |
| Design Data | 2.2-19 |
| Failure | 2.2-16 |
| Functional | 2.2-7 |
| Rapid $\Delta$P | |
| Detection | 2.8-9 |
| Sensor | 2.8-20 |
| Test | 2.8-9 |
| Rate Gyro | 2.3-1 |
| Refrigeration | |
| Components | 2.4-104 |
| Design Data | 2.4-119 |
| Failure | 2.4-115 |
| Functional | 2.4-7 |
| General | 2.4-1 |
| Limitation | 2.4-124 |
| Operations | 2.4-104 |
| REG Bus | |
| Design Data | 2.1-48 |
| Failure | 2.1-46 |
| Functional | 2.1-13 |
| Functional, General | 2.1-4 |
| General | 2.1-1 |
| Regenerative Heat Exchanger | |
| Components, AM | 2.4-62 |
| Component, RS | 2.4-105 |
| Regulator, AM Voltage | |
| Component | 2.1-37 |
| Design Data | 2.1-47 |
| Failure | 2.1-45 |
| Functional | 2.1-9 |
| General | 2.1-1 |
| Regulator, ATM Voltage | 2.1-1 |
| Rendezvous | 2.9-1 |
| Restraint, Equipment | 2.5-11 |
| Restraint, Utility | 2.5-11 |
| Fixed | 2.5-12, 2.5-134 |
| Portable | 2.5-12 |
| Sleep | 2.5-11 |
| Restraint, Utility (cont'd) | |
| Thigh | 2.5-9 |
| Waste Management | 2.5-11, 2.5-88 |
| Return Bundle, Fecal | 2.5-100 |
| Return Container, Urine | 2.5-96, 2.5-100 |
| RF | |
| DCS | 2.7-1 |
| Functional | 2.2-8 |
| RTTA | 2.2-15, 2.2-19 |
| **S** | |
| S-II Separation | |
| Attitude Control | 2.3-27 |
| Seq Interlock | 2.11-4 |
| S190 Window | 2.0-43 |
| Sampler, Water | 2.5-122 |
| Screen, Trash | 2.5-71 |
| Liquid Dump | 2.5-138 |
| Secondary O2 Pack | 2.5-59, 2.5-147 |
| Separator, Urine | 2.5-87, 2.5-92 |
| Motor | 2.5-92, 2.5-144 |
| Power Cable | 2.5-92, 2.5-144 |
| Sequential Bus | 2.1-4, 2.1-19 |
| Sequential Events | 2.11-5 |
| Servicing, LSU/PCU | 2.5-61 |
| SEVA | 2.5-59, 2.5-64 |
| Shoe, Triangle | 2.5-6, 2.5-144 |
| Shunt Regulator, AM | |
| Component | 2.1-39 |
| Failure | 2.1-46 |
| General | 2.1-1 |
| Skylab Program | 1.0-1 |
| Sleep Compartment | 2.0-83 |
| Snaps | 2.5-13, 2.5-140 |
| Soap | 2.5-133 |
| Solar Array, ATM | 2.1-1 |
| Solar Array, OWS | |
| Cells | 2.1-24 |
| Design Data | 2.1-46 |
| Failure | 2.1-44 |
| Functional, Config | 2.1-6 |
| Functional, Gen | 2.1-4 |
| General | 2.1-1 |
| Module and Array | 2.1-27 |
| Power Unit | 2.1-31 |
| Structure | 2.0-86 |
| Solar Noise Burst Monitor | 2.0-26 |
| Solids Trap | 2.4-91 |
| Sorbent Canister | 2.4-91 |
| South Atlantic Anamoly | 2.5-153 |
| Spacesuit, A7LB | 2.5-56, 2.5-64 |
| Spare Parts | 2.5-143 |
| Speaker Box, CSM | 2.2-4 |
| Squeezer | 2.5-122, 2.5-141 |
| Star Tracker | 2.3-1 |
| State-of-Charge | 2.1-9 |
| Stowage, Labels | 2.5-33 |
| AM | 2.5-36 |
| Film Vaults | 2.5-36, 2.5-47 |
| Food Boxes | 2.5-45, 2.5-73 |
| Food Chiller | 2.5-45, 2.5-77 |
| Food Freezers | 2.5-45, 2.5-77 |
| LSU Containers | 2.5-36, 2.5-59 |
| MDA | 2.5-33 |
| OWS | 2.5-40 |
| Trash Container | 2.5-40, 2.5-69 |
| Urine Freezer | 2.5-47, 2.5-96 |
| Straps | 2.5-11, 2.5-100 |
| Strap, PGA Hanger | 2.5-13, 2.5-64 |
| STS Structure | 2.0-55 |

| TITLE | PAGE NO. |
|---|---|
| Suit Cooling | 2.4-95, 2.4-99 |
| Components | 2.4-99 |
| Functional | 2.4-95 |
| Suit (See SPACESUIT) | |
| Sun Sensor | 2.3-1 |
| Supply Line, Wardroom Water | 2.5-108 |
| Urine System Flush Water | 2.5-113 |
| WMC Water | 2.5-118 |
| Switch Selector | |
| General | 2.11-1 |
| Thermal Control | 2.4-57 |
| Thruster Control | 2.3-6 |

T

| TITLE | PAGE NO. |
|---|---|
| Table | |
| Food | 2.5-83 |
| Top | 2.5-83 |
| TACS Spheres | 2.0-86 |
| Tape Player | 2.5-67 |
| Tape Recorder, AM | |
| Component | 2.6-34 |
| Design Data | 2.6-37 |
| Failure | 2.6-36 |
| Limitations | 2.6-38 |
| Select Logic | 2.6-5 |
| Tape Recording | 2.6-8, 2.6-38 |
| Te | 2.7-1, 2.7-9 |
| Teleprinter | |
| Component | 2.2-11 |
| Failure | 2.2-16 |
| Functional | 2.2-7 |
| Limitations | 2.7-17 |
| Television | |
| Component | 2.2-11 |
| Functional | 2.2-5 |
| Limitations | 2.2-20 |
| Temperature Controller | 2.4-59 |
| Temp Transducer | 2.6-20 |
| Tethers | 2.5-9, 2.5-59 |
| Thermal Capacitor, AM | 2.4-39, 2.4-57 |
| Thermal Capacitor, Refrigeration | 2.4-101, 2.4-105 |
| Thermal Control | |
| Components | 2.4-37 |
| Design Data | 2.4-117 |
| Failure | 2.4-111 |
| Functional | 2.4-4 |
| General | 2.4-1 |
| Limitations | 2.4-121 |
| Thrust | 2.0-86, 2.3-27 |
| Thruster | |
| C&W | 2.3-14 |
| Component | 2.3-16 |
| Control | 2.3-6 |
| Design Data | 2.3-23 |
| Failure | 2.3-21 |
| Fire Indication | 2.3-14 |
| Functional | 2.3-3 |
| Time Base | 2.11-3 |
| Time Correlation Buffer | |
| Component | 2.7-9 |
| Design Data | 2.7-16 |
| Failure | 2.7-15 |
| Functional | 2.7-1 |
| Tissue | 2.5-133 |
| Tools | 2.5-140 |
| Tool Kit | 2.5-140 |
| Towels | 2.5-133 |
| Tr | |
| Components | 2.7-9 |
| Functional | 2.7-1 |
| Limitations | 2.7-17 |
| Transducer Group Select Logic | 2.6-2 |
| Transducers | |
| CO2 Partial Pressure | 2.6-22 |
| Current | 2.6-26 |
| Dew Point | 2.6-20 |
| Gas Flow | 2.6-22 |
| Liquid Flow | 2.6-26 |
| O2 Partial Pressure | 2.6-22 |
| Position | 2.6-26 |
| Pressure | 2.6-22 |
| Temp | 2.6-20 |
| Water Level | 2.6-26 |
| Transfer Bus | |
| Functional | 2.1-13 |
| General | 2.1-1 |
| Loads, Gen | 2.1-4 |
| Transmission | |
| Inst | 2.6-12, 2.6-38 |
| RF | 2.2-8 |
| Transmitter | |
| Component | 2.2-15 |
| Design Data | 2.2-19 |
| Failure | 2.2-16 |
| Launch/Orbit Selection | 2.2-8, 2.6-8 |
| Limitations | 2.2-20, 2.6-38 |
| TM | 2.6-38 |
| Trash | 2.5-69, 2.5-71 |
| Tray | |
| Food | 2.5-83 |
| Galley | 2.5-77 |
| Urine | 2.5-96, 2.5-47 |
| Truss | 2.0-66 |
| Tx | |
| Component | 2.7-9 |
| Functional | 2.7-1 |
| Limitations | 2.7-17 |

U

| TITLE | PAGE NO. |
|---|---|
| Umbilical | 2.5-59, 2.5-61 |
| Universal Mount | 2.5-12 |
| Urine Dump | 2.5-99, 2.5-136 |
| Urine Freezer | |
| Refrigeration | 2.4-111 |
| Storage | 2.5-47 |
| Waste Management | 2.5-96 |
| Urine Inlet Line | 2.5-86, 2.5-88 |
| Utensils, Eating | 2.5-83 |
| Utility Power | 2.1-21, 2.1-42 |

V

| TITLE | PAGE NO. |
|---|---|
| Vacuum Cleaner | 2.5-100 |
| Vacuum Vent | 2.5-138 |
| Valve | |
| Cabin Relief | 2.4-23 |
| Condensate Dump | 2.4-84 |
| Equalization | 2.4-23 |
| Hx Coolant Flow Bypass | 2.4-67 |
| Habitation Area Latching Vent | 2.4-23 |
| Habitation Area Solenoid Vent | 2.4-23 |
| Habitation Area Vent | 2.4-23 |
| Latching Solenoid | 2.4-30 |
| Limitations, TACS Control | 2.3-27 |
| Manual Interconnect | 2.4-91 |
| Mol Sieve Gas Selector | 2.4-84 |
| Mol Sieve Solenoid | 2.4-91 |
| Radiator Bypass, AM | 2.4-60 |
| Radiator Bypass, RS | 2.4-104, 2.4-105 |
| Solenoid | 2.4-35 |
| TACS Control | 2.3-16, 2.3-22 |

| TITLE | PAGE NO. |
|---|---|

Valve (cont'd)
Temperature Control................2.4-39, 2.4-62
Temperature Control, RS............2.4-104, 2.4-105
Three-Position Selector............2.4-35
WMC Water Dispenser................2.5-121, 2.5-144
Wardroom Water Dispenser...........2.5-118, 2.5-144
Velcro.............................2.5-13, 2.5-140
Venting............................2.4-11
Voice Recording....................2.6-8, 2.6-38
Voltage Transducer
C&W................................2.8-20
Inst...............................2.6-26
Vomitus............................2.5-86, 2.5-96

W

Wardroom...........................2.0-77
Warning Condition..................2.8-5
Washcloth..........................2.5-130
Waste Tank.........................2.0-85, 2.0-86
Water
Bleeding...........................2.5-122
Drinking...........................2.5-121
Equipment Cleansing................2.5-121
Food Reconstitution................2.5-118
Personal Hygiene...................2.5-121
Purification.......................2.5-122
Softening..........................2.5-112
Water Chiller (See CHILLER)
Water Dump.........................2.5-134, 2.5-136
Water Gun (See H20 GUN)
Water Level Transducer.............2.6-26
Water Network
Urine System Flush.................2.5-113
WMC................................2.5-118
Wardroom...........................2.5-108
Water Pump.........................2.4-62, 2.4-99
Water Reservoir Pressure Regulator....2.4-30
Water Separator....................2.4-84
Water Tank.........................2.5-103, 2.4-99
Wipes..............................2.5-133
Work Table, IMSS...................2.5-153