

TEST OPERATIONS TECHNICIANS MANUAL

TEST  
OPERATIONS  
TECHNICIANS  
MANUAL

SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

# S-II TEST OPERATIONS TECHNICIANS MANUAL

SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

PREPARED BY  
MANPOWER DEVELOPMENT  
SEAL BEACH  
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E. R. Dumas  
Program Safety Representative  
Saturn S-II Test Operations

PREFACE

The Test Operations Technicians Manual was prepared to provide North American Rockwell Test Operations technicians with a central source of fundamental reference material. Manpower Development has compiled this manual from information obtained from numerous official sources. However, with continual engineering changes to the S-II stage and supporting equipment, certain information in this manual will become obsolete. The binder used for this manual will permit the holder to insert new information as revisions occur.

The information used in this manual is for reference purposes only.

The latest specifications and drawings must be consulted for official information.

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I. INTRODUCTION

WORKMANSHIP

Workmanship has been defined as the skill with which an individual applies ability, talent, and experience to a given task. While interpretations of this term may vary, the concept of "individual application" cannot be disputed, for it is personal effort and craftsmanship that affects the quality of the finished product. This applies whether the product is a simple device or a technically complex process requiring the contributions of many.

Dedicated application of collective skills and talents characterize the high-level performance of Test Operations technicians. This pride of performance has paid off in the past; the same philosophy will continue to support the Saturn S-II program in the future.

ATTITUDE

Attitude, broadly defined, is the manner in which a person characteristically acts, feels, and thinks. On the job, an individual's attitude—his mood, disposition, and opinions—directly affect his performance and productivity. Indirectly, this same attitude will be reflected in the overall product.

Teamwork implies cooperation and is ideally composed of high-level personal performances melded into a single, all-encompassing effort. The achievement of such a goal depends on individual awareness that the resulting program, process, or product can be no better than the contributions that are part of it. This is why no single participant can afford the attitude that his effort does not count.

The philosophy of the Test Operations technician is positive and therefore productive. This mutual sharing of responsibility, successfully demonstrated in the past, will continue to provide a significant contribution to the Saturn S-II program.

SAFETY

Potential hazards exist in all work areas. Employee safety depends on the use of appropriate procedures and proper equipment on the job. Unsafe conditions should be reported immediately to the responsible supervisor or safety representative. Employees alert to such "warnings" can save lives.

Any task involving toxic or flammable materials, or cryogenic or high-pressure systems, requires special employee training. Inexperienced workers should regard such activities "off limits".

Some jobs require protective clothing or equipment. Obviously, such work should never be attempted until the appropriate gear has been issued and its use thoroughly demonstrated. The employee who neglects to use these precautions is a risk—both to himself and to his fellow employees.

The safety of Test Operations personnel can be assured only if each individual is aware of the situation—and is willing, at all times, to assume a personal responsibility for his actions.

## SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

### GOOD HOUSEKEEPING

Within industry, the term "good housekeeping" means more than keeping an area clean. Industrial housekeeping standards keep work areas safe.

Rules that prohibit placing tools and hardware on ledges, sills, and equipment surfaces are established with obvious hazards in mind. Such misplaced articles can cause serious damage to equipment as well as increasing the danger of tripping or slipping.

Hand tools, small utility items (nuts, washers, bolts, etc.), and miscellaneous scrap items should be placed in bread pans, trays, or tote boxes. These receptacles can be situated on work benches or—if they do not constitute a tripping hazard—on the floor of the working area.

When a test stand and engine are under construction or modification, the surrounding area cannot be entirely free of scrap items at all times. However, a concerted effort should be exercised in keeping the area as uncluttered as possible.

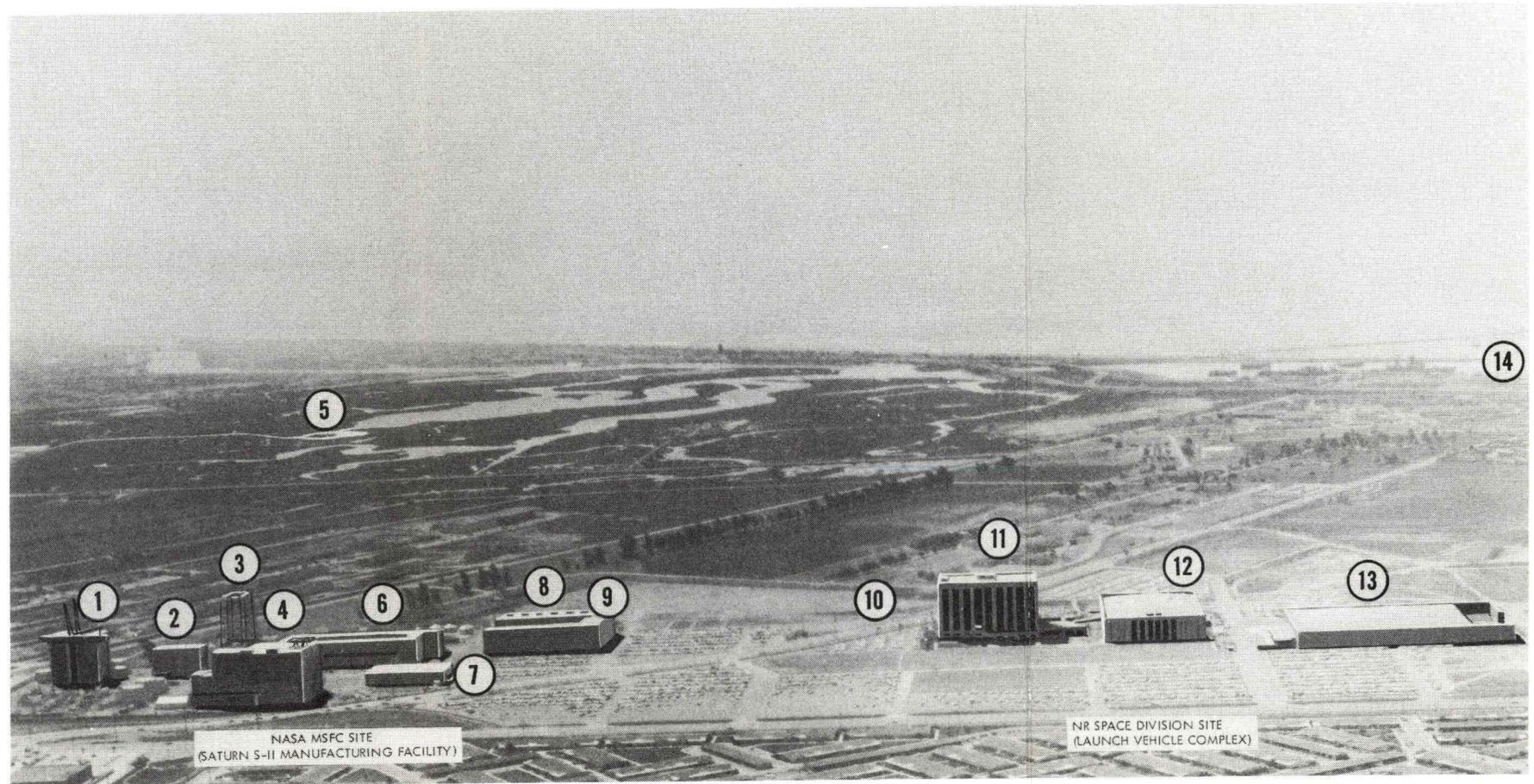
It must be emphasized that no article is too small to cause costly hardware damage or serious physical injury. For this reason, the success of the mission and the safety of personnel depend upon a constant and cooperative maintenance of rigorous housekeeping standards.

## II. TEST SITES

## SEAL BEACH FACILITIES

- |  |  |  |
|--|--|--|
| ① VERTICAL CHECKOUT (BUILDING S-15)              | ⑥ BULKHEAD FABRICATION (BUILDING S-02)   | ⑪ ADMINISTRATION (BUILDING 80)             |
| ② PAINT AND PACKAGE (BUILDING S-014)             | ⑦ SERVICE (BUILDING S-01)                | ⑫ ENGINEERING AND LABORATORY (BUILDING 81) |
| ③ STRUCTURAL STATIC TEST FIXTURE (BUILDING S-06) | ⑧ BONDING AND SUBSYSTEMS (BUILDING S-14) | ⑬ WAREHOUSE (BUILDING 86)                  |
| ④ VERTICAL ASSEMBLY (BUILDING S-03)              | ⑨ SUBASSEMBLY (BUILDING S-18)            | ⑭ SEAL BEACH DOCK                          |
| ⑤ PERMANENT PNEUMOSTATIC TEST SITE               | ⑩ BAY BLVD                               |  |

Manufacturing of the S-II stage is accomplished at Seal Beach, California, located approximately 1 mile from the U.S. Naval harbor. The facilities consist of a service building, vertical assembly building, a bulkhead fabrication building, hydrostatic test site, vertical checkout building and a pneumatic paint and packaging building. All structural welding, assembly, hydrostatic testing, component installation, tank cleaning, sealing, final assembly, and system checkout are accomplished at the Seal Beach facility. Various structural and system components are procured from outlying facilities. Final assembly of all components of the S-II stage is accomplished at Seal Beach. All logistic and engineering personnel required to support the S-II stage are also located at Seal Beach.





SPACE-MISSISSIPPI TEST FACILITY

Mississippi Test Facility is a component installation of the National Aeronautics and Space Administration's George C. Marshall Space Flight Center. MTF is the first major NASA installation to be contractor-operated.

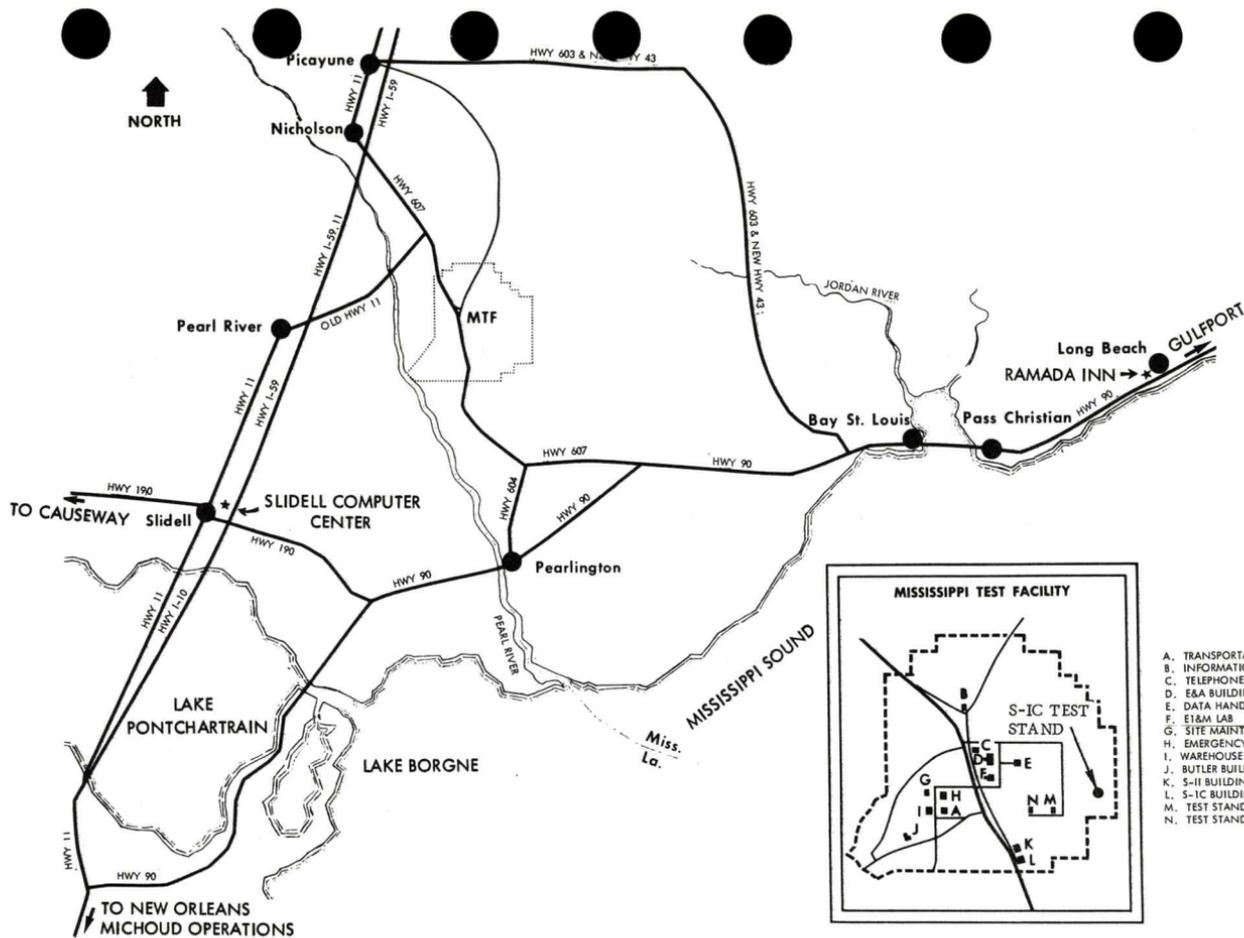
The General Electric Company operates and maintains the facility, providing site services, technical systems and test support to NASA, stage contractors and other tenants. North American Rockwell is responsible for conducting flight acceptance testing of S-II stages at MTF. The Boeing Company also conducts similar testing of S-IC stages at MTF.

Upon arrival at MTF, S-II stages go through the following general steps:

1. Positioning in the service building for depackaging, physical inspection, installation of appropriate static firing instrumentation, and other test preparation functions
2. Installation in one of the two test stands constructed to support static firings.
3. Functional testing to verify individual system operation and an integrated systems test to assure satisfactory combined systems operations.
4. Tanking tests to verify stage structural integrity and proper propellant filling and topping rates.
5. Static firing tests to certify that the stage and its systems are ready for flight.
6. Post-static firing checks to assure stability of the overall systems in terms of static firing environment.

At the completion of static firing and post-static firing tests, S-II stages are refurbished as necessary, thoroughly inspected, and packaged in the service building for shipment to KSC.

SPACE-MISSISSIPPI TEST OPERATIONS



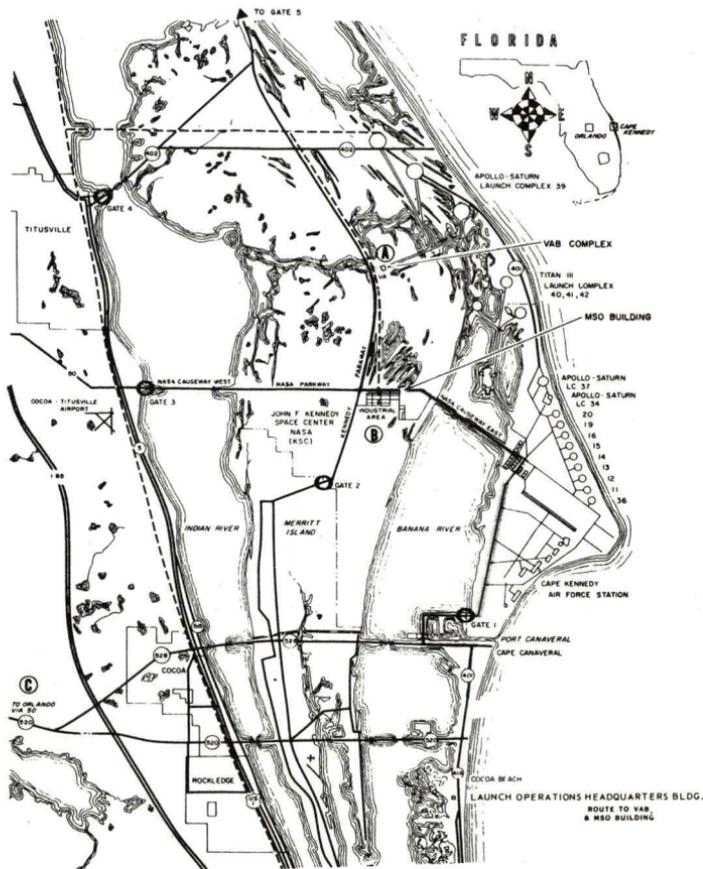
# SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

## KENNEDY SPACE CENTER

The Kennedy Space Center is the flight headquarters for NASA manned space flight programs. S-II Test Operations supports the Saturn V Program at KSC by providing final reliability and qualification checking of S-II stages.

Four distinct areas of support exist:

1. Low bay - individual S-II stage checkout and GSE maintenance
2. High bay - support during the integrated vehicle checkout and maintenance of GSE unique to the S-II stage
3. Launch pad - maintenance of GSE unique to the S-II stage, and support during final checkout and servicing of the Saturn V
4. Launch operations - inflight verification that mission specification requirements have been met.



### III. RELIABILITY

## RELIABILITY

### DEFINITION OF RELIABILITY

Reliability, in a technical or industrial reference, describes the characteristic, or quality, of a piece of equipment. Because it defines how the equipment will perform in the future, it can be measured only as a probability—the probability of success. The specific definition used by Reliability engineers states that "the reliability of a device is the probability that it will do what it is supposed to do, in the environment in which it is designed to operate, for a specified period of time."

The probability of success is based on directly comparable experience or tests. Reliability, therefore, requires data collection, statistical analysis, and the use of mathematical formulas to describe the situation, based on probability theory.

Two points must be emphasized. First, reliability is not a quality of the design. It is a quality of the hardware as built, checked out, and delivered. If there are weaknesses in the design, it will not be reliable. On the other hand, the design plan may not be followed, or may not be followed exactly.

The second point concerns the time element. To qualify as reliable, a device must operate without failure for the prescribed time. A synonym for reliability is dependability, a factor that cannot be measured by quality control. Probabilities can only be predicted statistically. Quality control, using go, no-go criteria, is essential to a high reliability program, but it cannot measure how long the device will last under field use. This does not minimize the importance of quality control. Any reliability prediction assumes that, as far as can be determined, the device was in an operating condition when delivered.

### SATURN S-II RELIABILITY REQUIREMENT

For the Saturn S-II vehicle, reliability must be based on ground test experience under carefully controlled, simulated flight conditions. For practical reasons, the usual rocket test program of determining operational readiness by destructive flight testing of a substantial number of vehicles is out of the question. The Saturn launch vehicle is the first one specially designed for launching men into space, and the need for reliability in this mission is obvious. Not so obvious is the fact that the space program would only be feasible from a cost standpoint with a very high reliability. The cost of repeating a Saturn V launch exceeds 130 million dollars. Accordingly, the reliability goal for the Saturn S-II stage was set at 95 percent, demonstrated to a confidence level of 90 percent.

### THE RELIABILITY GOAL

For design purposes, 16 systems were identified in the Saturn S-II stage. Each system has, in effect, a "failure budget". Since each system is required for overall stage performance, the probability of success for the stage is the product of the individual system reliabilities. Consider a

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signal or impulse with a 99-percent chance of traveling through a system without failure. The chance of traveling through 16 such systems in sequence is  $0.99 \times 0.99 \times 0.99$  etc. Following this product rule, each system must average much higher than 99-percent reliability for an over-all reliability of 95 percent. If there are several functional components in each system, each component must be considerably more reliable than the system in which it operates. The apportioned reliability goals for S-II stage systems are listed in the following figure.

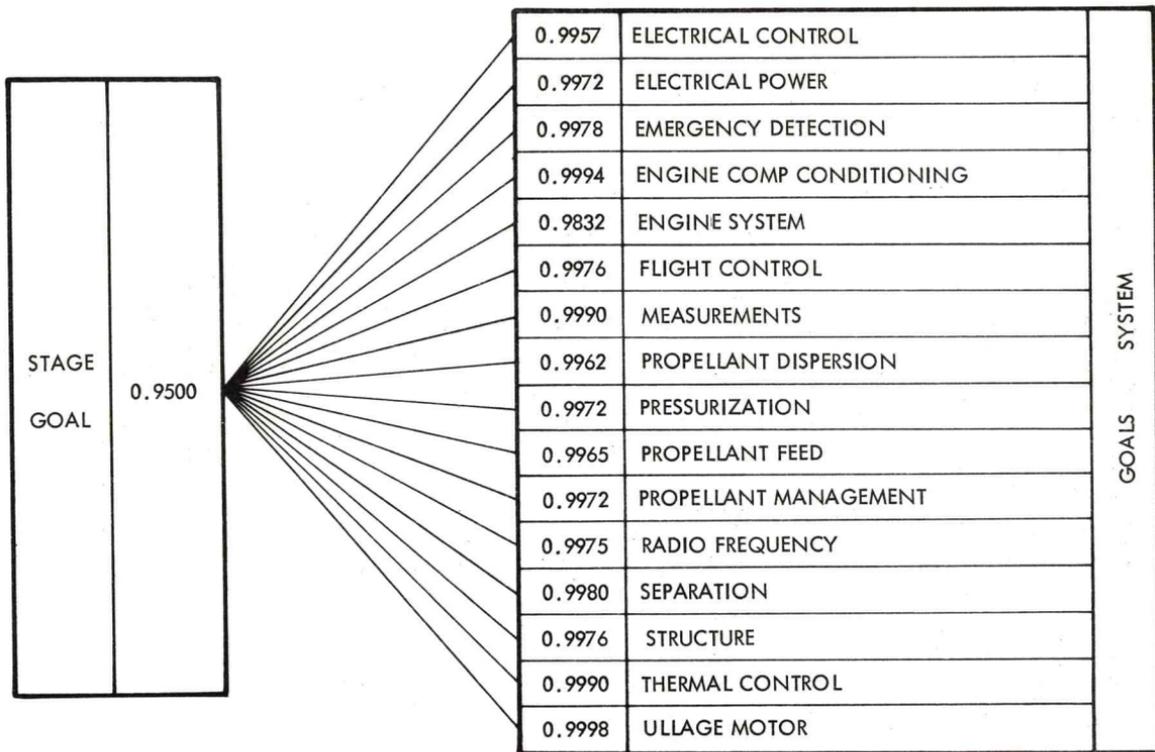
### CONFIDENCE

Directly associated with reliability is the measurement of statistical confidence in the calculated probabilities. For example, a low reliability goal of 50 percent requires only a few successes and no failures to give a very high confidence that the goal has been met. But if the reliability goal is raised to 99 percent, many more tests will be required to yield the same confidence. With the reliability goal as a fixed requirement, the more tests that are successfully completed, the higher the confidence the goal has been met. A requirement for a high reliability is not a real constraint unless the contract requires that it be demonstrated to a specified confidence level. As a consequence, increasingly higher confidence levels for S-II hardware have been established as reliability milestones.

Seventy percent confidence in component reliability is established by the basic component qualification tests. Additional component tests and system and stage testing, including component evaluation, raises this confidence to 90 percent. Similarly, checkout and testing of systems and stages are designed to ultimately achieve 90-percent confidence in the 95-percent reliability of S-II stages.

### RELIABILITY ATTAINMENT IN S-II PROGRAM

The mathematical approach to reliability goals and their measurement has direct application to the number of tests to be performed; however, testing alone does not make an item reliable. Reliability is accomplished by a detailed and organized program to eliminate errors and omissions that ultimately cause unreliability. The detection of defects through tests and checkouts is an important part of the reliability program; however, reliability begins with the earliest phases of design.



Stage to Subsystem Apportionment

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In the S-II program, detailed analyses were made of all engineering drawings, specifications, schematics, and operating plans to identify and list all possible failure modes, or ways in which equipment could fail. Based on these analyses, design changes were recommended to eliminate as many critical failure modes as possible, and to determine which items were the most critical. Three categories of equipment were established for stage items, based on potential failure effect on the mission, and the time between start of failure and the resulting mission loss. In terms of time to failure, three types of mission failures were defined: catastrophic, critical, and deferred.

In case of a catastrophic failure, the loss of the mission could occur in one-half second or less. The only hope of saving the crew would be automatic abort, and the chance of survival would be low. In event of a critical failure, the loss could occur between one-half second and five seconds after the failure event. Here, the chance of crew survival would be very good. The third type of mission failure includes incidents where the time to hazard is five seconds or longer, permitting evasive action or possibly an alternate mission.

In addition to time to hazard, potential failures are classified according to the number of individual failures that must occur to result in mission loss. In a first-order failure, a single failure event will cause mission loss. A second-order failure mode is one where two separate failures cause loss of the mission. Combining the type of mission failure with the order of equipment failure provides the following three categories of equipment:

### Airborne Systems Criticality Category Ratings

Category	Potential Failure Order and Type
I	First-order catastrophic Second-order catastrophic First-order critical
II	Second-order critical First-order deferred Third-order catastrophic
III	Third-order critical Second-order deferred

## INSTRUMENT CLASSES

In terms of purpose, there is the obvious distinction between flight articles and GSE. However, within flight articles, instrumentation may be further divided into classes. This refinement is based on the fact that some instruments are essential for the flight mission, while others have only a measurement mission.

## Instrument Classes

Class	Definition
A	Instruments required for operations in flight; i. e. , operation of command and control system and the emergency detection system
B	Instruments used during checkout and launch operations in a monitoring and controlling capacity
C	Instruments used for secondary monitoring malfunction isolation, or design performance measurement
D	Instruments used strictly for analysis of design systems development, or proof of adequacy of environmental and performance criteria

## GROUND SUPPORT EQUIPMENT CATEGORIES

Ground support equipment, like flight equipment, is also divided into critical groups. Here, failure order refers to the effect on the stage prior to launch rather than to mission loss. It should also be noted that GSE failures that occur during checkout are more critical than those occurring prior to checkout. The four categories of GSE are defined as follows:

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GSE Criticality Category Ratings

Category	Potential Failure Order and Type
I	First-order failure during checkout, the effect of which is:  Personnel hazard Failure to detect stage malfunction Undetectable stage failure
II	Second-order failure during checkout, the effect of which is:  Personnel hazard Failure to detect stage malfunction Undetectable stage failure  First-order failure during checkout, the effect of which is:  Detectable stage damage
III	First-order failure prior to checkout, the effect of which is:  Detectable stage damage  First-order failure prior to checkout, the effect of which is:  Undetectable stage damage
IV	All remaining failure modes not included in first three categories

Following the initial design reliability analysis, a number of organized activities are conducted to assure the reliability of the final product. These include failure-mode-cause analysis, detailed instructions for suppliers, design reviews, the confidence testing already described, and record keeping for traceability. The depth of these activities (the number of design reviews, etc.) depends on the criticality category. The minimum requirements for each category are shown in the following table.

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The qualification, reliability, and quality maintenance tests performed on production hardware samples are called Application Approval Tests. In addition, a significant part of the total confidence development plan involves testing performed on the actual equipment to be launched. These tests are called the Operational Assurance Tests.

### OPERATIONAL ASSURANCE TEST

This phase of testing is performed on production equipment before the flight mission. In-process and stage checkout acceptance testing support the application approval test results. The formulation of the required tests is based on test results obtained in application approval testing.

Three control levels established for operational assurance testing compare the operation of flight stage equipment to confidence level criteria, and provide a positive identification of continued satisfactory operation. Control level A is assigned to items that have been acceptably completed in process testing. The functional characteristics must not drift beyond designated limits during any of these tests. Control level B, assigned to the S-II stage, indicates satisfactory operation during combined systems operation in the factory. Control level C is assigned to the S-II stage subsequent to the static firing program at MTF and the final combined systems test prior to mating operations KSC.

These relationships are shown on page III-9.

The final phase of the reliability program is to accumulate evidence of flight readiness and provide this to the customer in formal documents. The Certificate of Flight Worthiness is provided with each stage, and the Flight Readiness Report is submitted prior to launch.

The Certificate of Flight Worthiness is a one-page document signed by the responsible managers at five points in the production of an S-II stage. The first endorsement sets forth the drawings, specifications, and operating plans that define the design and all subsequent actions affecting the stage. The second endorsement verifies that the stage has been built as agreed upon, has been checked out, and is ready for shipment from Seal Beach. The third endorsement certifies that the stage has been static-fired, checked out, and is ready for shipment from MTF. Each of these first three endorsements are signed by both NR and the NASA. The last two endorsements are signed by the NASA only. The fourth endorsement certifies the stage is ready for placing in the Saturn V stack. The final endorsement assures its readiness for flight.

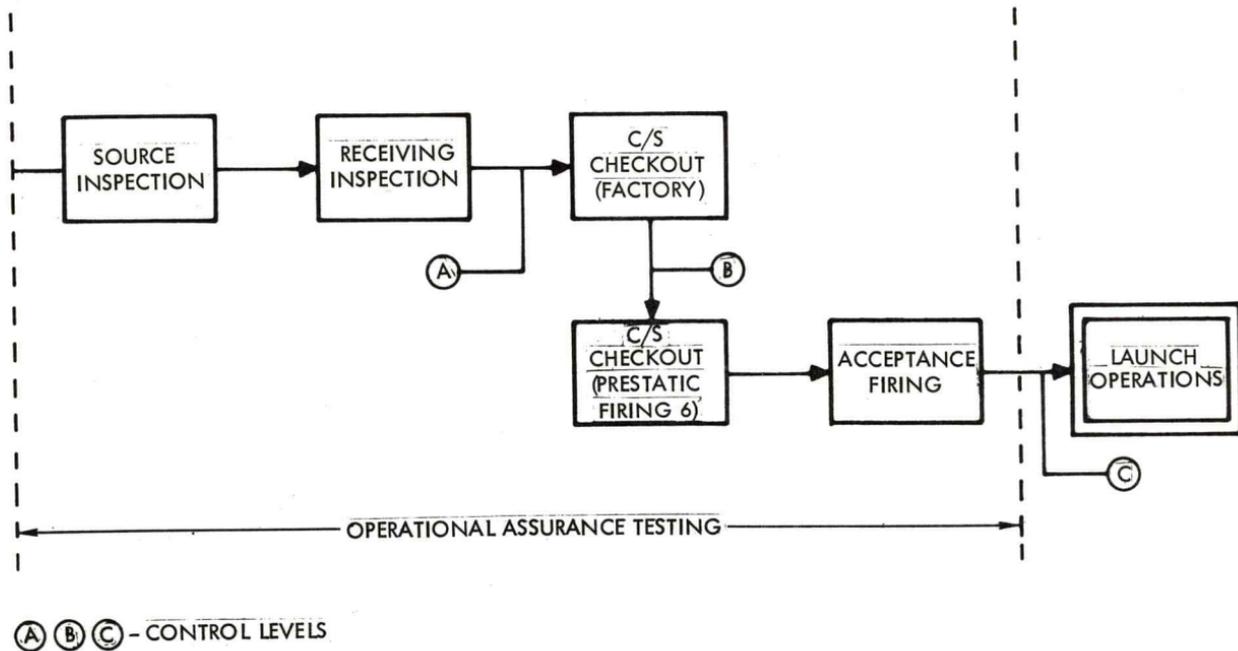
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S-II Program Criticality Category Applicability

Equipment Criticality Category	Failure Mode Analysis		Procurement	NR Procurement Spec	SCD only	Commercial Part	Design Review	Preliminary	Major	Application Approval	T & Q A Major	Testing	Qualification	Reliability	Quality Maintenance	Traceability
	Effect Analysis	Cause Analysis														
Flight Equipment																
I	X	X		X			X	X	X				X	X	X	X
II	X	X		X			X	X	X				X	X	X	X
III	X				X			X					X		X	X
Flight Instrumentation																
I	X	X		X			X	X	X				X	X	X	X
II A & B	X	X		X			X	X	X				X	X	X	X
II C & D	X	X		X			X	X	X				X	X	X	X
III A	X				X			X					X		X	X
III B	X				X			X					X		X	X
III C	X				X			X					X		X	X
III D	X				X			X					X		X	X
Auxiliary, Handling, Service and Checkout Equipment End Items																
I	X	X		X			X	X	X				X	X	X	X
II	X	X		X			X	X	X				X	X	X	X
III	X				X			X					X		X	X
IV	X				X			X					X		X	X
Subunits																
I	X	X		X			X	X	X				X	X	X	X
II	X	X		X			X	X					X		X	X
III	X				X											
IV	X					X										
SD & SE End Items																
I	X	X		X			X	X					X	X		X
II	X	X			X								X			X
III	X				X											
IV	X					X										
Subunits																
I	X	X		X				X					X			X
II	X	X				X					X					
III	X					X										
IV	X					X										

NOTES

- Not applicable to Battleship SDD.
- Requirements for supplier-conducted failure mode analysis, qualification, and/or reliability testing can be imposed only in procurement specifications.
- SD high reliability parts meet requirements of Category I.
- Military specification parts meet Category III.
- Commercial nonfunctional material and parts are permitted in all criticality Category III areas only through approval of the Reliability Manager.
- This table reflects minimum program requirements.
- T&QA major design review consists of test operations, reliability, quality control and design. It covers the use of equipment, hazardous conditions, and effect of failure on test hardware or facility.



Control Level Attainment on Deliverable Hardware

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Any deviation to the requirements is listed in a "Log of Exceptions" attached to the certificate. These exceptions, which may involve incomplete testing, out-of-tolerance results, or necessary hardware replacements, must be resolved before the last endorsement is signed. In this way, the document is the customer's primary tool for controlling the integrity of each stage. In particular, it assures the completeness and adequacy of Test Operations activities with regard to a specific stage.

The Flight Readiness Report is a summary of all actions taken to ensure a reliable stage, with emphasis on the problems encountered, corrective actions, and an assessment of their effect on the reliability of the stage.

Before this effort can be concluded, reliability engineers must devise systems for problem reporting, analysis, corrective action, and recurrence prevention. To help carry out this function, a reliability engineer assigned to each stage observes its progress through various checkouts and captive firings.

### TEST OPERATIONS ROLE IN RELIABILITY

The reliability of the end product is influenced by everyone who comes in contact with it—the people who assemble, check, and handle it. More than 50-percent of the failures recorded may be traced to mistakes made in assembly and subsequent operations. Not only is the hardware degraded by inadequate and uncontrolled processes, erroneous and costly tests result in so-called unconfirmed failures. Reliability requirements are so high, the customer frequently insists that items involved be scrapped, even though actual failure cannot be established. Consequently, a great burden is placed on test technicians to ensure that thousands of hours of labor are not wasted by an erroneous reading or test setup.

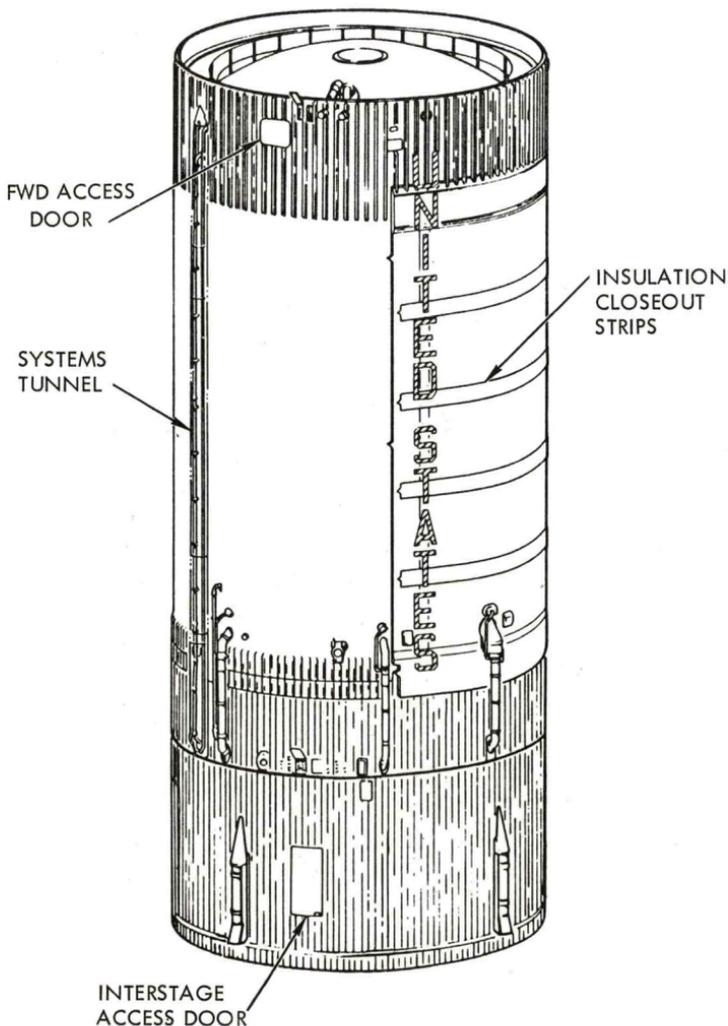
In addition, launch readiness necessarily depends on the adequacy of operating time records, accuracy of failure reports, and the successful completion of the prescribed checkouts. In every program of test operations for a complex vehicle, there is a tendency to jury-rig test setups, substitute hardware in the vehicle without recording the facts, and, in general, employ short-cuts to "make it work" and deliver on time. Even with a successful launch, exactly what was launched becomes doubtful in these cases, and the benefits for succeeding operations are lost.

In the Saturn S-II program, there will be no launches without assurance that everything involved has been thoroughly checked out and is ready. In the final analysis, it is the test technicians who must determine whether the reliability goal will be attained. On this hangs the future of space exploration.

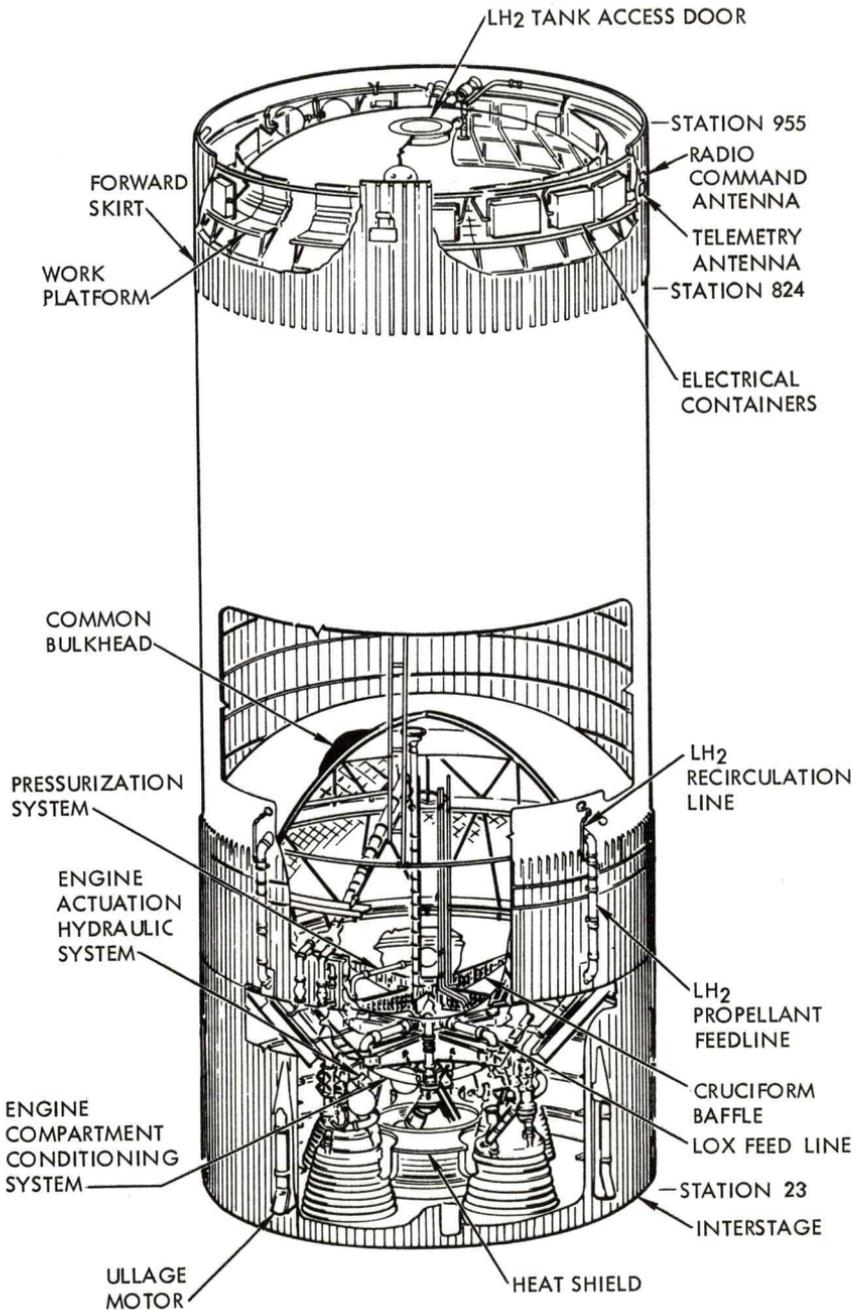
IV. STAGE MECHANICAL

## S-II STAGE STRUCTURE

The second stage structure consists of an interstage, which links the S-II stage with the S-1C first stage; a thrust structure and aft skirt assembly, which supports and houses the five J-2 engines; an ellipsoidal liquid oxygen tank; a bolting ring, which attaches the liquid oxygen tank to the second stage structure; six aluminum cylinder walls, which are welded together to form the liquid hydrogen tank, a forward domed bulkhead; and the forward skirt, which connects with the (S-1VB) Saturn V third stage. Another important part of the structure is the 60-foot systems tunnel, located outside the liquid hydrogen tank, which carries all wires between the S-1C and the S-1VB stages.

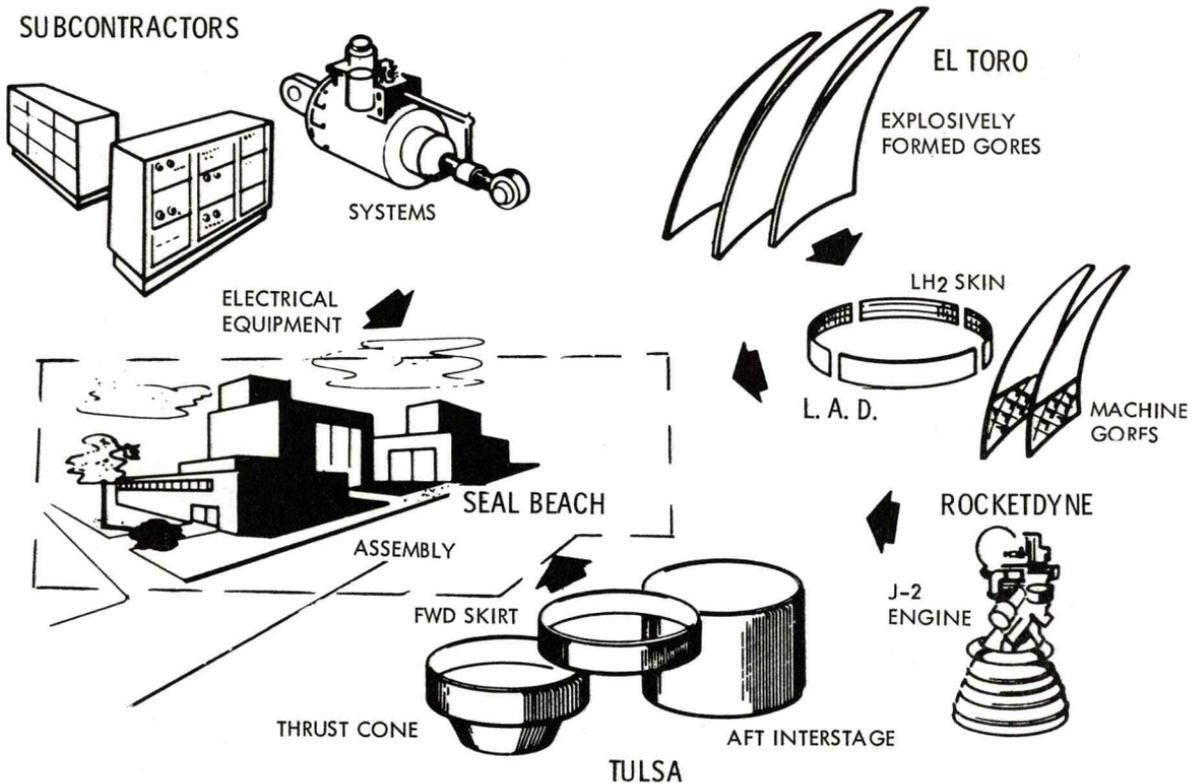


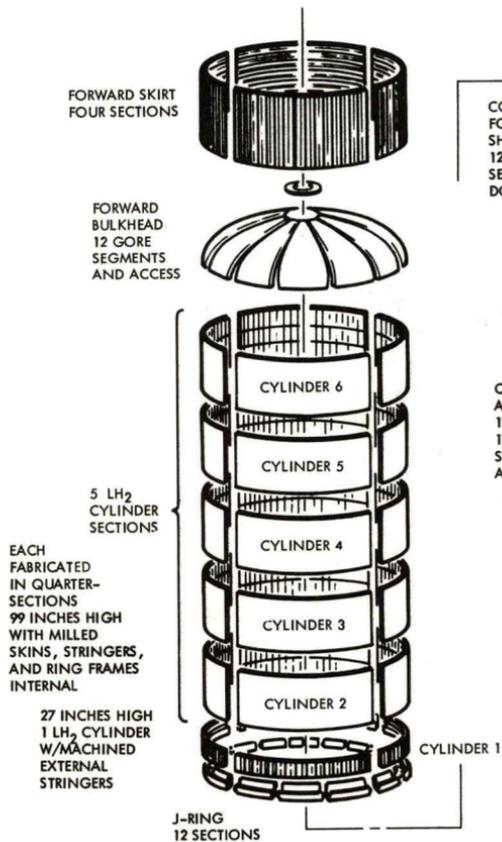
STAGE CUTAWAY



STAGE FABRICATION

SUBCONTRACTORS





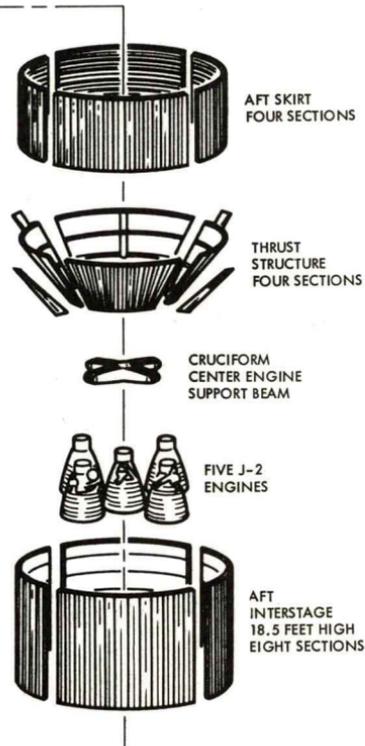
COMMON BULKHEAD  
FORWARD FACING  
SHEET  
12 GORE  
SEGMENTS AND  
DOLLAR SECTION

COMMON BULKHEAD  
INSULATION

COMMON BULKHEAD  
AFT FACING SHEET  
12 GORE SEGMENTS  
12 WAFFLE  
SECTIONS  
AND DOLLAR SECTION

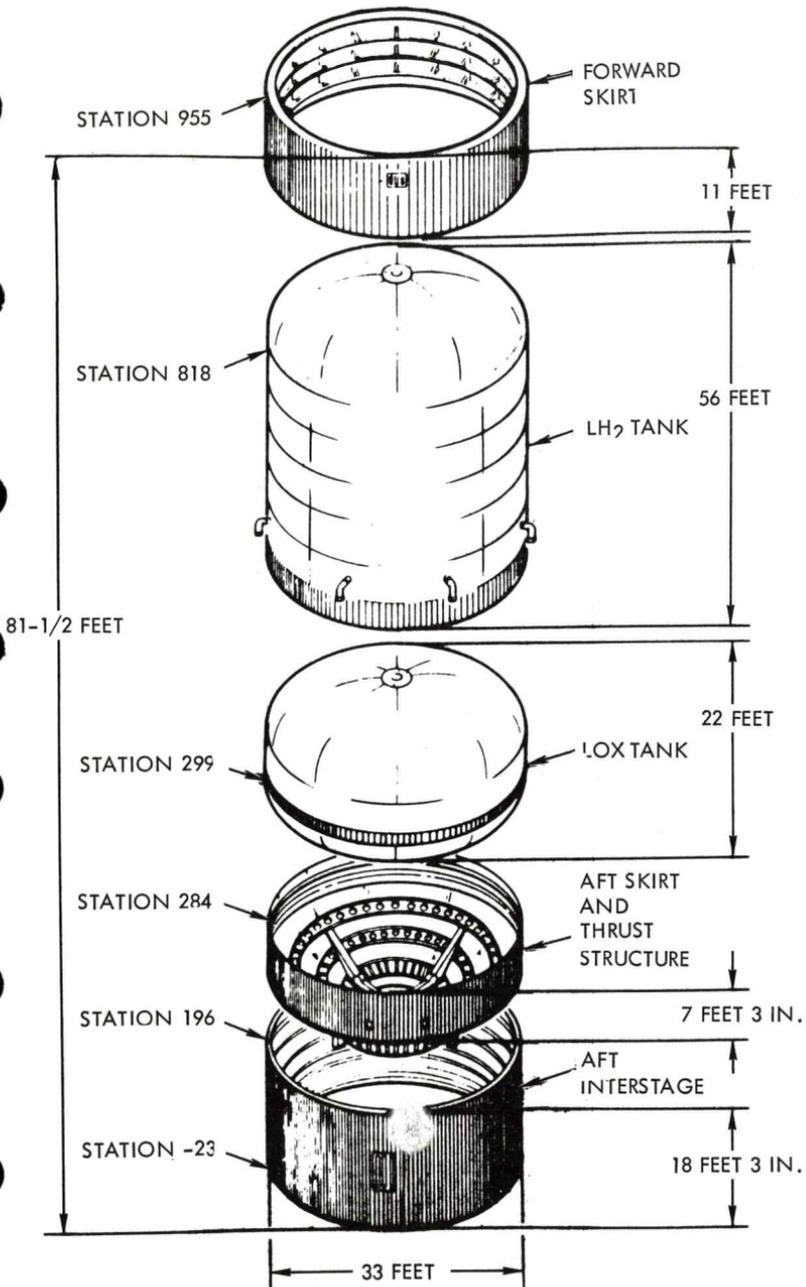
AFT LOX BULKHEAD  
12 GORE SEGMENTS  
AND 12 WAFFLE  
SECTIONS

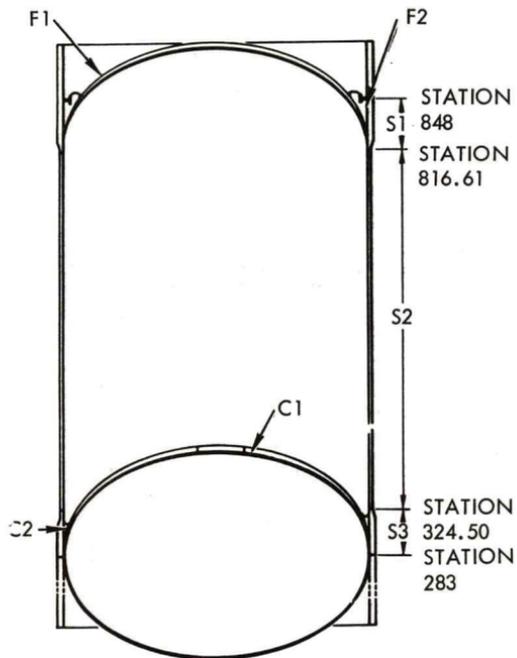
BOLTING RING  
12 SEGMENTS



S-II EXPLODED VIEW

S-II SUBASSEMBLIES





CIRCUITS AND DISCONNECTS						
DISCONNECT				CIRCUIT SERVED		
NO.	SIZE (IN.)	FUNCTION	LOCATION ARM NO.	NO.	NAME	
1	1/2	INLET	4	F1	FORWARD BULKHEAD INSULATION	
2	3/4	OUTLET	4			
3	1/2	INLET	4	F2	FORWARD SKIRT UNINSULATED AREA	
4	1	OUTLET	4			
5	1/2	INLET	3A	S2	SIDEWALL INSULATION	
6	3/4	OUTLET	4			
7	1	INLET	3A	C1	COMMON BULKHEAD CORE	
8	1-1/2	OUTLET	3A			
9	1/4	OUTLET	3A	C2	J-RING AREA	
10	1-1/2	INLET	4	S1	FORWARD SKIRT BOLTED INSULATION	
11	1/2	INLET	3A	S3	LOWER CYLINDER AND BOLT-RING INSULATION; ALSO J-RING AREA	

S-II INSULATED AND UNINSULATED AREAS

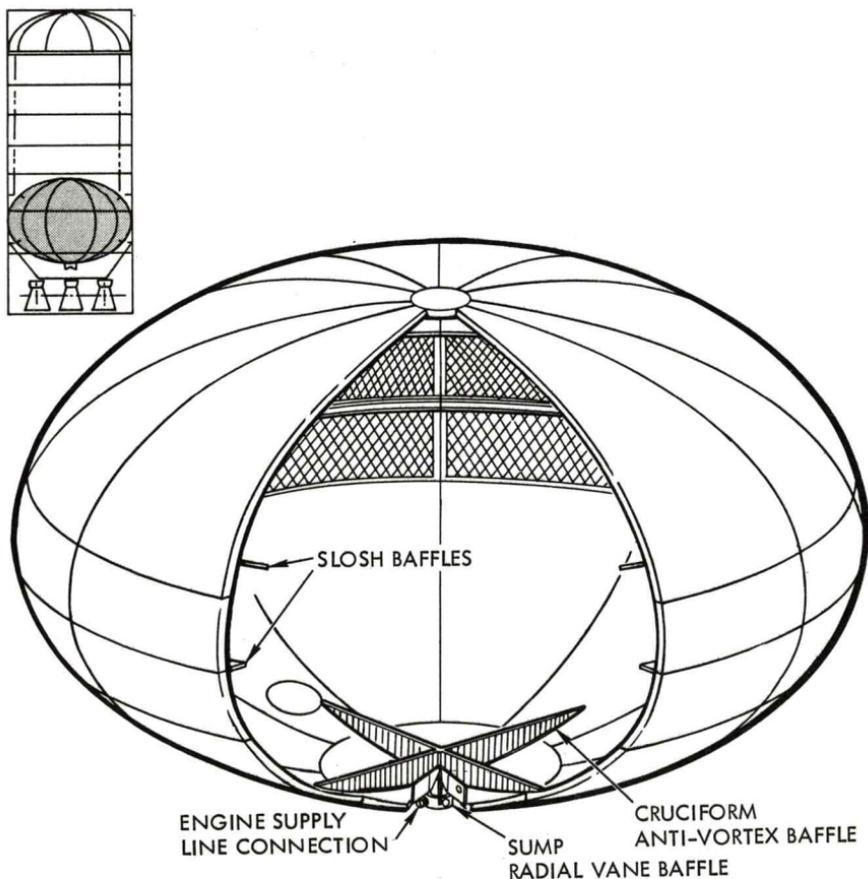
## SLOSH AND VORTEX SYSTEM

## SLOSH BAFFLES

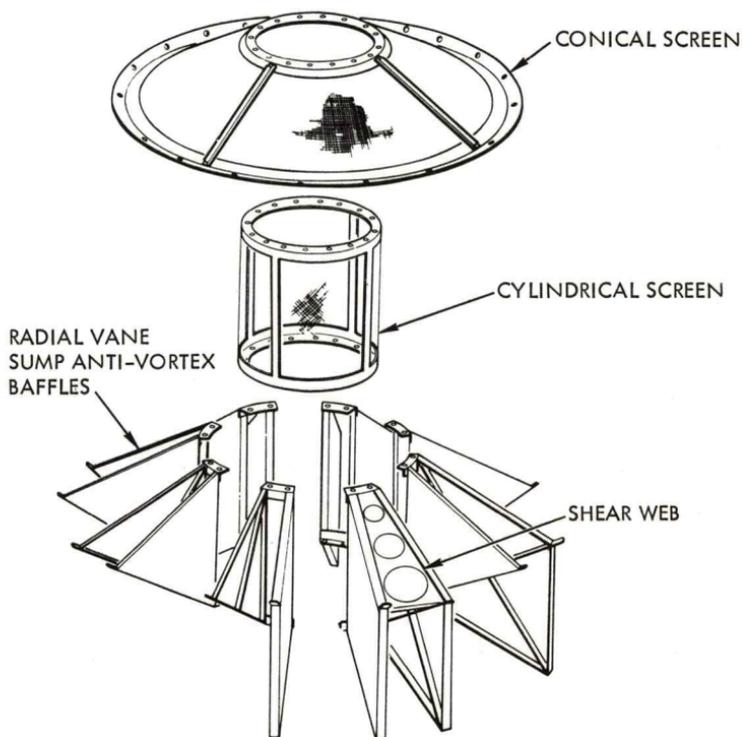
Sloshing is of vital concern because it can affect the dynamics of the entire vehicle and may prevent complete drainage of the tanks. Two ringed slosh baffles are installed in the LOX tank to dampen S-IC and S-II boost sloshing. No baffles are required in the LH<sub>2</sub> tank.

## VORTEX SYSTEM

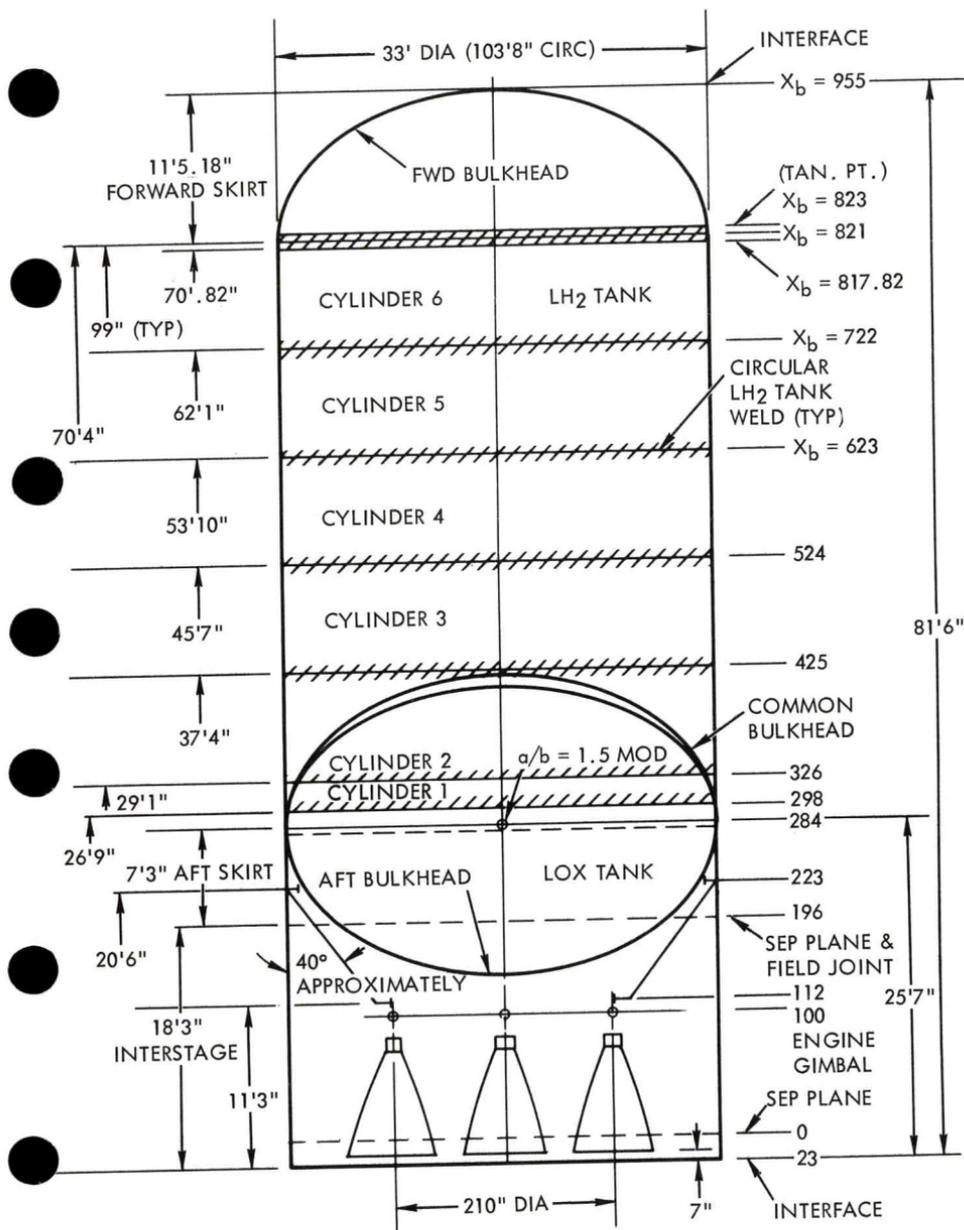
A vortex is a type of two-dimensional or planar motion in which all particles of a fluid move in circular orbits around a common axis. A cruciform and radial vane baffle system are incorporated in the LOX tank and sump area to minimize vortex effects.



LOX SUMP BREAKDOWN



STRUCTURAL ASSEMBLY LOCATIONS



FORWARD SKIRT STRINGER AZIMUTHS

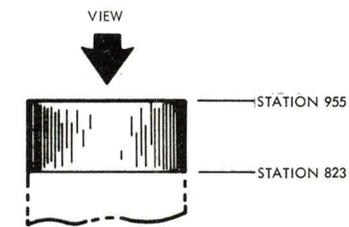
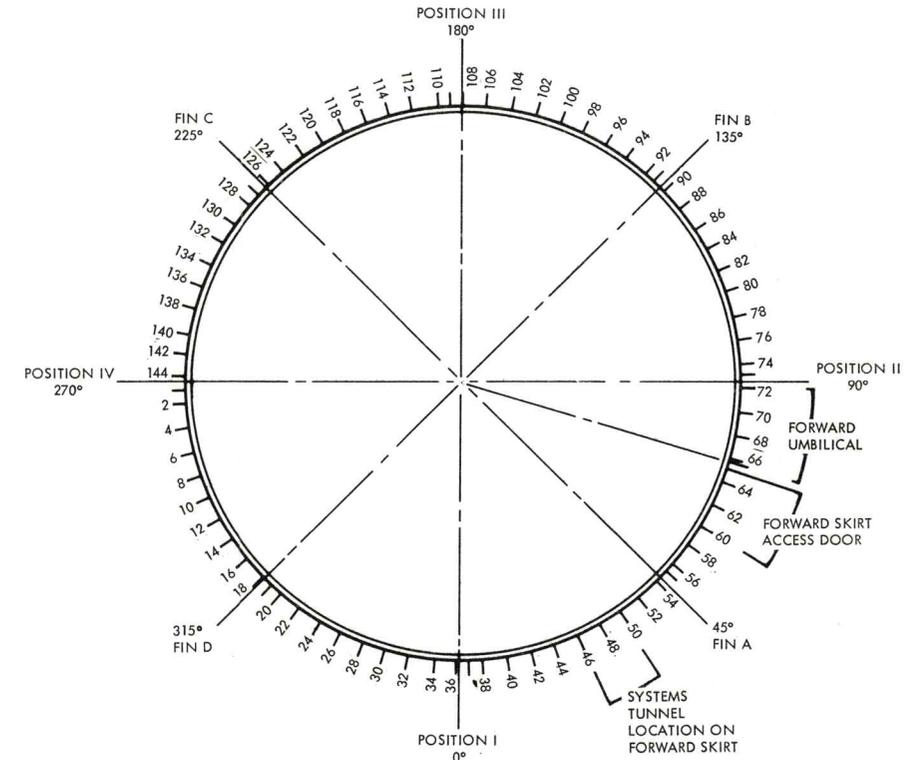
STRINGER ORIENTATION

STRINGER	DEGREES	MINUTES
1	271	45
2	274	15
3	276	45
4	279	15
5	281	45
6	284	15
7	286	45
8	289	15
9	291	45
10	294	15
11	296	45
12	299	15
13	301	45
14	304	15
15	306	45
16	309	15
17	311	45
18	314	15
19	316	45
20	319	15
21	321	45
22	324	15
23	326	45
24	329	15
25	331	45
26	334	15
27	336	45
28	339	15
29	341	45
30	344	15
31	346	45
32	349	15
33	351	45
34	354	15
35	356	45
36	359	15
37	1	45
38	4	15
39	6	45
40	9	15
41	11	45
42	14	15
43	16	45
44	19	15
45	21	45
46	24	15
47	26	45
48	29	15

STRINGER	DEGREES	MINUTES
48	29	15
49	31	45
50	34	15
51	36	45
52	39	15
53	41	45
54	44	15
55	46	45
56	49	15
57	51	45
58	54	15
59	56	45
60	59	15
61	61	45
62	64	15
63	66	45
64	69	15
65	71	45
66	74	15
67	76	45
68	79	15
69	81	45
70	84	15
71	86	45
72	89	15
73	91	45
74	94	15
75	96	45
76	99	15
77	101	45
78	104	15
79	106	45
80	109	15
81	111	45
82	114	15
83	116	45
84	119	15
86	124	15
87	126	45
88	129	15
89	131	45
90	134	15
91	136	45
92	139	15
93	141	45
94	144	15
95	146	45
96	149	15

STRINGER	DEGREES	MINUTES
97	151	45
98	154	15
99	156	45
100	159	15
101	161	45
102	164	15
103	166	45
104	169	15
105	171	45
106	174	15
107	176	45
108	179	15
109	181	45
110	184	15
111	186	45
112	189	15
113	191	45
114	194	15
115	196	45
116	199	15
117	201	45
118	204	15
119	206	45
120	209	15
121	211	45
122	214	15
123	216	45
124	219	15
125	221	45
126	224	15
127	226	45
128	229	15
129	231	45
130	234	15
131	236	45
132	239	15
133	241	45
134	244	15
135	246	45
136	249	15
137	251	45
138	254	15
139	256	45
140	259	15
141	261	45
142	264	15
143	266	45
144	269	15

CAUTION: STRINGER LOCATIONS ARE DIFFERENT FOR VARIOUS SUBASSEMBLIES ON THE S-II STAGE. WHENEVER REFERRING TO STRINGER LOCATIONS, BE POSITIVE THAT THE PROPER LOCATION CHART IS BEING USED FOR THE MATCHING SUBASSEMBLY.



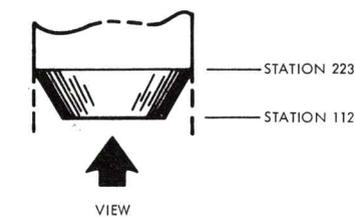
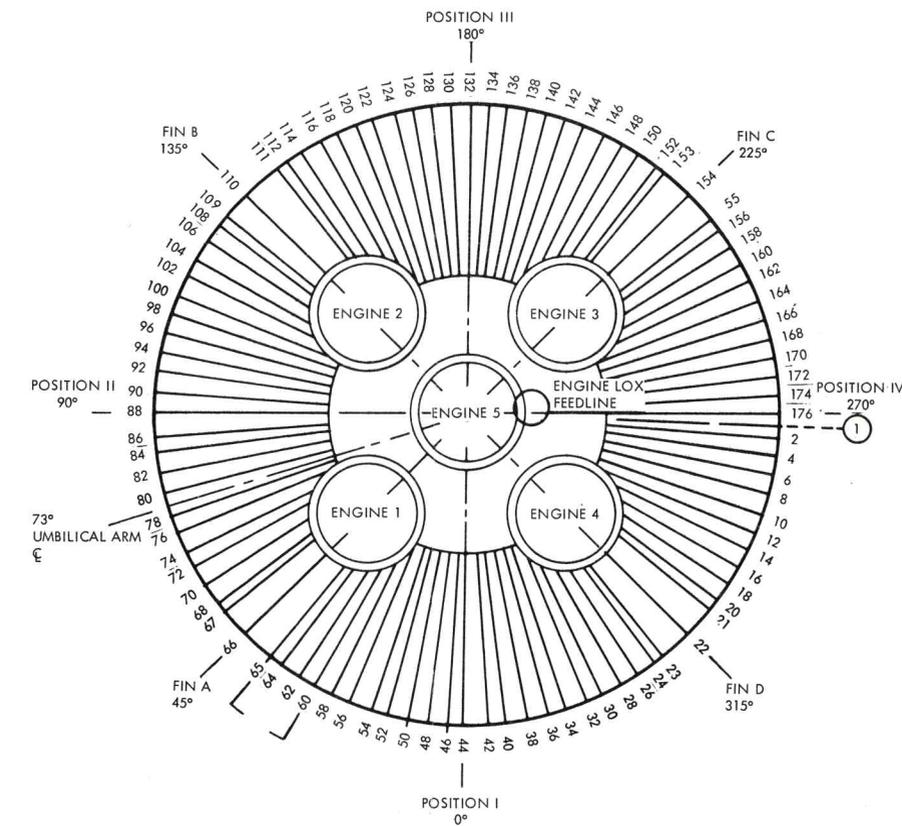
NOTE: FORWARD SKIRT LOOKING AFT (FROM TOP DOWN) ONLY EVEN STRINGERS SHOWN

STRINGER	DEGREES	MINUTES	SECONDS
1	271	50	3.81
2	273	40	7.64
3	275	30	11.45
4	277	20	15.28
5	279	10	19.11
6	281	0	22.92
7	282	50	26.75
8	284	40	30.57
9	286	30	34.39
10	288	20	38.21
11	290	10	42.03
12	292	0	45.85
13	293	50	49.68
14	295	40	53.49
15	297	30	57.32
16	299	21	1.15
17	301	11	4.96
18	303	1	8.79
19	304	51	12.60
20	306	41	16.43
21	308	31	20.26
22	315	0	0.00
23	321	28	39.74
24	323	18	43.57
25	325	8	47.40
26	326	53	51.21
27	328	48	55.04
28	330	38	58.85
29	332	29	2.68
30	334	19	6.51
31	336	9	10.32
32	337	59	14.15
33	339	49	17.97
34	341	39	21.79
35	343	29	25.61
36	345	19	29.43
37	347	9	33.25
38	348	59	37.08
39	350	49	40.89
40	352	39	44.72
41	354	29	48.55
42	356	19	52.36
43	358	9	56.19
44	0	0	00.00
45	1	50	3.81
46	3	40	7.64
47	5	30	11.45
48	7	20	15.28
49	9	10	19.11
50	11	0	22.92
51	12	50	26.75
52	14	40	30.57
53	16	30	34.39
54	18	20	38.21
55	20	10	42.03
56	22	0	45.85
57	23	50	49.68
58	25	40	53.49
59	27	30	57.32

STRINGER	DEGREES	MINUTES	SECONDS
60	29	21	1.15
61	31	11	4.96
62	33	1	8.79
63	34	51	12.60
64	36	41	16.43
65	38	31	20.26
66	45	0	0.00
67	51	28	39.74
68	53	18	43.57
69	55	8	47.40
70	56	58	51.21
71	58	48	55.04
72	60	38	58.85
73	62	29	2.68
74	64	19	6.51
75	66	9	10.32
76	67	59	14.15
77	69	49	17.97
78	71	39	21.79
79	73	29	25.61
80	75	19	29.43
81	77	9	33.25
82	78	59	37.08
83	80	49	40.89
84	82	39	44.72
85	84	29	48.55
86	86	19	52.36
87	88	9	56.19
88	90	0	0.00
89	91	50	3.81
90	93	40	7.64
91	95	30	11.45
92	97	20	15.28
93	99	10	19.11
94	101	0	22.92
95	102	50	26.75
96	104	40	30.57
97	106	30	34.39
98	108	20	38.21
99	110	10	42.03
100	112	0	45.85
101	113	50	49.68
102	115	40	53.49
103	117	30	57.32
104	119	21	1.15
105	121	11	4.96
106	123	1	8.79
107	124	51	12.60
108	126	41	16.43
109	128	31	20.26
110	135	0	0.00
111	141	28	39.74
112	143	18	43.57
113	145	8	47.40
114	146	58	51.21
115	148	48	55.04
116	150	38	58.85
117	152	29	2.68
118	154	19	6.51

STRINGER	DEGREES	MINUTES	SECONDS
119	156	9	10.32
120	157	59	14.15
121	159	49	17.97
122	161	39	21.79
123	163	29	25.61
124	165	19	29.43
125	167	9	33.25
126	168	59	37.08
127	170	49	40.89
128	172	39	44.72
129	174	29	48.55
130	176	19	52.36
131	178	9	56.19
132	180	0	0.00
133	181	50	3.81
134	183	40	7.64
135	185	30	11.45
136	187	20	15.28
137	189	10	19.11
138	191	0	22.92
139	192	50	26.75
140	194	50	30.57
141	196	30	34.39
142	198	20	38.21
143	200	10	42.03
144	202	0	45.85
145	203	50	49.68
146	205	40	53.49
147	207	30	57.32
148	209	21	1.15
149	211	11	4.96
150	213	1	8.79
151	214	51	12.60
152	216	41	16.43
153	218	31	20.26
154	225	0	0.00
155	231	28	39.74
156	233	18	43.57
157	235	8	47.40
158	236	58	51.21
159	238	48	55.04
160	240	38	58.85
161	242	29	2.68
162	244	19	6.51
163	246	9	10.32
164	247	59	14.15
165	249	49	17.97
166	251	39	21.79
167	253	29	25.61
168	255	19	29.43
169	257	9	33.25
170	258	59	37.08
171	260	49	40.89
172	262	39	44.72
173	264	29	48.55
174	266	19	52.36
175	268	9	56.19
176	270	0	0.00

CAUTION: STRINGER LOCATIONS ARE DIFFERENT FOR VARIOUS SUBASSEMBLIES ON THE S-II STAGE. WHENEVER REFERRING TO STRINGER LOCATIONS, BE POSITIVE THAT THE PROPER LOCATION CHART IS BEING USED FOR THE MATCHING SUBASSEMBLY.



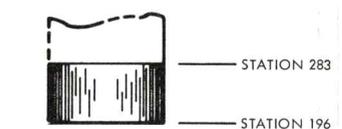
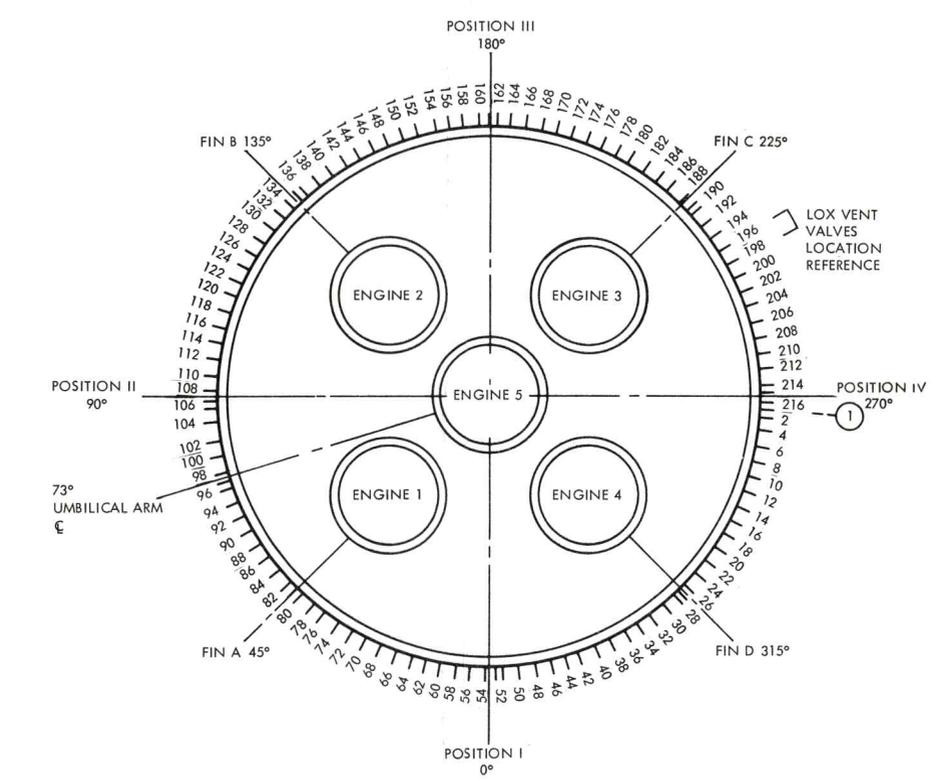
NOTE: THRUST CONE STRINGER ORIENTATION; ONLY EVEN STRINGERS SHOWN, EXCEPT IN SPECIFIC AREAS

STRINGER AZIMUTHS

STRINGER	DEGREES	MINUTES									
1	272	30	55	2	30	109	92	30	163	182	30
2	274	10	56	4	10	110	94	10	164	184	10
3	275	50	57	5	50	111	95	50	165	185	50
4	277	30	58	7	30	112	97	30	166	187	30
5	279	10	59	9	10	113	99	10	167	189	10
6	280	50	60	10	50	114	100	50	168	190	50
7	282	30	61	12	30	115	102	30	169	192	30
8	284	10	62	14	10	116	104	10	170	194	10
9	285	50	63	15	50	117	105	50	171	195	50
10	287	30	64	17	30	118	107	30	172	197	30
11	289	10	65	19	10	119	109	10	173	199	10
12	290	50	66	20	50	120	110	50	174	200	50
13	292	30	67	22	30	121	112	30	175	202	30
14	294	10	68	24	10	122	114	10	176	204	10
15	295	50	69	25	50	123	115	50	177	205	50
16	297	30	70	27	30	124	117	30	178	207	30
17	299	10	71	29	10	125	119	10	179	209	10
18	300	50	72	30	50	126	120	50	180	210	50
19	302	30	73	32	30	127	122	30	181	212	30
20	304	10	74	34	10	128	124	10	182	214	10
21	305	50	75	35	50	129	125	50	183	215	50
22	307	30	76	37	30	130	127	30	184	217	30
23	309	10	77	39	10	131	129	10	185	219	10
24	310	50	78	40	50	132	130	50	186	220	50
25	312	30	79	42	30	133	132	30	187	222	30
26	314	10	80	44	10	134	134	10	188	224	10
27	315	50	81	45	50	135	135	50	189	225	50
28	317	30	82	47	30	136	137	30	190	227	30
29	319	10	83	49	10	137	139	10	191	229	10
30	320	50	84	50	50	138	140	50	192	230	50
31	322	30	85	52	30	139	142	30	193	232	10
32	324	10	86	54	10	140	144	10	194	234	10
33	325	50	87	55	50	141	145	50	195	235	50
34	327	30	88	57	30	142	147	30	196	237	30
35	329	10	89	59	10	143	149	10	197	239	10
36	330	50	90	60	50	144	150	50	198	240	50
37	332	30	91	62	30	145	152	30	199	242	30
38	334	10	92	64	10	146	154	10	200	244	10
39	335	50	93	65	50	147	155	50	201	245	50
40	337	30	94	67	30	148	157	30	202	247	30
41	339	10	95	69	10	149	159	10	203	249	10
42	340	50	96	70	50	150	160	50	204	250	50
43	342	30	97	72	30	151	162	30	205	252	30
44	344	10	98	74	10	152	164	10	206	254	10
45	345	50	99	75	50	153	165	50	207	255	50
46	347	30	100	77	30	154	167	30	208	257	30
47	349	10	101	79	10	155	169	10	209	259	10
48	350	50	102	80	50	156	170	50	210	260	50
49	352	30	103	82	30	157	172	30	211	262	30
50	354	10	104	84	10	158	174	10	212	264	10
51	355	50	105	85	50	159	175	50	213	265	50
52	357	30	106	87	30	160	177	30	214	267	30
53	359	10	107	89	10	161	179	10	215	269	10
54	0	50	108	90	50	162	180	50	216	270	50

STRINGER ORIENTATION

CAUTION: STRINGER LOCATIONS ARE DIFFERENT FOR VARIOUS SUBASSEMBLIES ON THE S-II STAGE. WHENEVER REFERRING TO STRINGER LOCATIONS, BE POSITIVE THAT THE PROPER LOCATION CHART IS BEING USED FOR THE MATCHING SUBASSEMBLY.



NOTE: STRINGER ORIENTATION FOR AFT SKIRT, LH<sub>2</sub> TANK, INTERSTAGE AND STATIC FIRING SKIRT ONLY. ONLY EVEN STRINGERS SHOWN. VIEW LOOKING FORWARD.

SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

S-II STAGE IDENTIFICATION AND CONFIGURATION-CHANGE-POINT INFORMATION

Saturn S-II Articles	Model No.	Production No.	Configuration Change Points for Flight Stages	NASA Serial No.
Static test article	V7-1	1		S-II-S
All-systems test vehicle	V7-1	2		S-II-T
Dynamic test stage	V7-1	3		S-II-D
Facilities checkout stage	V7-1	4		S-II-F
Flight stage	V7-1	5	V1-	S-II-1
Flight stage	V7-1	6	V2-	S-II-2
Flight stage	V7-1	7	V3-	S-II-3
Flight stage	V7-1	8	V4-	S-II-4
Flight stage	V7-1	9	V5-	S-II-5
Flight stage	V7-1	10	V6-	S-II-6
Flight stage	V7-1	11	V7-	S-II-7
Flight stage	V7-1	12	V8-	S-II-8
Flight stage	V7-1	13	V9-	S-II-9
Flight stage	V7-1	14	V0-	S-II-10
Flight stage	V7-1	15	11-	S-II-11
Flight stage	V7-1	16	12-	S-II-12
Flight stage	V7-1	17	13-	S-II-13
Flight stage	V7-1	18	14-	S-II-14
Flight stage	V7-1	19	15-	S-II-15
Battleship test vehicle	V7-2			

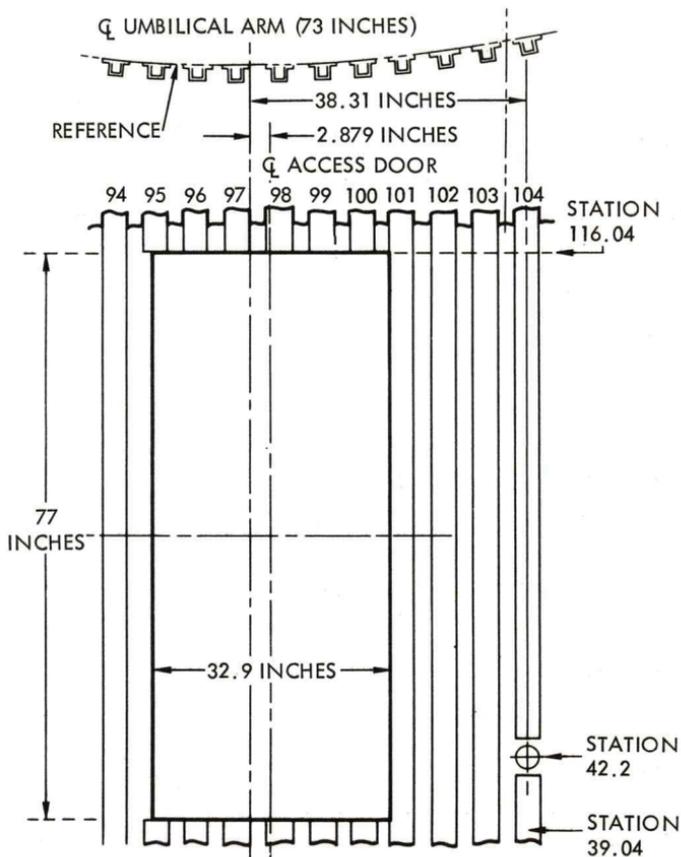
Vehicle Change Point	Description
XX-200	Preparation for shipment from Seal Beach (MSC)
XX-500	Preparation for shipment to KSC (acceptance test complete)
XX-900	Initiation of countdown at KSC for launch

Note: As of 27 May 1968, the above change points will be the only configuration change points applicable to S-II stages. (This may be subject to change in the future.) Configuration change point prefixes for S-II-1 through S-II-10 are V1-, V2-, V3-, etc.; whereas prefixes for S-II-11 and subsequent stages are 11-, 12-, 13-, and etc. An example for change-point XX-500 on the S-II-3 stage would be V3-500 and for the change point XX-500 on the S-II-12 would be 12-500.

GSE UMBILICAL SERVICE REQUIREMENTS

LOWER UMBILICAL ARM (ACCESS ARM)



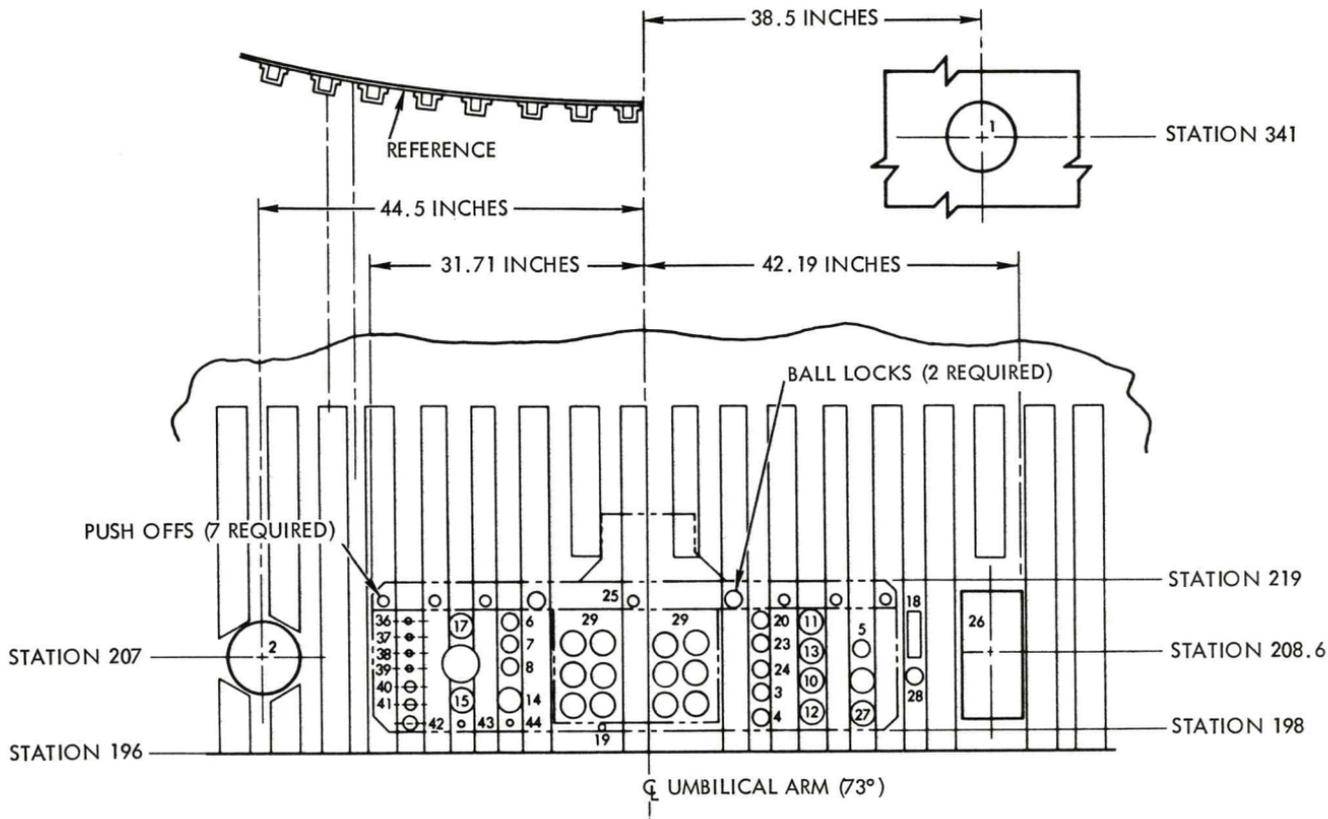
INTERMEDIATE UMBILICAL ARM DISCONNECTS (KEY)

Call-out	Disconnects	Disconnect Size (inches)	Maximum Pressure (psig)	Medium	Specification Number
1	LH <sub>2</sub> fill and drain	8	132	LH <sub>2</sub>	MC144-0005
2	LOX fill and drain	8	132	LOX	MC144-0005
3	LOX tank fill and vent valve actuation	1/2	750	He	MC144-0010
4	LOX tank vent valve and pressure switch checkout	1/2	37	He	MC144-0010
5	LH <sub>2</sub> fill valve and purge valve actuation	1/2	750	He	MC144-0010
6	Turbo purge	1/2	100	He	MC144-0010
7	GH <sub>2</sub> start tank vent control	1/2	500	He	MC144-0010
8	Engine helium bottle fill	1/2	3200	He	MC144-0010
10	GH <sub>2</sub> start tank fill	1	1500	GH <sub>2</sub>	MC144-0011
11	LH <sub>2</sub> pump seal drain	1	130	LH <sub>2</sub> /GH <sub>2</sub>	MC144-0011
12	GH <sub>2</sub> start tank vent and relief	1	1500	GH <sub>2</sub>	MC144-0011
13	Thrust chamber jacket purge	1	750	He	MC144-0011
14	LOX recirculation helium bubbling	1	400	He	MC144-0011
15	LOX fill and drain overboard dump	1	132	LOX/He	MC144-0011
17	Recirculation pneumatic control system	1	3250	He	MC273-0013
18	Electrical equipment purge	2.25 by 5.81	2	GN <sub>2</sub>	G7-820365
19	Electrical disconnect purge	1/2	2	He	
20	GH <sub>2</sub> pressurization systems purge	1/2	750	He	MC144-0010
21					
22					
23	Pressurization system pressure checkout	1/2	1000	GN <sub>2</sub>	MC144-0010
24	Recirculation pressure regulator checkout	1/2	1000	GN <sub>2</sub>	MC144-0010
25	GSE actuation	1/2	750	GN <sub>2</sub>	
26	Engine compartment conditioning	8 x 17	2.5	GN <sub>2</sub>	G7-820371
27	Recirculation LH <sub>2</sub> return line purge bleed	1	50	GN <sub>2</sub>	MC144-0011
28	Electrical ground disconnect	Shell size 18	1 conn req		

INTERMEDIATE UMBILICAL ARM DISCONNECTS (KEY) (CONT)

Call-out	Disconnects	Disconnect Size (inches)	Maximum Pressure (psig)	Medium	Specification Number
29	Electrical disconnects	Shell size 40	12 conn req		
30	Purge lines for LOX fill	1/2	100	He	1 required
		3/4	100	He	1 required
31	Purge line for LH <sub>2</sub> fill	3/4	15.7	He	1 required
32	Actuation lines	1/2	750	GN <sub>2</sub>	6 required
33	Sensing lines	3/8			4 required
34					
35	Cryogenic disconnect purge	1/2			9 required
36	LH <sub>2</sub> seal joints inlet	1/4	25		MC273-0055
37	LH <sub>2</sub> seal joints outlet	1/4	25		MC273-0055
38	LOX seal joints inlet	1/4	25		MC273-0055
39	LOX seal joints outlet	1/4	25		MC273-0055
40	LH <sub>2</sub> insulation inlet	1/2	25		MC273-0055
41	Common bulkhead purge inlet	1	25		MC273-0055
42	Common bulkhead purge outlet	1-1/2	25		MC273-0055
43	J-ring purge inlet	1/4	25		MC273-0055
44	J-ring purge outlet	1/4	25		MC273-0055

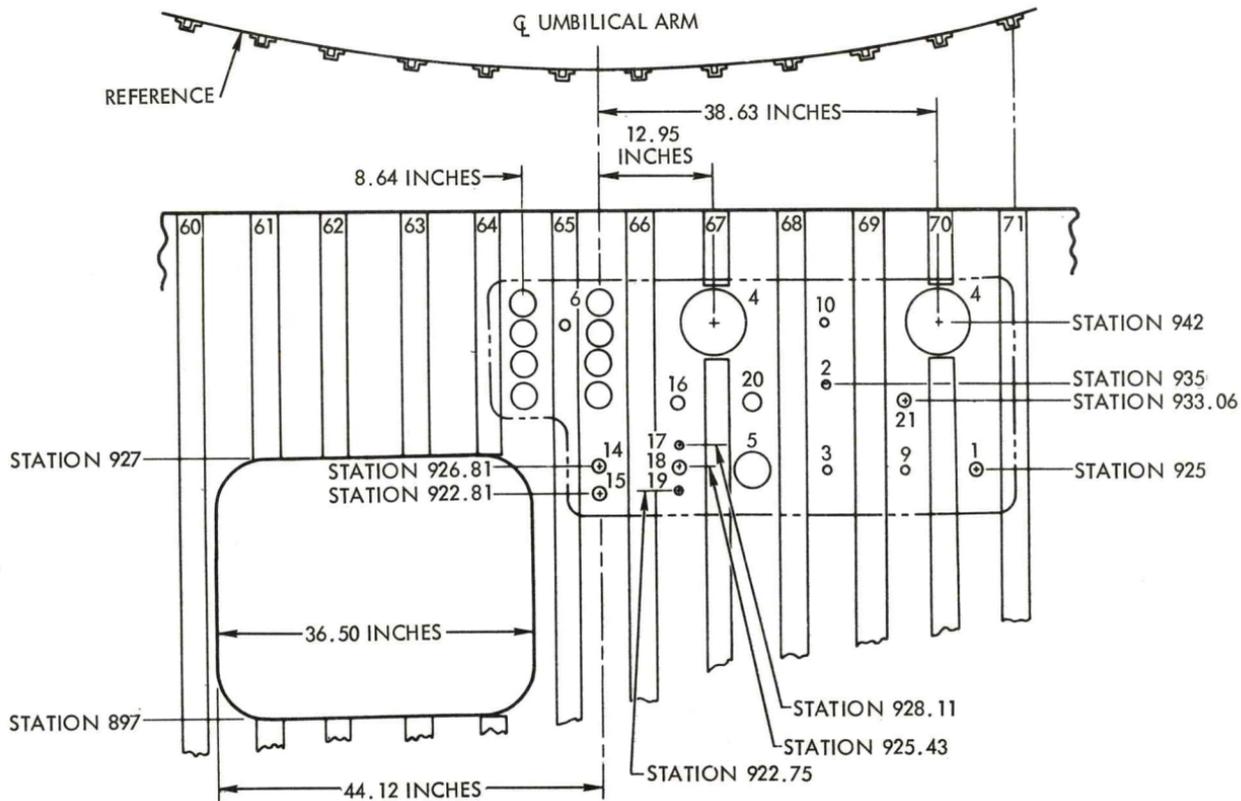
INTERMEDIATE UMBILICAL ARM DISCONNECT LOCATIONS



## FORWARD UMBILICAL ARM DISCONNECTS (KEY)

Callout	Disconnects	Disconnect Size (inches)	Maximum Pressure (psig)	Medium	Specification No.
1	LH <sub>2</sub> tank He prepressure	1		He	
2	LH <sub>2</sub> tank pressure switch and vent valve C/O	1/2	22	He	MC144-0010
3	LH <sub>2</sub> tank vent valve actuation	1/2	750	He	MC144-0010
4	LH <sub>2</sub> tank vent valve disconnect (2)	7	22	GH <sub>2</sub>	MC273-0017
5	Electrical equipment purge	4	2	GN <sub>2</sub>	MC273-0016
6	Electrical disconnect purge	1/2	2	He	
7					
8					
9	Pressurization system pressure regulator checkout	1/2	1000	GN <sub>2</sub>	MC144-0010
10	GSE actuation	1/2	750	GN <sub>2</sub>	
11	Electrical disconnects - shell size No. 40				8 connectors required
12	Sensing line	3/8			2 required
13	Actuation line	1/2	750	GN <sub>2</sub>	1 required
14	Insulation purge inlet forward bulkhead	1/2	25		MC273-0055
15	Uninsulated purge inlet	1/2	25		MC273-0055
16	Insulation purge outlet forward bulkhead	3/4	25		MC273-0055
17	Seal joints inlet	1/4	25		MC273-0055
18	LH <sub>2</sub> insulation outlet	3/4	25		MC273-0055
19	Seal joints outlet	1/4	25		MC273-0055
20	Forward skirt insulation pressure	1 1/2	25		MC273-0055
21	Uninsulated purge outlet	1	25		MC273-0055

FORWARD UMBILICAL ARM DISCONNECT LOCATIONS



IV-23

EXTERIOR COMPONENT LOCATIONS (KEY)

Callout	Major Components	Length	Diameter	Station
	Saturn S-II stage	81'6"	33' at Mold Line	-23 to 955
	Forward skirt	10'11"	33'3" OD	818 to 955
	LH <sub>2</sub> tank (exterior)	45'	33'1.7" OD	284 to 818
	Aft skirt	7'4"	33'4" OD	196 to 284
	Aft interstage	18'3"	33'4" OD	-23 to 196
	Systems tunnel	60'11"	Protrusion - 13"	199 to 930
	Forward Skirt	Dimension	Azimuth	Station
1	Access hatch	36.5" x 30"	65°30'	897 to 927
2	Umbilical connect panel	46.6" x 26.5"	73°	920 to 946.5
3	Radio command antenna	11" x 5"	*	920.5 to 925.5
4	Telemetry antenna	20" x 8"	*	900 to 908
	*Four required at 100°30', 170°30', 260°30', and 350°30'			
LH <sub>2</sub> TANK				
6	Recirculation pumps	10" dia	*	☉ 368
7	Recirculation return line	4" dia	40°40'	205 to 382
8	LH <sub>2</sub> feed lines	9" OD	*	211 to 345
9	LH <sub>2</sub> fill - and drain valve	8" dia	80°	☉ 341
	*Five required at 45°, 98°20', 135°, 225°, and 315°			

EXTERIOR COMPONENT LOCATIONS (KEY) (CONT)

Callout	Forward Skirt	Dimension	Azimuth	Station
AFT SKIRT				
10	LOX vent valves		240°	☉ Sta. 250
11	Umbilical connect	55" x 17.5"	73°	198.5 to 216
12	LOX fill- and drain-line	8" dia	60°	☉ 207
13	Engine compartment purge	8" x 17"	80°	☉ 207
AFT INTERSTAGE				
14	Access hatch	32.9" x 77.0"	73°20'	39.04 to 116.04
15	LOX pump drain-seal disconnect	2" dia	84°	☉ 42.2
16	Ullage rockets	12.5" dia x 89"	*	Stringers 29, 83, 137, and 191

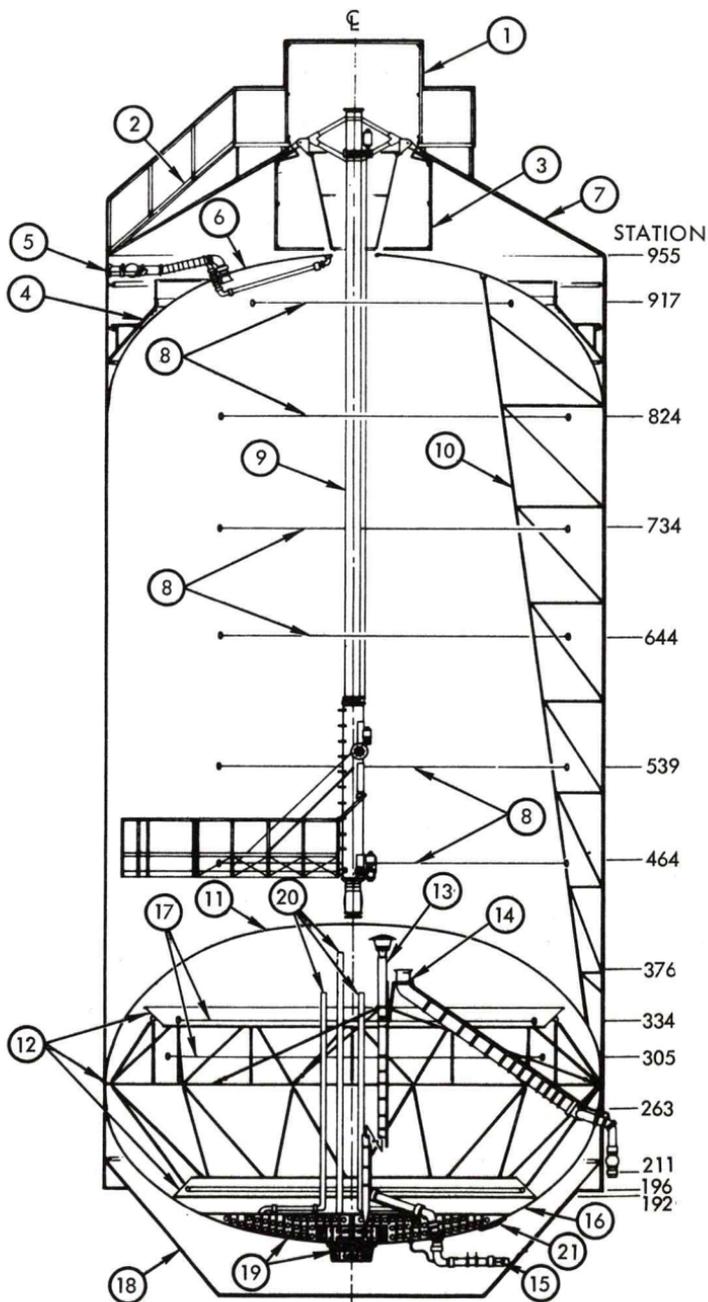


LH<sub>2</sub> AND LOX TANK COMPONENT LOCATIONS (KEY)

Callout	Component	Dimension	Azimuth	Station
1	LH <sub>2</sub> tank servicing mechanism cover (A7-59)			*
2	Forward stage access platform (A7-44)			*
3	LH <sub>2</sub> tank clean room (A7-39)			*
4	Forward skirt maintenance walkway (A7-38)			
5	LH <sub>2</sub> vent lines		76°45' & 84°15'	942
6	LH <sub>2</sub> forward bulkhead			823 to 955
7	Forward hoisting frame (H7-24)			955 to 1051
8	LH <sub>2</sub> sensor support cable			
9	LH <sub>2</sub> tank servicing mechanism (A7-35)			
10	Capacitance probe support structure			
11	Common bulkhead			
12	LOX anti-slosh baffles		Extends 360°	334, 283, & 192
13	Support mast	6-inch diameter	240° 24" radius	155 to 410
14	LOX vent line	10-inch diameter	240°	381 to 254
15	LOX vent valves		240°	250
16	Aft bulkhead			284 to 421
17	LOX sensor support cable			
18	Thrust cone			112 to 223
19	Anti-vortex baffles			Sump and aft
21	LOX tank access door			

\*Mounted to the forward hoisting frame

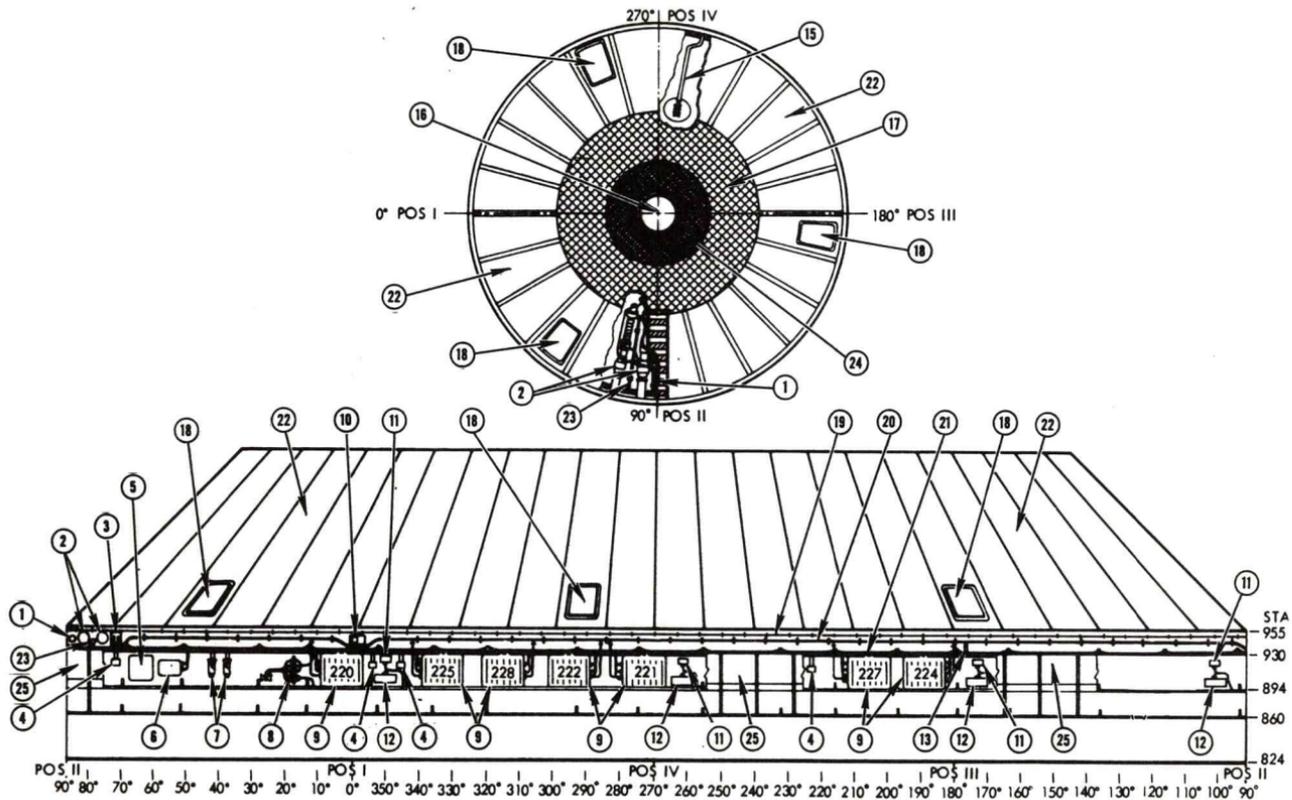
LH<sub>2</sub> AND LOX TANK COMPONENT LOCATIONS



## FORWARD SKIRT COMPONENT LOCATIONS (KEY)

Callout	Component	Dimension	Azimuth	Station
1	Desiccant line	5.25 x 4 dia	88°20'	939
2	LH <sub>2</sub> vent line		76°45' & 84°15'	942
3	Umbilical disconnect panel	16.25 x 14.9	72°	938.5
4	J-box	9 x 6 x 6		
5	Forward skirt access hatch	36.5 x 30	63°30'	897-927
6	Destruct container	28 x 20 x 9	55°30'	912
7	Disconnect panels	12 x 5 x 5	40°80' & 45°30'	920
8	Systems tunnel disconnect panel		20°	912
9	Forward skirt equipment containers	49 x 32 x 10	As indicated	912
10	Rate gyro		0°	943
11	Radio command antenna (4 typ)	9 x 3 x 6	100°30' 170°30'	923
12	Telemetry antenna (4 typ)	24 x 16 x 9	260°30' 350°30'	904
13	Microphone bracket		176°	930
15	Cryogenic receptacle pad and line	24" dia	260°	
16	LH <sub>2</sub> manhole	36" dia	Stage $\bar{C}$	955
17	Forward stage access platform (A7-44)			1051
18	Access hatch (A7-24)		7°30', 127°30' & 247°30'	972
19	Dc power line			947
20	Thermal control supply line			942
21	Main electrical harness			930
22	Forward hoisting frame (A7-24)			955-1051
23	LH <sub>2</sub> pressure regulator	9.5 x 7.5 x 10.25	76°45'	915
24	Floor (A7-39)			
25	Forward skirt work platform			895

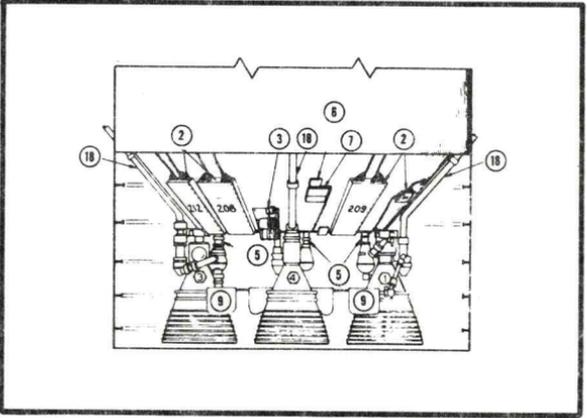
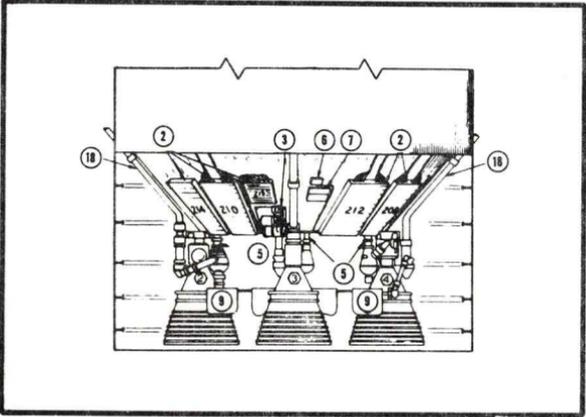
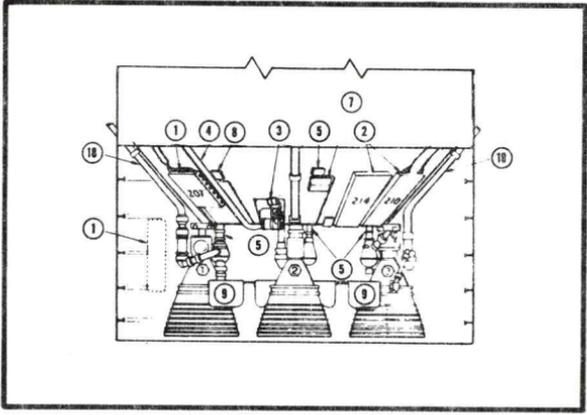
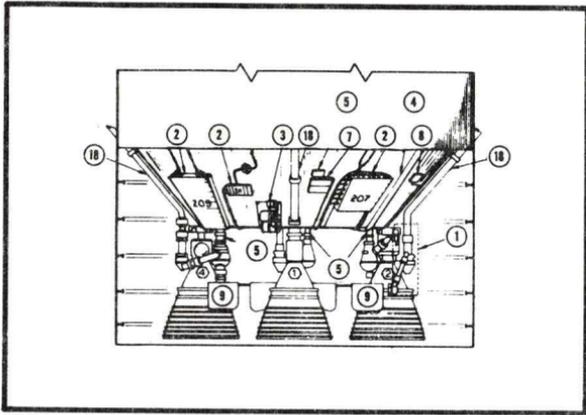
FORWARD SKIRT COMPONENT LOCATIONS



AFT INTERSTAGE COMPONENT LOCATIONS (KEY)

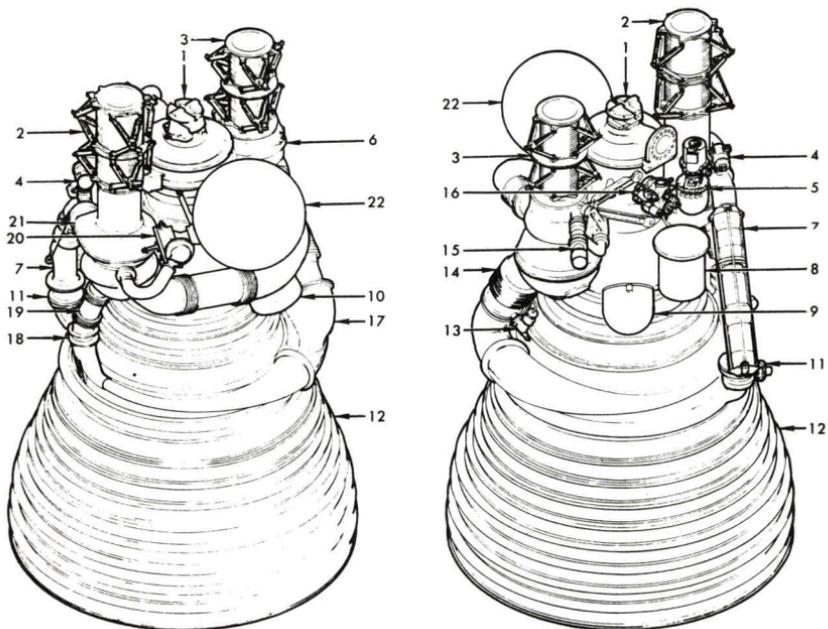
Callout	Component	Dimension (inches)	Azimuth	Station
1	Aft interstage access hatch	32.9 x 77.2	73°20'	☉ 77.5
2	Aft skirt equipment containers			☉ 139
3	ARMA panels	36.75 x 29.625 x 10		112 to 140
4	Conditioning system supply line			
5	LOX feed lines	8 outside diameter		
	inboard	45		142 to 89
	outboard	82		142 to 112
6	Inverters	12 x 8.62 x 4		180 to 190
7	J-2 engine interface	13 x 20.45 x 7.93		150
8	Instrumentation J box	9 x 6 x 6	154°30' & 334°30'	115
9	Heat shield			46
10	LH <sub>2</sub> feed lines	9 outside diameter		
	inboard	258		211 to 94
	outboard	353		211 to 117

AFT INTERSTAGE COMPONENT LOCATIONS



## J-2 ENGINE DESCRIPTION

The J-2 rocket engine is a high-performance, multiple-restart engine using liquid oxygen and liquid hydrogen as propellants and designed to be used singly or in clusters. The only substances used in the engine are the propellants and helium gas. The extremely low operating temperature of the engine prohibits the use of lubricants or other fluids. The engine features a single tubular-walled, bell-shaped thrust chamber, and two independently driven, direct-drive turbopumps for liquid oxygen and liquid hydrogen. A high-speed, direct-drive, power takeoff is provided at the oxidizer turbopump turbine for hydraulic pump operation. Both turbopumps are powered in series by a single gas generator utilizing the same propellants as the thrust chamber.

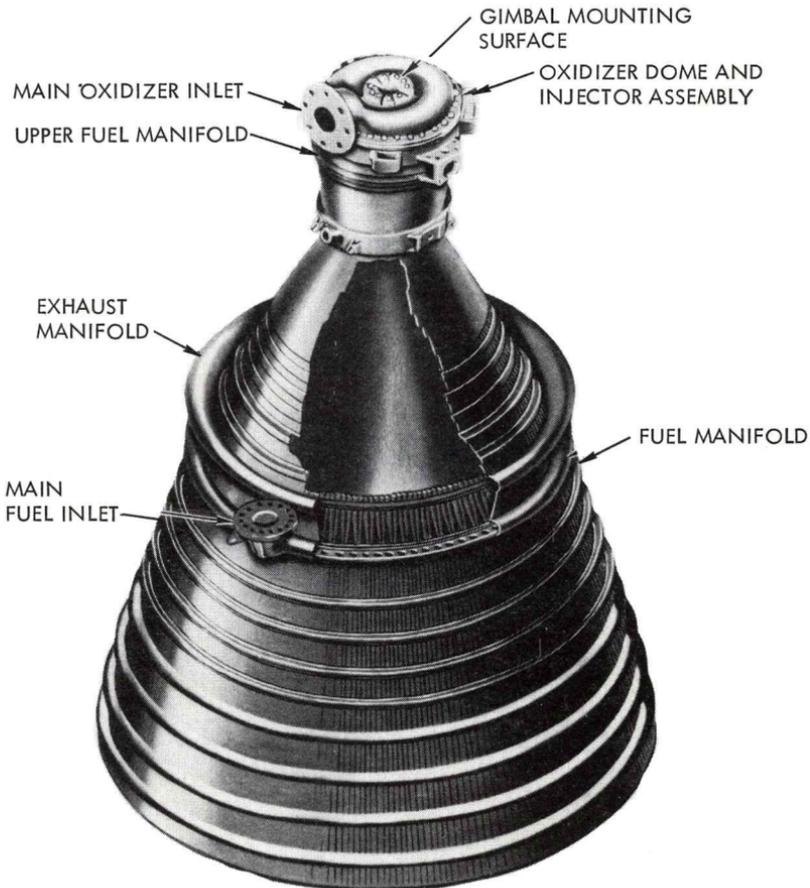


1. GIMBAL
2. FUEL INLET DUCT
3. OXIDIZER INLET DUCT
4. FUEL BLEED VALVE
5. GAS GENERATOR
6. OXIDIZER TURBOPUMP
7. HIGH PRESSURE FUEL DUCT
8. ELECTRICAL CONTROL PACKAGE
9. PRIMARY FLIGHT INSTRUMENTATION PACKAGE
10. AUXILIARY FLIGHT INSTRUMENTATION PACKAGE
11. MAIN FUEL VALVE

12. THRUST CHAMBER
13. ANTI-FLOOD CHECK VALVE
14. HEAT EXCHANGER
15. PROPELLANT UTILIZATION VALVE
16. PNEUMATIC CONTROL PACKAGE
17. EXHAUST MANIFOLD
18. OXIDIZER TURBINE BYPASS VALVE
19. TURBINE BYPASS DUCT
20. START TANK DISCHARGE VALVE
21. FUEL TURBOPUMP
22. START TANK

## THRUST CHAMBER

The thrust chamber is constructed of stainless steel tubes of 0.012-inch wall thickness. Tubes with thin walls are required for heat-transfer purposes. The thrust chamber tubes are stacked longitudinally and furnace-brazed to form a single unit. The chamber is bell-shaped with a 27.5-to-1 expansion area ratio for efficient operation at altitude and is regeneratively cooled by the fuel. Fuel enters from a manifold located midway between the thrust chamber throat and exits at a pressure of more than 1000 psi. In cooling the chamber, the fuel makes a one-half pass downward through 180 tubes and is returned in a full pass up to the thrust chamber injector through 360 tubes.



## ENGINE OPERATION

## START SEQUENCE

Start sequence is initiated by supplying energy to two spark plugs in the gas generator and two in the augmented spark igniter for ignition of the propellants. Next, two solenoid valves are actuated: one for helium control, and one for ignition phase control. Helium is routed to hold the propellant bleed valves closed and to purge the thrust chamber LOX dome, the LOX pump intermediate seal, and the gas generator oxidizer passage. In addition, the main fuel valve and ASI oxidizer valve are opened, creating an ignition flame in the ASI chamber that passes through the center of the thrust chamber injector.

After a delay of 1 second, during which time fuel is circulated through the thrust chamber to condition the engine for start, the start tank discharge valve is opened to initiate turbine spin.

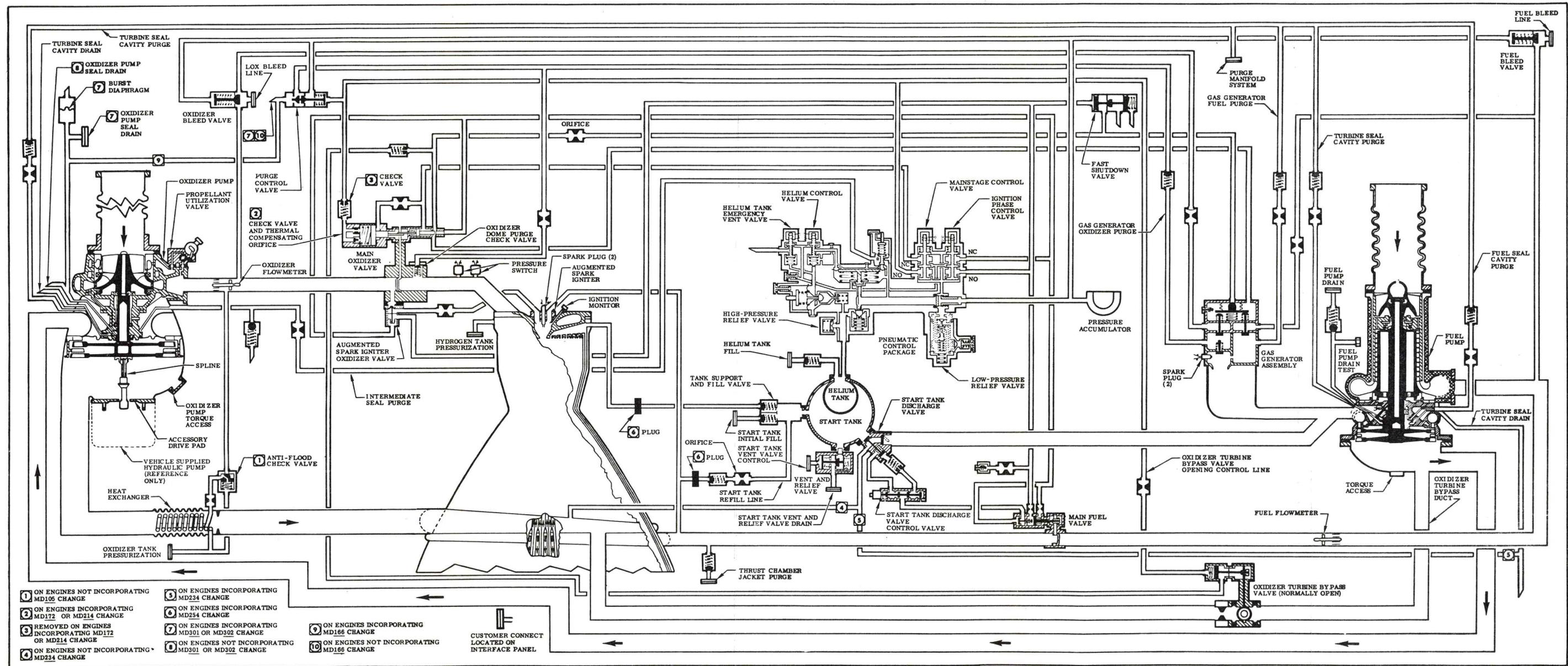
After an interval of 0.450 second, the start tank discharge valve is closed, and a mainstage control solenoid is actuated to:

- Turn off gas generator and thrust chamber helium purges
- Open the gas generator control valve (hot gases from the gas generator now drive the pump turbines)
- Open the main oxidizer valve to the first position (14 degrees) allowing LOX to flow to the LOX dome to burn with the fuel that has been circulating through the injector
- Close the oxidizer turbine bypass valve (a portion of the gases for driving the oxidizer turbopump were bypassed during the ignition phase)
- Gradually bleed the pressure from the closing side of the oxidizer valve pneumatic actuator, controlling the slow opening of this valve for smooth transition into mainstage

Energy in the spark plugs is cut off, and the engine is operating at rated thrust.

## CUTOFF SEQUENCE

When the engine cutoff signal is received by the electrical control package, it deenergizes the mainstage and ignition phase solenoid valves and energizes the helium control solenoid deenergizer 1-second timer. This, in turn, permits closing pressure to the main fuel valve, main oxidizer valve, gas generator control valve, and augmented spark igniter valve. The oxidizer turbine bypass valve and propellant bleed valves open, and the gas generator and LOX dome purges are initiated for 1 second, at which time the helium control solenoid deenergizes.



J-2 Engine Schematic

J-2 ENGINE PRESTART SUBSYSTEM CONDITIONING

System Operation	Function	Pressure (psig)	Temperature (F)	Flowrate	Gas	Remarks
Engine compartment purge	Purge	1.5±0.5	Ambient	300 to 500	N <sub>2</sub>	
Diffuser purge	Purge		40 minimum at each diffuser inlet	6.0 minimum per engine		
Engine thrust chamber purge	Purge	225±25	110±50	22 nominal per 5 engines	N <sub>2</sub>	Used during propellant loading and after engine cutoff
Engine thrust chamber purge	Purge	100 - 325	Ambient	3.0 nominal per 5 engines	He	Used prior to thrust chamber chilldown
Engine thrust chamber chilldown	Purge	700±200	-390±30	75±25 per 5 engines	He	
Engine turbopump and gas generator (GG) purge	Purge	95±20	105±55	0.30 nominal per 5 engines	He	
Engine LOX dome, GG injector, and LOX pump intermediate seal purge	Purge	400±25	105±55	12.5 nominal per 5 engines	He	Pressure measured at engine helium bottle regulator output
Engine helium bottle purge	Purge	1000 max	Ambient		He	
Engine helium bottle prepressure	Actuation	1000±100	Ambient	Static	He	

J-2 ENGINE PRESTART SUBSYSTEM CONDITIONING (CONT)

System Operation	Function	Pressure (psig)	Temperature (F)	Flowrate	Gas	Remarks
Engine helium bottle pressure	Bottle pressure	3000±200	Ambient		He	
Engine start tank purge	Purge	95±20	Ambient	0.3 nominal per 5 engines	He	
Start tank vent valve actuation pressure	Actuation	400±25	Ambient	Static	He	
Engine start tank chilldown	Purge	600 max	-275±25	30 nominal per 5 engines	H <sub>2</sub>	
Engine start tank pressurization	Bottle pressure	1175±15	-260±40	30 nominal per 5 engines	H <sub>2</sub>	
LOX system helium injection bottle pressure	Bottle pressure	3000 +250 -100	Ambient	60 scfm nominal per 5 engines	He	

## ULLAGE PRESSURE REQUIREMENT

S-II end boost requirements for maximum conditions and maximum flowrate (+8 percent mixture ratio) are as follows:

	LH <sub>2</sub> Tank (psi)	LOX Tank (psi)
Nominal J-2 NPSH	4.00	12.50
Maximum Variations	3.15	7.90
*NPSH (NR-SD Design)	7.15	20.40
Vapor Pressure	24.00	18.40
Line and Bellows Pressure Drops	<u>4.62</u>	<u>6.50</u>
Subtotal	35.77	45.30
Fluid Head	-1.62	-6.54
Minimum Ullage Pressure - Requirement	<u>34.15</u>	<u>38.76</u>
Safety Margin	<u>2.85</u>	<u>1.24</u>
Minimum Ullage Pressure - Supplied	<u>37.00</u> psia	<u>40.00</u> psia
Vent Band	<u>2.00</u>	<u>2.00</u>
Tank Pressure Maximum	<u>39.00</u> psia	<u>42.00</u> psia

S-II start requirements (0 to 250 seconds) for maximum conditions and maximum flowrates are as follows:

	LH <sub>2</sub> Tank (psi)	LO <sub>2</sub> Tank (psi)
Nominal J-2 NPSH	4.00	12.50
Maximum Variations	3.15	7.90
NPSH* (NR-SD Design)	7.15	20.40
Vapor Pressure	16.20	15.50
Line and Bellows Pressure Drop	<u>4.62</u>	<u>6.50</u>
Subtotal	27.97	42.40
Fluid Head	-1.66	-8.75
Minimum Ullage Pressure - Supplied	<u>26.31</u>	<u>33.65</u>
Safety Margin	<u>2.19</u>	<u>2.35</u>
Minimum Ullage Pressure - Supplied at Start	<u>28.50</u> psia	<u>36.00</u> psia
Regulator Band	<u>1.50</u>	<u>1.50</u>
Ullage Pressure at Start Maximum	30.00 psia	37.50 psia
Dead Band	<u>7.00</u>	<u>2.50</u>
Vent Band	<u>2.00</u>	<u>2.00</u>
Tank Pressure Maximum	39.00 psia	42.00 psia

NOTE: S-II tank ullage pressures subject to change. Refer to applicable process specification for latest change.

\*Net Positive Suction Head  
(Needed to prevent cavitation at pump inlets)

## ENGINE COMPARTMENT CONDITIONING SYSTEM

The purpose of this system is to purge the engine and interstage areas of explosive mixtures and to maintain proper temperature in critical regions of the aft compartment of the second stage. The compartment is purged before tanking and while the propellants are loaded.

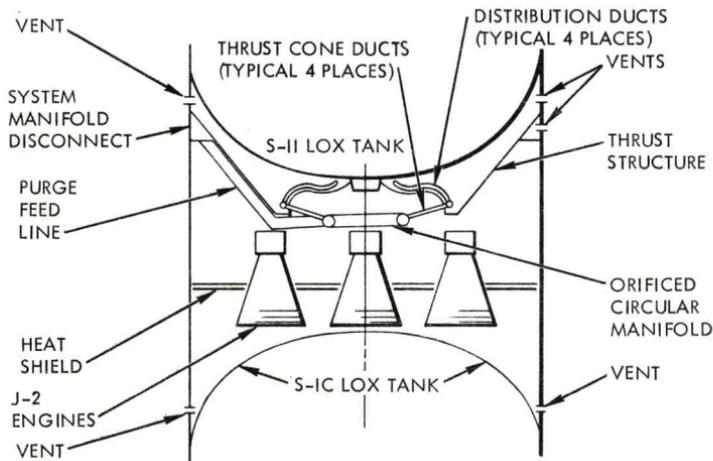
The system consists of a 13-inch-diameter feedline, manifold, ducts, and a series of vents surrounding the engine compartment and skirt area. The system provides temperature control for the hydraulic systems and certain components on the J-2 engines. The purge gas is forced through orifices in the manifold to the following areas requiring warming: the area between the thrust structure and the liquid oxygen tank; the bottom of the thrust structure, including the lower surface of the thrust cone; the aft skirt and interstage; and the top surface of the heat shield.

The vent holes are located under the supporting hat sections on the outside of the aft skirt; this prevents wind, rain, and dust from entering the engine compartment. The vents are located so that the flow pattern provides good thermal control and expels hazardous gases.

The aft skirt and interstage are purged with warm (80 to 250 degrees) nitrogen. The nitrogen is sent through the feedline into the manifold and then through ducts to the temperature-sensitive areas. By maintaining a 98-percent nitrogen atmosphere in the engine compartment, desired temperatures are maintained and the danger of fire or explosion resulting from propellant leaks is minimized.

MTF will use the S7-40 nitrogen purge and thermal control servicing unit to control nitrogen to the S-II stage system during static firing.

At KSC nitrogen will be supplied by Boeing facilities for the S-II stage system.

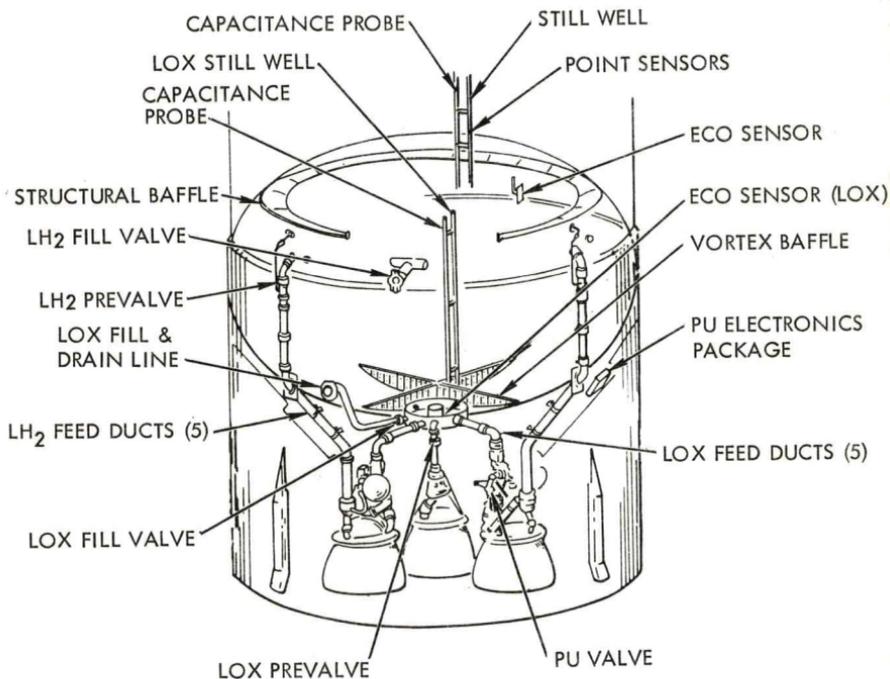


## PROPELLANT FEED SUBSYSTEM

The purpose of the propellant feed subsystem is to transfer the liquid propellants from their tanks to the five J-2 engines.

Each tank has five prevalves to control or stop the flow through separate feedlines to the engines. Solenoids control helium pressure to open and close the valves; if pressure or electrical power is lost, the valves will automatically stay open.

The feedlines (except the center engine liquid oxygen line) are 8 inches in diameter and vacuum-jacketed. Thermocouples (temperature measuring devices) in the vacuum jackets permit periodic vacuum checks; rupture discs in the jackets relieve excessive pressure. The feedlines also have bellows to allow for thermal expansion and freedom of movement.



PROPELLANT RECIRCULATION SYSTEM

LH<sub>2</sub> RECIRCULATION SYSTEM

The main purpose of the LH<sub>2</sub> recirculation subsystem is to keep the liquid propellants in the engine pumps. By keeping the propellants moving through lines, valves, and pumps the subsystem also keeps these parts chilled.

The subsystem pumps the propellants through the feedlines and valves and back to the LH<sub>2</sub> tank through a single return line. The pumps are powered from a 56-volt dc battery system located in the interstage. Before liftoff, power from the LH<sub>2</sub> recirculation subsystem is supplied by ground equipment.

LOX RECIRCULATION SYSTEM

The LOX recirculation system works on the basis of a thermal syphon; heat entering the system is used to provide pumping action by means of fluid density differences across the system. Helium gas is used to supplement the density differences, thereby improving the pumping action.

Recirculation of oxygen begins at the start of tanking; LH<sub>2</sub> recirculation begins just before launch. The propellants continue to circulate through first stage firing and up until just before the first stage and second stage separate.



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## RECIRCULATION SYSTEM

Actuation pressure for recirculation system valves and propellant feed prevalues is supplied by a stage-mounted helium receiver charged to 3000±250 psig prior to liftoff. A pressure regulator maintains a pressure level of 750 psig to two surge chambers. One surge chamber supplies 750 psig to the LOX prevalues and recirculation system valves and one surge chamber supplies 750 psig to the LH<sub>2</sub> prevalues and recirculation system valves.

Part Number	Nomenclature
P45	Recirculation system helium fill disconnect
P47	Recirculation system actuation regulator
P48	LOX recirculation system actuation surge chamber
P51	LOX return line solenoid valve
P53	LH <sub>2</sub> recirculation pump discharge and return line valves solenoid control valve
P55	LOX actuation system check valve
P56	LH <sub>2</sub> actuation system check valve
P65	LH <sub>2</sub> recirculation actuation system relief valve
P66	LOX recirculation actuation system relief valve
P67	LH <sub>2</sub> recirculation actuation system relief valve test connector
P68	LOX recirculation actuation system relief valve test connector
P69	LH <sub>2</sub> recirculation actuation system surge chamber
P72	Recirculation system emergency actuation connector
P76	Helium injection disconnect
P94	Recirculation system emergency actuation connector
P99	Recirculation system bleed valve
P102	Recirculation system helium receiver
P105	Recirculation system emergency actuation check valve
P200	Helium injection supply check valve
P201	Helium injection supply receiver
P202	Helium injection supply pressure regulator
P203	Helium injection supply relief valve
P204	Helium injection control valve 1

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Part Number	Nomenclature
P205	Helium injection control valve 2
P206A	Helium injection check valve (Engine 1)
P207A	Helium injection orifice plate (Engine 1)
P208	Helium injection orifice plate
E2A	LOX turbopump (Engine 1)
E3A	LOX main control valve (Engine 1)
E4A	LH <sub>2</sub> turbopump (Engine 1)
E5A	LH <sub>2</sub> main fuel control valve (Engine 1)
E6A	LOX gas generator bleed valve (Engine 1)
E7A	LH <sub>2</sub> gas generator bleed valve (Engine 1)
F3A	LOX prevalve (Engine 1)
F4A	LH <sub>2</sub> prevalve (Engine 1)
F5A	LOX return line valve (Engine 1)
F6A	LH <sub>2</sub> recirculation pump discharge valve (Engine 1)
F10	LH <sub>2</sub> return line valve
F11	LH <sub>2</sub> feed system purge valve
F16A	LOX prevalve solenoid valve (Engine 1)
F17A	LH <sub>2</sub> prevalve solenoid valve (Engine 1)
F18	LH <sub>2</sub> feed system purge disconnect
F19A	LH <sub>2</sub> recirculation pump (Engine 1)

PRESSURIZATION SYSTEM

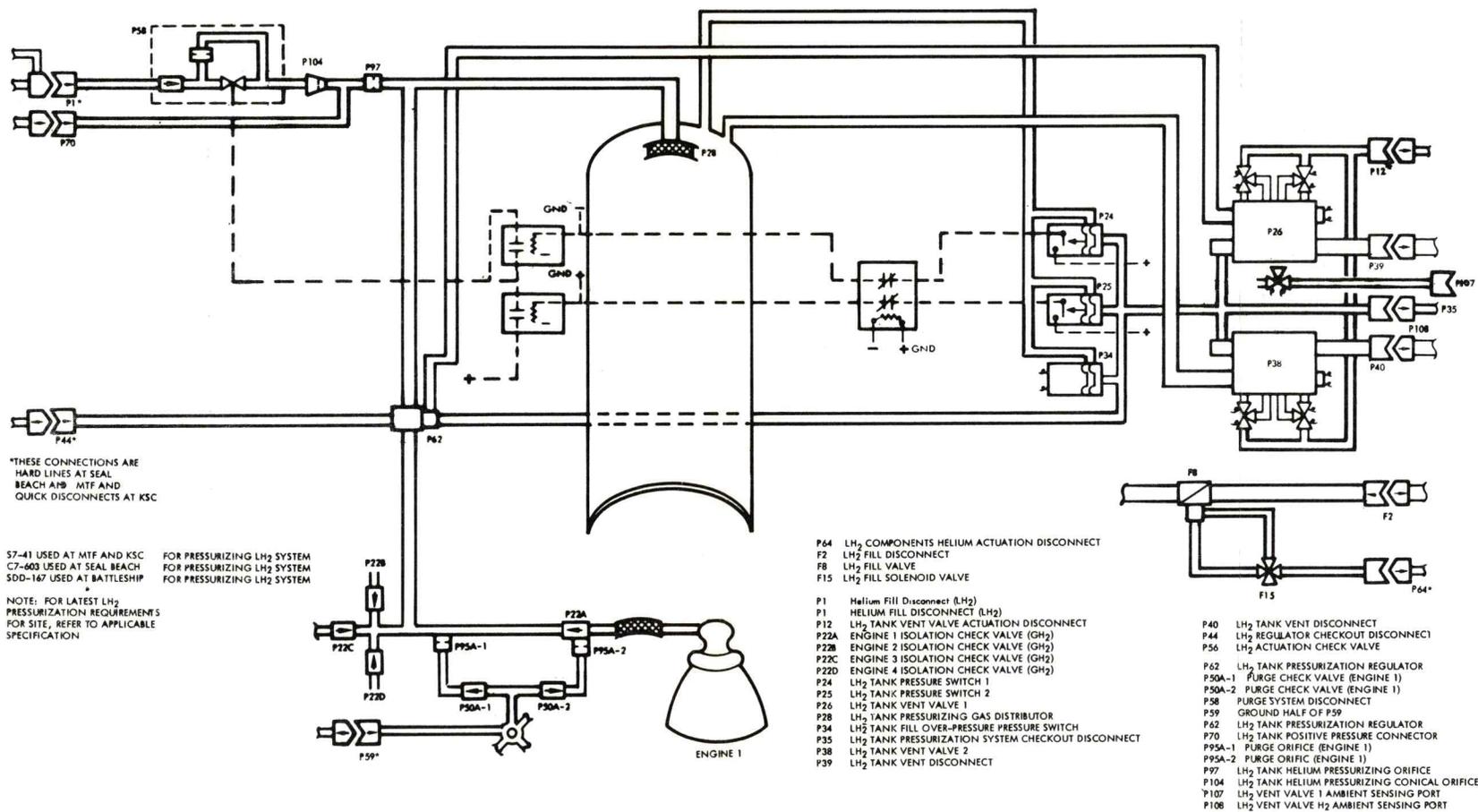
Pressurization of the propellant tanks is a three-stage process. Before launch, pressurization is obtained with gaseous helium from ground support equipment. After J-2 engine start, the pressurization is maintained with gaseous oxygen and gaseous hydrogen converted from the liquid oxygen and hydrogen. Step pressurization of 300 seconds is accomplished after J-2 engine start.

Before launch, both the liquid hydrogen (LH<sub>2</sub>) and liquid oxygen (LOX) tanks are pressurized with gaseous helium that flows directly into the stage pressurization lines from ground support equipment. Pressure switches that sense ullage pressure maintain the required pressurization level.

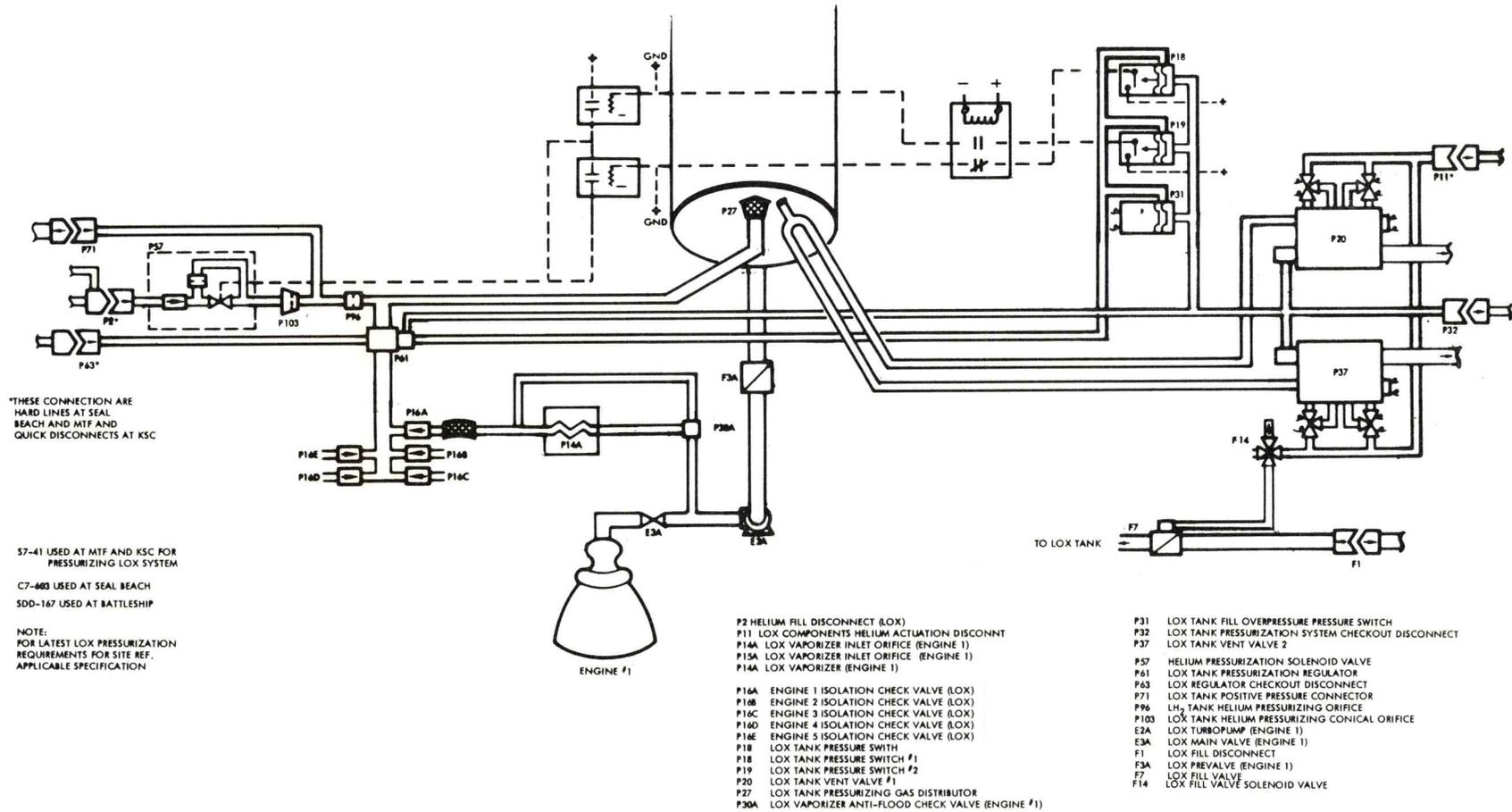
After liftoff, boiloff of the liquid propellants maintains adequate pressure until the stage's engines are ignited. A fitting on the fuel injector manifold of the engines permits gaseous hydrogen (converted from its liquid state) to flow through a common manifold, a pressurization line, and regulator back to pressurize the liquid hydrogen tank during J-2 engine firing. Some liquid oxygen is bled through a heat exchanger before reaching the LOX dome, converted to a gaseous state, and diverted to a pressurization line and a regulator where it flows back to pressurize the liquid oxygen tank. The flow of pressurant gas into the LH<sub>2</sub> tank is automatically stepped up after 300 seconds of a J-2 engine firing, and the greater flow of gas and the increase of pressure continue for the rest of the firing period.

NOTE: For ullage pressure switch settings and ullage pressures, see the latest process specification for the site and vehicle configuration. Because of various engineering changes, these pressures will change.

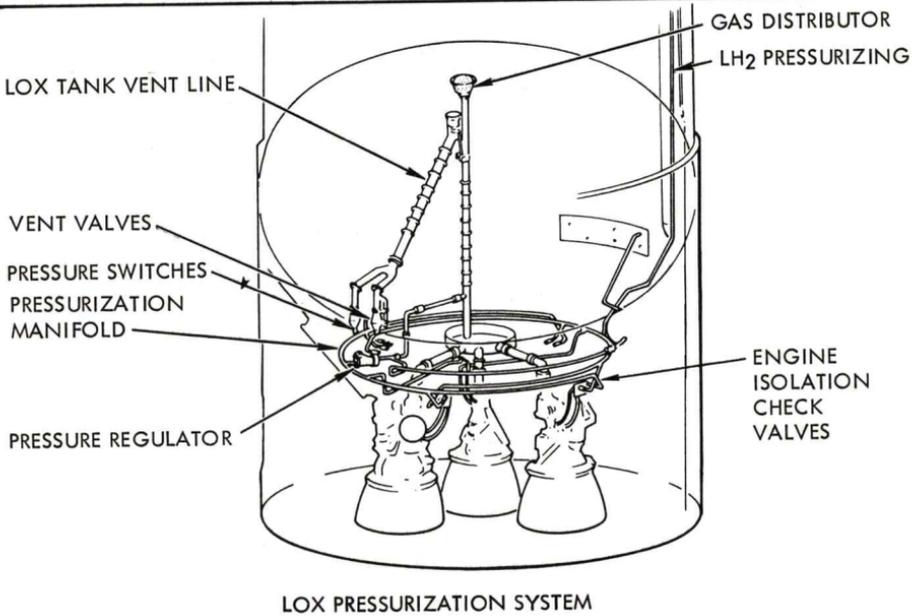
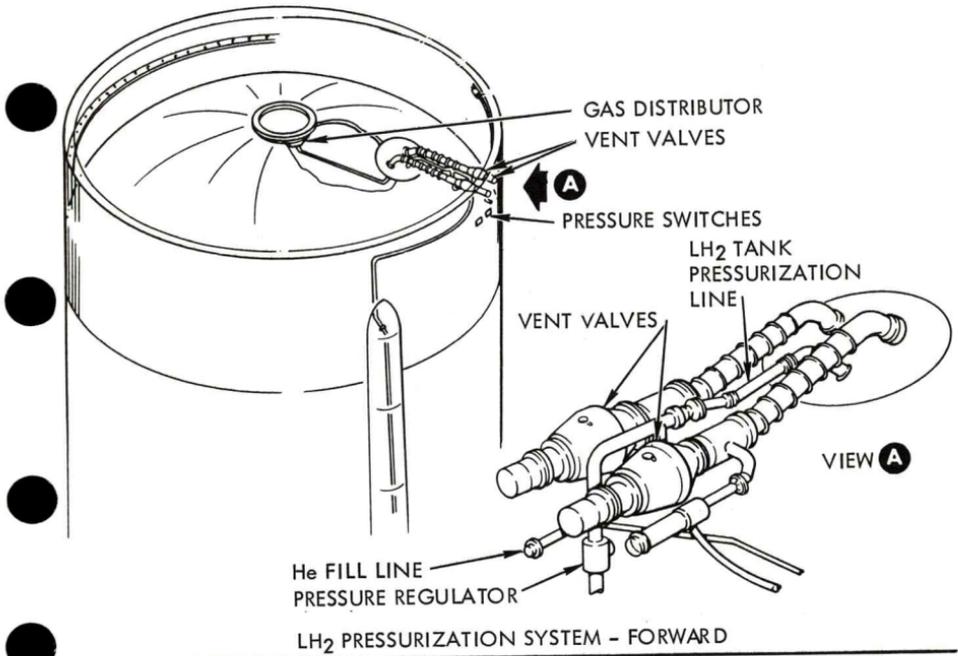
LH<sub>2</sub> PRESSURIZATION SYSTEM



LOX PRESSURIZATION SYSTEM



PRESSURIZATION SYSTEM



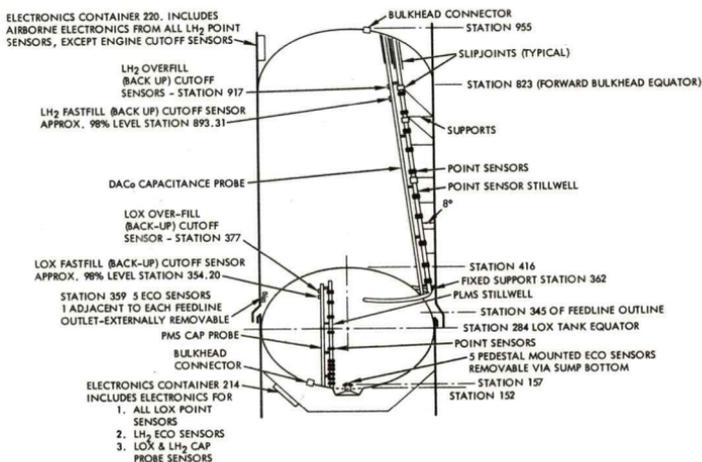
## PROPELLANT MANAGEMENT SYSTEM

The propellant management (PM) system consists of the propellant loading, propellant mass indication, propellant utilization, engine cutoff, and propellant level monitoring configurations.

The functions of the PM system are performed by hot wire point sensors, continuous capacitance sensors, propellant utilization (PU) valves, and associated electronic control equipment. The PU, propellant loading (PL) and propellant mass indication (PMI) subsystems use capacitance sensing equipment; the engine cutoff (ECO), propellant level monitoring (PLM), and PL backup fast fill and overflow cutoff use discrete liquid-level point sensors. The capacitance sensors are continuous cylindrical, coaxial capacitors located in each propellant tank with associated electronics in electrical Container 214. This subsystem senses the propellant mass in each tank, transmits mass indication signals for PL and PMI, analyzes the rate of propellant consumption for PU, and subsequently controls each engine propellant utilization valve. In this manner, the rate of propellant consumption is properly controlled.

Point sensors are installed on the stillwell for level monitoring. They are open-mounted in the tanks near each feedline outlet for ECO, and are similarly mounted near the top of the tanks for fast-fill and overflow cutoff. Each point sensor senses the passing of liquid by monitoring the change of resistance in a platinum wire element. Associated electronics are located in Container 214 (thrust structure) for ECO and all LOX sensors.

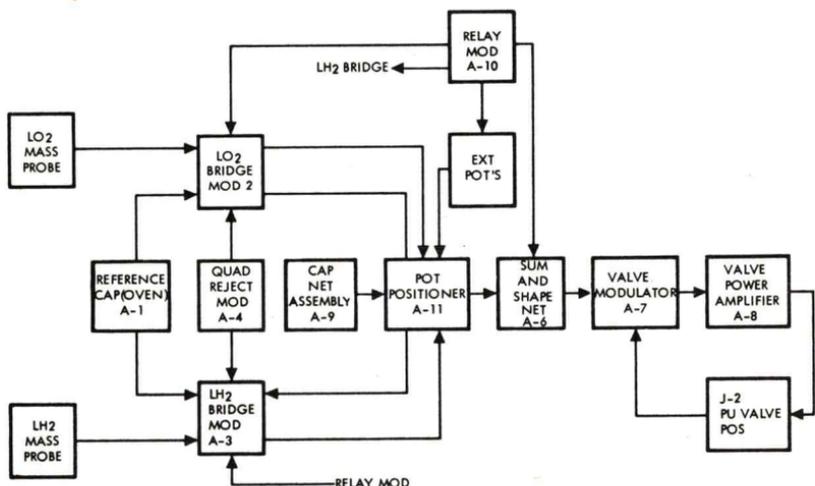
All remaining LH<sub>2</sub> sensor electronics are located in Container 220 (forward skirt). Level signals are then transmitted by hardwire to the GSE and via a multiplexing resistance network to the telemeter. The ECO subsystem has a voting network that provides the engine cutoff signal whenever two sensors in either tank indicate that the tank is dry. The PLM is also used for calibrating the capacitance probe in the propellant tanks.



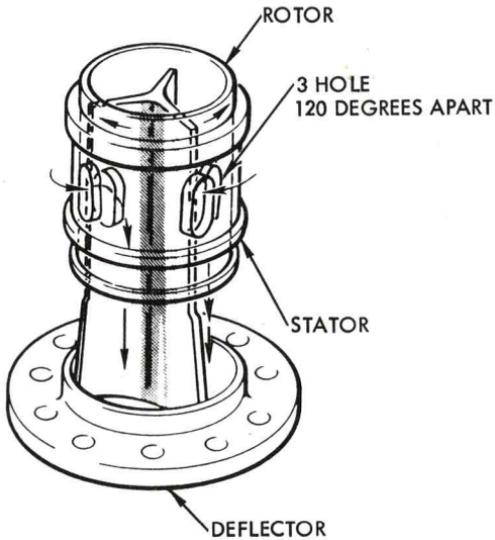
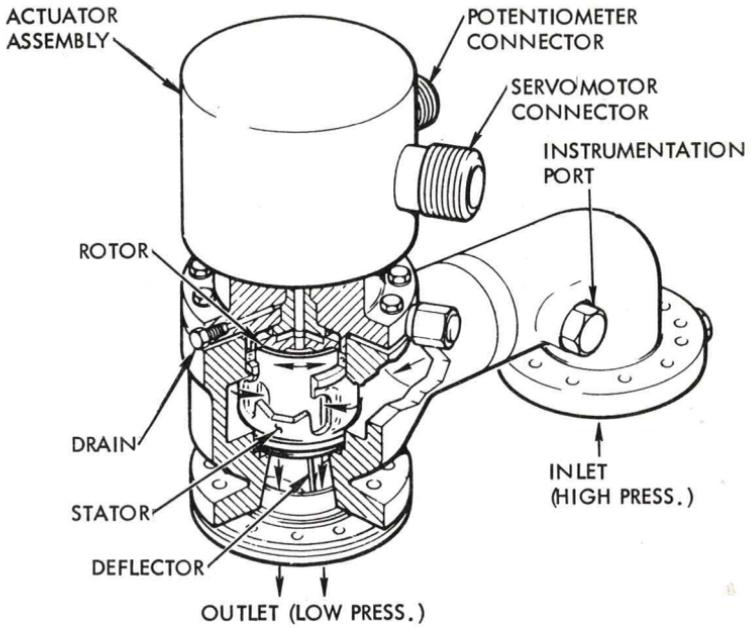
## PROPELLANT UTILIZATION VALVE

The propellant utilization (PU) valve is an electrically operated, two-phase, motor-driven oxidizer transfer valve located at the oxidizer turbo-pump outlet volute. The propellant utilization valve ensures the simultaneous exhaustion of the contents of the propellant tanks. During engine operation, propellant level sensing devices in the vehicle propellant tanks control the valve gate position. This adjusts the oxidizer flow and ensures simultaneous exhaustion of fuel and oxidizer.

The PU valve also provides thrust variations to maximize payload. The second stage, for example, operates with the PU valve in the closed position for more than 70 percent of the firing duration. This valve position provides 225,000 pounds of thrust at a 5.5:1 propellant (oxidizer to fuel by weight) mixture ratio. During the latter portion of the flight, the PU valve position is varied to provide simultaneous emptying of the propellant tanks.



PROPELLANT UTILIZATION VALVE



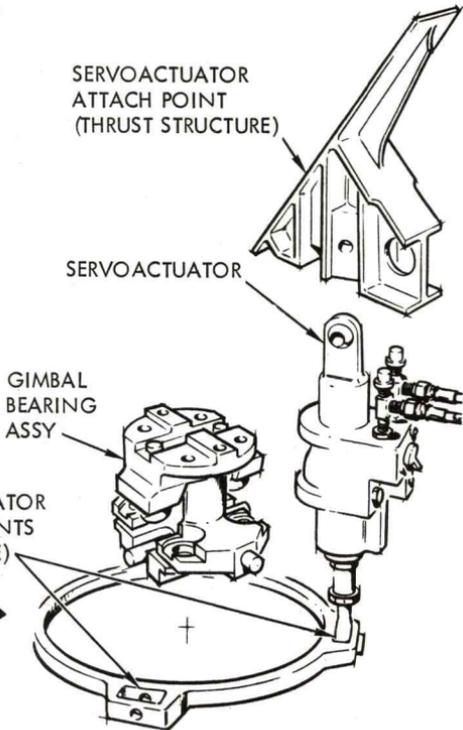
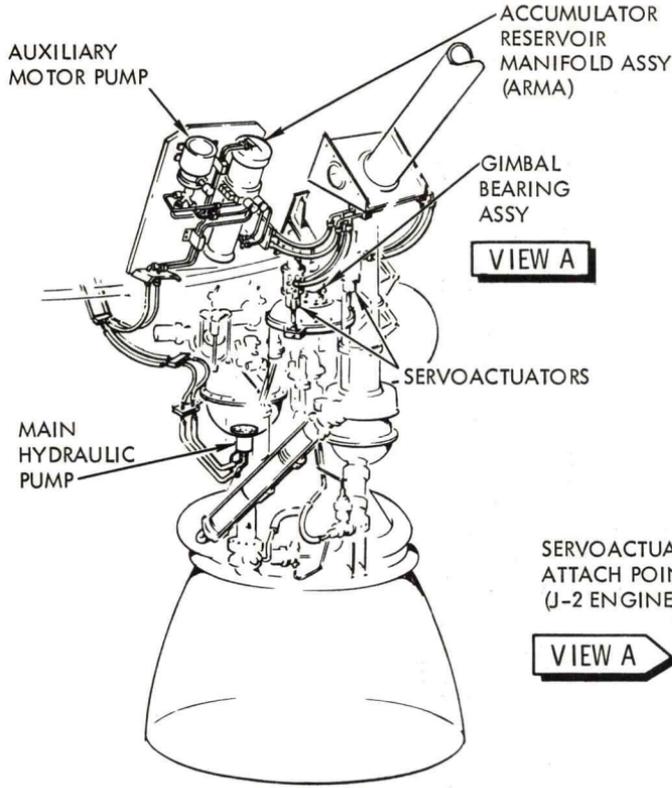
## FLIGHT CONTROL SYSTEM

Flight control of the second stage is maintained by gimbaling of the rocket thrust engines for thrust vector (direction) control. These engines are the four outboard engines. The fifth J-2 engine, located in the center of the cluster, is stationary.

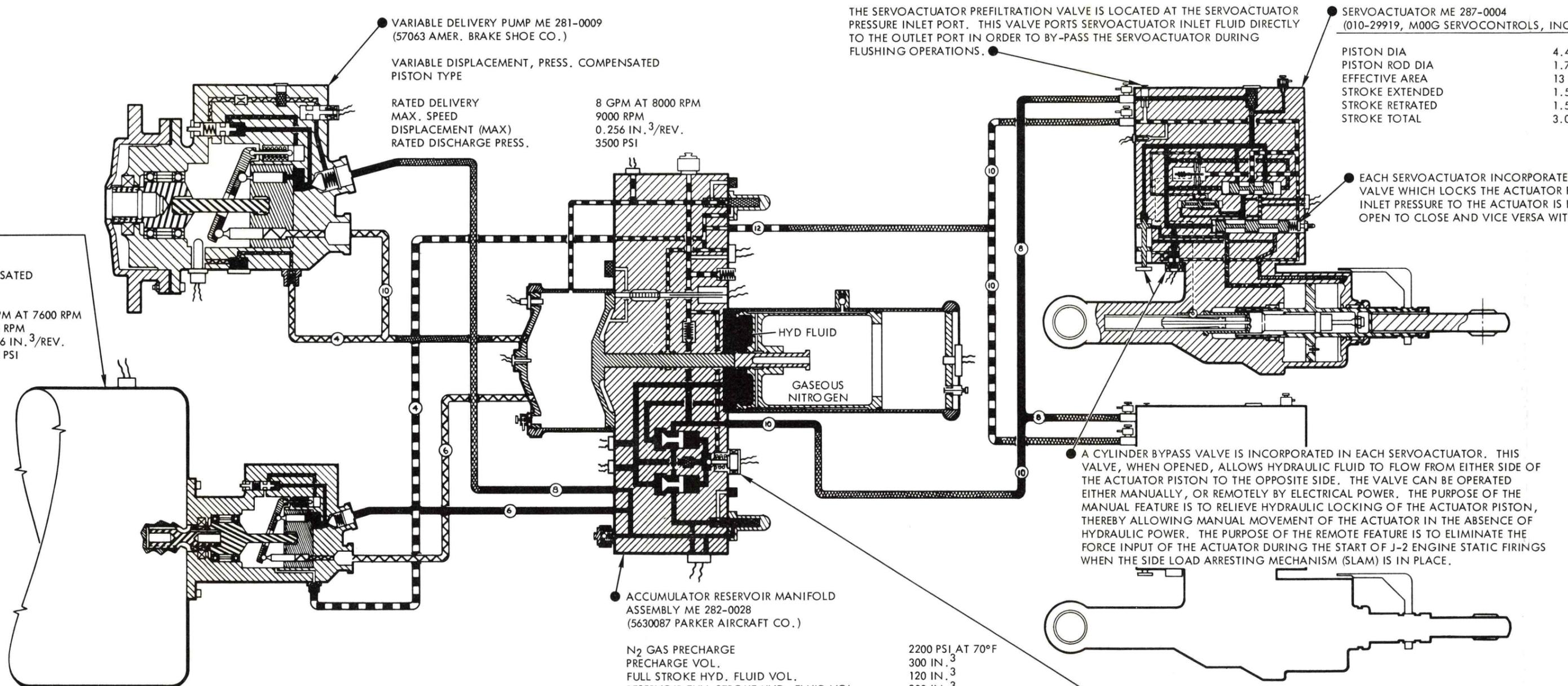
Each outboard engine has a separate engine actuation system that provides the force to position the engine. Gimbaling is achieved by hydraulic-powered actuators controlled by electrical signals generated through a flight control computer located in the instrument unit just above the S-IVB stage. Hydraulic power for operating each of the gimbaling actuators is supplied by individual engine-driven hydraulic pumps. Each system is self-contained, and operates under a pressure of 3500 psi. The components of each hydraulic system are attached to the thrust structure above each of the outboard engines. The main hydraulic pump is driven by the liquid oxygen turbopump on the respective engine. Two servoactuators that control each engine programmed for gimbaling are located on the engine outboard side. One servoactuator is on the pitch plane, and the other servoactuator is on the yaw plane. Each actuator will gimbal the engine plus or minus 7 degrees in pitch or yaw and plus or minus 10 degrees in combination to correct for roll errors at a minimum rate of 8 degrees per second.

During flight, the guidance system continuously determines an optimum vehicle steering command based on the vehicle's position, velocity, and acceleration. This system, located in the instrument unit, has a guidance signal processor that delivers attitude correction signals to the flight control computer in the instrument unit. These signals are shaped, scaled, and summed electronically. These summed error signals are then directed to the servoactuator amplifiers, which, in turn, drive their respective servoactuators in the second stage. These signals cause the servoactuators to position the engines.

ENGINE ACTUATION SYSTEM



HYDRAULIC SYSTEM SCHEMATIC



VARIABLE DELIVERY PUMP ME 281-0009  
(57063 AMER. BRAKE SHOE CO.)

VARIABLE DISPLACEMENT, PRESS. COMPENSATED PISTON TYPE

RATED DELIVERY 8 GPM AT 8000 RPM  
MAX. SPEED 9000 RPM  
DISPLACEMENT (MAX) 0.256 IN.<sup>3</sup>/REV.  
RATED DISCHARGE PRESS. 3500 PSI

AUXILIARY, VARIABLE DELIVERY, MOTOR PUMP ME 281-0010  
(57064 AMER BRAKE SHOE CO.)

VARIABLE DISPLACEMENT, PRESS. COMPENSATED PISTON TYPE

RATED DELIVERY 2 GPM AT 7600 RPM  
MAX SPEED 8000 RPM  
DISPLACEMENT (MAX.) 0.066 IN.<sup>3</sup>/REV.  
RATED DISCHARGE PRESS. 3650 PSI

THE AUXILIARY PUMP IS USED ONLY DURING CHECKOUT AND TO MAINTAIN A WARM FLUID DURING PROPELLANT LOADING JUST PRIOR TO LAUNCH. THE AUXILIARY PUMP CANNOT OPERATE IN FLIGHT.

ACCUMULATOR RESERVOIR MANIFOLD ASSEMBLY ME 282-0028  
(5630087 PARKER AIRCRAFT CO.)

N<sub>2</sub> GAS PRECHARGE 2200 PSI AT 70°F  
PRECHARGE VOL. 300 IN.<sup>3</sup>  
FULL STROKE HYD. FLUID VOL. 120 IN.<sup>3</sup>  
RESERVOIR FULL STROKE HYD. FLUID VOL. 200 IN.<sup>3</sup>  
RESERVOIR OPERATING PRESS. 90 PSI

RELIEF VALVES:	HIGH PRESS.	LOW PRESS.
CRACKING PRESS.	3850 PSI, MIN.	200 PSI, MIN.
RESEAT PRESS.	3700 PSI, MIN.	175 PSI, MIN.
RATED FLOW	8 GPM AT 4450 PSID	8 GPM AT 225 PSID

THE SERVOACTUATOR PREFILTRATION VALVE IS LOCATED AT THE SERVOACTUATOR PRESSURE INLET PORT. THIS VALVE PORTS SERVOACTUATOR INLET FLUID DIRECTLY TO THE OUTLET PORT IN ORDER TO BY-PASS THE SERVOACTUATOR DURING FLUSHING OPERATIONS.

SERVOACTUATOR ME 287-0004  
(010-29919, MOOG SERVOCONTROLS, INC.)

PISTON DIA 4.442 IN.  
PISTON ROD DIA 1.749 IN.  
EFFECTIVE AREA 13 IN.<sup>2</sup>  
STROKE EXTENDED 1.51 IN.  
STROKE RETRATED 1.51 IN.  
STROKE TOTAL 3.02 IN.

EACH SERVOACTUATOR INCORPORATES A PRESSURE ACTUATED HYDRAULIC LOCK VALVE WHICH LOCKS THE ACTUATOR PISTON, HENCE THE ENGINE, IN THE EVENT INLET PRESSURE TO THE ACTUATOR IS LOST. THE LOCK VALVE ACTUATES FROM OPEN TO CLOSE AND VICE VERSA WITHIN A PRESSURE BAND OF 1300 TO 1700 PSI.

A CYLINDER BYPASS VALVE IS INCORPORATED IN EACH SERVOACTUATOR. THIS VALVE, WHEN OPENED, ALLOWS HYDRAULIC FLUID TO FLOW FROM EITHER SIDE OF THE ACTUATOR PISTON TO THE OPPOSITE SIDE. THE VALVE CAN BE OPERATED EITHER MANUALLY, OR REMOTELY BY ELECTRICAL POWER. THE PURPOSE OF THE MANUAL FEATURE IS TO RELIEVE HYDRAULIC LOCKING OF THE ACTUATOR PISTON, THEREBY ALLOWING MANUAL MOVEMENT OF THE ACTUATOR IN THE ABSENCE OF HYDRAULIC POWER. THE PURPOSE OF THE REMOTE FEATURE IS TO ELIMINATE THE FORCE INPUT OF THE ACTUATOR DURING THE START OF J-2 ENGINE STATIC FIRINGS WHEN THE SIDE LOAD ARRESTING MECHANISM (SLAM) IS IN PLACE.

THE LOCK-UP VALVES CONSIST OF TWO NORMALLY OPEN VALVES ACTUATED BY A SOLENOID. THE VALVES CLOSE THE ACCUMULATOR INLET AND OUTLET PORTS, THUS STORING HIGH PRESSURE FLUID IN THE ACCUMULATOR. THE FLUID IS AVAILABLE TO GIMBAL THE ENGINE AT S-IC/S-II STAGE SEPARATION PRIOR TO FULL MAIN PUMP OPERATION.

SYSTEM DATA

FLUID	MIL-H-5606A
SUPPLY PRESSURE	3500 PSI
RETURN PRESSURE	100 PSI
ESTIMATED FLUID CAPACITY	510 IN. <sup>3</sup>
ESTIMATED NORMAL SYSTEM TEMP	40 - 275°F
ESTIMATED MAXIMUM SYSTEM TEMP	275°F

LINE DATA

TUBE MATERIAL 304 CRES PER MIL-T-6845

CODE	TUBE O.D.	WALL THICKNESS
12	3/4	0.035
10	5/8	0.058
8	1/2	0.049
6	3/8	0.049
4	1/4	0.020

SUPPLY, PRESSURE	
RETURN	
SUPPLY, PUMP	
EXTEND	
RETRACT	
VENT OR DRAIN	
CONTROLLED PRESS.	
FLEXIBLE HOSE	

V. VALVES

V. VALVES

## S-II STAGE VALVES

The pictorial and descriptive information is intended to provide a ready reference to the general functional characteristics of each component. Maintenance of S-II stage valves is limited to removal and replacement with exception of normal checkout procedures specified within applicable specifications.

Components used in liquid oxygen or liquid hydrogen systems, either directly or indirectly, will require special handling to prevent possible contamination of the system.

## WARNING

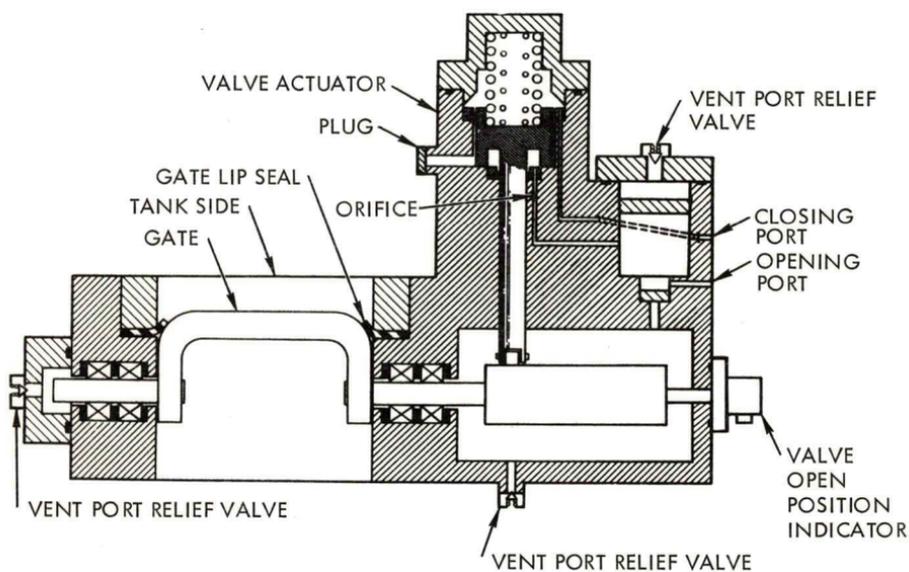
When removing or replacing a valve or system component, do not touch the surface with bare hands, because a contaminating residue from oil on the hands may be left on parts. The use of contaminated parts in a liquid oxygen, or indirect liquid oxygen, or liquid hydrogen system can cause an explosion that would result in serious injury to personnel and damage to the vehicle. Wear clean, low-lint gloves (Nylon 66) when handling parts.

## CAUTIONS

1. Never attempt to loosen or tighten any fitting or begin removing any valve or system component while it is pressurized.
2. Sound a warning and evacuate personnel from the area near vent openings before venting pressure from the system. Remove all loose materials from the vent areas prior to venting the system.
3. Do not use contaminated covers, closures, plates, metal plugs, or caps on parts cleaned for liquid oxygen or hydrogen service. The use of contaminated items can cause an explosion that would result in serious injury to personnel and damage to the vehicle.
4. Use caution when handling valves to prevent nicking and scratching of sealing flange areas.

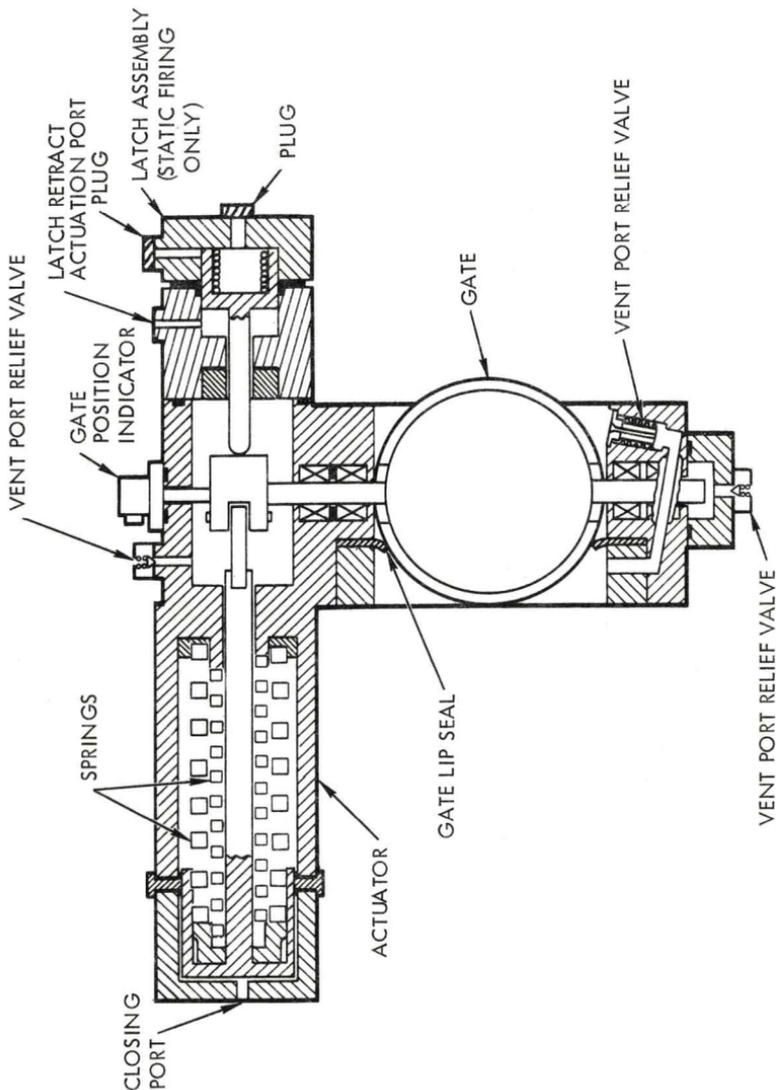
## V7-480450 FILL AND DRAIN VALVE

These valves are normally closed, pneumatically actuated, double-action butterfly-type valves. The valve is used on both the LOX and LH<sub>2</sub> fill and drain system. The fill valve acts as a main shut-off for tanking and detanking operations. Capacity flow for LH<sub>2</sub> is 10,000 gpm and LOX flow is 5000 gpm during normal tanking.



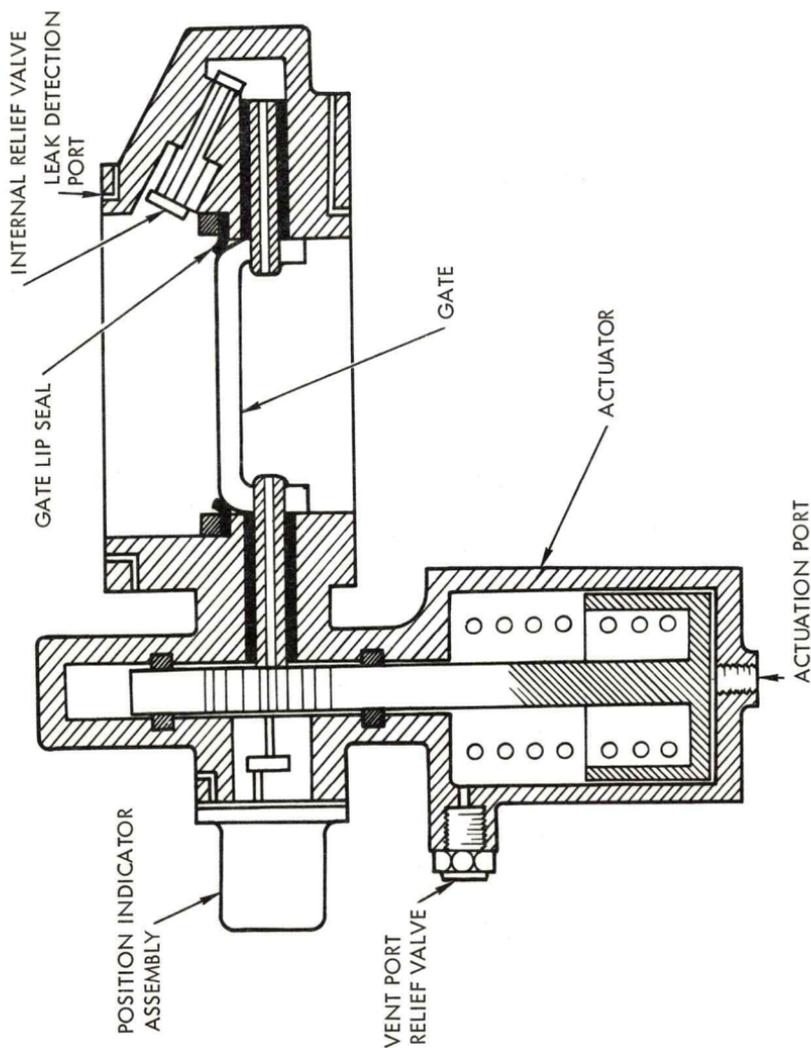
V7-480500 AND V7-480700 LOX AND LH<sub>2</sub> PREVALVES

The prevalue is a double-acting, pneumatically actuated, normally open, butterfly-type valve incorporating a position indicator and a relief valve. The prevalue is used as an emergency shutoff valve during static firing. The LH<sub>2</sub> prevalue will be closed prior to J-2 engine firing to prevent LH<sub>2</sub> feedback during chardown. The built-in relief valve prevents over-pressurization of the engine feed ducts in the event all system valves are closed and the ducts are filled with propellants.



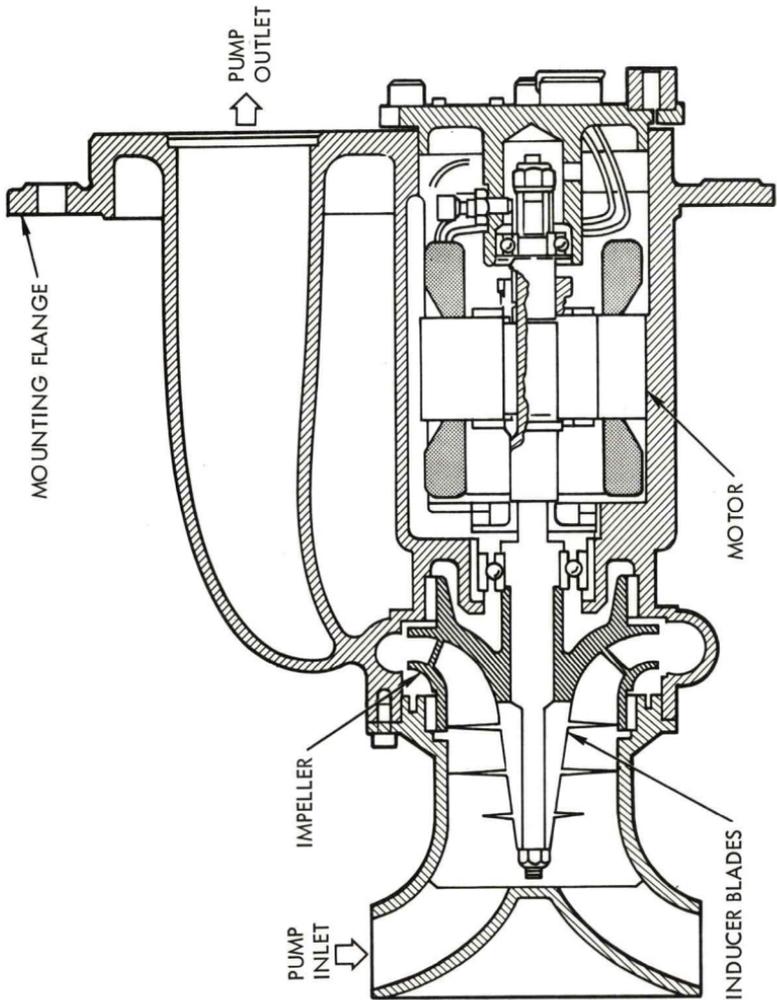
## V7-480328 VALVE, RECIRCULATION

The S-II stage uses 11 V7-480328 valves. Five are used as LH<sub>2</sub> recirculation pump discharge valves; one is a LH<sub>2</sub> recirculation return line valve; five are LOX recirculation return line valves. These valves are normally open, single-action, pneumatically actuated, butterfly-type valves. A built-in relief valve prevents buildup of pressure within the recirculation lines whenever fluid is trapped between closed valves.



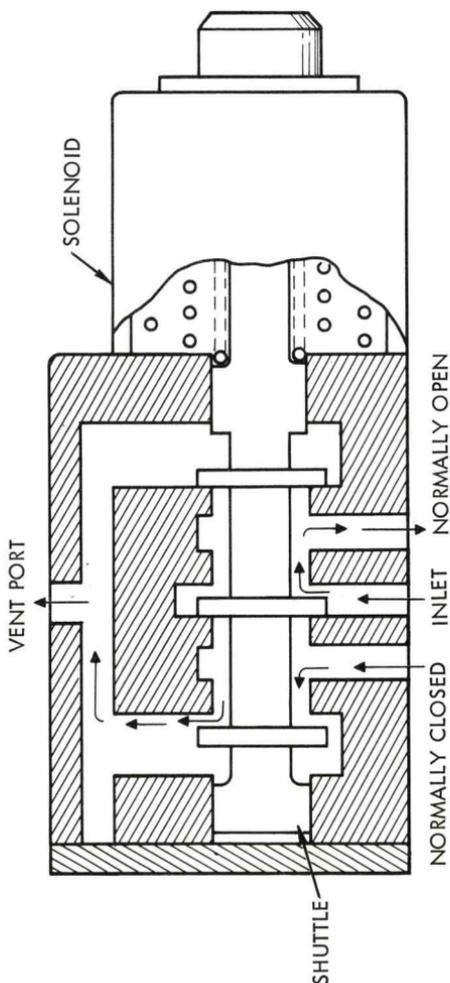
ME281-0015 LH<sub>2</sub> RECIRCULATION PUMP

The LH<sub>2</sub> centrifugal pump with LH<sub>2</sub>-cooled bearings is driven by an integrally sealed electric motor. The entire pump and motor is submerged in the LH<sub>2</sub> tank. A tachometer generator provides an output signal for pump speed. Five pumps (one per LH<sub>2</sub> feed duct) provide a flow of LH<sub>2</sub> propellant for chilldown of the engine feed system prior to J-2 engine start.



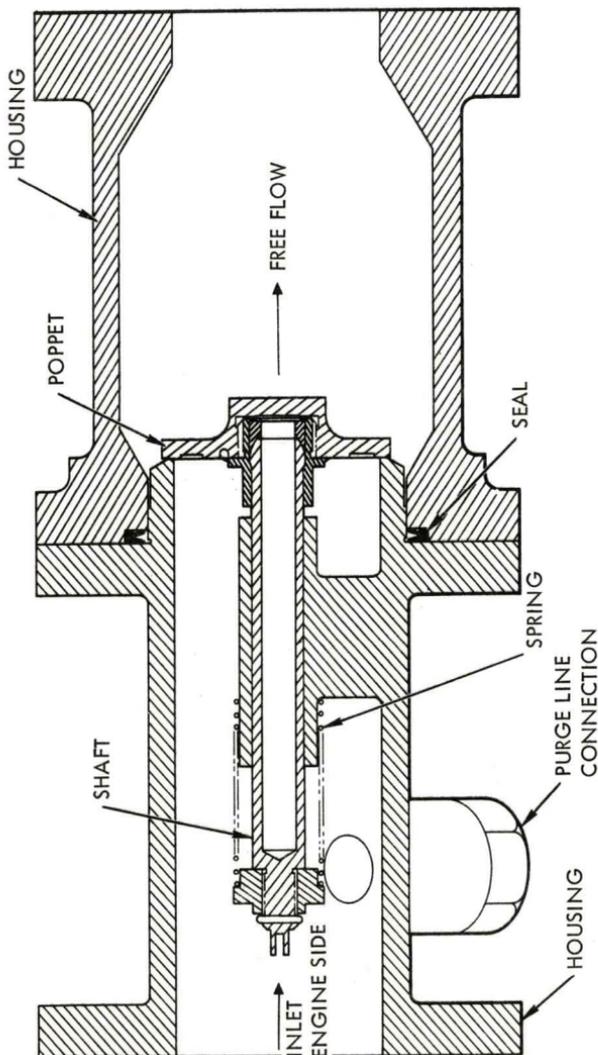
## V7-480521 FOUR-WAY SOLENOID VALVE

This four-way solenoid-actuated valve consists of a solenoid and a four-ported valve body. Deenergized, the inlet port is open to one of the actuation ports (a normally open port), and the other port (a normally closed port) is open to the vent port. Energized, the valve shuttle is shifted to a position that opens the normally closed port to inlet pressure and the normally open port to the vent port. This valve is used to control the S-II stage fill and drain valves.



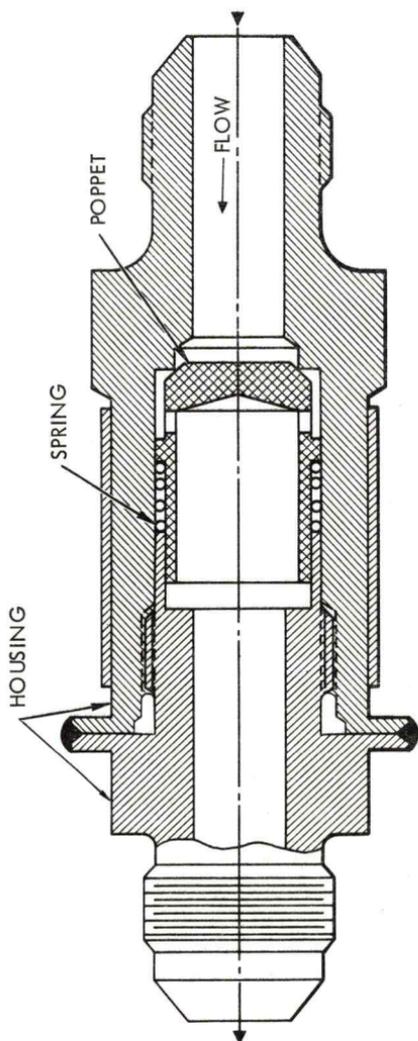
## V7-490935 ENGINE ISOLATION CHECK VALVE

A spring-controlled check valve is used in the LOX and LH<sub>2</sub> pressurization system. The valves are located between the engine connect panel and the pressurization regulator. One valve is used for each of the five engines that provide LOX tank pressurization; one valve is at each of the four outboard engines that provide the LH<sub>2</sub> tank pressurization. These valves prevent loss of pressurizing gas in the event of a flex line failure or a premature engine shutdown.



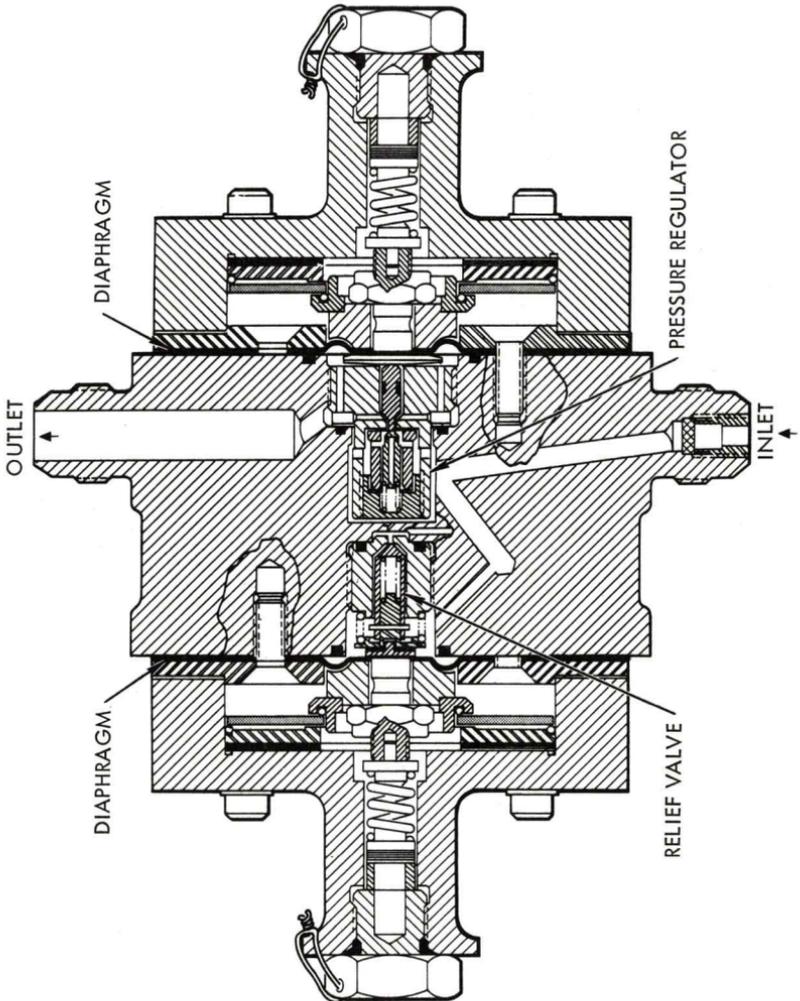
## ME284-0074 CHECK VALVE

The check valve consists of a housing and spring-loaded poppet that permits flow in one direction only. A total of 10 of these valves are used per S-II stage. Eight of these check valves are used in the purge system to prevent the loss of  $\text{GH}_2$  by bypassing the engine isolation check valves in the event of a premature engine shutdown or a break in the purge line upstream of the engine isolation check valve. Two of the ME284-0074 check valves are also used to prevent loss of helium from the recirculation actuation system surge receivers in the event of a break in the actuation pressure line upstream of the check valve.



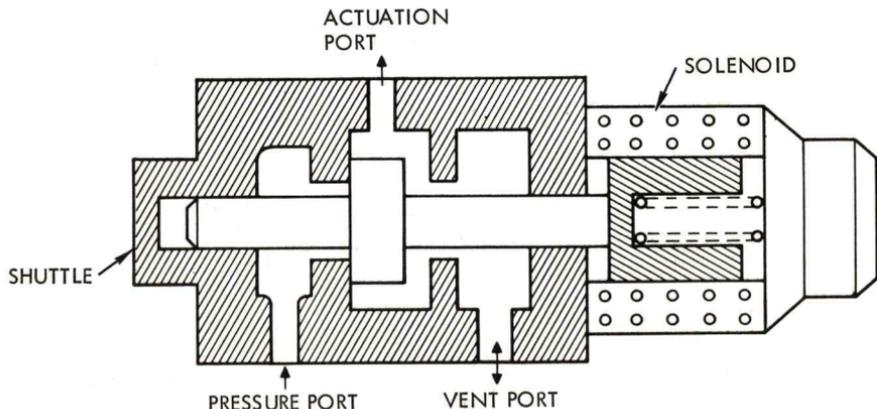
ME284-0158 PRESSURE REGULATOR

This regulator controls the helium gas pressure used for the recirculation system for valve actuation and the helium injection system.

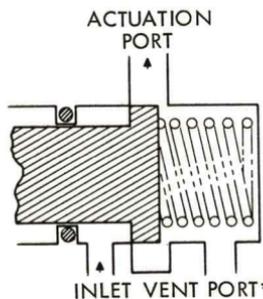


ME284-0159 THREE-WAY SOLENOID VALVE

The solenoid valve is a three-way, normally closed, two-position continuous-duty unit with hermetically sealed electrical components. The valve is so designed that, in the deenergized position, the pressure port is closed and the actuation port is open to the vent port. Five valves are used on the S-II stage; two for helium injection system, one to actuate the LOX recirculation return line valves, one to actuate the LH<sub>2</sub> recirculation valves, and one for helium receiver supply depletion.



0001

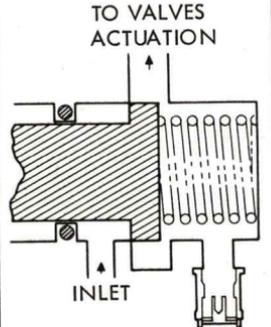


\*VENT PORT CAPPED FOR HELIUM INJECTION

VENT PORT CONNECTED TO GSE HELIUM SUPPLY FOR EMERGENCY ACTUATION OF LH<sub>2</sub> RECIRCULATION VALVES

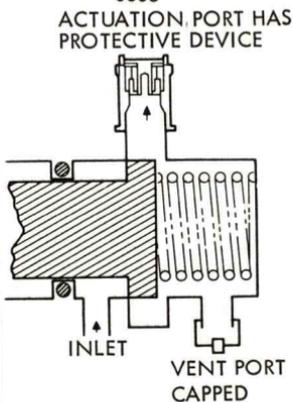
FUNCTIONAL SCHEMATIC

0002



LH<sub>2</sub> & LOX RECIRCULATION RETURN VALVE ACTUATION

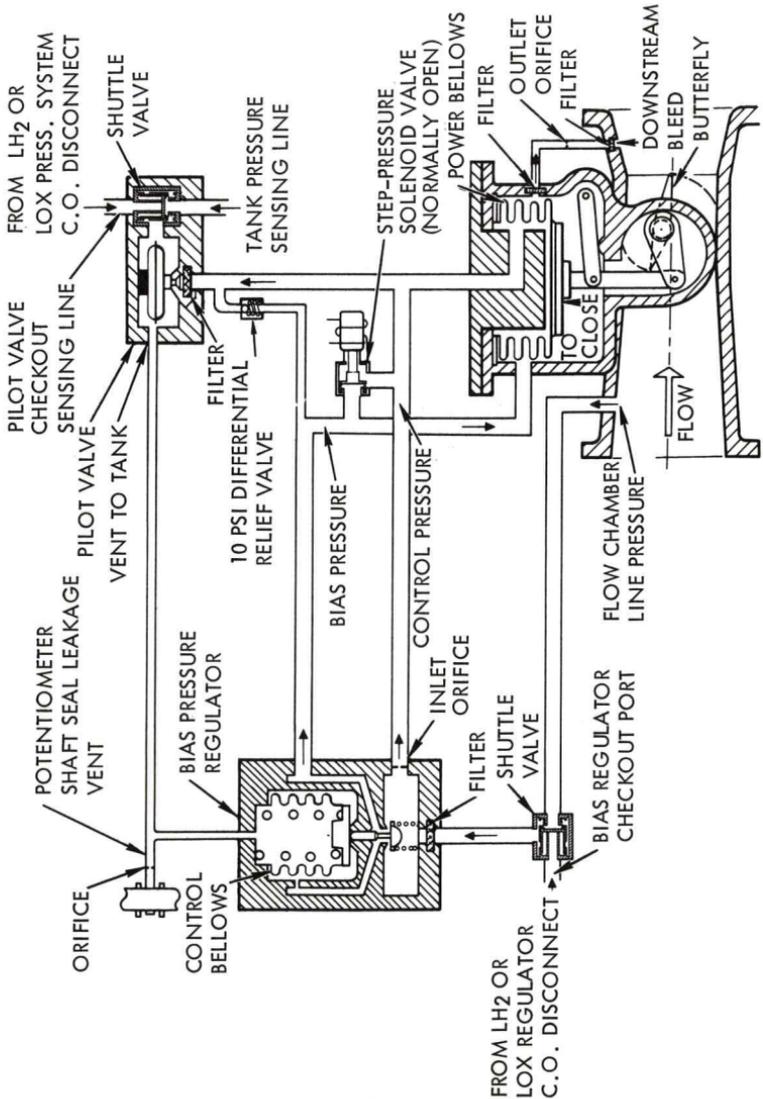
0003



HIGH PRESSURE HELIUM DEPLETION

ME284-0161 LOX AND LH<sub>2</sub> TANK PRESSURIZATION REGULATOR

The pressurization regulator is a normally open valve that regulates the flow of pressurizing gas from the J-2 engines to maintain ullage pressure in the propellant tanks during S-II boost. The regulator consists of a pilot valve assembly, a bias control regulator assembly, a power bellows assembly, and a normally open (deenergized) solenoid valve. When the solenoid is energized, the valve is in the regulating mode. When the solenoid is deenergized, the regulator is in the step-pressurization mode, allowing unregulated pressure from the J-2 engines to enter the propellant tanks. With different pressure settings for LOX and LH<sub>2</sub>, the same basic regulator is used for LOX and LH<sub>2</sub> systems.



VENT VALVE OPERATION

Each vent valve has two electric solenoids that control helium pressure for closing and opening of the vent valves during ground operation only. One solenoid is normally open, and one solenoid is normally closed. The normally open solenoid controls the closing of the vent valve. The normally closed solenoid controls the override closing of the vent valve.

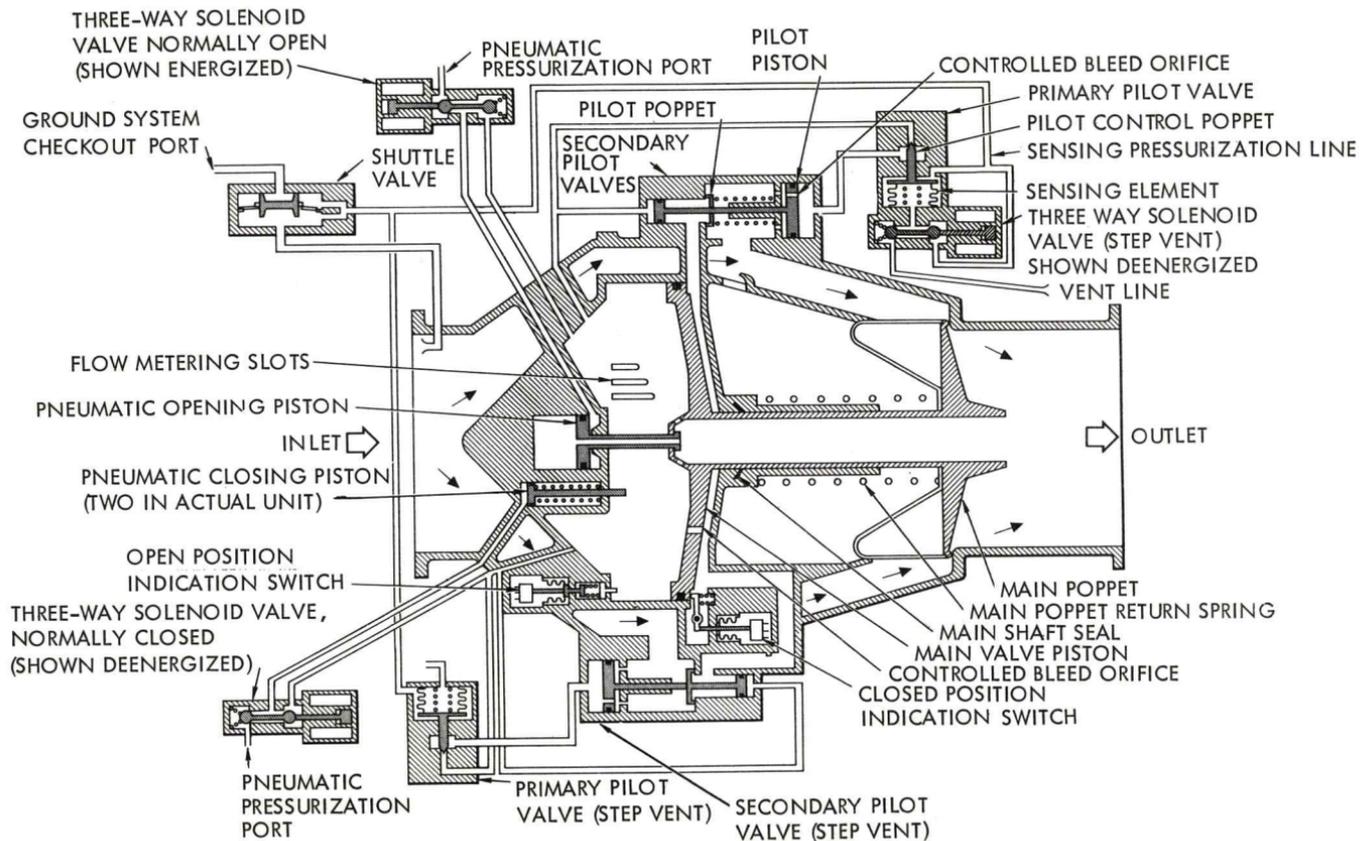
At liftoff, the LH<sub>2</sub> vent valves are controlled by the low-pressure vent step pilot valve (solenoid). At S-IC engine cutoff, the high-pressure primary pilot valve is in control. Any time during the launch, if the tank pressure exceeds the value setting of the low-pressure step vent pilot valve or the high pressure pilot valve, the vent valves will open and relieve the excessive pressure from the LH<sub>2</sub> tank.

The LOX vent valves are essentially the same as the LH<sub>2</sub> vent valves, with the exception of the step vent solenoid. Ground control of both LOX and LH<sub>2</sub> vent valves requires 750-psi helium pressure and 28-vdc electrical power. With 750-psi helium pressure at the vent valve open control solenoid and a loss of electrical power at the open control solenoid, the vent valve will open.

WARNING

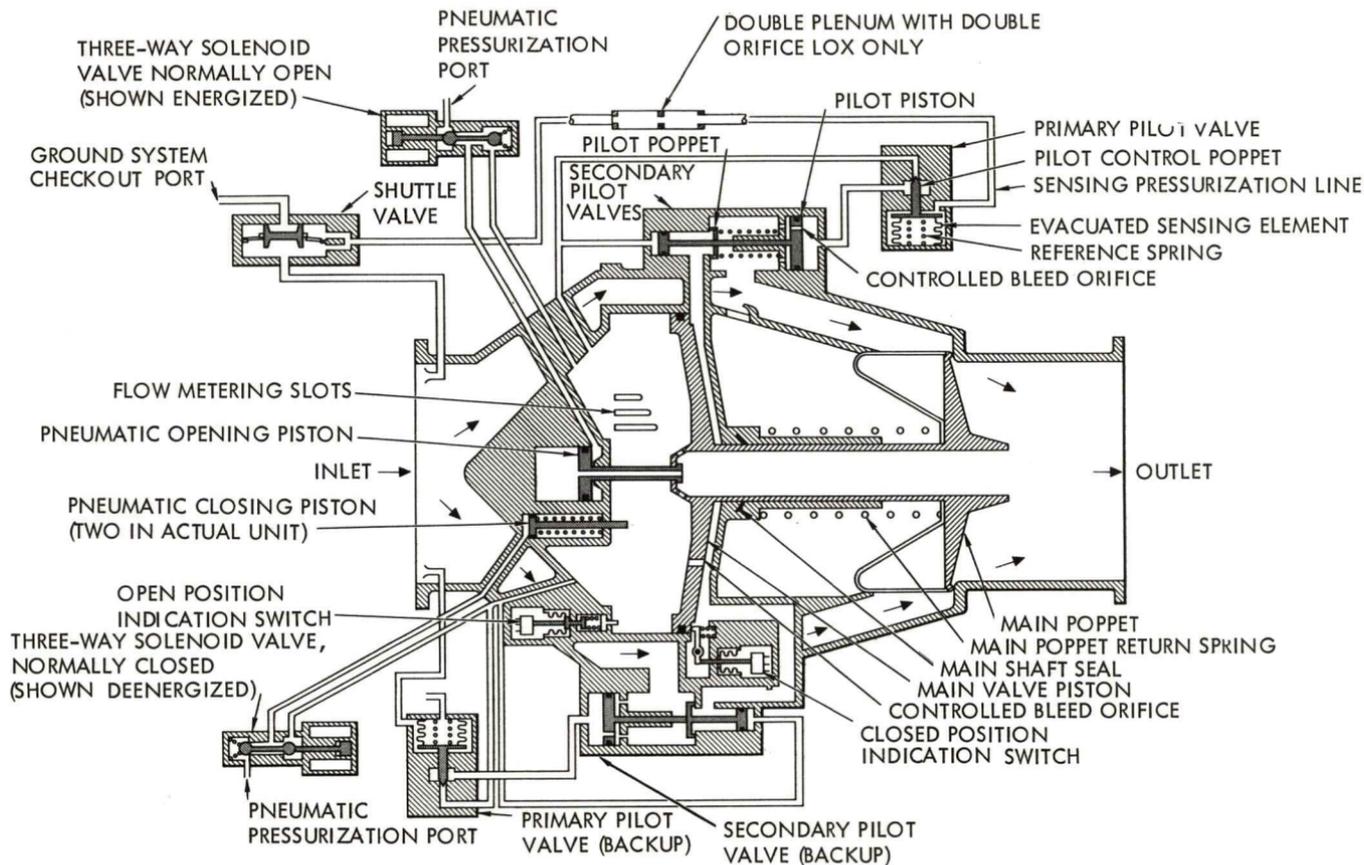
Personnel working near the vent valve exhaust area could be injured during ground checkout should a loss of electrical power occur with 750-psi helium pressure at the open solenoid valve.

# LH<sub>2</sub> VENT AND RELIEF VALVE



V-13

LOX VENT AND RELIEF VALVE



V-14

VI. PLUMBING

FLUID LINE FITTINGS

Flexible and rigid fluid line fittings recommended for general design use at Space Division of North American Rockwell Corp. on the S-II Saturn, and GSE will be specified on engineering drawings. When reordering replacement items, refer to appropriate drawing.

AN FITTINGS

Standard AN flared tube fittings may be used in all fluid systems, except spacecraft and prelaunch GSE or directly associated GSE fluid systems, unless authorized in applicable documents and drawings.

MS PRECISION-TYPE FITTINGS:

Precision-type flared tube fittings are close-tolerance versions of equivalent standard AN flared tube fittings, except that sealing surface finishes are better and imperfect threads are not permitted. Only precision-type MS fitting will be used in spacecraft and prelaunch ground support equipment fluid systems, unless otherwise specified by contract.

MS, NASA FITTINGS:

NASA flared tube fittings have minor tolerance improvements and finer sealing surface finishes than do precision-type MS fittings.

INSTALLATION OF AN AND MS FITTINGS

It is absolutely necessary that open ends of tubing and fittings be kept capped until they are connected into the system. If they are disconnected at any time, they must be capped at once. Expensive units can become contaminated or permanently damaged by dirt and chips if this is not done.

Immediately prior to installation of fittings, lubricate the sleeve bearing outer surface and the male threads of fittings by applying a thin coating of prescribed compound. Do not allow the compound to coat the inside of the tube or flare.

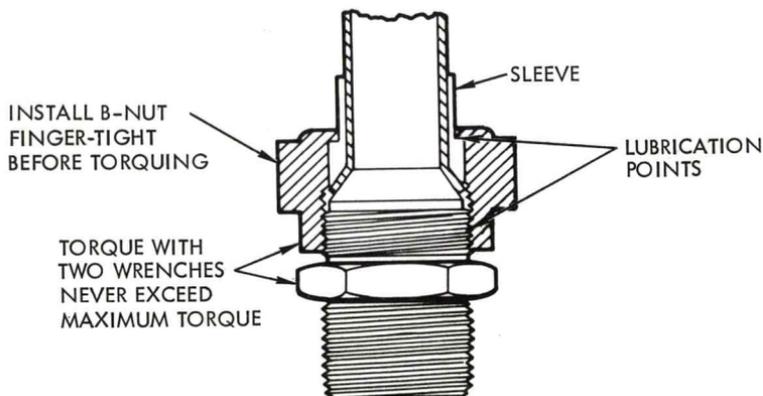
Place the tube in position, making certain that it is not scratched during installation, and see that the tube flares or tube ends meet the fittings squarely and fully. Never use the B-nut to draw the tube to the fitting as the flare or sleeve might be spun off or damaged.

Using fingers only, start the nut on the fitting and turn it until flares or sleeves are firmly seated. Never use a wrench until the nut is finger-tight.

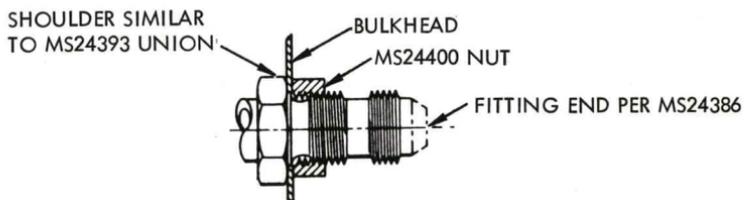
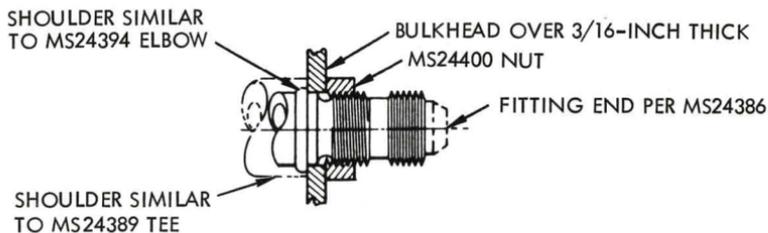
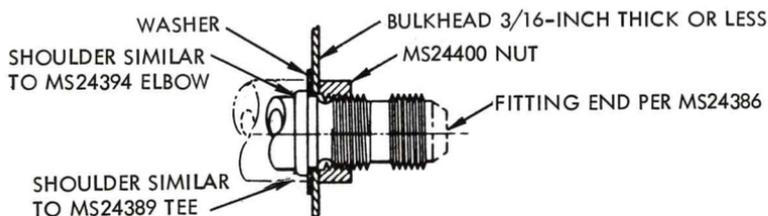
After the nut is firmly in place, tighten the B-nut with a torque wrench. Use a second wrench on the hex of the body to counteract the torque of the wrench on the B-nut.

If the fitting leaks, correct the defect if possible, and replace if necessary.

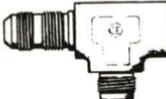
NOTE: Do not tighten the B-nut over the maximum torque recommended. Never attempt leak correction with pressure in the system.



INSTALLATION OF MS24386 FITTING ENDS THROUGH NONPRESSURIZED BULKHEADS



SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

<p>AN783 MS24388</p>  <p>TEE - STRAIGHT THREAD</p>	<p>AN784 MS24389</p>  <p>TEE - STRAIGHT THREAD</p>	<p>AN919 MS24399</p>  <p>REDUCER</p>	<p>AN827 MS24403</p>  <p>CROSS</p>
<p>AN924 MS24400</p>  <p>NUT</p>	<p>AN814 MS24391</p>  <p>PLUG AND BLEEDER</p>	<p>AN815 MS24392</p>  <p>UNION</p>	<p>AN832 MS24393</p>  <p>UNION</p>
<p>AN816</p>  <p>NIPPLE</p>	<p>AN818</p>  <p>COUPLING NUT</p>	<p>MS20819(J)</p>  <p>COUPLING SLEEVE</p>	<p>AN833 MS24394</p>  <p>ELBOW</p>
<p>AN821 MS24401</p>  <p>ELBOW</p>	<p>MS20822</p>  <p>ELBOW</p>	<p>AN929</p>  <p>CAP - PRESSURE SEAL TUBE</p>	<p>AN837 MS24396</p>  <p>ELBOW</p>
<p>AN938</p>  <p>TEE - STRAIGHT THREAD</p>	<p>AN939</p>  <p>ELBOW - STRAIGHT THREAD</p>	<p>AN941</p>  <p>ELBOW - STRAIGHT THREAD</p>	<p>AN893 MS24397 REDUCER</p>  <p>BUSHING - STRAIGHT THREAD</p>
<p>AN894 MS24398 EXPANDER</p>  <p>BUSHING - STRAIGHT THREAD</p>	<p>MS20826</p>  <p>TEE</p>	<p>AN6289</p>  <p>NUT</p>	

FITTINGS

O-RINGS

GENERAL

1. Used as moving and nonmoving seals
2. Manufactured in many different sizes and from a variety of materials
3. Must be compatible with system fluids and pressures
4. In general, different types of O-rings are not interchangeable.
5. MS28778, MS28775, and AN6230 O-rings are the most commonly used.
6. Buna-N O-rings are not suitable for use at cryogenic temperatures.
7. Beware of O-ring shelf life; do not use outdated materials.

MS28778 O-RINGS

MS28778 (gasket-straight thread tube fitting, boss) O-rings are required for gasket applications on AND10056 and AND10057 straight thread tube fittings in AND10050 bosses for port connections of pumps, valves, and other units in hydraulic and pneumatic systems (MIL-P-5510). They are also used with three-piece tube fittings for mounting in straight thread bosses.

MS28778 O-ring sizes are indicated by dash numbers that refer to tubing size in 1/16-inch increments. For example, tubing measuring 1/4 inch uses a Dash-4 fitting that requires a Dash -4 O-ring.

Although MS28778 and AN6227B O-rings are apparently the same, they are not interchangeable. AN6290 O-ring dash numbers are not comparable to AN6227B O-ring dash numbers.

MS28778 O-rings are supplied in Buna-N material and are identified by a 1/32-inch-wide nonpermanent blue stripe around the outer circumference.

Installation of an O-ring with a fitting requires the fitting to have a hex shoulder of sufficient width to cover the entire O-ring. Some AN fittings are not suitable for use with O-rings. For use with AND10057 bulkhead flared tube connections in pneumatic or hydraulic systems to 3000 psi, the installation requires an AN6289 nut and an AN6291 leather ring. For use in fuel systems, an AN924 nut is used in lieu of an AN6289 nut and AN6291 leather rings.

## SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

### AN6227B O-Rings (MS28775 Equivalent)

AN6227B O-rings (Packing O-ring hydraulic) are designed for hydraulic service (MIL-P-5516). They are suitable for moving or nonmoving seals. The usual application is with hydraulic pistons, valve stems, or other installations involving reciprocating, rotary, or oscillating movement. Provisions must be made for lubrication when they are installed as moving seals in pneumatic systems. AN6227B O-rings are not designed for use with fittings.

These O-rings are furnished in a range of various cross-section widths and diameter sizes to fit standard O-ring gland dimensions per MIL-P-5514. For use with pressures from 1500-3000 psi, the gland design has provisions for backup rings of leather, Teflon, Kel-F, or other materials to prevent extrusion of the O-ring. AN6227B dash numbers do not represent size increments but must be chosen according to the required ID and the cross-sectional width of the groove dimension.

AN6227B O-rings can be identified by two or three colored dots on the outer diameter, the number and color of the dots varying between manufacturers. They are supplied in Buna-N material.

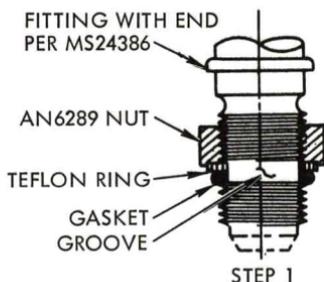
Rectangular grooves as established in MIL-P-5514 must be used for AN6227B O-ring installation. Care must be taken not to scratch or nick the O-ring. Lubrication compatible to the system should be employed. AN6227B O-rings are not acceptable substitutes for AN6290 O-rings in tube fitting applications. AN6227B O-rings require AN6246 backup rings for pressures from 1500 to 3000 psi.

### AN6230B O-Rings (MS28775 Equivalent)

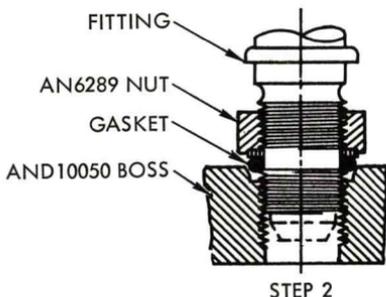
AN6230B O-rings (Gasket O-ring hydraulic) are designed for nonmoving gasket applications in hydraulic service (MIL-P-5516). This O-ring is comparable to AN6227B but is limited to static applications. It is furnished in ID dimensions of 1-5/8 inch through 4-5/8 inches and is available only in a 1/8-inch cross-section size. AN6230B dash numbers are not comparable to AN6227B or AN6290 dash numbers.

Installation of AN6230B O-rings is the same as AN6227B O-rings except that for pressures from 1500 to 3000 psi the AN6230B O-ring requires an AN6244 backup ring.

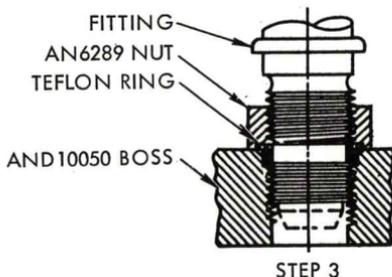
INSTALLATION OF HYDRAULIC AND PNEUMATIC MS24386  
FITTING INTO AND10050 BOSS



Assemble as shown in Step 1. Work the Teflon ring into the counterbore of the AN6289 Nut; then turn the AN6289 Nut down until the gasket is pushed firmly against the lower threaded section of the fitting.



Install the fitting into the AND10050 Boss and, at the same time, keep the AN6289 Nut turning with the fitting until the gasket contacts the AND10050 Boss, as shown in Step 2. This point can be determined by a sudden increase in torque. With the fitting in this position, put a wrench on the AN6289 nut to hold it from turning and, at the same time, turn the fitting in 1-1/2 turns. Position the fitting by turning in not more than one additional turn.



Hold fitting and turn AN6289 Nut down tightly against AND10050 Boss, as shown in Step 3. Slight extrusion of the Teflon ring is not detrimental.

SEALS

BOSS SEALING RECOMMENDATIONS FOR HOT GAS AND CRYOGENIC APPLICATIONS

The following seals are recommended in a preferred order:

1. Temperature range 500 to 1000 F:  
NATORQ P/N VD261-0123 - XXXX (silver-plated)  
Harrison "K" P/N 12100 AA (gold-plated)
2. Temperature range -423 to 500 F:  
Harrison "K" P/N 12100 CR (Teflon-coated)  
NATORQ P/N VD261-0123 - XXXX
3. All service bulkhead application:  
NATORQ VD261-0066 - XXXX
4. Transducer applications limited to low torque values and high temperature:  
Harrison "K" P/N 12100 AA (gold-plated)
5. Transducer applications limited to low torque values and cryogenic temperature:  
Harrison "K" P/N 12100 CR (Teflon-coated)

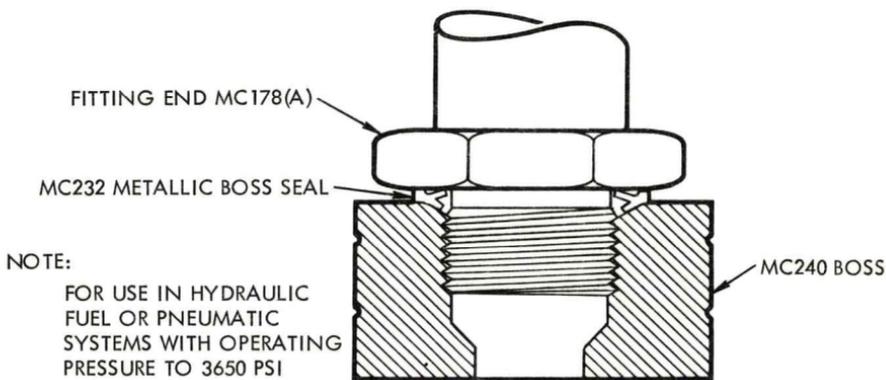
BOSS SEALING LIMITATIONS FOR HOT GAS AND CRYOGENIC APPLICATIONS

The following limitations and recommendations are made for boss seals:

1. Recommended increased torque values for the above seals used in conjunction with standard fittings must be taken for the drawing or specification.
2. Do not use AN900 series copper crush washers or AN901 series asbestos filled copper gaskets in AN10050 boss seal applications.
3. Do not use elastomer O-rings above or below their rated maximum temperatures--not even for a short time.
4. In applications where Photocon transducers are applied in AN10050 or MC240 threaded boss ports, the torque requirements are limited by the transducer and must comply to the manufacturer's recommendations.

5. Boss seals should never be reused unless they can be leak-checked per system pressure requirements. Retorquing is permissible provided that the seal fitting combination has not been subjected to zero torque conditions, which disrupts the original continuity between the contacting surfaces. In this situation, leak-check after retorquing.
6. The use of bulkhead fittings is not recommended for high temperature or cryogenic applications; however, in special installations where bulkhead fittings must be incorporated, elastomer O-rings should be replaced with metal NATORQ bulkhead seals.
7. Teflon O-rings are not recommended for cryogenic or high temperature applications. The cold flow properties of Teflon combined with a noncaptivating seal cavity will allow the initial seal preloading to relax.

INSTALLATION OF MC178 FITTING END TO BOSS  
(USING METALLIC BOSS SEALS)



1. Upon removal of metallic boss seal or fitting from polyethylene envelopes, inspect the sealing surfaces for possible damage. Avoid touching the sealing surfaces with bare hands.
2. Place short-lipped sealing surface of the metallic boss seal against the hex face of the fitting.
3. Install fitting, with assembled metallic seal, into straight boss, MC240. Rotate fitting into boss until finger-tight. Apply torque wrench, making sure to position wrench fully on her flats to avoid distortion of hex sealing surface, and torque fitting per torque table.

## INSTALLATION OF NATORQ SEALS

The NATORQ Boss Seals, ME261-0023-XXXX and ME261-0023-XXX shall be preset as follows:

Place the seal on the bulkhead fitting by screwing it over the fitting thread. Nest the seal outside diameter in the nut recess. (See figure below.) The tapered end of the seal shall face toward the end of the fitting. Keeping the seal snugly in the nut recess, adjust the face of the seal to dimension A in fitting thread relief.

Lubricate the AND10050 boss and fitting threads per specification.

Install the bulkhead fitting in the female fitting so that the seal is centered in the chamber of the AND10050 boss.  
The nut shall not turn while the fitting is being installed.

Tighten the nut until the seal edge bottoms against the fitting thread relief diameter. The nut shall be tightened to the torque values specified on the drawing. Do not turn the fitting when tightening the nut.

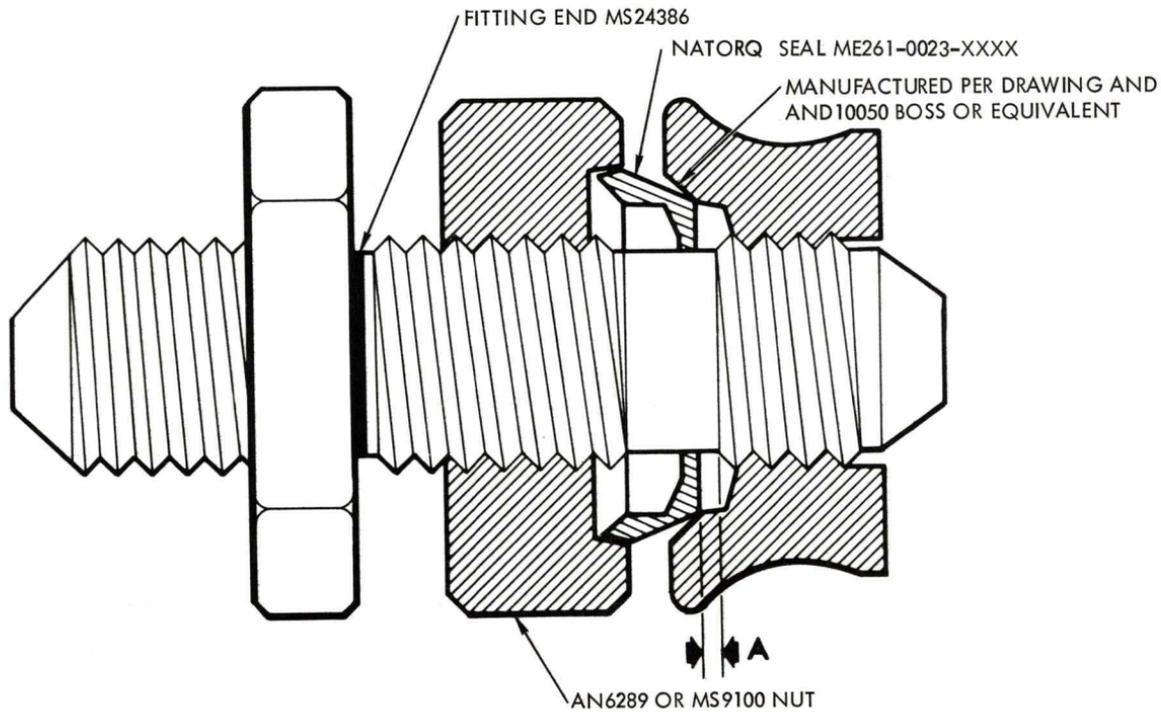
When removing the bulkhead fitting from the female fitting, loosen the nut just enough to allow removal of the fitting. When removing the fitting from the female fitting, the position of the nut and the deformed seal shall not be disturbed. Excessive movement of the nut may cause the seal to leave the nut recess or to jam against the fitting thread.

All fittings and bosses must conform to dimensions shown on the applicable drawings, including specified tolerances and finishes. Inspection for conformance should be accomplished prior to installation.

The fitting and seal assembly may be used repeatedly, unless the seal is damaged or is inadvertently removed from the nut recess. The seal may be replaced by turning the nut clockwise until the seal separates from the nut. Remove the seal by cutting it into two places, 180 degrees apart. Do not scratch or otherwise damage the fitting during the seal removal.

Dash No.	Seal Type	A Dimension (inch)
-0001	Type I	1/64
-0002	Type I	1/16
-0003	Type I	3/32
-0004	Type I	5/64
-0005	Type I	5/46
-0006	Type II	1/16
-0007	Type II	1/16
-0008	Type II	1/16
-0009	Type II	1/16
-0010	Type II	5/64
-0011	Type II	3/32
-0012	Type II	7/64
-0013	Type II	7/64
-0014	Type II	7/64

NATORQ SEAL INSTALLATION



INSTALLATION OF ME261-0033  
(K-SEALS)

The K-seals, ME261-0033, may be used only with male fittings that have an integral shoulder against the seal, because the seal will not prevent leakage in threaded sections between a nut and fitting. The K-seal requires no presetting operation so the installation may be accomplished as follows:

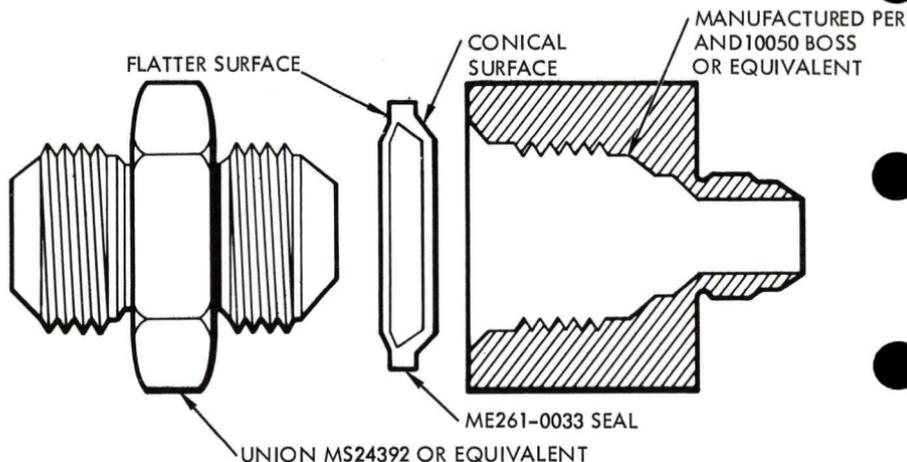
Thoroughly clean the fittings and seal.

Assemble the seal on the fitting as shown below. Extreme care should be exercised to align the seal as shown with the conical surface of the seal mating against the chamfer of the AND10050 boss, and the flatter surface against the shoulder of the male threaded fitting. The position of the seal cannot be determined after the fitting has been tightened.

Tighten the fitting with a wrench to the torque values specified on the appropriate drawing.

NOTE: The sealing surfaces shall not be touched with bare hands.

The seals are reusable if they are replaced in the same installation. Extreme care shall be exercised to avoid nicks, scratches, and other surface imperfections which may impair the sealing function.



INSTALLATION OF CONICAL SEALS ON FLARED END FITTING  
(MC 185)

When specified on the Engineering drawing, install the conical seal as shown below. To ensure proper alignment of the conical seal on end fitting, the seal must be free of nicks, scratches, or dents. With the seal positioned on the end of the fitting, place the flared end of the tube over the seal and engage the nut. Continue to tighten the nut with fingers until the tube and fitting are firmly seated against the seal.

The companion fitting shall be held with a wrench, and the B-nut only shall be rotated in tightening of the nut to the required torque.

Wrenches used for tightening B-nuts or equivalent shall be the 12-point type, providing a minimum of five points of contact between nut wrenching flats and wrench.

The B-nut shall be tightened a minimum of two torque applications before pressure test. It is recommended that torque wrench be shifted 1/4 of a turn between applications of torque to B-nut.

Companion fitting or tube shall not be allowed to rotate during tightening operation.

Torque values for AN and MS nuts and fittings will be taken from Engineering installation drawings and specifications.

HYDROGEN AND OXYGEN SYSTEMS

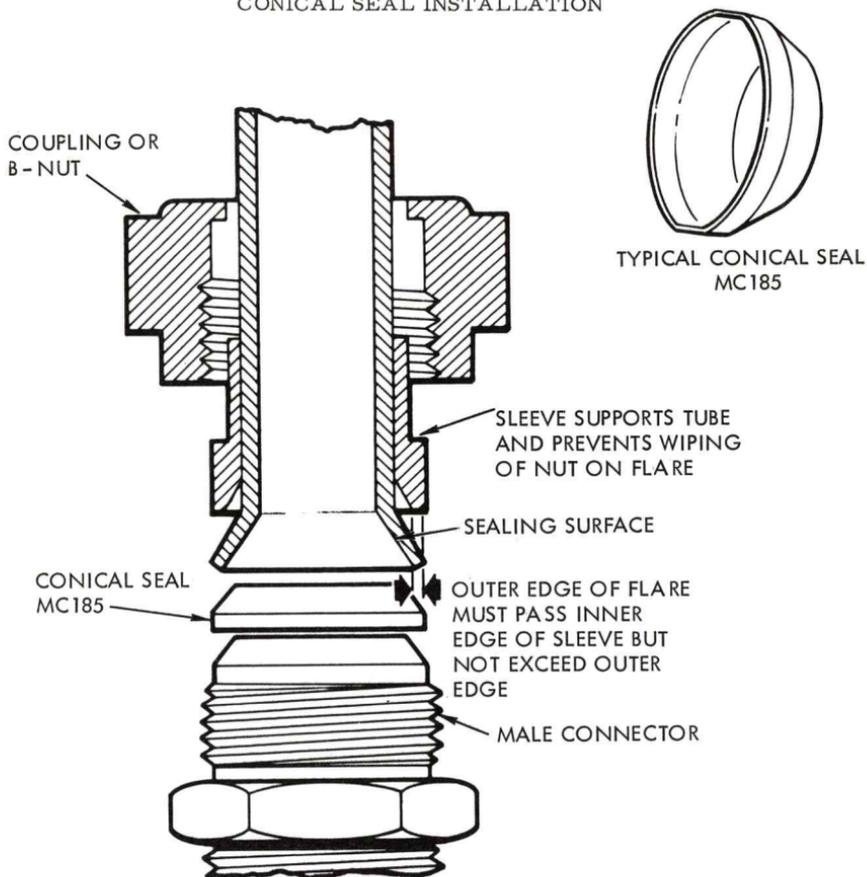
MC185 conical seals shall be used in all threaded flare type tube connections. Use aluminum seals for aluminum lines, and copper seals for CRES lines and fittings.

ALL OTHER SYSTEMS, LIQUID OR GASEOUS (EXCEPT ENGINE ACTUATION SYSTEM)

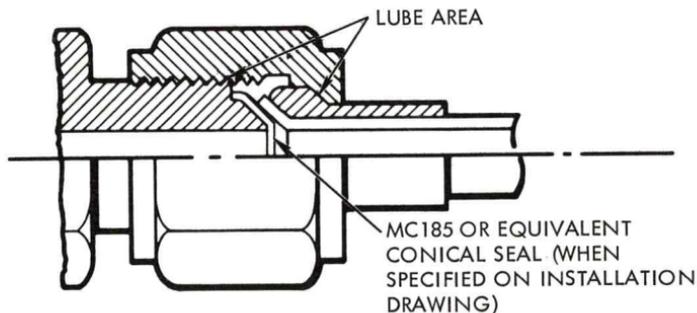
Whenever a threaded flare type tube connection is disassembled, an MC185 conical seal shall be installed during reassembly of the connection. Aluminum seals shall be used for aluminum lines and copper seals shall be used for CRES lines and fittings.

NOTE: When a joint must be loosened or broken, the conical seal shall be removed and destroyed and a new seal installed. No conical seal shall be used more than once.

CONICAL SEAL INSTALLATION



TYPICAL TUBE TO FITTING INSTALLATION UTILIZING MC185 CONICAL SEAL



FLARED RIGID TUBE ASSEMBLY

## LUBRICANTS

## DEFINITIONS AND FUNCTIONS

The general term lubricants includes the following specific terms and functions:

Lubricant . . . . .	a material used to reduce friction between threaded devices or sliding surfaces
Sealant . . . . .	a material used to effect a seal between two surfaces
Antiseize . . . . .	a material used to allow easy disassembly of threaded parts
Thread compound . . . . .	a compound used with NPT joints to perform the function of sealant, lubricant, and antiseize

## APPLICATION OF LUBRICANTS

The number of application points shall vary with the size of the fitting. Where more than one application is required, the application points shall be equally spaced around the circumference of the threads. The number of application points for the various thread sizes (based on straight thread fitting sizes) is as follows:

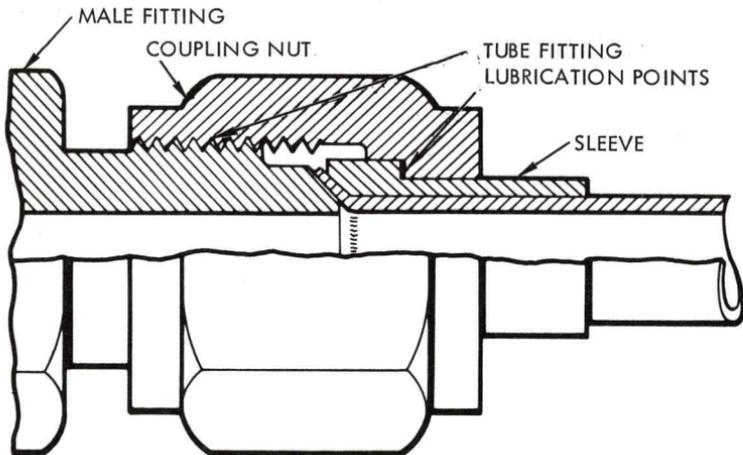
Thread Size, (inches, diameter)	Number of Application Points	Approximate Width of Streak (inches)
Up to 1/2	1	1/8 to 1/4
Over 1/2 up to 1	1	3/8
Over 1 up to 1-3/4	2	1/2
Over 1-3/4 up to 2-1/2	3	1/2
Over 2-1/2 up to 3	4	1/2
Over 3	5	1/2

## GOOD PRACTICE TIPS

1. Do not use a lubricant if doubt exists concerning its compatibility in the system.
2. Lubricants must be compatible with all downstream materials in fluid systems.
3. Lubricants contaminated with dirt, grit, metal chips, or other foreign matter must be discarded.

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4. Use lubricants from original marked cans only. Do not return excess to the container.
5. Some lubricants have a shelf life. Be aware of the date on the container.
6. Avoid excessive lubrication. Lubricants should be applied in a streak across male threads. The amount of lubricant depends on thread size. Follow application procedures in the appropriate process specification MA0112-008 for Saturn II.
7. Do not lubricate female threads or flares. Interior and exterior thrust surfaces of the tubing sleeve must be lightly lubricated to prevent galling during torquing of B-nuts.
8. Do not apply lubricant to the end of a fitting.



The end faces of threaded parts and sealing surfaces of flared fittings that have inadvertently come in contact with the lubricant shall be carefully wiped clean to remove any visual indication of lubricant prior to connecting threaded parts.

VII. PROPELLANTS AND SOLVENTS

HELIUM INFORMATION SUMMARY

COMMON NAME

Helium

CHEMICAL FORMULA

He

NR SPACE DIVISION USAGE

Valve actuation

Pressurizing

Purging

PHYSICAL PROPERTIES

Density-gas: 0.010329 lb/ft<sup>3</sup>

Freezing point: -455 F

Boiling point: -452 F

Critical temperature: -450.11 F

Volume expansion, liquid to gas at NTP: 754.2 to 1

Odor: None

Appearance: Colorless and tasteless

CHEMICAL PROPERTIES

Inert

Helium is the lightest of the inert gases, its lightness surpassed only by hydrogen. Helium content of air is only about 1-1/2 parts per million, making helium production from air processing economically prohibitive. The commercial source, at present, is from three major natural gas wells located in the U.S. These are controlled by the Bureau of Mines.

STORAGE

Helium is handled and stored in cylinders (1800 to 2000 psig) as a gas. The handling of gaseous helium is perfectly safe provided the following precautions are followed:

Helium cylinders should never be stored near furnaces, radiators or other heat source. The cylinder temperature should never be allowed to exceed 125 F.

Protect cylinders from mechanical shock; any damage to the cylinder valve or safety device can be extremely dangerous. A suitable platform will be used to hold the cylinders at all times. Never drop cylinders or permit them to strike each other violently.

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Cylinders should be stored in a definitely assigned location with full and empty cylinders stored separately. Storage room must be dry, cool and well ventilated.

### PERSONNEL HAZARD CHARACTERISTICS

Avoid contact of either liquid or cold gaseous helium with any part of the body. The effect is similar to that of a burn.

Toxicity: No hazard. However it does present the danger of asphyxiation. Should the air be displaced with helium, it can cause dizziness, unconsciousness or even death.

### SAFETY CLOTHING REQUIRED

Face shield, asbestos gloves, plastic apron and sleeves, and rubber boots are required. A self-contained breathing apparatus is also required in confined areas where helium is leaking.

### FIRST AID

If a person becomes groggy or loses consciousness when working with helium, transfer him to a well ventilated area immediately. If his breathing has stopped, apply artificial respiration. Whenever a person loses consciousness, summon a physician immediately.

### FIRES

Nonflammable. It will not support combustion and is nontoxic.

NITROGEN INFORMATION SUMMARY

COMMON NAME

Liquid nitrogen (LN<sub>2</sub>)

CHEMICAL FORMULA

N<sub>2</sub>

NR SPACE DIVISION USAGE

Supply gaseous nitrogen (GN<sub>2</sub>). Simulate liquid oxygen refrigerant and to purge various stage and GSE units.

PHYSICAL PROPERTIES

Freezing point: -346 F  
Boiling point: -320 F  
Critical temperature: -232.7 F  
Gas density relative to air: 0.966  
Liquid to gas ratio: 1:679  
Odor: None  
Appearance: Clear, colorless liquid

CHEMICAL PROPERTIES

Inactive and stable

STORAGE

Storage tanks are constructed of stainless steel, double wall, and are vacuum insulated against heat transfer.

Tanks are vented and provided with burst diaphragms and relief valves.

Vented gases should be dispersed in a manner that does not permit buildup of a suffocating vapor blanket in any area.

AVAILABILITY

Source: Air, universally available.

Manufacturing method: Air is compressed and cooled regeneratively to liquid air. Nitrogen is boiled off (fractional distillation), leaving LOX (Hampson-Linde process). This process is adaptable to field use:

PERSONNEL AND HAZARD CHARACTERISTICS

Temperature: Because of the extreme cold, living tissue is destroyed on contact with either LN<sub>2</sub> or exposed uninsulated pipes or lines. The effect is similar to that of a burn.

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Toxicity: No toxic hazard if atmospheric O<sub>2</sub> content is between 19.5% and 24% by volume. However, if the O<sub>2</sub> level falls below 19.5%, there is danger of asphyxiation. If sufficient GN<sub>2</sub> is present to reduce the atmospheric O<sub>2</sub> content to 6.8%, fatalities will occur within 8 minutes 100% of the time.

LN<sub>2</sub> tank may condense LOX from atmosphere, which drips down sides of tank to surrounding area. This could release GO<sub>2</sub> concentration, which may contaminate personnel, clothing, or combustible trash.

Never trap liquid nitrogen in a line between valves. As the liquid expands to gas, extremely high pressures will result, causing the line to burst. This could be hazardous to nearby personnel.

### SAFETY CLOTHING REQUIRED

Face shield, asbestos gloves, plastic apron and sleeves, and rubber boots are required. Life line and supplied air mask for work inside tanks are also necessary.

### FIRST AID

With water deluge, wash off LN<sub>2</sub> and warm exposed area. Medical treatment is required.

OXYGEN INFORMATION SUMMARY

COMMON NAME

LOX (liquid oxygen)

CHEMICAL FORMULA

O<sub>2</sub>

NR SPACE DIVISION USAGE

Oxidizer in bipropellant engine systems

PHYSICAL PROPERTIES

Pounds of liquid per gallon: 9.527  
Freezing point: -362 F  
Boiling point: -297.4 F  
Critical temperature: -181.8 F  
Liquid specific gravity: 1.138  
Gas density relative to air: 1.103  
Liquid to gas ratio: 1:862  
Odor: none  
Appearance: pale blue, clear liquid

CHEMICAL PROPERTIES

Stable against mechanical shock in pure form.

Impact-sensitive to an unpredictable degree if contaminated, especially with organic materials.

If mixed with grease, oils, petroleum derivative fuels, alcohol, etc., it forms a high-impact sensitive gel that may be detonated by spark or flame as well as by mechanical shock.

Storage:

LOX storage tanks are stainless steel, double wall, and are vacuum insulated against heat transfer.

The tanks are vented and provided with burst diaphragms and relief valves.

The storage area must be kept clear of fire hazards.

Vented gases must be directed away from personnel and combustible material.

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## AVAILABILITY

Source: Air, universally available.

Manufacturing methods: Air is compressed and cooled regeneratively to liquid air; nitrogen is boiled off, leaving LOX (Hampson-Linde Process). The process is adaptable to field use.

## PERSONNEL HAZARD CHARACTERISTICS

Low temperature: Because of the extreme cold, living tissue is destroyed on contact with either LOX or exposed uninsulated pipes or lines. The effect is similar to that of a burn.

Toxicity: No hazard. Inhalation has an exhilarating effect.  
Corrosion: None.

## SAFETY CLOTHING REQUIRED

Face shield, loose fitting gauntlet - cuffed asbestos gloves, plastic apron and sleeves, and high-top rubber boots.

## WARNING

GOX AND LOX SATURATED CLOTHING  
MUST BE REMOVED AND AIRED FOR  
2 HOURS

## FIRST AID

To wash off LOX, deluge with tepid water and warm affected area. Prompt medical treatment is required.

## FIRES

LOX evaporates to pure gaseous oxygen, which supports combustion in a very intense manner. Clothing or combustible trash give no indication of gaseous oxygen saturation until violent combustion takes place. Gaseous oxygen is an extreme fire hazard in combination with any combustible material.

HYDROGEN INFORMATION SUMMARY

COMMON NAME

Hydrogen

CHEMICAL FORMULA

H<sub>2</sub>

PHYSICAL PROPERTIES

Pounds of liquid per gallon: 0.54  
Expansion ratio: liquid to gas 1:848  
Dielectric constant at BP: 1.23  
Boiling point (1 atm) -423.2 F  
Freezing point: -434.6 F  
Critical state: -400 F

GENERAL PROPERTIES

Hydrogen as a liquid is odorless, colorless, nontoxic, noncorrosive, but is highly flammable.

Hydrogen as a gas is colorless, odorless, and nontoxic, but presents a danger of asphyxiation and has wide flammability limits; it contaminates with air (air crystals sink in, but solubility is essentially zero).

Volume increase to Standard Temperature and Pressure (STP) conditions: 780 times from gas to liquid.

Volume increase at boiling point: 53 times.

PRODUCTION

It is produced by the oxidation of petroleum or the reduction of methane gas. Liquefaction in Joule-Thompson cycle, plus catalytic treatment to obtain pure para.

Desired liquid: 99.8 percent para, 0.2 percent ortho (= equilibrium hydrogen); gas: 75 percent ortho, 25 percent para (= normal hydrogen).

STORAGE LOSSES

Uninsulated vessel: up to 70 percent per hour. Well-insulated 25,000-gallon sphere: 25 percent per day; 500,000-gallon sphere: 0.06 percent per day.

## SUITABLE MATERIALS

METALS. Austenitic stainless steels, aluminum alloys, copper, copper alloys, nickel, nickel alloys, Monel and Everdur.

NON METALS. Dacron, Teflon, Kel-F, Mylar films, Nylon, and Asbestos impregnated with Teflon.

## SAFETY PRECAUTIONS

Ground all wires; use nonspark tools and shoes; wear protective clothing that is easily removable; maintain positive pressure in dewars, and gas traps in vents (prevent oxidation contamination); ensure safe disposal (burnoff) of vent gases; verify building clearances, blowout or open walls.

## PERSONNEL HAZARD CHARACTERISTICS

The potential hazards in handling liquid hydrogen (LH<sub>2</sub>) stem mainly from three important properties: (1) the liquid is extremely cold and will cause burns, (2) very small amounts of liquid are converted into large amounts of gas, and (3) the issuing gas is highly flammable, with a potential explosion hazard.

## SAFETY CLOTHING REQUIRED

Protect eyes with a face shield or safety goggles. (Safety spectacles without side shields do not give adequate protection.) Always wear gloves when handling anything that is in contact with or may recently have been in contact with liquid hydrogen. Asbestos gloves are recommended. High-top shoes and cuffless trousers worn outside the shoes are good practice when handling any cryogenic liquid.

## FIRST AID

Should a person become groggy or lose consciousness, summon a physician immediately. Keep all sources of ignition away from the overcome person. When handling the liquid using proper protective clothing, make certain that there is a safety shower, hose, or a large open container of water nearby. Use water to wash off any area of the body that is accidentally splashed with the liquid.

## FIRES

Highly flammable

Evacuate all personnel (not engaged in firefighting) well outside the area. If at all possible, shut off the flow of liquid or gaseous hydrogen. Use large quantities of water, preferably in the form of a spray; if electrical equipment is involved in the fire, make certain that the electrical supply is disconnected before using water for firefighting, or use carbon dioxide or dry chemical extinguishers.

## COMPRESSED GAS BOTTLES

Compressed gas bottles or cylinders are used to transport and store such gases as nitrogen, helium, oxygen, acetylene, argon, hydrogen, carbon dioxide, fluorine, and refrigerants at pressures up to 3000 psi. Careful handling of these containers is essential to prevent serious accidents from the high pressures or dangerous gases involved. The following rules should be observed:

## Storage

1. Store in compatible areas. Store fuel and oxidizers in separate areas.
2. Store upright and chained in position to prevent falling.
3. Store at temperatures of less than 125 F, and preferably out of the direct sunlight. In freezing weather keep valves dry.
4. Store containers marked "MT" or "full" separately.

## Transport

1. Protective cap must be in place prior to movement.
2. Handle carefully. Do not drop or bang together.
3. Secure containers by chocks and chains or place on an approved rack.
4. Keep acetylene bottles upright. (They contain liquid acetone in a porous filler. The liquid may cause a fire if it gets into the regulator.)

## Use

1. Open valves slowly and observe systems for leaks. If containers or cylinder valves leak, do not attempt repair. Return the cylinder to the vendor, clearly marking it as defective.
2. Regulators and pressure gauges provided for use with a particular gas must not be used with other gases.
3. Do not use a wrench to close valves equipped with handwheels.
4. Release the adjusting screw of the regulator before opening a cylinder valve; close the cylinder valve and release the pressure from the regulator before removing it.
5. Never lubricate bottle fittings. Lubricants can cause explosions upon contact with oxidizers.
6. Left-hand threads are indicated by a groove around the circumference of the nuts.
7. Leave at least 25 psi in empty bottles to prevent contamination.
8. Acetylene regulators must be set below 15 psi to avoid possible explosion.

9. Compressed gas bottles require an I. C. C. inspection every 5 years. This date is stamped on the neck of each bottle.

COMPRESSED GAS BOTTLES ARE  
POTENTIALLY DANGEROUS —  
TREAT THEM WITH RESPECT.

## FIRST AID TREATMENT

ALL MATERIALSCRYOGENS, STORABLE OXIDIZERS, STORABLE FUELS,  
PYROPHORIC FUELS, AND SOLVENTS

## SKIN CONTACT:

Flush with large quantities of water for purposes of dilution, warming the affected area in the case of cryogenics, cooling the affected area in the case of pyrophoric fuels, and generally washing the area off to remove the material.

## EYE CONTACT:

Hold the eyes open and flush with water to wash the liquid out for a minimum period of 15 minutes.

## INHALATION:

Remove the person from the contaminated area. Do not allow the person to walk; carry him.

## INGESTION:

Summon medical help.

## BREATHING STOPS:

Apply artificial respiration or mouth-to-mouth resuscitation.

In all cases when a person requires First Aid—summon medical help.

Propellants and Solvents	FIRE CONTROL METHOD					
	Water Cooling and Dilution			Suffocation Method		
	Stream	Spray	Fog	CO <sub>2</sub>	Dry Chemical	Foam
<u>Cryogenics</u>						
LOX	No	No	Yes	No	No	No
LN <sub>2</sub>	Not Flammable →					
He	Not Flammable →					
LF <sub>2</sub>	No	No	Possibly(a)	No	No	No
FLOX	No	No	Possibly(a)	No	No	No
LH <sub>2</sub>	Yes	Yes	Yes	Yes(b)	Yes	No
<u>Storable Oxidizers</u>						
NTO	Yes	Yes	Yes	No	No	No
H <sub>2</sub> O <sub>2</sub>	Yes(c)	Yes(c)	Yes	No	No	No
IRFNA	Yes(d)	Yes(d)	Yes	No	No	No
CTF	No	No	Possibly(a)	No	No(e)	No

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Propellants and Solvents	FIRE CONTROL METHOD					
	Water Cooling and Dilution			Suffocation Method		
	Stream	Spray	Fog	CO <sub>2</sub>	Dry Chemical	Foam
<u>Storable Fuels</u>						
HZ	Yes	Yes	Yes	Yes	Yes	Yes(f)
MMH	Yes	Yes	Yes	Yes	Yes	Yes(f)
UDMH	Yes	Yes	Yes	Yes	Yes	Yes(f)
HYDYNE	Yes	Yes	Yes	Yes	Yes	Yes(f)
RP-1	No	No	Yes	Yes	Yes	Yes
Ethyl Alc	Yes	Yes	Yes	Yes	Yes	No (Dissolves)
<u>Pyrophoric Fuels</u>						
PB	No	No	Possibly(g)	Yes(h)	Yes(h)	Yes(i)
TEA	No	No	Possibly(g)	Yes(h)	Yes(h)	Yes(i)
TEB	No	No	Possibly(g)	Yes(h)	Yes(h)	Yes(i)
TEAB	No	No	Possibly(g)	Yes(h)	Yes(h)	Yes(i)
<u>Solvents</u>						
Acetone	No	No	Yes	Yes	Yes	Yes
Freons	Not Flammable(j) →					
TRICH	No	No	Yes	Yes	Yes	Yes

- (a) Fluorine FLOX and CTF react with water; therefore, it cannot be used to put out a fluorine-fed fire, but a controlled fog stream can substantially reduce toxic effluent by controlled reaction.
- (b) CO<sub>2</sub> is not as effective as water because of the high temperatures involved.
- (c) Large amounts of water can effectively dilute peroxide.
- (d) Large amounts of water on IRFNA can cause an increase in vapor pressure in an enclosed area.
- (e) Dry chemicals can be used to decontaminate spills.
- (f) Foam tends to break down rapidly due to the high temperature of hydrazine-fed fires. CO<sub>2</sub> is effective in most cases involving small fires especially for protection of personnel.
- (g) Pyrophoric fuels react violently with water, therefore, water cannot be used to put out a fire, but a controlled fog can be used to burn up the fuel faster while providing cooling for the surrounding area.
- (h) CO<sub>2</sub>, dry chemical, and foam are effective as long as they cover the fire; once removed, the fire may reignite.
- (i) Foam and water deluge are the most effective control.
- (j) At the present time, freon solvents are considered to be nonflammable.

Propellants and Solvents	SAFETY CLOTHING DATA					
	Head Hat or Hood	Face Shield or Hood	Body Clothes or Suit	Hand Gloves	Foot Shoes or Boots	Respiratory Equipment Required
<u>Cryogenics</u>						
LOX	Hard Hat	Face Shield(a)	Work Clothes	Asbestos	Work	None
LN <sub>2</sub>	Hard Hat	Face Shield(a)	Work Clothes	Asbestos	Work	Yes(b)
LHe	Hard Hat	Face Shield(a)	Work Clothes	Asbestos	Work	Yes(b)
LF <sub>2</sub>	Gra-Lite Hood(c)	Gra-Lite Hood(c)	Gra-Lite Suit(c)	Neoprene	Neoprene	Yes(d)
FLOX	Gra-Lite Hood(c)	Gra-Lite Hood(c)	Gra-Lite Suit(c)	Neoprene	Neoprene	Yes(d)
LH <sub>2</sub>	Hard Hat	Face Shield(a)	Work Clothes(e)	Asbestos	Work	Yes(b)
<u>Storable Oxidizers</u>						
NTO	Gra-Lite Hood	Gra-Lite Hood	Gra-Lite Suit	Vinyl-Coated	Neoprene	Yes(d)
H <sub>2</sub> O <sub>2</sub>	Hard Hat	Face Shield(a)	Vinyl Apron	Vinyl-Coated	Neoprene	Yes(f)
IRFNA	Gra-Lite Hood	Gra-Lite Hood	Gra-Lite Suit	Vinyl-Coated	Neoprene	Yes(d)
CTF	Gra-Lite Hood(c)	Gra-Lite Hood(c)	Gra-Lite Suit(c)	Neoprene	Neoprene	Yes(d)
<u>Storable Fuels</u>						
HZ	Gra-Lite Hood	Gra-Lite Hood	Gra-Lite Suit	Vinyl-Coated	Neoprene	Yes(d)
MMH	Gra-Lite Hood	Gra-Lite Hood	Gra-Lite Suit	Vinyl-Coated	Neoprene	Yes(d)
UDMH	Gra-Lite Hood	Gra-Lite Hood	Gra-Lite Suit	Vinyl-Coated	Neoprene	Yes(d)
HYDYNE	Gra-Lite Hood	Gra-Lite Hood	Gra-Lite Suit	Vinyl-Coated	Neoprene	Yes(d)
RP-1	Hard Hat	Face Shield(a)	Work Clothes	Neoprene	Work	Yes(d)
Ethyl Alc	Hard Hat	Face Shield(a)	Work Clothes	Vinyl-Coated	Work	Yes(d)

Propellants and Solvents	SAFETY CLOTHING DATA					
	Head Hat or Hood	Face Shield or Hood	Body Clothes or Suit	Hand Gloves	Foot Shoes or Boots	Respiratory Equipment Required
<u>Pyrophoric Fuels</u>						
PB	Gra-Lite Hood	Gra-Lite Hood	Gra-Lite Suit	Vinyl Coated	Neoprene	Yes(d)
TEA	Hard Hat	Face Shield(a)	Apron(g)	Asbestos	Heavy Rubber	Yes(d)
TEB	Hard Hat	Face Shield(a)	Apron(g)	Asbestos	Heavy Rubber	Yes(d)
TEAB	Hard Hat	Face Shield(a)	Apron(g)	Asbestos	Heavy Rubber	Yes(d)
<u>Solvents</u>						
Acetone	Hard Hat	Face Shield(a)	Plastic Apron	Neoprene	Work	Yes(d)
Freons	Hard Hat	Face Shield(a)	Plastic Apron	Neoprene	Work	Yes(d)
Trich	Hard Hat	Face Shield(a)	Plastic Apron	Neoprene	Work	Yes(d)

(a) Safety glasses must be used when face protectors are used.  
 (b) Required when suffocation hazard is present.  
 (c) Armalon suits will replace Gra-Lite suits as they become available.  
 (d) Required when MAC value is exceeded.  
 (e) Aluminized hood, coveralls and gloves required for full protection.  
 (f) Required when excessive vapors are present  
 (g) Impregnated asbestos open-back jacket or apron.

## LIQUID PROPELLANT, PRESSURANT, AND SOLVENT DATA

Name	Formula	Boiling Point, F	Freezing Point, F	Specific Gravity-Vapor at STP(a)	Liquid Density		Flash Point F
					lbs/cu ft	lbs/gal.	
Oxygen (LOX)	O <sub>2</sub>	-297	-362	1.1	71.27	9.527 at -297 F	None
Nitrogen	N <sub>2</sub>	-320	-346	0.966	50.46	6.746 at -320 F	None
Helium	He	-452	-456	0.13	7.798	1.042 at -452 F	None
Fluorine	F <sub>2</sub>	-306	-363	1.3	93.8	12.54 at -306 F	None
Flox (30%/70%)	F <sub>2</sub> + O <sub>2</sub>	-301	-363	1.2	78.03	10.431	None
Hydrogen	H <sub>2</sub>	-423	-434	0.069	4.418	0.591 at -423 F	N. D. (b)
Nitrogen Tetroxide (NTO)	N <sub>2</sub> O <sub>4</sub>	70	12	3.2	90.34	12.08 at 70 F	None
Hydrogen Peroxide (98%)	H <sub>2</sub> O <sub>2</sub>	302	31	1.1	90.055	12.041 at 68 F	None
Inhibited Red Fuming Nitric Acid (IRFNA)	HNO <sub>3</sub>	150	-55	3.2	94.456	12.627 at 60 F	None
Chlorine Pentafluoride (CPF)	ClF <sub>5</sub>	8	-153	4.5	129.4	15.9 at 8 F	None
Chlorine Trifluoride (CTF)	ClF <sub>3</sub>	53	-105	3.2	114.0	15.24 at 53 F	None
Hydrazine (HZ)	N <sub>2</sub> H <sub>4</sub>	236	35	1.1	62.691	8.417 at 68 F	100-126
Monomethylhydrazine (MMH)	CH <sub>3</sub> NHNH <sub>2</sub>	189	-62	1.59	54.86	7.334 at 68 F	61-63
Unsymmetrical-dimethylhydrazine (UDMH)	H <sub>2</sub> NN(CH <sub>3</sub> ) <sub>2</sub>	146	-71	2.1	48.8	6.524 at 68 F	3
Hdyne	Amine Mixture	148	-120	Heavier than Air	53.21	7.113 at 68 F	46
Jet Fuels, RP-1, JP-5	Hydrocarbon Mixtures	350-525	-40	Heavier than Air	50.568	6.76 at 68 F	110

## LIQUID PROPELLANT, PRESSURANT, AND SOLVENT DATA (CONT)

Name	Formula	Boiling Point, F	Freezing Point, F	Specific Gravity-Vapor at STP(a)	Liquid Density		Flash Point F
					lbs/cu ft	lbs/gal.	
Ethyl Alcohol (ALC)	CH <sub>3</sub> CH <sub>2</sub> OH	173	-174	1.59	49.285	6.588 at 68 F	55
Pentaborane (PB)	B <sub>5</sub> H <sub>9</sub>	140	-52	2.2	39.14	5.232 at 77 F	(c)
Triethylaluminum (TEA)	Al(C <sub>2</sub> H <sub>5</sub> ) <sub>3</sub>	381	-63	Flame in Air	52.3	6.991	(c)
Triethylboron (TEB)	B(C <sub>2</sub> H <sub>5</sub> ) <sub>3</sub>	203	-135	Flame in Air	43.458	5.809	(c)
Triethylaluminumboron (TEAB - 85% TEB, 15% TEA)	AIB(C <sub>2</sub> H <sub>5</sub> ) <sub>3</sub>	202	-141	Flame in Air	44.784	5.987	(c)
Acetone	CH <sub>3</sub> COCH <sub>3</sub>	134	-99	2.0	49.769	6.653 at 68 F	0
Trichloroethylene (TRICH)	CHClCCl <sub>2</sub>	186	-124	4.53	90.873	12.148 at 68 F	N. D. (b)
Trichlorotrifluoroethane (Freon TF)	CCl <sub>2</sub> FCCLF <sub>2</sub>	118	-31	Heavier than Air	98.437	13.16 at 68 F	None
Tetrachlorodifluoroethane (Freon BF)	CCl <sub>2</sub> FCCL <sub>2</sub> F	199	104	Heavier than Air	102.027	13.64 at 68 F	None

(a) Standard Temperature (68 F) and Pressure (14.7 psia).  
 (b) Not determined.  
 (c) Pyrophoric.

## LIQUID PROPELLANT, PRESSURANT, AND SOLVENT DATA (CONT)

Name	Flammable Limits Percent by Volume	Appearance		Odor	Vapor Hazard
		Liquid	Vapor		
Oxygen (LOX)	Nonflammable	Blue	Invisible	None	Supports Combustion
Nitrogen N <sub>2</sub>	Nonflammable	Colorless	Invisible	None	Suffocation
Helium (He)	Nonflammable	Colorless	Invisible	None	Suffocation
Fluorine (F <sub>2</sub> )	Nonflammable	Yellow	Brownish	Pungent	Supports Combustion, Toxic
FLOX (30% 70%)	Nonflammable	Greenish	Green-Brown	Pungent	Supports Combustion, Toxic
Hydrogen (H <sub>2</sub> )	4 - 75	Colorless	Invisible	None	Fire, Suffocation
Nitrogen Tetroxide (NTO)	Nonflammable	Brown	Brown	Pungent	Supports Combustion, Toxic
Hydrogen Peroxide (98%) (H <sub>2</sub> O <sub>2</sub> )	Nonflammable	Colorless	Invisible	None	Supports Combustion, Toxic
Inhibited Red Fuming Nitric Acid (IRFNA)	Nonflammable	Orange	Brown	Pungent	Supports Combustion, Toxic
Chlorine Pentafluoride (CPF)	Nonflammable	Greenish	Nearly Colorless	Pungent	Supports Combustion, Toxic
Chlorine Trifluoride (CTF)	Nonflammable	Greenish	Nearly Colorless	Pungent	Supports Combustion, Toxic
Hydrazine (HZ)	4.7 - 100	Colorless	Invisible	Ammonia	Fire, Toxic
Monomethylhydrazine (MMH)	2.5 - 98	Colorless	Invisible	Ammonia	Fire, Toxic
Unsymmetrical- dimethylhydrazine (UDMH)	2.3 - 80	Colorless	Invisible	Ammonia	Fire, Toxic
Hydyne	3.0 - 45	Colorless	Invisible	Ammonia	Fire, Toxic
Jet Fuels, RP-1, JP-5	0.8 - 6	Colorless	Invisible	Kerosene	Fire, Toxic

## LIQUID PROPELLANT, PRESSURANT, AND SOLVENT DATA (CONT)

Name	Flammable Limits, Percent by Volume	Appearance		Odor	Vapor Hazard
		Liquid	Vapor		
Ethyl Alcohol (ALC)	4.3 - 19	Colorless	Invisible	Alcohol	Fire, Toxic
Pentaborane (PB)	Pyrophoric	Colorless	Invisible	Pungent	Pyrophoric, Toxic
Triethylaluminum (TEA)	Pyrophoric	Colorless	Invisible	Combustion byproducts	Pyrophoric, Toxic
Triethylboron (TEB)	Pyrophoric	Colorless	Invisible	Combustion byproducts	Pyrophoric, Toxic
Triethylaluminumboron (TEAB - 85% TEB, 15% TEA)	Pyrophoric	Colorless	Invisible	Combustion byproducts	Pyrophoric, Toxic
Acetone	3.0 - 11.0	Colorless	Invisible	Mint-like	Fire, Toxic
Trichloroethylene (TRICH)	12.5 - 90	Colorless	Invisible	Chloroform	Fire, Toxic
Trichloromonofluoromethane	Nonflammable	Colorless	Invisible	Irritating	Toxic
Trichlorotrifluoroethane (Freon TF)	Nonflammable	Colorless	Invisible	Irritating	Toxic
Tetrachlorodifluoroethane	Nonflammable	Colorless	Invisible	Irritating	Toxic

## SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

## COMPATIBLE MATERIALS

CRYOGENICS			
Service	Metals	Nonmetals	Lubricants
Liquid Oxygen	Stainless Steel 18-8 Copper Bronze Brass Aluminum Monel	Teflon Kel-F Asbestos Certain Silicon rubbers	*
Liquid Nitrogen & Liquid Helium	Some Chrome- Nickel Steels (Austenitic-9 per- cent Nickel)** Stainless Steel 18-8 Copper Brass Bronze Copper-Silicon alloys Monel Aluminum Shredded Lead	Teflon Kel-F Cotton-free Asbestos Graphite (Selected types)	*
Fluorine and FLOX	Monel Aluminum Stainless Steel 304L 347 Copper Brass	None	None
Liquid Hydrogen	Stainless Steel 300 series Austenitic Copper Bronze Brass Monel Aluminum	Dacron Teflon Kel-F Nylon Mylar films Asbestos impreg- nated with teflon	*
STORABLE OXIDIZERS			
Nitrogen Tetroxide	Carbon Steels Aluminum Stainless Steel Nickel Inconel	Ceramic (acid resistant) Pyrex glass Teflon Kel-F Asbestos (cotton free)	*

## COMPATIBLE MATERIALS (CONT)

STORABLE OXIDIZERS (CONT)			
Service	Metals	Nonmetals	Lubricants
Hydrogen Peroxide	Aluminum 1060, 1260, 1360, 5254, 5652 Stainless Steel 304, 304ELC, 309, 310, 316, 316ELC, 317, 321, 347	Teflon Kel-F	*
Inhibited Red Fuming Nitric Acid	Aluminum 1060, EC, 1100, 3003, 3004, 6061, 5052, 5154 Stainless Steel 347, 19-9DL, 19-9DX, 304ELC, 321, 303, 316	Kel-F Teflon Polyethylene	*
Chlorine Trifluoride	Stainless Steel 18-8 Copper Silver-solder Brass Steel Magnesium Monel Nickel	Pyrex glass	None
STORABLE FUELS			
Hydrazine	Aluminum 1100 & 3003 Stainless Steel 303, 304, 321, 347 Nickel	Polyethylene Teflon Kel-F unplasticized	*
Monomethylhydrazine	Stainless Steel 304, 307 Aluminum 3003, 5052, 5154, 1060, 6061 Durimet 20	Polyethylene Teflon Kel-F unplasticized	*

## SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

## COMPATIBLE MATERIALS (CONT)

STORABLE FUELS (CONT)			
Service	Metals	Nonmetals	Lubricants
Unsymmetrical Dimethylhydrazine	Low carbon steels Aluminum Stainless Steel 300 series	Teflon Kel-F Butyl Rubber JM-76	*
Hydyne	Stainless Steels Nickel Monel Aluminum 1100, 5052-0	Teflon Polyethylene	*
RP-1	Most Metals	Neoprene Teflon Kel-F Buna-N Synthetics	*
Ethyl Alcohol	Most Metals	Polyvinyl Chloride Neoprene Rubber Kel-F Teflon Polyethylene Asbestos gasket material	*
PYROPHORIC FUELS			
Pentaborane	Aluminum 5052-S, 6061-T6, 7075-T6, 2024-T3, 3003-H14, 356-T6 Stainless Steel 18-8 Low carbon steel K-monel Monel M-8330-B Nickel Nichrome "V" Magnesium Fed QQ-M44A, Fed QQ-M-56-A263 Titanium C-130AM, C-110AM Copper Brass Hastelloy	Kel-F Kel-F-5500 Teflon Fluorosilicone Rubber Fluoroflex "T" Glass Viton "A" & "B" Dry Asbestos Garlock 230 Carbon	*

## COMPATIBLE MATERIALS (CONT)

PYROPHORIC FUELS (CONT)			
Service	Metals	Nonmetals	Lubricants
Triethylaluminum Triethylboron Triethylaluminum- boron	Stainless Steel Copper Iron	Glass Teflon Kel-F	*
SOLVENTS			
Acetone Freons Trichloroethylene	Stainless Steel 300 series Nickel Steel	Teflon Kel-F Polyethylene	*
<p>*For the proper lubricants to be used in this system check the appropriate process specification and/or specification drawing.</p> <p>**9 percent nickel limited to -320 F (LN<sub>2</sub>).</p>			

LIQUID PROPELLANT DEFINITIONS

Ambient

Condition of surrounding area. Thus ambient temperature or pressure is the prevailing temperature or pressure surrounding the object in question, usually room conditions.

Anhydrous

Containing no water.

Atmosphere

A unit of pressure equal to 14.7 psi at sea level.

Auto-Ignition Temperature

The lowest temperature at which a substance in contact with air (or other oxidizer if specified) will ignite spontaneously and continue to support combustion.

Boiling Point

The temperature at which the vapor pressure of a liquid becomes equal to the pressure of the ambient atmosphere. Boiling point varies with the pressure of the liquid.

Catalyst or Catalytic Agent

Any substance which, by virtue of its presence, affects the rate of a chemical reaction and which may be recovered practically unchanged at the end of the reaction.

Compatible

Having no undesirable effect with or upon another material under specified conditions of use.

Corrosive

A material which acts upon another material in such a way as to destroy or damage it permanently. Example: Acid destruction of the interior of a pipe or tubing installation.

Critical Pressure

The existing pressure at the critical temperature.

Critical Temperature

The highest temperature at which a gas can be liquefied without regard to the pressure applied.

Cryogenic Temperature

An arbitrary temperature of  $-238^{\circ}\text{F}$  ( $-150^{\circ}\text{C}$ ) that has been chosen as the upper limit of the critical temperature of cryogenic gases.

Decomposition

Separation of a propellant or solvent into two or more substances which can cause a rapid rise in system pressure.

Density

Concentration of material either liquid or solid, measured by the weight per unit volume.

Ductile

Able to stand deformation under a load without fracture. Also, pliant or flexible. In rocket testing we are concerned with the ability of certain materials to remain pliant or flexible at test temperatures.

Explosion

The sudden release of energy, usually in the form of large volumes of gas which exert pressure on the surrounding medium.

Explosive Limits

For vapors, defined as the upper and lower limits of vapor concentration that will propagate flame if ignited (synonymous with flammable limits). For suspensions of dusts and aerosols, defined as upper and lower weight concentrations per unit volume that will propagate fire.

Fire Point

Ignition temperature. The lowest temperature at which a flame is continuously supported over a liquid surface upon exposure to open flame.

Flammable

Combustible. A material which can be ignited.

Flammable Limits, Upper and Lower

Limits established by the richest and leanest mixtures of flammable gas and air that will support flame propagation upon ignition. They are expressed in terms of percentages of gas or vapor in air by volume (e. g., the flammable limits of gasoline are 6 percent to 1 percent and mixtures beyond these limits are too rich or too lean respectively, to support flame propagation).

## SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

### Flash Point

The minimum temperature at which the surface of a liquid may be momentarily ignited by an open flame.

### Freezing Point

The temperature at which a material changes from a liquid state to a solid state. The freezing point is slightly dependent upon pressure.

### Fuel

Any combustic material which can burn with an oxidizer.

### Hygroscopic

Capable of absorbing moisture from the air.

### Hypergolic

A term applied to describe self-ignition of a fuel and oxidizer upon contact with each other.

### Impervious

Impenetrable; pertaining to clothing which may be impenetrable to certain fluids, chemicals, etc.

### Inert

Incapable of producing a reaction. A material which will not burn or support combustion.

### Inhibit

To check or retard a chemical action.

### Liquid Propellant

A chemical in liquid form used as a fuel, oxidizer, or monopropellant to provide the combustion necessary for the production of thrust by a rocket engine.

### Liquid to Gas Ratio

A comparison of the volume of the liquid state of a material at its boiling point, to the volume of its gaseous state at standard temperature and pressure (59 F and 14.7 psia). Example: 1 cubic foot of liquid oxygen, at its boiling point, will evaporate into 862 cubic feet of gaseous oxygen at 59 F and one atmosphere. Therefore, the liquid to gas ratio is 1:862.

### Maximum Allowable Concentration

The maximum amount of a toxic gas or vapor that the body can stand for an 8-hour period in one day, for an indefinite number of days, without

## SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

causing any effect to health. It is expressed in parts per million (ppm), by volume, of the gas or vapor in air. The majority of rocket propellants are toxic by nature.

### Monopropellant

A single material, usually utilized with a catalyst to cause it to react for purposes of powering a rocket engine or some component thereof.

### Oxidizers (or Oxidizing Agents)

A chemical that will actively support combustion or oxidation of a fuel.

### Padding (or Blanketing)

Filling the void or ullage of a closed container with an inert gas (usually nitrogen) to prevent oxidation of the chemical contained therein, and to avoid the formation of flammable or explosive mixtures by excluding air from the container.

### Passivation

The treatment of metals to render them inert to the action of a particular chemical or mixture by the formation of an impervious film on the contact surface.

### psia

Pounds per square inch absolute (14.7 psia = 1 atmosphere at sea level; 0 psia = a complete absence of pressure or a vacuum).

### psig

Pounds per square inch gauge (0 psig = 1 atmosphere at sea level).

### Pyrophoric

Any fuel or other material which will ignite spontaneously upon contact with air.

### Pyrotechnic

A mixture of an oxidizing agent and solid fuel designed to produce light, heat or perform some other non-propulsive function. Usually used as igniters.

### Solid Propellant

A solid mixture consisting of a fuel and oxidizer cured in the form of a block or "grain" which fits into the combustion chamber of the rocket for the production of thrust.

Specific Gravity

The ratio of the weight of any volume of a substance to the weight of an equal volume of some substance taken as a standard or unit. Water is usually the standard for solids and liquids, and air for gases.

Stability

State of balance. A condition in which opposing forces exactly balance or equal each other. In rocket usage, thermal and shock stability are important. Thermal stability refers to a material's ability to remain stable when a change of temperature occurs, and shock stability refers to a material's ability to remain stable when subjected to shock.

Storable

Refers to liquid propellants which may be stored over a period of time at or near ambient conditions without chemical or physical change (i. e. , NTO, MMH, IRFNA, etc. ).

Threshold Limit Value (TLV)

Concentrations of airborne contaminants to which most workers can be exposed during working hours (that is, 8 hours a day, 5 days a week) for indefinite periods without adversely affecting their health; sometimes referred to as MAC (maximum allowable concentration).

Toxic

Poisonous, or causing poisoning.

Ullage

Unfilled space above the liquid in a container.

Specific Gravity-Vapor

Is the relative density of a vapor as compared with the density of air which is taken as 1. Example: Acetone vapor density is 2.00, air density is 1.00. Acetone vapors are twice as heavy as air.

Vapor Pressure

The pressure exerted by the evaporation of a liquid at any given temperature.

VIII. STAGE ELECTRICAL

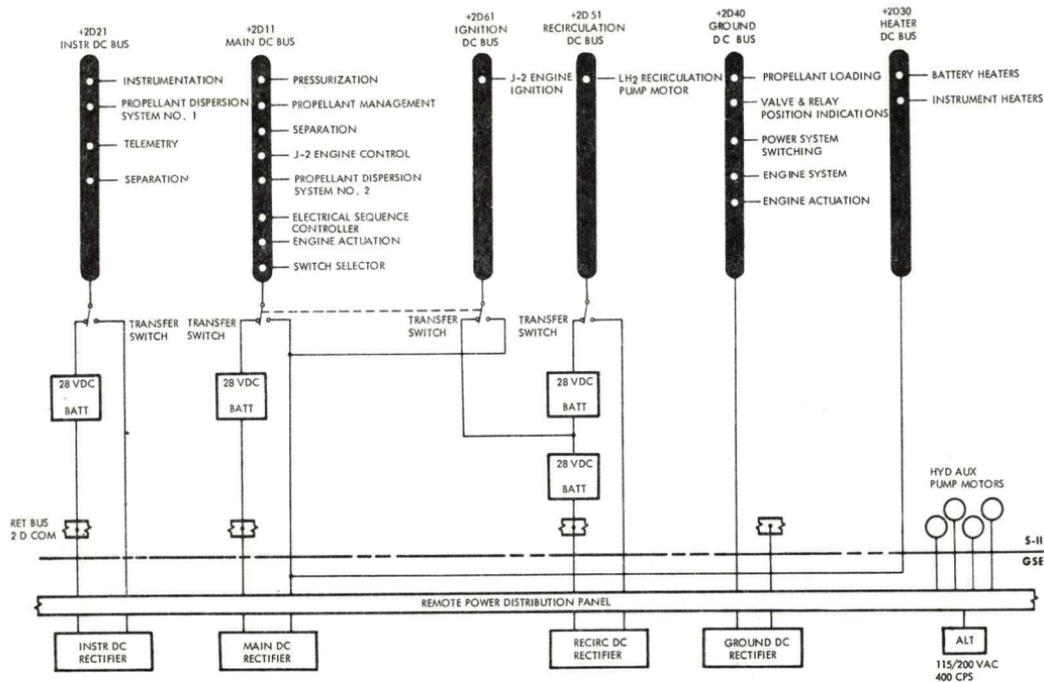
S-II STAGE ELECTRICAL POWER DISTRIBUTION SYSTEM

The electrical power distribution system consists of six stage-mounted dc buses. In addition, a ground ac bus system supplies 400-cps power to operate four auxiliary hydraulic pump motors. During ground checkout and operation of all stage subsystems, electrical power will be supplied to the stage buses from ground rectifier power. For flight, the electrical power system buses are powered from four 28-vdc batteries. Each battery employs 20 silver-zinc cells using a potassium hydroxide electrolyte.

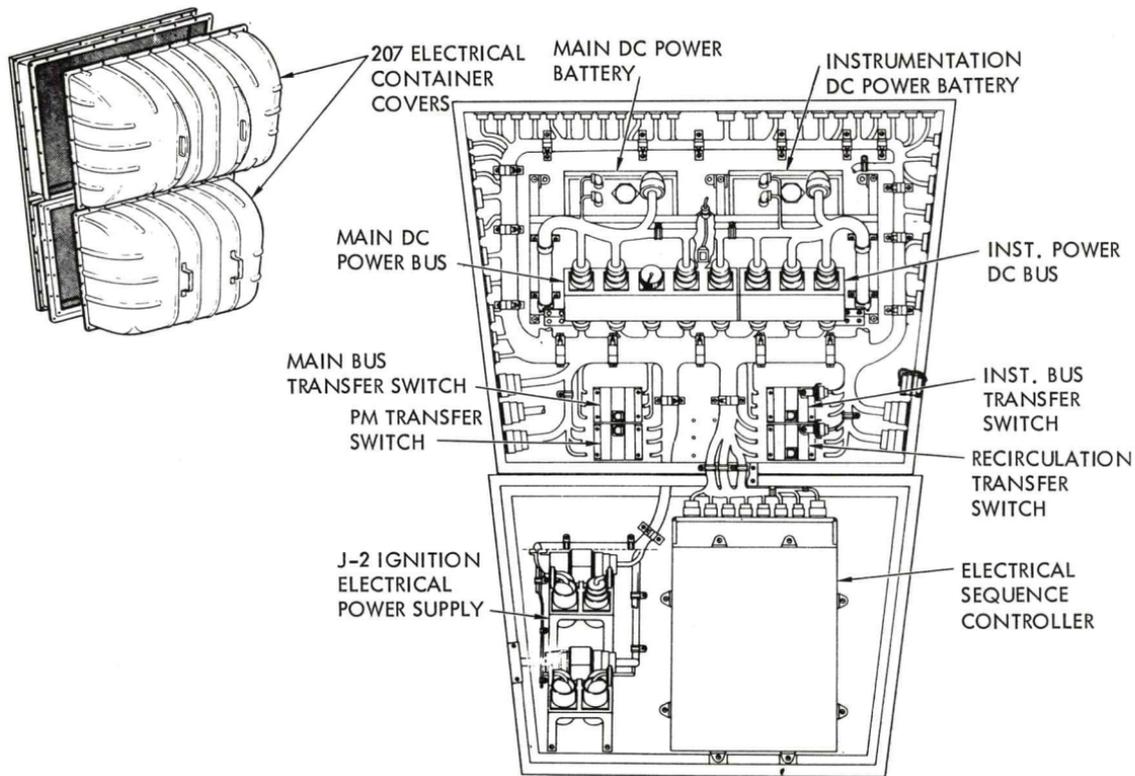
Two of the four batteries (main and instrumentation) are located inside of the 207A1 electrical container, which is mounted on the thrust structure between Engine 1 and Engine 2. The remaining two batteries (recirculation) are located in the S-II interstage; these two batteries will be ejected along with the interstage at second-plane separation

Motorized power transfer switches having a make-before-break action prevent power interruption during transfer from ground power to battery power. The transfer switches are located in the 207A1 electrical container.

# ELECTRICAL POWER DISTRIBUTION

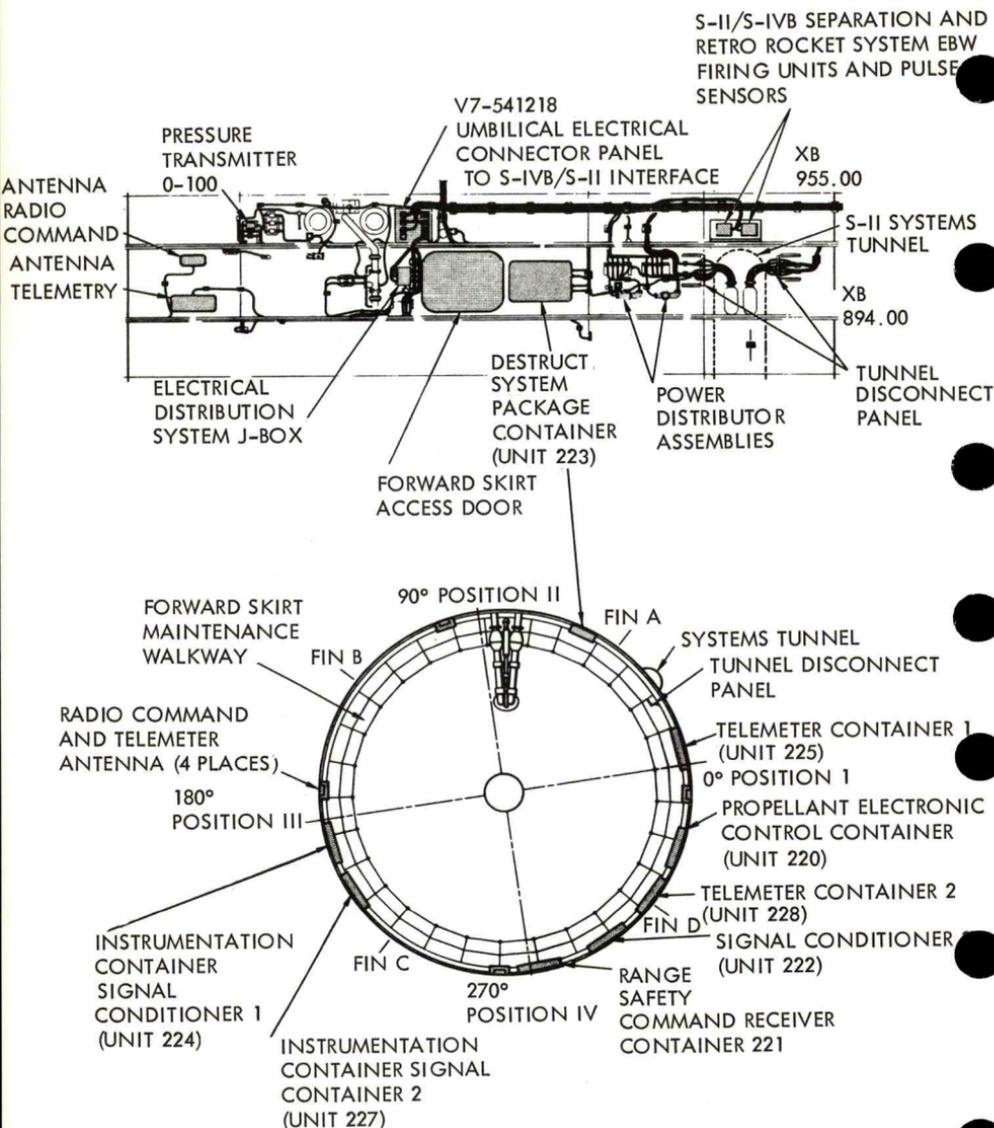


S-II ELECTRICAL CONTAINER 207

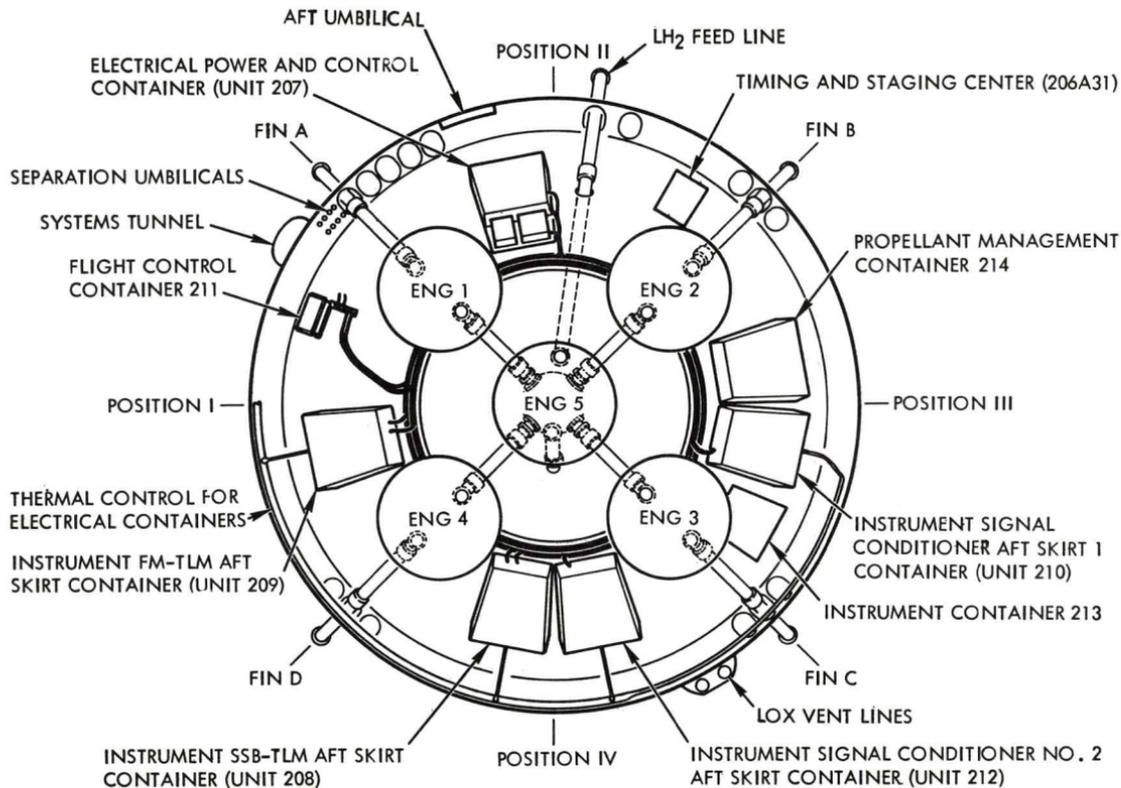


SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

SATURN S-II GENERAL ARRANGEMENT — FORWARD SKIRT



S-II AFT SKIRT ELECTRICAL CONTAINER LOCATION



VIII-5

S-II ELECTRICAL CONTROL SYSTEM

The electrical control system is a stage-mounted system designed to perform the following functions:

Control propellant fill valve solenoids for ground fill and detanking operations.

Sense tanked propellant mass and control propellant utilization valves.

Control propellant tank pressurization and vent valve solenoids for ground and flight operations.

Control hydraulic accumulator lock-up solenoid valves for ground and flight operation.

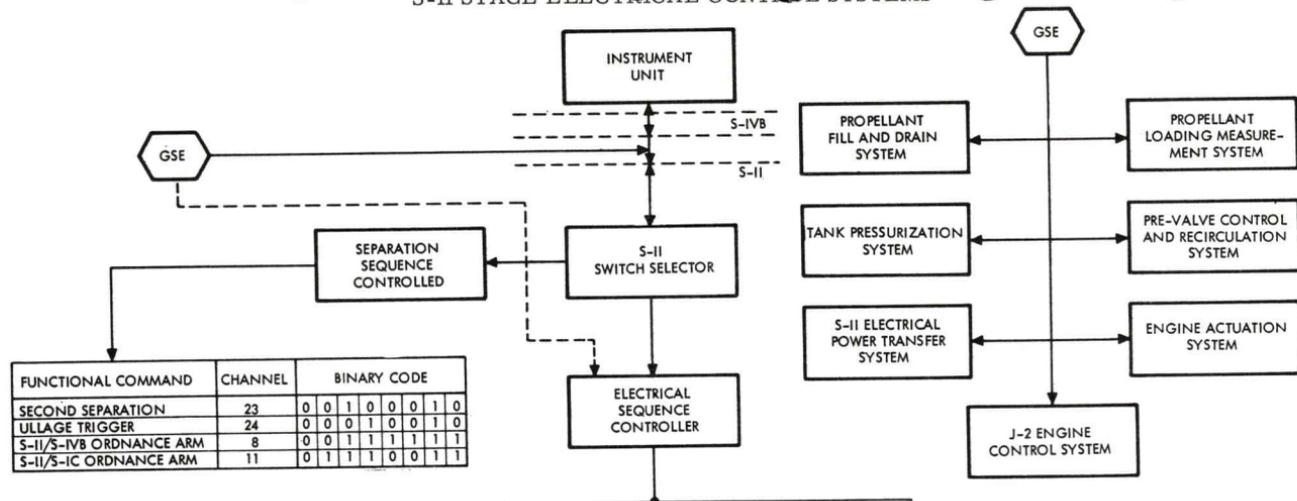
Control the fuel and oxidizer recirculation system for ground and flight operation.

Start and cutoff of the J-2 engine systems, monitor certain conditions of the engine systems, and either act on these conditions or transmit information to other systems for action.

Operation of the propellant prevalues in event of system malfunctions and during normal engine shutdown.

Stimuli for the electrical control system are provided from ground support equipment (GSE), propellant sensing transducers, the switch selector, the instrumentation unit, and the propellant dispersion system.

S-II STAGE ELECTRICAL CONTROL SYSTEMS

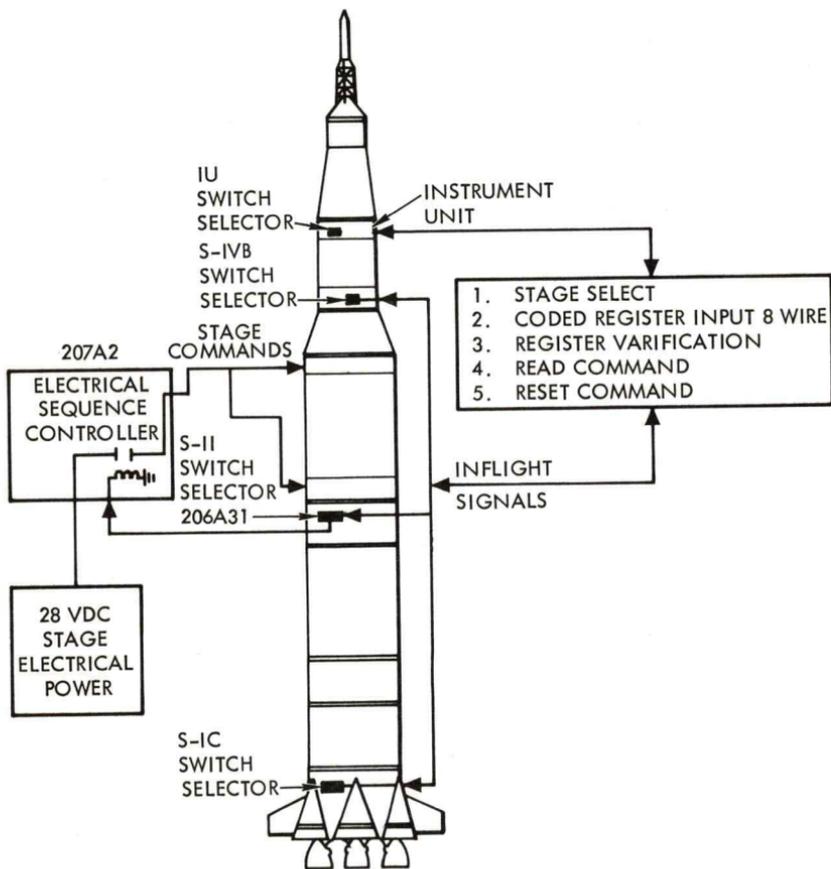


FUNCTIONAL COMMAND	CHANNEL	BINARY CODE
SECOND SEPARATION	23	0 0 1 0 0 0 1 0
ULLAGE TRIGGER	24	0 0 0 1 0 0 1 0
S-II/S-IVB ORDNANCE ARM	8	0 0 1 1 1 1 1 1
S-II/S-IC ORDNANCE ARM	11	0 1 1 1 0 0 1 1

FUNCTIONAL COMMAND	CHANNEL	BINARY CODE							
		DIGIT 8	DIGIT 7	DIGIT 6	DIGIT 5	DIGIT 4	DIGIT 3	DIGIT 2	DIGIT 1
LOX STEP PRESSURIZATION	14	0	0	0	0	1	1	0	1
ENGINE START COMMAND	33	0	0	0	1	1	1	0	0
STOP SSB NO. 2 CALIBRATION	70	0	1	1	0	1	1	0	0
START SSB NO. 2 CALIBRATION	28	0	1	1	1	1	1	0	1
STOP SSB NO. 1 CALIBRATION	46	0	1	0	0	0	0	1	0
S-II/S-IVB SEPARATION	5	0	0	0	0	0	0	1	0
LH <sub>2</sub> DEPLETION ENGINE CUTOFF ARM	42	0	1	0	1	1	1	1	0
START PHASE LIMITER RESET	6	0	0	1	0	1	1	0	1
LH <sub>2</sub> STEP PRESSURIZATION	7	0	0	0	1	1	1	0	1
ENGINES CUTOFF-COMMAND	18	0	0	1	1	0	0	1	1
RECIRCULATION STOP	48	0	0	1	0	1	1	0	0
START SSB NO. 1 CALIBRATION	105	0	1	0	0	1	1	0	0
STOP PAM-FM/FM CALIBRATION	9	0	0	0	1	0	0	1	1
START PHASE LIMITER	25	0	0	1	1	1	1	0	1
PREVALVES CLOSE ARM COMMAND	99	0	1	0	1	0	1	1	0

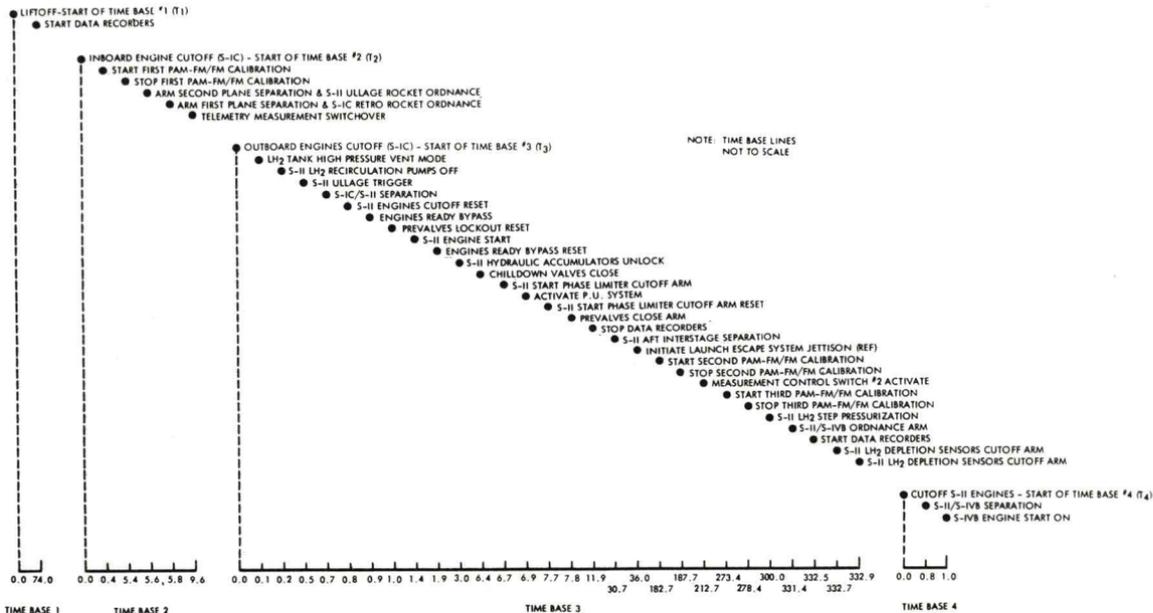
FUNCTIONAL COMMAND	CHANNEL	BINARY CODE
CHILDDOWN VALVES CLOSE COMMAND	88	0 1 0 0 1 1 1 0 0 0
HYDRAULIC ACCUMULATORS UNLOCK	12	0 1 0 0 0 1 1 0 1 0
LOX DEPLETION ENGINE CUTOFF ARM	3	0 1 1 0 0 0 0 0 1 0
START PAM-FM/FM CALIBRATION	30	0 0 0 0 0 0 0 0 1 1
START RECORDERS	71	0 0 0 0 1 0 1 1 1 1
STOP RECORDERS	104	0 1 1 1 0 1 1 1 1 1
START TIMER (RECORDER)	66	0 0 1 0 0 1 0 0 1 1
MEAS. SWITCH NO. 2 ACTIVATE	90	0 0 1 0 0 0 1 1 1 1
P. U. ACTIVATE	32	0 1 0 0 0 0 0 1 1 1
PRE-VALVE LOCKOUT RESET	19	0 1 0 1 0 0 0 1 1 0
ALL ENGINE CUTOFF RESET	31	0 0 1 0 0 0 0 0 1 1
ENGINE READY BYPASS COMMAND	20	0 1 1 0 1 1 1 1 0
ENGINE READY BYPASS RESET	49	0 0 0 0 0 1 1 0 0 0
LH <sub>2</sub> TANK HIGH PRESSURE VENT MODE	38	0 0 1 1 1 0 0 0 0 1

SWITCH SELECTOR INTERFACE



# TYPICAL FLIGHT SEQUENCE

- STAGE EXTERNAL POWER ON
- PURGE STAGE EQUIPMENT CONTAINERS
- AUXILIARY HYDRAULIC PUMP ON & PROPELLANT TANK CHILLDOWN
- PROPELLANT LOADING
- START FUEL & OXIDIZER RECIRCULATION
- LOCKUP HYDRAULIC ACCUMULATORS
- TRANSFER TO INTERNAL BATTERIES



## EMERGENCY DETECTION SYSTEM

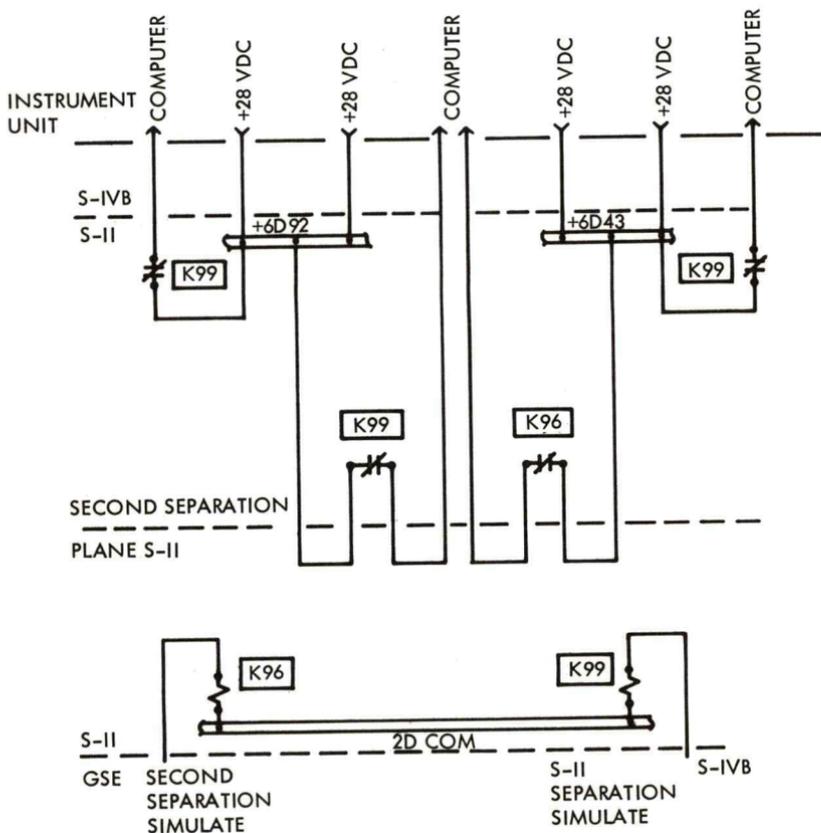
The emergency detection system (EDS) is designed to be compatible and integral with the electrical control subsystem. It provides for the following stage functions:

Redundant all-engine cutoff signals from the IU.

Transmits redundant mainstage OK signals to the IU.

Transmits redundant S-IC/S-II, interstage, and S-II/S-IVB separation indications to the IU.

Transmits of S-IC EDS information through the S-II to the IU.

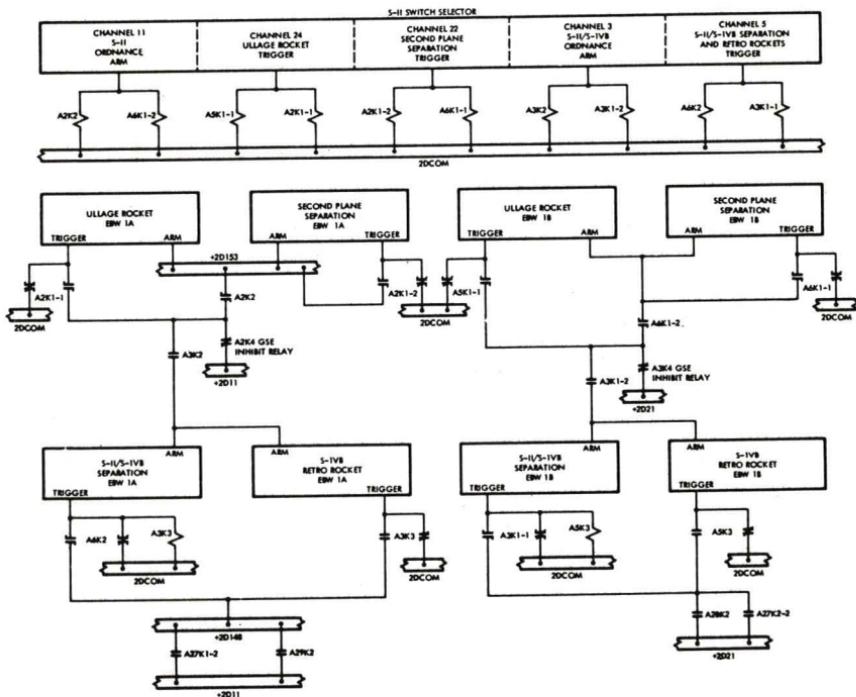


## SEPARATION SYSTEM

After liftoff, the S-II separation system is armed through sequencing stimuli from the IU to the S-II switch selector.

At time of S-IC engine cutoff, the S-II switch selector will trigger sequence firing of the four ullage rockets on the S-II interstage. Immediately after the ullage rockets are ignited, the S-IC switch selector will trigger first-plane separation at Station 0. Approximately 30 seconds after first-plane separation, the S-II switch selector will sequence second-plane separation at Station 196. At S-II engine cutoff, the S-II switch selector will sequence S-II/S-IVB separation and fire the S-IVB retrorockets.

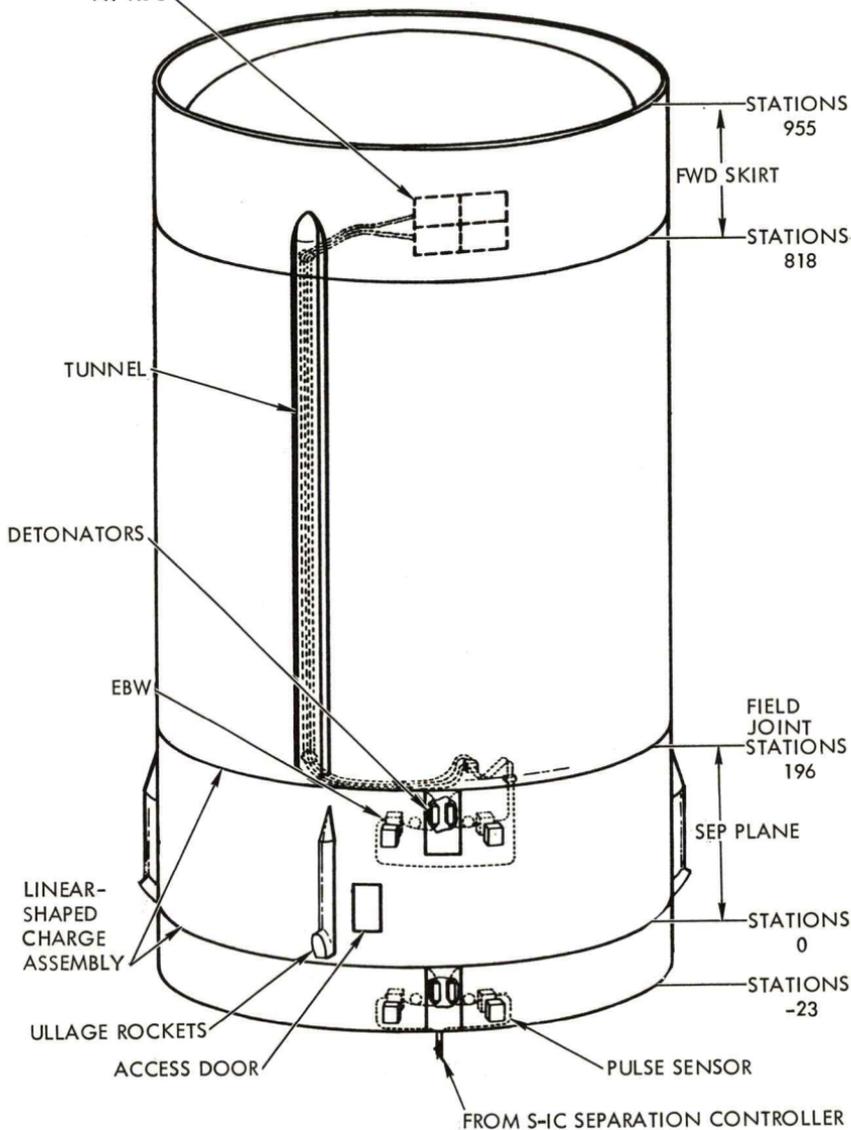
(MCR5084 - S-II-3 &amp; SUBS)



SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

S-II SEPARATION SYSTEM COMPONENT LOCATION

S-IVB SEPARATION SYSTEM  
 EBW AND PULSE SENSORS  
 MOVED TO S-IVB INTERSTAGE  
 AT KSC



# SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

## PROPELLANT DISPERSION SYSTEM

### GENERAL

The function of the S-II propellant dispersion system is to provide thrust termination, safe ejection of payload, and propellant dispersion.

The propellant dispersion system consists of two parallel and identical subsystems.

In the event of a mission abort, the range safety officer will initiate the propellant dispersion sequence. A tone code-modulated RF signal arming the system will be transmitted. This will be followed, after a minimum delay of three seconds, by the propellant dispersion command.

The ARM command is intercepted by the antenna and routed through the signal distribution assembly to the range safety receivers and decoded. The ARM signal is sent to the range safety controller which applies power to the exploding bridge wire (EBW) firing units. This allows a capacitor in the firing unit to charge. After a minimum of three seconds, the propellant dispersion command is received, decoded, and sent to the controller. At this point, a trigger signal is sent to the EBW firing unit. This discharges the capacitor, producing a large amount of current. This current passes through the EBW detonator, igniting the confined detonation fuse (CDF), and then passes through the safe/arm device, setting off the explosive charges. The charges for both tanks cause the skin to rupture, thereby dispersing the propellants into the atmosphere.

In order to minimize the possibility of an explosion during the propellant dispersion sequence, the propellants are dispersed from opposite sides of the vehicle.

### LH<sub>2</sub> TANK PROPELLANT DISPERSION ASSEMBLY

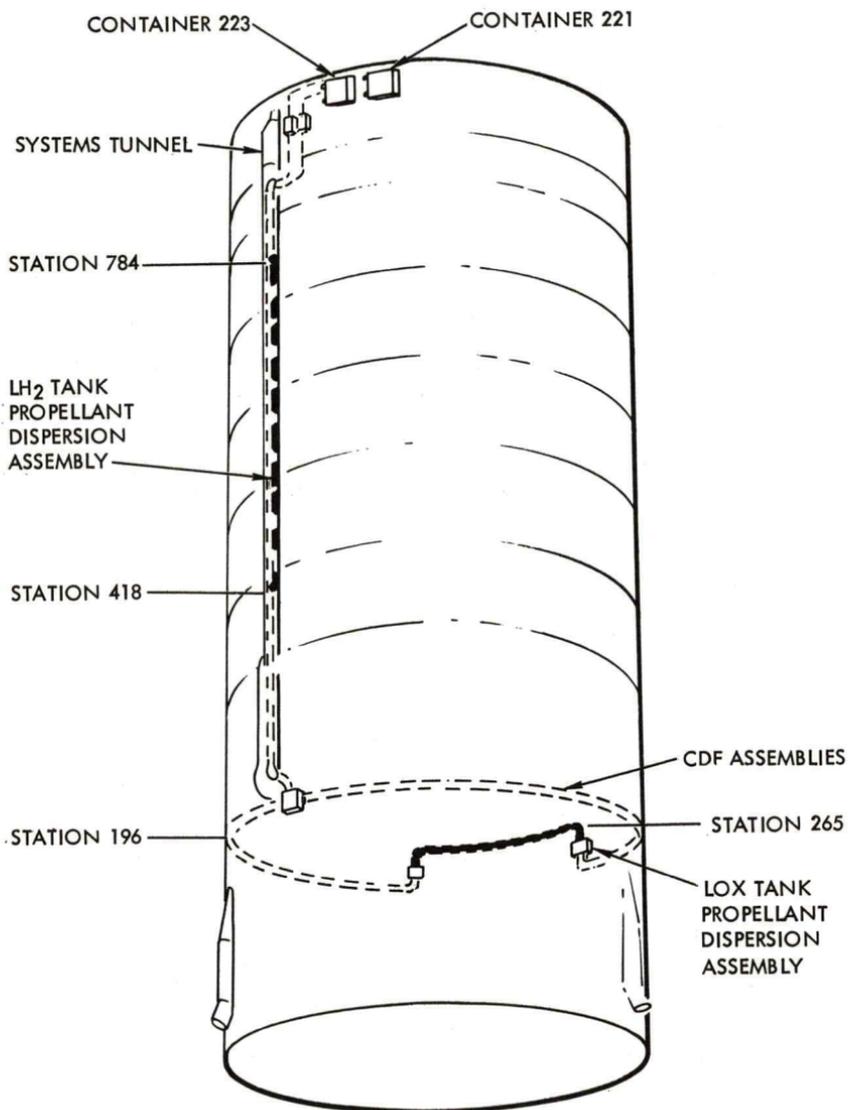
The LH<sub>2</sub> tank propellant dispersion will be accomplished by the explosion of a linear-shaped charge mounted vertically on the LH<sub>2</sub> tank and enclosed in the systems tunnel (Stations 418 to 784). The charge assembly is 30.5 feet long, and contains 450 grains of explosive per foot.

### LO<sub>2</sub> TANK PROPELLANT DISPERSION ASSEMBLY

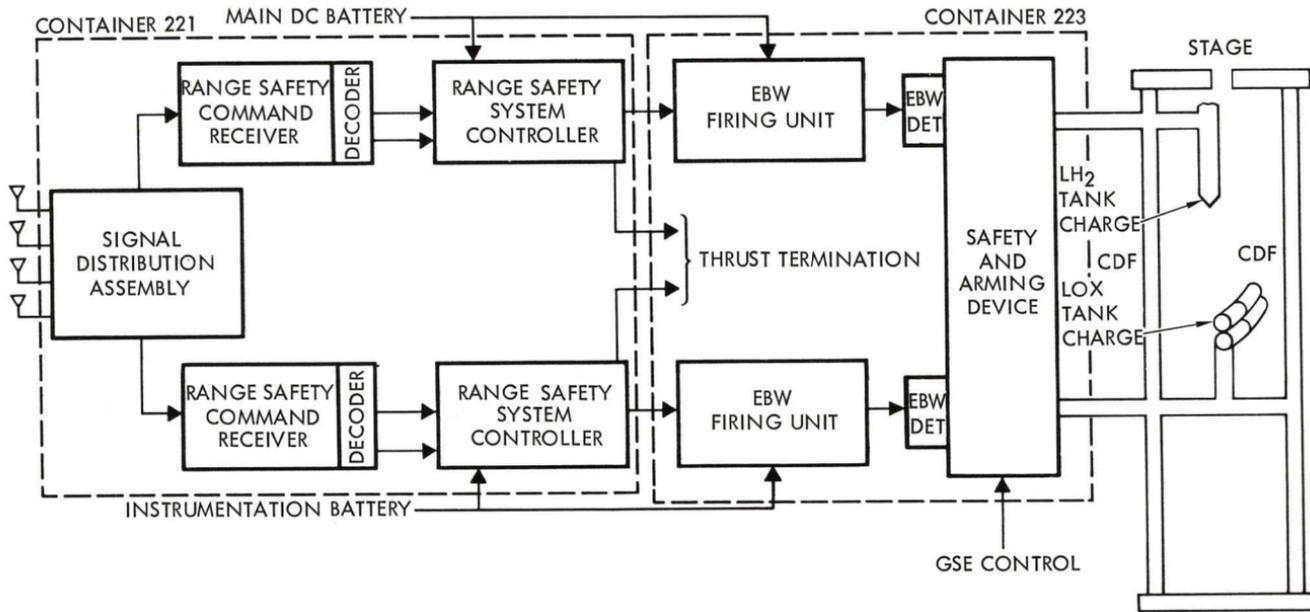
The LO<sub>2</sub> tank propellant dispersion will be accomplished by the explosion of a tubular charge (RDX granular\*) mounted on the aft skirt (Station 196-240) and positioned 0.25 inches from the LO<sub>2</sub> tank skin. The charge assembly, 20 feet in length, is constructed of aluminum tubing with plastic sleeving. It contains 800 grains of explosive per foot. Two lengths, mounted one above the other, are designed to produce a 20-foot gash in the LO<sub>2</sub> tank as well as the skirt.

\*RDX is the explosive Cyclonite

PROPELLANT DISPERSION SYSTEM LOCATIONS



PROPELLANT DISPERSION SYSTEM BLOCK DIAGRAM

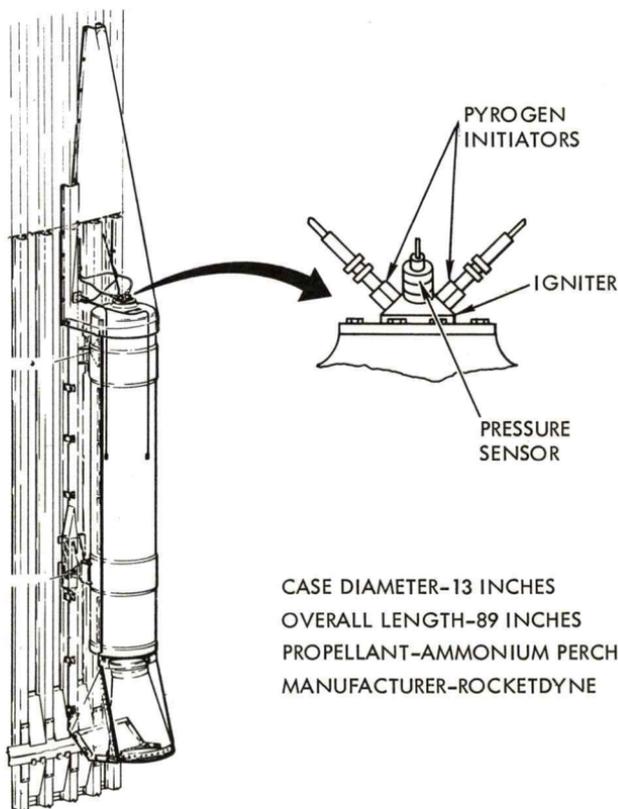


VIII-15

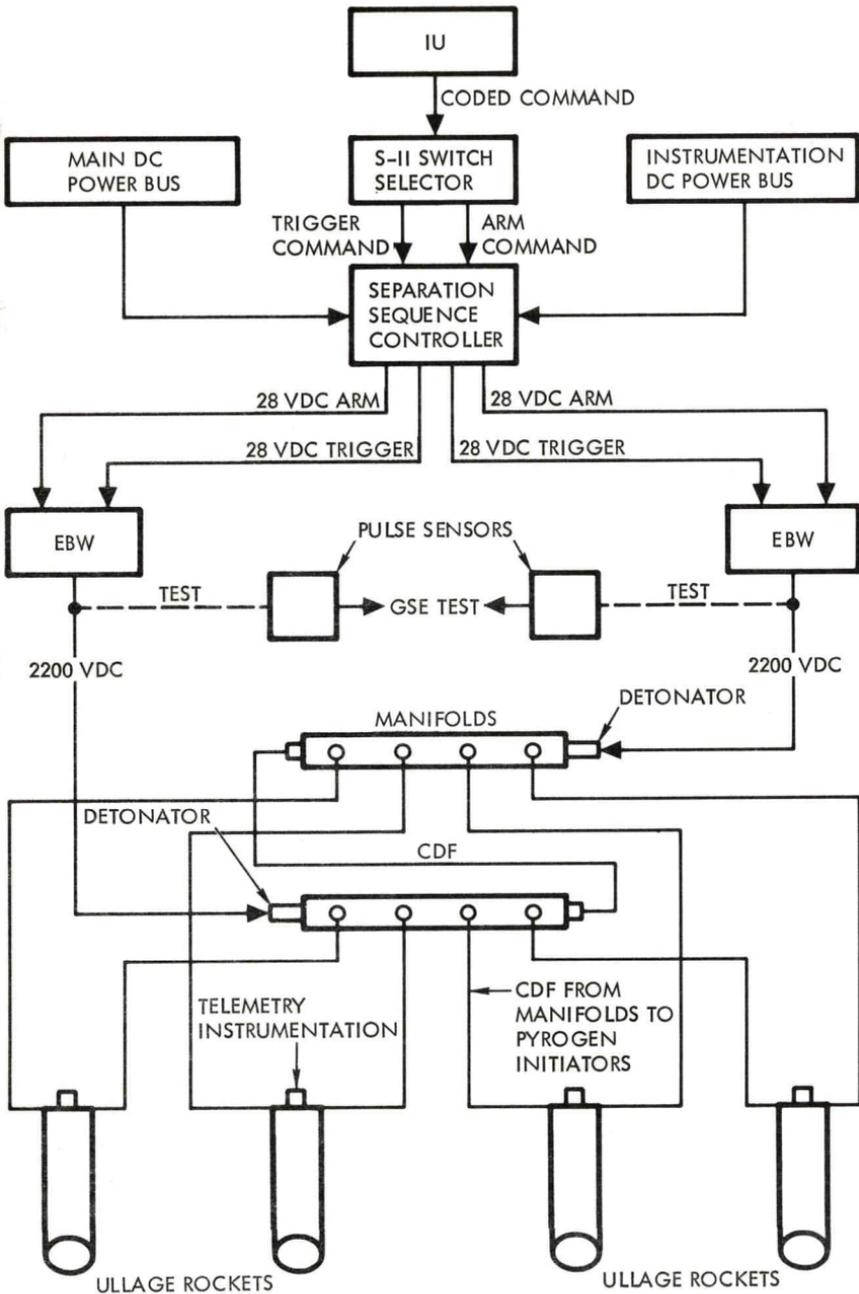
## ULLAGE MOTORS

The solid propellant ullage motors are used to provide artificial gravity by momentarily accelerating the second stage forward after first stage burnout. This moment of forward thrust is required in the weightless environment of outer space to make certain that the liquid propellant is in proper position to be drawn into the pumps before the start of the second stage engines.

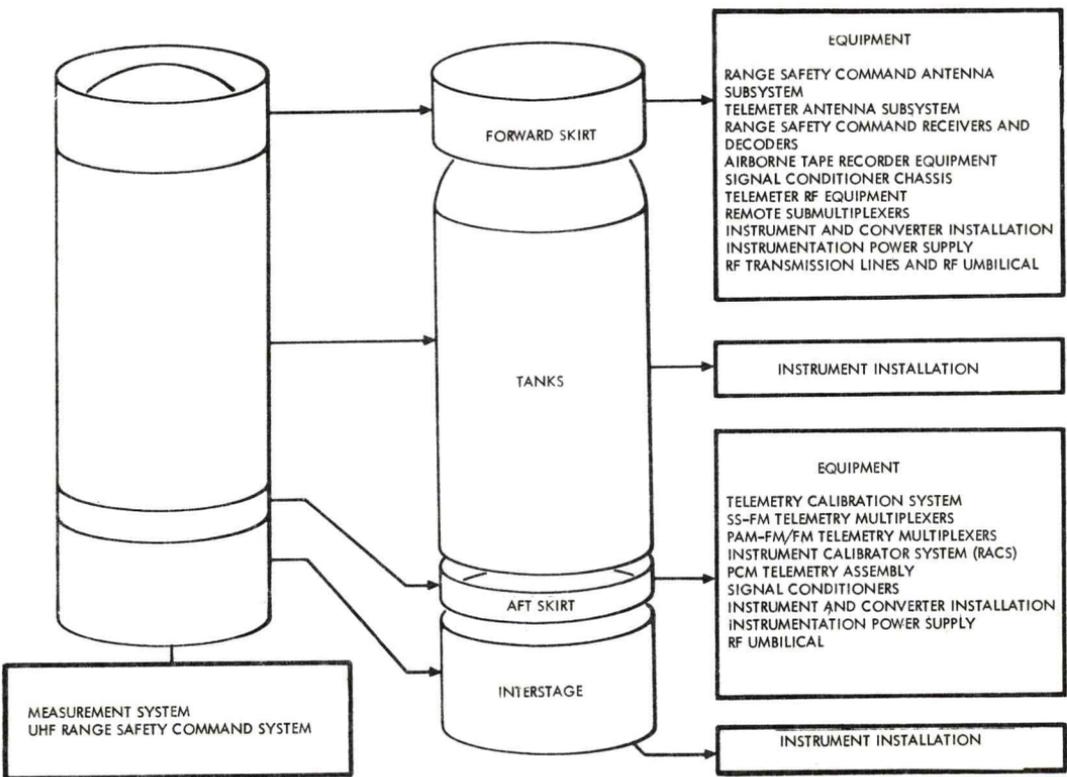
The four ullage motors are used on the stage where they are attached around the periphery of the interstage structure between the first and second stages. Each ullage motor measures 12.5 inches in diameter and 89 inches long. Each motor provides 22,500 pounds of thrust for approximately four seconds. The motors use Flexadyne solid propellant in a formulation developed specifically to provide high performance and superior mechanical properties under operating conditions encountered in space. Ullage motor nozzles are canted 10 degrees to reduce exhaust impingement against the interstage structure.



ULLAGE MOTOR BLOCK DIAGRAM



INSTRUMENTATION SYSTEMS LOCATIONS  
(MEASUREMENT AND RF)



## TELEMETER SUBSYSTEM

Several telemetry subsystems are provided in the S-II stage to multiplex the transducer and signal conditioner outputs for subsequent modulation of carriers and transmission to the ground. Three basic types of telemetry subsystems are used: PAM-FM/FM and PCM/FM for airborne telemetry measurements of relatively low frequency, SS-FM for airborne telemetry measurements of relatively high frequency, and PCM/DDAS (PCM/FM) measurements, with coaxial cable transmission for automatic checkout of the S-II stage.

## Telemetry Channels for S-II-6 and Subsequent Stages

Telemetry Subsystem	Continuous Channel Capability
I FM/FM	14
II FM/FM	14
III PCM/FM and PCM/DDAS	Time-shares and encodes outputs of two model 270 TDM's, and time-shares digital words.

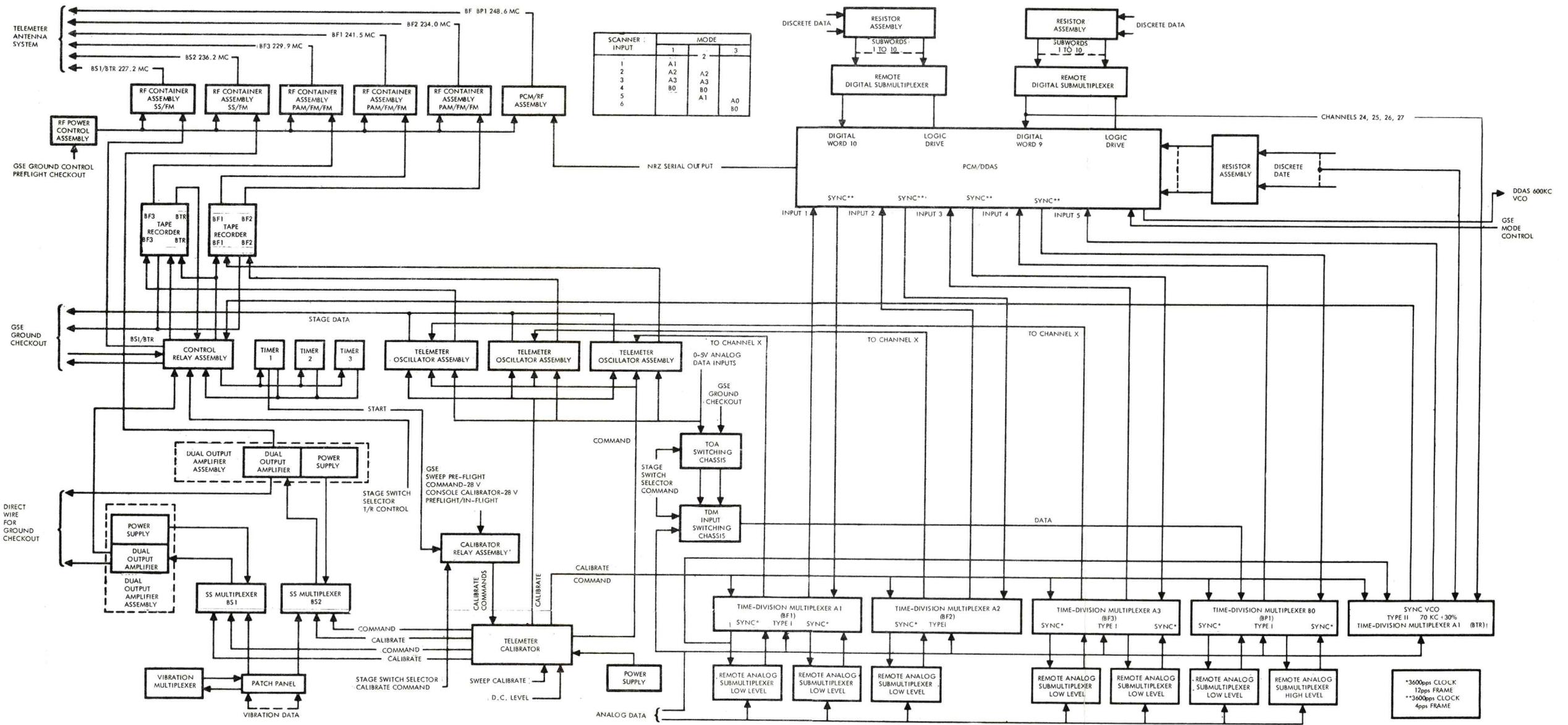
## PAM-FM/FM TELEMETRY

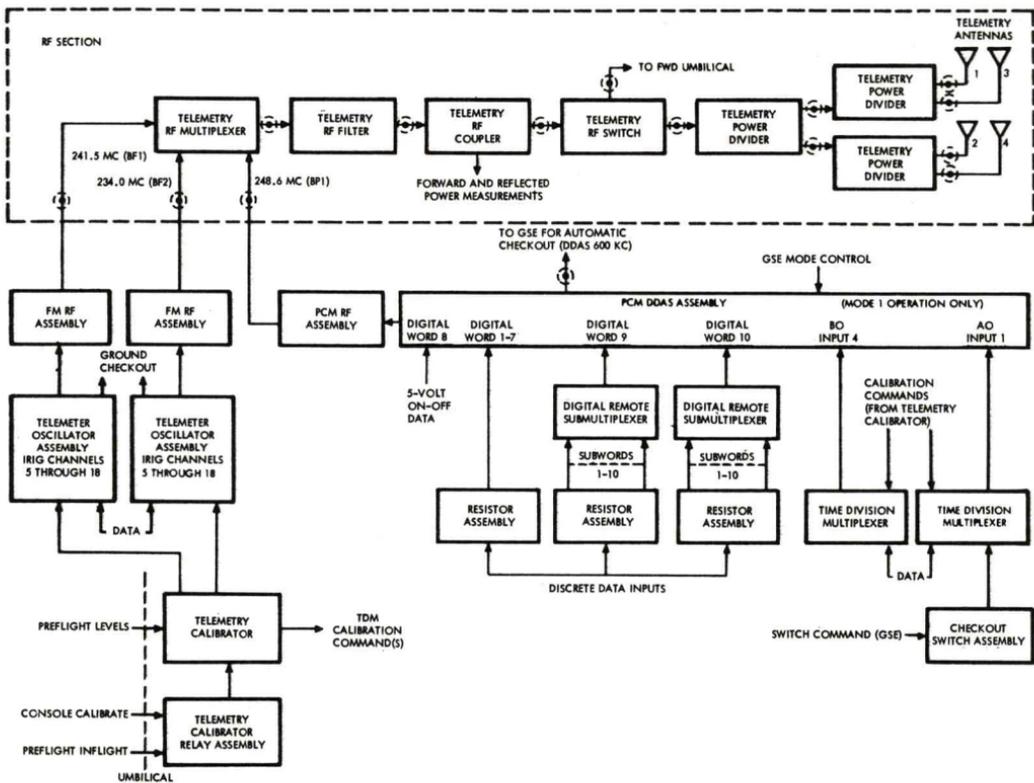
Three RF links in the 225- and 260-mc band carrying PAM-FM/FM telemetry are being used for the S-II.

## PCM/FM AND PCM/DDAS TELEMETRY

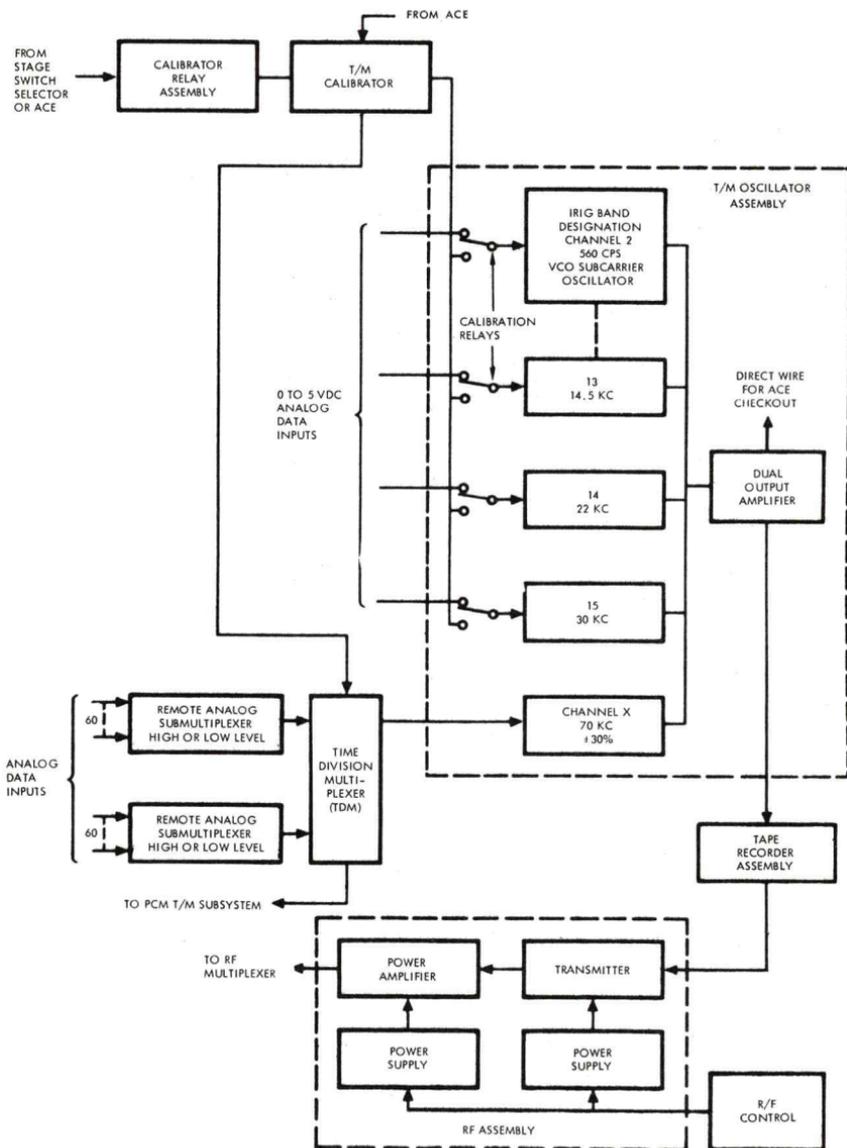
This subsystem is a PCM/FM telemetry with two outputs that simultaneously carry the same information. One output is a 600-kc carrier FM-modulated by the PCM wavetrain. The equipment necessary to produce this output is the stage portion of the PCM/DDAS and is used in automatic checkout of the stage and its systems. The second output is a VHF carrier FM-modulated by the PCM wavetrain. The equipment necessary to produce this output is the PCM/FM telemetry.

TELEMETER SYSTEM BLOCK DIAGRAM  
(S-II-1 THROUGH S-II-5)

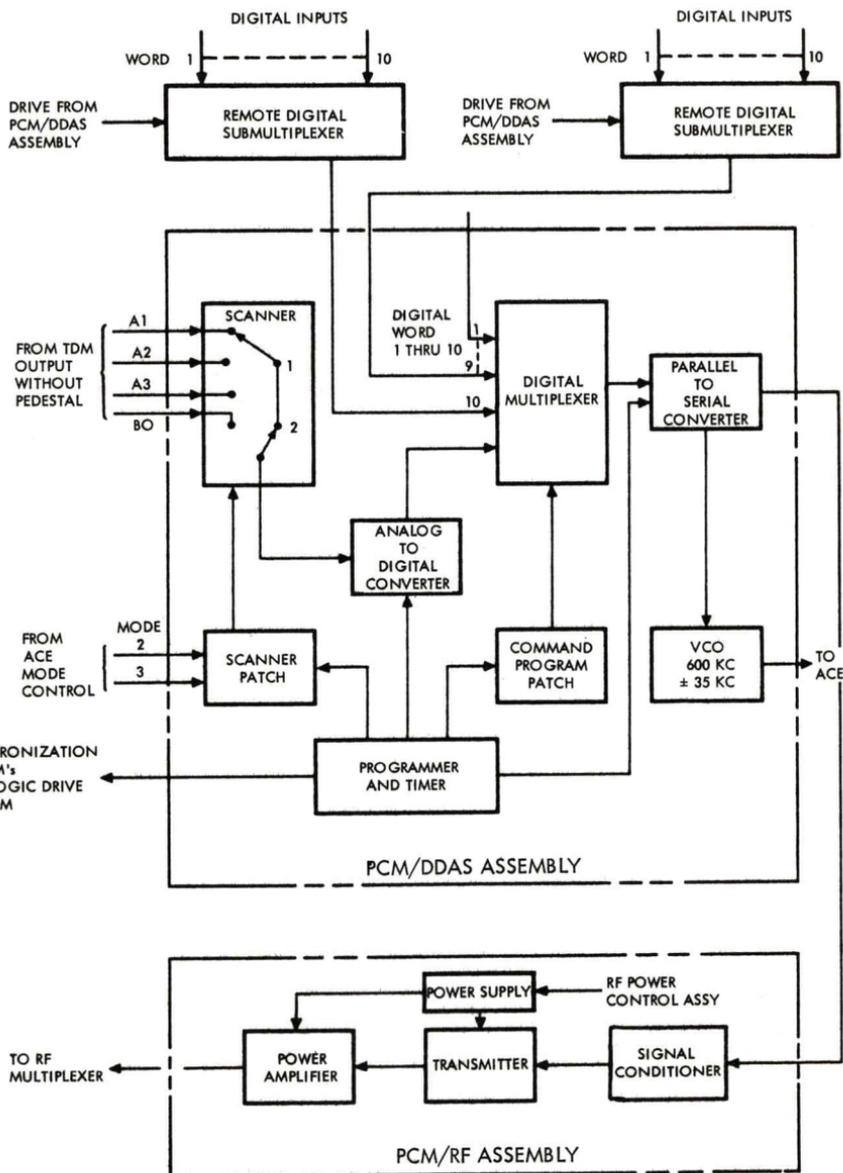


TELEMETRY SYSTEM BLOCK DIAGRAM FOR S-II-6  
AND SUBSEQUENT STAGES

PAM-FM/FM TELEMETER SUBSYSTEM—  
TYPICAL BLOCK DIAGRAM



PCM TELEMETER SUBSYSTEM—TYPICAL  
BLOCK DIAGRAM



## MEASUREMENTS

General measurement implementation of the S-II stage is illustrated on the following page. This table indicates typical measurements according to measured variable categories. The letter designation and order of each measurement classification category is that of the IPCL\* format. The designating letter precedes the first digit of each identifying measurement number in the IPCL. Entries in the columns opposite each measured variable category show the transducer operating principle, primary and secondary signal conditioning, signal characteristics at the data acquisition/transmission interface, availability of RACS, and typical telemetry subsystems utilized.

## MEASUREMENTS BY STAGES

Beginning with S-II-6 systems, a reduction in the number of stage measurements is planned as flights increase confidence in stage design and reliability. The measurements for stages S-II-1 through S-II-5 are those required for gross malfunction analysis and prelaunch checkout operations in addition to those required to assist in design evaluation or support special problem investigations. The only measurements planned for the S-II-6 and subsequent stages are those considered necessary for gross malfunctions and prelaunch checkout analysis. Measurements quantities for S-II stages are listed by measured variables in a subsequent table.

## TELEMETRY MEASUREMENTS FOR S-II STAGES

Type	Stage Number					
	S-II-1	S-II-2	S-II-3	S-II-4	S-II-5	S-II-6 and Subsequent
Acceleration	8	11	11	11	11	4
Acoustic (sound pressure level)	5	5	5	5	5	
Temperature	326	321	321	320	320	83
Pressure	203	197	201	186	186	104
Vibration	60	60	60	60	60	
Flow	10	10	10	10	10	10
Position	36	36	36	36	36	36
Discretes	228	230	226	226	226	226
Liquid level	6	6	6	6	6	4
Electrical parameter	63	63	60	59	59	33
Telemeter power	4	4	4	4	4	2
Angular velocity	3	3	3	3	3	
Strain	16	16	16	16	16	
Revolutions per minute	10	10	10	10	10	10
Total	978	972	969	952	952	512

\*IPCL—Instrumentation program and components list

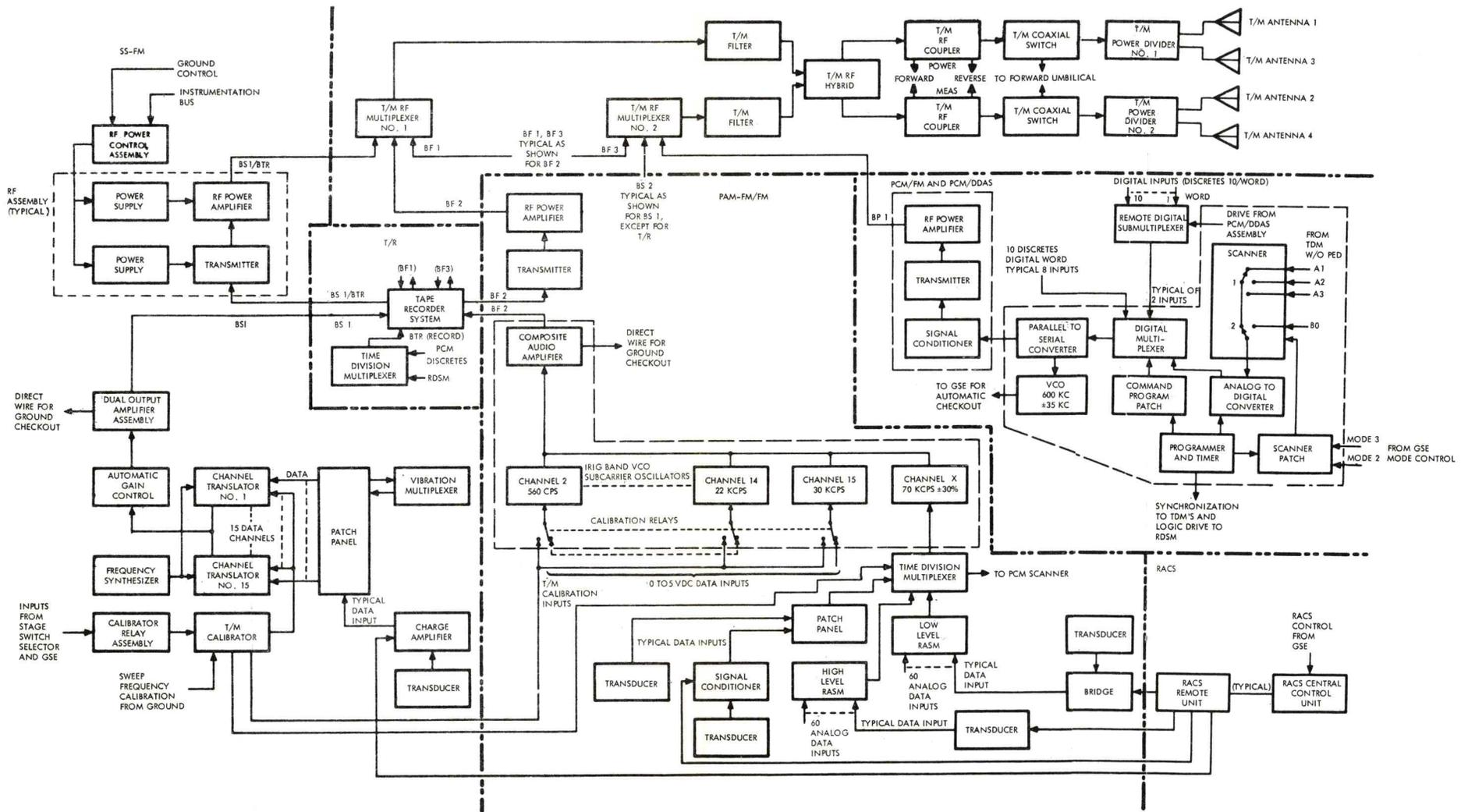
## SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

## MEASUREMENT IMPLEMENTATION BY MEASUREMENT CATEGORIES

MEASUREMENT CLASSIFICATION	TYPE/FUNCTION	TRANSDUCER TYPE	SIGNAL CONDITIONING		TELEMETRY INPUT SIGNAL	RACS	TYPICAL TELEMETRY
			PRIMARY	SECONDARY			
A ACCELERATION	BODY MODAL	DC/DC STRAIN GAUGE	DEMODULATOR IN TRANSDUCER	REGULATED AC PWR SOURCE IN TRANSDUCER	2.5k2.5 VOLT LOW AUDIO	YES	FM/FM AND PCM/FM
	STAGE LONGITUDINAL	DC/DC SERVO FORCE BALANCE	SERVOAMPLIFIER IN TRANSDUCER	REGULATED PWR SOURCE INTEGRAL WITH TRANSDUCER	0-5 VDC COARSE AND AND FINE RANGES	YES	FM/FM AND PCM/FM
B ACOUSTIC	EXTERNAL AERO-DYNAMIC INTERNAL SOUND PRESSURE	PIEZOELECTRIC	CHARGE AMPLIFIER		2.5k2.5 VDC AUDIO	YES	SS/FM CONTINUOUS
		PIEZOELECTRIC	CHARGE AMPLIFIER	ACOUSTIC CONDITIONER ±28 VDC REG POWER	0-5 VDC PROPORTIONAL TO TRUE RMS LEVEL	YES	PAM/FM/FM AND PCM/FM
C TEMPERATURE	PROBE AND SURFACE	PLATINUM WIRE	ASYMETRICAL BRIDGE	+10 -1 VDC REG POWER SUPPLY ±28 VDC REG POWER SUPPLY	0-100 MV OR 0-500 MVDC	YES	PAM/FM/FM AND PCM/FM
	PROBE HIGH-RANGE PROBE HEAT FLUX	PLATINUM WIRE THERMOCOUPLE SPECIAL DUAL THERMOCOUPLE	BRIDGE IN PROBE REF JUNCTION	DC AMPLIFIER DC AMPLIFIER	0-5 VDC 0-5 VDC	NO YES YES	
D PRESSURE	ABSOLUTE AND DIFF	POTENTIOMETER AND BOURDON TUBE OR CAPSULE	INTEGRAL WITH TRANSDUCER	5 VDC REG POWER SUPPLY	0-5 VDC	NO	FM/FM CONTINUOUS
	ABSOLUTE AND DIFF	BONDED STRAIN GAUGE	INTEGRAL WITH TRANSDUCER	INTEGRAL POWER SUPPLY	0-5 VDC	YES	PAM/FM/FM PCM/FM
	ABSOLUTE AND DIFF (VERY-LOW-PRESSURE)	DIAPHRAGM AND DIFFERENTIAL CAPACITOR	INTEGRAL WITH TRANSDUCER	INTEGRAL POWER SUPPLY	0-5 VDC		
E VIBRATION	EQUIPMENT/STRUCTURAL	PIEZOELECTRIC CRYSTAL	CHARGE AMPLIFIER		2.5k2.5 VDC	YES	SS/FM CONTINUOUS MULTIPLEXED
F FLOW	PROPELLANT FLOW	TURBINE FLOW METER	WAVE SHAPING AND AMPLIFICATION MODULE	SIGNAL MIXER* ±28 VDC REG POWER	BINS 3 V -2.5 V PULSE DUAL PULSE TRAIN (SEE RPM)	YES	FM/FM CONTINUOUS
G POSITION	HYD FLUID VOLUME	DIFFERENTIAL TRANSFORMER	DEMODULATOR INTEGRAL WITH TRANSDUCER	INTEGRAL POWER SUPPLY	0-5 VDC	NO	PAM/FM/FM AND PCM/FM
	VALVE POSITION	POTENTIOMETER		5 VDC REG POWER SUPPLY	0-5 VDC	NO	
K DISCRETES	0 OR 28 VDC	NONE	NONE		0 OR 28 VDC	NO	PCM/FM
L LIQUID LEVEL	PROPELLANT LEVEL	POINT SENSORS AND CAPACITANCE PROBE	PJ SYSTEM COMPUTER		0-5 VDC	NO	PCM/FM
M ELECTRICAL PARAMETERS	BATTERY CURRENT	MAGNETIC AMPLIFIER	INTEGRAL WITH TRANSDUCER	±28 VDC REG POWER	0-5 VDC	YES	PAM/FM/FM PCM/FM
	28/56 VDC VOLTAGES 400 CPS FREQUENCY		VOLTAGE ATTENUATORS FREQUENCY CONVERTER	±28 VDC REG POWER	0-5 VDC 2.5k2.5 VDC FREQ DEVIATION	NO YES	FM/FM
N MISC ANALOG SIGNALS					0-5 VDC	NO	
R ANGULAR VELOCITY	VEHICLE/STAGE RATE-OF-TURN	RATE GYRO	INTEGRAL WITH TRANSDUCER		2.5k2.5 VDC	YES	FM/FM AND PCM/FM
S STRAIN	FORWARD SKIRT STRUCTURAL STRAIN	STRAIN GAUGE	BRIDGE MODULE	DC AMPLIFIER	0-5 VDC	YES	PCM/FM
T RPM	PROPELLANT PUMP TURBINE SPEED	ELECTROMAGNETIC PICKUP	WAVE SHAPING AND PULSE DIVISION	±28 VDC REG POWER	BIAS 3 V ±1.5 PULSE DUAL PULSE TRAIN	YES	FM/FM CONTINUOUS*

\*FLOWMETER AND CORRESPONDING PUMP SPEED SIGNALS ARE MIXED (IN A COMMON SIGNAL MIXER) TO FORM A DUAL (POSITIVE AND NEGATIVE) PULSE TRAIN FED TO A SINGLE TLM CHANNEL.

S-II MEASUREMENT SUBSYSTEMS  
 TYPICAL SIGNAL FLOW DIAGRAM  
 (S-II-1 THROUGH S-II-5)

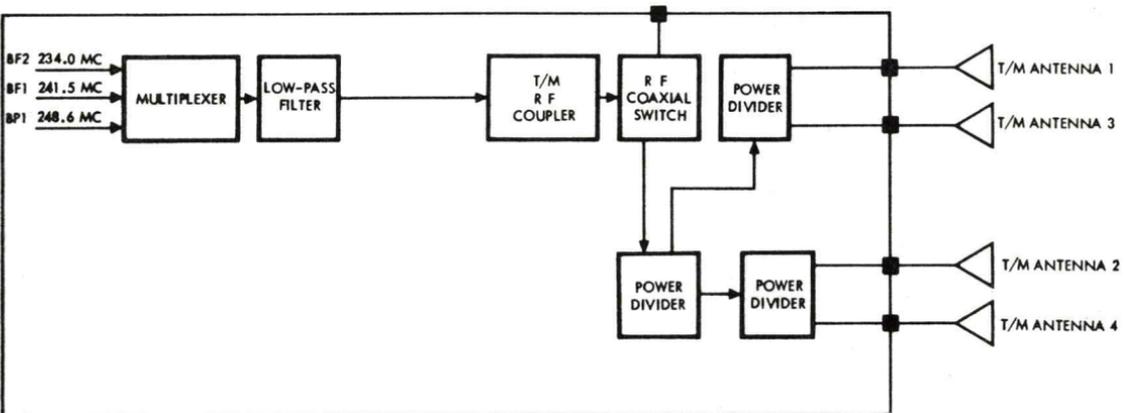


## ANTENNA SUBSYSTEM

The antenna subsystem accommodates six telemetry carriers. The frequency channel assignments are 227.2, 229.9, 234.0, 236.2, 241.5, and 248.6 mc. A hybrid permits the use of 2 three-channel multiplexers and a single antenna subsystem in satisfying the measurement subsystem antenna requirements. By interlacing the channel carriers, i. e., routing channels 1, 3, and 5 through one multiplexer and channels 2, 4, and 6 through the other, a channel-to-channel isolation of 20 db is attained with a channel separation of only 2 mc.

Low-pass filters are provided in each input leg of the hybrid. The purpose of the filters is to suppress harmonic and beat frequencies that might interfere with other RF systems on the Saturn V vehicle. RF couplers placed between each hybrid output leg and the respective power divider permit an evaluation of telemetry RF equipment performance during checkout, as well as in flight, by providing a measurement of forward and reflected power. Two coaxial switches, which provide a ground link to GSE through the umbilical connector, enable a ground checkout of the telemetry subsystems and preclude radiation through the antennas during this checkout. Three RF link transmitters (234.0, 241.5, and 248.6 mc) are used for the S-II-6 and subsequent vehicles.

TELEMETRY ANTENNA SUBSYSTEM FOR  
S-II-6 AND SUBSEQUENT STAGES



(For S-II-1 Through S-II-5, See Pages VIII-29 and VIII-30)

Abbreviations

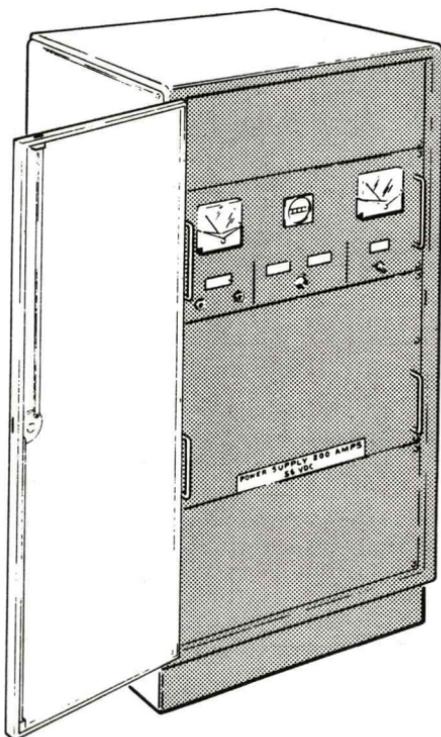
A/D	Analog-to-digital
C-W	Continuous wave
DDAS	Digital data acquisition system
FM	Frequency modulation
IRIG	Inter-range instrumentation group
MC	Megacycle
NRZ	Nonreturn to zero
PAM	Pulse amplitude modulation
PCM	Pulse code modulation
SS	Single sideband
TDM	Time division multiplexer
VHF	Very high frequency
IPCL	Instrumentation program and components list

IX. CHECKOUT EQUIPMENT

SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

56-VOLT DC-200A POWER SUPPLY RACK

This rack provides 56-vdc power to operate the S-II stage LH<sub>2</sub> recirculation pump motors. It is used at Battleship, Seal Beach, and MTF.



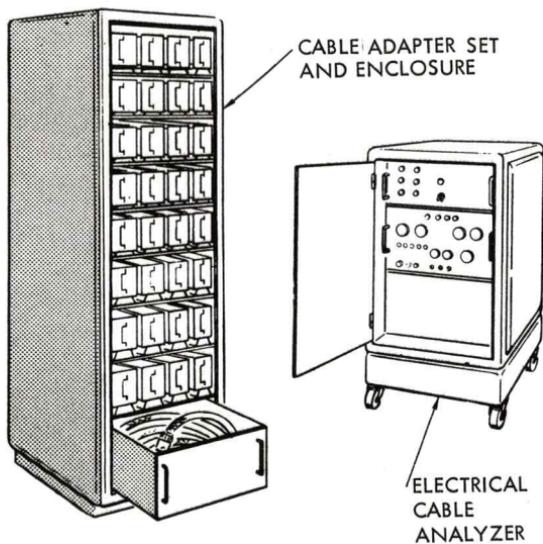
CHECKOUT EQUIPMENT

GENERAL

Checkout equipment used to check and monitor S-II systems, sub-systems, and related data are briefly described in the following figures and text.

C7-28 ELECTRIC CABLE TEST SET

The electric cable test set Model C7-28 provides cable assembly testing with visual and audible alarms to indicate circuit trouble. It is used at MTF.



C7-35 ACCEPTANCE STAND NO. 1 CABLE INSTALLATION

The C7-35 is a cable installation which provides multiconductors for interconnection and transmission of electrical power and signals between the S-II stage and GSE and between GSE items. The installed cabling shall be capable of sustaining the maximum loads anticipated during S-II stage static firing. It is used at MTF only.

C7-38 MTF FIRING CONTROL CENTER CABLE INSTALLATION

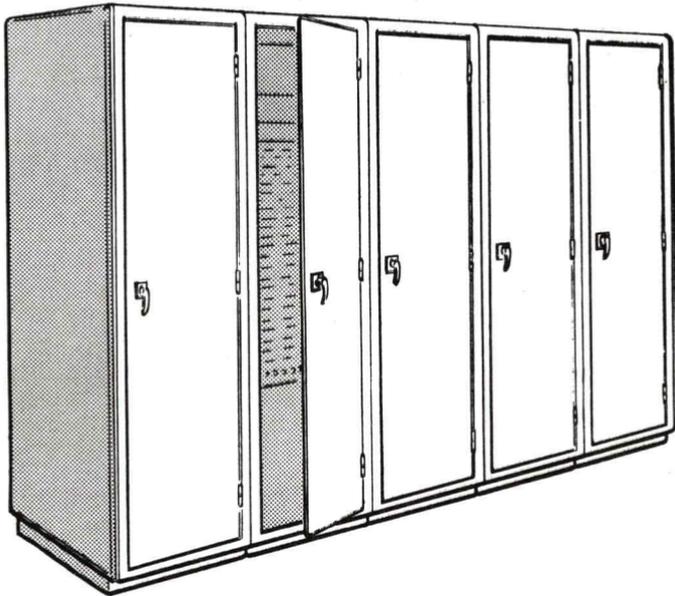
The C7-38 is a cable installation that provides multiconductors for interconnection and transmission of electrical power and signals between the S-II stage and GSE and between GSE items. The installed cable shall be capable of sustaining the maximum loads anticipated during S-II stage static firing. It is used at MTF only.

C7-40 ACCEPTANCE STAND NO. 2 CABLE INSTALLATION

The C7-40 is a cable installation that provides multiconductors for interconnection and transmission of electrical power and signals between the S-II stage and GSE and between GSE items. The installed cable shall be capable of sustaining the maximum loads anticipated during S-II stage static firing. It is used at MTF only.

C7-41 REMOTE POWER DISTRIBUTION RACK

The C7-41 transfers and monitors power to the GSE and stage buses. It is used at Battleship, Seal Beach, and MTF.



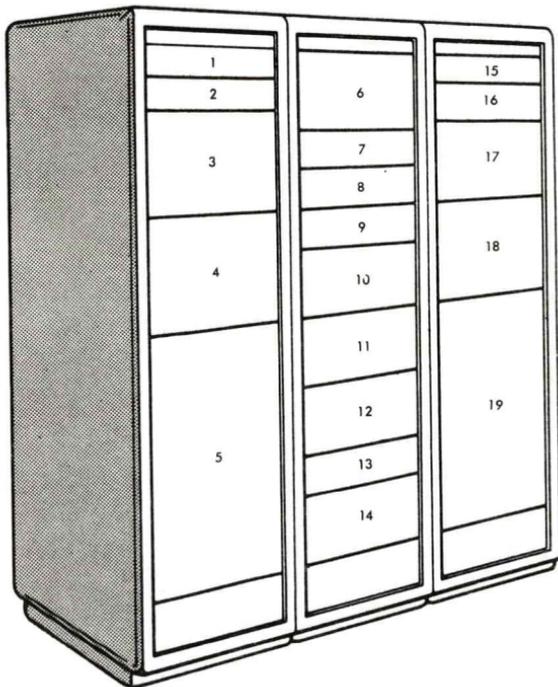
# SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

## C7-44 GROUND EQUIPMENT TEST SET (GETS)

The ground equipment test set (GETS), Model No. C7-44, is used for debugging during early stages of program development. Later GETS utilization shifts to verifying functional readiness of the GSE automatic checkout system.

All hardware stimuli ordinarily transmitted from the electrical check-out station (C7-200 series) to the S-II stage are received by GETS. Through proper patching and switching, GETS simulates the required stage response to be transmitted back.

GETS operation is completely manual and independent of computer control. A test point selector and digital voltmeter enable GETS to monitor voltages. It is used at Seal Beach and MTF.

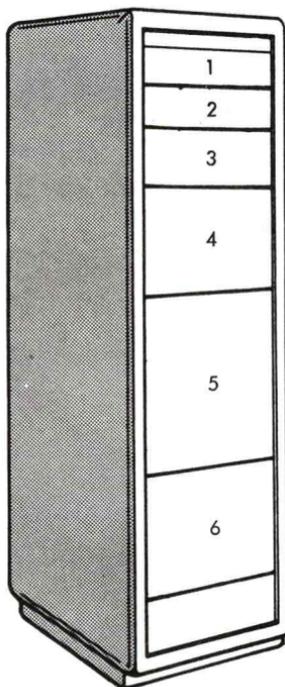


1. POWER DISTRIBUTOR
2. BLANK
3. HAZARDOUS MONITOR SWITCHING
4. HAZARDOUS CONDITION SIMULATOR
5. PATCH PANEL NO. 1
6. BLANK
7. TIME DELAY
8. DIGITAL VOLTMETER
9. TEST POINT SELECTOR
10. INTERCOM
11. FLIGHT CONTROL SIMULATOR NO. 1
12. IU COMMAND DECODER
13. DECODER SWITCHING
14. FLIGHT CONTROL SIMULATOR NO. 2
15. BLANK
16. EXTERNAL TEST POINT
17. CONTROL SWITCHING
18. SYSTEMS SIMULATOR
19. PATCH PANEL NO. 2

## C7-48 TIME CODE RACK

The time code rack is a single-bay cabinet accommodating the time code generator, requisite logic, WWV receiver, and power control.

It provides serial time, AMR B-1 (pulse train), to oscillographs for recording time of day and provides serial time, AMR D-5 (carrier), to the tape recorders. The rack also provides date and time in digital form (hours, minutes, and seconds) to all remote time displays in the automatic checkout stations and provides a 200-kc square-wave master clock signal to all automatic checkout stations. It is used at Seal Beach and MTF.

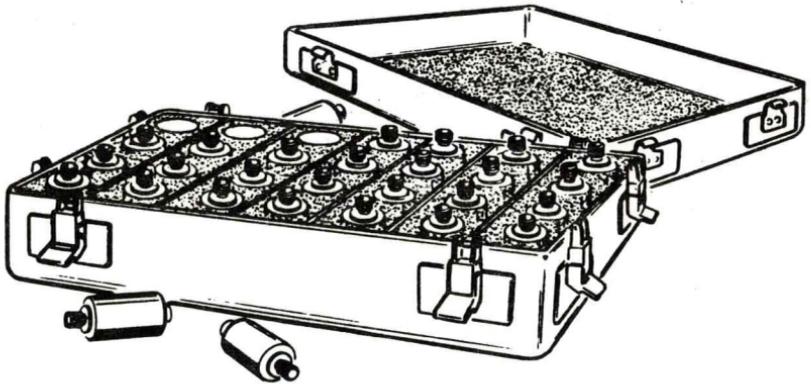


1. POWER CONTROL
2. BLANK
3. OSCILLOSCOPE SWITCH
4. OSCILLOSCOPE
5. DECOMMUTATION SYSTEM
6. BLANK

SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

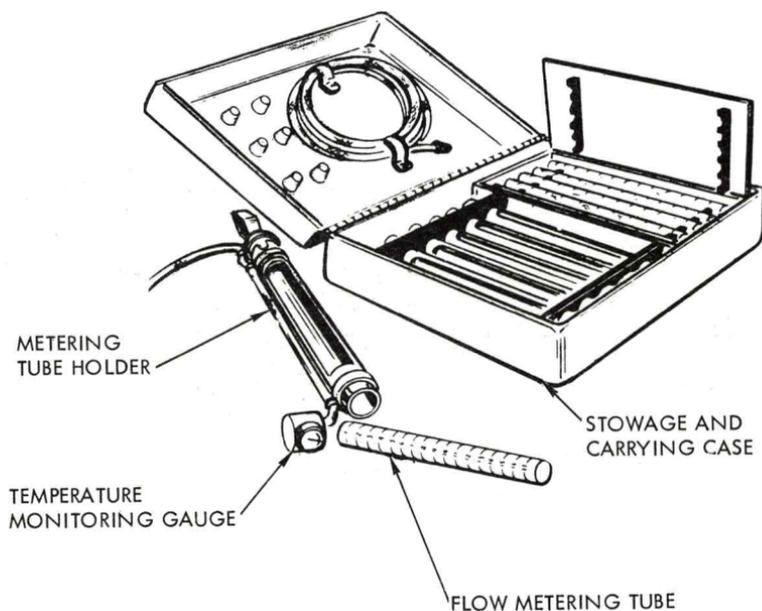
C7-50 MANUAL PRESSURE CHECKOUT TRANSDUCER SET

The C7-50 is used in conjunction with the C7-603 console to allow the capability of indicating pneumatic pressure variances for checkout of the S-II stage pneumatic and propellant systems. The C7-50 is used at Battleship, Seal Beach, and MTF.



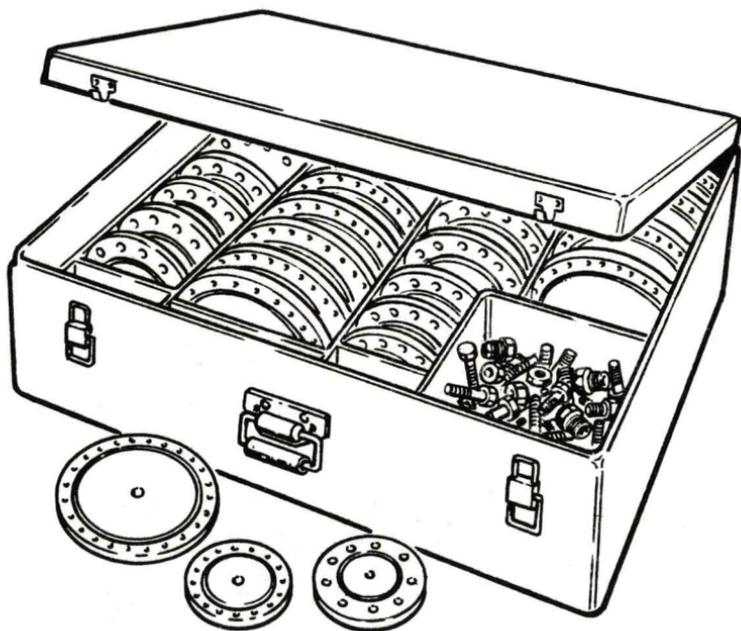
C7-51 ENGINE SYSTEM FLOW MONITORING UNIT

The C7-51 provides capabilities for monitoring and measuring S-II stage pneumatic or propellant system helium gas flowrates of 0.3 to 10,000 scim and nitrogen gas flowrate of 0.22 to 4,000 scim. The unit indicates the temperature of the gas being measured. It is used at Battleship, Seal Beach, MTF, and KSC.



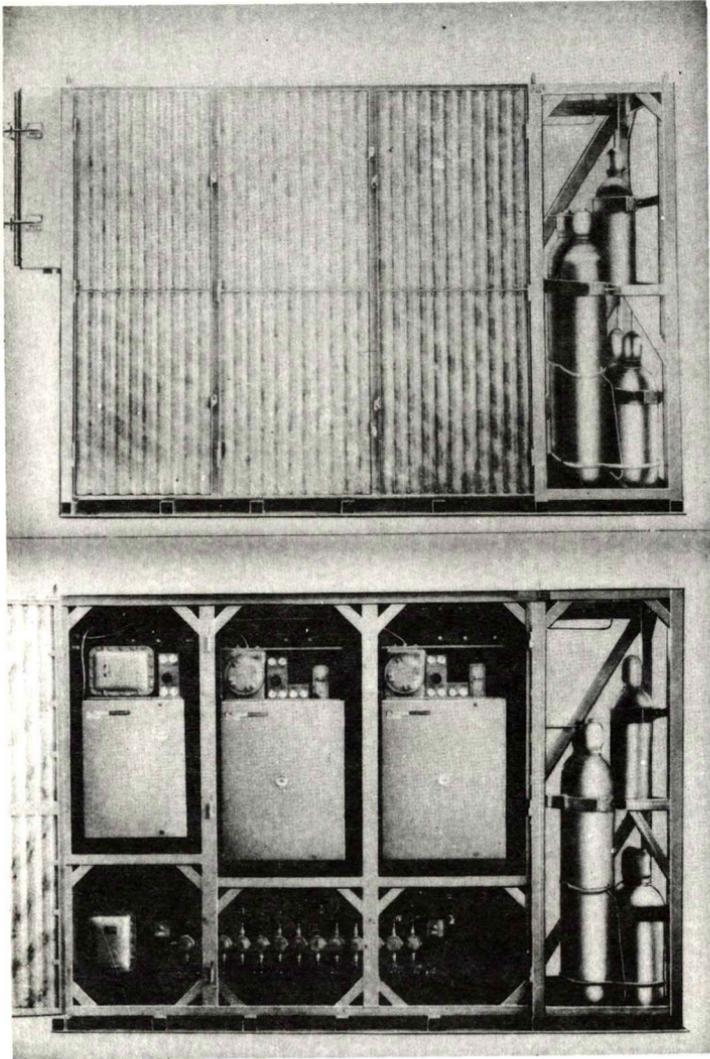
C7-53 PNEUMATIC CHECKOUT BLANKING PLATE SET

The C7-53 are pressure-holding devices that enable isolation of various S-II stage pressure systems, whereby certain sections or sub-systems can be leak-checked separately. It is used at Battleship, Seal Beach, MTF, and KSC.



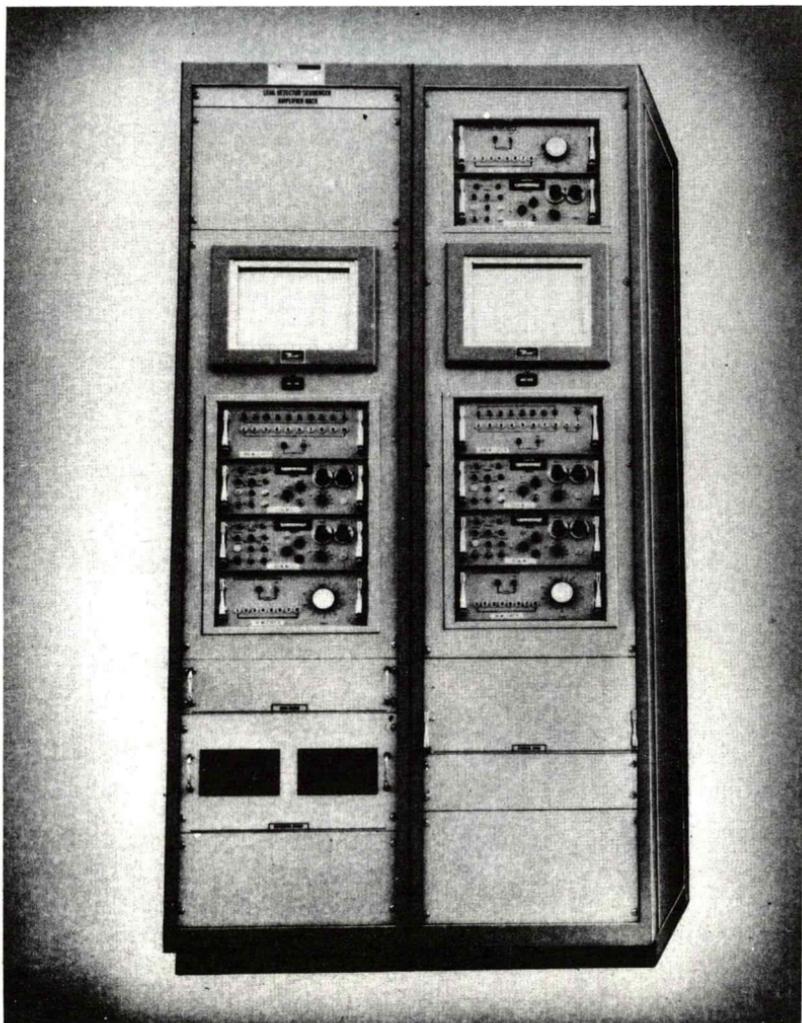
C7-55 PROPELLANT TANKS AND INSULATION LEAK DETECTOR

The C7-55 receives gas samples from the stage directly or through the C7-45 and analyzes, by use of chromatography, the hydrogen, oxygen, nitrogen and helium content to determine leakage on the S-II stage. It is used at MTF and KSC.



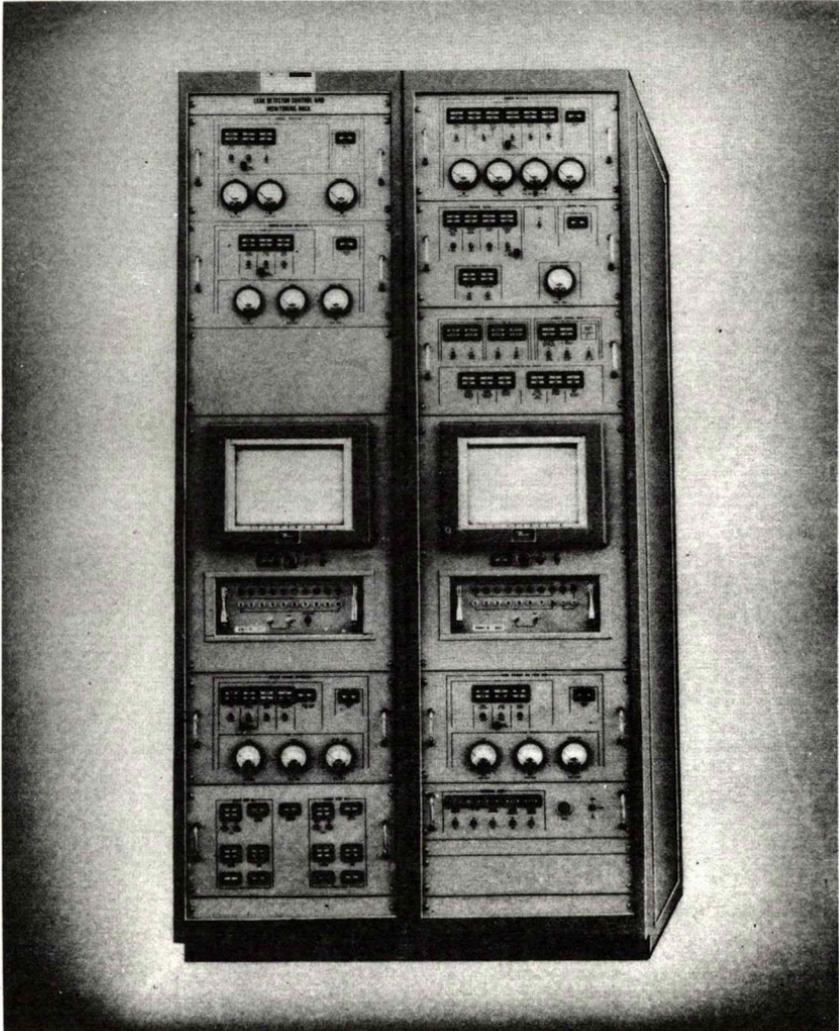
C7-56 LEAK DETECTOR AMPLIFIER SEQUENCER RACK

The C7-56 sequence-amplifier rack provides automatic, manual control, and monitoring capabilities for the propellant tank leak detection system. It is used at MTF and KSC.



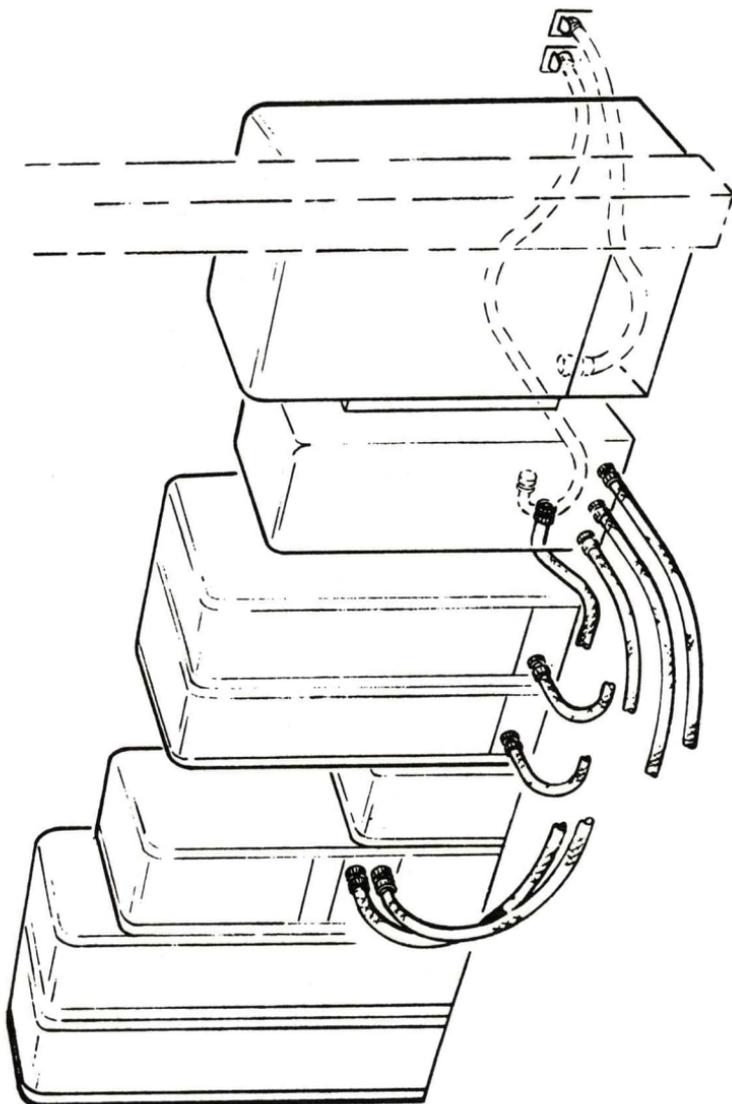
C7-57 LEAK DETECTOR CONTROL AND MONITORING RACK

The C7-57 rack is capable of performing remote control and monitoring of the vacuum system during cryogenic operations, remote controlling and monitoring of structural leak detection during certification test, and remote controlling and monitoring of insulation leak detection and purge system during cryogenic conditions. It is used at MTF and KSC.



## C7-59 ENGINE CHECKOUT ELECTRICAL POWER CABLE SET

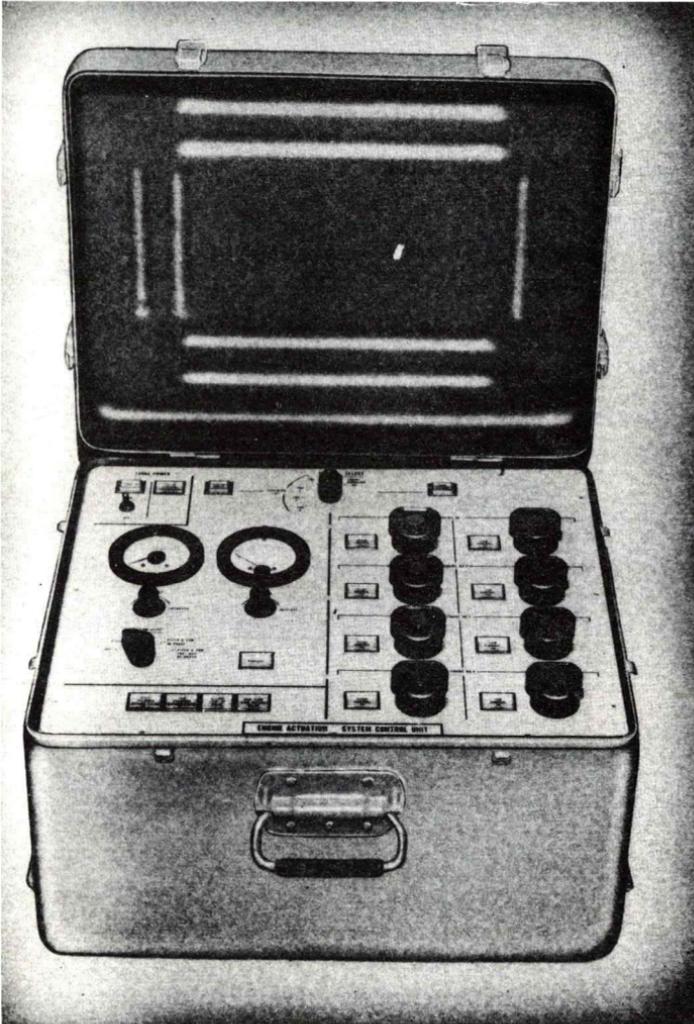
The C7-59 cable set provides multiconductors for interconnection of electrical power in the J-2 engine shops between the electrical checkout console assembly, flight instrumentation checkout console, and the data recorder console assembly. The consoles are Government-furnished GSE and facility. It is used at Seal Beach, Battleship, and MTF.



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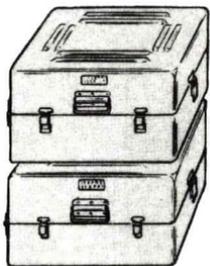
C7-64 ENGINE ACTUATION SYSTEM CONTROL UNIT

The C7-64 control unit provides electrical control for clearance, polarity, and leakage checks, and servicing for bleeding and flushing the engine actuation system. It is used at Battleship, Seal Beach, and MTF.

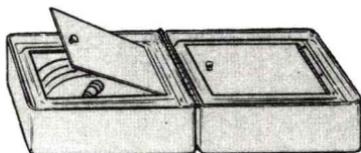


C7-70 S-II PNEUMATIC CONSOLE TEST SET

The C7-70 provides capabilities for local control and electrical monitoring of the electropneumatic components of the S-II LH<sub>2</sub> heat exchanger (Model A7-71), S-II pneumatic console set (Model S7-41), and J-2 engine purge unit (Model S7-49). The test set will provide for visual verification of open and closed positions of valves, actuated pressure switch positions, and operation of standard temperature and pressure transducers on an individual basis. It is used at MTF, KSC, and MSFC.

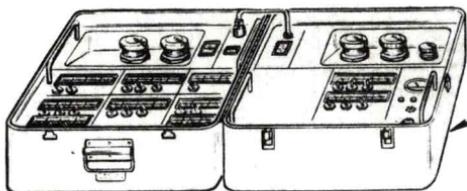
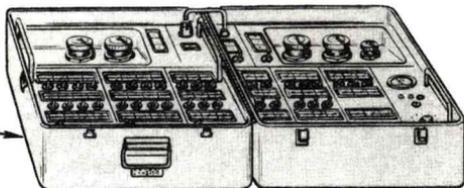


STACKED CABLE STORAGE CASES



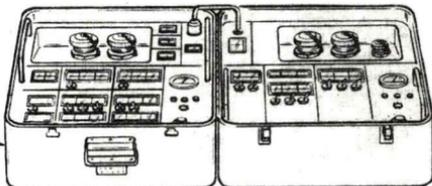
STORAGE CASE IN OPEN POSITION

ACTUATION PURGE AND CHECKOUT TESTER (1419-A3)



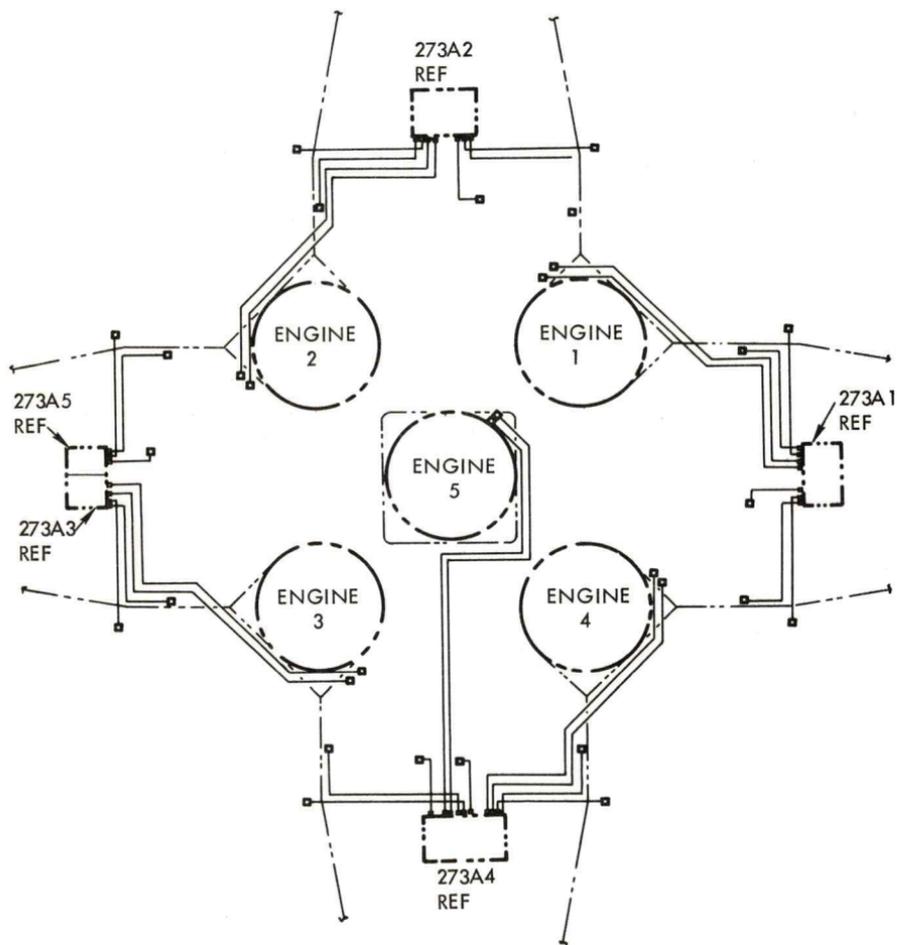
PNEUMATIC CONTROL TESTER (1419-A2)

REGULATION AND DISTRIBUTION TESTER (1419-A1)



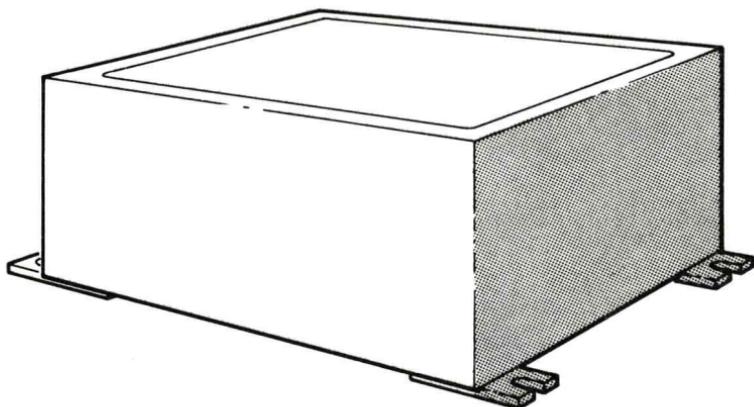
## C7-72 HARNESS SET - ELECTRICAL SLAM

The C7-72 electrically connects the side-load arresting mechanism system (SLAM) and the SLAM junction boxes to facilitate control and monitoring of the SLAM system during static firing of the S-II stage. It is used at Battleship and MTF.



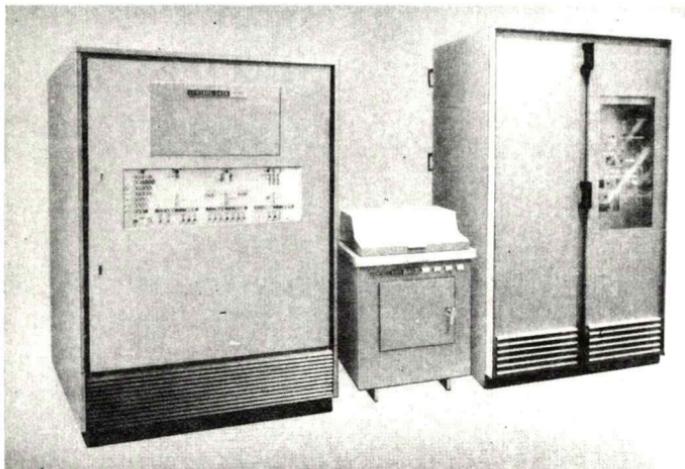
C7-73 SIDE-LOAD ARRESTING MECHANISM JUNCTION BOX SET

The C7-73 SLAM junction boxes provide an electrical interface for the SLAM harness set C7-72 and the GSE cable installations. It is used at Battleship and MTF.



C7-77 DIGITAL EVENTS RACK

The C7-77 detects and records changes on the S-II discrete measurement lines. When a change has been detected on a discrete input line, the state to which it changes, the time of change, the time of detection to the nearest millisecond, and an identifying number are all recorded on punched paper tape and on hard copy printout. It is used at Seal Beach and MTF.



SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

C7-79 POWER DISTRIBUTION SYSTEM, TEST CONTROL CENTER C1

The C7-79 power distribution system is capable of distributing electrical power peculiar to the S-II stage and the GSE. It is used at MTF only.

C7-80 POWER DISTRIBUTION SYSTEM, ACCEPTANCE STAND A-2

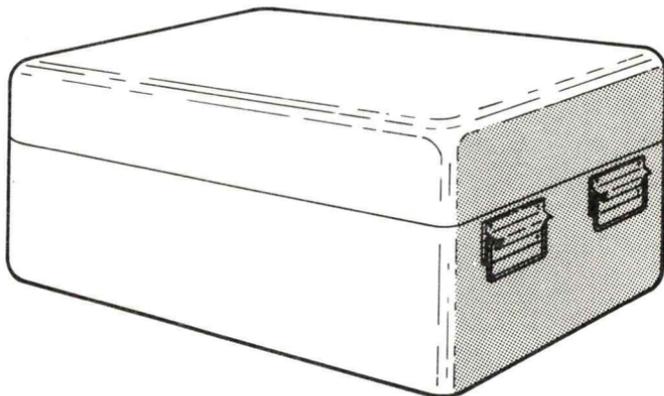
The C7-80 power distribution system is capable of distributing electrical power to the S-II stage and the GSE. It is used at MTF only.

C7-81 POWER DISTRIBUTION SYSTEM, ACCEPTANCE STAND A-1

The C7-81 power distribution system is capable of distributing electrical power to the S-II stage and the GSE. It is used at MTF only.

C7-84 PROPELLANT UTILIZATION TEST SET

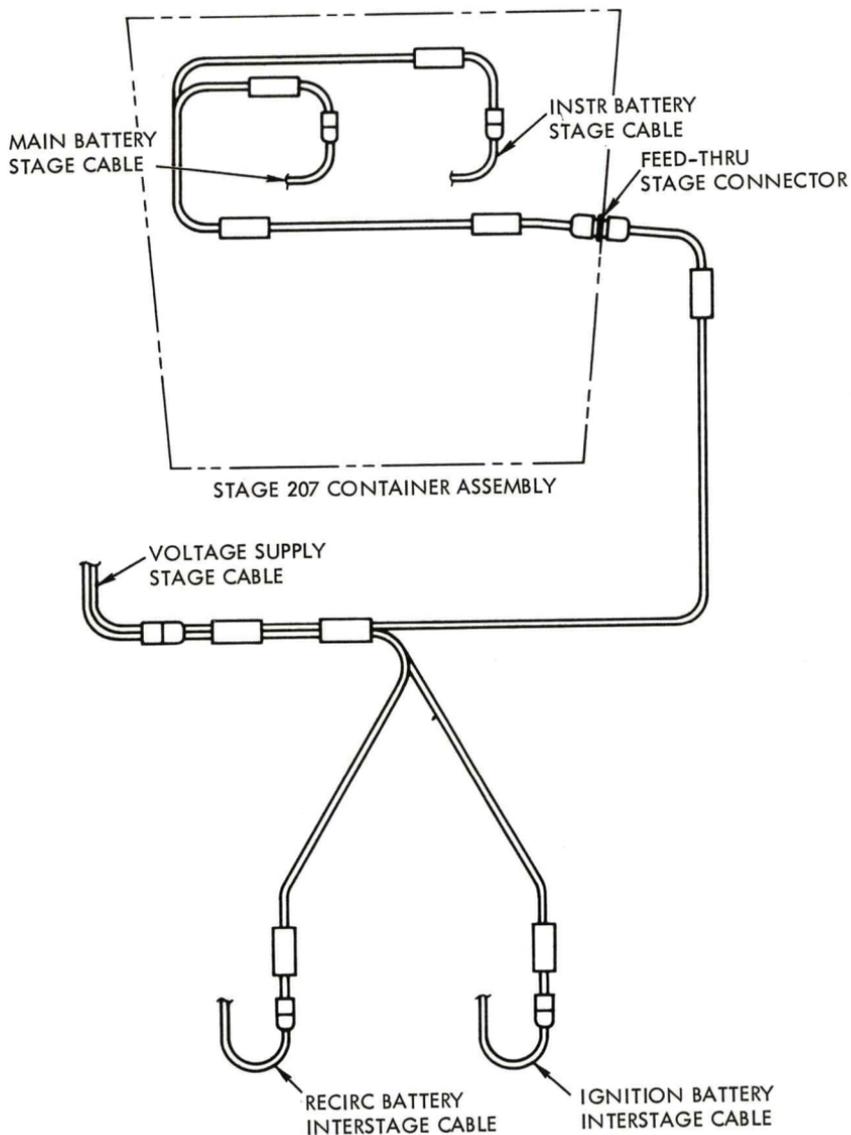
The C7-84 is used for calibrating the installed airborne propellant utilization system and to check the propellant utilization valves on the J-2 engines. The calibration unit is also capable of multipoint calibration of the installed airborne propellant utilization system. It is used at Battleship, Seal Beach, MTF, and KSC.



# SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

## C7-92 ELECTRICAL STAGE BATTERY SIMULATION WIRING HARNESS SET

The C7-92 provides a means to carry 28-vdc power to the main, instrumentation, and ignition bus systems and 56-vac power to the recirculation bus system during simulated flight test on the S-II stage. It is used at Seal Beach, MTF, and KSC.

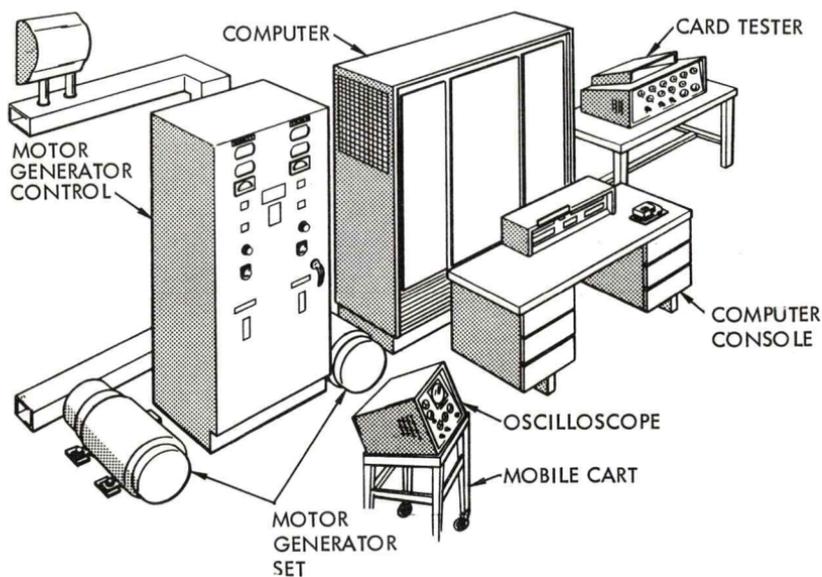


# SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

## C7-100 SERIES C7-101 AUTOMATIC CHECKOUT COMPUTER

The automatic checkout computer consists of four components mounted in suitable enclosures: main frame, control console, motor-generator set, and motor-generator control. The computer is interconnected by cables to other units within and to peripheral equipment.

The computer is a general purpose, single-address, digital unit sequenced by internally stored programs. The main frame housing accommodates three major functional sections: arithmetic, internal high-speed memory, and input/output. It is used at Seal Beach and MTF.



## C7-102 TEST CONDUCTOR CONSOLE

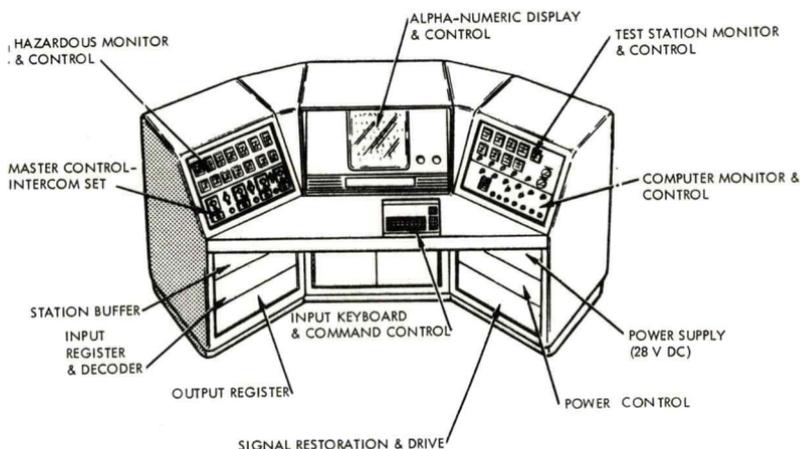
The test conductor console encompasses many subsystems in a single housing. This equipment provides control and visual indicators that enable operating personnel to monitor test progress of the S-II stage.

The hazardous condition monitor and control subsystem indicates the occurrence of a condition that could affect the safety of personnel, the stage, or related GSE. All such signals must come through the electrical check-out station.

The test station monitor and control unit provides selective switching between the console and the several stations and provides certain station status displays.

On a cathode-ray tube (CRT), the alphanumeric display presents measured test data, high and low limits, etc., that enable the test conductor to determine test status and make decisions on questionable features of tests in progress.

During any automatic test procedure, the computer monitor and control subsystem provides eight computer status indications and three computer controls. It is used at Seal Beach and MTF.



C7-103 PROGRAM INPUT RACK

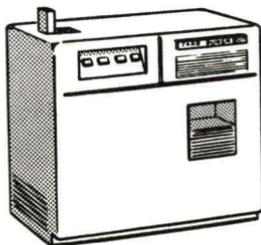
The program input rack includes three units: card reader, card punch controller, and card punch. This equipment inserts test programs into the working memory of the automatic checkout computer C7-101.

The test program format usually consists of a series of punched cards interpreted by the card reader. Card information is transferred as digital signals to the computer. When a punched tape program format is utilized, the paper tape reader (part of the C7-101) is substituted for the card reader.

The card reader processes standard IBM, 12-row, 80-column cards at the rate of 250 cards per minute. Information, sensed photoelectrically, is transferred to the computer memory one column (12 bits) at a time. Card reader operation may be either on-line (computer input) or off-line (line printer input).

The card punch controller serves as a signal adapter (format converter) and provides timing control, accommodating the rapid microsecond operation of the computer to the slower millisecond operation of input/output equipment.

The card punch operates automatically, processing 100 cards per minute. To secure compatibility with the computer, the 12-bit columns of the standard IBM card format are translated into intelligence representing four computer-words. It is used at Seal Beach and MTF.



CARD PUNCH



CARD PUNCH  
CONTROLLER

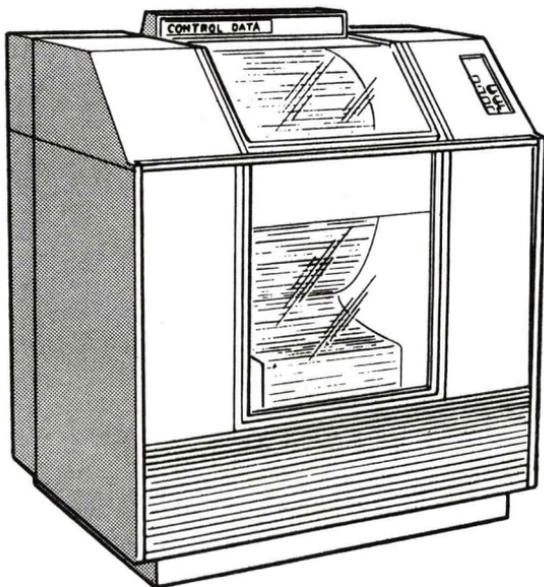


CARD READER

## C7-104 DATA PRINTOUT RACK

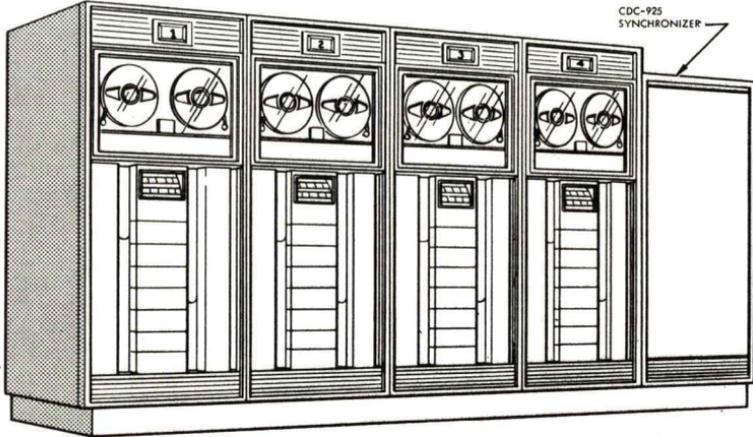
The data printout rack supplies permanent printed records of tests performed by the automatic checkout GSE.

The rack consists of a line printer that is utilized with the automatic checkout computer and the program input rack. It has both on-line and off-line capabilities. For a 12-inch (120 columns) line of alphanumeric characters, the line printer produces hard copy at 200 lines per minute. All occurrences of an individual letter, number, or symbol in one line are printed at the same instant through the action of print hammers in combination bringing the inked ribbon and paper copy into contact with a rotating drum. Line space and printing signals are generated from the computer memory. It is used at Seal Beach and MTF.



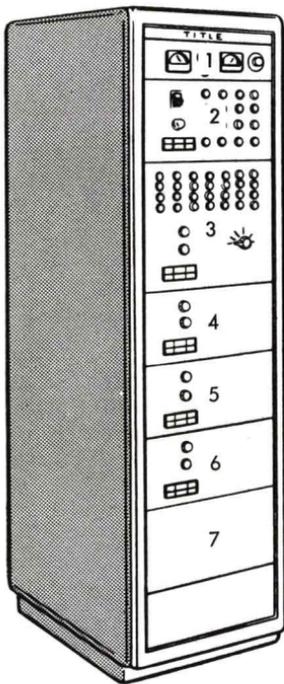
C7-105 AUXILIARY MEMORY RACK

The auxiliary memory rack stores all test programs and data processed by the automatic checkout computer. Data received by the auxiliary memory from the computer are stored until the computer requests the data for print-out or for use in computation. The program initially sent to the computer is stored in the auxiliary memory until shifted to the computer working memory for execution. It is used at Seal Beach and MTF.



## C7-106 BUFFER EQUIPMENT RACK

The buffer equipment rack enables automatic control of the checkout station and automatic reception of test measurement data from the station by the automatic checkout computer. Through its solid-state circuitry, the rack equipment provides in/out switching capability, presents visual indication of malfunctions, and ensures compatibility of command signals transmitted to the checkout station. The rack interfaces both the automatic checkout computer and the individual checkout stations. At each of the latter, a station buffer drawer duplicates, to a degree, the functions of computer buffer input/output circuitry of the rack. It is used at Seal Beach and MTF.



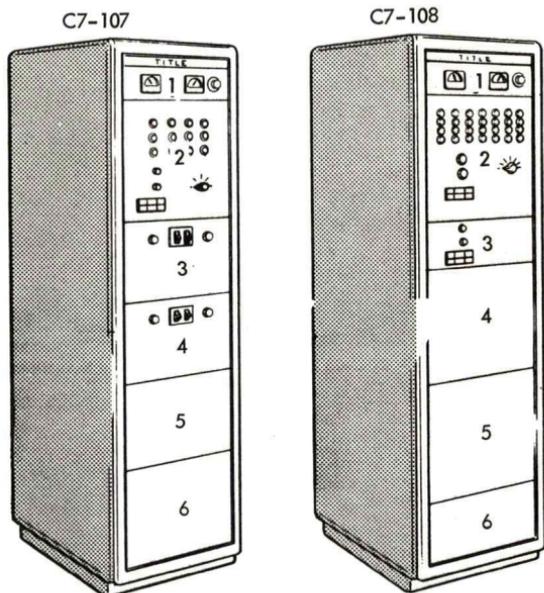
1. RACK IDENTIFICATION PANEL
2. POWER CONTROL
3. LAMP DRIVER POWER SUPPLY
4. FUNCTION INDICATOR
5. COMMAND CONTROL
6. DATA CONTROL
7. COMPUTER BUFFER INPUT/OUTPUT

# SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

## C7-107 LOCAL DIGITAL DRIVER LINK RACK AND C7-108 REMOTE DIGITAL DRIVER LINK RACK

These two racks, jointly utilized, enable signal transmission between the computer, electrical checkout station, and the C7-800 static firing racks when the latter two assemblies are physically separated from the computer complex by more than 100 feet.

Both racks provide amplification of digital commands, data, and control signals. These signals are received from the buffer equipment rack by rack C7-107 and transmitted through rack C7-108 to the electrical checkout station. Signals originating at the electrical checkout station are routed back through these racks to the computer complex. Both racks provide for termination and driving of digital control signals transmitted by coaxial cable. Terminators and drivers effect matching of coaxial cable types for short- and long-distance transmission. Function indicators in the two racks facilitate troubleshooting and isolate malfunctions. It is used at MTF only.

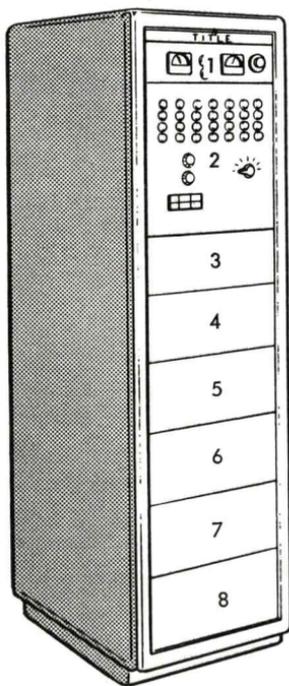


1. POWER CONTROL
2. FUNCTION INDICATOR
3. BUFFER INPUT AMPLIFIER
4. LOCAL/AUTOMATIC
5. BLANK
6. BLANK

1. POWER CONTROL PANEL
2. FUNCTION INDICATOR  
DRAWER
3. STATION OUTPUT  
AMPLIFIER DRAWER
4. BLANK
5. BLANK
6. BLANK

## C7-109 COMPUTER ISOLATION RACK

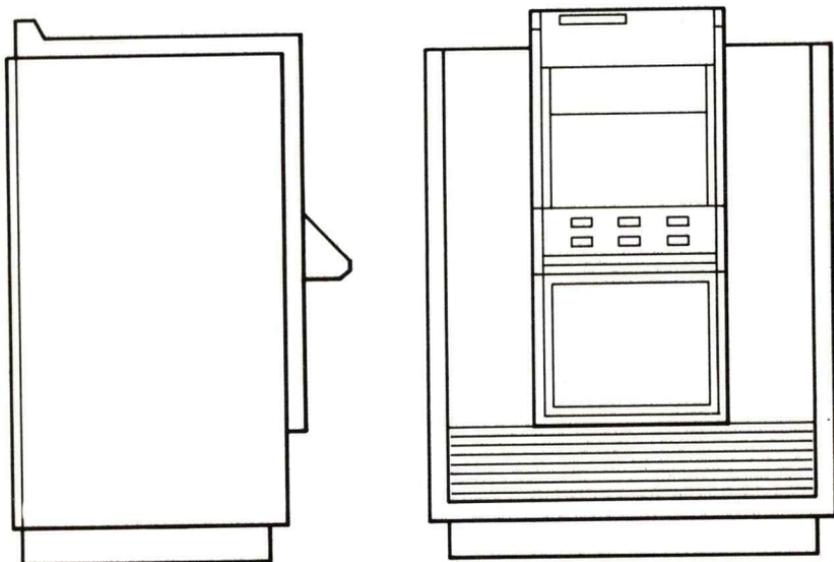
The computer isolation rack has three functions. It provides input/output isolation to isolate the computer main frame ground from the GSE signal ground. The rack's channel pair line driver effects logic level conversion to drive the buffer equipment and alphanumeric display of the test conductor console C7-102. It also switches control from the computer to the test conductor console. They are used at Seal Beach and MTF.



1. POWER CONTROL
2. FUNCTION INDICATOR
3. CONSOLE SWITCHING DRAWER
4. CHANNEL PAIR LINE DRIVER
5. INPUT ISOLATION DRAWER
6. OUTPUT ISOLATION DRAWER
7. BLANK
8. BLANK

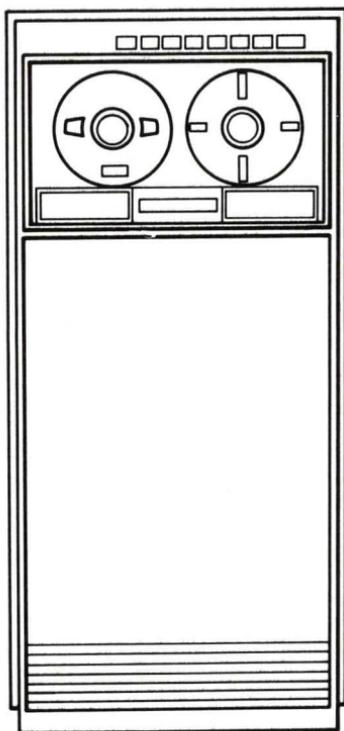
C7-110 HIGH SPEED PRINTER

The C7-110 provides a printed record of the computer programs and GSE test results. The high-speed line printer translates coded digital information from the automatic checkout computer C7-101 and the magnetic tape transport in the auxiliary memory rack C7-105 into hard copy alpha-numeric characters. It is used at Seal Beach and MTF.



C7-111 DATA TAPE RECORDER RACK

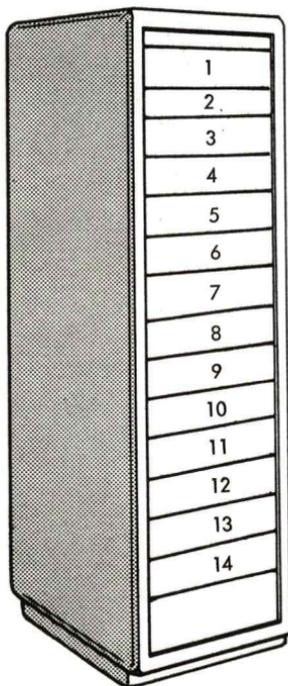
The C7-111 provides data storage for the digital events rack C7-77. It is used at Seal Beach and MTF.



C7-200 SERIES  
C7-201 AUTOMATIC CONTROL RACK

The automatic control rack provides buffering and decoding functions for the electrical checkout station. Encoded logic signals are received from the computer C7-101 and converted into signals acceptable to station control logic.

Rack equipment consists of subaddress and control instruction decoders, input and output registers, station buffer, and echo check circuitry. It is used at Seal Beach and MTF.



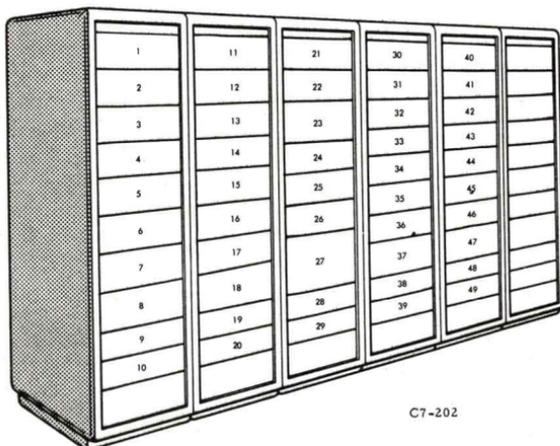
1. POWER CONTROL
2. BLANK
3. BLANK
4. DECODER DRIVER
5. SUB ADDRESS DECODER NO. 2
6. SUB ADDRESS DECODER NO. 1
7. CONTROL INSTRUMENT DECODER
8. CLOCK DRIVER
9. INPUT REGISTER
10. ECHO CHECK
11. ECHO CHECK DISPLAY LOGIC
12. OUTPUT REGISTER NO. 1
13. OUTPUT REGISTER NO. 2
14. STATION BUFFER

## C7-202 MANUAL CONTROL AND DISPLAY RACK

This rack consists of the command distributor display and manually operated control panels. The former displays all stimuli generated from the command distributor. Each stimulus is functionally described, such as a valve turn-on, vent, etc. These functional callouts are printed on decals that fit over display lamps. Each lamp remains activated as long as the stimulus to the stage is in-work. Each display panel is standard in configuration.

The command distributor display is hard-wired from relay contacts in the signal distribution rack C7-204. This hard-wiring ensures relay closure and stimuli transfer from the command distributor to the stage.

The manual control panels (named for the systems being checked) and their associated displays are used for fault isolation and manual operation of the station. The rack receives status signal inputs from the test conductor console C7-102, the signal distribution rack C7-204, and the stage substitutes rack C7-210. Rack outputs are sent to the local static firing "A" rack C7-801. It is used at Seal Beach and MTF.



C7-202

- |  |   |
|--|---|
| 1. DESTRUCT SYSTEM CONTROL DISPLAY       | 25. SERVO, ANALYZER CONTROL NO. 2           |
| 2. SEPARATION SYSTEM CONTROL DISPLAY     | 26. STATION SELECT CONTROL                  |
| 3. ELECTRICAL POWER CONTROL DISPLAY      | 27. BLANK                                   |
| 4. DESTRUCT SYSTEM CONTROL               | 28. BLANK                                   |
| 5. SEPARATION SYSTEM CONTROL             | 29. LOCAL CONTROL LOGIC NO. 1               |
| 6. ELECTRICAL POWER CONTROL              | 30. PRESSURIZATION CONTROL DISPLAY          |
| 7. BLANK                                 | 31. PROPELLANT FEED CONTROL DISPLAY         |
| 8. BLANK                                 | 32. THERMAL CONTROL DISPLAY                 |
| 9. BLANK                                 | 33. PRESSURIZATION CONTROL                  |
| 10. POWER CONTROL DISPLAY NO. 1          | 34. PROPELLANT FEED CONTROL                 |
| 11. FLIGHT CONTROL DISPLAY NO. 2         | 35. THERMAL CONTROL                         |
| 12. BLANK                                | 36. BLANK                                   |
| 13. FLIGHT CONTROL NO. 1                 | 37. BLANK                                   |
| 14. FLIGHT CONTROL NO. 2                 | 38. BLANK                                   |
| 15. BLANK                                | 39. BLANK                                   |
| 16. BLANK                                | 40. PNEUMATIC CONSOLE CONTROL NO. 1 DISPLAY |
| 17. BLANK                                | 41. PNEUMATIC CONSOLE CONTROL NO. 2 DISPLAY |
| 18. BLANK                                | 42. HYDRAULIC CONSOLE CONTROL DISPLAY       |
| 19. BLANK                                | 43. PNEUMATIC CONSOLE CONTROL NO. 1         |
| 20. LOCAL CONTROL LOGIC NO. 2            | 44. PNEUMATIC CONSOLE CONTROL NO. 2         |
| 21. SERVO ANALYZER CONTROL DISPLAY NO. 1 | 45. HYDRAULIC CONSOLE CONTROL               |
| 22. SERVO ANALYZER CONTROL DISPLAY NO. 2 | 46. BLANK                                   |
| 23. ENGINE POSITION INDICATOR            | 47. BLANK                                   |
| 24. SERVO ANALYZER CONTROL NO. 1         | 48. BLANK                                   |
|  | 49. BLANK                                   |

## C7-204 SIGNAL DISTRIBUTION RACK

The signal distribution rack provides stimuli from 0 to 32 volts dc to excite various systems in the S-II stage (and the mechanical checkout station). Stimuli sensing is monitored through the input patch panel by a test point selector for measurements in the electrical checkout station.

The rack contains a programmable power supply and associated control logic, test point selectors and associated control logic, and a +6-volt supply providing operating voltage for relay drivers. It also has a control providing power distribution within the rack and patch panels for mating the electrical checkout station to the S-II stage.

The programmable power supply control logic can be operated manually (from control panels within the station) or automatically (from the computer control). Outputs from the programmable supply are applied from the command distributor.

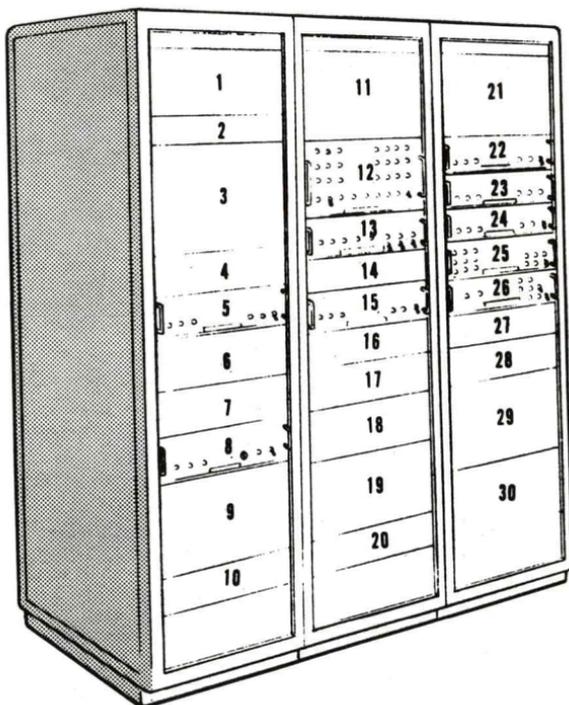
The command distributor furnishes hardwire stimuli to actuate the S-II stage. The command distributor control logic can be operated by manual control panels of the C7-202 or automatically from the computer. It is used at Seal Beach and MTF.

- |   |   |
|---|---|
| 1. POWER CONTROL                            | 32. STATION DRIVER NO. 2                    |
| 2. TEST POINT SELECTOR CONTROL LOGIC NO. 1  | 33. STATION DRIVER NO. 2                    |
| 3. +6 POWER SUPPLY                          | 34. BLANK                                   |
| 4. COMMAND DISTRIBUTOR CONTROL LOGIC NO. 1  | 35. FREQUENCY CALIBRATOR                    |
| 5. COMMAND DISTRIBUTOR CONTROL LOGIC NO. 1  | 36. COMMAND DISTRIBUTOR RELAY NO. 1         |
| 6. COMMAND DISTRIBUTOR CONTROL LOGIC NO. 1  | 37. COMMAND DISTRIBUTOR RELAY NO. 1         |
| 7. COMMAND DISTRIBUTOR CONTROL LOGIC NO. 1  | 38. COMMAND DISTRIBUTOR RELAY NO. 1         |
| 8. COMMAND DISTRIBUTOR CONTROL LOGIC NO. 1  | 39. COMMAND DISTRIBUTOR RELAY NO. 1         |
| 9. COMMAND DISTRIBUTOR CONTROL LOGIC NO. 1  | 40. COMMAND DISTRIBUTOR RELAY NO. 1         |
| 10. COMMAND DISTRIBUTOR CONTROL LOGIC NO. 1 | 41. RELAY NO. 2                             |
| 11. COMMAND DISTRIBUTOR CONTROL LOGIC NO. 1 | 42. COMMAND DISPLAY RELAY                   |
| 12. COMMAND DISTRIBUTOR CONTROL LOGIC NO. 1 | 43. BLANK                                   |
| 13. BLANK                                   | 44. BLANK                                   |
| 14. TEST POINT SELECTOR                     | 45. PROGRAMMABLE OSCILLATOR                 |
| 15. BLANK                                   | 46. BLANK                                   |
| 16. COMMAND DISTRIBUTOR RELAY NO. 1         | 47. BLANK                                   |
| 17. COMMAND DISTRIBUTOR RELAY NO. 1         | 48. COMMAND DISTRIBUTOR CONTROL LOGIC NO. 1 |
| 18. COMMAND DISTRIBUTOR RELAY NO. 1         | 49. COMMAND DISTRIBUTOR CONTROL LOGIC NO. 1 |
| 19. COMMAND DISTRIBUTOR RELAY NO. 1         | 50. COMMAND DISTRIBUTOR CONTROL LOGIC NO. 1 |
| 20. COMMAND DISTRIBUTOR RELAY NO. 1         | 51. COMMAND DISTRIBUTOR CONTROL LOGIC NO. 1 |
| 21. COMMAND DISTRIBUTOR RELAY NO. 1         | 52. COMMAND DISTRIBUTOR CONTROL LOGIC NO. 1 |
| 22. COMMAND DISTRIBUTOR RELAY NO. 1         | 53. COMMAND DISTRIBUTOR CONTROL LOGIC NO. 2 |
| 23. COMMAND DISTRIBUTOR RELAY NO. 1         | 54. BLANK                                   |
| 24. COMMAND DISTRIBUTOR RELAY NO. 1         | 55. BLANK                                   |
| 25. BLANK                                   | 56. BLANK                                   |
| 26. OUTPUT PATCH PANEL                      | 57. +6 POWER SUPPLY                         |
| 27. 7 AM CAL BRATOR CONTROL LOGIC           | 58. BLANK                                   |
| 28. STATION DRIVER NO. 1                    | 59. TEST POINT SELECTOR CONTROL LOGIC NO. 1 |
| 29. STATION DRIVER NO. 1                    | 60. TEST POINT SELECTOR                     |
| 30. STATION DRIVER NO. 1                    | 61. INPUT PATCH PANEL                       |
| 31. STATION DRIVER NO. 1                    | 62. PROGRAMMABLE POWER SUPPLY               |
|   | 63. PROGRAMMABLE POWER SUPPLY               |
|   | 64. POWER SUPPLY CONTROL LOGIC SUPPLY       |
|   | 65. BLANK                                   |



## C7-205 SPECIAL DATA RACK

The C7-205 rack measures voltage and frequency to detect hazardous voltage conditions. It is used at Seal Beach and MTF.



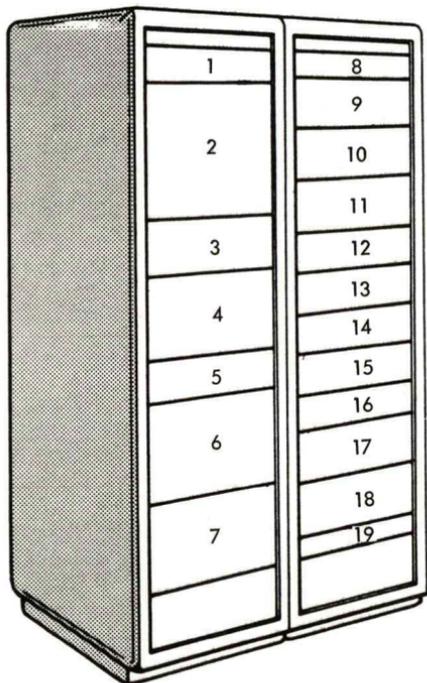
- |                               |                                   |
|-------------------------------|-----------------------------------|
| 1. POWER CONTROL              | 17. BLANK                         |
| 2. BLANK                      | 18. AC VOLTAGE STANDARD           |
| 3. DIGITAL MULTIMETER         | 19. BLANK                         |
| 4. DMM CONTROL LOGIC          | 20. BLANK                         |
| 5. DATA TRANSFER LOGIC        | 21. ENGINE MEAS NO. 3             |
| 6. UNIVERSAL COUNTER TIMER    | 22. ENGINE MEAS NO. 2             |
| 7. COUNTER TIMER CONTROL      | 23. ENGINE MEAS NO. 1             |
| 8. UTC BUFFER                 | 24. ENGINE SIGNAL CONVERTER NO. 2 |
| 9. AC VOLTAGE STANDARD        | 25. ENGINE SIGNAL CONVERTER NO. 1 |
| 10. BLANK                     | 26. BLANK                         |
| 11. BLANK                     | 27. BLANK                         |
| 12. LIMIT DETECTORS           | 28. BLANK                         |
| 13. LIMIT DEI SELF TEST LOGIC | 29. OUTPUT REG. NO. 1             |
| 14. CMD DESTRUCT CONT NO.     | 30. BLANK                         |
| 15. MEAS. CALIB SYSTEM        |                                   |
| 16. INTERCOM SET              |                                   |

# SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

## C7-208 STATION CONTROL AND DISPLAY RACK

Equipment in this rack provides local control of measuring instruments (digital multimeter and counter timer), ground power supplies, limit detectors, and echo check.

The rack displays indicate parameters of test status and stage responses (automatic display), the contents of input or output registers (echo-check display), responses originating within the electrical checkout station (station status 1 and status 2), and critical or hazardous conditions on the stage (station status 3). It is used at Seal Beach and MTF.



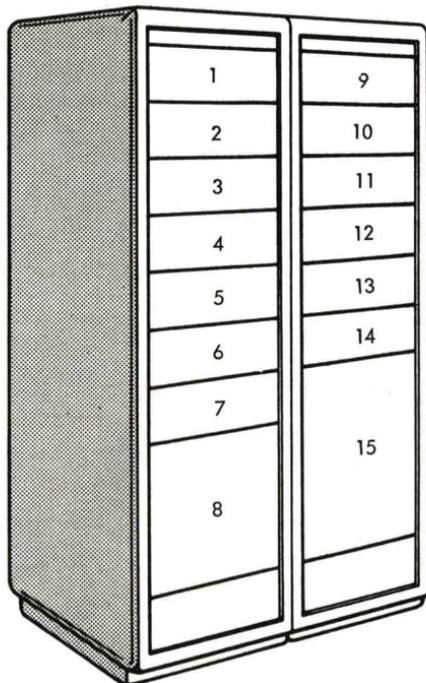
1. POWER CONTROL
2. AUTOMATIC DISPLAY
3. ECHO CHECK DISPLAY
4. STATION & POWER CONTROL
5. MEASUREMENTS CALIBRATION CONTROL
6. PRINTER
7. AUTOMATIC DISPLAY LOGIC
8. STATION STATUS 1
9. STATION STATUS 2
10. STATION STATUS 3
11. LIMIT DETECTOR CONTROL
12. DMM UTC CONTROL
13. TEST POINT SELECTOR CONTROL
14. TEST CONTROL
15. INTERCOMMUNICATION SET
16. BLANK
17. -6V DC POWER SUPPLY
18. 28V DC POWER SUPPLY
19. BLANK

## C7-209 LOCAL CONTROL AND DISPLAY RACK

Rack equipment consists of engine stimuli display, propellant fill display, engine stimuli controls, and propellant fill control.

The stimuli displays act as status boards for stimuli sent from the electrical checkout station to the engine and propellant fill systems. A legend light for each stimulus is controlled individually from auxiliary contacts on the command distributor relays in rack C7-204. Each light comes ON when its respective stimulus is sent to the stage. It remains ON until the stimulus is removed.

The stimuli control panels contain the functionally identified switches necessary to initiate transmission of stimuli to the stage engine and propellant fill systems. The switches generate subaddresses and control instructions that are sent via control logic drawers to the command distributor. The switches are used only during the manual (local) mode of operation. The C7-209 is used at Seal Beach and MTF.



1. ENGINE STIMULI DISPLAY NO. 1
2. ENGINE STIMULI DISPLAY NO. 2
3. ENGINE STIMULI DISPLAY NO. 3
4. ENGINE STIMULI DISPLAY NO. 4
5. ENGINE STIMULI DISPLAY NO. 5
6. ENGINE STIMULI CONTROL NO. 1
7. ENGINE STIMULI CONTROL NO. 2
8. BLANK
9. BLANK
10. PROPELLANT FILL DISPLAY
11. BLANK
12. PROPELLANT FILL CONTROL
13. BLANK
14. ENGINE STIMULI CONTROL NO. 3
15. BLANK

## C7-210 STAGE SUBSTITUTES RACK

The stage substitutes rack of the electrical checkout station provides stimuli necessary to check out the operation of the flight control, engine actuation, and separation systems of the S-II stage. The rack accomplishes these functions with circuitry provided from the instrument unit substitutes, stage substitutes, and response control devices. Also included in the rack is the instrument unit binary computer substitute, which controls the S-II stage switch selector.

For checking the flight control systems, eight servoamplifiers provide signals necessary for gimbaling the four outboard rocket engines of the S-II stage. Response of the eight actuators to the applied gimbaling commands is monitored by the multiplexer and multiplexer control logic drawers in the rack.

The separation system of the S-II stage is checked through rack firing and sensor simulator equipment.

The engine actuation system utilizes start-stop sequences for periodic cycling of auxiliary motor pumps to prevent freezing of the hydraulic fluid controlling the system. The circuitry necessary is contained in the flight control logic and relay drawers of the rack. The C7-210 is used at Seal Beach and MTF.

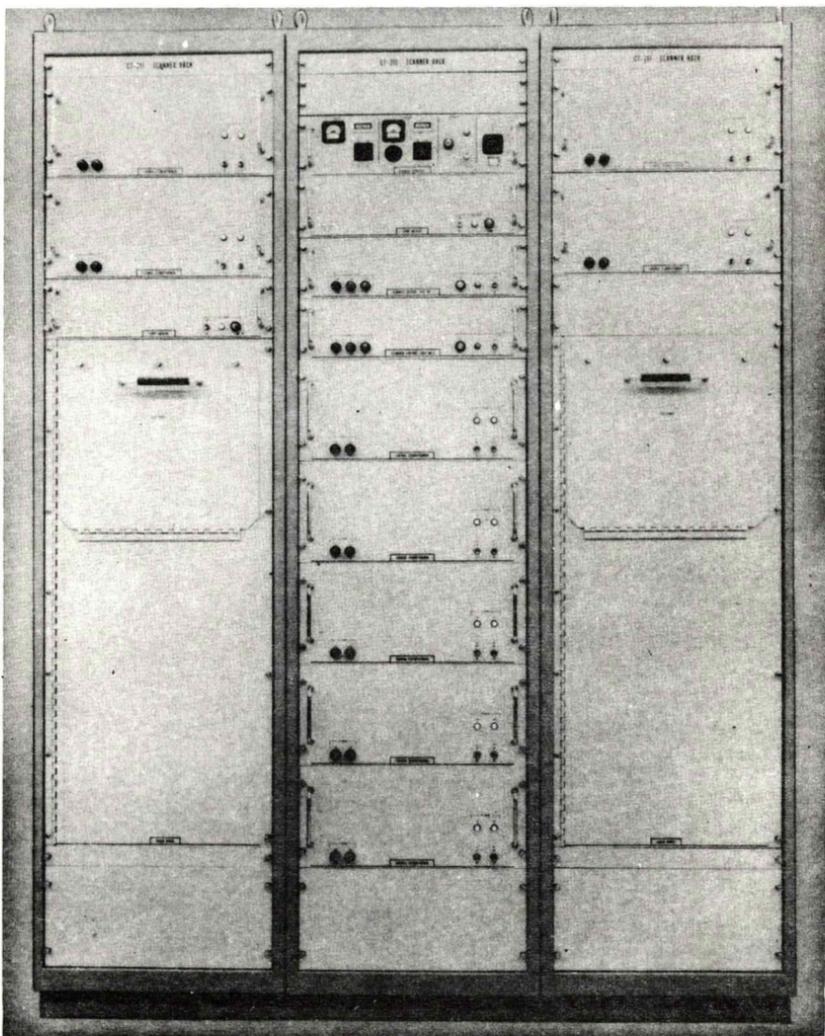


C7-210

- |                                      |   |
|--------------------------------------|---|
| 1. POWER CONTROL                     | 21. VCO                                     |
| 2. BLANK                             | 22. +5 VDC POWER SUPPLY                     |
| 3. BLANK                             | 23. FLIGHT CONTROL LOGIC NO. 1              |
| 4. BLANK                             | 24. FLIGHT CONTROL RELAY NO. 1              |
| 5. -28 VDC POWER SUPPLY              | 25. FLIGHT CONTROL AMPLIFIERS               |
| 6. +28 VDC POWER SUPPLY              | 26. OUTPUT PATCH PANEL                      |
| 7. BLANK                             | 27. BLANK                                   |
| 8. BLANK                             | 28. DIFFERENTIAL AMPLIFIERS                 |
| 9. BLANK                             | 29. MULTIPLEXER CONTROL LOGIC               |
| 10. FIRING AND SENSOR SIMULATOR      | 30. MULTIPLEXER                             |
| 11. BLANK                            | 31. BLANK                                   |
| 12. -6 VDC POWER SUPPLY              | 32. SERVO ANALYZER POWER SUPPLY & MODULATOR |
| 13. +6 VDC POWER SUPPLY              | 33. SERVO ANALYZER CORRELATOR               |
| 14. BLANK                            | 34. SERVO ANALYZER CONTROL LOGIC NO. 1      |
| 15. COMPUTER SIMULATOR DECODER NO. 2 | 35. SERVO ANALYZER CONTROL LOGIC NO. 1      |
| 16. COMPUTER SIMULATOR DECODER NO. 1 | 36. BLANK                                   |
| 17. COMPUTER SIMULATOR               |   |
| 18. INPUT PATCH PANEL                |   |
| 19. BLANK                            |   |
| 20. BLANK                            |   |

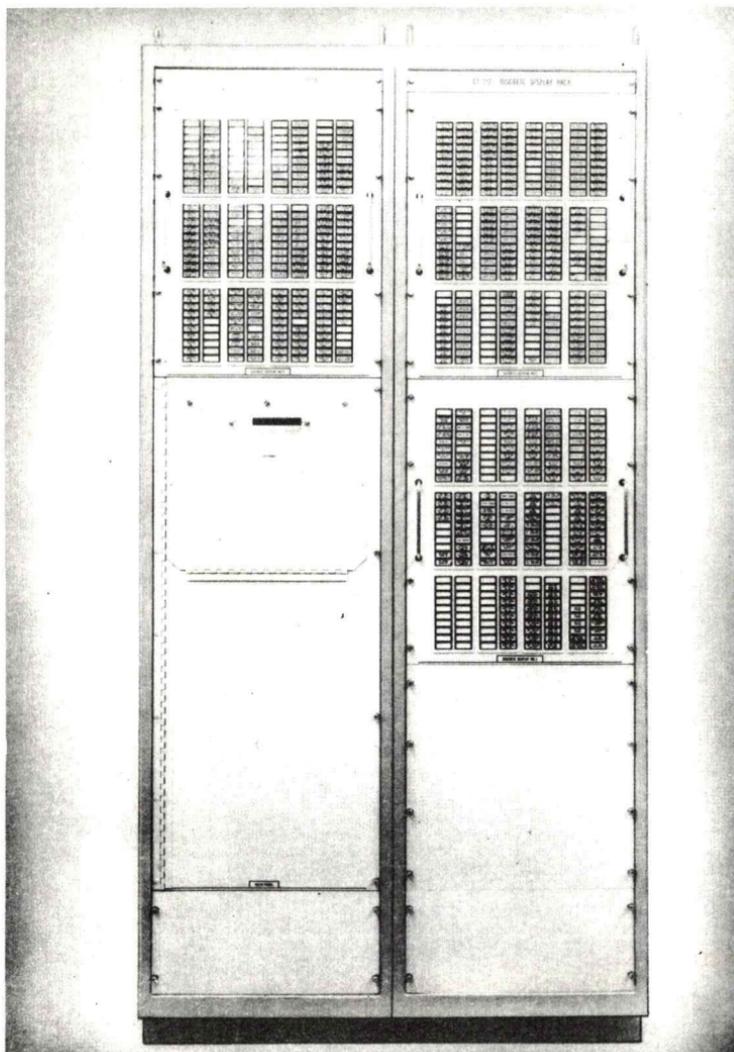
## C7-211 SCANNING RACK

The C7-211 scans the S-II stage hardwire and selected GSE discretes. The rack is capable of scanning a minimum of 1296 discretes (24 discretes on each word). It is used at Seal Beach and MTF.



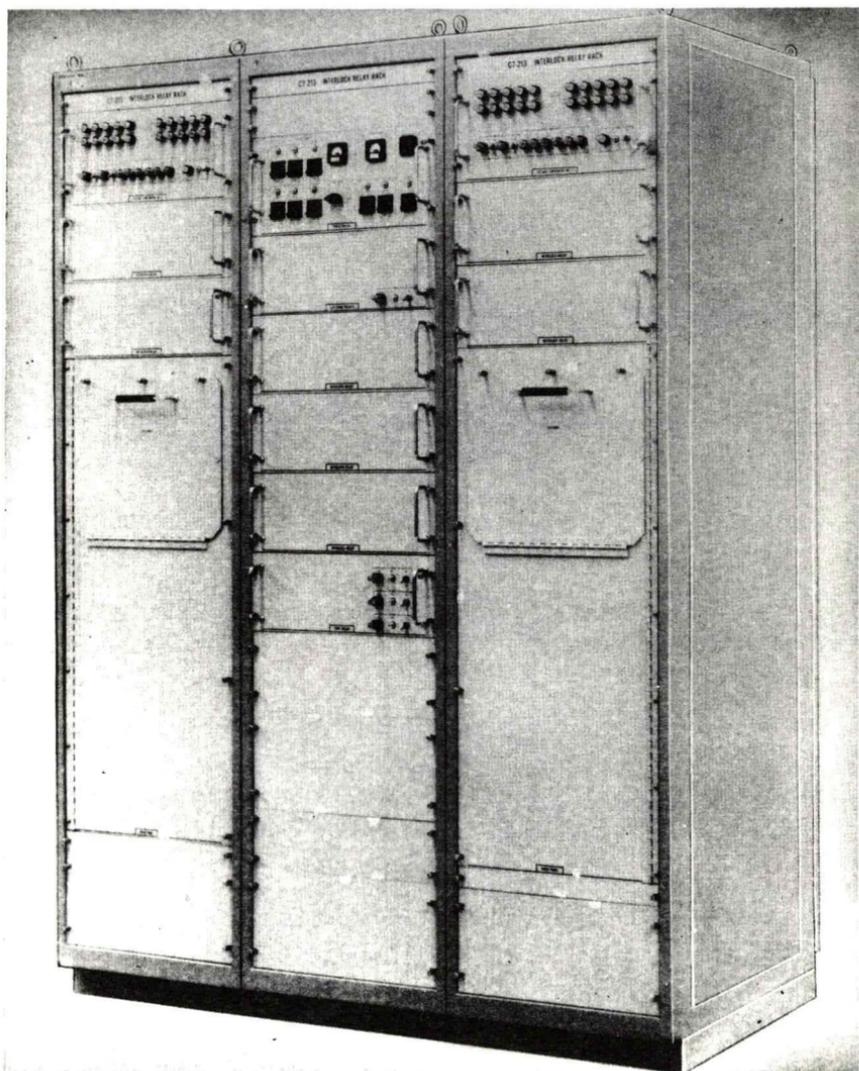
C7-212 DISCRETE DISPLAY RACK

The C7-212 rack displays discrete responses from the mechanical stations, S-II stage systems, and the C7-213 interlock rack. It is used at Seal Beach and MTF.



## C7-213 RELAY INTERLOCK RACK

The C7-213 rack provides relay interlocking of commands to the S-II stage and responses from the stage. It is used at Seal Beach and MTF.



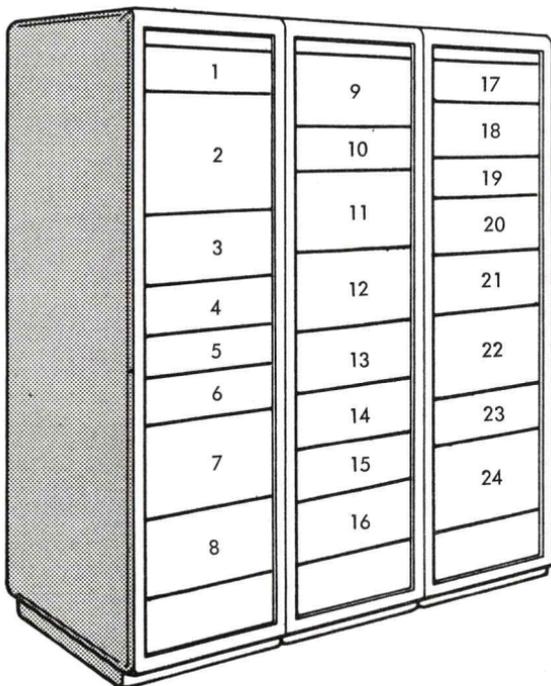
# SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

## C7-307 COMMAND DESTRUCT RECEIVER CHECKOUT RACK

This rack is used to check command destruct receivers on the bench and in the stage. This three-bay console houses both commercial and contractor furnished equipment.

Proper operation is verified for stage-installed receivers, power dividers, filters, and hybrid and interconnecting coaxial cable links. The following receiver parameters are checked: two-channel sensitivity and RF distribution, threshold deviation and function, and limiter output. Operation of each command antenna and its associated cabling is verified by VSWR measurement.

The rack has two operating modes: fully manual or remote control. The latter is limited to on-off switching of rack tone coder channels from the electrical checkout station. It is used at Seal Beach and MTF.

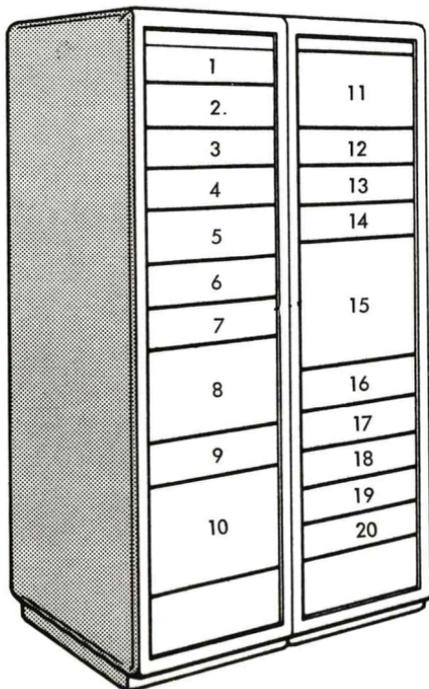


1. POWER CONTROL
2. AUTOMATIC DISPLAY
3. COUNTER
4. TONE CODER
5. INTERCOM
6. -28V POWER
7. AUTO DISPLAY LOGIC
8. BLANK
9. BLANK
10. CODER DISPLAY
11. FM SIGNAL GENERATOR
12. MANUAL CONTROL
13. AUDIO SIGNAL GENERATOR
14. -6V DC POWER SUPPLY
15. RF VOLTAGE STD
16. RF INPUT SELECTOR
17. BLANK
18. OSCILLOSCOPE
19. DCVTVM
20. AC VTVM
21. COMPUTER TEST PANEL
22. +28 V DC POWER SUPPLY
23. IMPEDENCE BRIDGE
24. STORAGE DRAWER

# SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

## C7-400 SERIES C7-401 AUTOMATIC CONTROL AND DISPLAY RACK

The automatic control and display rack performs the following functions: interfaces the telemeter checkout station with the computer complex; selects and interlocks the mode of operation, manual or automatic; and displays six selectable data channels from the DDAS, mode of operation, and status of telemeter station digitizing instruments. It is used at Seal Beach and MTF.



1. POWER CONTROL
2. BLANK
3. DATA SELECTION  
DECODER NO. 1
4. DATA SELECTION  
DECODER NO. 2
5. MANUAL CONTROL
6. INTERCOM
7. MEASUREMENTS  
CALIBRATION CONTROL
8. PRINTER
9. CLOCK DRIVER
10. BLANK
11. BLANK
12. CI DECODER
13. SA DECODER
14. AUTO DISPLAY  
LOGIC
15. AUTO DISPLAY
16. DECODER DRIVER
17. INPUT REGISTER
18. OUTPUT REGULATOR NO. 1
19. OUTPUT REGULATOR NO. 2
20. STATION BUFFER

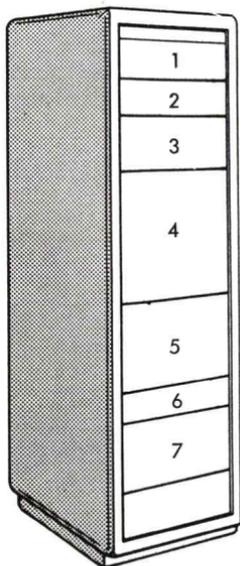
# SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

## C7-402 MANUAL CONTROL AND DISPLAY RACK

The manual control and display rack contains display, control, and logic circuitry. The rack becomes functional only when manual control of the station is commanded from the test conductor console C7-102. Rack equipment includes the station status display, manual (local) controls, an intercom set, and power control panel.

The station status display is an array of lamps energized by feedback from measurement devices within the station to indicate proper activation of station equipment.

The manual (local) controls consist of the switches and logic required to simulate the computer. Switching instructions generated manually from this section operate through the same logic circuitry used by the computer when programmed for automatic control. It is used at Seal Beach and MTF.



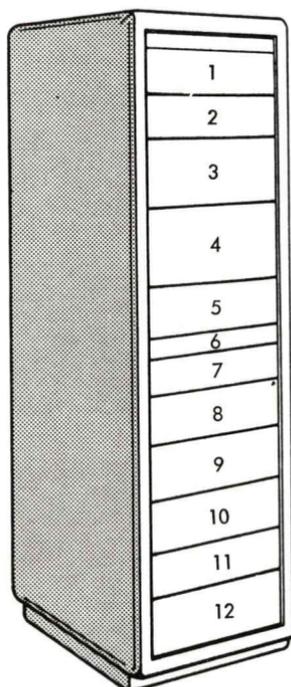
1. POWER PANEL
2. BLANK
3. STATION STATUS
4. LOCAL CONTROL NO. 2
5. LOCAL CONTROL NO. 1
6. INTERCOM
7. BLANK

## C7-403 PCM RACK

The PCM rack processes simulated or actual stage-generated telemetry data. By means of rack equipment, the PCM signal from the stage is demodulated, regenerated, and decommutated; a 72-kc clock signal is generated and synchronized with the clock signal originating in the stage; and partial routing is accomplished for signals to the computer and various display circuits. The rack itself mounts only one display.

There are three source categories for equipment mounted in the rack: NASA-furnished, contractor-furnished, and commercial items.

Rack components furnished by NASA are the power supply, source selector, signal simulator, correlator, and data control unit. The C7-403 is used at Seal Beach and MTF.

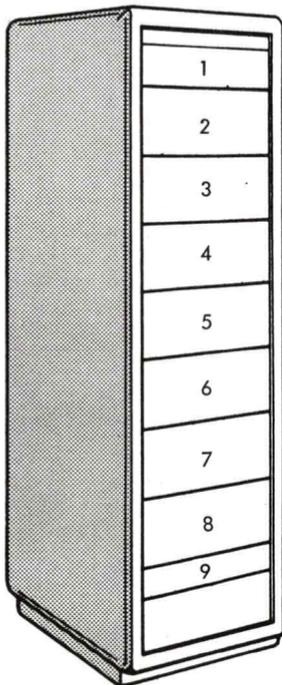


1. POWER SUPPLY
2. SOURCE SELECTOR
3. RECEIVER-DEMODULATOR
4. SIGNAL SIMULATOR
5. SIGNAL SYNCHRONIZER
6. BLOWER UNIT
7. QUICK LOOK PANEL
8. DATA SWITCH PANEL
9. CORRELATOR PANEL
10. DATA CONTROL PANEL
11. BLANK
12. BLOWER

## C7-406 COMPUTER ADAPTER RACK

The computer adapter rack contains necessary logic for converting straight binary codes to BCD and for routing required words to station displays and the computer C7-101. Rack equipment consists of a binary-to-BCD converter and display select registers.

Inputs from the correlator (in the PCM rack C7-403) are converted from binary to BCD format. These converted signal outputs are accepted by the display select registers. When supplied appropriate inputs from the data switching unit (in C7-403), the registers transmit requested words to other displays in the station. The C7-406 is used at Seal Beach and MTF.



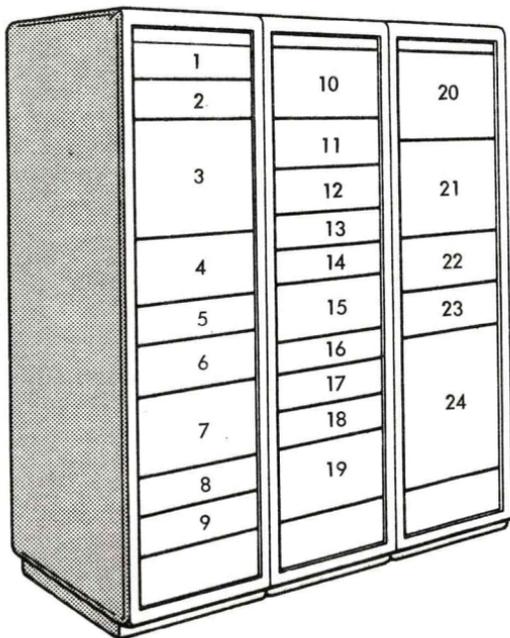
1. POWER PANEL
2. BINARY TO BCD CONVERTER
3. DISPLAY SELECT REGISTER
4. DISPLAY SELECT REGISTER
5. DISPLAY SELECT REGISTER
6. DISPLAY SELECT REGISTER
7. DISPLAY SELECT REGISTER
8. DISPLAY SELECT REGISTER
9. BLANK

# SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

## C7-500 SERIES C7-510 AUTOMATIC CONTROL AND DISPLAY RACK

This rack provides display, buffering, and decoding functions for the digital data acquisition station when the latter is under control of computer C7-101. Encoded logic signals are received from the computer and converted into signals acceptable to station control logic; stage responses are converted to a BCD format and transmitted to the computer.

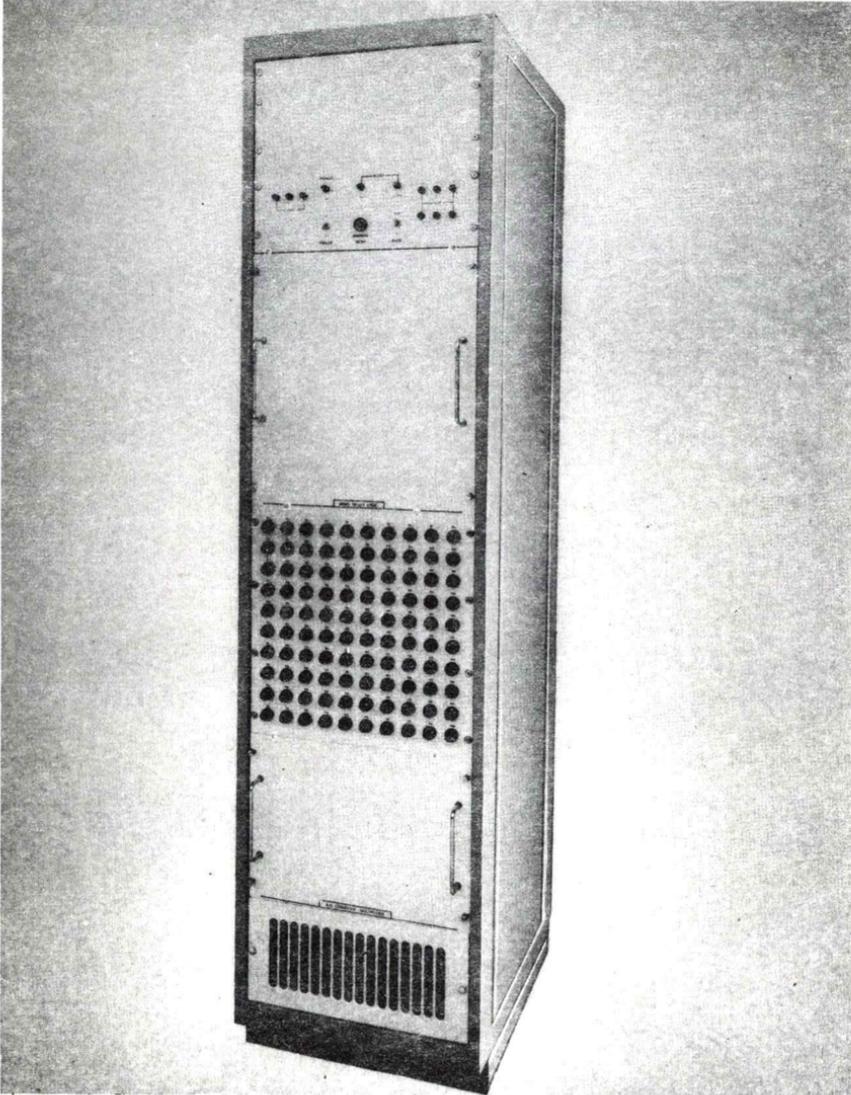
The rack contains controls and circuitry for the automatic display, echo-check display (with associated logic), discrete display input and output registers, station buffer, logic level and word selector buffers, subaddress decoder, station (flip-flop gating) driver, echo check, and a power control panel. It is used at Seal Beach and MTF.



1. POWER PANEL
2. BLANK
3. AUTOMATIC DISPLAY
4. DISCRETE DISPLAY
5. ECHO CHECK
6. ECHO CHECK DISPLAY
7. AUTOMATIC DISPLAY LOGIC
8. ECHO CHECK DISPLAY LOGIC
9. BLANK
10. BLANK
11. -28VDC POWER SUPPLY
12. -6VDC POWER SUPPLY
13. SUB ADDRESS DECODER
14. INPUT REGISTER
15. STATION DRIVER
16. STATION BUFFER
17. OUTPUT REGISTER NO. 1
18. OUTPUT REGISTER NO. 2
19. T-TIME & TEST SEQUENCE
20. BLANK
21. BLANK
22. LOGIC LEVEL BUFFER
23. WORD SELECTOR BUFFER
24. WORD SELECTOR

C7-511 PCM FORMAT RACK

The PCM format rack converts PAM and continuous data to a PCM format for comparison in the computer selection of channels to be digitized for computer entry. It is used at Seal Beach and MTF.

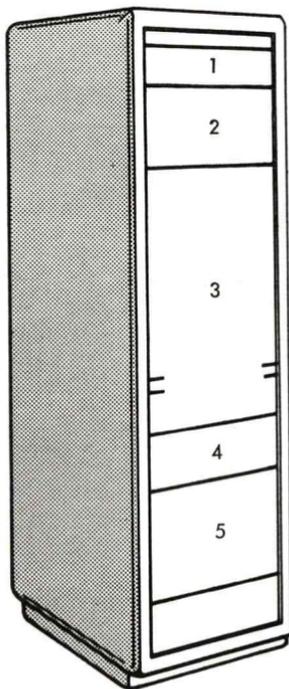


C7-512 OSCILLOGRAPH RACK

The oscillograph rack contains equipment necessary to record analog outputs of the single sideband rack C7-518, discriminator rack C7-514, and the decommutation rack C7-513.

There is one oscillograph rack for each of these three sources. The three racks are identical except for the galvanometers used in the 36-channel oscillographs. The type of galvanometer used is determined by the frequency range of the information to be recorded.

Inputs are first applied to the patch panels in the oscillograph racks, then to galvanometer control panels where the signals are attenuated to produce the proper amount of deflection on the oscillographs. The C7-512 is used at Seal Beach and MTF.



1. POWER CONTROL
2. ATTENUATORS
3. OSCILLOGRAPH
4. PATCH PANEL
5. STOWAGE DRAWER

SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

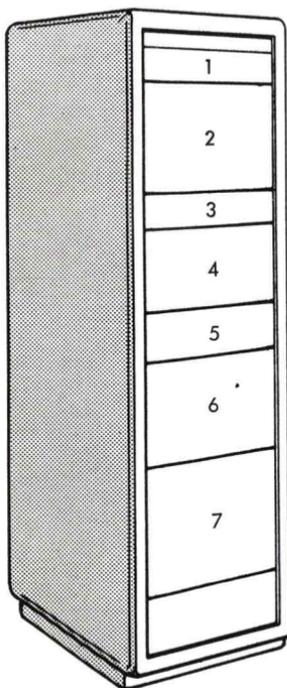
C7-513 DECOMMUTATION RACK

Rack equipment includes an oscilloscope, subcommutation and commutation simulators, and a decommutator.

The oscilloscope permits visual inspection of the pulse train from the pulse amplitude modulation (PAM) discriminator system (in rack C7-514).

The subcommutation and commutation simulators provide PAM test signals for standard IRIG channels, including the special 300-channel, 3600-pps pulse train to align the decommutator.

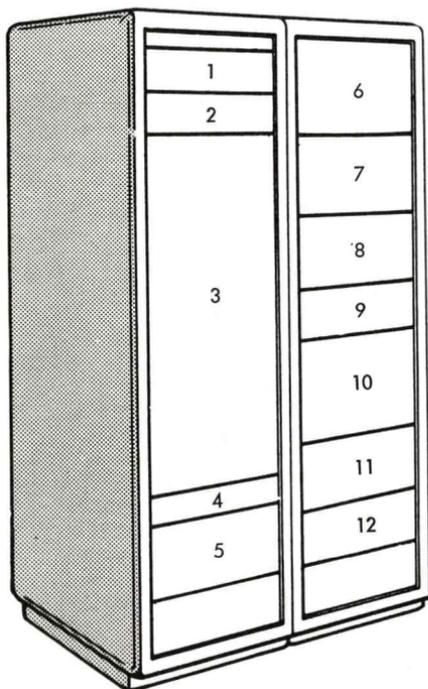
The decommutator separates the time-shared channels of the PAM pulse train and provides analog data for any 30 percent of the 270 data. The C7-513 is used at Seal Beach and MTF.



1. POWER CONTROL
2. BLANK
3. WWV RECEIVER
4. TIME CODE GENERATOR
5. TIME CODE GENERATOR LOGIC
6. BLANK
7. BLANK

## C7-514 DISCRIMINATOR RACK

Equipment in the discriminator rack discriminates the composite video signals which are channeled to measuring instruments (IRIG bands 1-18) or to the decommutator rack (70-kc  $\pm$ 30 percent band). It also sets up the preemphasis schedule of the SCO's and calibrates the airborne telemeters and the discriminator system. The C7-514 is used at Seal Beach and MTF.



1. POWER CONTROL
2. BLANK
3. DISCRIMINATOR SYSTEM
4. MIXER & DEMODULATOR
5. DISCRIMINATOR CALIBRATOR
6. BLANK
7. SCO SPECTRUM ANALYZER
8. INPUT PATCH PANEL
9. OUTPUT SWITCH PANEL
10. VCT & VHF CONVERTER
11. COUNTER TIMER
12. RF AMPLIFIER

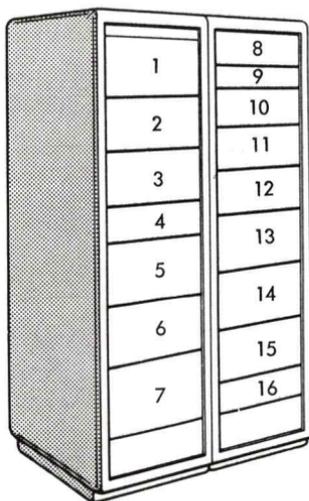
## C7-515 RECEIVER RACK

The receiver rack is used to check telemetry transmission from the S-II stage.

Standard IRIG VHF signals from stage telemetry are received by the rack. A multicoupler provides impedance matching and isolation from the antenna for six VHF telemeter receivers. These receivers tune to different frequencies and provide composite video signals of four IRIG PAM-FM channels and two SS-FM VHF channels.

An IRIG discriminator can be switched to any one of the four PAM-FM composite video signals, and an SS-FM demultiplexer can be switched to any one of the two SS-FM composite video signals by the receiver switch in the rack.

The rack also provides a power control panel, spare telemeter receiver, RF patch panel for flexible rack operation, a test VHF signal generator, and a record-playback patch panel for routing signals to the tape recorder rack C7-516. It is used at Seal Beach and MTF.



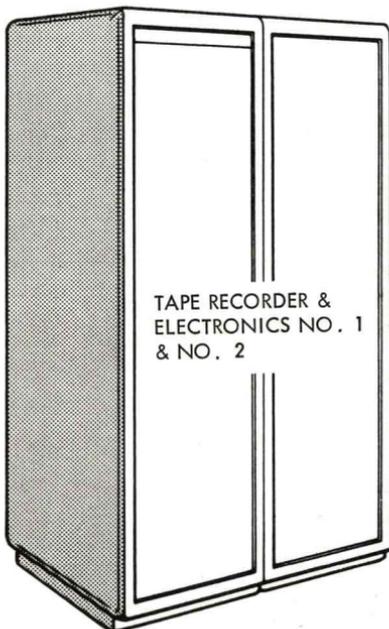
1. POWER CONTROL
2. BLANK
3. RECEIVER NO. 1
4. RECORD/PLAYBACK PATCH
5. SWITCH LOGIC
6. RECEIVER NO. 2
7. RECEIVER NO. 3
8. RECEIVER NO. 4
9. BLANK
10. MULTICOUPLER
11. RF SIGNAL GEN
12. RF PATCH
13. RECEIVER SWITCHES
14. RECEIVER NO. 5
15. RECEIVER NO. 6
16. RECEIVER NO. 7
17. -28V POWER SUPPLY

C7-516 TAPE RECORDER RACK

The two bays of this rack house two wide-band tape recorders, tape search and control system, record and playback patch panels, and power controls.

Each tape recorder has 14 tracks, with record and reproduce capability from 400 cps to 1.5 megacycles. The rack connects to the record-playback patch panel (in rack C7-515).

The tape recorder rack searches the tape and plays back any preset time interval that has been recorded. It records and plays back nine tape tracks, with channels assigned as follows: four PAM/FM channels; two single sideband channels; one reference channel containing 100-kc tape speed reference, 17-kc  $\pm 7.5$  percent tape speed servocontrol, and 70-kc  $\pm 7.5$  percent voice; one serial time code (AMR-D5) channel; and one PCM data channel on a 600-kc carrier. The C7-516 is used at Seal Beach and MTF.



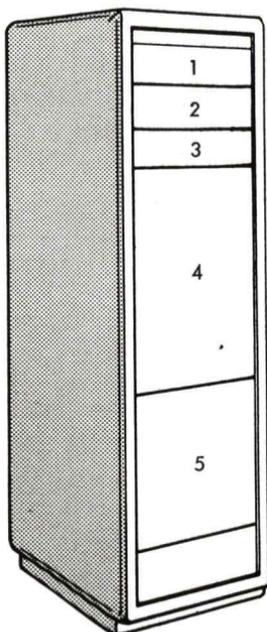
# SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

## C7-518 SINGLE SIDEBAND RACK

Equipment in the C7-518 rack includes an SS-FM demultiplexer, an SS-FM calibrator control, and a rack power control panel.

The SS-FM demultiplexer receives composite video signals from the receiver rack C7-515 in the form of one special service channel, 15 data channels, and a pilot tone in multiplex form. The demultiplexer separates the special service channel and the 15 data channels and restores the original data for display or recording purposes. The pilot tone remains internal to the demultiplexer and is used as a reference level and alarm signal.

The SS-FM calibrator control initiates a calibrate signal that is fed to SS-FM equipment in the S-II stage, and response is observed on the GSE for accuracy. The C7-518 is used at Seal Beach and MTF.



1. POWER CONTROL
2. BLANK
3. SS/FM CALIBRATOR CONTROL
4. SS/FM DEMULTIPLEXER
5. BLANK

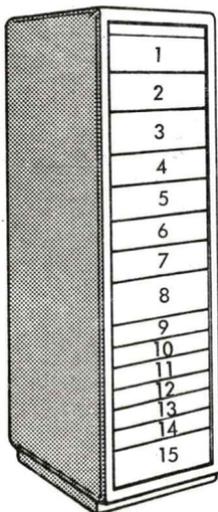
## C7-519 PCM RACK

The function of the PCM rack equipment is to decommutate the signal from the stage-borne DDAS (or to decommutate a simulated equivalent signal) and to select particular data items for routing to and presentation on a quick-look display.

The synchronizer component in the rack regenerates the PCM signal (actual or simulated) and generates a clock signal in synchronization with the clock pulse in the S-II stage. The regenerated PCM signal is transmitted to the correlator unit, and the clock signal is routed to both the correlator and data control units.

The correlator is utilized for series-to-parallel conversion and sync-pattern recognition. The data control unit provides word addresses to the data switch and quick-look display.

Both analog and digital information from selected channels are presented on the quick-look display. Selection of channel outputs for display is accomplished manually. The rack is used at Seal Beach and MTF.

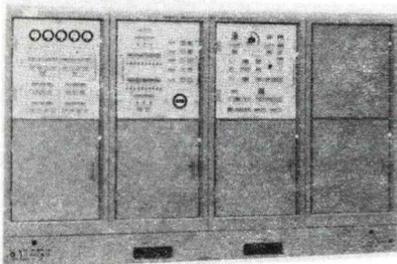


1. POWER SUPPLY
2. SIGNAL SIMULATOR
3. SIGNAL SYNCHRONIZER
4. CORRELATOR UNIT
5. DATA CONTROL UNIT
6. QUICK LOOK UNIT
7. DATA SWITCH UNIT
8. D TO A CONVERTER-  
POWER SUPPLY
9. D TO A CONVERTER
10. D TO A CONVERTER
11. D TO A CONVERTER
12. D TO A CONVERTER
13. D TO A CONVERTER
14. D TO A CONVERTER
15. BLOWER

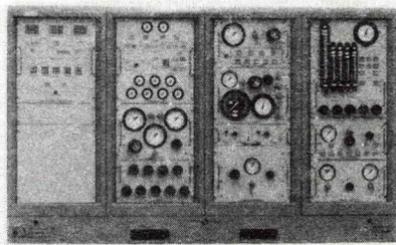
C7-519

C7-603 PNEUMATIC CHECKOUT CONSOLE SET

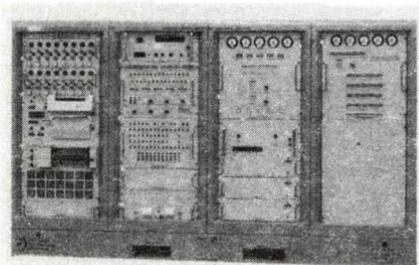
The C7-603 controls and distributes gaseous nitrogen and helium for leak and functional checkout of the S-II stage engine pressurization and propellant systems. It is used in conjunction with the C7-200 series GSE during functional checkout of the S-II stage or remotely during leak-check operations. It is used at Seal Beach and MTF.



AUTOMATIC SECTION



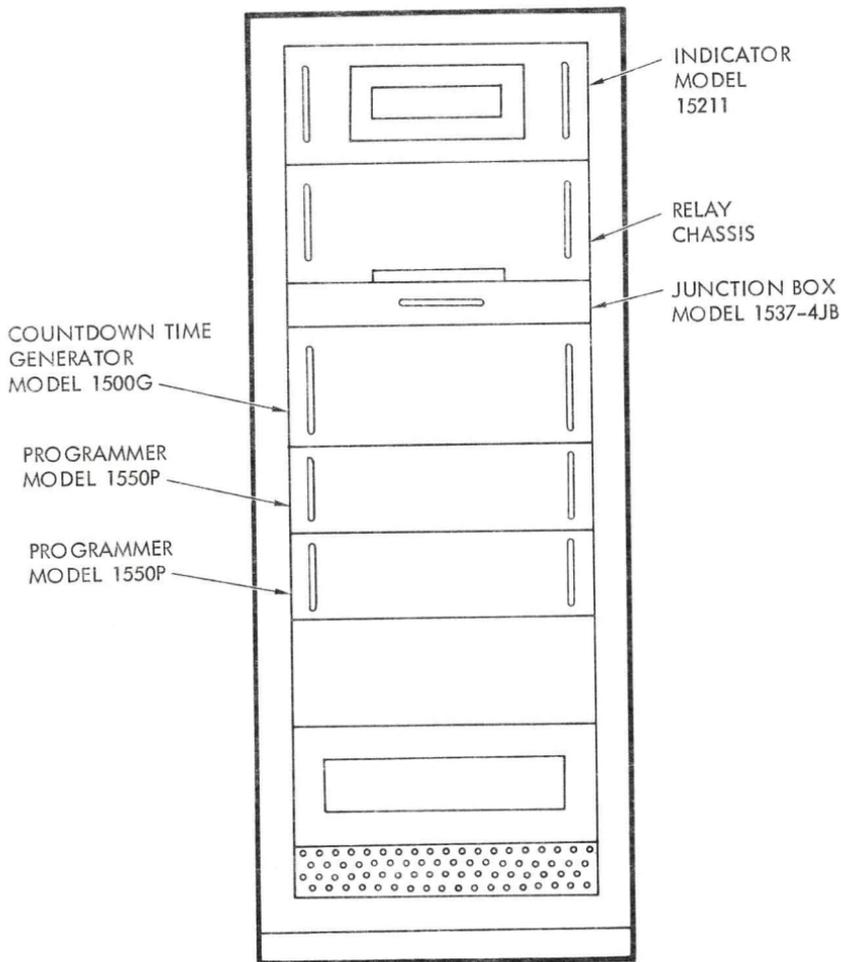
MANUAL SECTION



RECORDER SECTION

## COUNTDOWN PROGRAMMER 950A (1001 AND 1002)

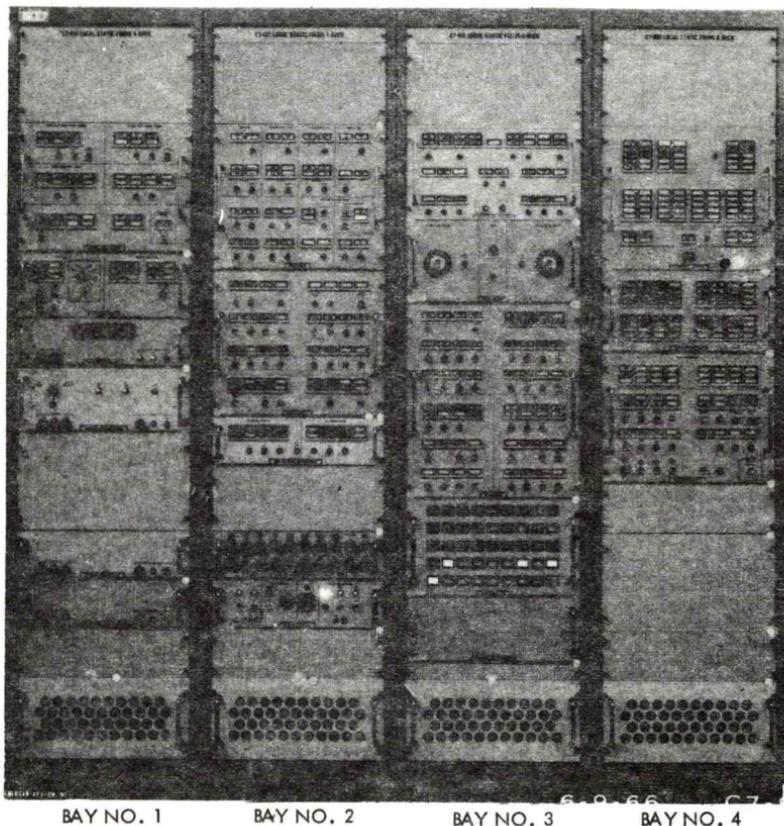
The countdown programmer ties into the C7-801 and C7-802 to provide 0.1-second time output signals for automatic sequencing during static firing of the S-II stage. It is used at the MTF C1 and C2 test control center only.



## C7-800 SERIES

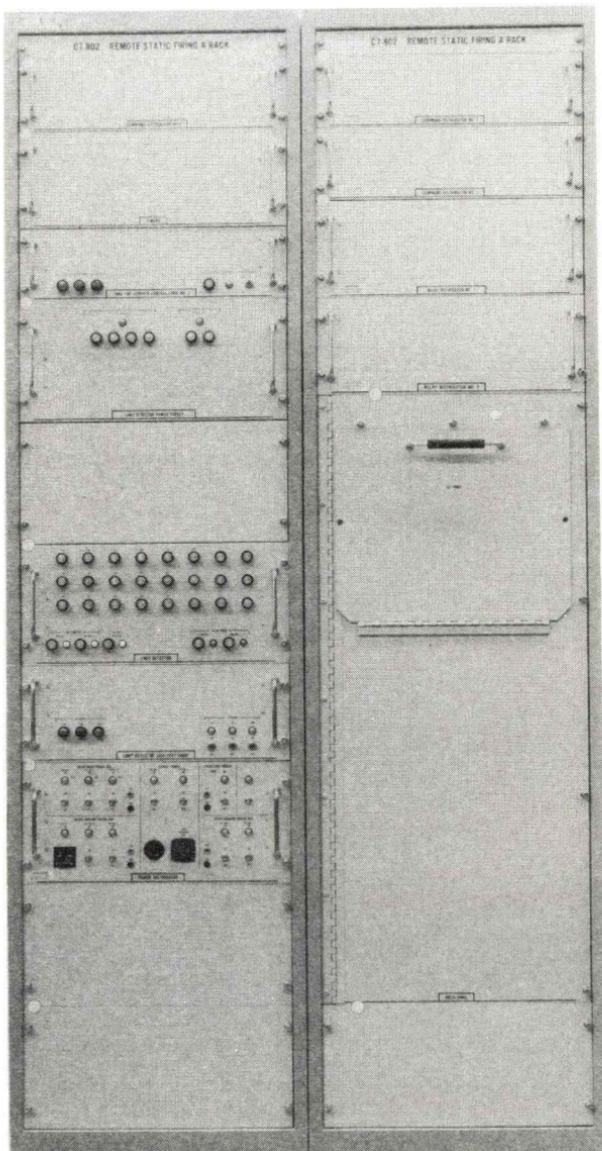
## C7-801 LOCAL STATIC FIRING RACK

The local static firing rack provides an interface for separation of the electrical checkout station at MTF static firing facilities. The C7-801 ties into the C7-802 rack allowing manual control of countdown operations during static firing. It is used at MTF only.



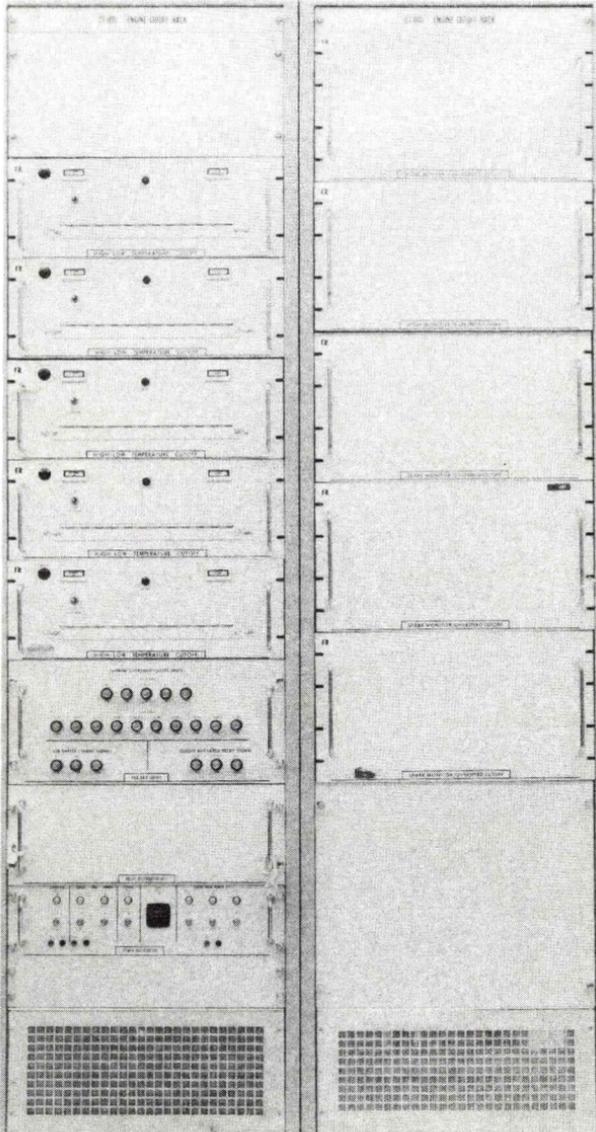
C7-802 REMOTE STATIC FIRING "A" RACK

The C7-802 provides relay capability to process commands from the C7-801 during static firing operations. It is used at MTF only.



C7-805 ENGINE CUTOFF RACK

The C7-805 provides for automatic and test control center generated cutoff signals, to cut off all five J-2 engines during static firing. The rack monitors critical stage parameters and will initiate engine cutoff if any one parameter exceeds prescribed limits. It is used at MTF only.



X. AUXILIARY EQUIPMENT

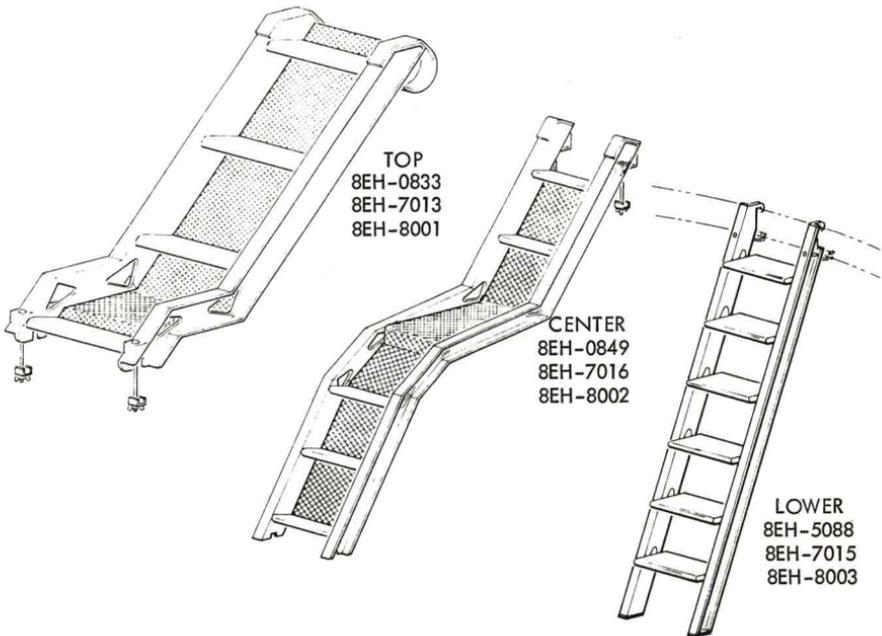
SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

EQUIPMENT HANDLING

THRUST STRUCTURE ACCESS LADDER

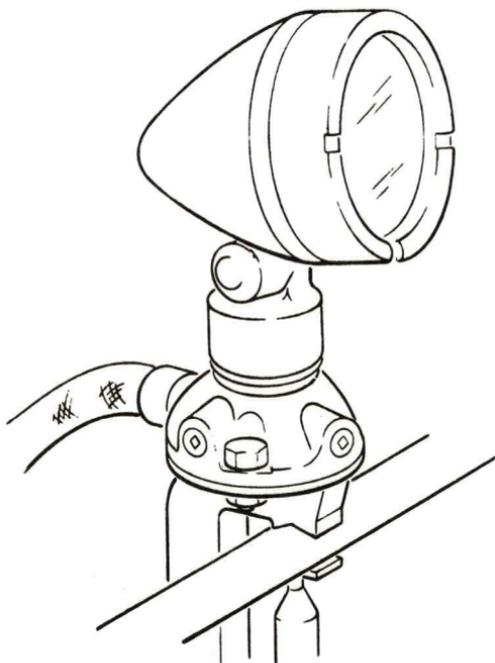
The ladder provides personnel access to the thrust cone interior, and is designed to prevent damage to mechanical and electrical installations and 2020 aluminum. Three sections are required to complete one full-length-ladder.

Access Ladder	Lower Section	Center Section	Top Section
Seal Beach	8EH-5088	8EH-0849	8EH-0833
MTO	8EH-7015	8EH-7016	8EH-7013
KSC	8EH-8003	8EH-8002	8EH-8001
S-II Stage Station	X <sub>b</sub> 39 to X <sub>b</sub> 112	X <sub>b</sub> 112 to X <sub>b</sub> 167	X <sub>b</sub> 167-up
Capacity	1 person	2 persons	1 person



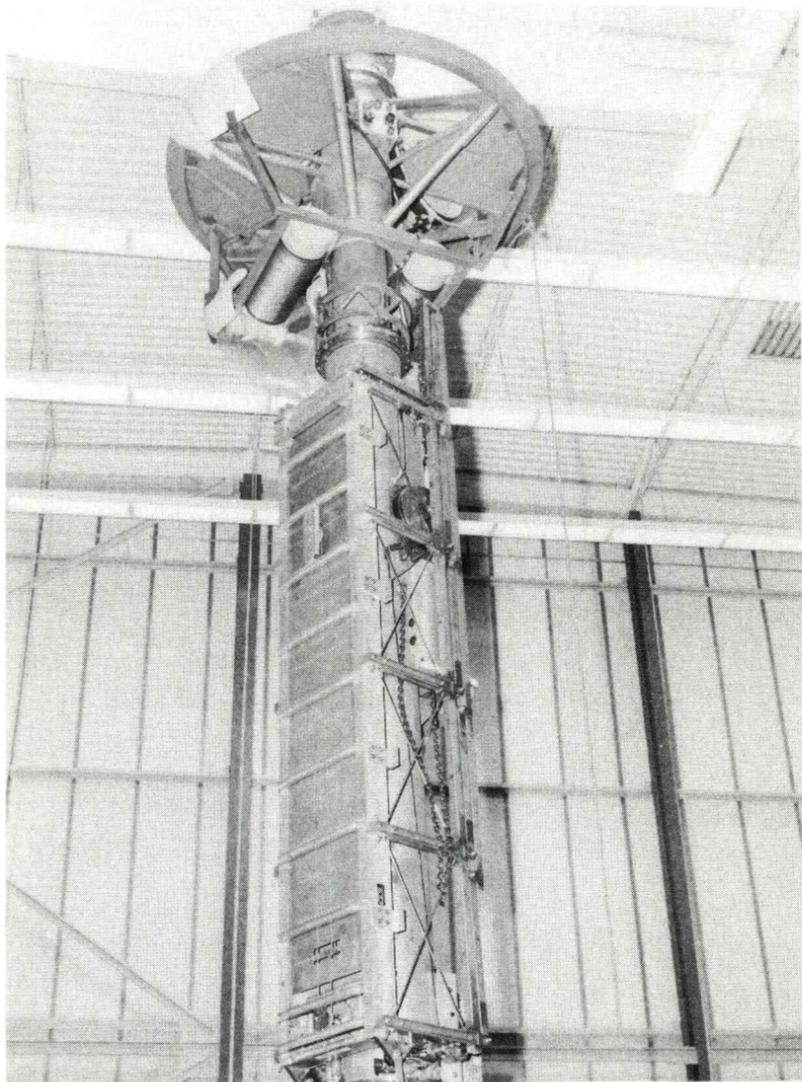
A7-14 ENGINE COMPARTMENT LIGHT SET

The A7-14 set is made up of 30 floodlight assemblies and associated cable harnesses. The 120 volt, 60 cps lights provide 100 foot-candles of illumination to the engine compartment. The set is used at Battleship and MTF.



A7-35 LH<sub>2</sub> TANK SERVICING MECHANISM

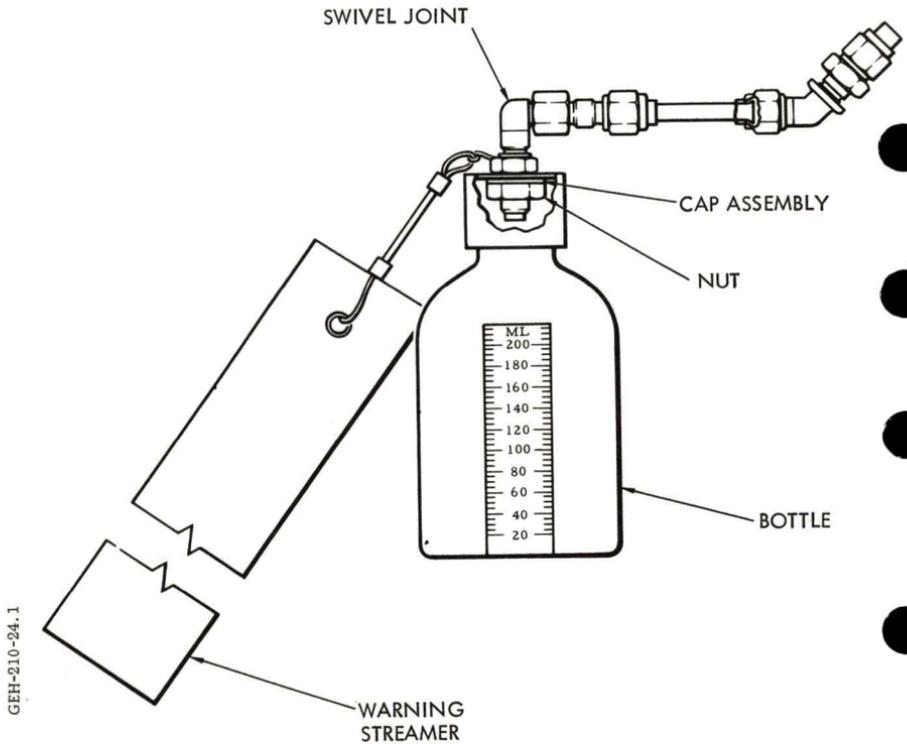
The A7-35 mechanism provides support for technicians and equipment when servicing the interior of the LH<sub>2</sub> tank. It is utilized at MTF.



A7-35 (C) Y

A7-36 PUMP SHAFT SEAL VISUAL LEAKAGE INDICATOR

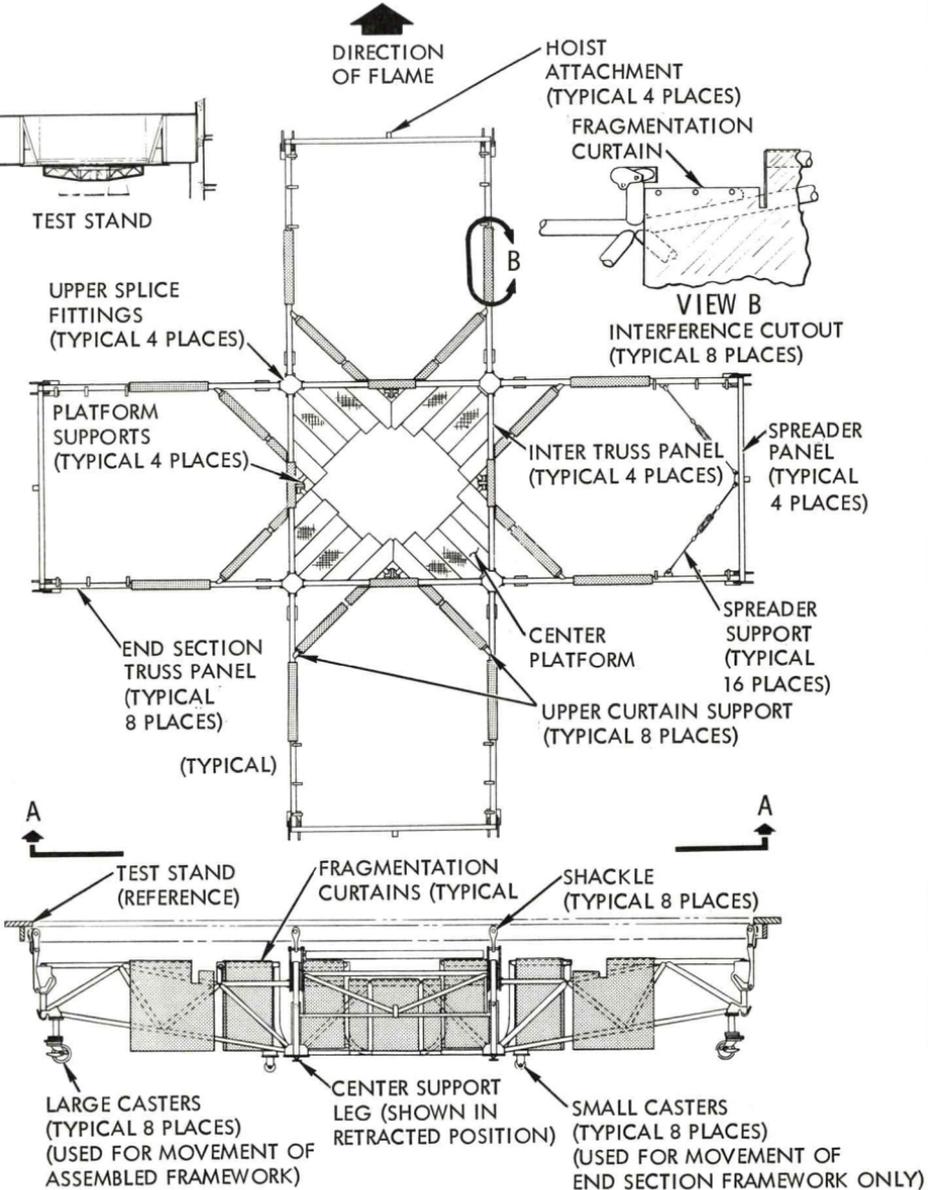
The A7-36 indicator provides a means of checking the amount of hydraulic fluid leakage from the auxiliary hydraulic pump and the main hydraulic pump shaft seal. It is used at Batteship, MSFC, and MTF.



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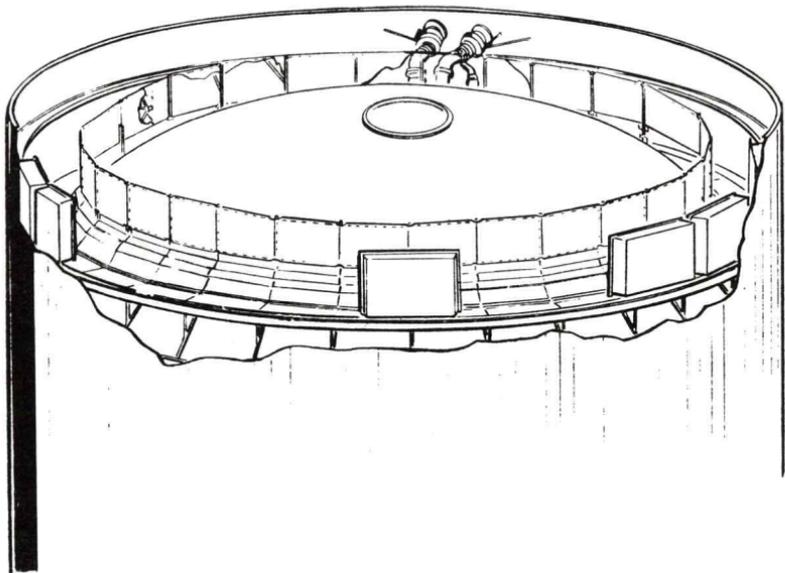
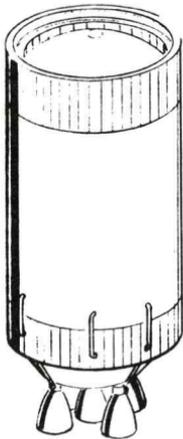
A7-37 STATIC FIRING FRAGMENTATION SHIELD

The A7-37 shield provides protection from J-2 engine explosions for the equipment in the S-II stage engine compartment. It is used at MTF.



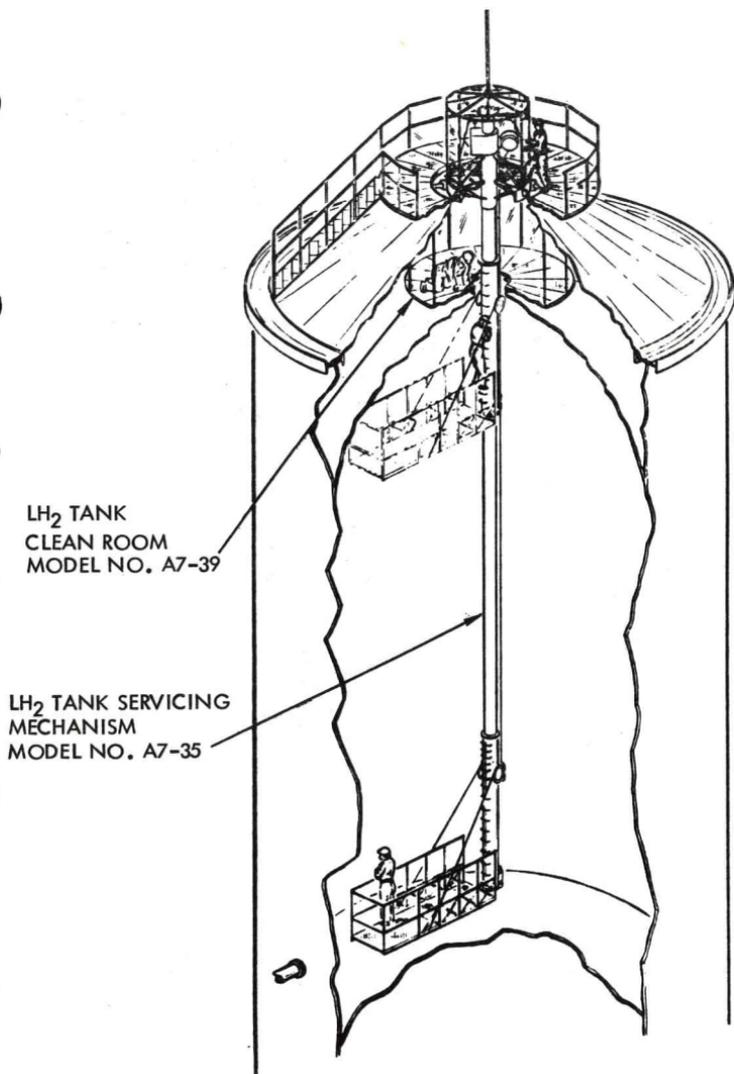
A7-38 FORWARD SKIRT MAINTENANCE WALKWAY

The A7-38 walkway provides a platform in the S-II stage forward skirt area for equipment maintenance. It is employed for the common bulkhead test unit at Battleship, Seal Beach, MSFC, MTF, and KSC.



A7-39 LH<sub>2</sub> TANK CLEAN ROOM

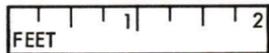
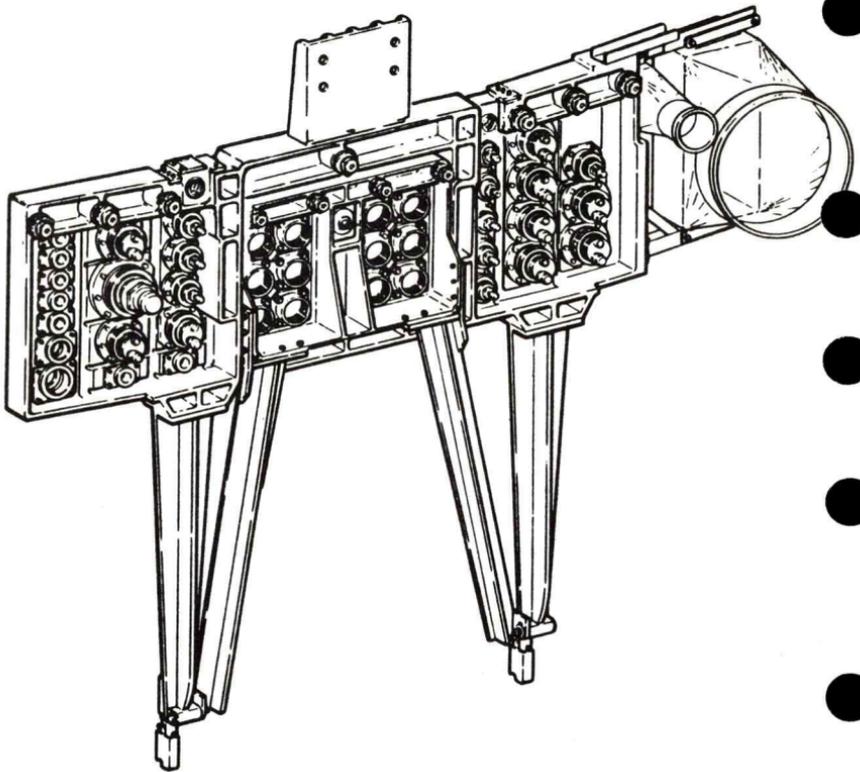
The A7-39 room provides an uncontaminated area below the H7-24 frame opening for personnel, equipment, and the LH<sub>2</sub> tank while maintenance procedures are in progress. The room is utilized at MSFC.



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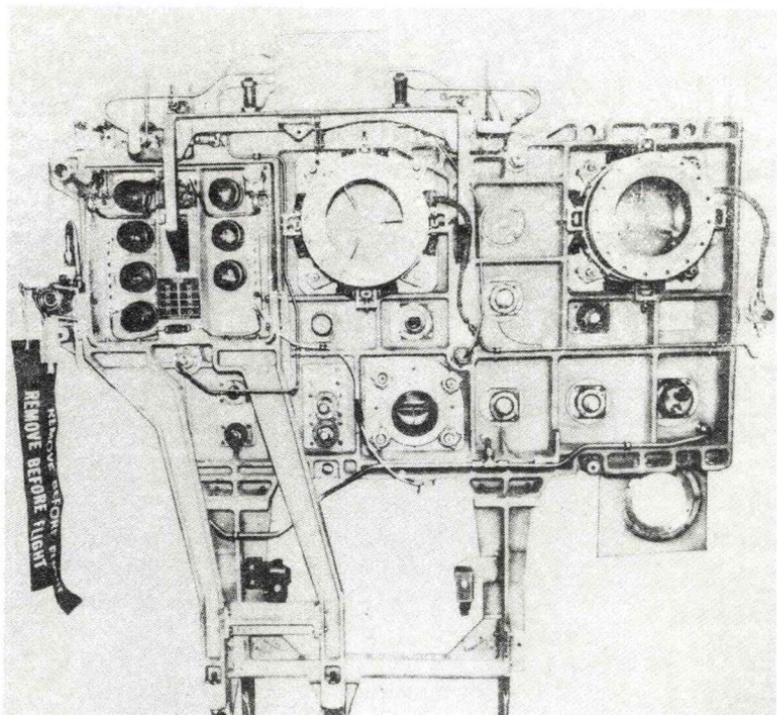
A7-41 UMBILICAL DISCONNECT ARM NO. 3A CARRIER  
PLATE ASSEMBLY

The A7-41 assembly is used for uncoupling all electrical and fluid disconnects (except LOX and LH<sub>2</sub>) from the airborne half of the S-II stage. The assembly is employed at MSFC and KSC.



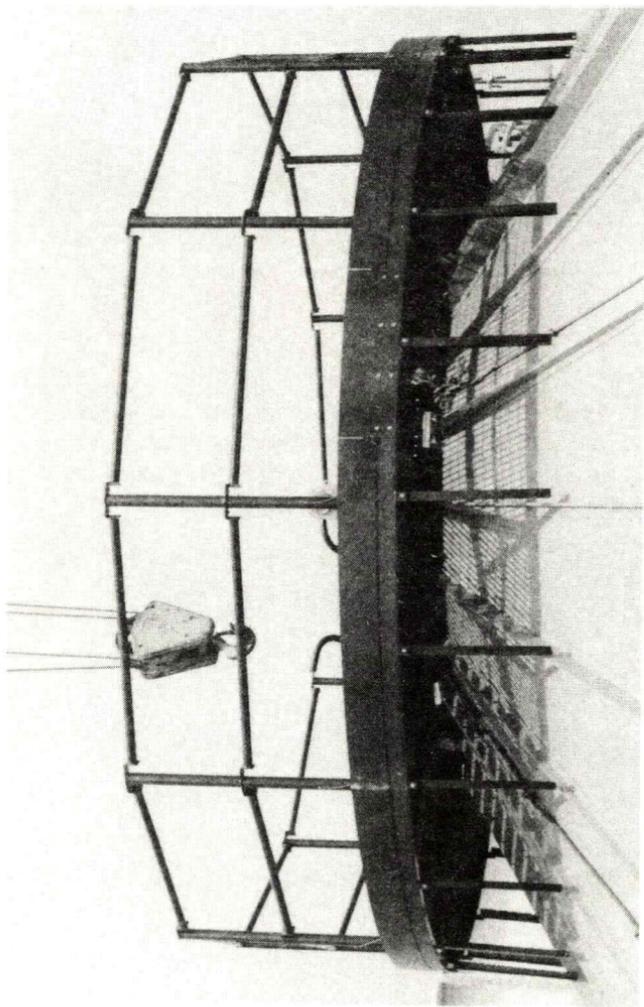
A7-42 UMBILICAL DISCONNECT ARM NO. 4 CARRIER  
PLATE ASSEMBLY

The A7-42 carrier plate assembly provides a means for uncoupling electrical and fluid disconnects from the airborne half of the S-II stage. The assembly is used at MSFC and MTF.



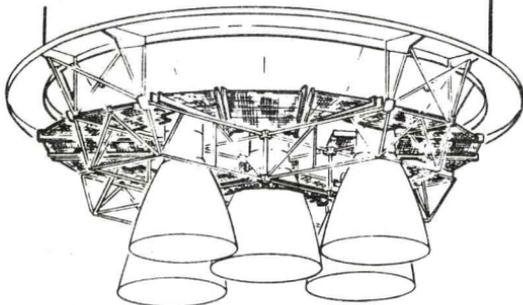
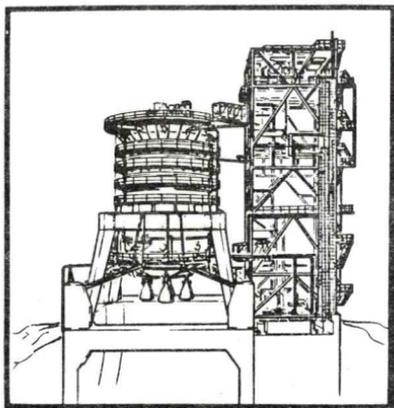
A7-44 FORWARD STAGE ACCESS PLATFORM

The A7-44 platform provides access to the forward hook and erecting sling (H7-23), and provides access for installing and removing the A7-35 servicing mechanism and the A7-39. It is employed at MSFC.



A7-47 STATIC FIRING HEAT SHIELD

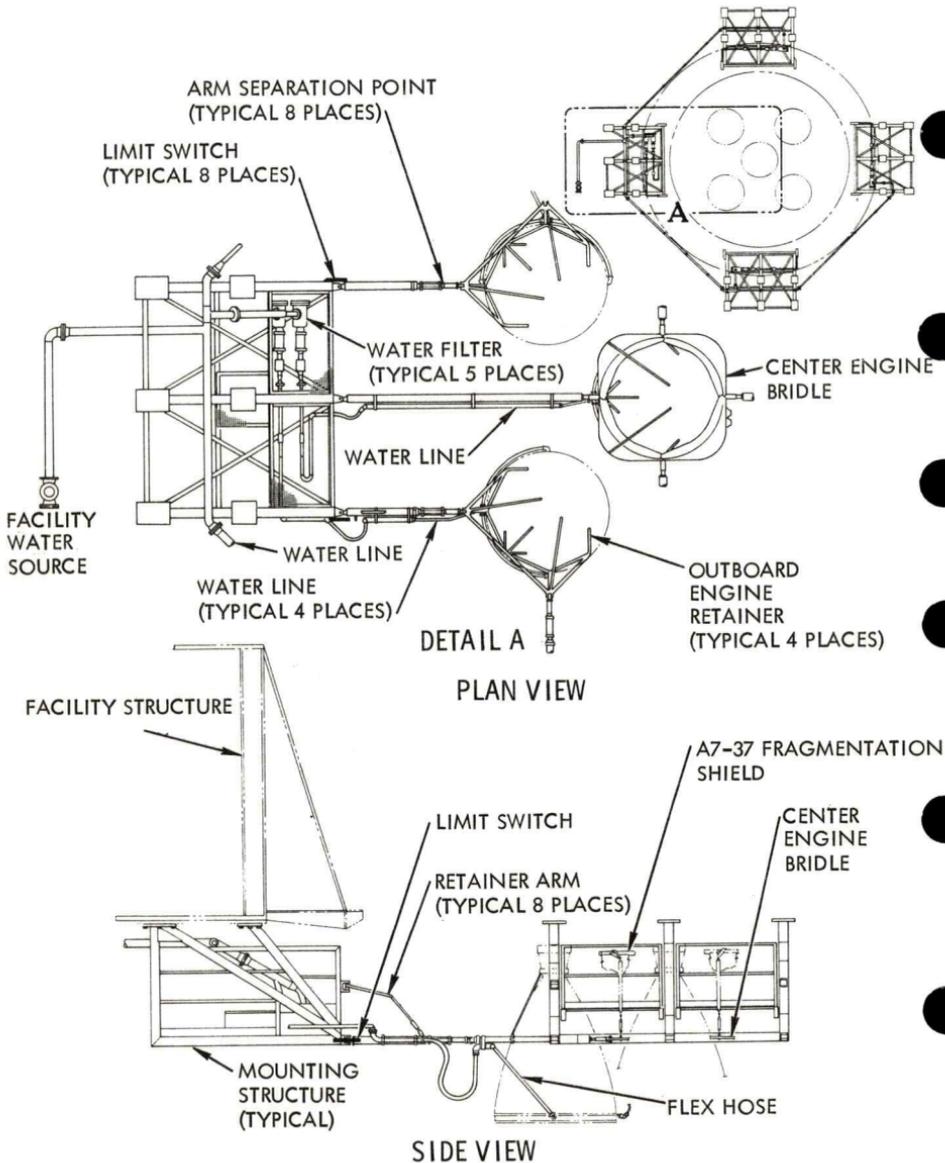
This shield provides heat protection for equipment in the S-II aft interstage area. It is used at Battleship and acceptance test stands (MTF).



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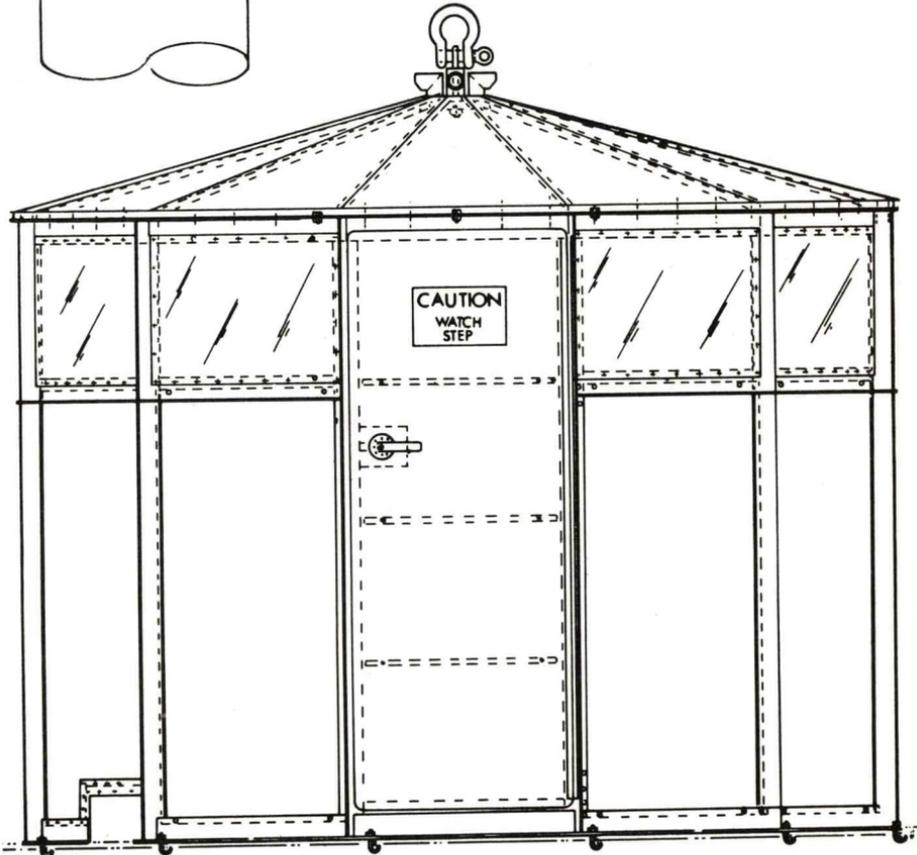
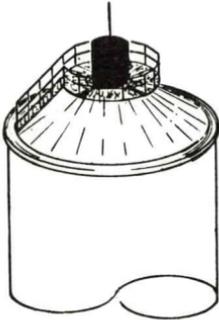
A7-51 SIDE-LOAD ARRESTING MECHANISM

The A7-51 mechanism restrains transient side-load actions of the J-2 engines generated during engine start, and provides for cooling and purging of the engine diffusers. It is used at MTF.



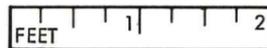
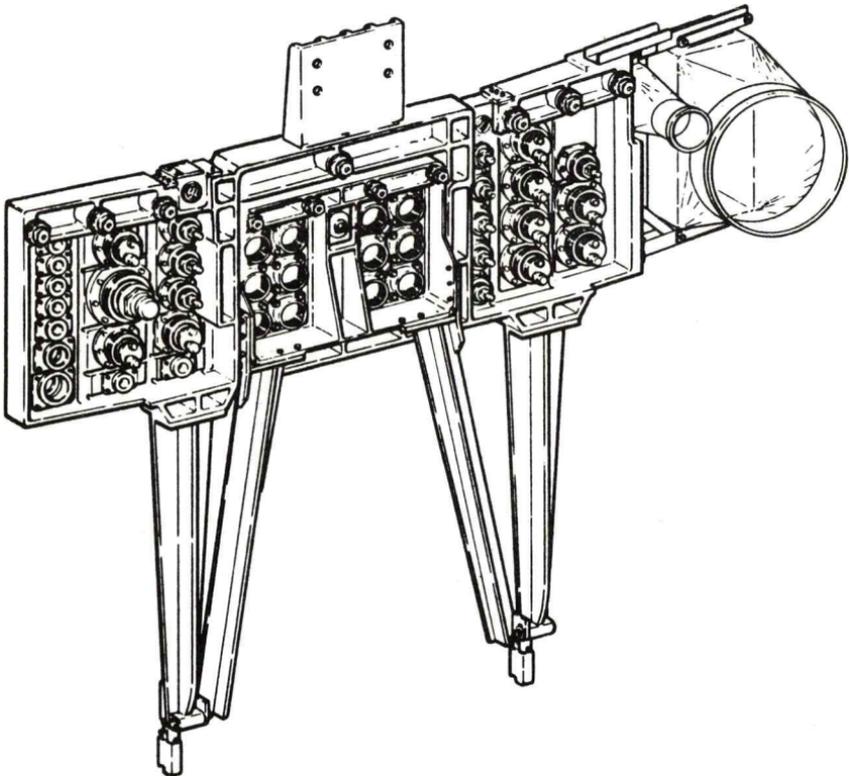
A7-59 LH<sub>2</sub> TANK SERVICING MECHANISM COVER

The A7-59 cover provides an enclosure above the opening on the H7-24 forward hoisting frame to prevent foreign elements from entering the LH<sub>2</sub> tank during tank entry. It is used at MTF and KSC.



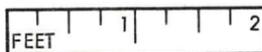
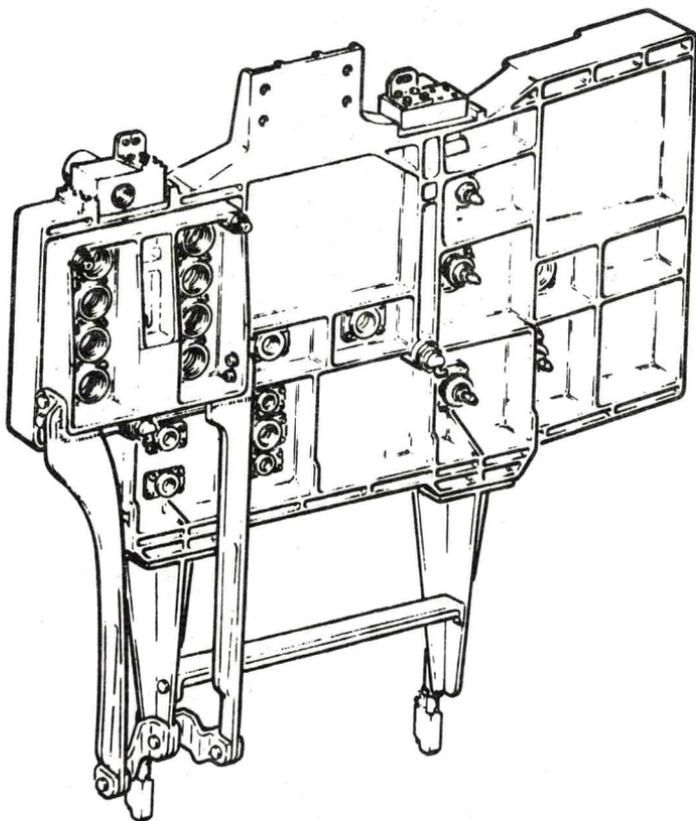
A7-61 FIXED UMBILICAL DISCONNECT ARM NO. 3A CARRIER  
PLATE ASSEMBLY

The A7-61 assembly supports the S-II stage umbilical disconnects between stage Stations 197 and 220 (except LOX disconnect) and permits remote ejection of the electrical disconnects. The assembly is used at Seal Beach and MTF.



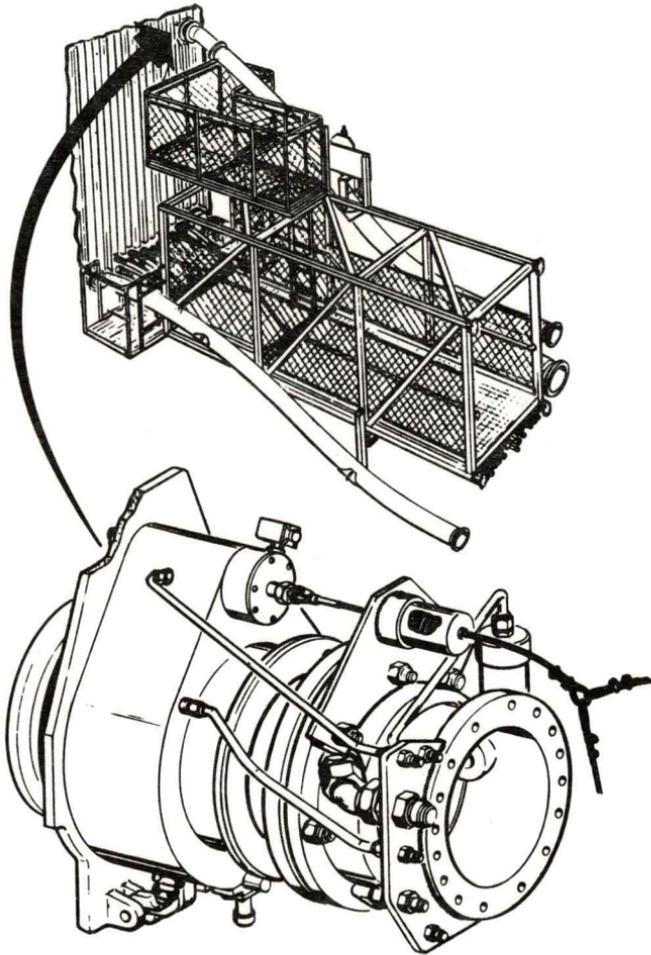
A7-62 FIXED UMBILICAL DISCONNECT ARM NO. 4 CARRIER  
PLATE ASSEMBLY

The A7-62 assembly supports the forward S-II stage umbilical disconnects and permits remote ejection of the electrical disconnects. It is utilized at Seal Beach and MTF.



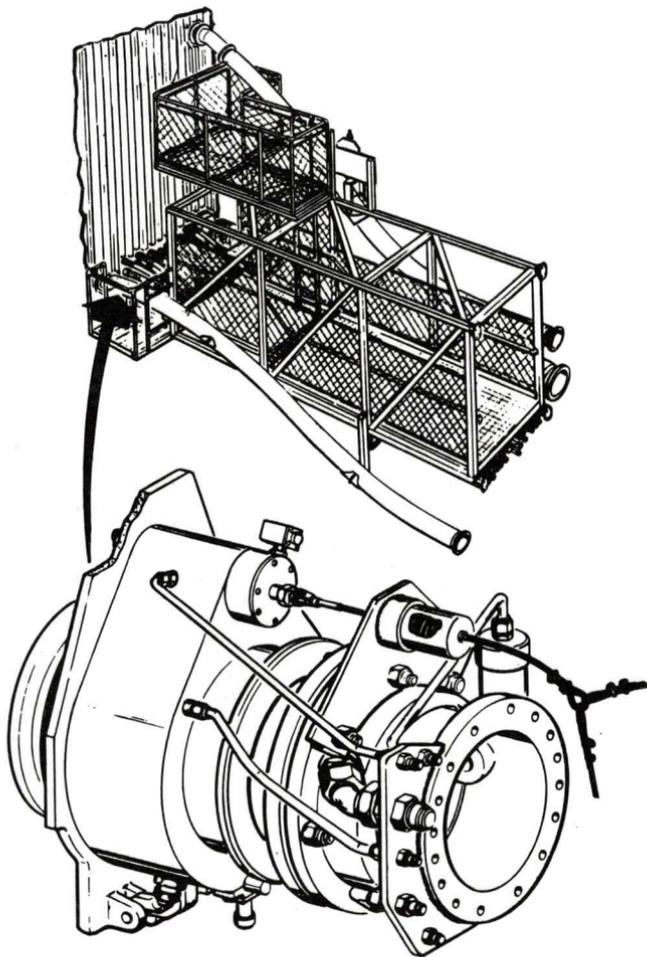
A7-64 LH<sub>2</sub> FILL DISCONNECT

The A7-64 disconnect provides for pneumatic or lanyard ejection of the LH<sub>2</sub> fill propellant disconnect. It is used at MSFC and KSC.



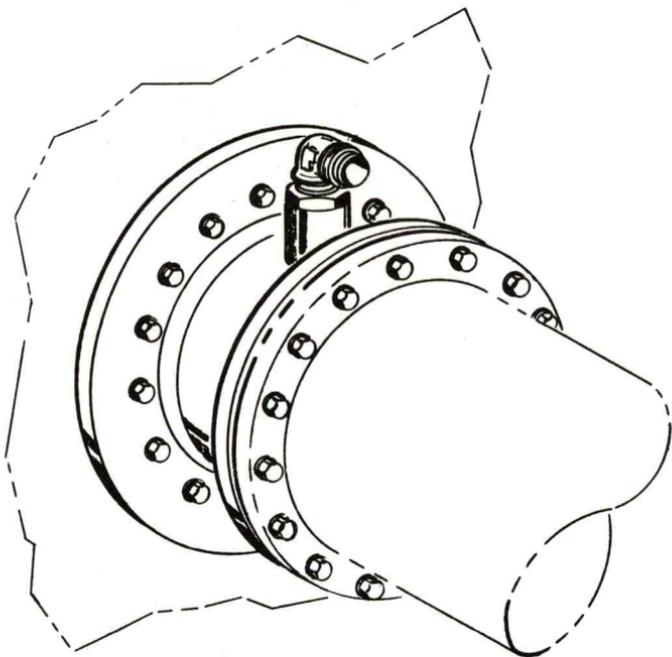
A7-65 LOX FILL DISCONNECT

The A7-65 disconnect provides for pneumatic or lanyard ejection of the LOX fill propellant disconnect. It is employed at MSFC and KSC.



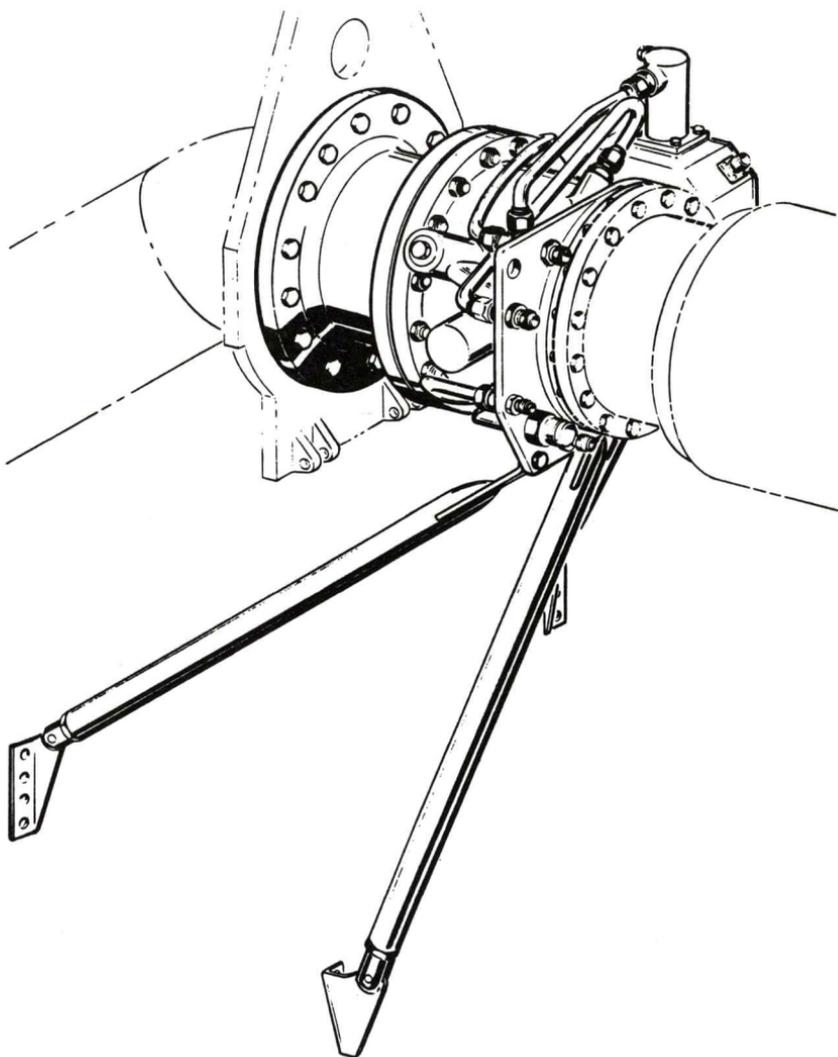
A7-66 LH<sub>2</sub> FILL DISCONNECT ADAPTER

The A7-66 adapter supports the LH<sub>2</sub> fill and drain line during static firing. The adapter is used at MTF.



A7-67 LOX FILL DISCONNECT ADAPTER

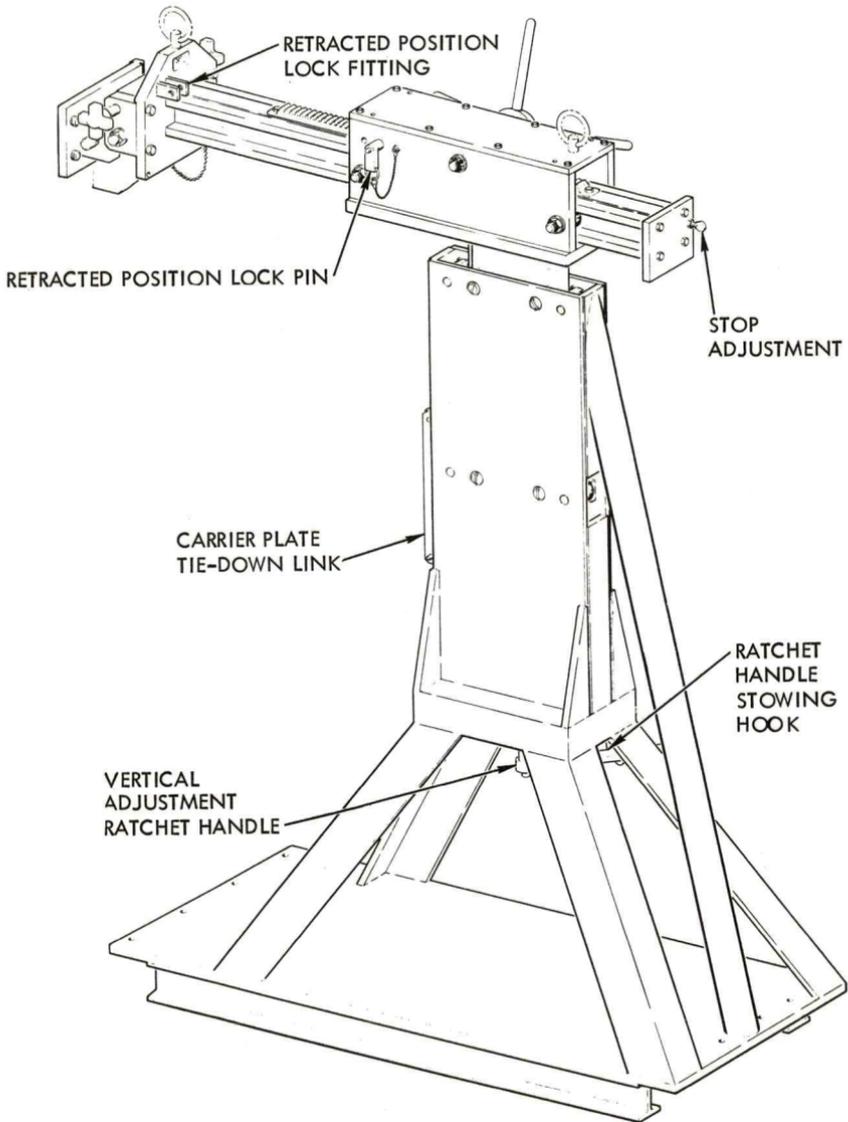
The A7-67 adapter supports the LOX fill and drain line during static firing. The adapter is used at MTF.



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A7-69 ARM NO. 3A CARRIER PLATE SUPPORT MECHANISM

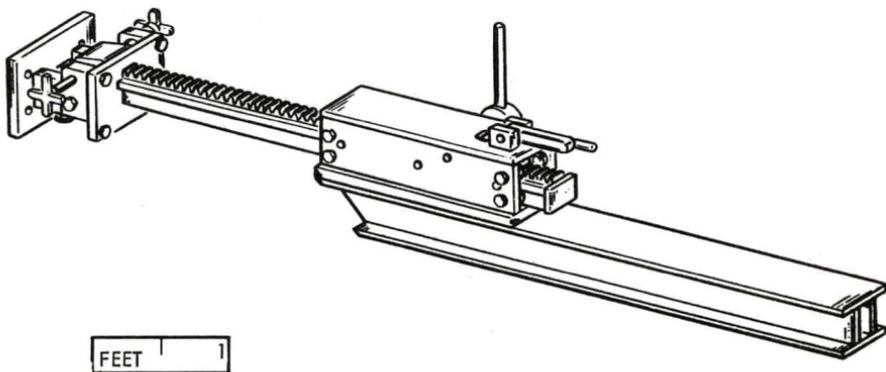
The A7-69 mechanism is used for installing and removing the A7-61 assembly on the S-II stage. The A7-69 mechanism also holds the A7-61 assembly after removal. It is utilized at MTF.



SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

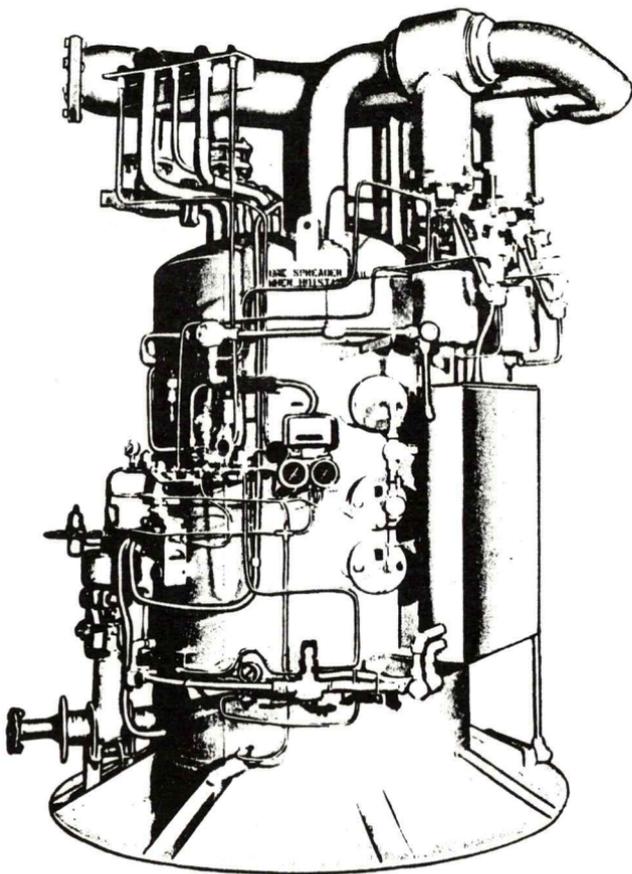
A7-70 ARM NO. 4 CARRIER PLATE SUPPORT MECHANISM

The A7-70 mechanism is used for installing and removing the A7-62 assembly on the S-II stage. The A7-70 mechanism is also used to hold the A7-62 assembly after removal. It is used at MTF.



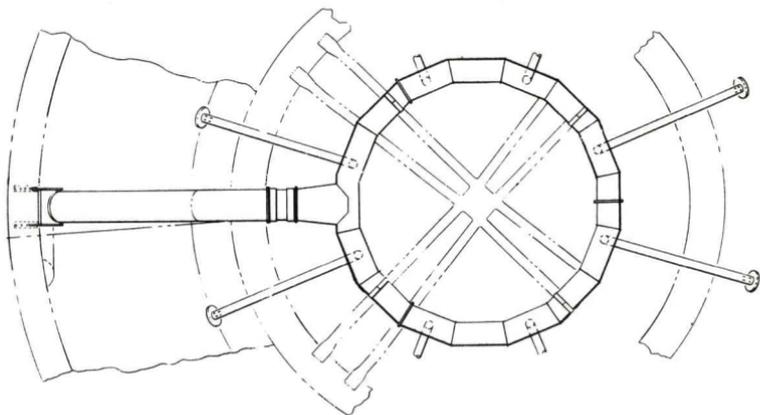
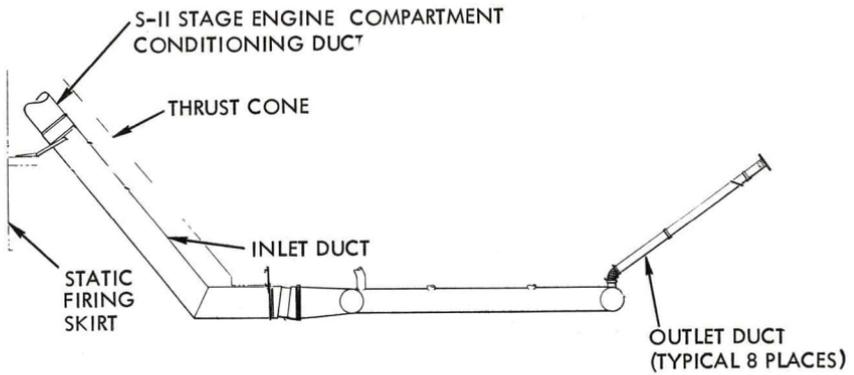
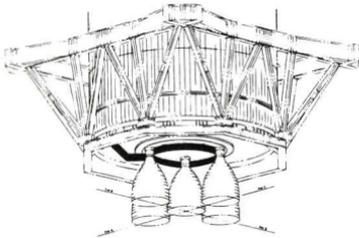
A7-71 LH<sub>2</sub> HEAT EXCHANGER

The A7-71 exchanger is a vacuum-insulated tank. When operational, it is filled with LH<sub>2</sub>, which is used to chill-down gaseous helium and hydrogen for preconditioning of engine components and pressurization of the propellant tanks prior to static firing and launch. It is employed at Battleship, MTF, MSFC, and KSC.



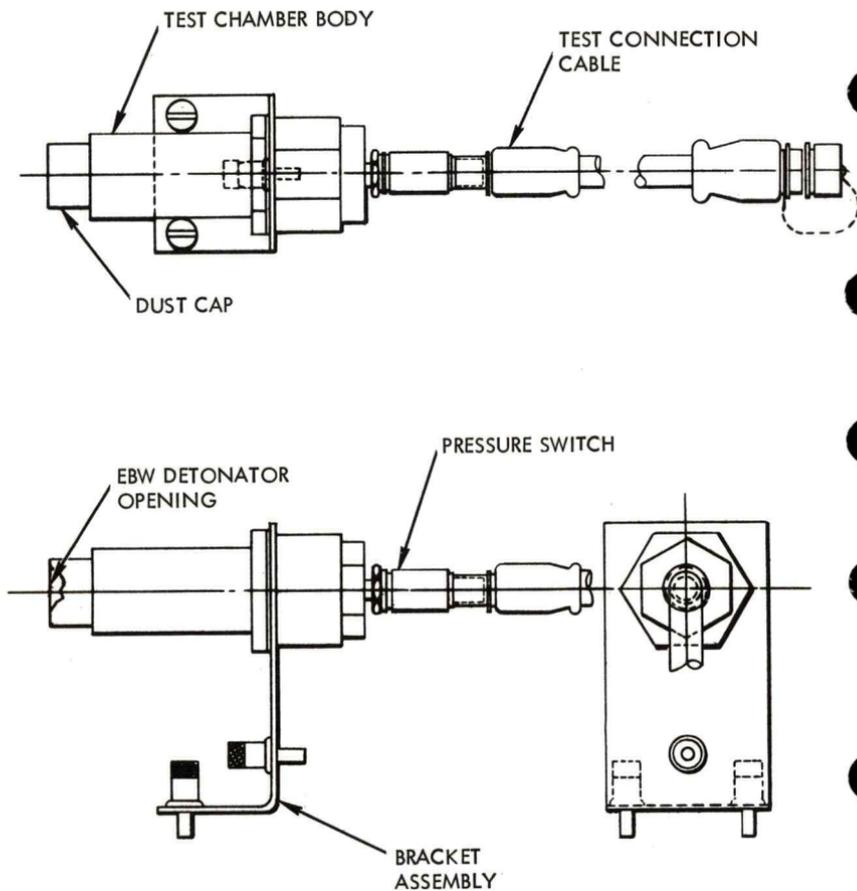
A7-73 STATIC FIRING PURGE MANIFOLD

The A7-73 manifold is used to distribute gaseous nitrogen throughout the engine bay area during static firing of the J-2 engines. It is used only at MTF.



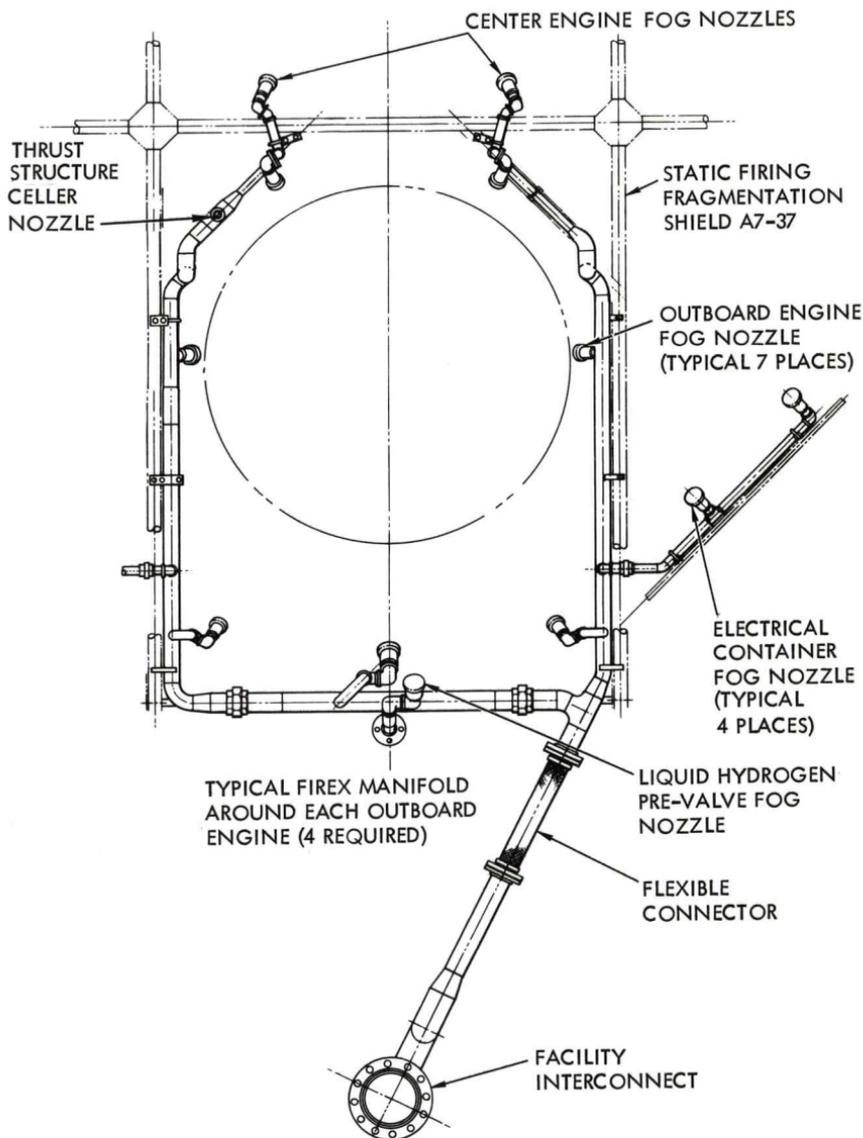
A7-74 EBW DETONATOR TEST CHAMBER ASSEMBLY SET

The A7-74 set is used for final checkout of the explosive bridge wire electrical circuits. It is used at KSC.



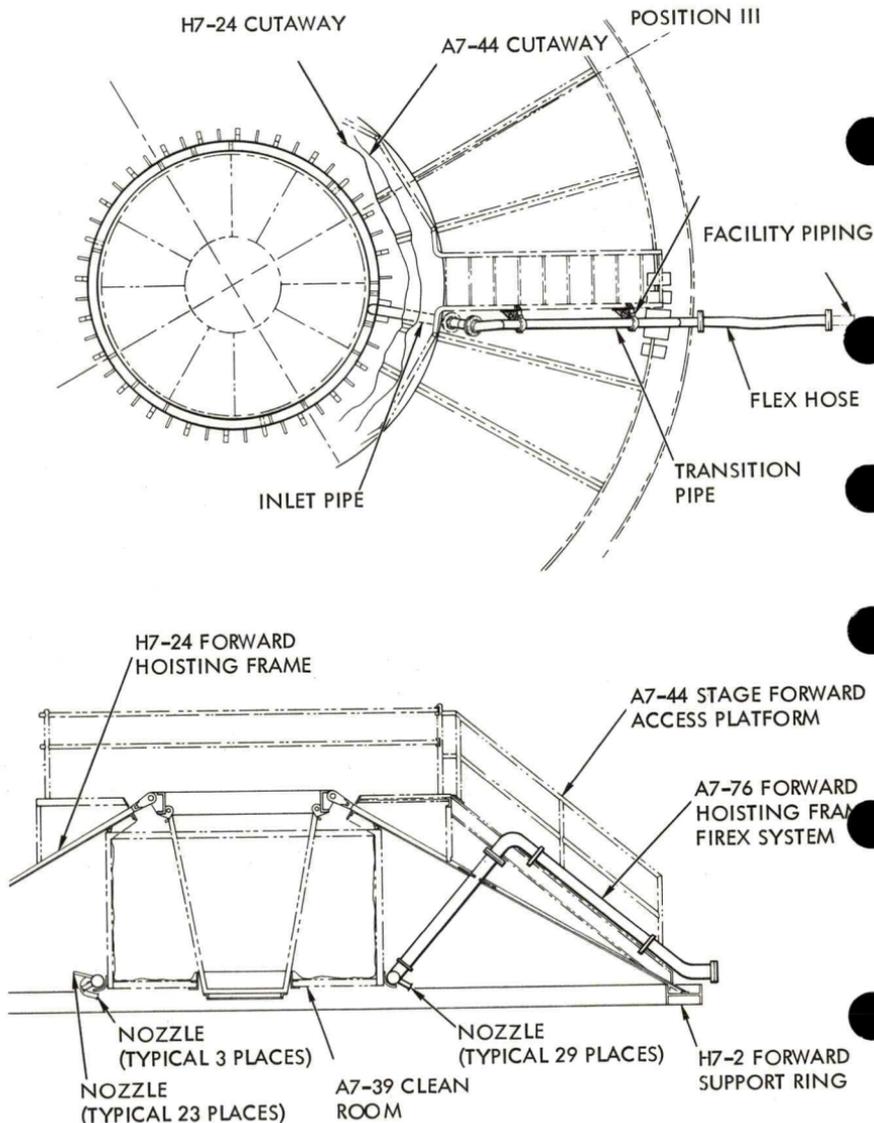
## A7-75 ENGINE AREA FIREX SYSTEM

The A7-75 firex system provides water to extinguish fires occurring in and about the S-II stage J-2 engines during static firing. The water is distributed in and around the engine compartment. It is utilized at MTF only.



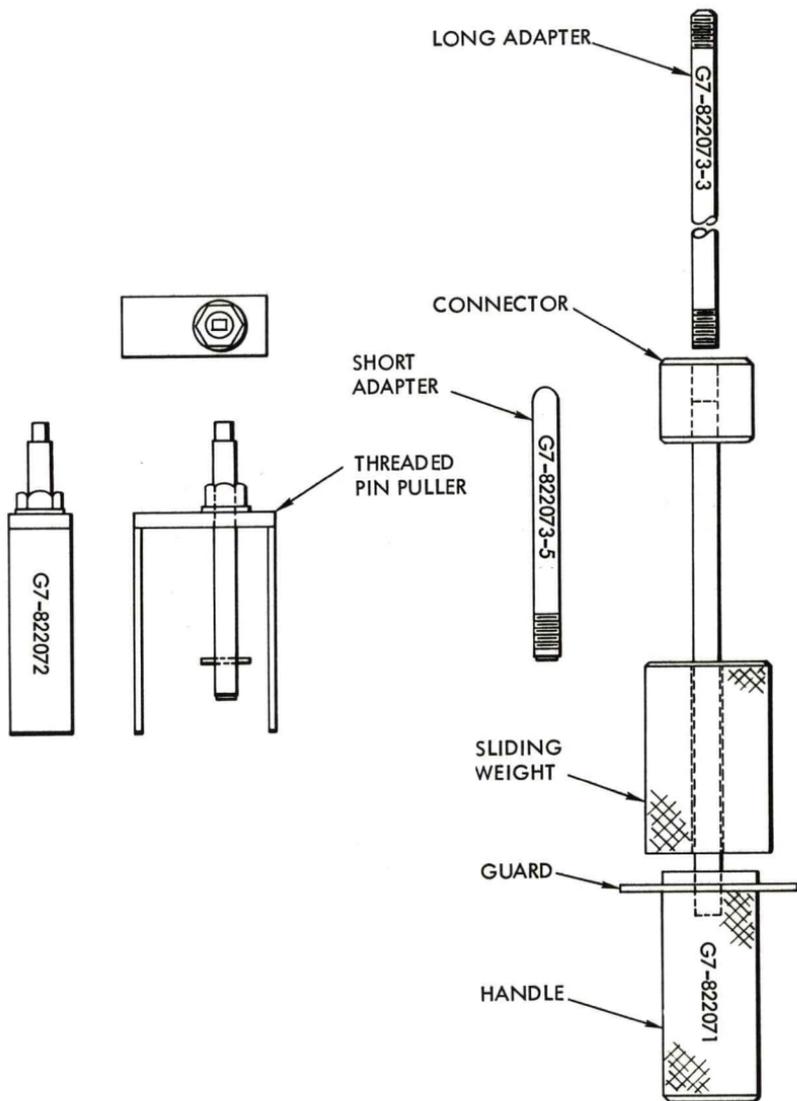
A7-76 FORWARD HOISTING FRAME FIREX SYSTEM

The A7-76 firex system provides for purging of the S-II stage forward bulkhead area with GN<sub>2</sub> whenever fire(s) or conditions for fire(s) have been detected while cryogenic loading and prior to static firing. It is used at MTF.



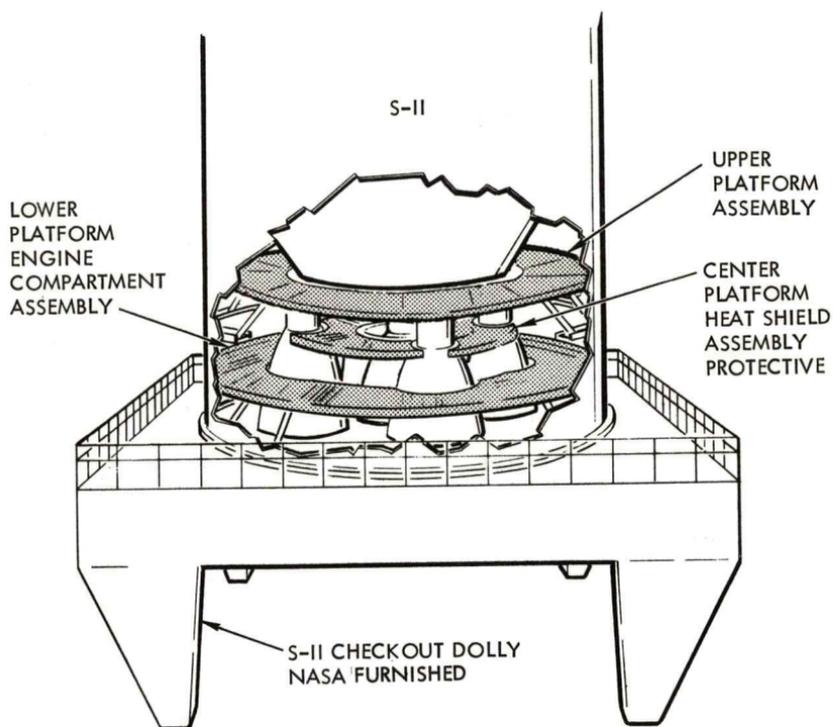
A7-83 ENGINE ACTUATOR PIN TOOL SET

The A7-83 tool set is used to install and remove the upper and lower engine actuator mounting pins. It is employed at Battleship, MTF, and KSC.



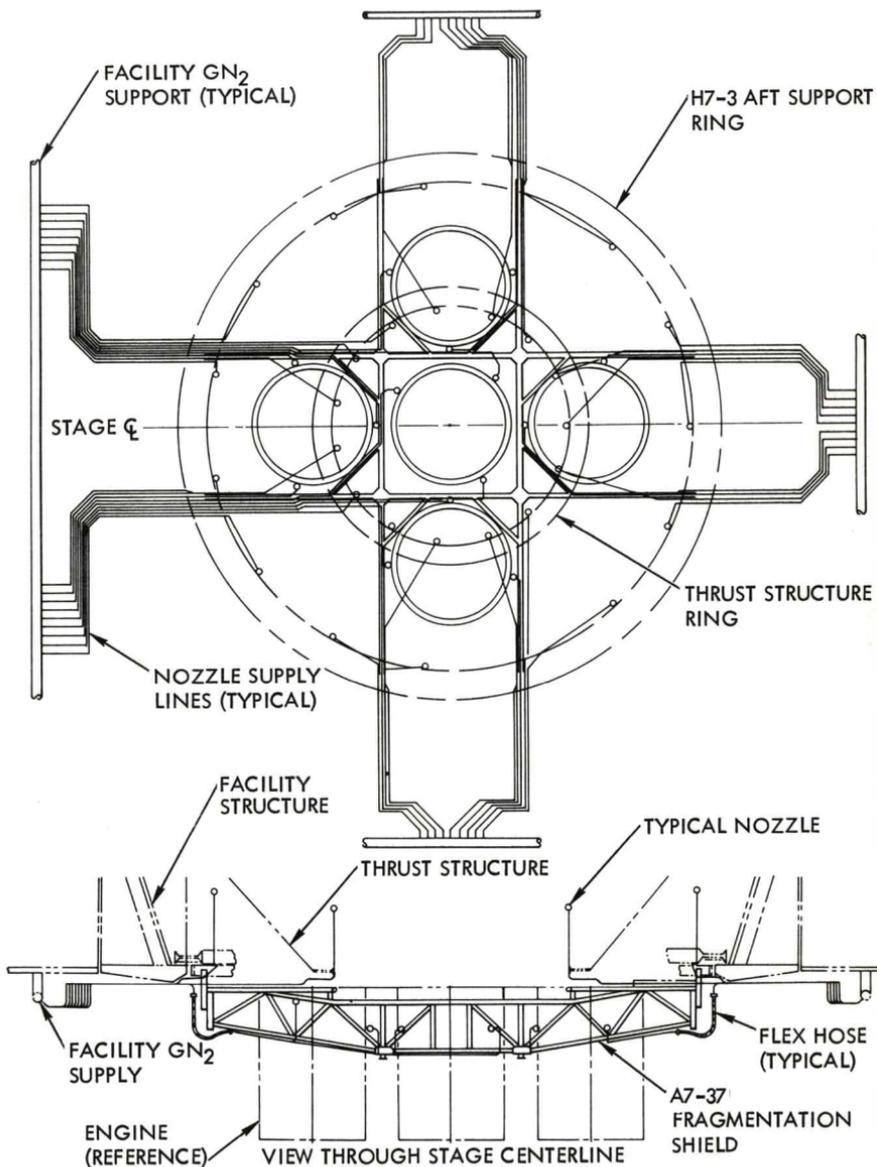
A7-84 ENGINE COMPARTMENT PLATFORM SET

The A7-84 set provides support for gaining access in the S-II stage engine compartment area to enable maintenance therein when the stage is in a vertical position. It is used at KSC.



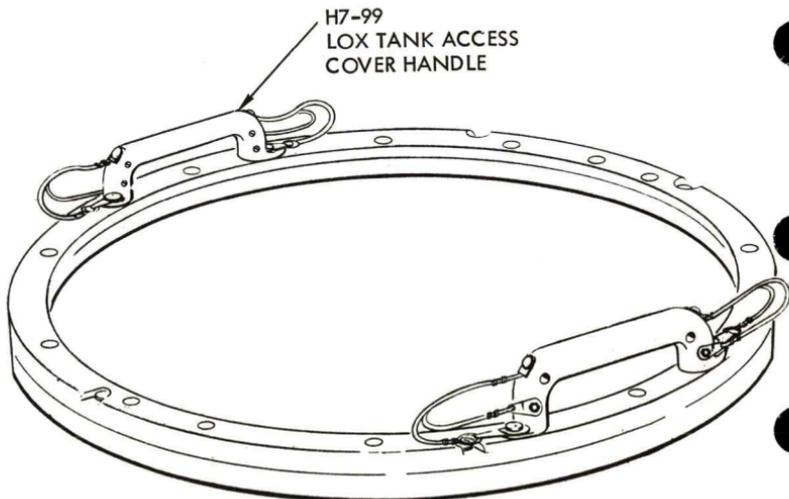
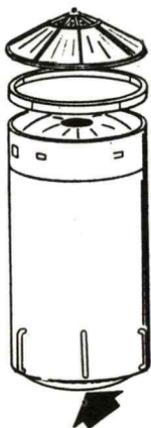
A7-86 ENGINE AREA GN<sub>2</sub> PURGE MANIFOLD

The A7-86 manifold provides for purging of the S-II stage engine area (boattail area) during static firing. It is used at MTF only.



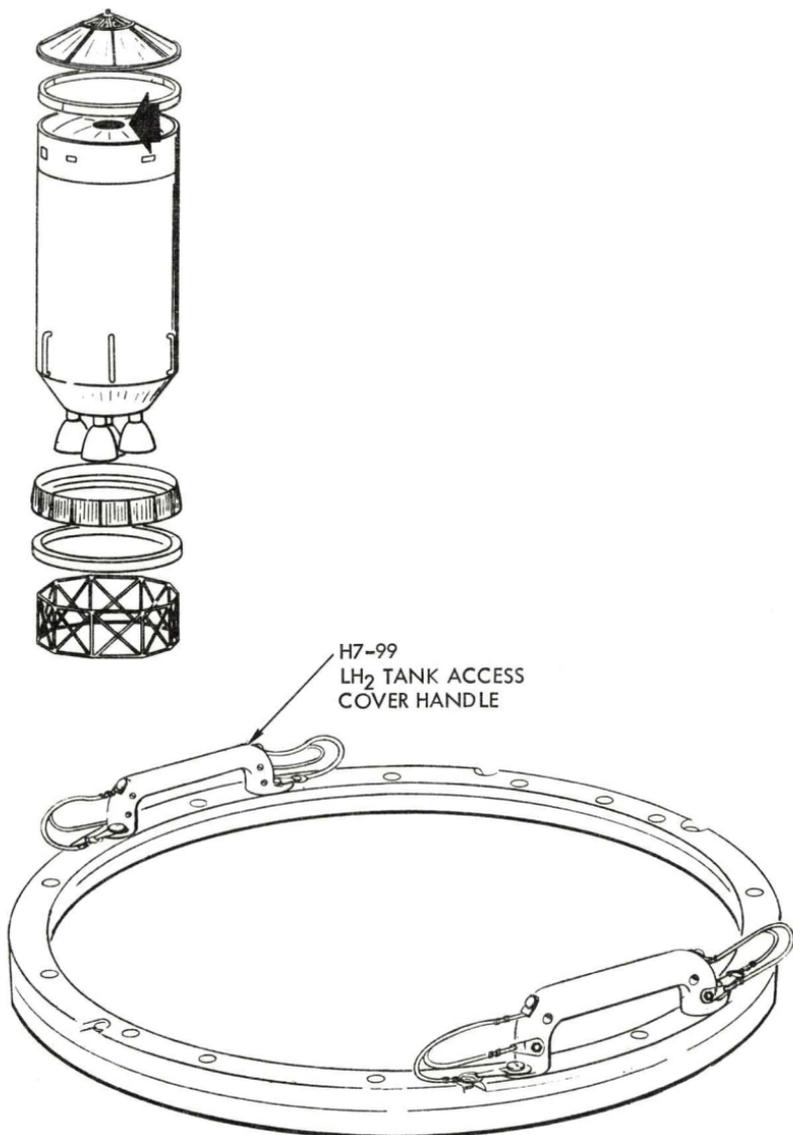
A7-88 LOX TANK ACCESS PROTECTIVE RING

The A7-88 ring is used to protect the critical sealing surfaces of the bolting flange LOX tank access opening when the access cover is removed. It is employed at Seal Beach, MTF and KSC.



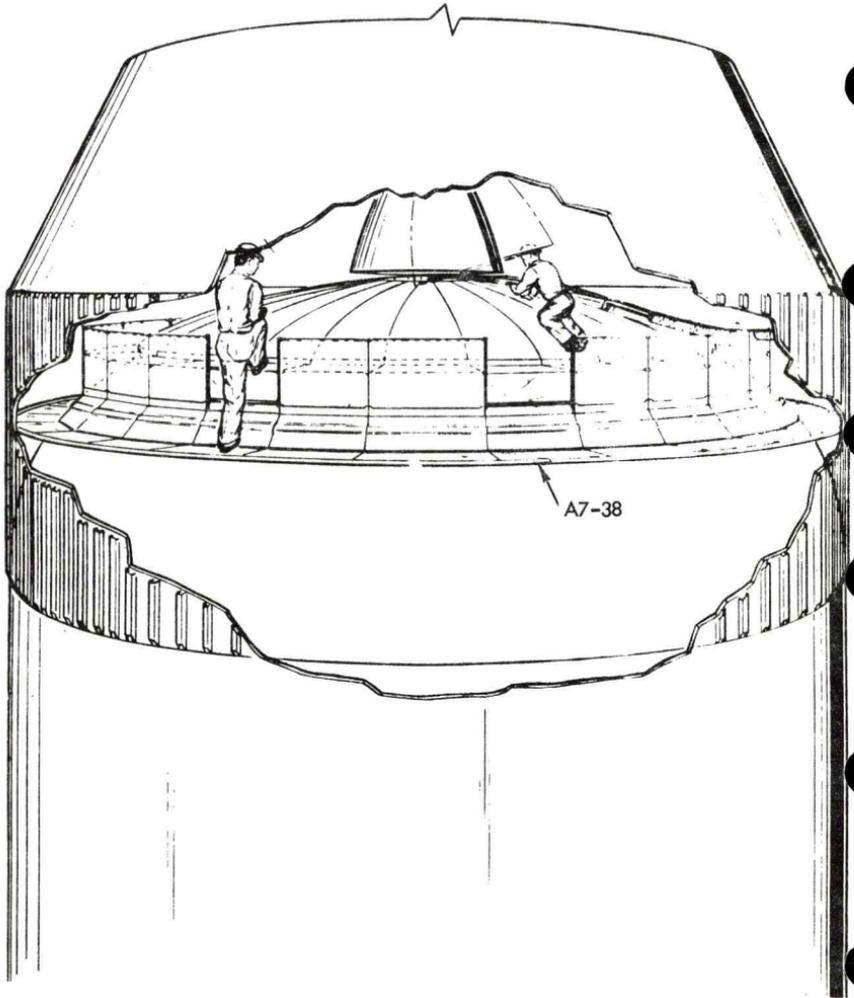
A7-89 LH<sub>2</sub> TANK ACCESS PROTECTIVE RING

The A7-89 ring is used to protect the critical sealing surfaces of the bolting flange LH<sub>2</sub> tank access opening when the access cover is removed. It is used at Seal Beach, MTF, and KSC.



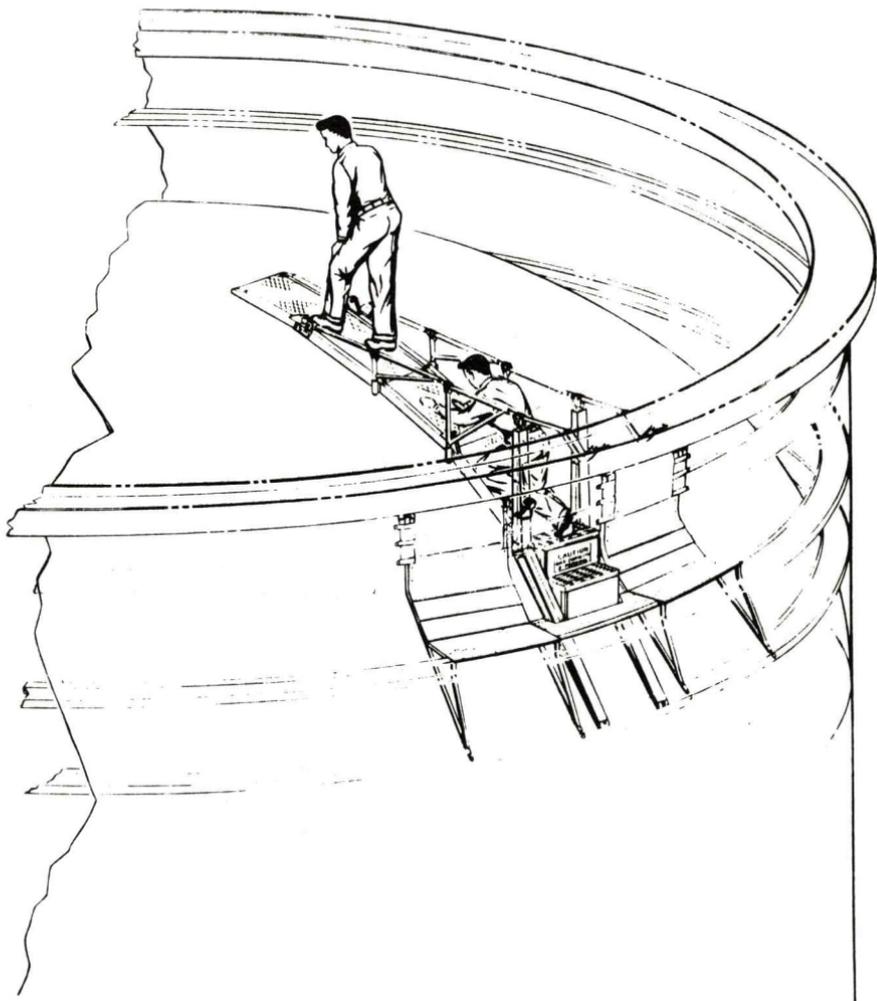
A7-91 FORWARD BULKHEAD PROTECTIVE SET

The A7-91 set prevents damage to the S-II stage forward bulkhead structure in the event that any kind of object(s) impacts the bulkhead during maintenance while the stage is in a vertical position. It is used at MSFC, MTF, and KSC.



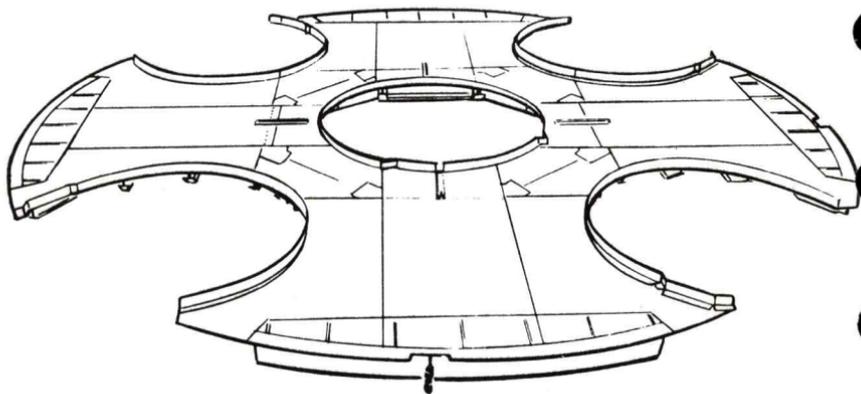
A7-96 FORWARD BULKHEAD EXTENDABLE ACCESS PLATFORM

The A7-96 platform provides access to the S-II stage forward bulkhead when the stage is in the vertical position, and also to the S-IVB stage engine bell area when the stage is in a stacked configuration. It is utilized at KSC.



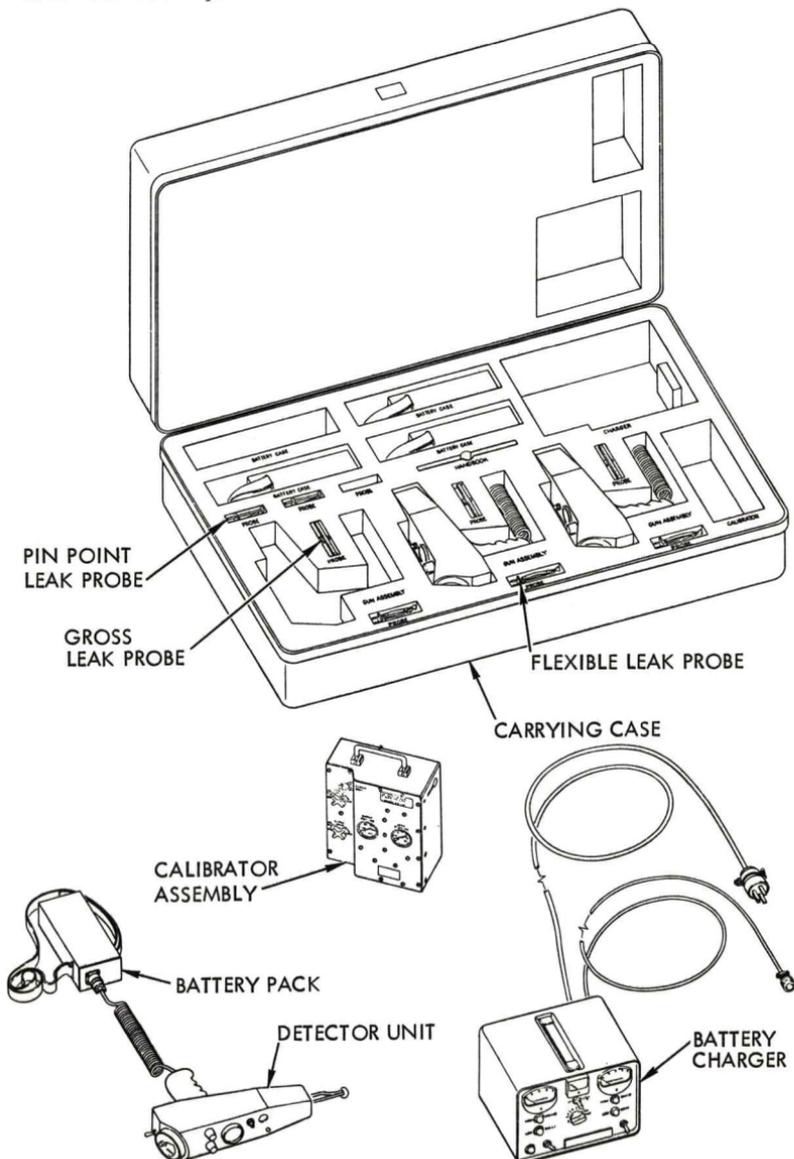
A7-116 ENGINE COMPARTMENT CENTER PLATFORM

The A7-116 platform provides access to the S-II engine area for maintenance and for removal and installation of the engines before installation of the heat shield when the stage is in a vertical position. It is employed at KSC.



A7-119 PORTABLE HELIUM LEAK DETECTOR SET

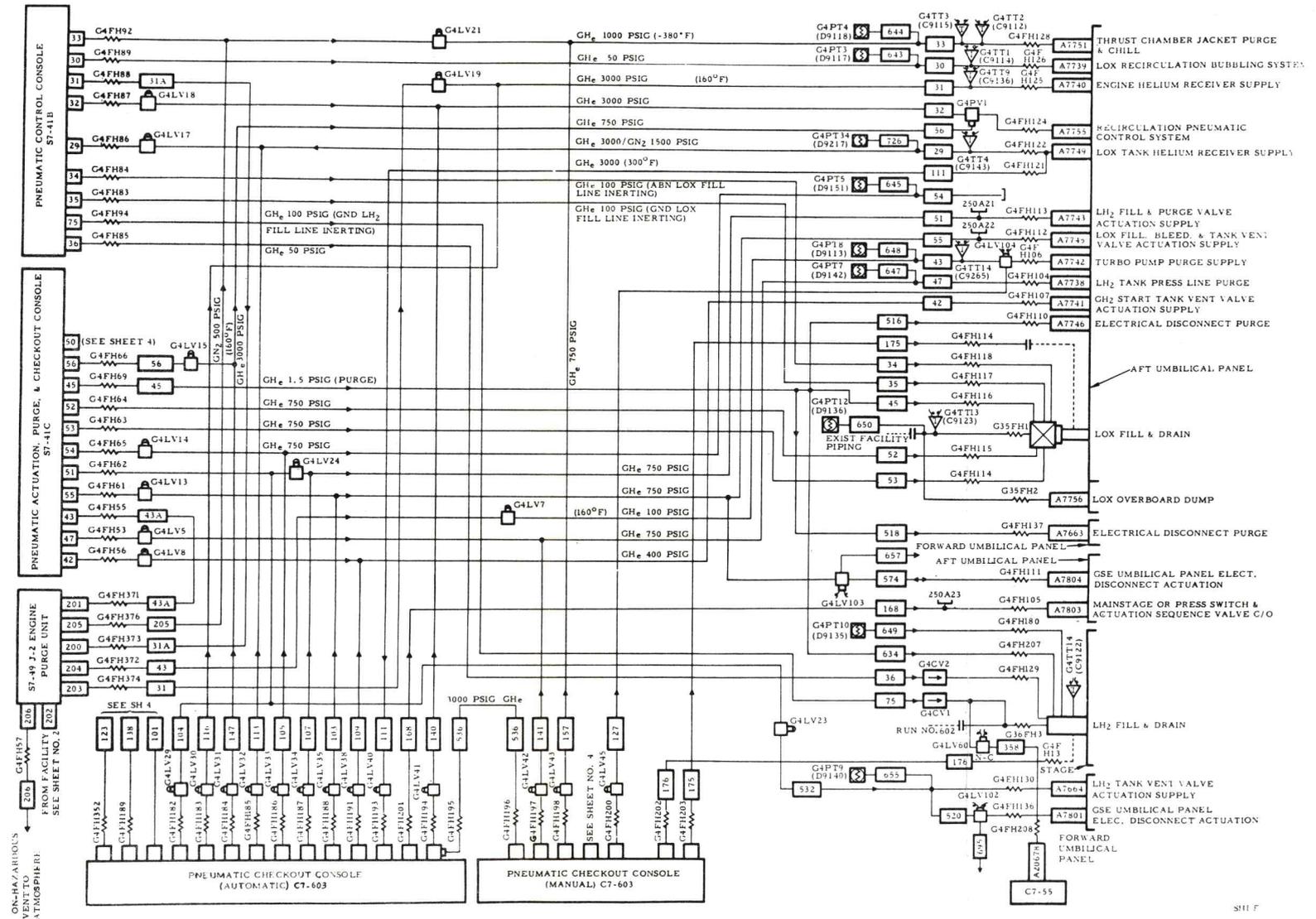
The A7-119 set is used to determine the location and magnitude of the leaks in the S-II stage propellant, engine, and pressurization system. It is used at Battleship, Seal Beach, MTF, and KSC.



XI. SERVICING EQUIPMENT

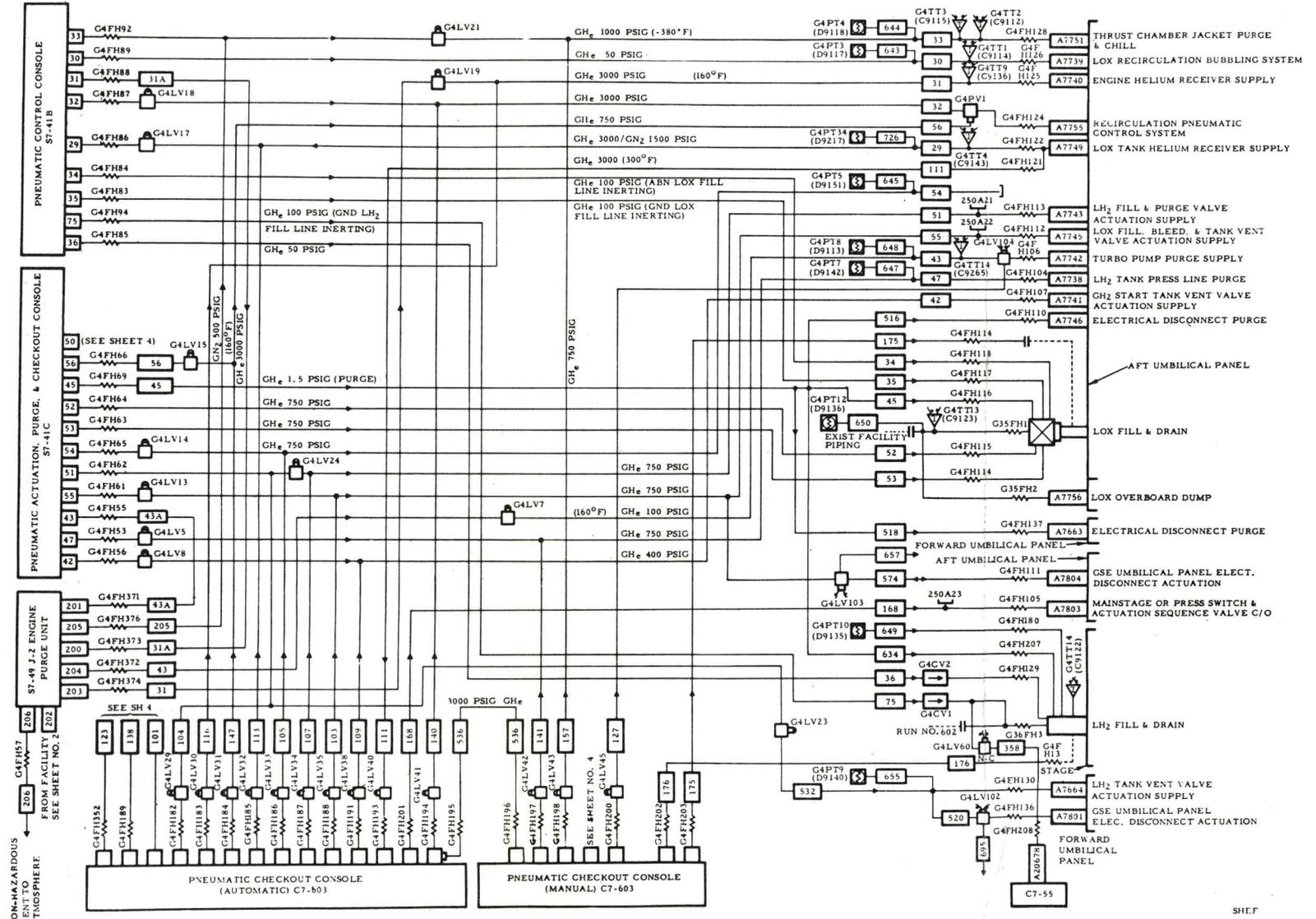
S-27 FLUID DISTRIBUTION SYSTEM

The S7-27 distributes fluids and gases from various checkout and servicing consoles to the S-II stage. The S7-27 is used at MTF only.



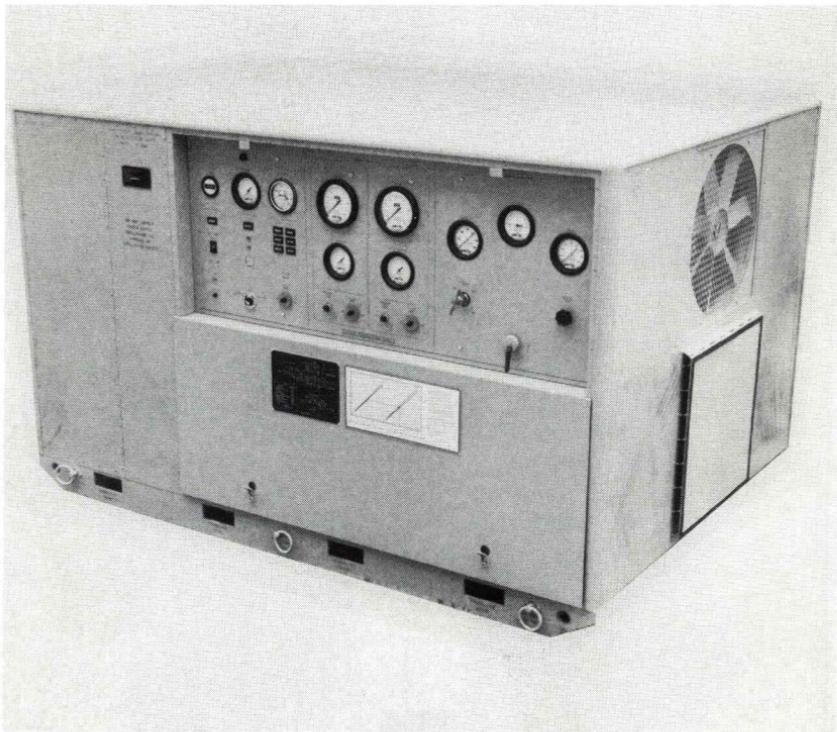
S7-33 FLUID DISTRIBUTION SYSTEM

The S7-33 is used to distribute fluids and gases from various checkout and servicing consoles to the S-II stage. The S7-33 is used at MTF only.



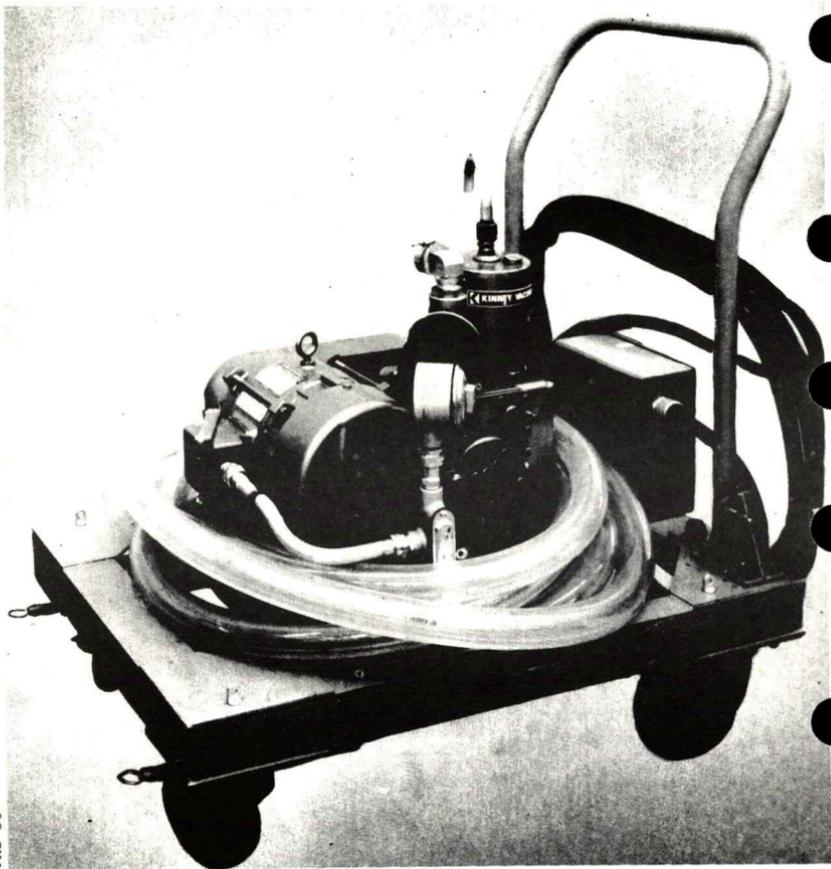
S7-34 AIR SERVICING UNIT

The S7-34 provides cooled air to the electrical containers through the S-II stage thermal control system with no propellants on board. The S7-40 unit will be used when propellants are on board for thermal control. It is used at Battleship, Seal Beach, and MTF.



S7-37 PORTABLE VACUUM PUMP UNIT

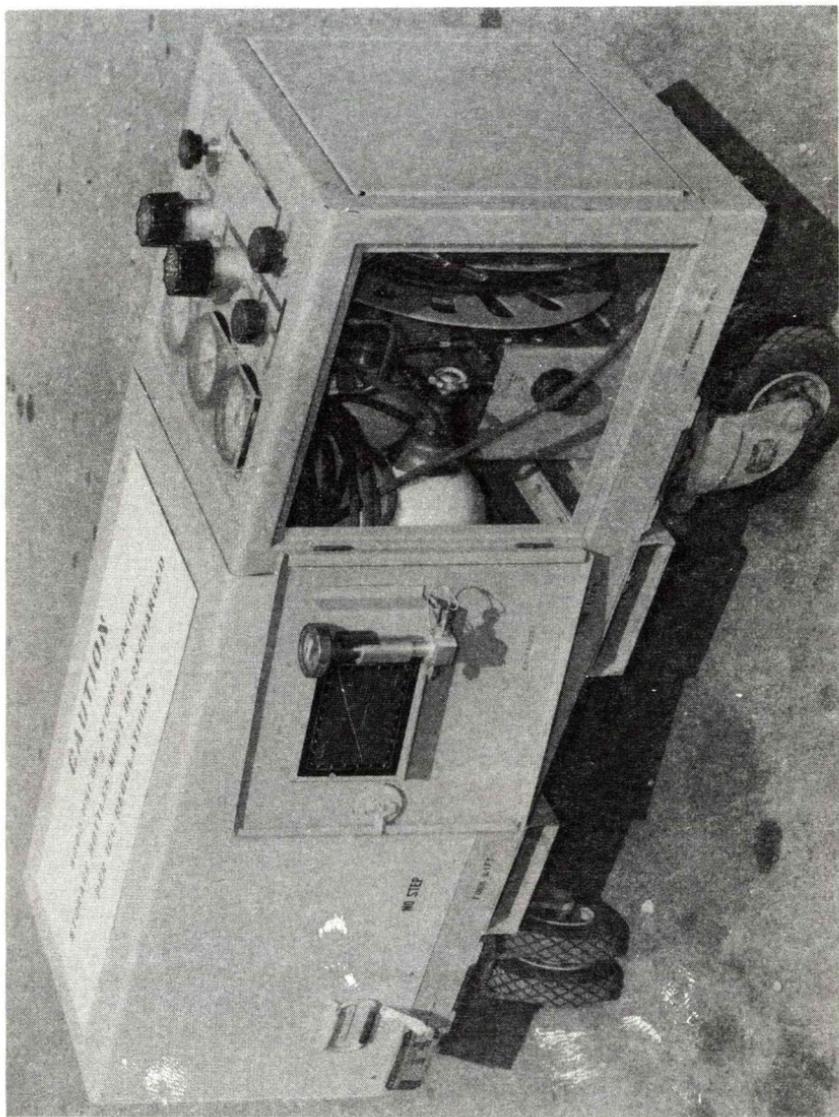
The S7-37 is used to evacuate vacuum-jacketed lines of GSE and the S-II stage. It is used at Battleship, Seal Beach, and MTF.



PRO-36

S7-38 HYDRAULIC ACCUMULATOR PRECHARGE SERVICING UNIT

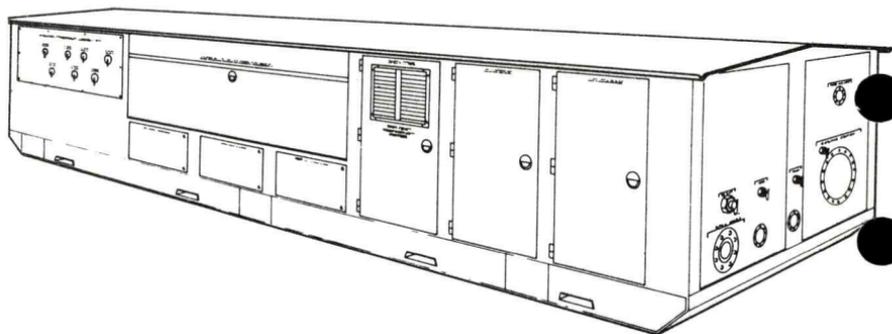
The S7-38 is used to precharge the pneumatic side of the S-II stage hydraulic accumulators to the required pressure for hydraulic operations. It is used at Battleship, Seal Beach, and MTF.



S7-38 (2) A

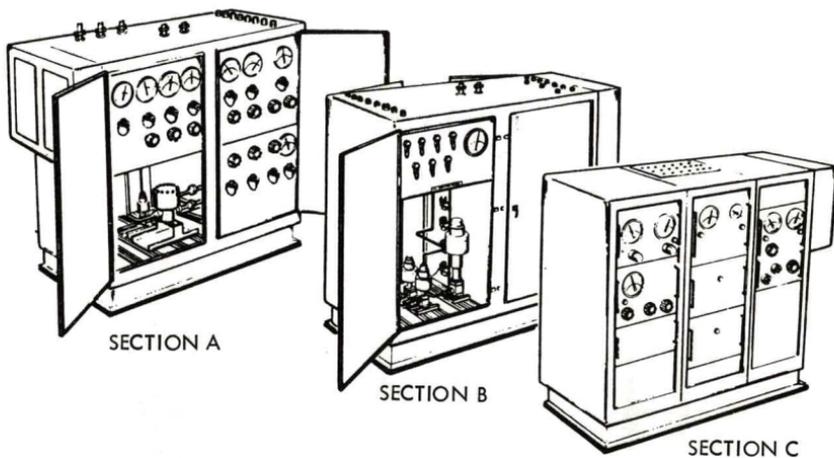
S7-40 NITROGEN PURGE AND THERMAL CONTROL  
SERVICING UNIT

The S7-40 servicing unit is capable of warming and regulating gaseous nitrogen received at high pressure for purging and thermally controlling the stage electrical containers and the stage engine compartment area and for purging the SLAM coolant system, including the engine thrust chamber diffusers during cryogenic loading and static firing. The S7-40 is used at Battleship and MTF.



## S7-41 PNEUMATIC CONSOLE

The S7-41 receives ambient temperature high-pressure helium, nitrogen, and hydrogen gas from facilities for processing, regulation, distribution, and control as required to accomplish servicing and checkout of the S-II stage pneumatic and propellant systems. The S7-41 is used at MTF, MSFC, and KSC.



SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

S7-42 ELECTRICAL PNEUMATIC SERVICING UNIT

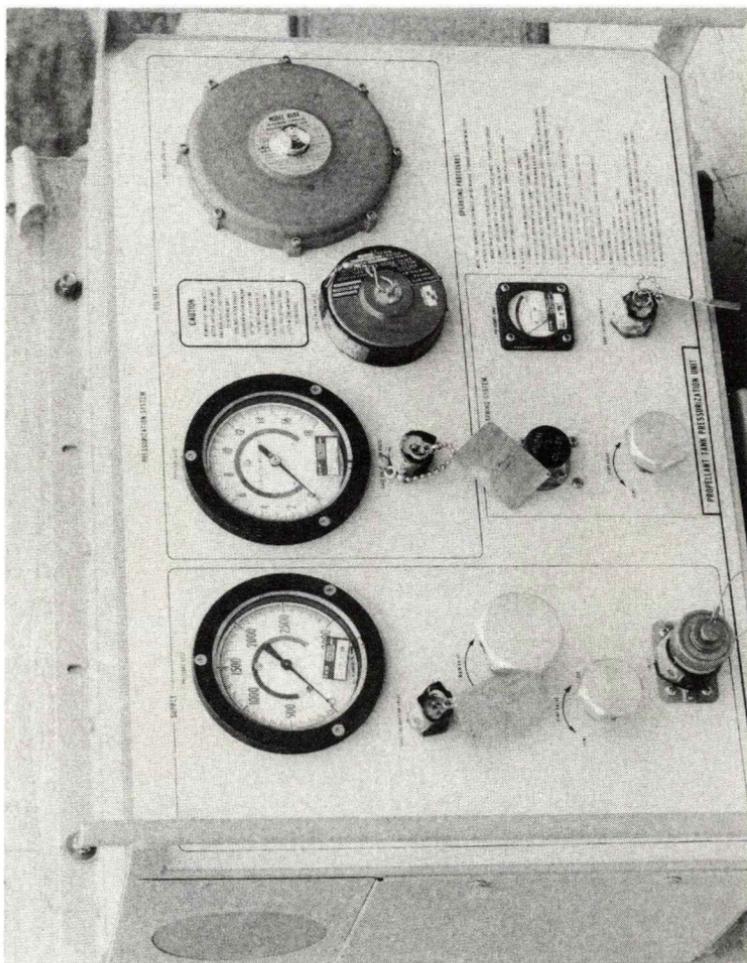
The S7-42 provides a means for remote control of the S-II pneumatic console set, S7-41, A7-71, and S7-49. The S7-42 is used at MTF.



GES-42-4

## S7-44 PROPELLANT TANK PRESSURIZATION UNIT

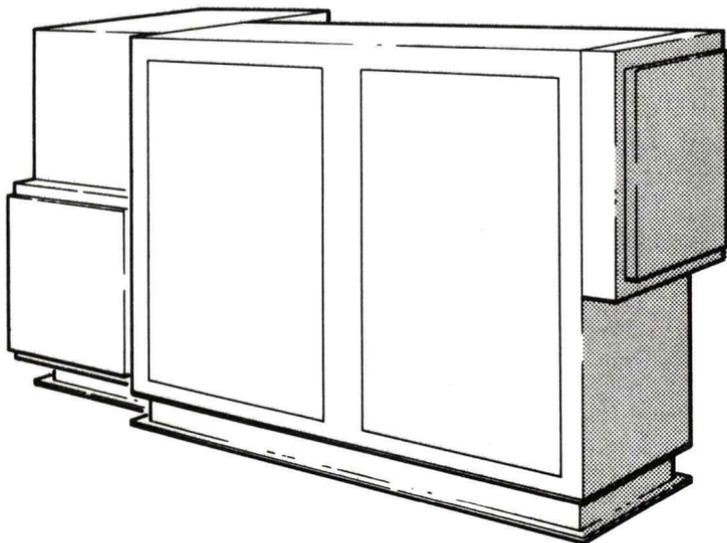
The S7-44 allows maintaining a positive gas pressure within the S-II stage propellant tanks (LOX and LH<sub>2</sub>) during stage transportation, storage, and standby (prior to static firing) to prevent condensation and tank collapsing. The S7-44 is used at Seal Beach, MTF, MSFC, and KSC.



S7-44 (1) A

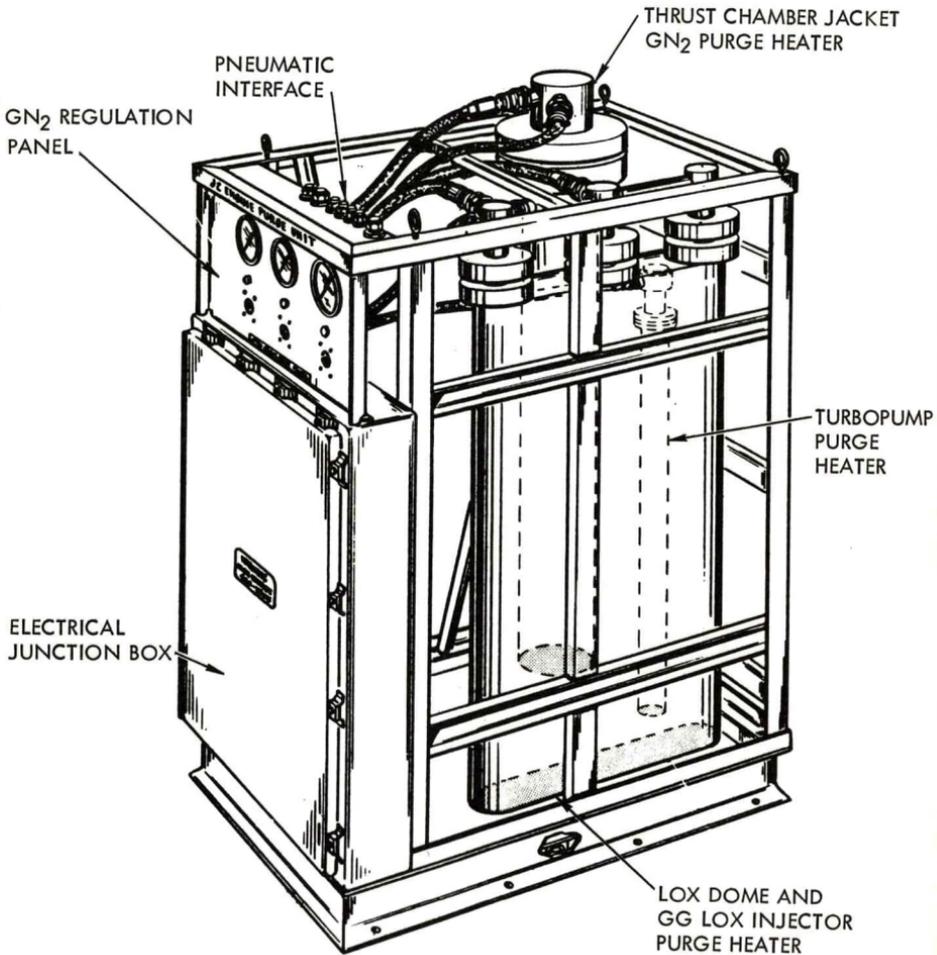
S7-45 INSULATION PURGE PNEUMATIC  
CONTROL CONSOLE

The S7-45 receives facility nitrogen and helium gas at 6000 to 3400 psig and conditions the pressure of each gas determined by stage requirements. The S7-45 interfaces with the S7-29 and C7-55 through interconnecting distribution lines. The S7-45 interfaces electrically with the C7-56 and C7-57 consoles. It is used at MTF and KSC.



## S7-49 J-2 ENGINE PURGE UNIT

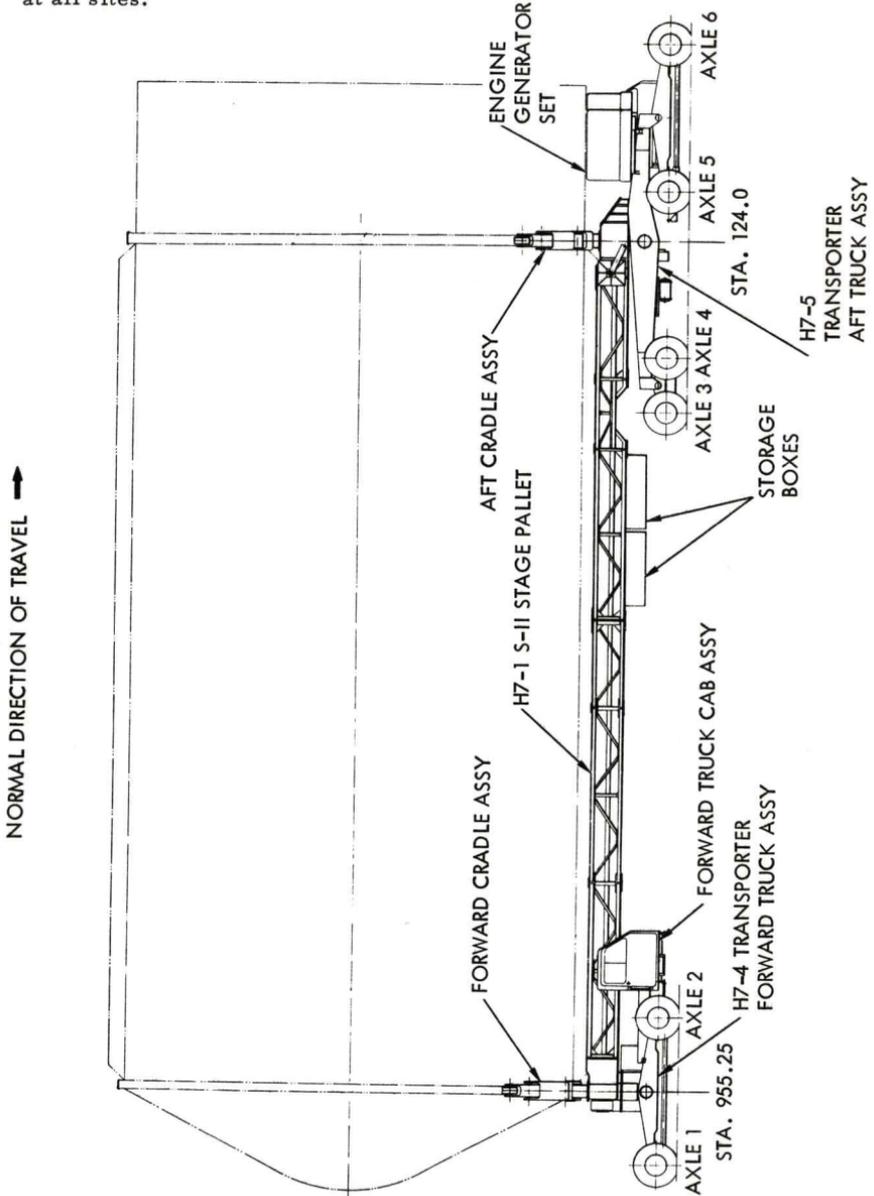
The S7-49 is used to dehumidify the J-2 engine injector system, turbine pump seal cavities and thrust chamber prior to engine static firing. It is used at MTF.



XII. HANDLING EQUIPMENT

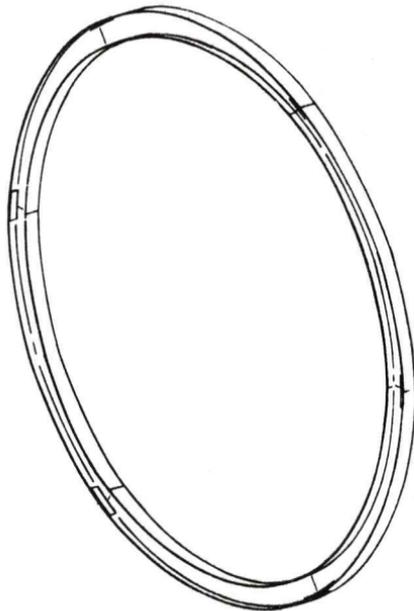
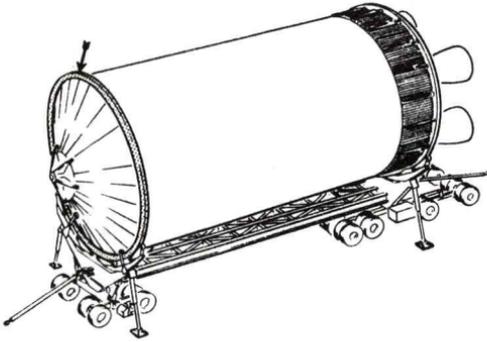
TYPE I STAGE TRANSPORTER  
H7-1, H7-4 AND H7-5

The Type I stage transport is used for transporting of the S-II stage at all sites.



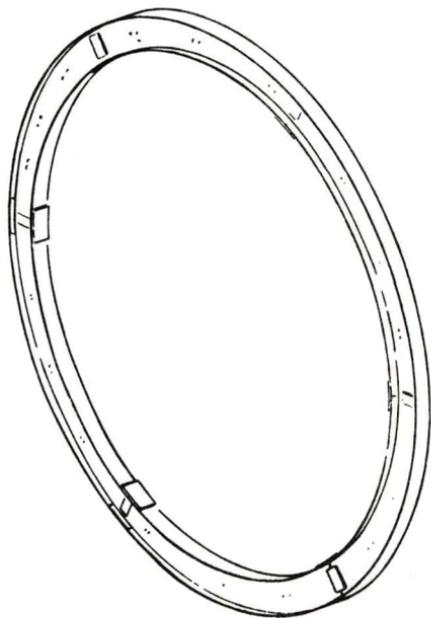
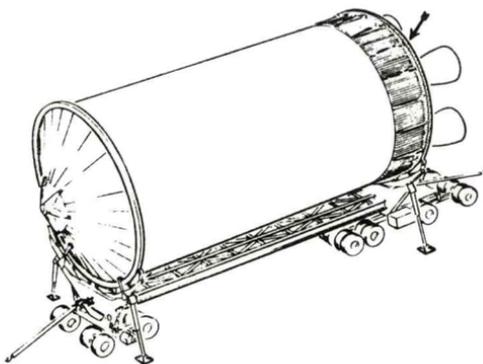
H7-2 STAGE SUPPORT FORWARD RING

This ring provides support for the forward end of the S-II stage when in a horizontal attitude. Its diameter is 396 inches.



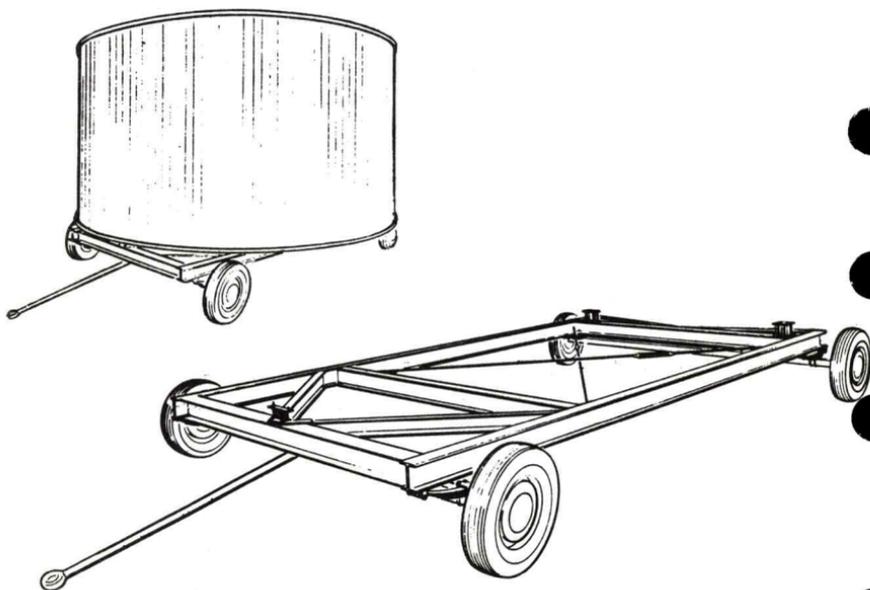
H7-3 STAGE SUPPORT AFT RING

This ring provides support for the aft end of the S-II stage when in a horizontal attitude. Its diameter is 396 inches, and it is used during transporting of the S-II stage at all sites.



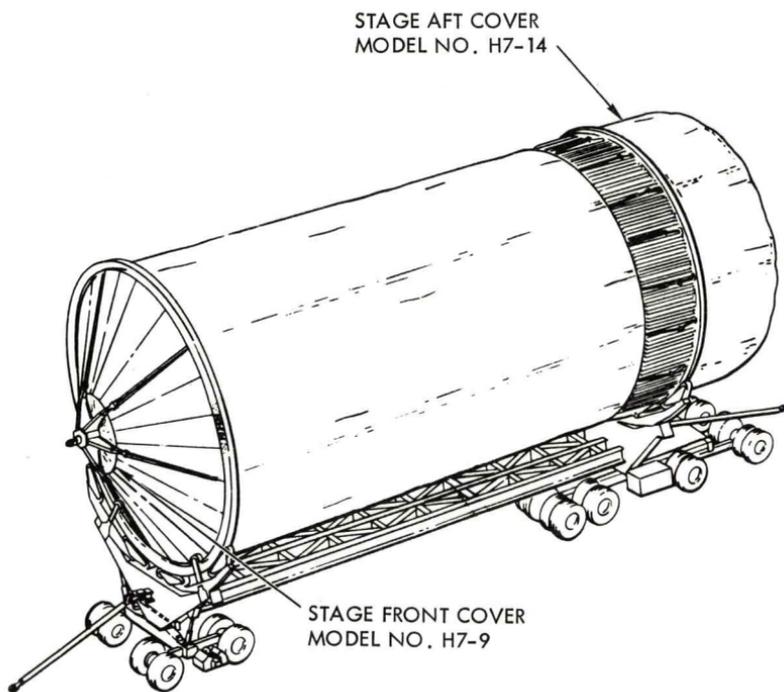
H7-8 AFT INTERSTAGE DOLLY

This dolly provides mobility and support for the aft interstage when in a vertical attitude. It is used at the manufacturing area (Seal Beach), Dynamic Test (MSFC), and staging KSC areas.



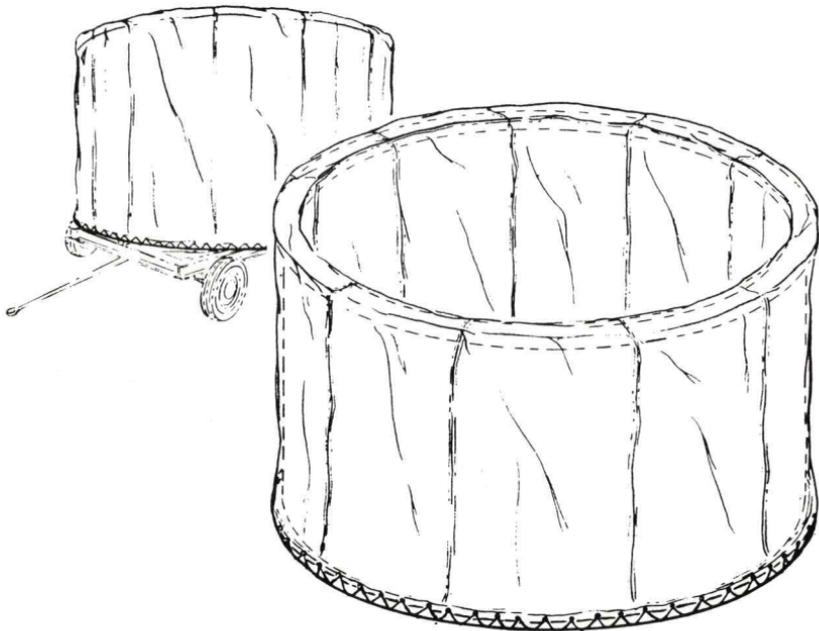
H7-9 AND H7-14 SHIPMENT COVERS

Both covers are used during storage and transporting the S-II stage at all sites.



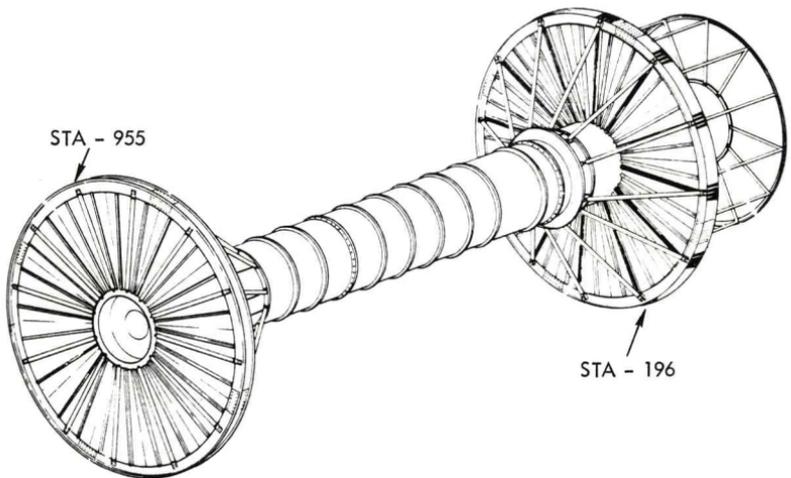
H7-13 AFT INTERSTAGE COVER

This cover provides environmental protection for the aft interstage during transportation and storage. Its diameter is 396 inches, and it is used with the aft interstage dolly. The covers are used at Seal Beach and KSC.



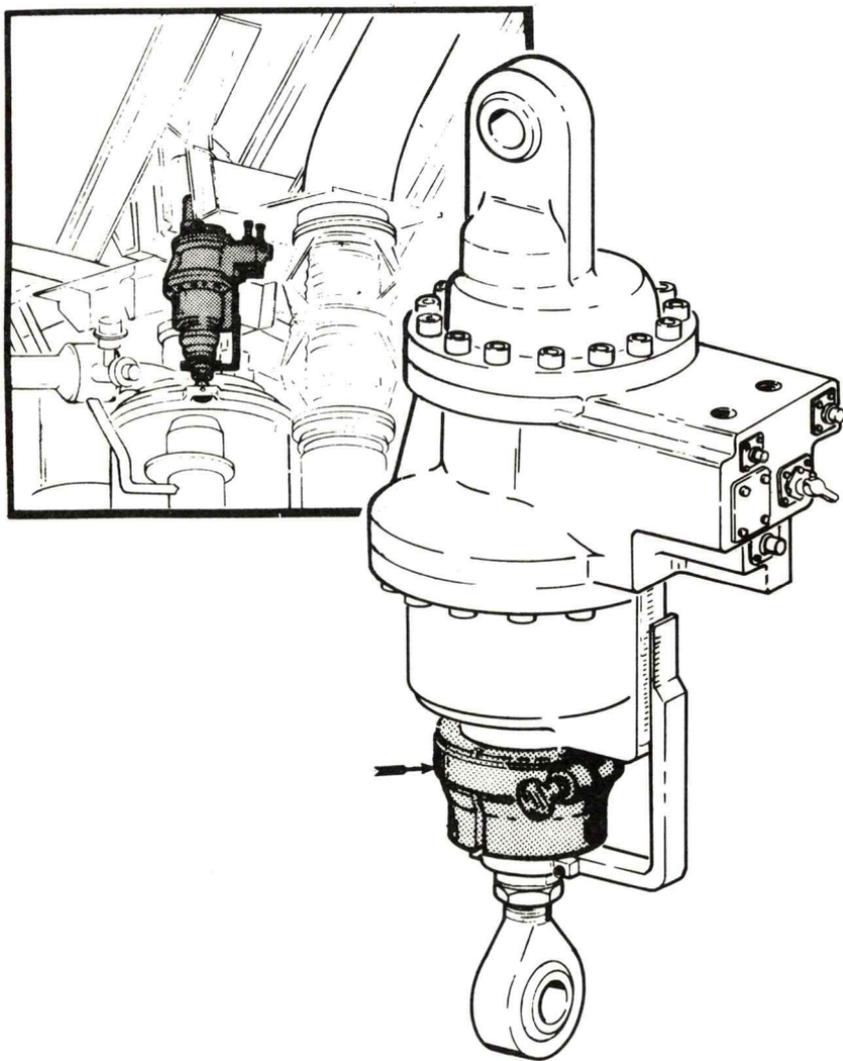
H7-17 STAGE FIT-UP FIXTURE

This fixture provides a means of verifying transportation procedures, proof loading, and compatibility testing of the mating surfaces of the S-II handling and transporting equipment. The H7-17 is used when required at all sites.



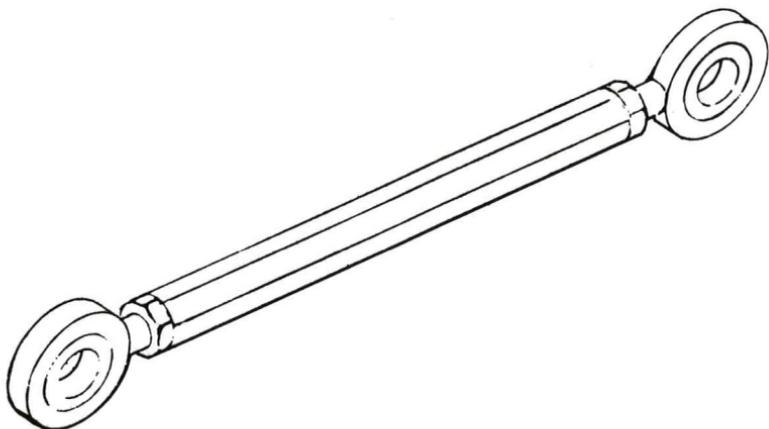
H7-19 ENGINE ACTUATOR LOCK NO. 1

This lock provides immobilization of the preproduction engine actuator to prevent any relative motion between the actuator body and the rod during ground handling and maintenance. One lock is required per engine actuator. The H7-19 is used on J-2 engines at all sites.



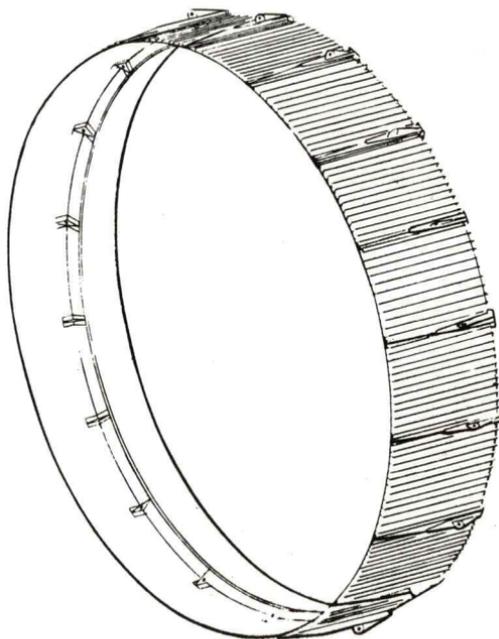
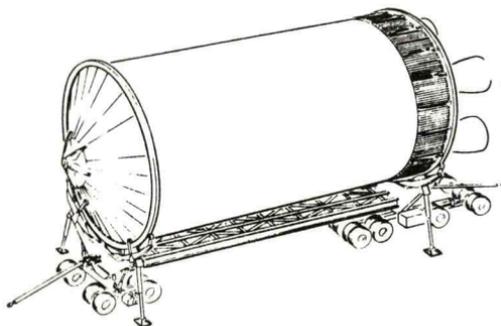
H7-20 ENGINE ACTUATOR SIMULATOR

This simulator provides a stabilizing element for a neutrally positioned engine when the engine actuator is removed. One simulator per engine actuator is required. The H7-20 is used on J-2 engines at all sites.



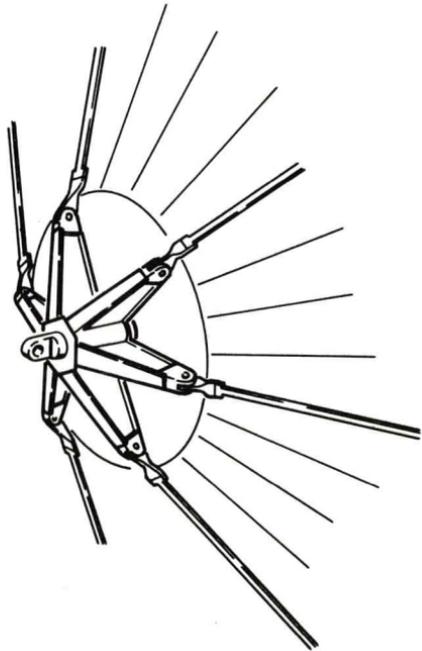
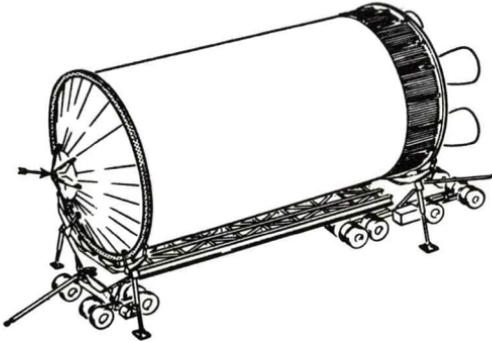
H7-21 STATIC FIRING SKIRT

The static firing skirt provides support for the S-II stage during handling and static firing operations. Its diameter is 396 inches, and it is used with the S-II stage. The H7-21 is used in transporting S-II stage and during static firing at MTF.



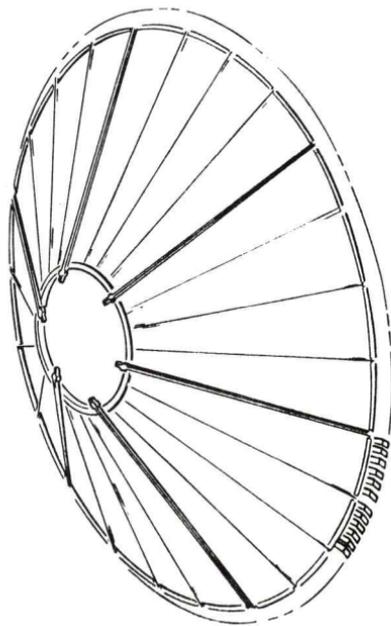
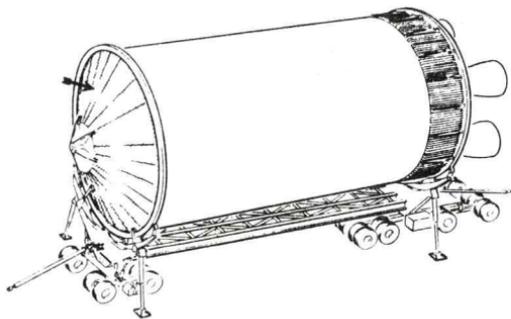
H7-23 STAGE ERECTING SLING

This sling provides support for the forward end of the S-II stage during hoisting operations and is used when transporting the S-II stage at all sites.



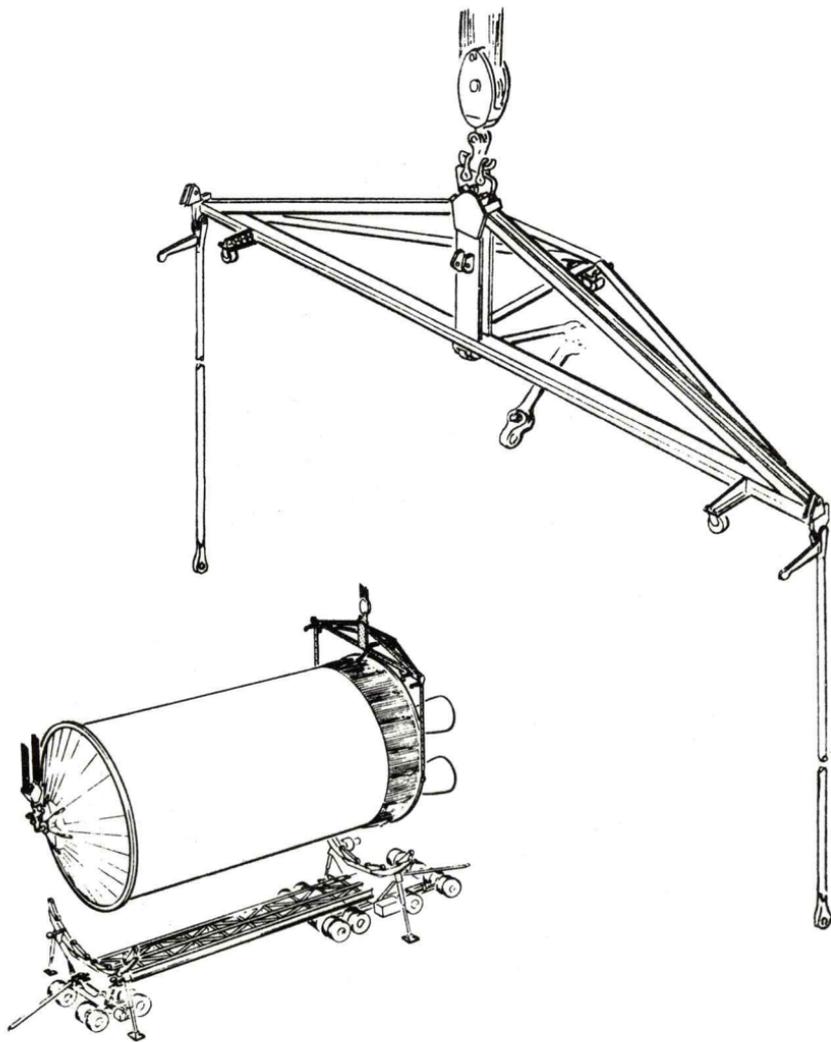
H7-24 FORWARD HOISTING FRAME

This frame provides a means of transmitting the weight of the S-II stage from the forward support ring (Model No. H7-2) to the stage erecting sling (Model No. H7-23) during forward stage hoisting operations. It is used at all sites.



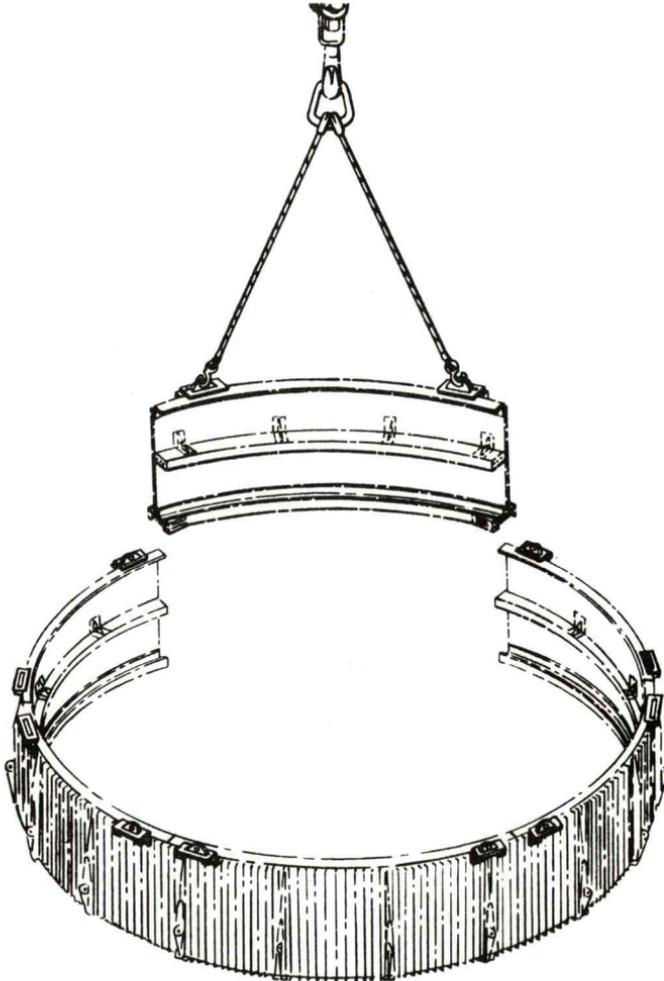
H7-25 AFT HOISTING FRAME

This frame provides a means of transmitting the weight of the S-II stage from the aft support ring (Model No. H7-3) to the hoisting crane hook during aft stage hoisting operations. It is used at Seal Beach, MTF, MSFC, and KSC.



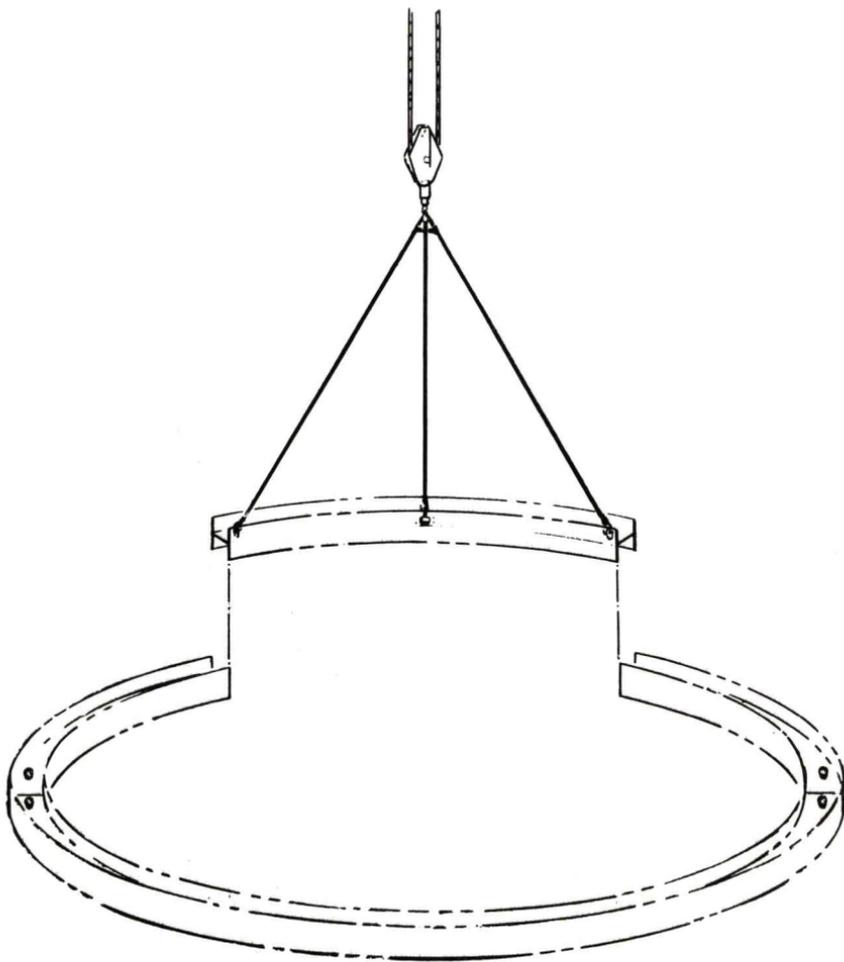
H7-27 INTERSTAGE AND STATIC FIRING SKIRT SEGMENT SLING

This sling provides support for the static firing skirt segments (Model No. H7-21) during hoisting operations. It is used at the manufacturing area (Seal Beach), Dynamic Test (MSFC), and KSC.



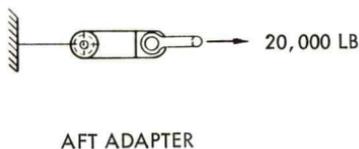
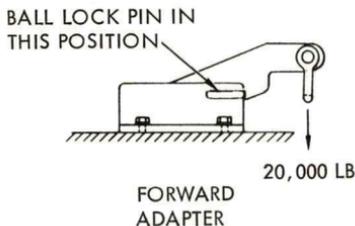
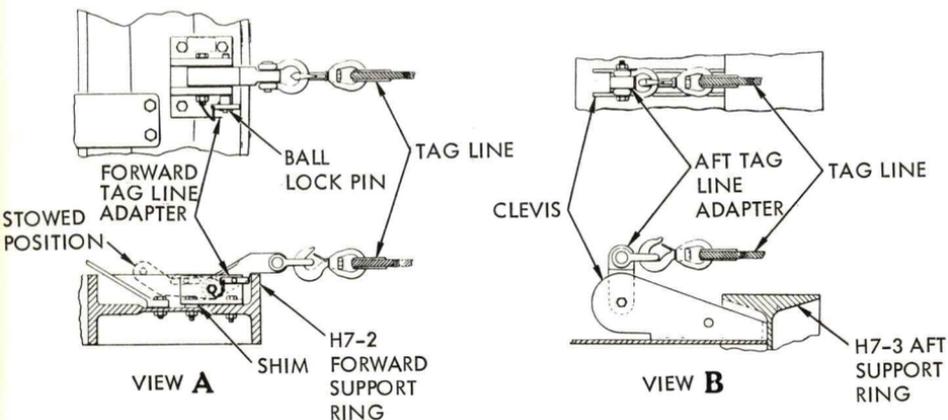
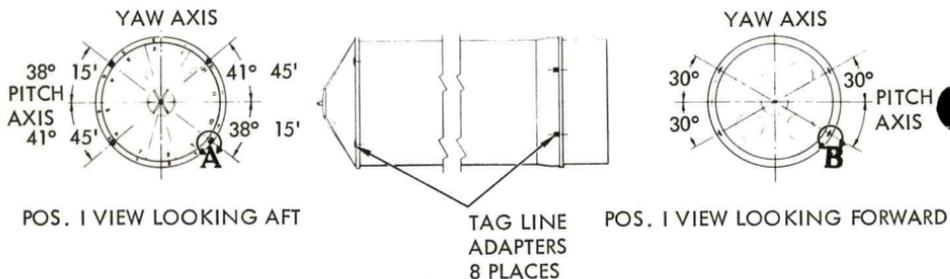
## H7-28 SUPPORT RING SEGMENT SLING

This sling provides support for the forward or aft support ring segments (Model No. H7-2 and H7-3) during hoisting operations for assembly or disassembly of the H7-2 or H7-3 rings. It is used at the manufacturing area (Seal Beach), Dynamic Test (MSFC), and staging KSC areas.



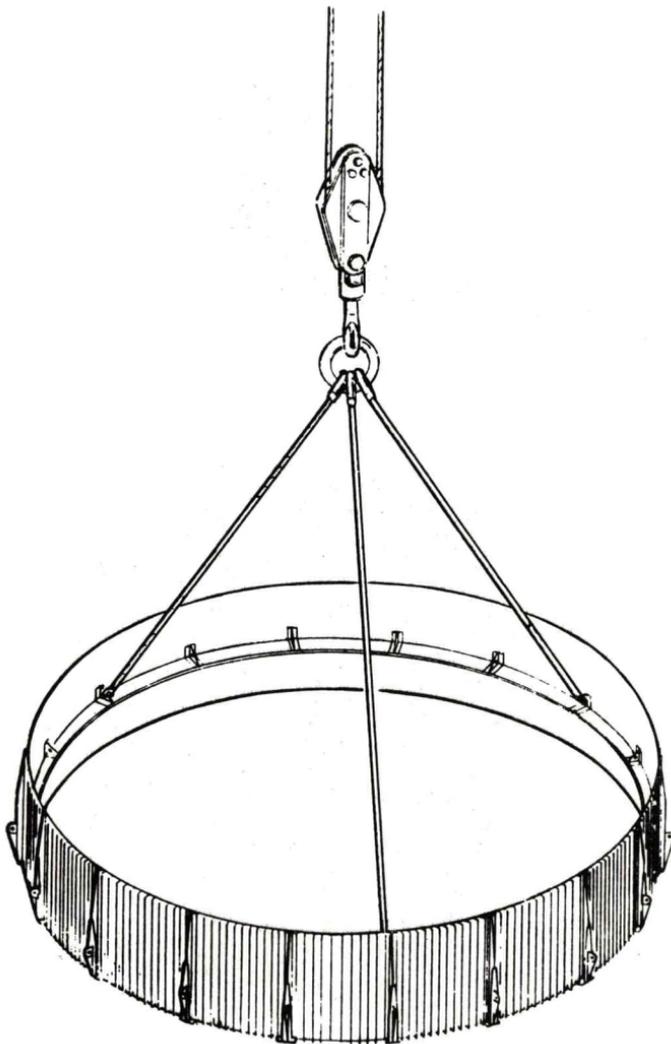
H7-29 TAG LINE ADAPTERS

The H7-29 adapter in conjunction with a tag line provides control of the S-II stage during stage handling. It is used at Seal Beach, MTF, MSFC, and KSC.



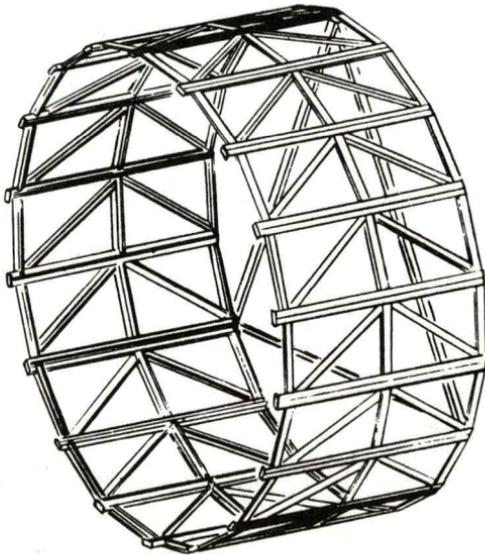
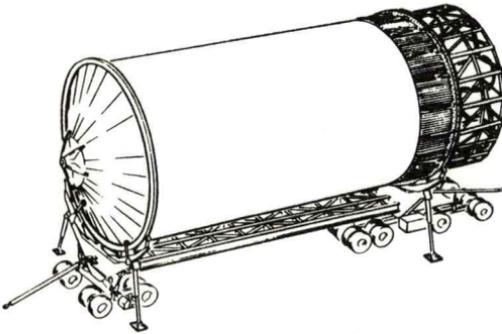
H7-30 INTERSTAGE AND STATIC FIRING SKIRT SLING

This sling provides support for the interstage and static firing skirt (Model No. H7-21) during hoisting operations and is used at the manufacturing area (Seal Beach), Dynamic Test (MSFC), and MTF.



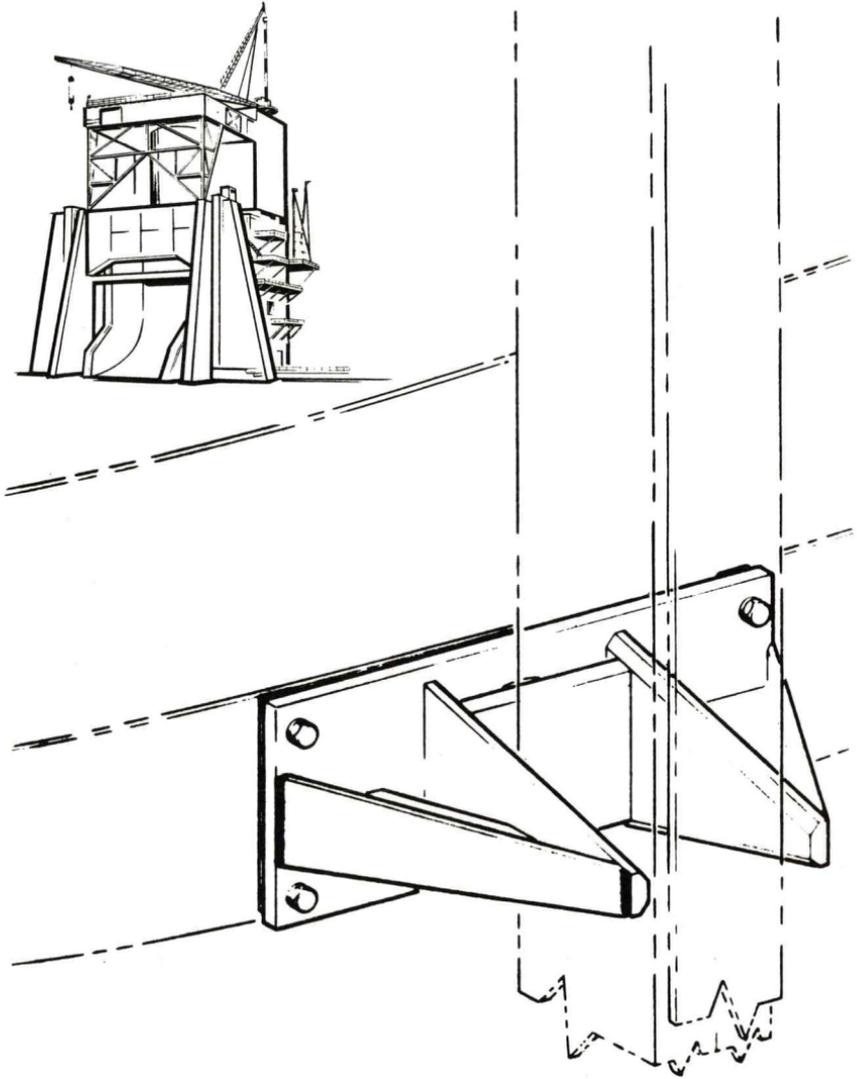
H7-72 ENGINE PROTECTIVE FRAME

This frame supports the aft stage cover (Model H7-14) and provides physical protection for the S-II stage engine compartment during handling and transportation. Its diameter is 396 inches. It is used with the transporter at all sites.



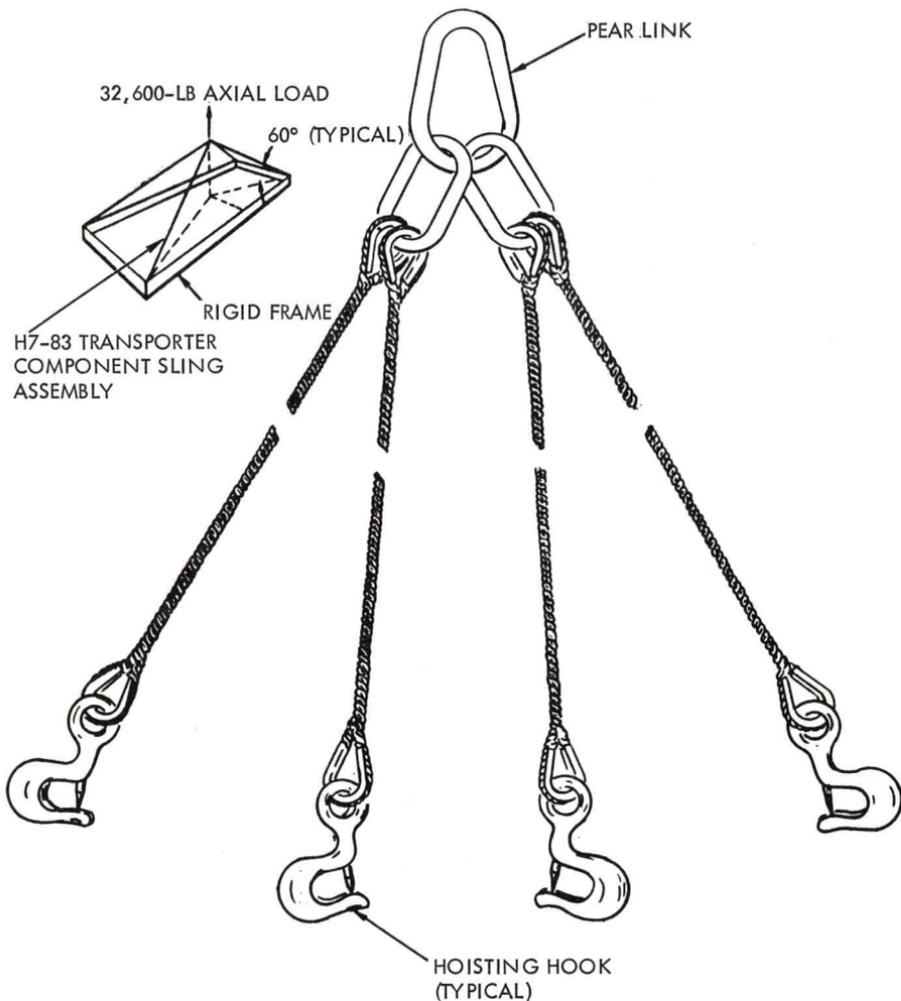
H7-79 STAGE GUIDE BRACKET SET

This set provides control and guidance of the S-II stage during the final lowering of the stage into the test stand. It is used at MTF only.



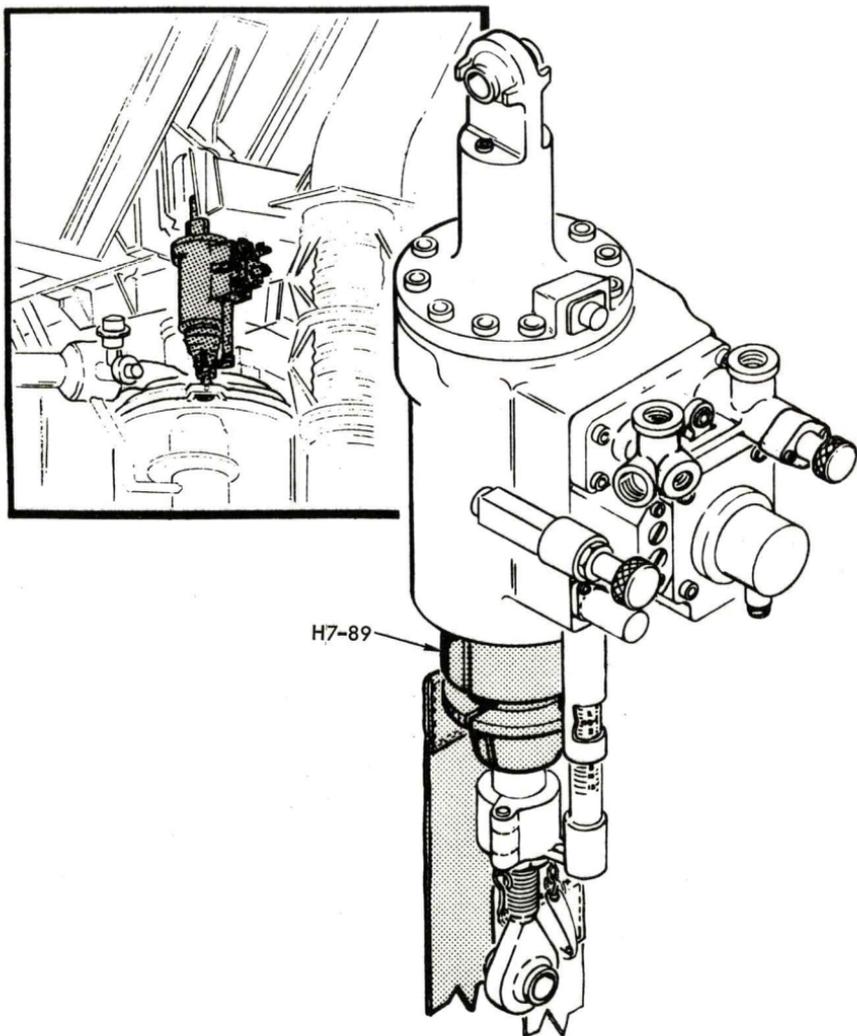
H7-83 TRANSPORTER COMPONENTS SLING

The H7-83 is used to support transporter components during hoisting operations for assembly or disassembly of the transporter. It is used at Seal Beach, MTF, MSFC, and KSC.



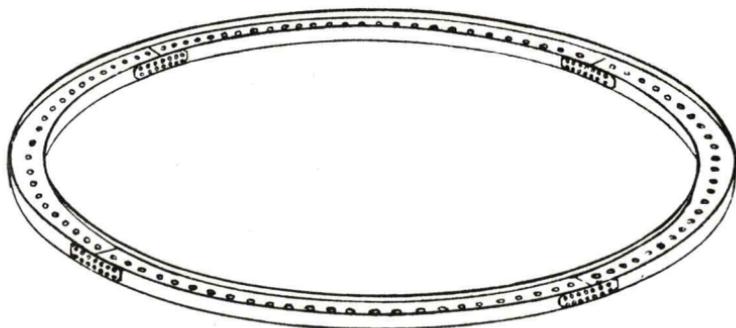
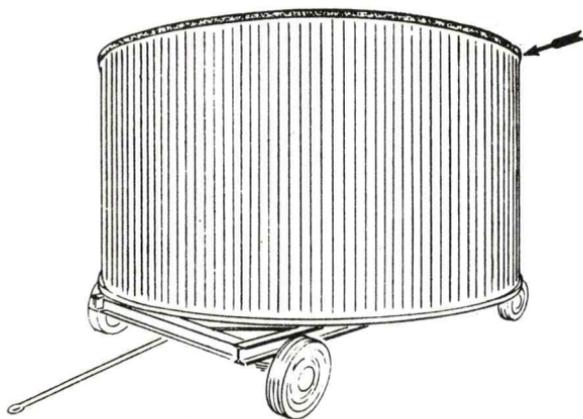
H7-89 ENGINE ACTUATOR LOCK NO. 2

This lock provides a means of immobilizing the production engine actuator to prevent any relative motion between the actuator body and the rod during ground handling and maintenance. It is used at all sites.



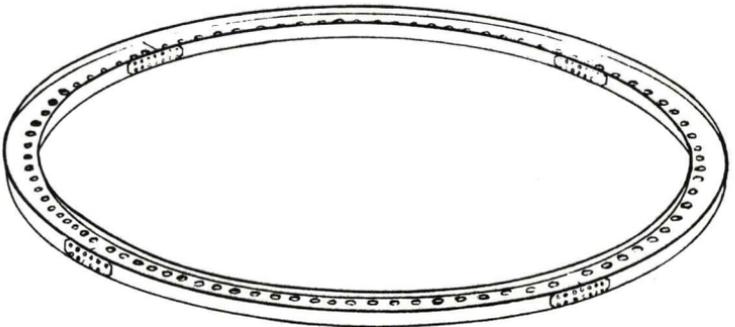
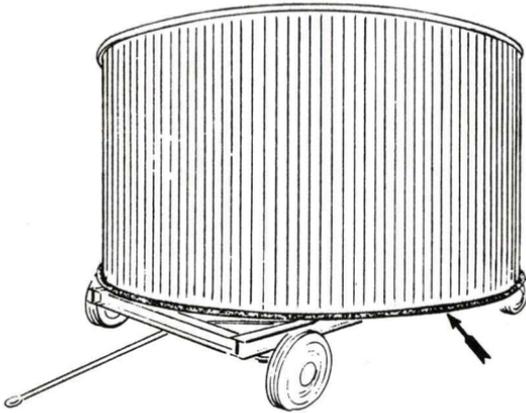
H7-92 INTERSTAGE FORWARD SUPPORT RING

This ring provides a supporting structure for the forward end of the S-II interstage. It is used at Seal Beach and KSC.



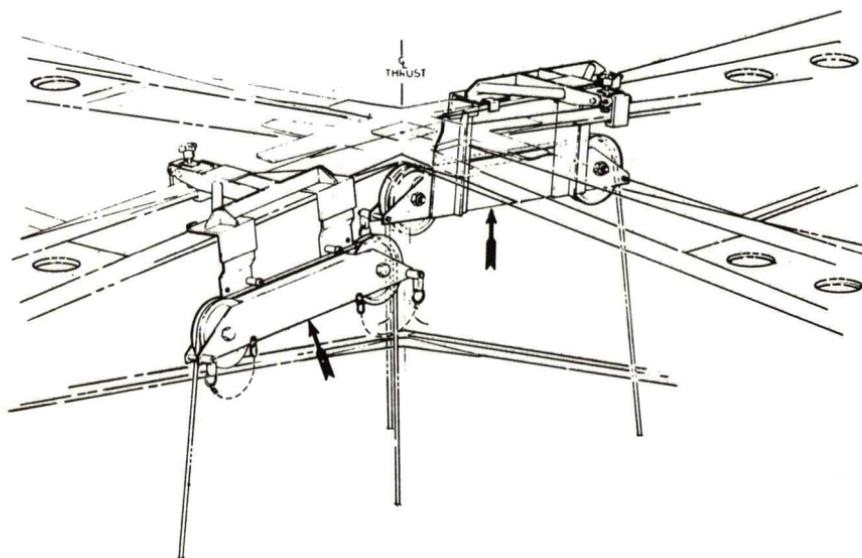
H7-93 INTERSTAGE AFT SUPPORT RING

This ring provides a supporting structure for the aft end of the S-II interstage. It is used at Seal Beach and KSC.



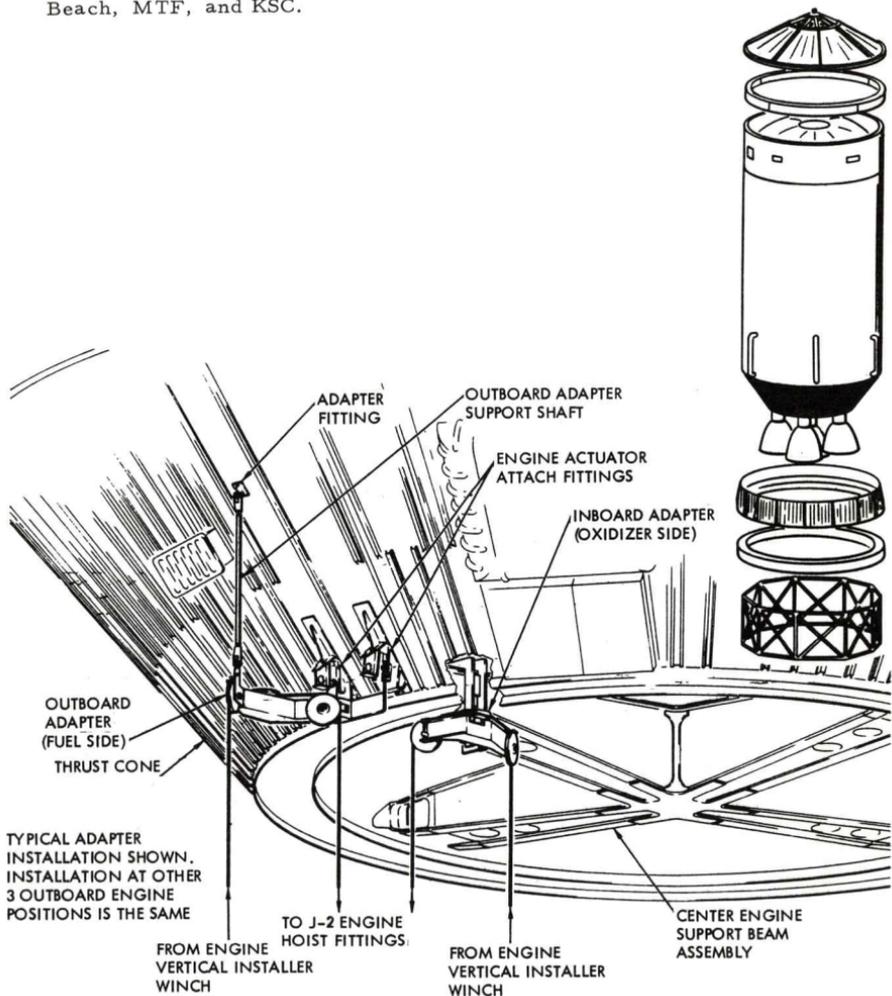
H7-94 CENTER ENGINE VERTICAL INSTALLATION ADAPTER

The H7-94 provides a guidance for the engine installer cables (GFE) during installation and removal, and to transmit the weight of the center J-2 engine from the engine installer cables to the center engine support beam. The H7-94 is used at Seal Beach, MTF, and KSC.



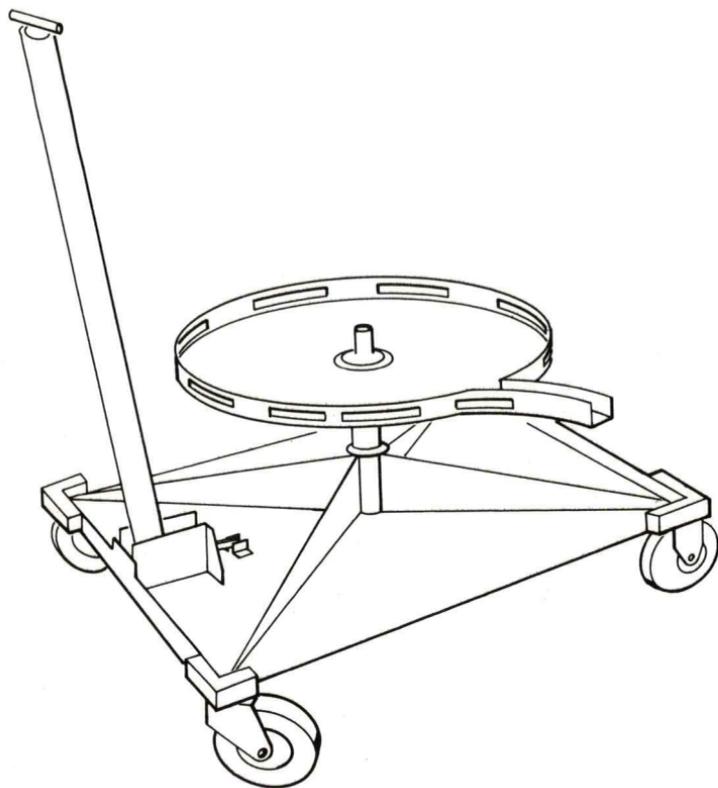
H7-95 OUTBOARD ENGINE VERTICAL INSTALLATION ADAPTER

The H7-95 adapter provides guidance for the engine installer cables (GFE) during installation and removal of J-2 engines. It is used at Seal Beach, MTF, and KSC.



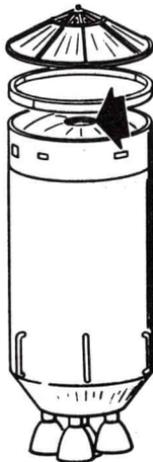
H7-97 SEPARATION LINEAR-SHAPED CHARGE INSTALLER

The H7-97 provides support during the unreeling of the linear-shaped charge while being installed in two areas on the S-II stage, Stations 0 and 196. The H7-97 is used at KSC only.

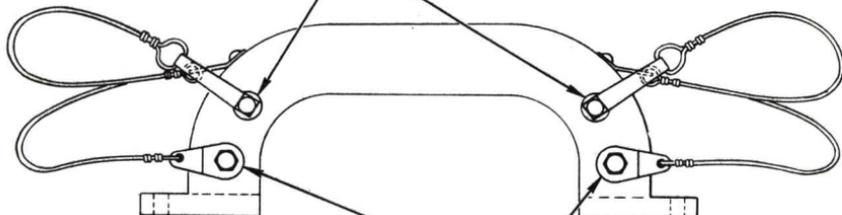


H7-99 LH<sub>2</sub> TANK ACCESS COVER HANDLE

The handle assembly provides means for supporting and manually manipulating the LH<sub>2</sub> tank access cover or the stage instrumentation containers during installation or removal. The H7-99 is used at Seal Beach, MTF, MSFC, and KSC.



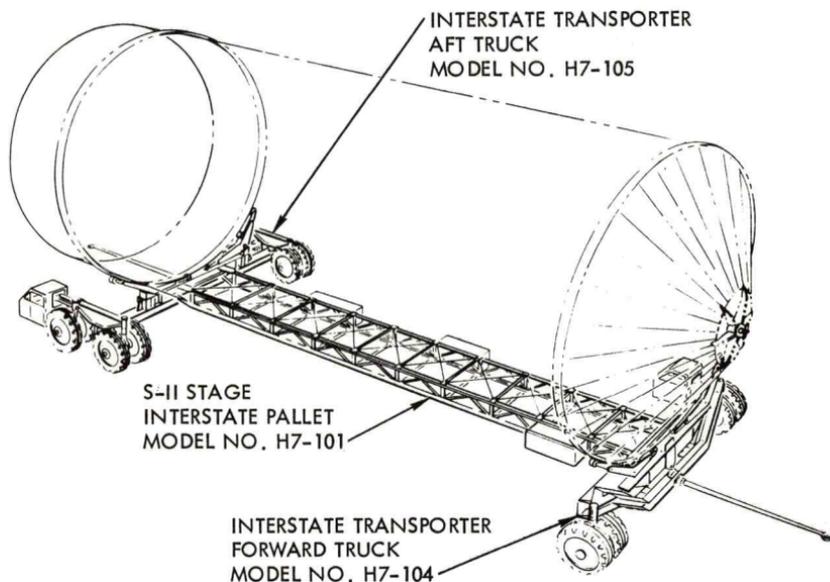
ATTACH PINS FOR  
INSTRUMENTATION  
COVERS OR LH<sub>2</sub>  
TANK ACCESS  
PROTECTIVE RING



ATTACH BOLTS FOR  
LH<sub>2</sub> ACCESS COVER

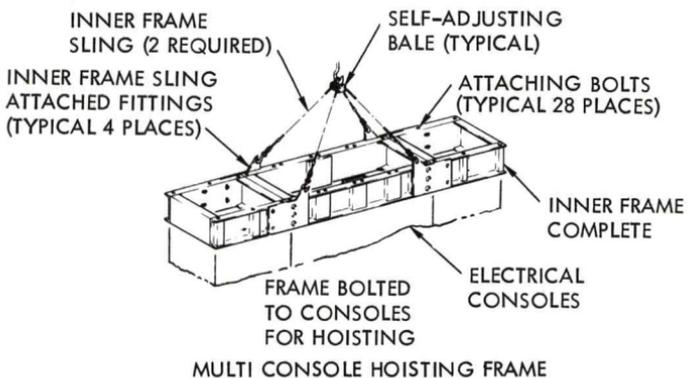
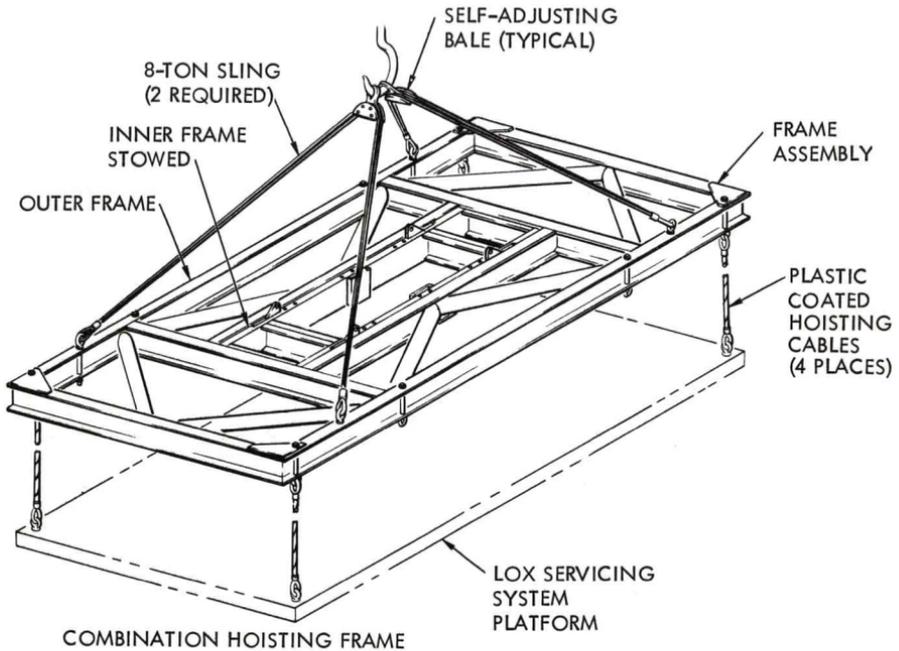
TYPE II STAGE TRANSPORTER  
H7-101, H7-104, AND H7-105

The H7-101 provides a cradle to support the S-II stage in a horizontal attitude and to provide the chassis of the stage transporter. The H7-104 forward truck converts the forward end of the S-II stage pallet H7-101 into a transporter configuration. The H7-105 aft truck converts the aft end of the S-II stage pallet H7-101 into an interstate transporter configuration. The stage transporter is used at Seal Beach, MTF, MSFC, and KSC.



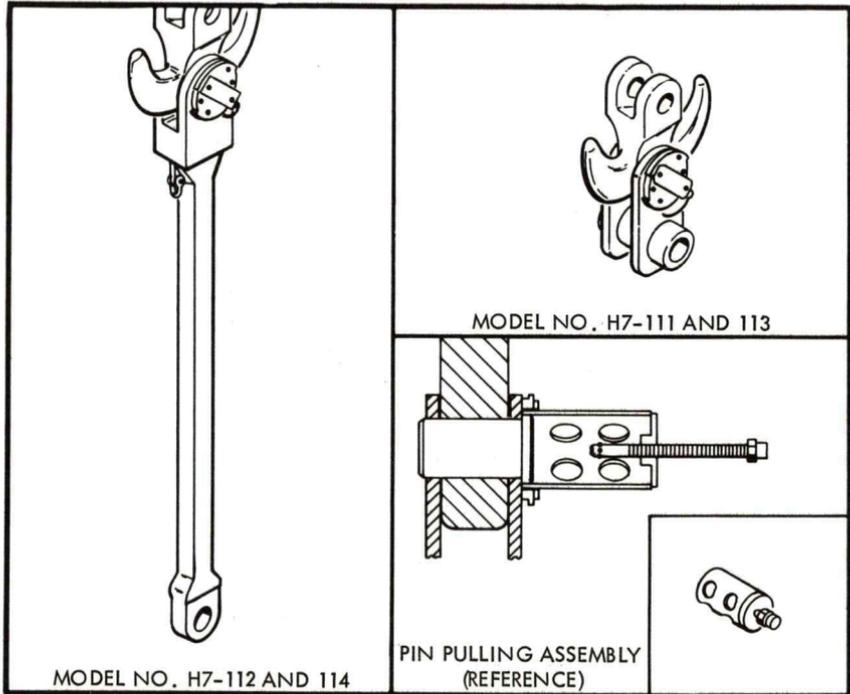
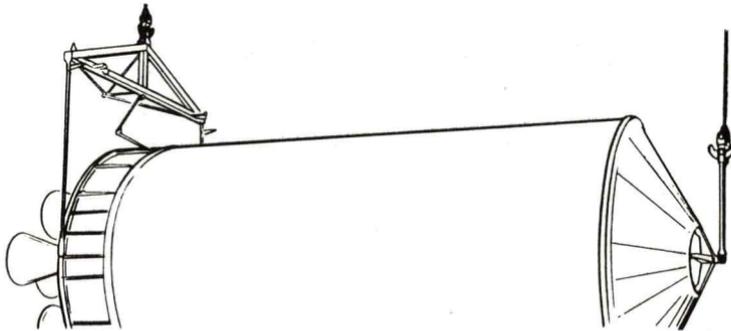
H7-106 ENGINE VERTICAL INSTALLER SLING

The H7-106 provides support for the GFE vertical engine installers, the S7-29 and any combination of one to four electrical equipment racks during installation or removal handling operations. It is used at Seal Beach and MTF.



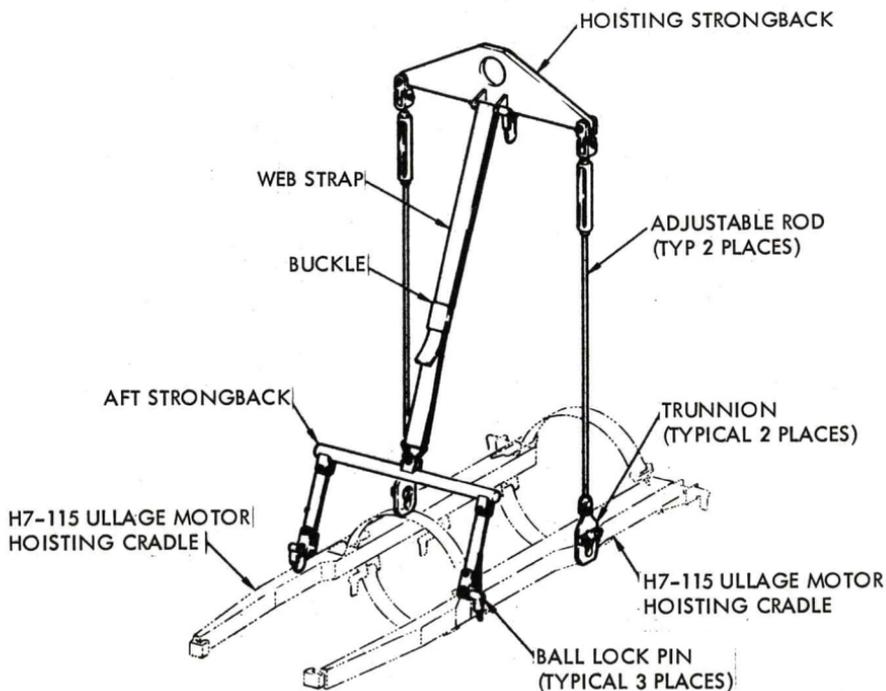
H7-111—H7-114 HOISTING EQUIPMENT

The H7-111 provides an interface for attaching the H7-25 aft hoisting frame with a 75- to 100-ton capacity hoist hook. It is used at MTF A-2 test stand. The H7-113 provides an interface for attaching the H7-25 aft hoisting frame with a 200-ton capacity hoist hook. It is used at MSFC. The H7-112 provides an interface for attaching the H7-23 stage erecting sling with a 75- to 100-ton capacity hoist hook. It is used at MTF A-2 test stand. The H7-114 provides an interface for attaching the H7-23 stage erecting sling with a 200-ton capacity hoist hook. It is used at MSFC.



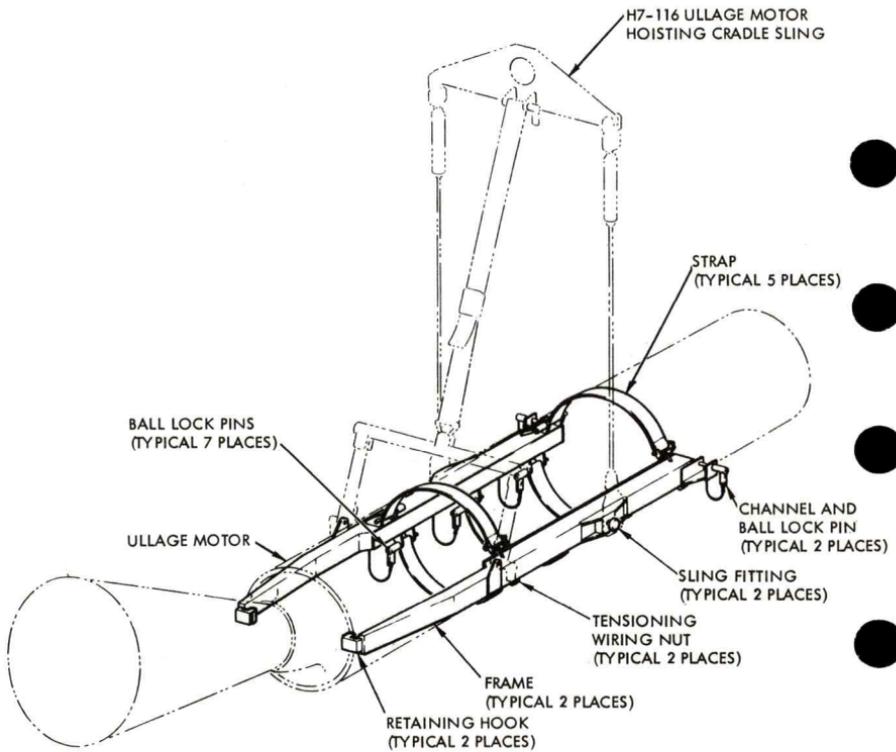
H7-115 ULLAGE MOTOR HOISTING CRADLE

The H7-115 provides cradle support for an S-II stage ullage motor during hoisting operations to install the motor on, or to remove the motor from, the S-II stage. It is used at KSC.



H7-116 ULLAGE HOISTING CRADLE SLING

The H7-116 provides the interfacing support element between the facility hoisting crane hook and the H7-115 ullage motor hoisting cradle during the installation and removal of ullage motors. It is used at KSC.



XIII. SPECIAL DEVELOPMENT DEVICES

# SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

## SPECIAL DEVELOPMENT DEVICES

Special Development Devices (SDD) are nonflight equipment similar or identical in function and configuration to GSE, but assigned to less stringent requirements and controls than GSE.

### SDD-103 BATTLESHIP STAND CABLE INSTALLATION

The SDD-103 cable installation provides the interconnecting wiring, in the service center, on the stand and auxiliary buildings, required for checkout and firing of the Battleship stage.

The cable installation consists of numerous cable assemblies and a few intercommunication J-boxes and stations. The cable assemblies are used to connect GSE to distributors and to interconnect intercommunication equipment. The SDD-103 consists of 750 cable assemblies, 40 intercommunication stations, and 3 intercommunication J-boxes.

### SDD-105 FIRING CONTROL CENTER CABLE INSTALLATION

The SDD-105 cable installation provides the interconnecting wiring, in the control center, required for checkout and firing of the Battleship stage.

This cable installation consists of numerous cable assemblies and intercommunication stations. The cable assemblies will be used to interconnect GSE with facility power, GSE to GSE, and GSE to the distributor.

The installation consists of 500 cable assemblies and 10 intercommunication stations.

### SDD-107 FACILITY BATTLESHIP STAND CABLE INSTALLATION

The SDD-107 cable installation provides the necessary wiring to interconnect the SDD-103 with the SDD-105 for Battleship stage testing.

This cable installation consists of distributors on the Battleship stand, permanently installed cable between the stand distributors and the distributor in the associated service center, permanently installed cable in the tunnel between the two service center distributors, and the control center distributor and wire harnesses in the distributors. The installation consists of 350,000 feet of bulk cable (average 60 conductors), 141,000 feet of coaxial cable, 1,200 wire harnesses, and 15 distributors with terminal strips.

SDD-110 BATTLESHIP FLUID DISTRIBUTION SYSTEM

The SDD-110 fluid distribution system is located at the stand. It supplies, distributes, and controls the fluids required for servicing and checkout of the Battleship stage.

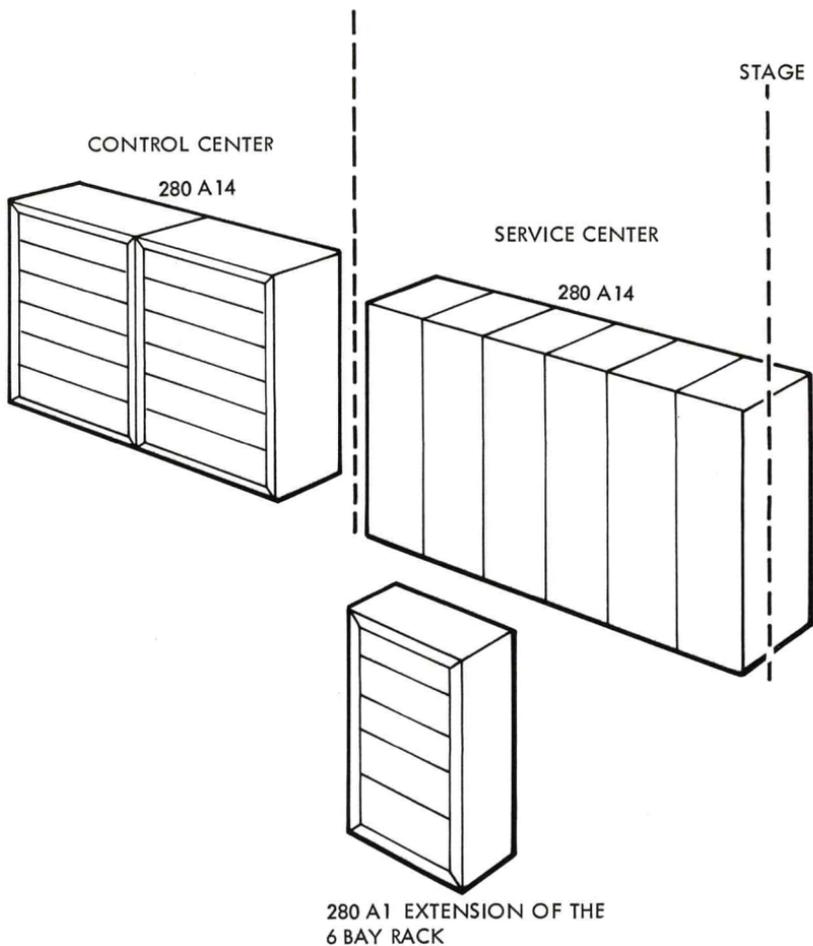
The liquid hydrogen distribution lines are an assembly of vacuum-jacketed straight and formed sections of stainless steel tubing. Each section is a complete assembly of inner and outer tubing, vacuum valve, burst disc, and vacuum gauge probe. Bellows joints are incorporated in the inner or carrier line to compensate for line contraction and expansion. The sections are welded together to form a continuous transfer line between the facility interface and the umbilical-arm interface.

The liquid oxygen lines are stainless steel with foam-glass insulation. Bellows joints are used to accommodate line contraction and expansion.

The hydraulic and gas distribution lines are stainless steel flared tubing joined together with fittings, valves, and hoses to form a continuous transfer line from the facility interface to the umbilical-arm interface.

SDD-130 SIGNAL CONDITIONING STATION

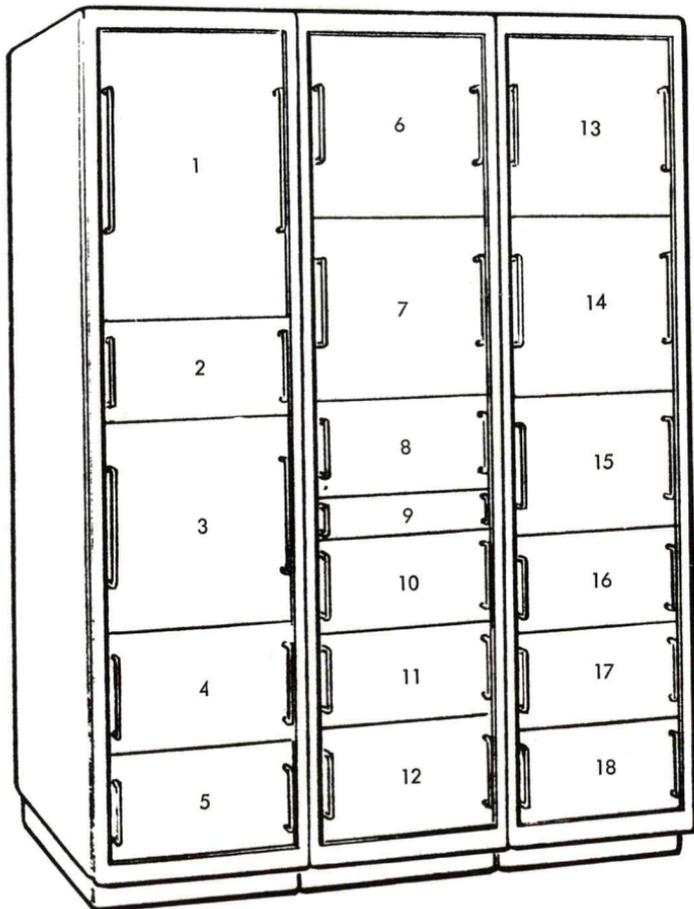
The SDD-130 complex is used to condition and/or fuse all functions to and from the stage with the end destination being the control center. It is used at Battleship only.



## SDD-131 FLIGHT CONTROL CHECKOUT RACK

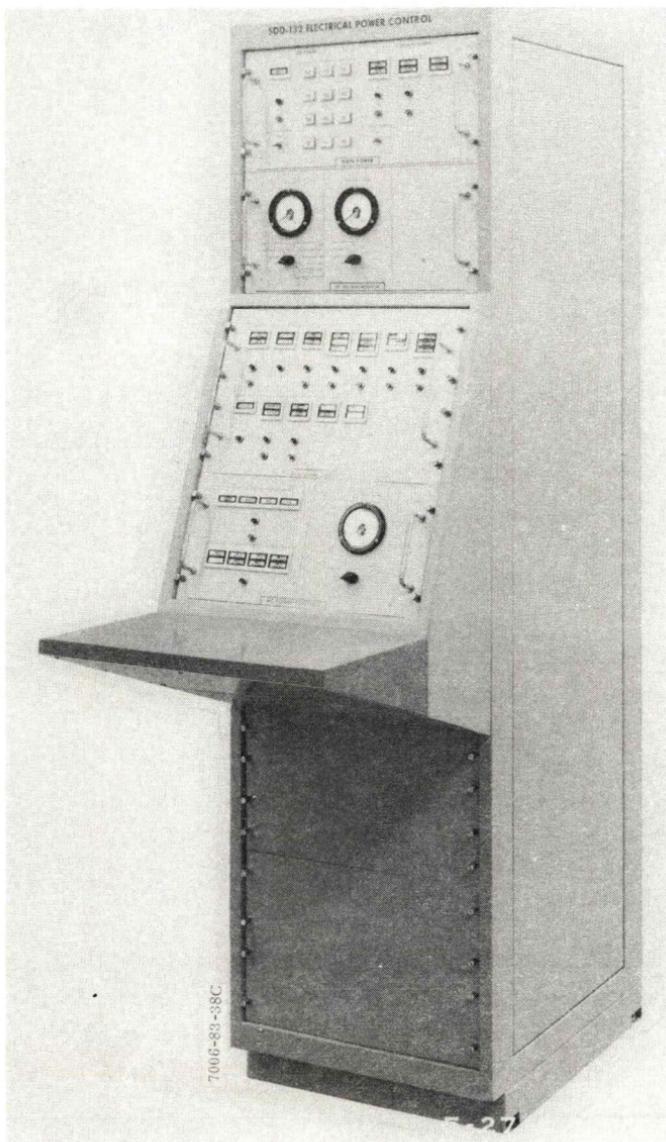
This rack provides and monitors electrical signals to control the C7-601 and the Battleship stage engine gimbaling equipment. It is used at Battleship.

- |  |                               |
|--|-------------------------------|
| 1. TAPE READER                               | 10. DUMMY PANEL               |
| 2. CONTROL PANEL                             | 11. DUMMY PANEL               |
| 3. PROGRAMMER PANEL                          | 12. INTERFACE PANEL           |
| 4. FUNCTION GENERATOR                        | 13. ENGINE DEFLECTION MONITOR |
| 5. INTERFACE PANEL                           | 14. ENGINE DEFLECTION CONTROL |
| 6. HYDRAULIC POWER CONSOLE<br>REMOTE CONTROL | 15. DUMMY PANEL               |
| 7. HYDRAULIC SYSTEM<br>MONITOR AND CONTROL   | 16. DUMMY PANEL               |
| 8. CIRCUIT BREAKER                           | 17. DUMMY PANEL               |
| 9. POWER SIGNAL SUPPLY                       | 18. INTERFACE PANEL           |



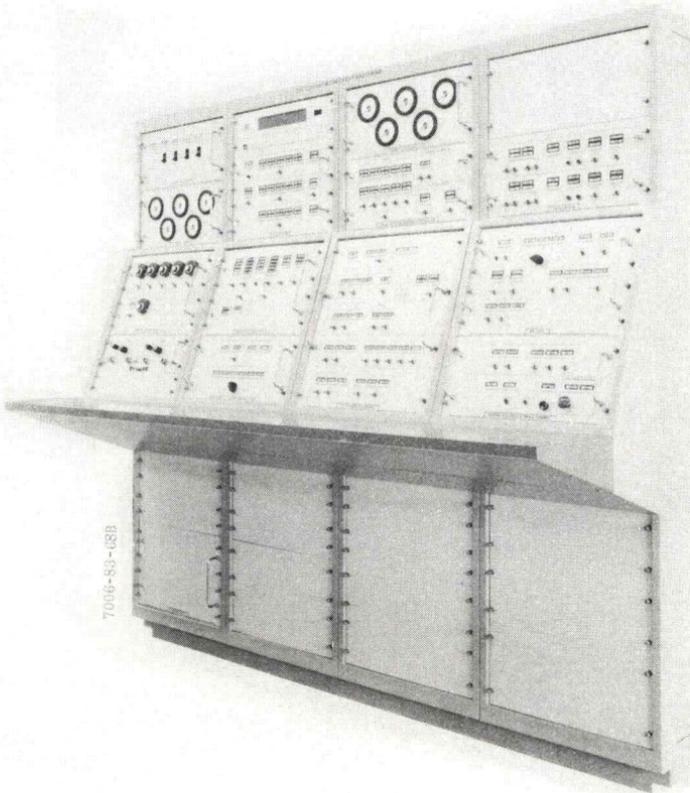
SDD-132 ELECTRICAL POWER CONTROL RACK

This rack provides and monitors electrical power to the Battleship stage and mechanical checkout station, C7-601, C7-603, and C7-605. It is used at Battleship only.



SDD-133 ENGINE CHECKOUT AND FIRING RACK

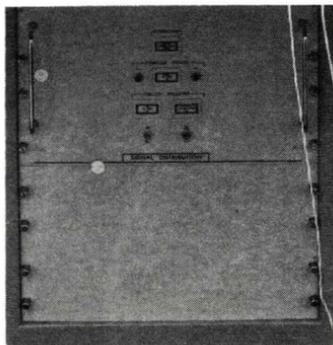
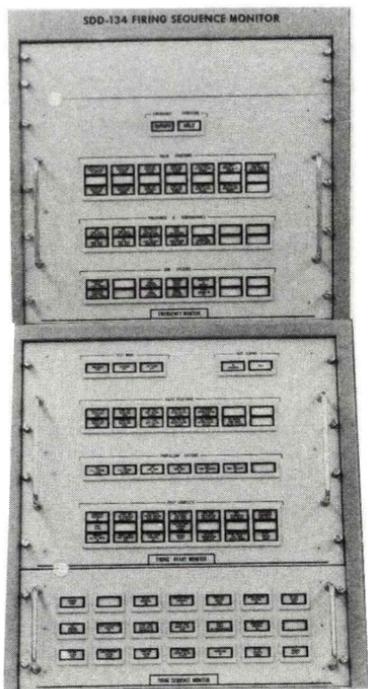
The SDD-133 is used to accomplish a prefiring checkout on the Battleship stage and engine components. It is used at Battleship only.



7006-83-02B

SDD-134 FIRING SEQUENCE MONITOR RACK

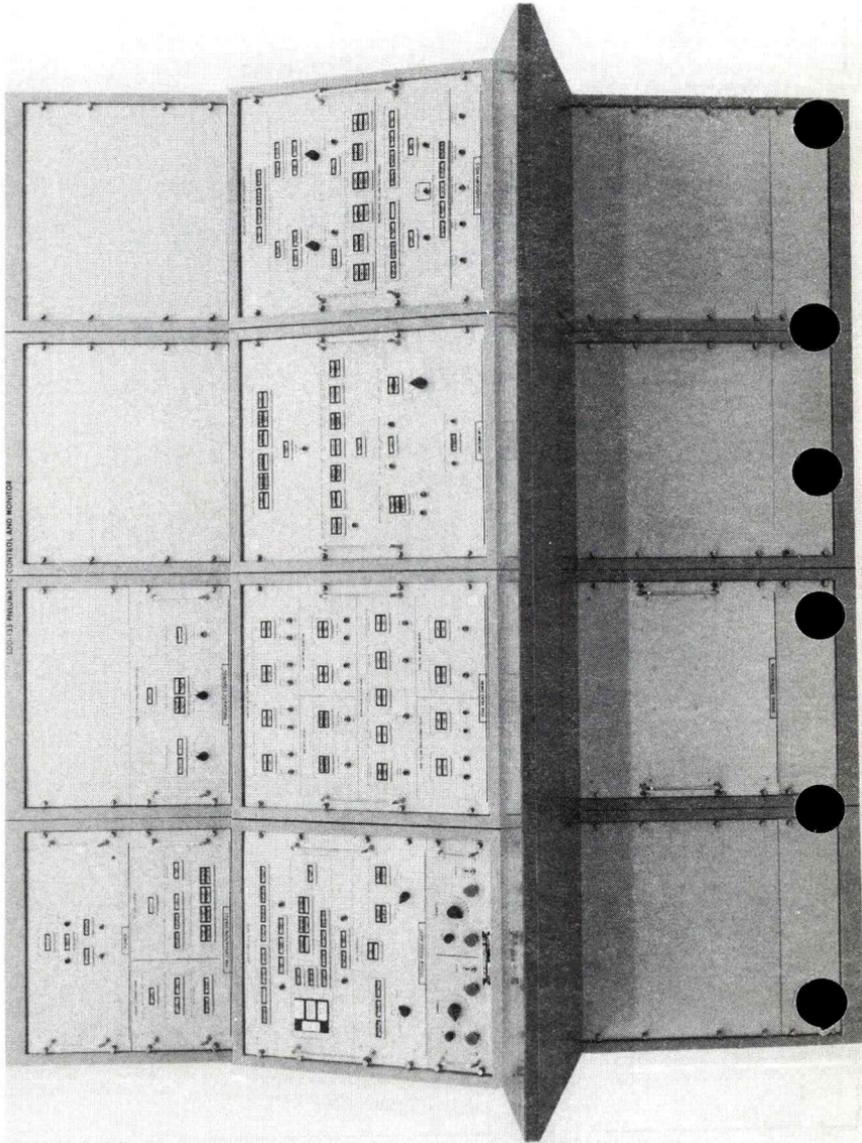
The SDD-134 is used to monitor emergency functions on stage and GSE. It is used at Battleship.



7006-83-85D

SDD-135 PNEUMATIC CONTROL AND MONITOR RACK

The SDD-135 provides the discrete electrical signals and visual display indications to verify satisfactory operating conditions of all pneumatically operated stage components. It is used at Battleship.

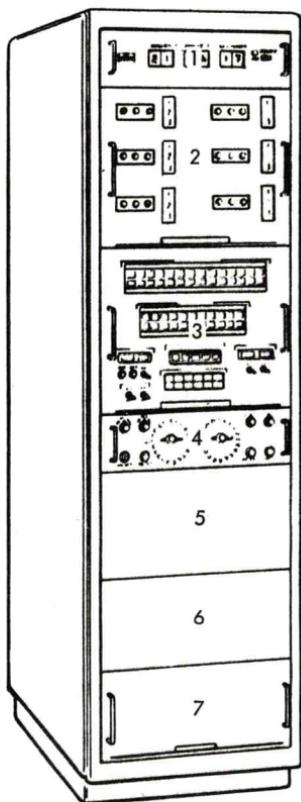


# SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

## SDD-136 INSTRUMENTATION CALIBRATION RACK

The SDD-136 provides a high or low mode of calibration for the signal conditioners associated with each stage transducer controlled by the remote automatic calibration system (RACS) equipment. It is used at Battleship.

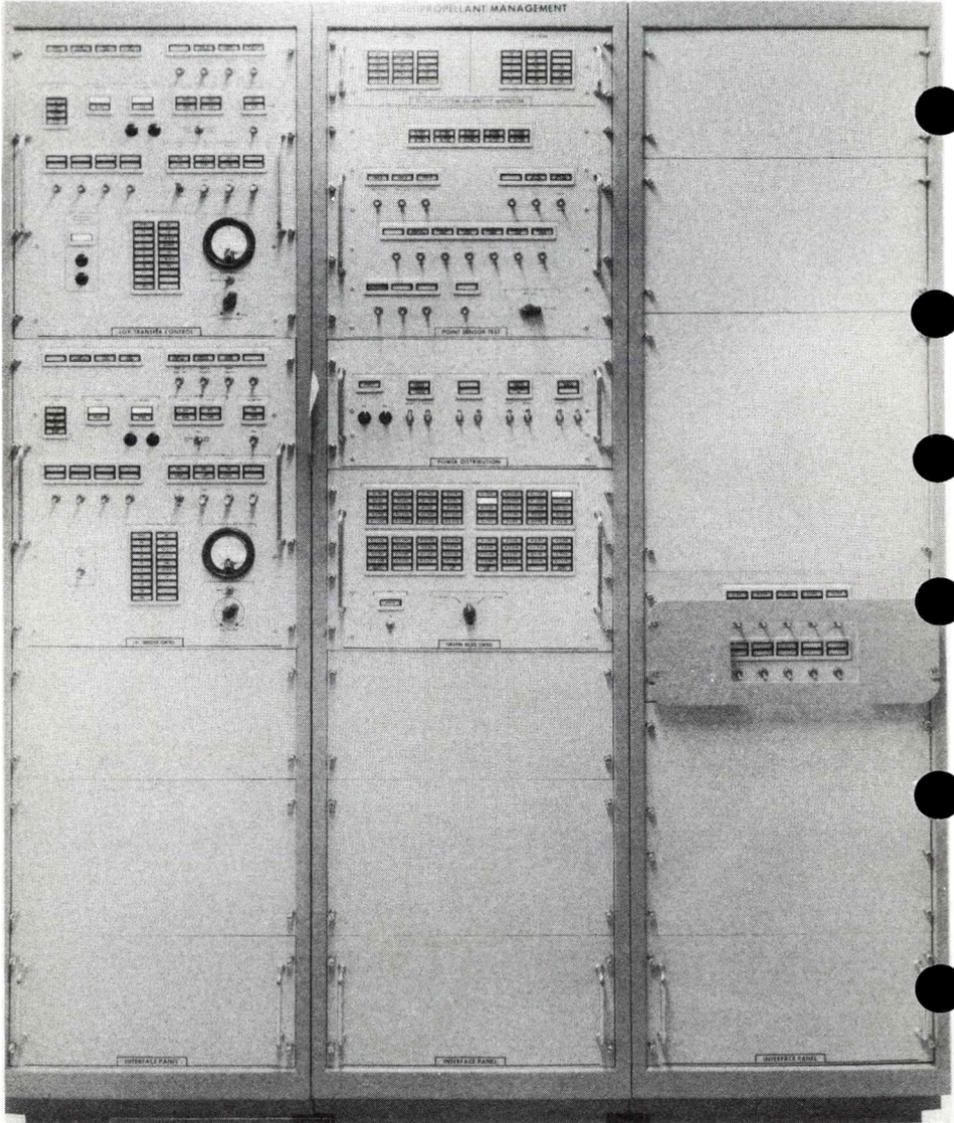
1. SYSTEM COUNTDOWN CLOCK
2. DUMMY PANEL
3. CALIBRATION CONTROL
4. INTERCOM
5. DUMMY PANEL
6. DUMMY PANEL
7. INTERFACE DISCONNECT PANEL



SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

SDD-141 PROPELLANT MANAGEMENT RACK

The SDD-141 is used for checkout and monitoring of the loading and recirculation systems. It is used at Battleship.



SDD-151 INTERCOMMUNICATION HEADSET

This headset provides personnel with intercommunication capabilities. It is used at Battleship and Seal Beach.



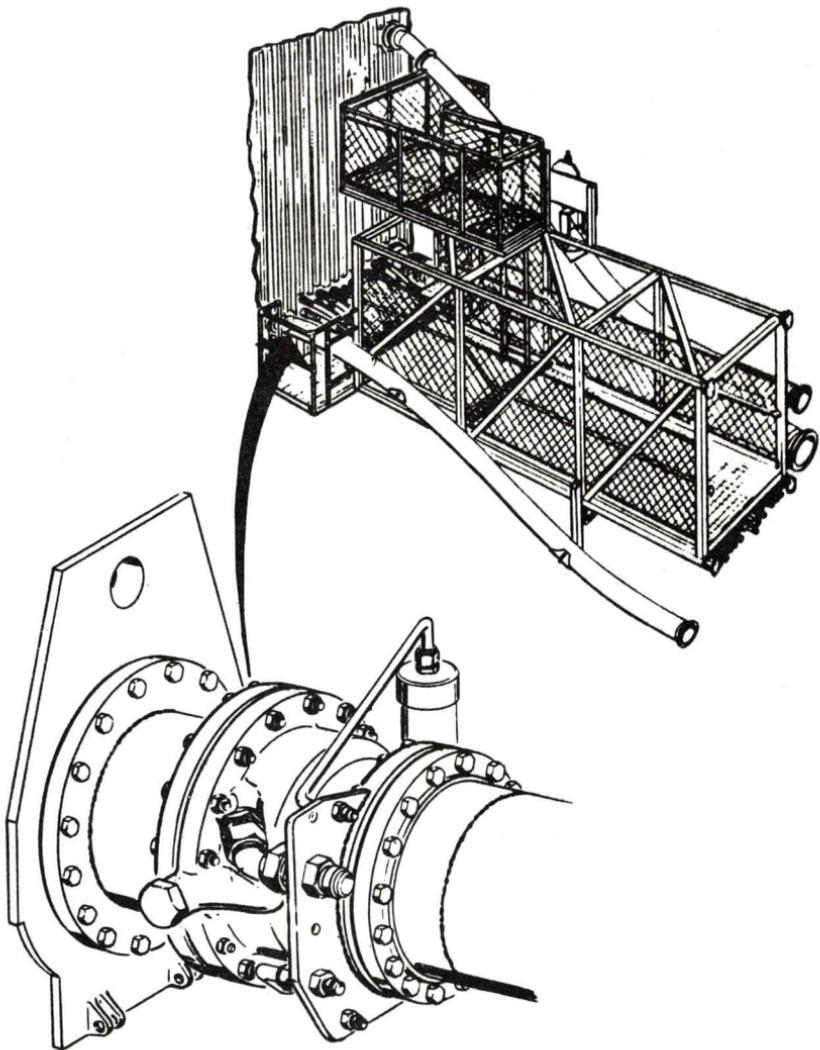
SDD-152 PROTECTIVE INTERCOMMUNICATION HEADSET

This headset provides personnel in high noise level areas with inter-communication capabilities. It is used at Battleship and Seal Beach.



SDD-153 STATIC FIRING LH<sub>2</sub> PROPELLANT COUPLING

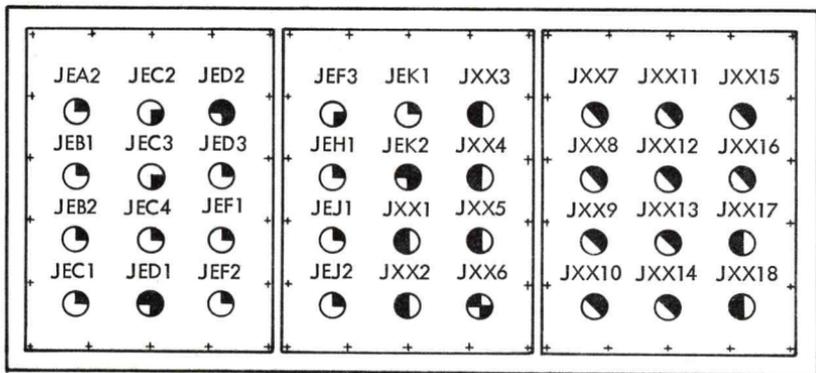
The SDD-153 provides a hardline connection between the fill line and stage for propellant loading. It is used at Battleship.



SDD-154 ELECTRICAL TERMINAL DISTRIBUTOR

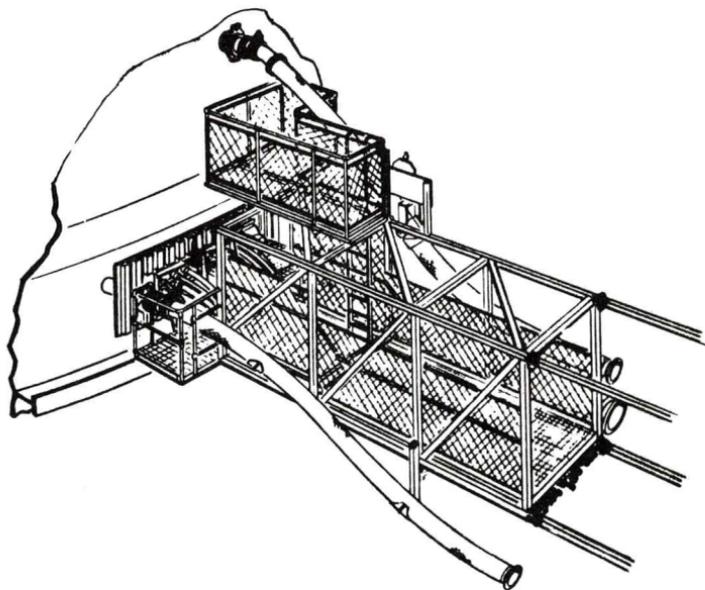
The SDD-154 is an eight-bay console which provides the terminals for the bulk cable connections between the S-II stage and GSE. It is used at Seal Beach only.

TYPICAL TERMINAL BAY



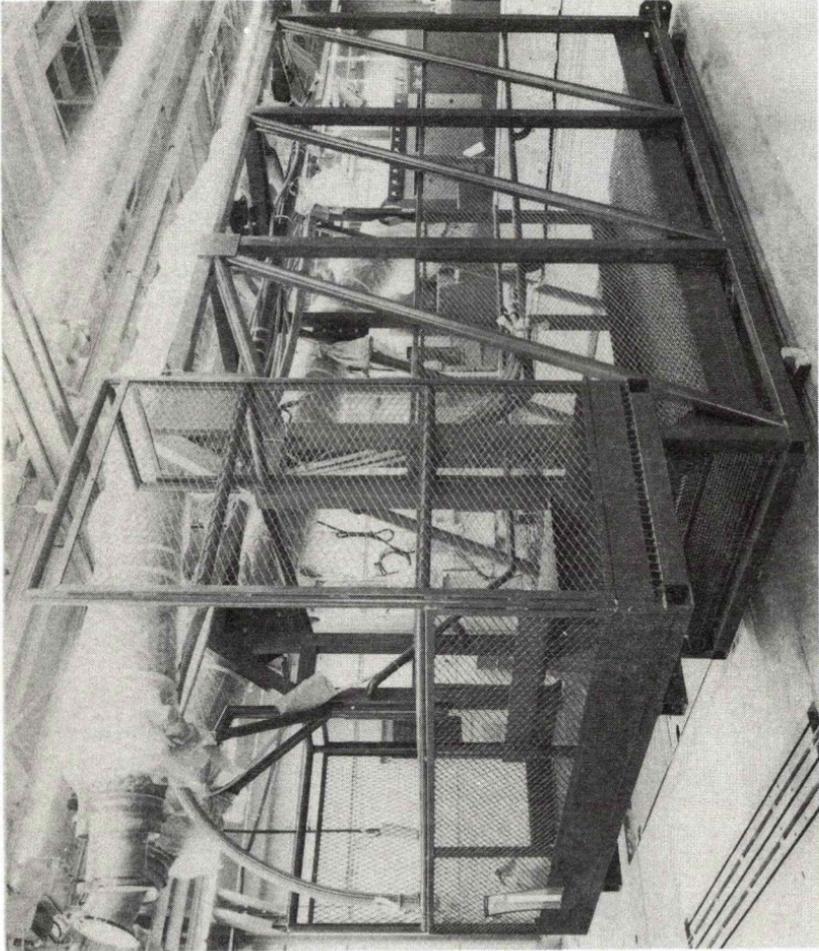
SDD-155 UMBILICAL DISCONNECT ARM NO. 3A

The SDD-155 supports fluid lines and electrical cables and provides a personnel access. It is used at Battleship.



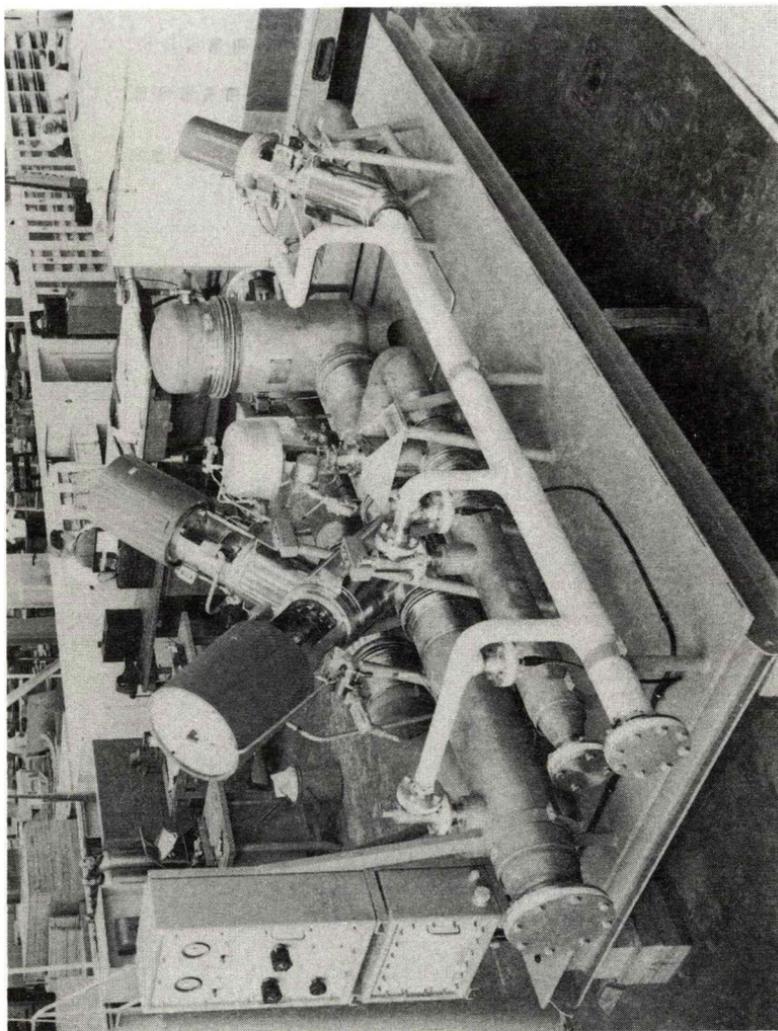
SDD-156 UMBILICAL DISCONNECT ARM 4

The SDD-156 supports fluid lines, electrical cables, and provides personnel access. It is used at Battleship.



SDD-157 LH<sub>2</sub> FILL AND TOPPING CONTROL SYSTEM

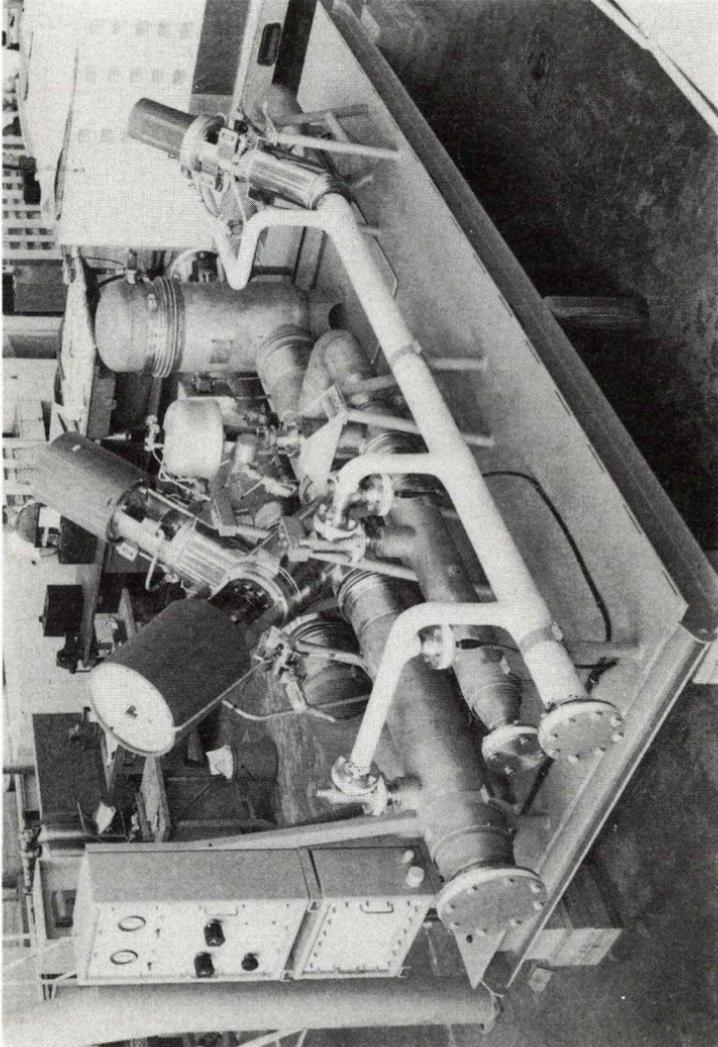
The SDD-157 provides remote controlled equipment for the LH<sub>2</sub> fill and topping operation. It is used at Battleship.



7006-88-109

SDD-158 LOX FILL AND TOPPING CONTROL SYSTEM

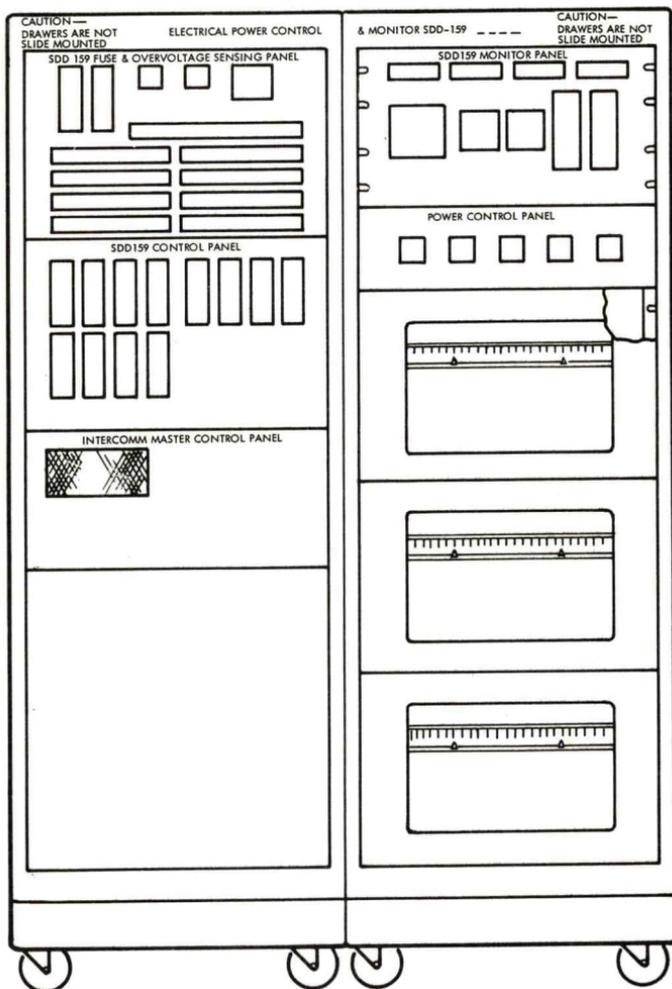
The SDD-158 provides remote controlled equipment for the LOX fill and topping operation. It is used at Battleship.



# SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

## SDD-159 ELECTRICAL POWER CONTROL AND MONITORING UNIT

The SDD-159 is required to provide the functions of power control and monitoring. The unit incorporates switches, indicating lights, meters and over- and under-voltage detectors to turn on/off, monitor and prevent dangerous conditions of the stage buses supplied through the C7-41. Recorders with approximately 50 channel capacity also are incorporated in this unit. It is used at Seal Beach.



SDD-163 STATION 7 CABLE INSTALLATION

The SDD-163 cable installation provides all interconnecting wiring and associated hardware required for checkout of the S-II in Station 7.

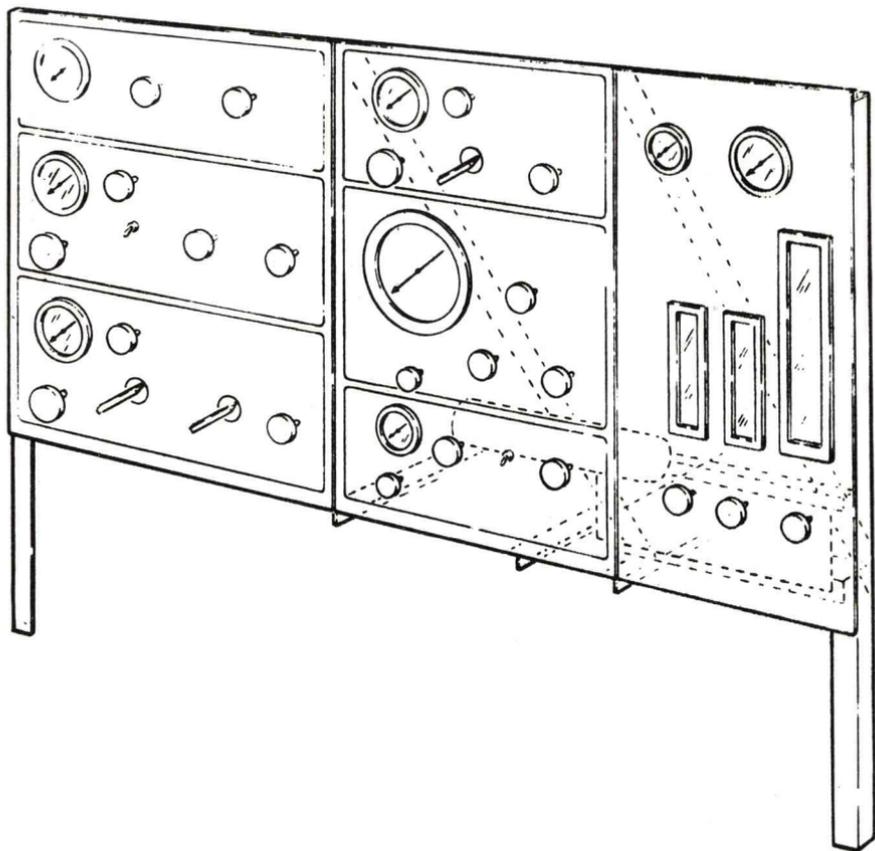
This cable installation consists of numerous cable assemblies, wire harnesses, distributors, and bulk cable. These items are used to connect GSE to facility power, GSE to GSE, GSE to Stage, and to interconnect inter-communications equipment. The installation consists of 3,000 feet of bulk cable, 150 cable assemblies, 75 wire harnesses, and 3 distributors. It is used at Seal Beach.

SDD-165 STATION 7 FLUID DISTRIBUTION SYSTEM

The SDD-165 system is used for supplying, distributing, and controlling the fluids for servicing and checkout of the stage at Station 7. The system for both pneumatic and hydraulic fluids consists of corrosion-resistant steel tubing with flared-end fittings joining the fittings, valves, and hoses. The pneumatic subsystem is installed between the facility interface, the checkout console, and the stage. The hydraulic subsystem connects the hydraulic console with the stage engine hydraulic systems. It is used at Seal Beach.

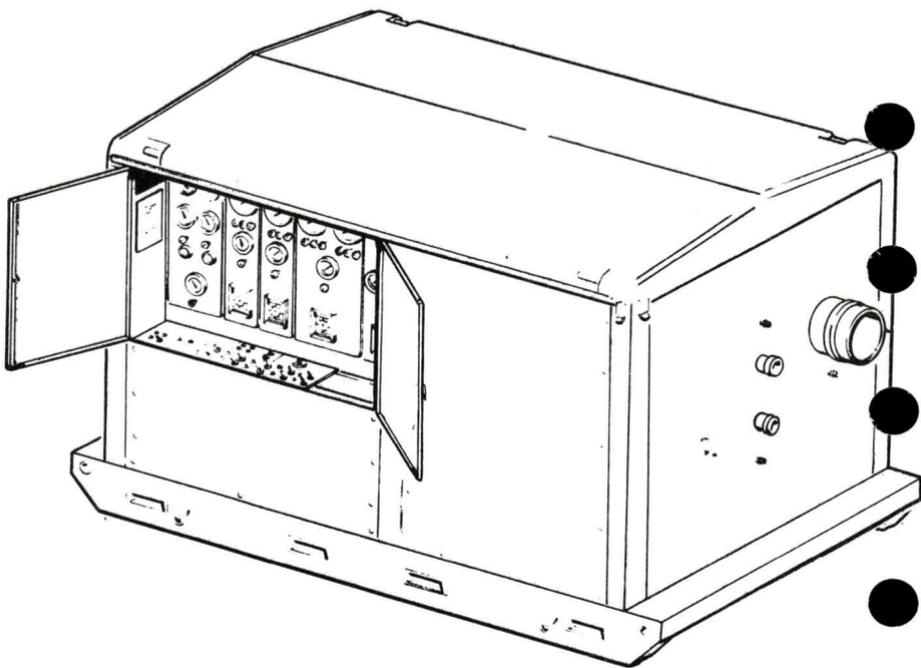
SDD-167 PNEUMATIC STIMULI UNIT

The SDD-167 provides for performance of pressurization checks on the stage and J-2 engines. It is used at Battleship and MTF.



SDD-168 PURGE AND THERMAL CONTROL NITROGEN UNIT

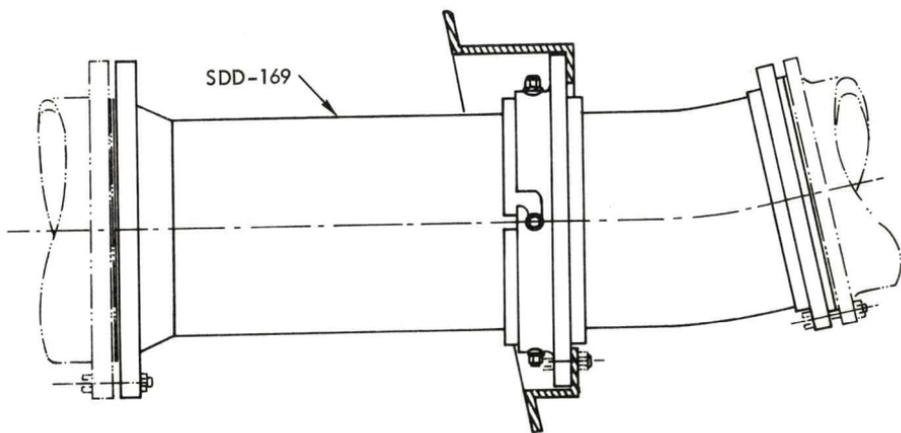
The SDD-168 provides local and remote control capabilities to purge the engine area and thermal control for forward and aft electrical containers. It is used at Battleship.



SDD-169 STATIC FIRING VENT COUPLING

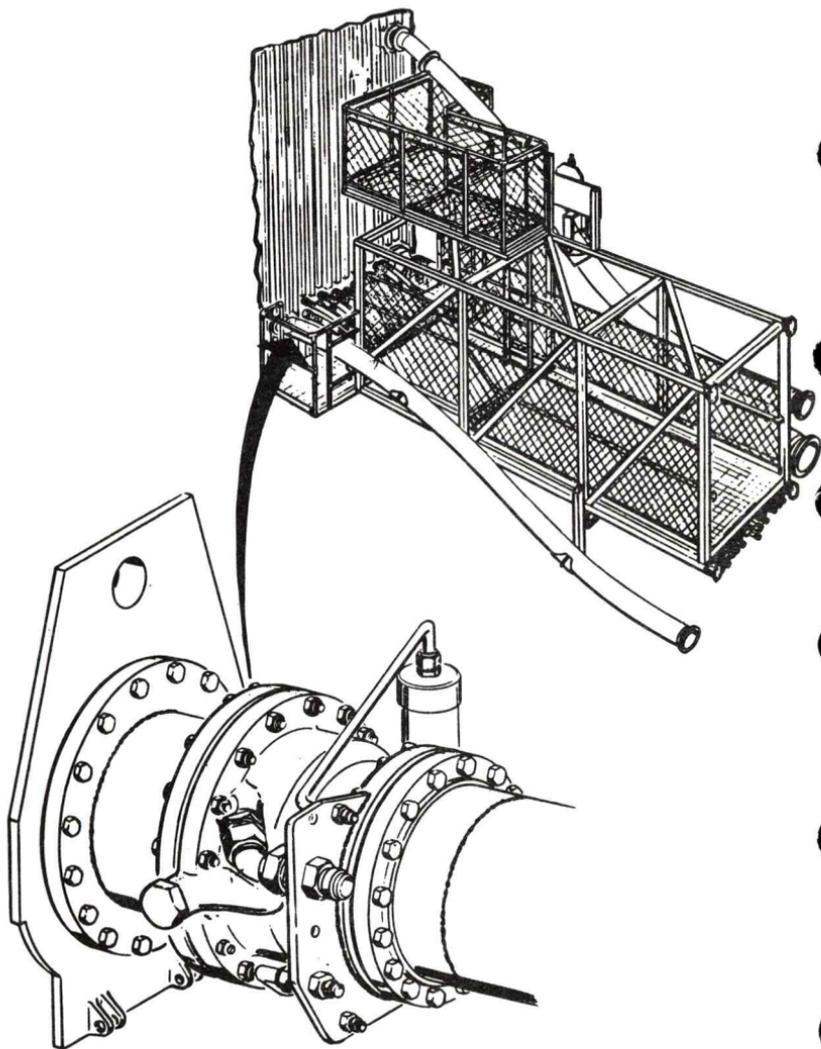
The SDD-169 is used for Battleship stage static firings. It serves as the ground half of the LH<sub>2</sub> vent disconnect coupling.

This unit consists of a short pipe which is flanged for bolt attachment to the ground line, stage, and stage line.



SDD-170 LOX STATIC FIRING PROPELLANT COUPLING

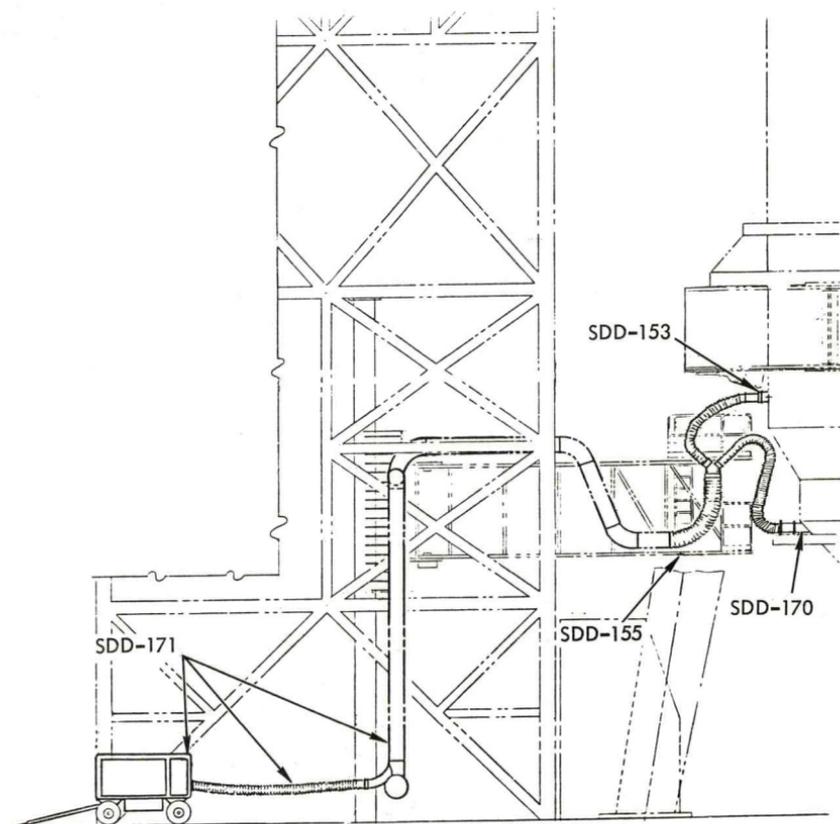
The SDD-170 coupling connects the LOX fill line to the stage. It is used at Battleship.



## SDD-171 TANK AIR CONDITIONING UNIT

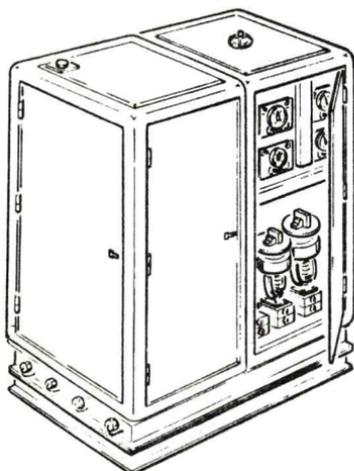
The SDD-171 unit provides conditioned air in the LH<sub>2</sub> and LOX tanks during in-tank maintenance and servicing.

The unit consists of one MA-8 trailer-mounted air conditioner, 100-micron absolute filters, an electrical cable adapter to adapt the unit cable to facility receptacle, and necessary sheet metal adapters to connect ducting from the unit to the stage. Air is introduced into the LH<sub>2</sub> and LOX tanks through the fill and drain disconnects and vented through the access openings (flow 65 scfm 50 F). It is used at Battleship only.

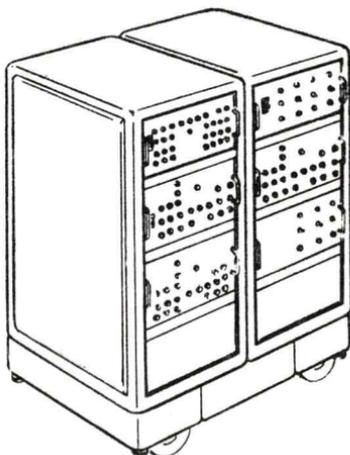


SDD-181 PNEUMATIC SERVICING CONSOLE SET

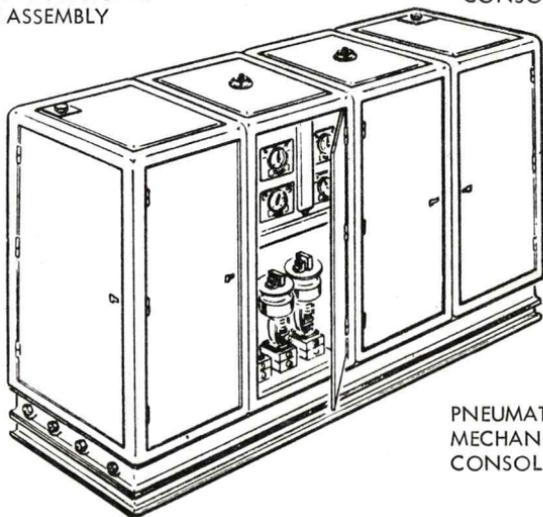
The SDD-181 controls the supply of helium, hydrogen and nitrogen gases at required temperatures and pressures upon command from the remote control center. It is used at Battleship.



PNEUMATIC SERVICE  
MECHANICAL SECTION B  
CONSOLE ASSEMBLY



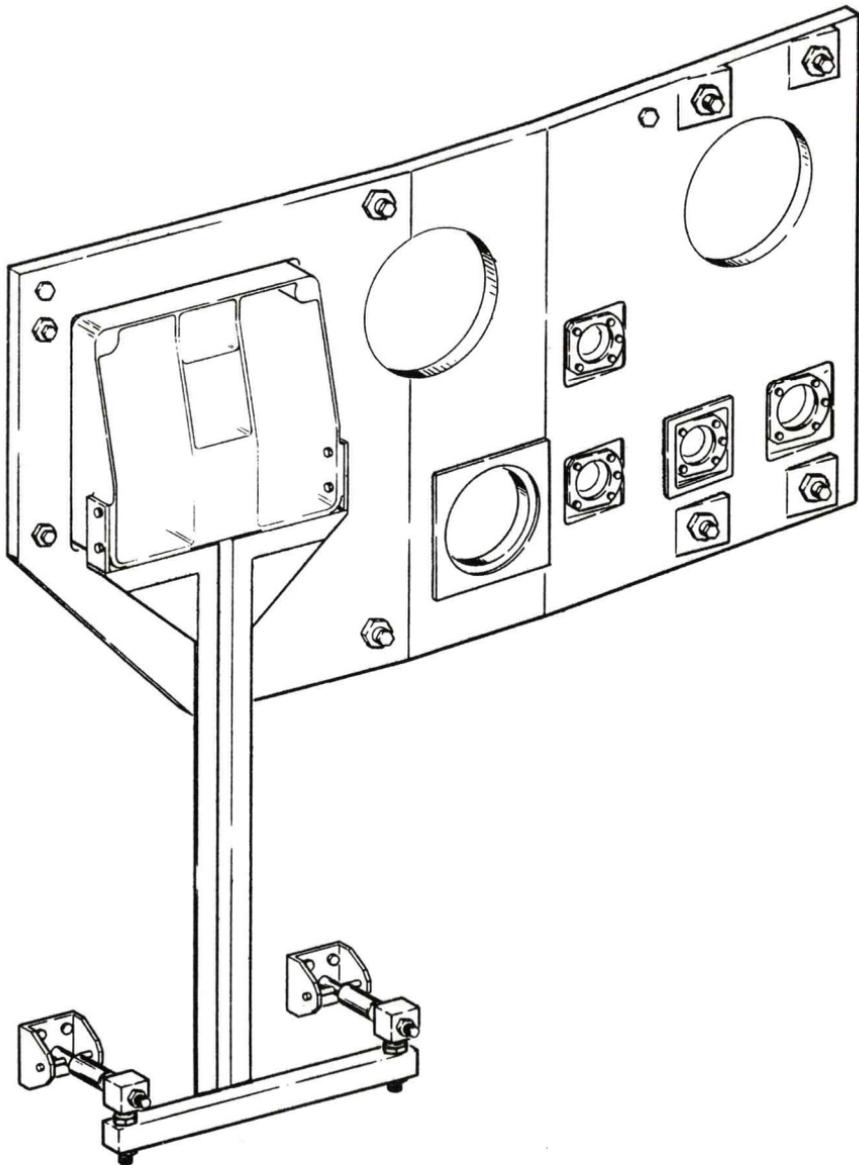
PNEUMATIC SERVICE  
ELECTRICAL SECTION  
CONSOLE ASSEMBLY



PNEUMATIC SERVICE  
MECHANICAL SECTION A  
CONSOLE ASSEMBLY

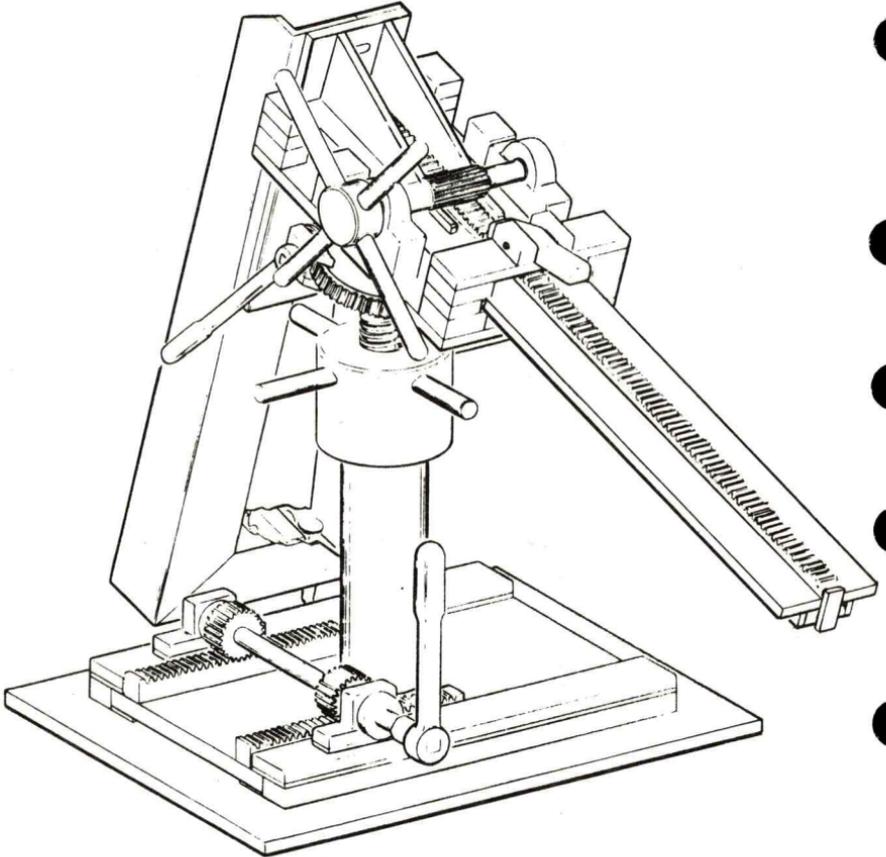
SDD-184 ARM NO. 4 CARRIER PLATE

The SDD-184 supports the umbilical disconnects on the S-II forward skirt. It is used at MSFC.



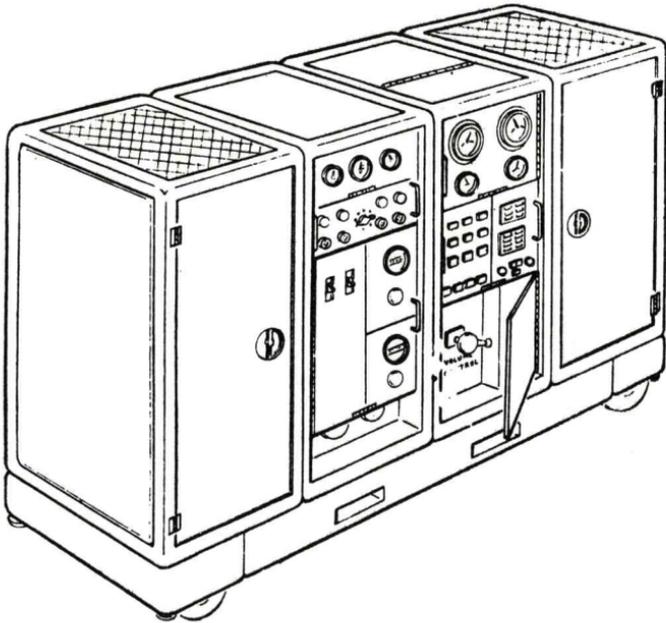
SDD-191 STATION VII FORWARD RETRACT MECHANISM

The SDD-191 provides a means to install the forward umbilical disconnect plate. It also removes, retracts, and stows the umbilical plate in Station VII at Seal Beach.



SDD-193 HYDRAULIC POWER CONSOLE

The SDD-193 is used for checking the functional characteristics of the engine hydraulic actuation system. It is used at Battleship and at Seal Beach.



## SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

### SDD-196 STATION VIII CABLE INSTALLATION

The SDD-196 installation provides all interconnecting wiring and associated hardware required for checkout of the S-II in Station VIII.

The cable installation consists of numerous cable assemblies, wire harnesses, distributors and bulk cable. These items are used to connect GSE to facility power, GSE to GSE, GSE to stage, and to interconnect communications equipment. It is used at Seal Beach.

### SDD-197 STATION IX CABLE INSTALLATION

The SDD-197 installation provides all interconnecting wiring and associated hardware required for checkout of the S-II in Station IX.

This cable installation consists of numerous cable assemblies, wire harnesses, distributors and bulk cable. These items will be used to connect GSE to facility power, GSE to GSE, GSE to stage, and to interconnect communications equipment. It is used at Seal Beach.

### SDD-198 STATION VIII FLUID DISTRIBUTION SYSTEM

The SDD-198 system is used for supplying, distributing, and controlling the fluids for servicing and checkout of the stage at Station VIII.

This system, for both pneumatic and hydraulic fluids, consists of corrosion-resistant steel tubing with a flared-end fitting joining the fitting, valves and hoses. The pneumatic subsystem is installed between the facility interface, the checkout console and the stage. The hydraulic subsystem connects the hydraulic console with the stage engine hydraulic systems. It is used at Seal Beach.

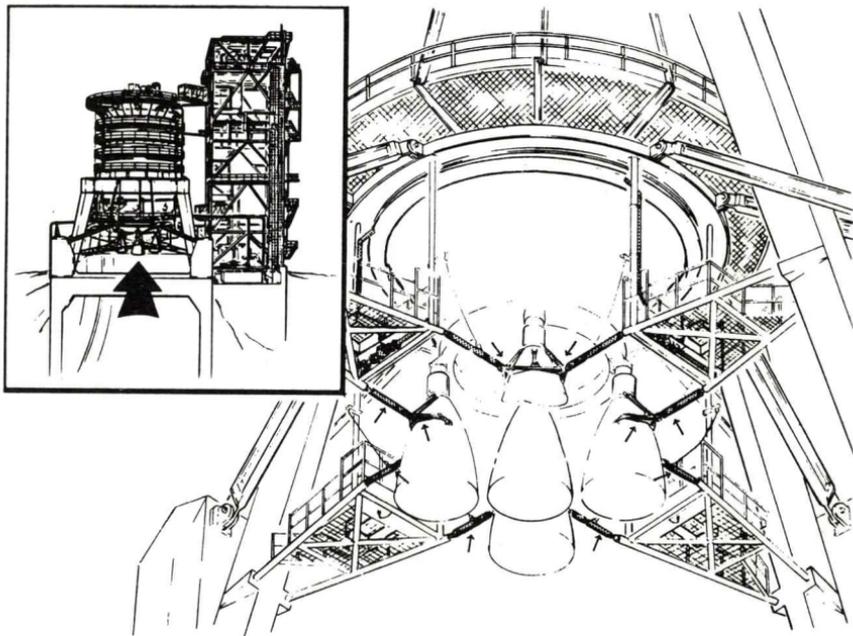
### SDD-199 STATION IX FLUID DISTRIBUTION SYSTEM

The SDD-199 system is used for supplying, distributing and controlling the fluids for servicing and checkout of the stage at Station IX.

This system, for both pneumatic and hydraulic fluids, consists of corrosion-resistant steel tubing with flared-end fittings, valves and hoses. The pneumatic subsystem is installed between the facility interface, the checkout console and the stage. The hydraulic subsystem connects the hydraulic console with the stage engine hydraulic systems. It is used at Seal Beach.

SDD-217 SIDE LOAD ARRESTING MECHANISM

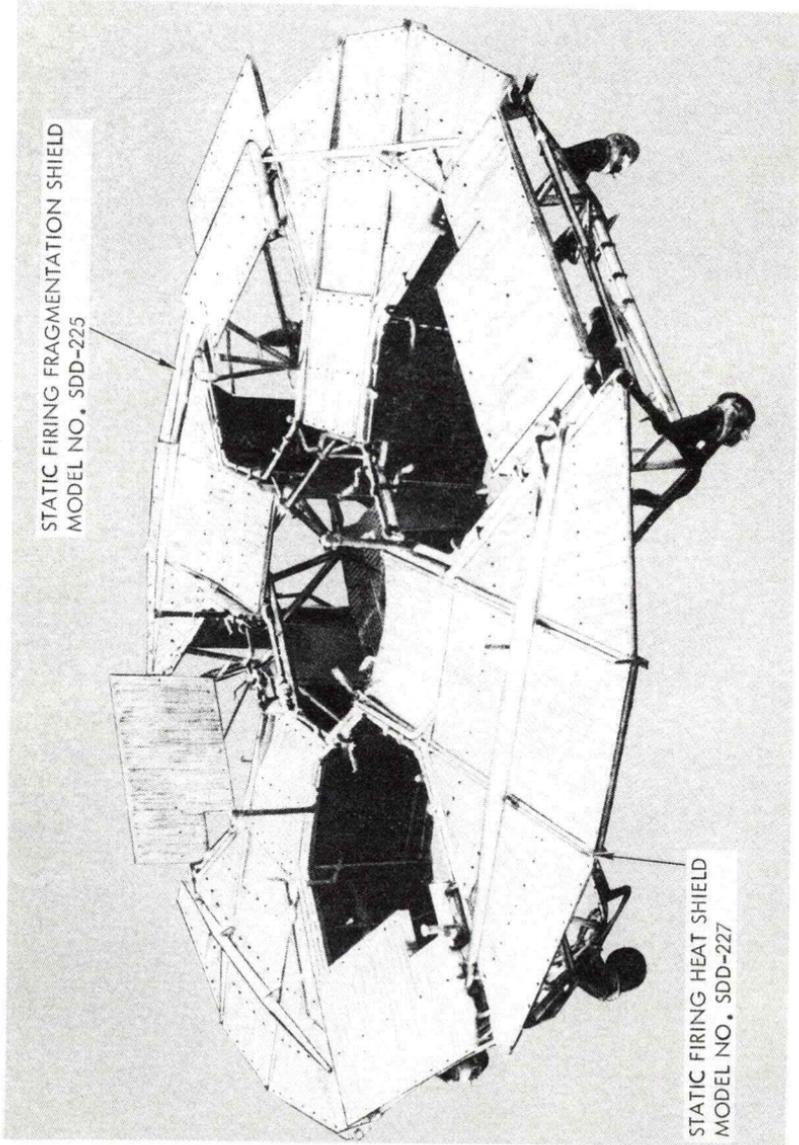
The SDD-217 provides engine restraint for engine side loads during thrust buildup. It includes provisions for cooling and purging the engine diffuser prior to engine start. It is used at Battleship.



SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

SDD-225 FRAGMENTATION SHIELD AND  
SDD-227 HEAT SHIELD

The SDD-225 provides protection to the equipment in the S-II engine compartment, stage structures, and adjacent engines in the event of a J-2 engine explosion. The SDD-227 provides protection to the engine compartment equipment and structure from radiant heat generated during J-2 engine firings. Both are used at Battleship.



# SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

## SDD-229 BATTLESHIP ENGINE AREA FIREX

The purpose of the SDD-229 is to apply water to the critical area in the event of an uncontrolled fire. Water is directed to the thrust structure interior and LOX tank aft bulkhead by means of cellar nozzles.

Combination straight stream/fog nozzles adjustable for either stream or fog are used in the following areas:

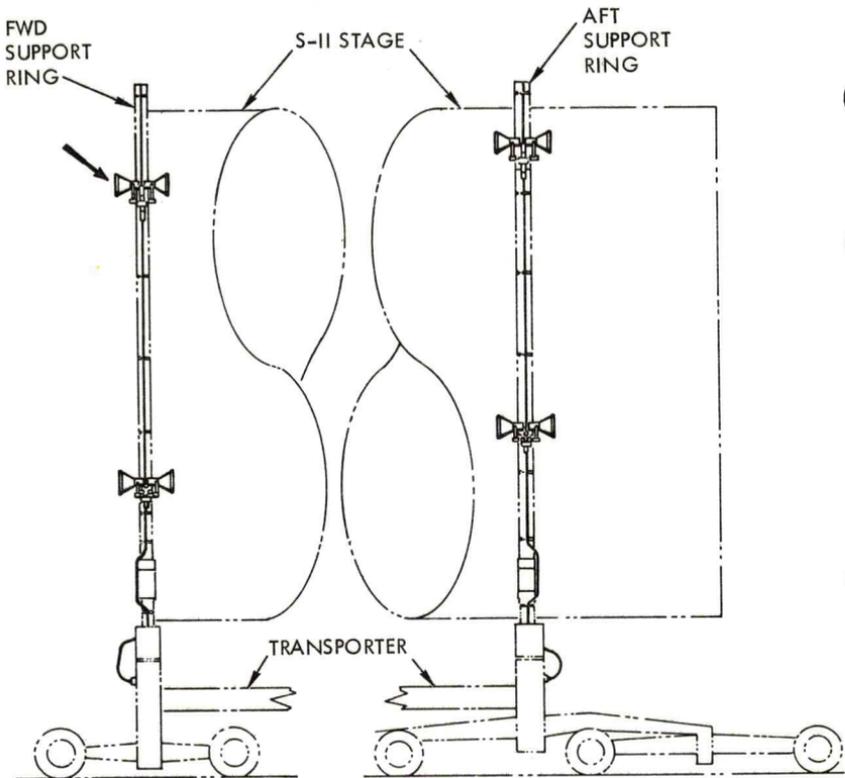
- J-2 engines
- Thrust structure exterior
- Electrical and instrumentation containers
- LH<sub>2</sub> ducts
- LH<sub>2</sub> prevalves

The unit consists of four steel manifolds each arranged to apply water to one of the outboard engines and one-fourth of the center engine. Water is supplied by the facility firex header through four main interface connections by means of a flexible connection between the header and the manifold. The main portion of the manifold is supported by the static firing fragmentation shield (SDD-225). Extensions of the manifold are supported by the static firing heat shield (SDD-227). The system is controlled by the valve-equipped main facility firex headers. The SDD-229 is used at Battleship only.

## SDD-232 TRANSPORT ILLUMINATION SET

The SDD-232 illumination set is used to provide illumination to the S-II during night highway transportation. This unit was formerly H7-18.

Eight 300-watt floodlights are mounted symmetrically in pairs on the forward support ring (H7-2). Eight are similarly mounted on the aft support ring (H7-3) when the stage is positioned on the transporter. The floodlights are adjustable 110 degrees vertically and 100 degrees horizontally. The bulbs provide steady illumination for a minimum of 24 hours. Mounting is accomplished by clamp-on mounting brackets, each of which supports two lights and one junction box. Power is supplied by a 120-vac, 2-phase, 60-cycle power source provided by the transporter unit. Power is transmitted by cables first from the power source to the junction boxes and then to the floodlights. It is used on the stage transporter at all sites.

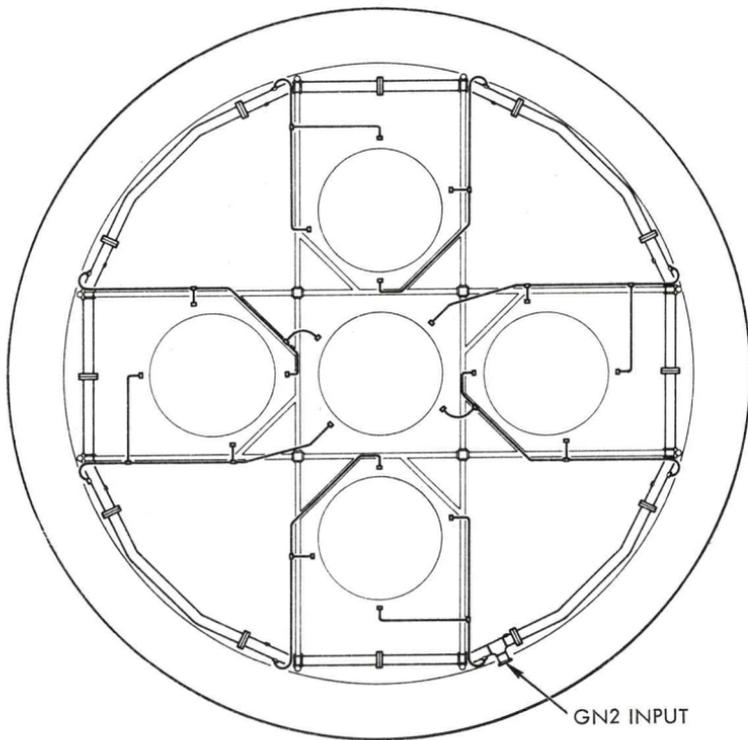


# SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

## SDD-233 ENGINE AREA GN<sub>2</sub> PURGE MANIFOLD

This unit is provided at the Battleship test stand for purging the engine area of GH<sub>2</sub> and GOX with the use of GN<sub>2</sub>, to eliminate potential fire hazards

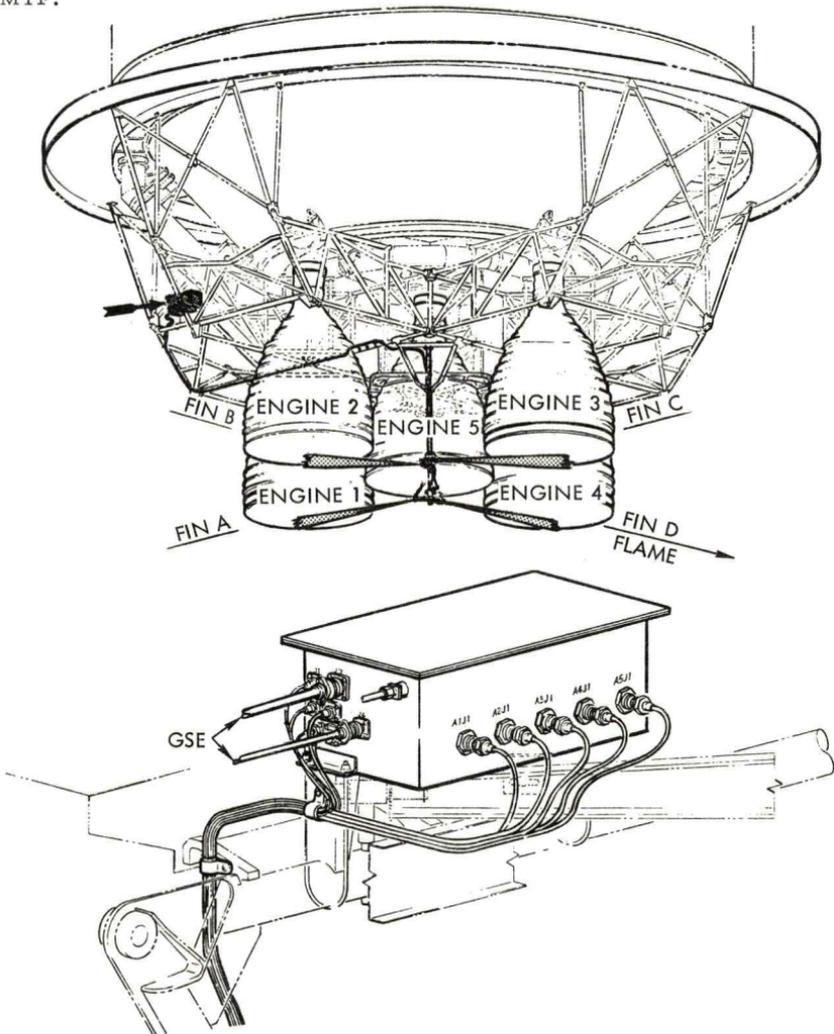
The manifold consists of a ring manifold fabricated from steel pipe. Attached to the manifold are 24 lines directing nitrogen flow to the critical areas of the boattail. The manifold is attached to the supports of the static firing heat shield and the fragmentation shield. Nitrogen is supplied to the manifold from the facility nitrogen bottle bank.



SDD-235  $\text{GH}_2$  BURNOFF IGNITION SYSTEM

The SDD-235 system consists of five burners and two supports attached to the static firing fragmentation shield. Two burners are mounted on one support and three burners on the other support.

This equipment provides a flame ignition source for consuming excess gaseous hydrogen during the prestart period of a stage static firing operation. The units are located at the Battleship and test stands A-1 and A-2 at MTF.

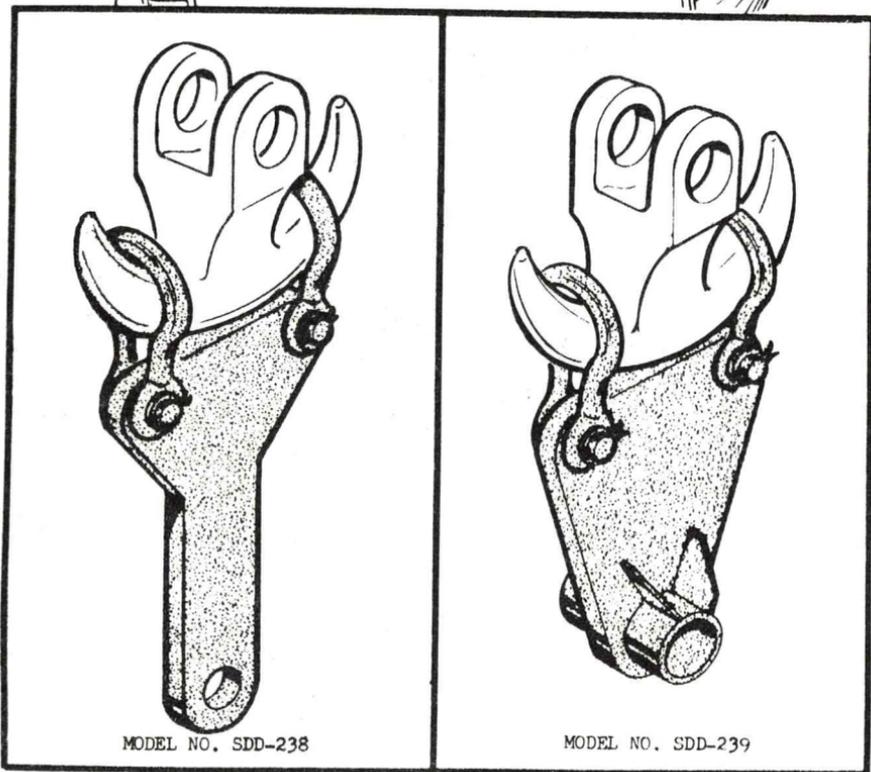
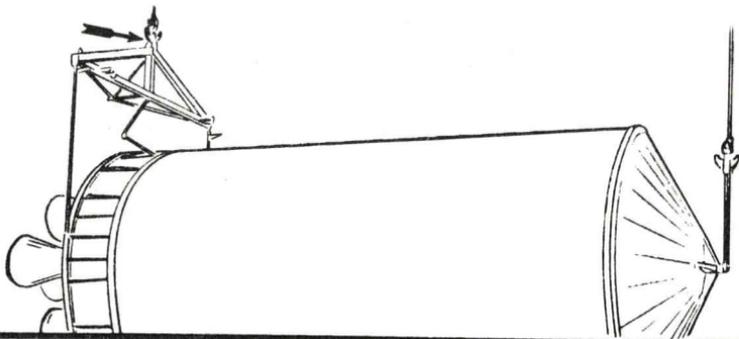


SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

SDD-238 STAGE ERECTING SLING ADAPTER (65 TONS)  
AND SDD-239 AFT HOISTING FRAME ADAPTER (65 TONS)

The SDD-238 is used to interconnect between Seal Beach crane hoisting hook and the stage erecting sling, H7-23.

The SDD-239 is used to interconnect between Seal Beach crane hoisting hook and the stage aft hoisting frame, H7-25. Both are used at Seal Beach.



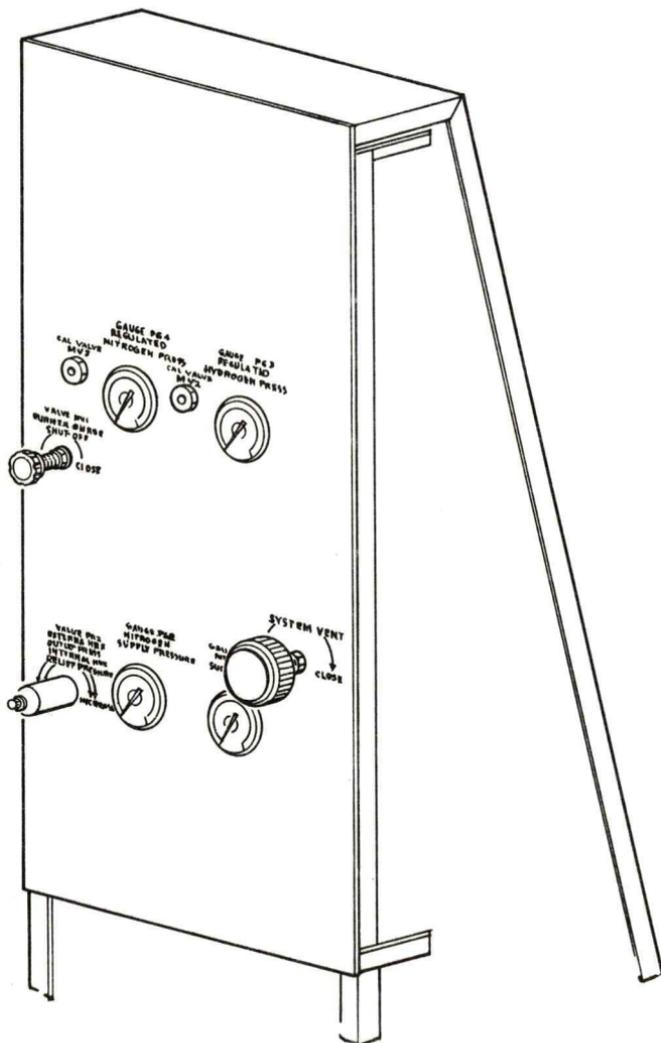
MODEL NO. SDD-238

MODEL NO. SDD-239

SDD-240 GH<sub>2</sub> BURNOFF REGULATION UNIT

The SDD-240 provides the facility to regulate GH<sub>2</sub> pressure down to 150 psig, for combustion, and to regulate a GN<sub>2</sub> supply down to 150 psig for system purging, before and after actual engine start.

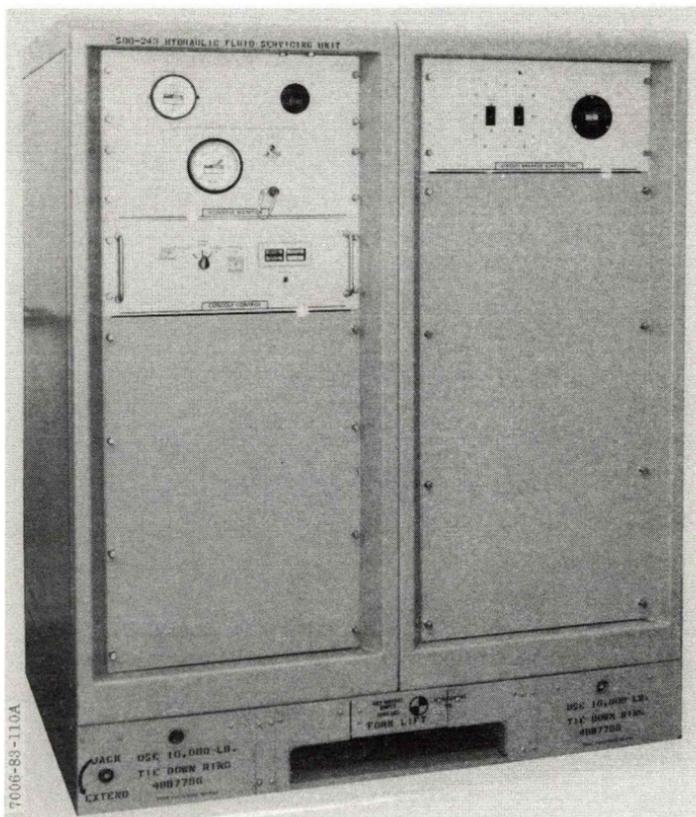
The regulation unit is housed in a single bay console continuously purged with GN<sub>2</sub>. The console houses the required regulators, valves, and gauges. It is used at Battleship and at MTF.



SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

SDD-243 HYDRAULIC FLUID SERVICING UNIT

The SDD-243 provides the hydraulic fluid and filtering system for the hydraulic power console SDD-193. It is used at Battleship and Seal Beach.

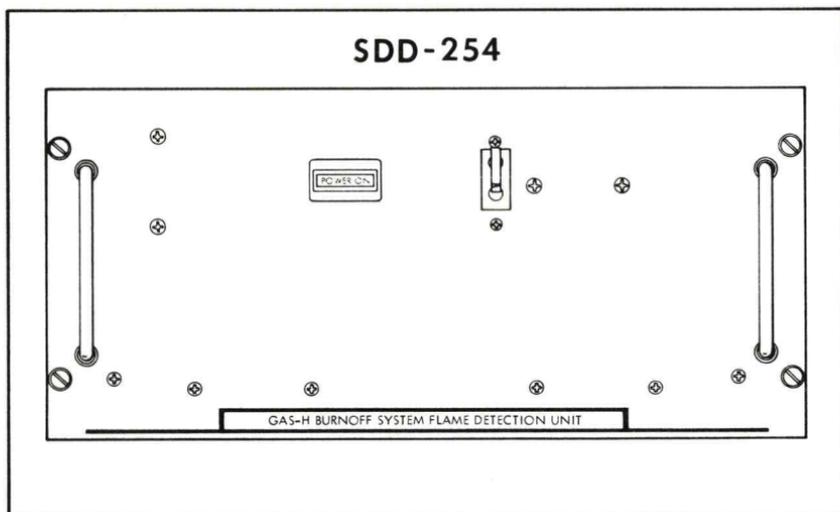


## SDD-254 FLAME DETECTION AND LOGIC UNIT

The SDD-254 provides local control of the SDD-240 regulation unit as well as control and monitoring of the SDD-235 ignition unit. Control of the SDD-254 is provided by the SDD-233 engine checkout and firing rack at BSTF and by the C7-801 at MTF. The SDD-254 is part of a system that provides a flame at the engine thrust chamber exit before engine start to burn off the hydrogen chilldown gas used as part of the normal static firing start sequence.

This unit consists of a single drawer of equipment housed in an instrument case. The drawer contains amplifiers, relays, and associated circuitry to perform GH<sub>2</sub> burnoff system functions.

The SDD-254 is used at Battleship only.

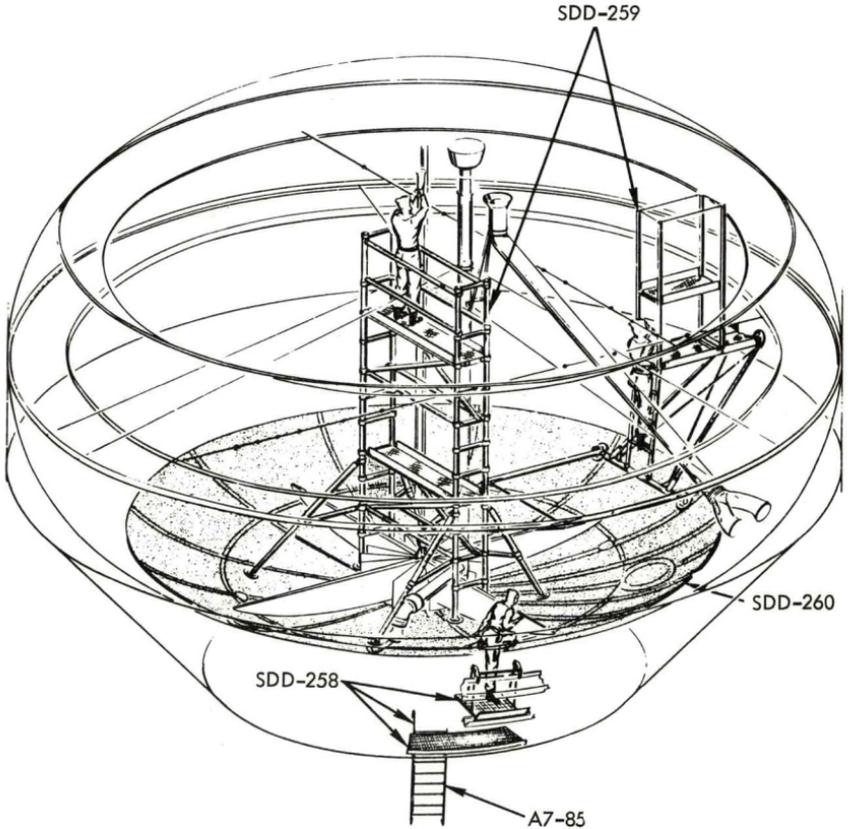


SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

SDD-258 LOX TANK ACCESS PLATFORM

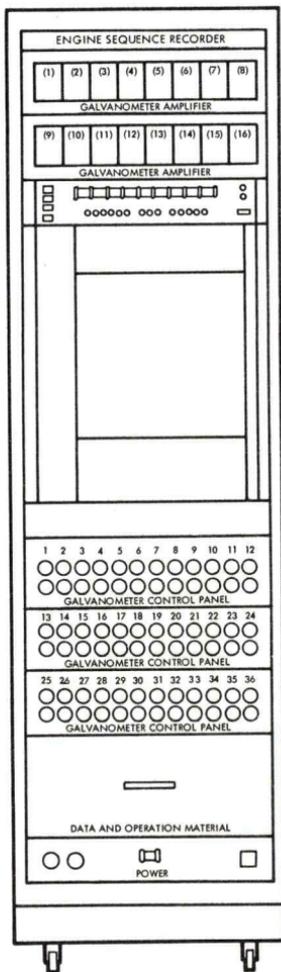
The SDD-258 is used in conjunction with SDD-259 and SDD-260. It services that portion of the S-II stage between Stations 112.000 and 167.50.

These SDD items are used at MTF and KSC.



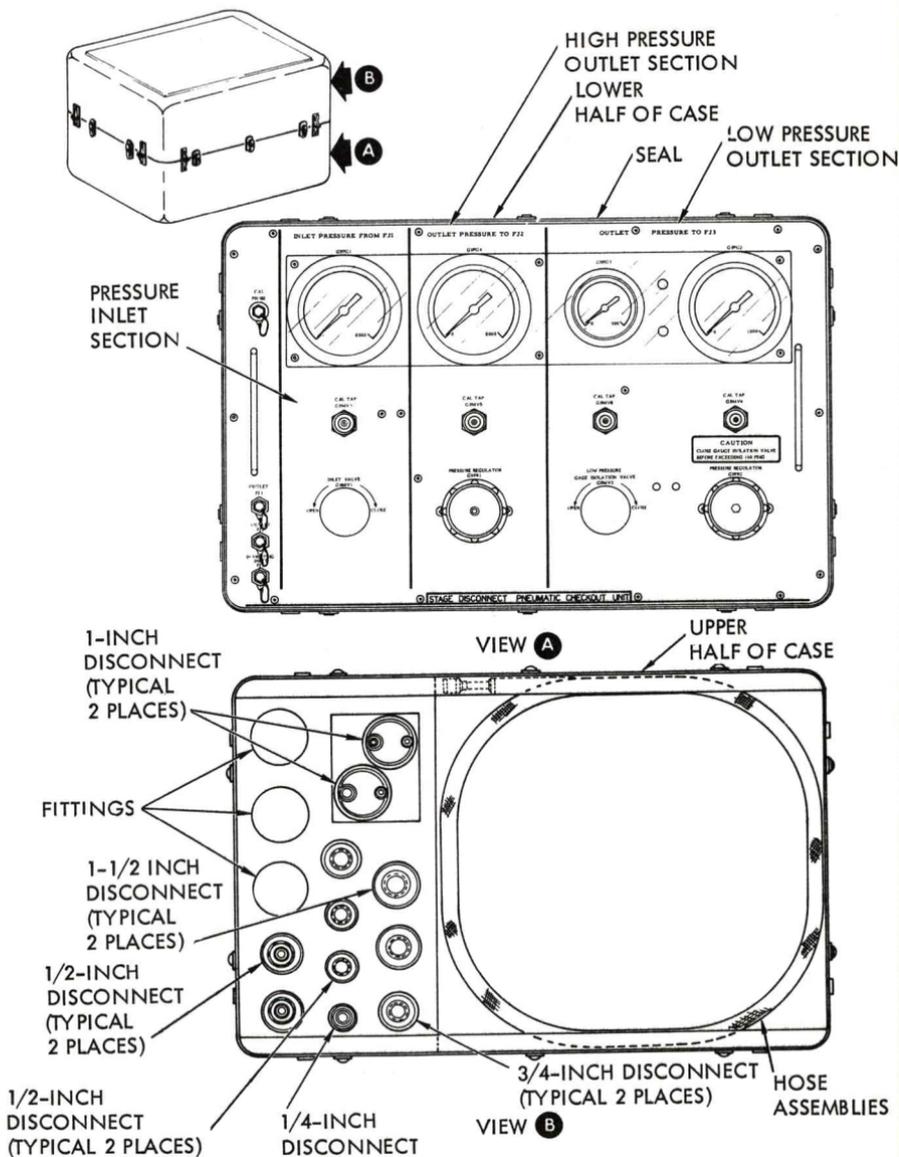
## SDD-273 ENGINE SEQUENCE RECORDER

The SDD-273 oscillograph recorders are used in lieu of C7-205 for J-2 engine valve analog measurements. Three SDD-273 units provide for a 108-channel oscillograph capability to monitor the following 0- to 5-volt analog valve position and 0- to 12-volt peak spark monitor measurements of each engine: (1) main oxidizer valve, (2) main fuel valve, (3) start tank discharge valve, (4) 66-control valve, (5) oxidizer turbine bypass valve, and (6) two 66 and two ASI spark monitors. Eleven engine sequence discrete signals per engine can be simultaneously recorded. The SDD-273 operates with the C7-205 and C7-48. It is used at Seal Beach only.



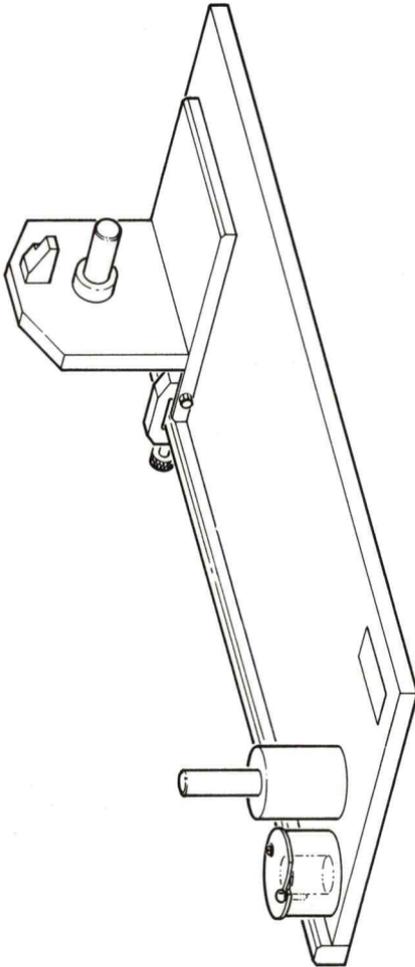
SDD-276 STAGE DISCONNECT PNEUMATIC CHECKOUT UNIT

The SDD-276 is used to leak check and proof pressure check the stage disconnects. It is used at MTF.



SDD-283 SERVOACTUATOR BENCH MEASUREMENT TOOL

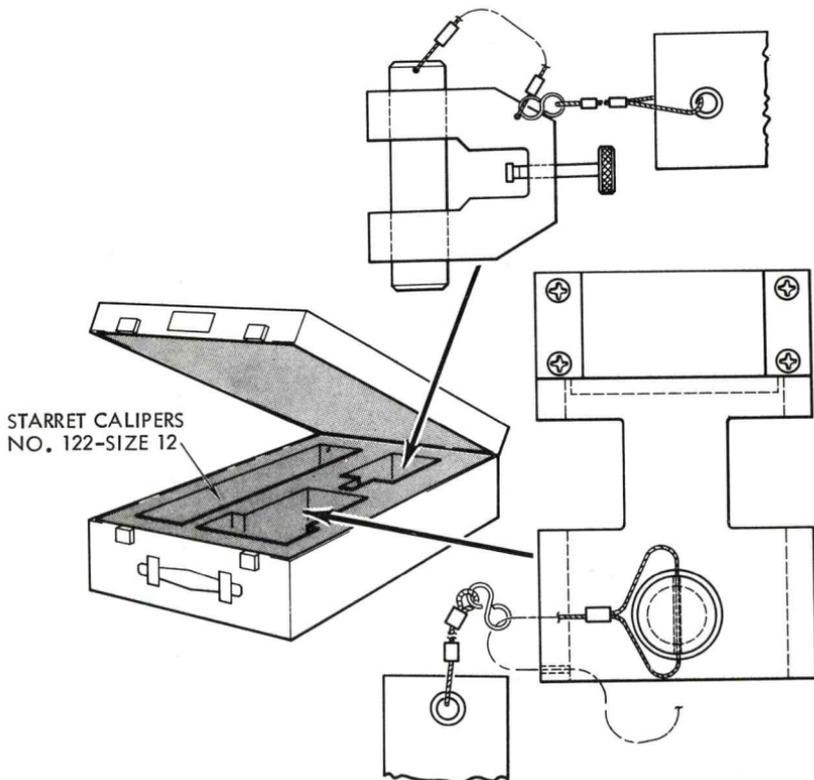
The SDD-283 is utilized in the clean room area for bench measurement check of the servoactuator. It is used to check the overall pin-to-pin length and the rod-end pin to midstroke mechanical lock length of each servoactuator. This information will be recorded in the engine log book and will be utilized as a basis for setting the exact servoactuator length required for precise alignment of the outboard engines. In addition, the center engine rigid struts will be installed on this tool and set to the specified length for correct center engine alignment. This tool has a rigid base plate with a movable, locking support. It is designed for a vernier to be incorporated with its use to obtain precise measurements. It is used at MTF and KSC.



SDD-284 SERVOACTUATOR ROD END JAM NUT  
TORQUING FIXTURE

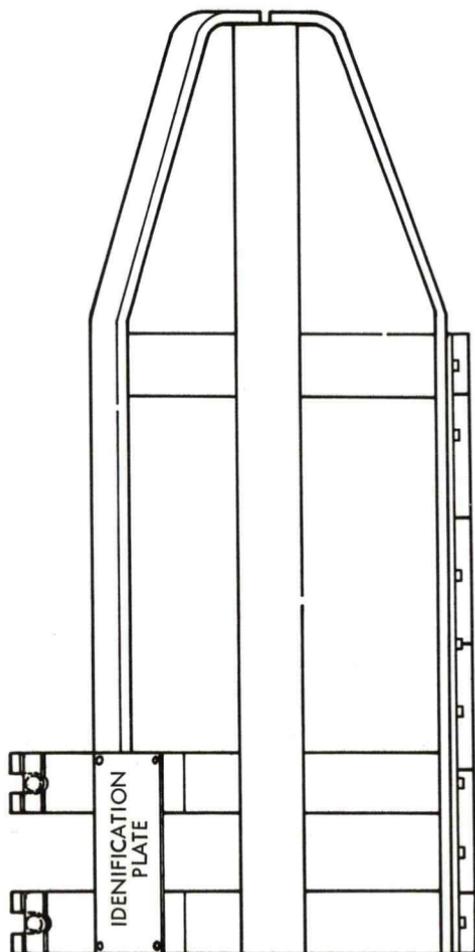
The SDD-284 consists of two assemblies: the length verification tool assembly and the torquing fixture tool assembly. The length verification tool consists of a vernier caliper, a dowel pin, and a dowel pin clamp. The torquing fixture consists of a cylinder body clamp (in two pieces) and a torque fixture body that is used between the dowel pin and the cylinder body clamp. This tool is designed to set the finite adjustment of the servo-actuator pin-to-pin length and then to hold the rod from moving until the locknut can be torqued.

The present wrench flats provided on the cylinder shaft are not of sufficient strength to permit this operation. Movement of the rod end is restricted by the fixture clamp bearing against the cylinder body when the actuator is under retract command. This also places the rod end in tension, thereby relieving the load on the locknut and permits locking and unlocking compatible with the capabilities of the rod end wrench flats. It is used at MTF and KSC.



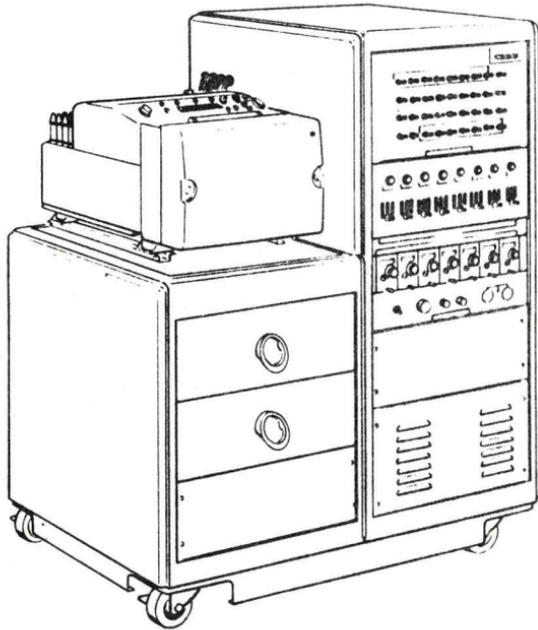
SDD-285 SERVOACTUATOR SUPPORT TOOL

The SDD-285 is used when the servoactuator is detached from the engine and is being cycled with simulated flight signals. Its purpose is to allow the actuator rod end to extend and retract without damage to the actuator or adjacent components. This tool is a metal envelope or sleeve designed to clamp around the actuator cylinder body and encompass the actuator rod end whether in the extended or retracted position. It is also designed with enough open space to permit access to the midstroke mechanical lock while installed on the actuator. It is used at MTF and KSC.



SDD-310 RECORDING OSCILLOGRAPH SYSTEM

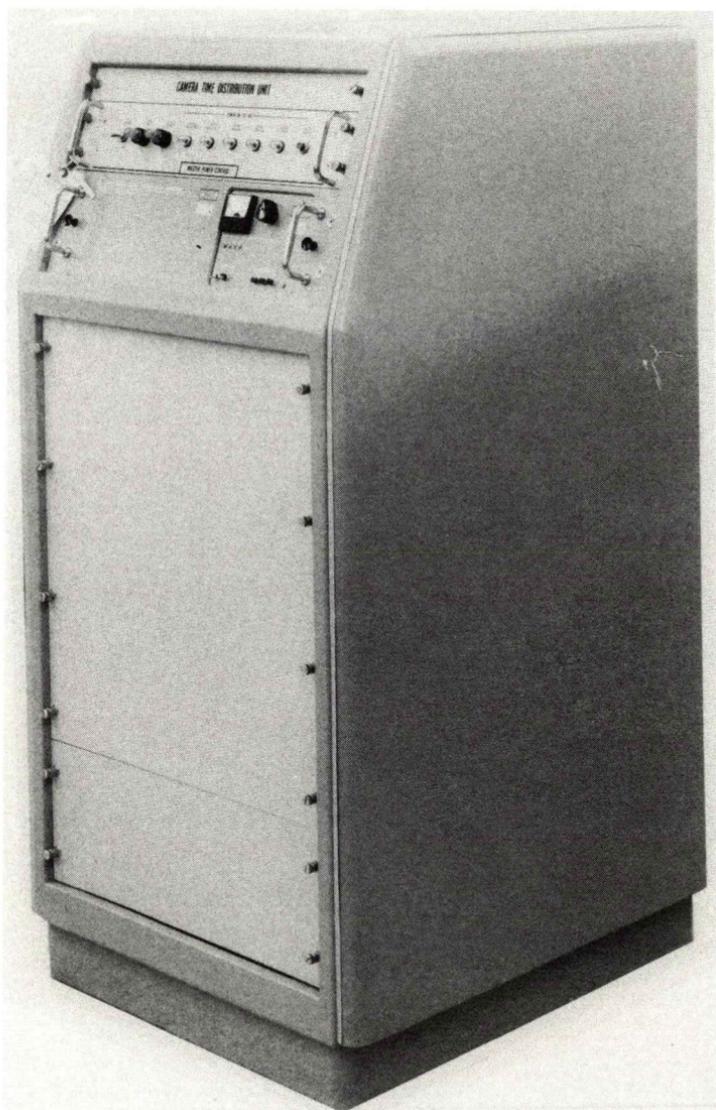
The SDD-310 recording oscillograph provides supplemental test data recording capability for Stations VIII and IX at Seal Beach.



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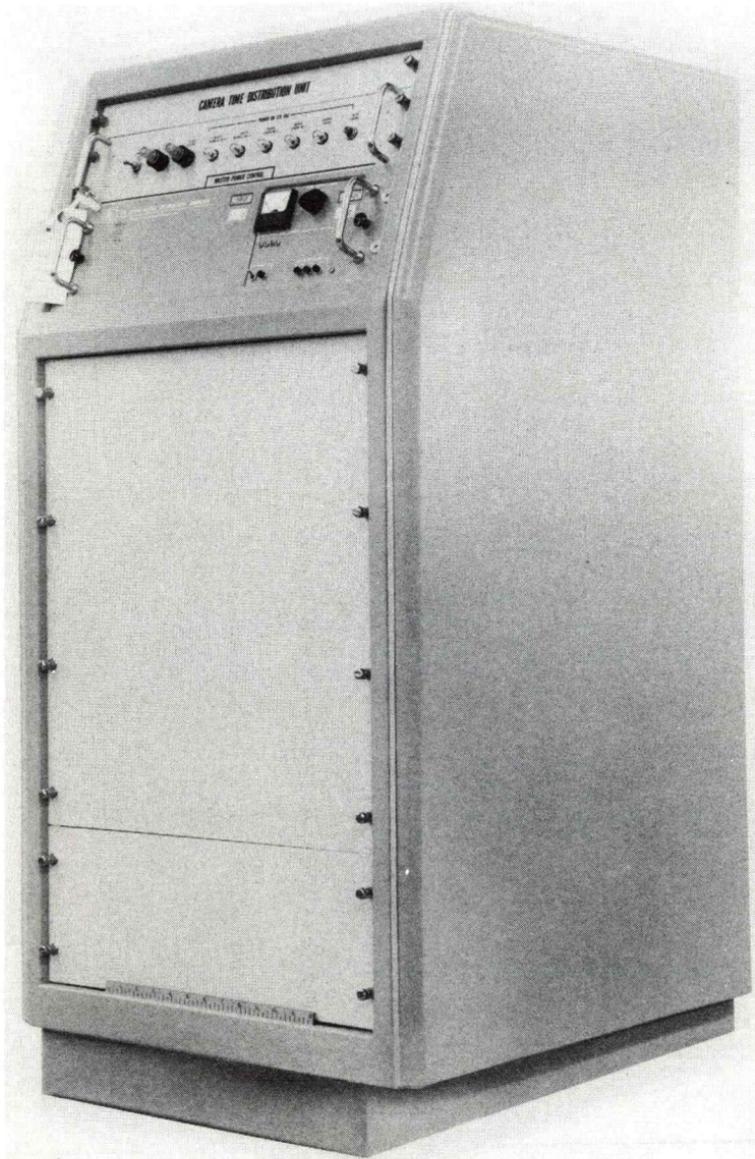
SDD-322 CAMERA TIME CODE SIGNAL DISTRIBUTION UNIT

The SDD-322 is located in the static firing observation bunker and provides timing signals to camera lamps which record time markings on motion picture film during static firing tests. It is used at Battleship.



SDD-324 FOUR CHANNEL TIME CODE SIGNAL  
DISTRIBUTION UNIT

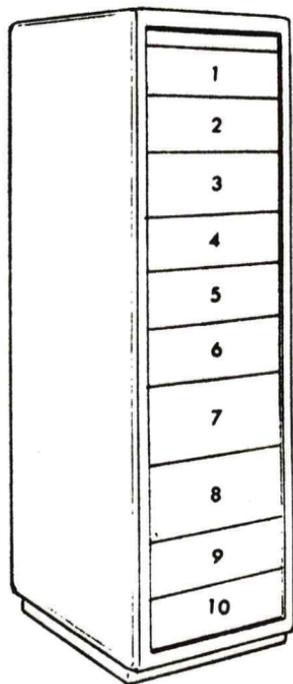
The SDD-324 provides signals to control and monitor the SDD-322 from the firing control center. It is used at Battleship.



SDD-325 AMPLIFIER AND REMOTE CALIBRATION RACK

The SDD-325 is used for remote calibration control of SDD-328. It is used at Battleship.

1. POWER CONTROL
2. BLANK
3. BLANK
4. INTERCOM
5. CALIBRATION CONTROL
6. CALIBRATION CONTROL
7. BLANK
8. BLANK
9. BLANK
10. BLANK



## SDD-328 STATIC FIRING SIGNAL CONDITIONING RACK

The SDD-328 is used for signal conditioning and calibration of stage temperature sensors, pressure sensors, and vibration pickup. It is used at Battleship.

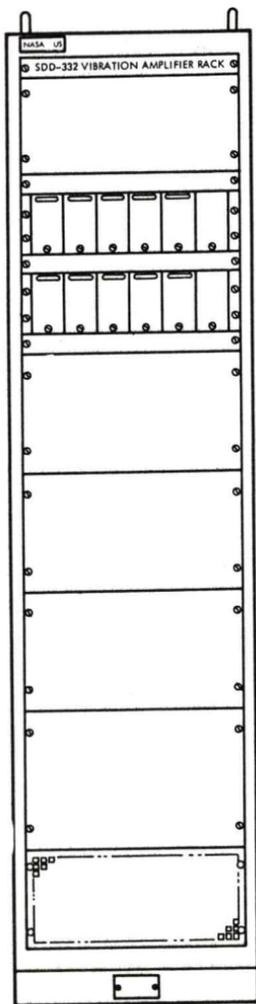
- |                                     |                           |                           |                              |
|-------------------------------------|---------------------------|---------------------------|------------------------------|
| 1. POWER CONTROL PANEL              | 35. IMPEDANCE BRIDGE      | 47. BLANK                 | 59. PRESSURE CONDITIONING    |
| 2. BLANK                            | 36. PRINTER               | 48. PRESSURE CONDITIONING | 60. BLANK                    |
| 3. TEMPERATURE CONDITIONING         | 37. BLANK                 | 49. PRESSURE CONDITIONING | 61. VENT                     |
| 4. TEMPERATURE CONDITIONING         | 38. VENT                  | 50. PRESSURE CONDITIONING | 62. POWER CONTROL PANEL      |
| 5. TEMPERATURE CONDITIONING         | 39. POWER CONTROL PANEL   | 51. PRESSURE CONDITIONING | 63. BLANK                    |
| 6. TEMPERATURE CONDITIONING         | 40. BLANK                 | 52. DIST. PANEL #2        | 64. TEMPERATURE CONDITIONING |
| 7. DIST. PANEL #1                   | 41. PRESSURE CONDITIONING | 53. BLANK                 | 65. TEMPERATURE CONDITIONING |
| 8. BLANK                            | 42. PRESSURE CONDITIONING | 54. VENT                  | 66. TEMPERATURE CONDITIONING |
| 9. VENT                             | 43. PRESSURE CONDITIONING | 55. BLANK                 | 67. TEMPERATURE CONDITIONING |
| 10. BLANK                           | 44. PRESSURE CONDITIONING | 56. PRESSURE CONDITIONING | 68. DIST. PANEL #3           |
| 11. TEMPERATURE CONDITIONING        | 45. BLANK                 | 57. PRESSURE CONDITIONING | 69. BLANK                    |
| 12. TEMPERATURE CONDITIONING        | 46. VENT                  | 58. PRESSURE CONDITIONING | 70. VENT                     |
| 13. TEMPERATURE CONDITIONING        |                           |                           |                              |
| 14. TEMPERATURE CONDITIONING        |                           |                           |                              |
| 15. BLANK                           |                           |                           |                              |
| 16. VENT                            |                           |                           |                              |
| 17. POWER CONTROL PANEL             |                           |                           |                              |
| 18. BLANK                           |                           |                           |                              |
| 19. AC AMPLIFIER                    |                           |                           |                              |
| 20. AC AMPLIFIER                    |                           |                           |                              |
| 21. AC AMPLIFIER                    |                           |                           |                              |
| 22. AC AMPLIFIER                    |                           |                           |                              |
| 23. CALIBRATION DISTRIBUTOR         |                           |                           |                              |
| 24. AC AMPLIFIER                    |                           |                           |                              |
| 25. AC AMPLIFIER                    |                           |                           |                              |
| 26. AC AMPLIFIER                    |                           |                           |                              |
| 27. BLANK                           |                           |                           |                              |
| 28. VENT                            |                           |                           |                              |
| 29. BLANK                           |                           |                           |                              |
| 30. AC/DC CONVERTER                 |                           |                           |                              |
| 31. INTERCOM                        |                           |                           |                              |
| 32. DIGITAL VOLTMETER & PRE-AMP     |                           |                           |                              |
| 33. LOCAL CALIBRATION CONTROL PANEL |                           |                           |                              |
| 34. CALIBRATION OSCILLATOR          |                           |                           |                              |



## SDD-332 VIBRATION AMPLIFIER RACK

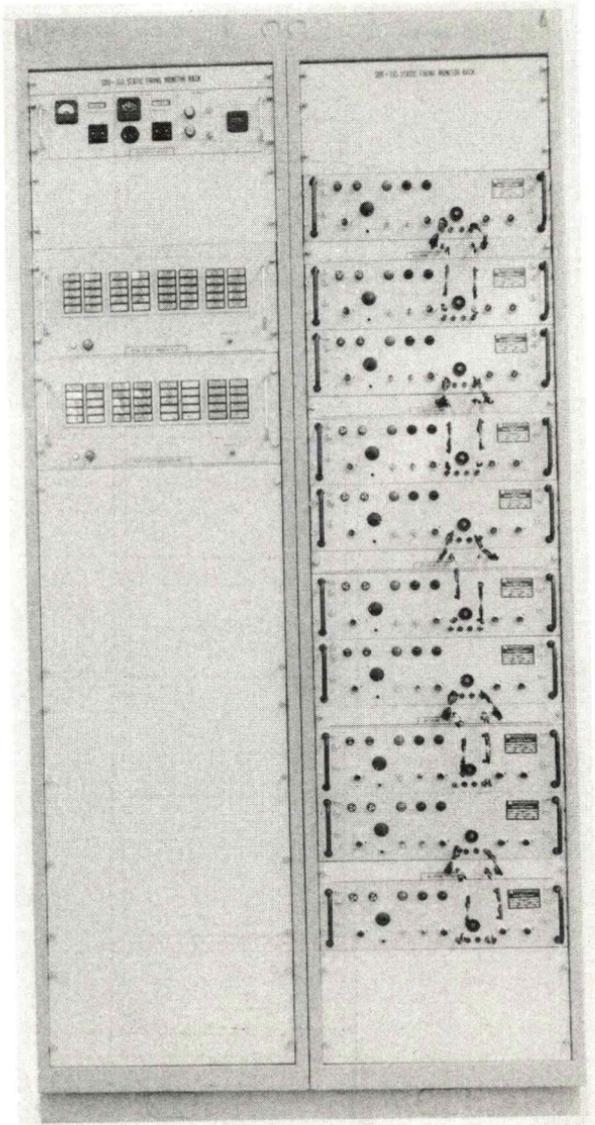
The SDD-332 provides the necessary gain to transmit vibration signals from the engine-mounted accelerometers to the vibration safety cutoff units in the static firing monitor rack (SDD-333). The unit is located in the service center.

The unit is a one-bay rack with two drawers containing the vibration safety cutoff amplifiers (GFP). Ten amplifiers, two per engine, are provided. It is used at Battleship only.



SDD-333 STATIC FIRING MONITOR RACK

The SDD-333 monitors and records the vibration level of each J-2 engine and displays actuation of engine cutoff signals and time code signals. It is used at Battleship.



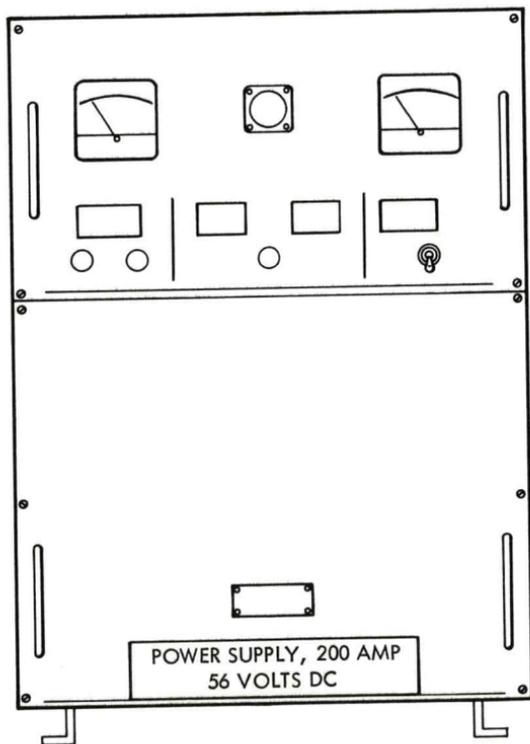
SPACE DIVISION of NORTH AMERICAN ROCKWELL CORPORATION

SDD-337 POWER SUPPLY (56 VDC)

The SDD-337 power supply provides electric power to operate the five LH<sub>2</sub> recirculation pump motors during checkout and simulated prelaunch operations.

The power supply provides a nominal output of 56 vdc at 200 amps with 480-, 440- or 208-volt 3-phase, 60-cycle input. The power supply maintains a nominal output of 56 volts within  $\pm 2.5$  volts, with an input variance of  $\pm 10$  percent. The output voltage level may be manually set at any level between 54 and 64 volts. A blower supplies ambient air at 450 cpm at a static pressure of one inch of water to the power supply.

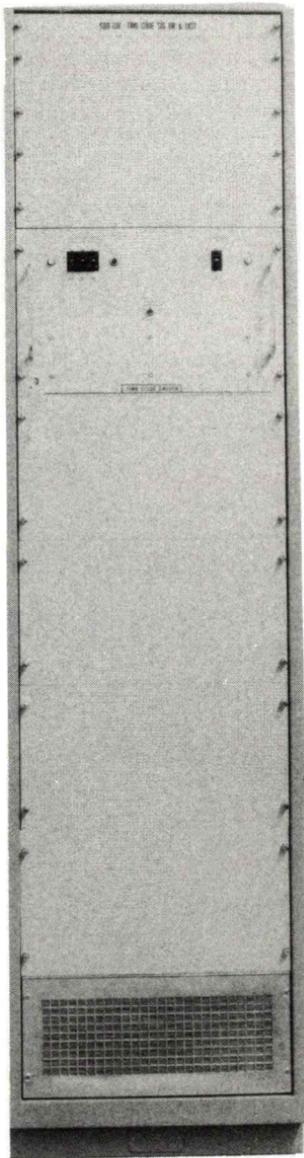
A local control panel is provided with the following equipment: ac meter, dc meter, running time indicator, ac input power-on indicator, dc output power-on indicator, two protective function indicators (overvoltage trip and overtemperature trip), ac power start, ac power stop, and dc power on-off switch. It is used at Battleship and Seal Beach.



SPACE DIVISION of NORTH AMERICAN ROCKWELL CORPORATION

SDD-338 TIME CODE SIGNAL DRIVER AND DISTRIBUTOR

The SDD-338 provides additional drive and distribution for real time of-day signals required to support static firing data correlation requirements. It is used at Battleship only.



XIV. RIGGING

## RIGGING

RIGGING SAFETY

Safety, as related to rigging and hoisting equipment operation, implies that the individual working with such equipment must be aware of the safety of others as well as himself and the object he intends to lift.

Carelessness is Costly

In 1967, 14,200 workers were killed and 2,200,000 injured on the job.\* The total cost to manufacturing alone amounted to \$7,300,000,000. These tragedies could have been avoided if the people involved had inspected the equipment with which they were working, followed instructions, and had used safety equipment provided for their protection. Had they thought first and acted second, these accidents would not have occurred.

Inspect Equipment FIRST

Practically all SD lifting equipment is periodically inspected and proof-loaded by the Maintenance Department each quarter. Each item is then tagged with a proof-loading tag for its safe lifting capacity. Anyone required to use this equipment must be familiar with the proof-loading tag, and at no time make any lifts with outdated or improperly tagged equipment. Finally, it is the responsibility of the person using the equipment to watch for wear or damage which may occur between inspection dates.

Both the crane operator and the person doing the rigging must inspect their equipment before each operation. The crane operator should first visually check the crane and crane path for obstructions, then check all operation control switches for proper working condition. The operator should assure no limit switches are blocked or inoperative. Any malfunction of the crane should be reported to the operator's supervisor; under no conditions should faulty equipment be used.

The person doing the rigging must continually inspect cables, blocks, hoists, and all other lifting and storing accessories. The operator is accountable for the load from the time it is raised to carrying position to its destination. The rigger is also responsible for the proper selection and application of the lifting devices, and for the load—from original condition of rest to carrying position. No sling, hoist, or other accessory should be used to make a lift if there is any doubt about its condition.

When rigging requires the use of jib cranes, coffering jacks, pull lifts, chain falls, chain or cable guards, and other accessories, the rigger is solely responsible for the selection and inspection of this equipment.

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\*Statistics compiled by the Los Angeles Chapter of the National Safety Council

## SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

### Safety Rules

1. Do not use more cable than you need when using a hoist.
2. Do not use hooks, slings, or other fittings that are not designed to lift the load.
3. Do not use bent hooks.
4. Loads shall be attached to the lifting hook by proper slings only.
5. Operator and personnel will stand clear when load is hoisted.
6. Chain and wire cable slings shall be free of kinks and twists.
7. Cables and hooks will be kept high enough to clear men or apparatus below.
8. Hook-up of the hoist shall be completed before the signal is given to hoist the load.
9. Only experienced men shall make slings or hook up loads.
10. Great care shall be taken to see that load is properly secured.
11. The signalman must warn all workmen to keep clear of the load.
12. No wire cable will be allowed to drag over objects.
13. Wire cable should be kept properly lubricated.
14. Do not operate cable over sheaves with improper size.
15. Do not expose cable to heat, moisture, or acid fumes.
16. Do not allow the load to swing or turn in circles.
17. The operator shall know maximum safe load limits.
18. The cable will be inspected constantly.
19. Lift load off the ground or jig 3 inches, then stop to check brake before hoisting.
20. Check hoist over cleared area at the start of each shift.
21. Do not use side pulls.
22. Do not leave load hanging at any time.
23. Check proof-loading dates on all equipment.
24. Protect cable from sharp edges and bends.
25. Lift load at its center of gravity.

General Industry Safety Orders

Riding on Loads: No employee shall ride on loads, slings, hooks, buckets or ship boxes except under exceptions covered by other orders of the Division.

Holding the Load: When a load of any kind is to be suspended for any considerable time, the dog or pawl, if one is provided, shall be used in addition to the brake which also will be applied. Cranes, hoists, or derricks shall not be left unattended while load is suspended, unless the load is suspended over water, a barricaded area, or is blocked up or otherwise supported from below, during repairs or an emergency.

Limit Switch: Before an electric hoist is operated for the first time during the shift, the operator shall test the operation of the limit switch over a cleared area under no load, and shall report any defect to his supervisor. The latter must have the defect corrected before the crane is permitted to operate.

The limit switch shall never be used as an operating control unless designed for such use. A second limit switch shall be located behind the control limit switch.

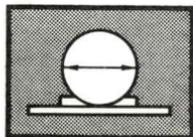
Signaling: Only qualified employees specifically designated and authorized by SD shall give signals. Crane operators shall not accept signals except from such personnel.

Wire Rope: Hoisting rope shall be wire rope, plow steel, or better grade, providing flexibility at least equal to that of standard plow steel hoisting rope composed of six strands of 19 wires each.

Defective or badly worn ropes shall not be used, and no rope shall be used in which more than 10 percent of the total wires are broken in any running foot.

Chock Sizes for Tanks

Chock sizes may be determined in accordance with the following rule:



For every foot diameter of the tank, use one inch of chock.

Example: If tank is 2 feet in diameter, use 2-inch chock.

Example: If tank is 3 feet in diameter, use 3-inch chock.

Example: If tank is 6 feet in diameter, use 6-inch chock.

All chocks should be chamfered to fit the curvature of the tank.

# SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

## Safety Rules of Thumb

The following rules are not substitutes for accurate tables or reference material, but are sometimes useful in making final safety checks.

### Nails

Safe load lateral resistance in pounds equals eight-times the pennyweight.

- 1-6d nail = 8 x 6, or 48 pounds
- 1-8d nail = 8 x 8, or 64 pounds
- 1-10d nail = 8 x 10, or 80 pounds

### Manila Rope

Safe load in tons equals diameter in inches squared. (This rule is not accurate in sizes larger than one inch.)

- 1" rope = 1 x 1, or 1 ton safe load
- 1/2" rope = 1/2 x 1/2, or 1/4 ton safe load
- For sisal rope, decrease safe loads by one-third

### Plow-Steel Cable

Safe load in tons is eight- times the diameter in inches squared.

$$1/2'' \text{ rope} = 1/2 \times 1/2 = 1/4 \times 8 = 2 \text{ tons}$$

### Open-Eye Hook

Safe load in tons is diameter of eye in inches squared.

$$2'' \text{ hook}, 2 \times 2 = 4 \text{ tons}$$

### Shackle

Safe load in tons is diameter of shackle squared and multiplied by 6.

Example:

$$\begin{aligned} D^2 \times 6 &= 5WL \text{ in tons} \\ \text{If } D &= 1/2'' \text{ then} \\ 1/2 \times 1/2 \times 6/1 &= 1-1/2 \text{ tons} \end{aligned}$$

### Chains

Safe load in tons is six- times the square of the diameter of chain stock.

Example:

$$\begin{aligned} D^2 \times 6 &= 5WL \text{ in tons} \\ D &= \text{Diameter of chain} \\ \text{stock if } D &= 1'' \text{ then} \\ 1'' \times 1'' \times 6 &= 6 \text{ tons} \end{aligned}$$

Plank for Scaffold

Two-inch by ten-inch (2" x 10") or two-inch by twelve-inch (2" x 12") plank, graded as suitable for fifteen hundred pounds per square inch (1,500 psi) bending stress, or better, may normally be used for a span in feet that is equal to or less than the width in inches.

Minimum Electrical Clearance

The operation of any equipment closer to high voltage lines than the distances listed below is positively prohibited.

Voltage	Minimum Clearance
300 to 8,700 volts	6 feet
8,700 to 15,000 volts	8 feet
15,000 to 35,000 volts	10 feet
35,000 to 50,000 volts	12 feet
50,000 to 100,000 volts	15 feet
100,000 to 132,000 volts	17 feet

The above clearances apply in any direction, vertical or horizontal.

USE OF RIGGING EQUIPMENT

Hand Signals for Boom Equipment Operation

The following signals are used to convey directions for the operation of rigging equipment:



USE LOAD LINE  
TAP FIRST ON HEAD:  
THEN USE REGULAR  
SIGNALS



USE WHIP LINE  
TAP ELBOW WITH  
ONE HAND; THEN  
USE REGULAR  
SIGNALS

RAISE LOAD



LOWER LOAD



SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION



RAISE LOAD SLOWLY



LOWER LOAD SLOWLY



RAISE BOOM



LOWER BOOM

RAISE BOOM AND  
LOWER LOAD -



EXTEND THUMB UPWARD  
AND FLEX FINGERS IN  
AND OUT AS LONG AS LOAD  
MOVEMENT IS DESIRED



LOWER BOOM AND  
RAISE LOAD -

EXTEND THUMB DOWNWARD  
AND FLEX FINGERS IN  
AND OUT AS LONG AS  
LOAD MOVEMENT IS DESIRED



SWING - EXTEND ARM,  
WITH FOREFINGER  
INDICATING DIRECTION  
OF SWING



STOP - EXTEND FOREARM  
AND HAND IN HORIZONTAL  
POSITION AND MAKE  
SLICING MOTION



DOG EVERYTHING



EMERGENCY STOP

## SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION



TRAVEL (BOTH TRACKS)-USE BOTH FISTS, MAKING A CIRCULAR MOTION INDICATING DIRECTION OF TRAVEL: FORWARD OR BACKWARD.  
(ONE TRACK) LOCK THE TRACK ON SIDE INDICATED BY RAISED FIST TRAVEL OPPOSITE TRACK IN DIRECTION INDICATED BY CIRCULAR MOTION OF OTHER FIST.



OPEN CLAMSHELL BUCKET



CLOSE CLAMSHELL BUCKET

(HAMMERHEAD CRANES ONLY)



MOVE CARRIAGE IN



MOVE CARRIAGE OUT

The foregoing signals are basic for operating boom equipment. Many special operations, such as pile-driving, caisson work, and very close work may require changes of basic signals which should be agreed on, in advance, by the operator and the signalman. However, such changes should not conflict with the basic signals. Any one-hand signal may be modified to indicate slow, cautious movement by placing the palm of the unused hand a short distance in front of the direction-indicating finger, as shown in "RAISE THE LOAD SLOWLY." No response should be made to unclear signals. Signals should be accepted only from the previously designated signalman.

### Eye Bolts

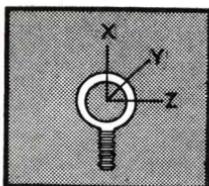
Eye bolts are very helpful for making lifts, and if a casting or housing has threaded holes, they should be used. Many sizes and types are available, but the new shorter thread length and heavier eye bolt is generally preferable to the longer shank bolt. Such bolts will stand up under greater side pull, and are better adapted for use in turning because of the heavier design.

There are two major points to remember about eye bolts. First, all threads should be fully engaged. Second, cables between the eye bolt and the hook should be as nearly vertical as possible. In other words, the larger the angle between the cable and the horizontal plane, the better.

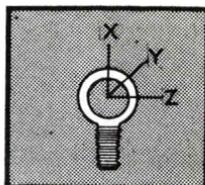
## SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

The ideal condition for using an eye bolt is when a single eye bolt is used and the cable is vertical. If the lift requires more than one eye bolt, the problem of bending the eye bolts arises. The greater the included angle between the two cables, the greater the tendency to bend the eye bolt. Sometimes the cable length can be increased in order to decrease the angle between cables. A spreader bar can also be used to prevent bending the eye bolts. Never thread a single cable through two eye bolts.

Manufacturers of eye bolts guarantee their bolt's safe working load in pounds. Manufacturers' catalogs provide the safe working load for each individual eye bolt. Recommended working loads for various points of hitching are shown in the following illustrations.



PLAIN PATTERN



DECREASED EYE

Work Load in Pounds				
	Size	X	Y	Z
Plain Pattern	3/8	500	170	100
	1/2	1,000	330	200
	5/8	1,400	470	280
	3/4	2,000	670	400
	7/8	2,300	770	460
	1	3,300	1,110	660
	Decreased Eye	1-1/4	1,700	1,000
1-1/2		2,700	1,600	1,350
2		5,000	3,000	2,500
2-1/2		6,000	3,600	3,000

Recommended Eye Bolt Working Loads

# SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

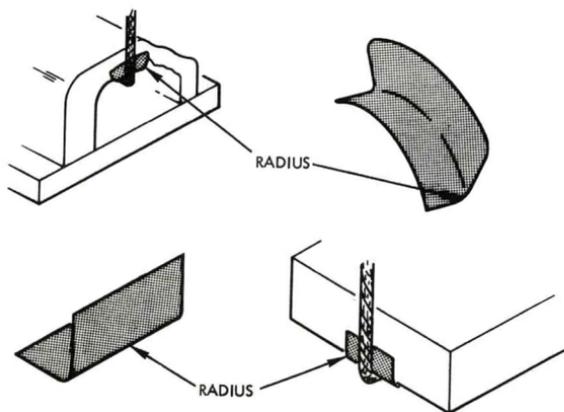
## Shackles

All shackle pins must be straight, and all screw-type pins must be installed all the way. If width between the eyes is greater than that listed in the following table, the shackle has been overstrained and must not be used.

SCREW-PIN TYPE SHACKLE		ROUND-PIN TYPE SHACKLE		SAFETY TYPE SHACKLE	
Diameter of Shackle (Inches)	Max Width Betw. Eyes (Inches)	Safe Working Load (Pounds)	Diameter of Shackle (Inches)	Max Width Betw. Eyes (Inches)	Safe Working Load (Pounds)
1/4	3/8	560	1-1/4	1-7/8	16,000
3/8	9/16	1,400	1-3/8	2	20,000
1/2	11/16	2,700	1-1/2	2-1/8	24,000
5/8	13/16	3,600	1-5/8	2-1/4	28,000
3/4	1-1/16	5,600	1-3/4	2-3/4	32,000
7/8	1-1/4	7,800	2	2-3/4	36,000
1	1-1/2	10,400	2-1/4	3-1/4	46,000
1-1/8	1-5/8	13,200	2-1/2	4	56,000

## Cable Guards

Many months of service can be added to the life of a sling or cable if a few simple rules are followed, one of which is the protection of cables over sharp edges or sharp bends. This can be accomplished by the use of cable guards. Cable guards are designed to fit over the contour of the part, one side a near match to the contour, the other side shaped to allow the cable to pass over a curving surface. In this manner, the cable is protected from the sharp edge.

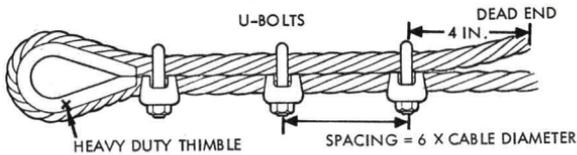


Cable Guard Protection

Crosby Clips

Crosby clips provide one of the most common methods of attaching a wire rope to equipment. These clips should be spaced apart not less than six times the rope diameter, and all clips must be placed on the rope with the U-bolts bearing upon the short or "dead" end of the rope. A heavy-duty thimble should be provided for every eye. If properly made, a clipped eye should develop about 80 percent of the strength of the rope. Beware of treacherous malleable iron clips.

To install Crosby clips, first bind the rope on itself at the toe of the thimble. Then apply the clip farthest from the thimble, at about 4 inches from the dead end of the rope, twisting it tightly. Next, install the clip nearest the thimble, hand-tightening the nuts. Next, put on the intermediate clips hand-tight. Finally, put a strain on the rope and, while the rope is under strain, tighten all loose clips.



Application of Crosby Clips

Application of Wire Rope Clips (Crosby Type)

The following illustrations show the proper (as opposed to improper) techniques for applying Crosby-type wire rope clips:



1. CORRECT METHOD - U-BOLTS OF CLIPS ON SHORT END OF ROPE. (NO DISTORTION ON LIVE END OF ROPE.)



2. WRONG METHOD - U-BOLTS ON LIVE END OF ROPE. (THIS WILL CAUSE MASHED SPOTS ON LIVE END OF ROPE.)



3. WRONG METHOD - STAGGERED CLIPS: TWO CORRECT AND ONE WRONG. (THIS WILL CAUSE A MASHED SPOT IN LIVE END OF ROPE DUE TO WRONG POSITION OF CENTER CLIP.)

SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

Number and Spacing for Safe Application of Crosby Clips  
(Six Times Diameter of Rope)

Rope Diameter (Inches)	Minimum Number Clips for Rope End	Spacing of Clips	Length of Wrench	Length of Rope Turned Back (Inches)
3/16	3	1-1/8	6-8	3-3/8
1/4	3	1-1/2	6-8	4-1/2
5/16	3	1-7/8	6-8	5-5/8
3/8	3	2-1/4	6-8	6-3/4
7/16	3	2-5/8	12	7-7/8
1/2	3	3	12	9
5/8	3	3-3/4	12	12
3/4	4	4-1/2	18	18
7/8	4	5-1/4	18	21
1	4	6	24	24
1-1/8	5	6-3/4	24	34
1-1/4	5	7-1/2	24	38
1-3/8	6	8-1/4	24	50
1-1/2	6	9	24	54
1-5/8	6	9-3/4	30	60
1-3/4	7	10-1/2	30	74
2	8	12	30	96
2-1/4	8	13-1/2	30	112
2-1/2	8	15	30	120

Alloy Chain

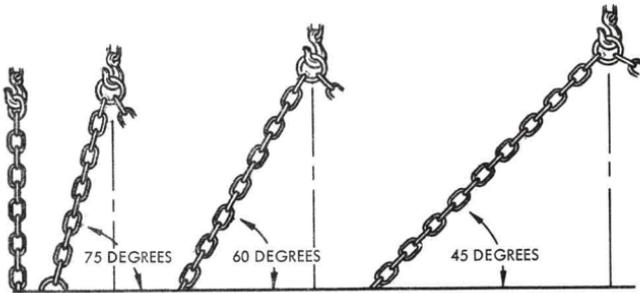
Safe loads, in pounds, for alloy chain are listed in the following table.

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Safe Loads in Pounds for Alloy Steel Chains

Size (Inch)	Vertical Load	Loads are given for 2 part bridle			Choker Hitch Vert. Load	Basket Hitch Vert. Load
		75° Angle	60° Angle	45° Angle		
3/8	6,600	12,750	11,400	9,300	4,950	13,200
1/2	11,250	21,700	20,000	16,000	8,438	22,500
5/8	16,500	31,900	29,000	23,500	12,375	33,000
3/4	23,000	44,500	40,000	32,500	17,250	46,000
7/8	28,750	55,500	50,000	40,000	21,562	57,500
1	38,750	74,800	67,000	55,000	29,062	77,500
1-1/8	44,500	86,000	77,000	63,000	33,375	89,000
1-1/4	57,500	111,000	100,000	81,500	43,125	115,000

Note: The above total loads were computed for two-leg slings. For three-leg sling, multiply by 1-1/2. For four-leg sling, multiply by 2.



Angles of less than 45 degrees are to be avoided.

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### Chain Wear

The following table gives computations of reduced capacity of chain due to wear.

Nominal Original Chain Size in Inches		Chain capacity is reduced by the following percent when diameter of worn section is as follows:		
		5 Percent	10 Percent	Remove From Service
1/4	0.250	0.244	0.237	0.233
3/8	0.375	0.366	0.356	0.335
1/2	0.500	0.487	0.474	0.448
5/8	0.625	0.609	0.593	0.559
3/4	0.750	0.731	0.711	0.671
7/8	0.875	0.853	0.830	0.783
1	1.000	0.975	0.949	0.895
1-1/8	1.125	1.100	1.070	1.010
1-1/4	1.250	1.220	1.190	1.120
1-3/8	1.375	1.340	1.310	1.230
1-1/2	1.500	1.460	1.430	1.340
1-5/8	1.625	1.590	1.540	1.450
1-3/4	1.750	1.710	1.660	1.570
1-7/8	1.875	1.830	1.780	1.680
2	2.000	1.950	1.900	1.790

### Fiber Ropes

#### Manila Rope

The properties of abaca (commonly known as manila) fiber ropes make them the best-suited natural fiber for cordage, especially for large ropes. Several agave fibers (commonly known as sisals) are also used in rope manufacture, especially in small sizes. Agaves, however, are not as satisfactory for most uses because their breaking strengths are from 20 to 40 percent lower than the breaking strength of manila rope.

Manila rope is often recommended for hoisting because of its ability to render or pay out evenly when used around capstans or bits.

New, high-grade manila rope is firm but pliant, ivory to light yellow in color, and has considerable luster. When drawn through the hand, it has a smooth feel. Sisal rope varies in color from white to yellowish white and lacks the gloss of high-grade manila. The fibers are stiff and harsh and tend to splinter. Acids, caustics, and corrosives deteriorate manila rope on contact. Exposure to acid fumes also destroys these fibers.

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### Synthetic Fibers

Synthetic fibers are gaining prominence as rope material. However, the successful use of synthetic rope depends on the physical properties and characteristics of the fiber; i. e., how it meets the requirements of the specific uses involved.

Nylon rope has two and one-half times the breaking strength of manila rope and about four times its working elasticity. Therefore, it is particularly suitable for shock loading, such as that required by safety lines.

When nylon rope is wet or frozen, its loss of strength is relatively small, and its resistance to abrasion is remarkably high compared to hard-fiber ropes. It also is highly resistant to organisms causing mildew and rotting and to attack by marine borers in sea water.

Atmospheric exposure of nylon rope produces little loss of strength over a considerable period. Wet nylon rope runs through blocks as easily as dry nylon rope since there is no swelling. Splices can be made readily and develop nearly the full strength of the rope.

Although resistant to petroleum oils and most common solvents and chemicals, nylon rope is affected by drying oils, such as linseed oil, and mineral acids, such as sulfuric and muriatic. Whereas manila rope begins to char at 300 F, nylon melts at 482 F but hardens when the flame is withdrawn.

Dacron rope is approximately 90 percent as strong as nylon but has much less stretch. It is not weakened by rot, mildew, or prolonged exposure to sea water. It retains its full strength when wet and shows little deterioration from long exposure to sun light. It has good resistance to abrasive wear and to both alkalis and acids except benzoic acid.

Orlon rope is resistant to mineral acids and common solvents. It has fair-to-good resistance to alkalis. Orlon has the best resistance of all synthetics to deteriorating from exposure to sunlight. Its resistance to rot is excellent.

The working elasticity of orlon rope is less than nylon, but more than manila. It has good resistance to abrasion and flexing under dry conditions.

Polyethylene rope is 75 percent stronger than manila. Its most outstanding characteristic is that it floats in water. It is unaffected by rot, mildew, and fungus growth, and is highly resistant to a wide variety of acids (except nitric) and alkalis, as well as to alcohol-type solvents and bleaching solutions. It is swelled and softened by hydrocarbons, particularly at temperatures above 150 F.

Polyethylene rope is excellent for use in the vicinity of high voltage electric lines. However, it is only moderately resistant to abrasion and high temperature. It will remain flexible at temperatures as low as -100 F, can be used continuously at temperatures up to 220 F, and intermittently at temperatures as high as 240 F.

Polypropylene rope is similar to polyethylene. Differences that make it more desirable are less weight for a given strength, less slippery, more buoyant in water, and more resistant to the effects of sunlight.

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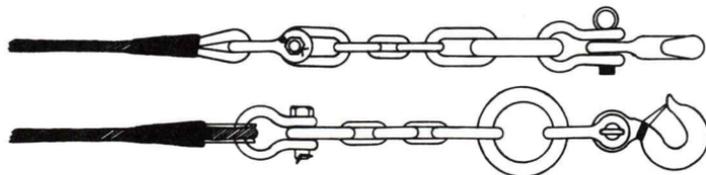
Glass fiber rope is used where resistance to high temperatures is essential, particularly in the electrical and chemical industries. Glass fiber rope is noncombustible, durable, resilient and flexible. It has excellent strength when dry, but not when wet. It is not recommended for use where abrasion and flexing conditions are severe and where rope is in contact with liquids. It is fairly resistant to mildew and rotting and is recommended for use where acid is present and for its dielectric properties.

Listed below are breaking strengths and safe loads of various fiber ropes. Material handling gear is illustrated and a table listing recommended gear sizes for various wire ropes is presented on the following page.

Breaking Strengths and Safe Loads of Manila, Nylon, Dacron Polypropylene, Three-Strand, Standard Lay Rope

Dia. (Inches)	Circumference	Average Weight per 100 Feet (Pounds)				*Average Breaking Strength (Pounds)			
		Manila	Nylon	Dacron	Polypro.	Manila	Nylon	Dacron	Polypro.
3/16	5/8	1.5	1.0	1.35	.71	450	1,100	860	800
1/4	3/4	2.0	1.6	2.16	1.10	600	1,850	1,380	1,300
5/16	1	2.9	2.6	3.1	1.84	1,000	2,850	2,100	1,900
3/8	1-1/8	4.1	3.8	4.3	2.85	1,350	4,000	2,950	2,750
7/16	1-1/4	5.3	5.4	6.5	3.70	1,750	5,500	4,100	3,500
15/32	1-3/8	6.2				2,250			
1/2	1-1/2	7.5	6.5	8.2	4.75	2,650	6,200	5,300	4,200
9/16	1-3/4	10.4	8.5	10.2	6.1	3,450	8,350	6,800	5,000
5/8	2	13.3	10.5	13.3	7.7	4,400	10,500	8,800	5,800
3/4	2-1/4	16.7	15.0	17.4	11.0	5,400	14,200	12,000	8,200
13/16	2-1/2	19.5				6,500			
7/8	2-3/4	22.5	20.5	25.0	15.4	7,700	19,000	16,300	11,500
1	3	27.0	27.0	30.5	18.7	9,000	24,600	19,800	14,000
1-1/16	3-1/4	31.3				10,500			
1-1/8	3-1/2	36.0	35.0	40.5	23.7	12,000	34,000	25,900	18,300
1-1/4	3-3/4	41.8	40.0	45.0	27.2	13,500	38,000	27,600	20,700
1-5/16	4	48.0	45.0	54.4	30.8	15,000	43,000	29,300	23,500
1-1/2	4-1/2	60.0	56.0	67.0	39.0	18,500	55,000	41,400	29,700
1-5/8	5	74.4	67.0	82.0	47.9	22,500	64,000	49,800	36,300
1-3/4	5-1/2	89.5	79.5	99.0	58.3	26,500	77,500	61,200	43,900
2	6	108	96.0	117.0	69.0	31,000	91,000	73,200	53,000
2-1/8	6-1/2	125	110.0	138.0	81.7	36,000	105,000	84,200	62,000
2-1/4	7	146	130.0	159.0	93.5	41,000	125,000	97,200	70,000
2-1/2	7-1/2	167	150.0	182.0	108.0	46,500	145,000	111,000	80,500
2-5/8	8	191	165.0	205.0	121.0	52,000	165,000	123,600	90,000
2-7/8	8-1/2	215			137.0	58,000			102,000
3	9	242	210.0	260.0	153.0	64,000	205,000	156,000	114,000
3-1/4	10	299	260.0	315.0	191.0	77,000	250,000	192,000	137,000
3-5/8	11	367	310.0	380.0	232.0	91,000	300,000	234,000	162,000
4	12	436	370.0	455.0	275.0	105,000	350,000	276,000	190,000

\*Recommended safe working load is 20 percent of the minimum breaking strength.



Material Handling Gear

Recommended Minimum Gear Sizes for Various Wire Rope Sizes

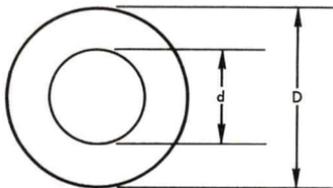
Improved Flow Steel Wire Rope 6-Strand; 19-Wire Hemp Center		New Alloy Steel Chain	Round Pin or Screw Shackle		Drop Forged Steel Hooks		Steel Rings and Links		
			Diameter of Pin (Inches)		Diameter		Diameter Stock		
Diameter (Inches)	Safe Load (Pounds)	Diameter of Link Stock (Inches)	Screw Pin	Round Pin	Eye	Throat	Circle	Oblong	Triangle
1/2	4,300	3/8	3/4	5/8	1-1/4	1-3/8	1	9/16	3/4
9/16	5,400	9/16	3/4	3/4	1-3/8	1-1/2	1-1/4	5/8	7/8
5/8	6,600	5/8	7/8	3/4	1-1/2	1-3/4	1-1/4	3/4	7/8
3/4	9,400	3/4	1	7/8	1-3/4	2	1-1/2	1	1
7/8	12,800	7/8	1-1/8	1	2-3/8	2-1/2	1-3/4	1-1/8	1-1/4
1	16,000	1	1-1/4	1-1/8	2-3/4	3	2	1-1/4	1-1/2
1-1/8	21,200	1-1/8	1-1/2	1-3/8	3-1/8	3-3/8	2-1/4	1-3/8	1-3/4
1-1/4	26,000	1-1/4	1-5/8	1-1/2	3-1/2	4	2-1/4	1-1/2	1-3/4
1-3/8	31,400	1-3/8	1-3/4	1-5/8	3-1/2	4	2-1/2	1-3/4	2
1-1/2	37,000	1-1/2	2	2	4	4-1/2	2-3/4	1-3/4	2-1/4

How to Estimate Weight

It is very important to estimate the approximate weight of the load to be lifted. This is a relatively simple but necessary operation.

The object may be determined by visualizing it as a square or rectangle. Deducting any small component parts or offshoots, calculate the volume of the object in cubic inches or feet by multiplying length times width times height. Take the component parts or offshoots and do the same thing. Visualize them as square or rectangular, and find their volume in cubic inches or feet. Both answers give the total volume to be lifted.

To determine what the material composition of the object is, ascertain the weight of material in pounds per cubic inch or feet. Multiply the cubic inch or foot measurement of the object times the cubic inch or foot weight of the material involved. This gives the approximate weight slightly overestimated. This gives a little "extra" in safety factor, sometimes needed on difficult lifts.



WEIGHT OF IRON PIPE  
 THE CONSTANT FOR IRON  
 PIPE = 2.67  
 LET "W" = WEIGHT AND  
 "K" = CONSTANT, D = OUTSIDE  
 DIAMETER, d = INSIDE DIAMETER,  
 THEN  
 $W = K (D^2 - d^2)$

## EXAMPLE

$$D = 4.500$$

$$d = 4.026$$

USING THE FORMULA  $W = K (D^2 - d^2)$  PLUG IN  
 KNOWN QUANTITIES AND SOLVE,

$$W = 2.67 (4.5^2 - 4.026^2)$$

$$W = 2.67 (20.25 - 16.21)$$

$$W = 2.67 \times 4.04$$

$$W = 10.78 \text{ LB PER LINEAR FOOT}$$

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WEIGHT OF STEEL PLATE					
Thickness in Inches	Pounds per Square Foot	Square Feet per Ton	Thickness in Inches	Pounds per Square Foot	Square Feet per Ton
3/8	15.3	131	1-1/8	45.9	44
1/2	20.4	98	1-1/4	51.0	39
5/8	25.5	79	1-3/8	56.1	35.7
3/4	30.6	65	1-1/2	61.2	32
7/8	35.7	56	1-3/4	71.4	28
1	40.8	49	2	81.6	24

WEIGHT OF OTHER MATERIALS

Material	Appropriate Weight per Cubic Foot (Pounds)	
Aluminum . . . . .	166	
Asphalt . . . . .	81	
Brass . . . . .	524	
Brick (Common) . . . . .	120	- (about 3 tons per thousand)
Bronze . . . . .	534	
Concrete . . . . .	150	- 4050 pounds per cubic yard
Copper . . . . .	537	
Crushed Rock . . . . .	95	- 2565 pounds per cubic yard
Dry Earth, Loose . . . . .	76	- 2052 pounds per cubic yard
Iron Casting . . . . .	450	
Lead . . . . .	708	
Lumber - Fir, Spruce . . . . .	32	- 2666 pounds per thousand feet
Lumber Oak . . . . .	62	- 5166 pounds per thousand feet
Magnesium . . . . .	109	
Mercury . . . . .	848	- per flask 76 pounds
Portland Cement . . . . .	94	- 376 pounds per barrel
River Sand . . . . .	120	- 3240 pounds per cubic yard
Steel . . . . .	490	
Water . . . . .	62.5	
Zinc . . . . .	437	

XV. ELECTRICAL MEASUREMENTS

## ELECTRICAL MEASUREMENTS.

## GENERAL

Separate meters, or separate sections of combination meters, are provided for measuring alternating and direct current. To avoid damage to instruments, the proper meter or meter section must be used.

Meters, or combination meter sections, are also graduated for given ranges (milli, micro, or units). The proper range must be used for the value to be measured. Where the expected range is unknown, the meter should be set to read the highest values likely to be encountered. If the first reading is too low to be measured on the scale used, further readings may be taken by switching to a lesser scale on multirange meters or using a separate meter of lower range.

Before taking a reading, the zero adjustment of the scale should be checked, especially if the meter is moved from horizontal to vertical position. If the meter does not indicate zero before use, adjustment may be made by setting the adjusting screw on the face of the meter. Meters should be read directly in front of the scale. Errors can occur if the meter is read at an angle.

## VOLTMETER

A voltmeter can measure the electromotive force applied to a circuit or it can measure the drop in voltage caused by a component in the circuit. It is always connected across the circuit with the positive terminal of the meter connected to the positive terminal of the circuit, and with the negative terminal of the meter connected to the negative terminal of the circuit. Either meter terminal may be connected to either circuit terminal to measure ac voltage. It is necessary, however, that the proper meter is used for the voltage measured; i. e., an ac voltmeter for ac voltage and a dc voltmeter for dc voltage, as the two are not interchangeable.

## AMMETER

An ammeter measures current flowing through a circuit. It is connected in series with the line delivering the current by breaking the line and inserting the meter. As with the voltmeter, when used to measure dc circuits, the meter must be inserted to read in the direction of current flow.

An ammeter will be damaged if it is placed across a circuit rather than in series with a resistance of some type. The type of ammeter used will be determined by the type of current measured as is the case with voltmeters.

## OHMMETER

An ohmmeter measures the resistance of a circuit or a component. It differs from other meters in that the scale is graduated in unequal divisions and that full-scale deflection reads zero ohms. Before connecting an ohmmeter to a circuit, the voltage supplied to the circuit must be removed. To prevent damage to the meter, no voltage other than that of the ohmmeter battery must be present. In addition to measuring resistance, the ohmmeter may also be used to check circuit continuity. The voltage source is removed from the circuit and the ohmmeter is connected in series with the line to be checked. The ohmmeter will indicate an open circuit as a high resistance reading.

## USE OF VOLT-OHM MILLIAMMETER (TRIPLETT 630-A)

There are five scales on the volt-ohm milliammeter. The top red scale, used to measure ohms, is marked from 0 to 1K (at left side). With the switch knob turned to  $\Omega$  X1, the ohms scale is read exactly as it is marked. With the switch knob turned to  $\Omega$  X10, the numbers on ohms scale must be multiplied by 10. Likewise,  $\Omega$  X1000 and  $\Omega$  X100,000 mean to multiply by 1000 and 100,000, respectively.

The second scale down (black) is used to read all dc voltages. The third scale (red) is used for all ac voltages except the 3-volt range. The latter is read on the bottom red scale (marked 3 at full scale).

The lowest scale is used for all decibel measurements. The chart near the lower right-hand corner of the dial is used in conjunction with the db scale as explained under the heading Measuring Output Volts.

Below the meter dial is a small bakelite screw which can be rotated with a small screwdriver to adjust the meter pointer to zero. For greatest accuracy, the pointer should always be on zero before making a measurement.

The large knob in the lower center of the panel is used to select all ranges. The markings are self-explanatory.

Left of the knob is a recessed ADJ control used when making resistance measurements.

The jacks marked COM and V -  $\Omega$  - A are used for most measurements (COM is negative).

The 630-A meter is accurate to within 1-1/2 percent of full scale reading on all dc ranges except the 6000-volt range. The 6000-volt range is accurate within 3 percent. Ac ranges, except 6000-volt ranges, are accurate to within 2-1/2 percent when used on 60-cycle sine wave voltages. The 6000-ac range is accurate to within 3 percent. The resistance ranges are accurate to within 1-1/2 percent of the scale length. Precision, nonaging resistors ensure lasting accuracy. All units are calibrated at 77 F.

All ac ranges are calibrated on a 60-cycle sine wave. Ranges should be chosen so that readings fall in the upper (right-hand) half of the scale. For greatest accuracy, the instrument should be in the horizontal position when it is read.

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The Triplet 630-A meter covers the ranges shown in the following chart.

Dc volts .....	0-3-12-60-300-1200-6000 at 20,000 ohms per volt
Ac volts .....	0-3-12-60-300-1200-6000 at 5000 ohms per volt
Dc microamperes .....	0-60 at 250 mv
Dc milliamperes .....	0-1.2-12-120 at 250 mv
Dc amperes .....	0-12 at 250 mv
Ohms .....	0-1000-10,000 (4.4-44 at center scale)
Megohms .....	0-1-100 (4400-440,000 at center scale)
Output volts .....	0-3-12-60-300-1200 ac at 5000 ohms per volt
Decibels .....	-30 to +4, 16, 30, 44, 56, 70 on 500-ohm line

## Measuring Dc Volts

The selector switch is rotated to the appropriate range for dc volts, starting with the highest range if there is doubt as to the approximate voltage. For greatest accuracy, ranges should be chosen so that readings fall in the upper (right-hand) half of the scale (see following sketch).

For all ranges up to the 6000/1200 volts range, the black test lead must be plugged into the COM jack and the red lead into the V- $\Omega$ -A jack. When 1200 to 6000 volts are to be measured, the selector switch must be set on the 6000/1200 range, the red lead must be plugged into the jack marked 6000 DCV, and the black lead plugged into the jack marked COM.

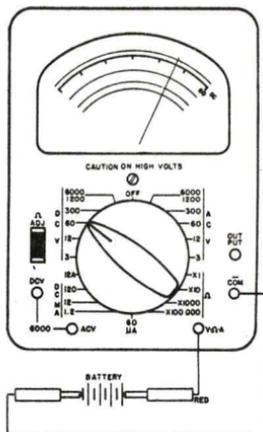
The test prods are then connected across the voltage source. The red lead is positive; if the meter reads backwards, polarity has been determined in error and the leads must be reversed.

Dc voltages are read on the top (black) scale. All scales are not marked exactly the same as the range indicated by the knob position. Thus 0-3 volts is read on the 0-300 scale by dividing by 100 (omitting two zeros) on all readings. The 0-1200 range is read on the 0-12 scale by adding two zeros, and the 0-6000 range is read on the 0-60 scale by adding two zeros.

The high sensitivity of 20,000 ohms per volt allows measurement in low-current grid and discriminator circuits.

## WARNING

Do not handle tester or leads when they are connected to high voltages. Make certain that no condensers are charged to a high voltage.



Measuring Dc Volts

Measuring Ac Volts

To measure ac voltage up to 300 volts, the black test lead is plugged into the COM jack and the red lead into the V-Ω-A jack. The selector switch is rotated to the appropriate range, starting with the highest range if there is doubt as to the approximate voltage. For greatest accuracy, readings should fall in the upper (right-hand) half of the scale (see following sketch).

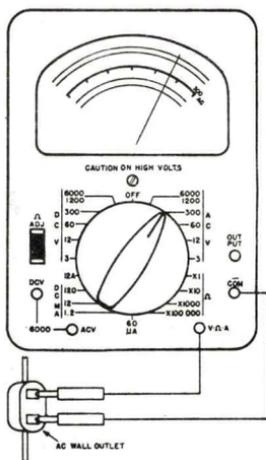
When 1200 to 6000 volts are to be measured, the selector switch is set on the 6000/1200 range, the red lead is plugged into the jack marked 6000 ACV, and the black lead is plugged into COM.

The test prods are then connected across the voltage source. As there is no polarity on ac, the red and black leads may be interchanged without causing the meter to read backwards.

The two lower red scales are used for ac voltage readings; the bottom scale is used only for the 0-3 range. When the 0 to 1200-ac volt range is used, two zeros are added to the 0-12 scale. When the 6000-volt range is used, two zeros are added to the 0-60 scale. No correction for frequencies is necessary from 25 cps to 1000 cps.

**WARNING**

Do not handle tester or leads when they are connected to high voltages.



Measuring Ac Volts

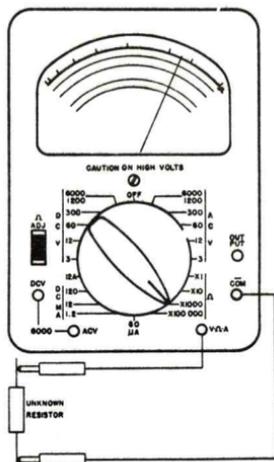
Measuring Dc Resistance

To measure dc resistance, the selector switch is rotated to the appropriate range for ohms (see sketch). This range is determined from the following chart:

To read	Set switch to
0-1000 ohm .....	X1
0-10,000 ohm.....	X10
0-1 megohm .....	X1000
0-100 megohm.....	X100 000

The black test lead is plugged into the COM jack and the red lead into the V-Ω-A jack.

The test prods are shorted together and the ADJ knob adjusted until the meter pointer reads 0 on the top red (Ω) scale. (The 0 for the ohms scale is at the extreme right side of the scale.) The 0 setting should be checked each time an ohm range is changed.



Measuring DC Resistance

The test prods are then connected across the resistor. If the resistor is wired in a circuit, one end of the resistor is disconnected before a reading is taken.

The basic scale 0-1K (0-1000) is used for reading on all ohm ranges by multiplying the scale numbers by 1, 10, 1000, or 100,000 as indicated by the selector switch setting.

In the measurement of resistance, a current is passed through the unknown resistor. Generally this current is so small as to be negligible. However, on the 0 to 1000 range, fairly high current is employed which could damage the fragile circuits being measured.

The current drain from the 1.5-volt battery is  $170 \mu\text{a}$  on ohm position X1 reading approximately center scale (4.4 ohms). Use of one of the higher ohm ranges for general continuity or circuit testing will give much longer battery life.

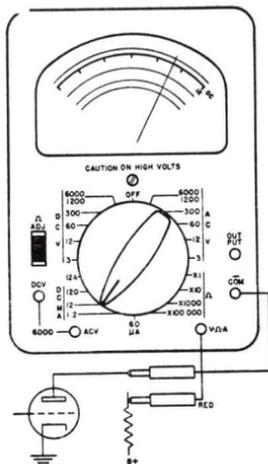
Since the scale of an ohmmeter is nonlinear, the accuracy of the reading cannot be expressed as a percent of full scale. Ohmmeter accuracy is generally referred to a linear scale such as the dc volt scale. Thus,  $\pm 1\frac{1}{2}$  ohms accuracy means an allowable  $\pm 0.9$  divisions on the dc scale. For example, 2 ohms could read from about 1.85 to 2.2 ohms and be within tolerance.

Metal parts of the circuit should not be touched when high ohm ranges are being used since body resistance can cause serious error.

#### Measuring Dc Current

To measure dc current, the black test lead is first plugged into the V- $\Omega$ -A jack. The selector switch is then rotated to the appropriate range for dc circuit, starting with the highest range if there is doubt as to the approximate current. Readings should fall in the upper (right-hand) half of the scale for greatest accuracy (see sketch).

The test prods are then connected in series with the circuit to be measured. Connecting the prods in parallel with any part of the circuit may burn out the meter and the shunt. If the meter reads backwards in the initial reading, polarity has been determined in error; this is corrected by reversing the leads. The electrical power must be connected to the circuit. Neither the meter nor the leads should be handled while they are attached to high voltage circuits.



Measuring Dc Current

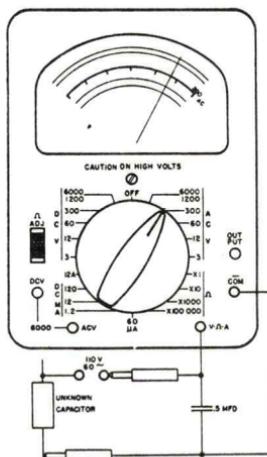
All current ranges (including microamperes, milliamperes, and amperes) are read on the upper black scale. When the 1.2-ma range is required, the 0-12 scale is used and divided by 10. When the 120-ma range is required, the 0-12 scale is used and multiplied by 10.

When the 60-microampere range is used, meter readings may vary from calculations. This may be caused by moisture or by a slight potential caused by the soldering or joining of dissimilar metals. Also, fumes or liquid acids or alkalis reacting with metal parts of the circuit may generate slight currents. In addition, contact by the body upon metal parts of the meter or circuit can promote electrical disturbances.

#### Measuring Capacity

The 630-A meter can be used to measure capacity by the arrangement shown in the accompanying sketch pictured as an ac voltmeter. The following chart can be used to determine the correct ac voltage range. The selector switch must be initially set on the 300-volt range since, if the condenser is shorted, serious damage may result to the meter on a low range setting.

To measure $\mu f$	Set selector switch to	Deflection in ac volts
0.002 0.004 0.006 0.008 0.010	3 ACV	0.45 0.83 1.25 1.65 2.10
0.020 0.04 0.05	12 ACV	4.3 7.7 9.7
0.08 0.10 0.2 0.4 0.6	60 ACV	14.5 17.5 30.0 45.0 57.0
0.8 1.0 2.0 5.0 10.0	300 ACV	65.0 75.0 85.0 95.0 100.0
NOTE: Do not perform this test on electrolytic condensers.		





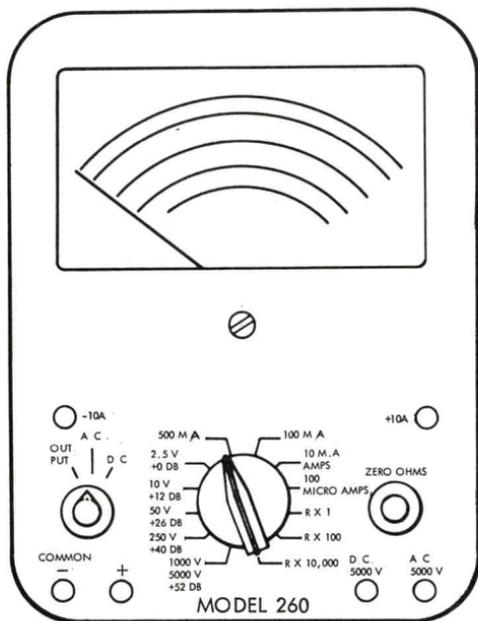
# SPACE DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

## Use of Simpson 260 Multimeter

The Simpson 260 multimeter is used in circuit analysis to measure voltage, current, and resistance. The following illustration and table show the meter and its correct usage.

Simpson 260 Multimeter Operation Chart

Value to be read	Plug positions	Ac-Dc switch position	Range selector switch position	Scale to read
2 vdc	Common and +	Dc	2.5 V	0 to 250 vdc, divide by 100
28 vdc	Common and +	Dc	50 V	0 to 50 vdc
300 vdc	Common and +	Dc	1000 V	0 to 10 vdc, multiply by 100
5000 vdc	Common and 5000 vdc	Dc	1000 and 5000 V	0 to 50 vdc, multiply by 100
3 vac	Common and +	Ac	10 V	0 to 10 vac
26 vac	Common and +	Ac	50 V	0 to 50 vac
115 vac	Common and +	Ac	250 V	0 to 250 vac
5000 vac	Common and 5000 vac	Ac	1000 and 5000 V	0 to 50 vac multiply by 100
Continuity	Common and +	Dc	R X 1	0 to 2M ohms (zero adjust)
1 to 99 ohms	Common and +	Dc	R X 1	0 to 2M ohms (zero adjust)
100 to 10,000	Common and +	Dc	R X 100	0 to 2M ohms multiply by 100 (zero adjust)
Over 10,000	Common and +	Dc	R X 10,000	0 to 2M ohms, multiply by 10,000
0 to 10 amps dc	-10A and +10A	Dc	500 MA	0 to 10 dc
Milliamperes	Common and +	Dc	500 MA	0 to 50 dc, multiply by 10
Microamperes	Common and +	Dc	100 Micro amps	0 to 10 dc, multiply by 10
Db values	Common and +	Ac	1 of 5 DB positions	-12 to +3 db



Precautions for meter protection:

1. Circuit power must be off before checking for continuity or measuring resistances.
2. Always connect the meter in series when reading milliamperes or amperes.
3. When doubt exists as to the values to be measured, set the range selector switch to the highest value first.
4. Report a defective meter immediately to instrument laboratory

## RESISTORS AND CAPACITORS

## GENERAL

The color codings of the bands or dots on a resistor or capacitor reveal resistance in ohms ( $\Omega$ ) or capacitance in micromicrofarads ( $\mu\mu\text{f}$ ). The voltage rating of a resistor or capacitor can be determined only by referring by part number to manufacturers' specifications.

Color Codes

The colors of the first two bands (or dots) represent the first and second digits of the resistance or capacitance. The following RETMA color code chart shows the values of the different colors. In this manner, a green band (5) and a red band (2) represent the number 52.

The color of the third band (or dot) represents the value of the multiplier used with the first and second digits. If a green band (5) and a red band (2) were followed by a third yellow band (10K), the value represented would be  $52 \times 10\text{K}$  or 520,000.

The fourth color band indicates the tolerance. The absence of the fourth band indicates a tolerance of 20 percent.

Fifth and sixth color bands are employed on capacitors only. They give the voltage in hundreds of volts. Thus if the colors of these bands were red and orange, they would represent the digits 2 and 3. As these colors represent voltage in hundreds of volts, red and orange represent 2300 volts.

Additional bands, represented by the letters G, H, I, and J are manufacturer's codings. They indicate classes and temperature coefficients. These values are not shown on the table and must not be considered when the color bands of ceramic radial lead, axial lead, and standoff capacitors are being interpreted.

RETMA Color Code for Resistors and Capacitors

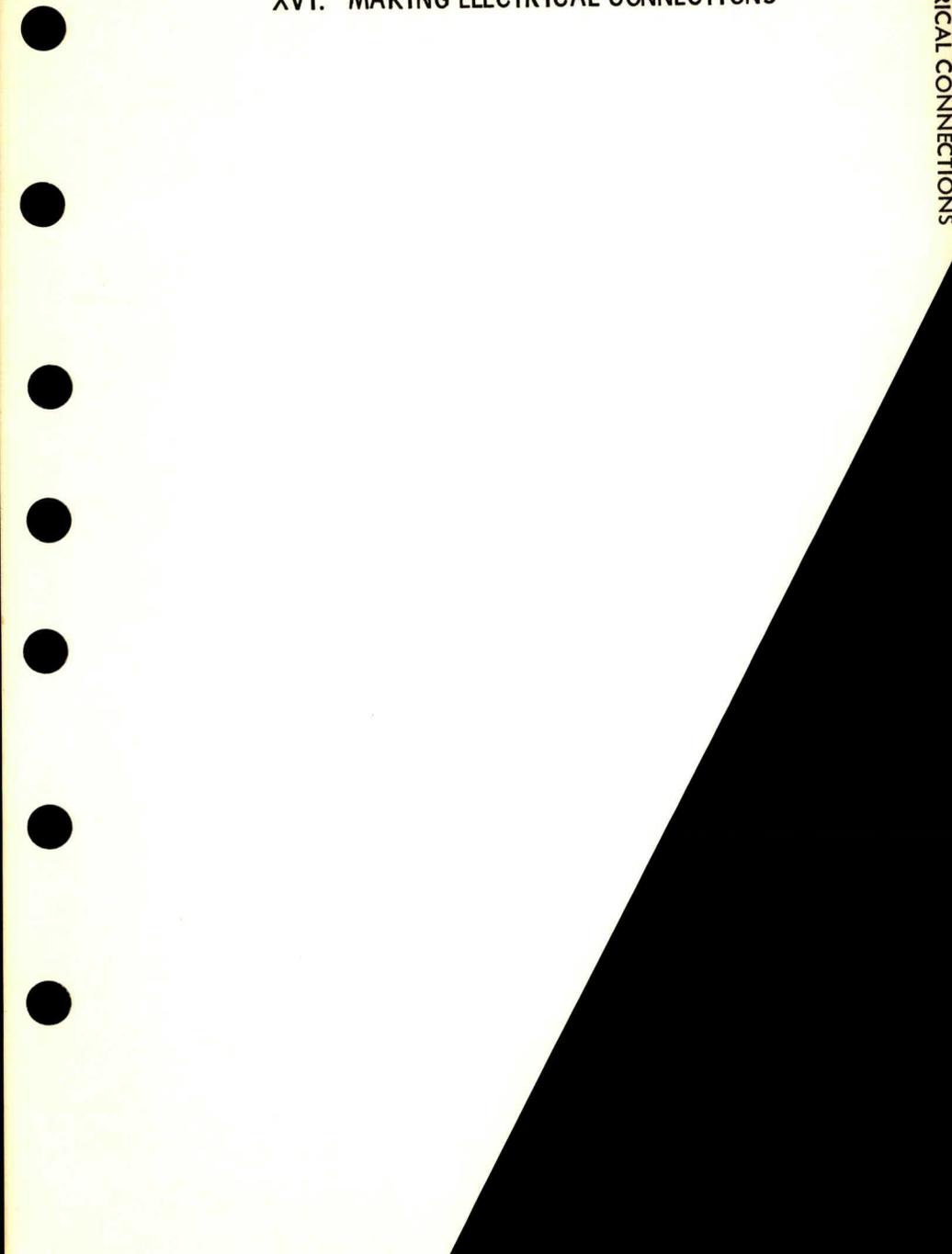
Color	Digit	Resistors		Molded Paper Capacitors		Molded Mica Capacitors		Ceramic Capacitors	
		Multiplier	Tolerance	Multiplier	Tolerance	Multiplier	Tolerance	Multiplier	Tolerance
Black	0	1		1	±20%	1	±20%	1	±20% or 2.0 μμf*
Brown	1	10		10		10		10	±1%
Red	2	100		100		100	±20%	100	±2%
Orange	3	1K		1K		1K	±3%	1K	±2.5%
Yellow	4	10K		10K	±5%	10K		10K	
Green	5	100K					±5%		±5% or 0.5 μμf*
Blue	6	1000K							
Violet	7	10,000K							
Gray	8	100,000K						0.01	±0.25 μμf*
White	9	1,000,000K			±10%			0.1	±10% or 1.0 μμf*
Gold		0.1	±5%	0.1	±5%	0.1	±5%		
Silver		0.01	±10%		±10%	0.01	±10%		
None			±20%		±20%				

Resulting values are in ohms for resistors, and in μμf for capacitors

"K" indicates thousand.

\*Capacitance less than 10 μμf

XVI. MAKING ELECTRICAL CONNECTIONS



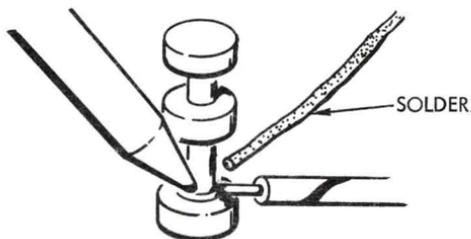
## SOLDERING ELECTRICAL CONNECTIONS

Soldered joints are often used in electrical and electronic circuits. If properly made, soldered joints make more reliable connections than most mechanical devices. An acceptable soldered joint, however, requires proper techniques and correct materials.

Surfaces to be soldered or tinned must be free of oxides, scale, oil, and other foreign matter. This cleaning should be performed just before flux is applied. Rosin is the only flux acceptable for use in instrumentation work. It may be either a liquid rosin flux or a rosin core solder. Eventual corrosion of circuit components will occur if acid fluxes are used because of the difficulty of removing all traces of flux from the finished joint. In a few instances, acid flux may be required but may be used only with permission of the Instrumentation Engineer in charge.

Whenever possible, surfaces to be connected by solder should be tinned before being joined. Tinning makes surfaces easier to join and results in more positive connections. Before acceptable tinning can be achieved, the iron itself must be properly tinned. First one side of the hot iron is cleaned to expose the metal. Rosin core solder is applied immediately. The process is repeated for the other soldering faces, excess solder being wiped off with a clean rag. The iron should also be wiped frequently during soldering operation.

Solder is always applied to the work and not to the soldering iron. Before the soldering operation is attempted, the iron should be clean, properly tinned, and heated to the proper working temperature. The iron should be held against the parts to be joined until the solder flows smoothly and envelops the work. Movement of the parts before the solder has solidified will result in a cold joint, which has a white appearance rather than the normal shiny silver glow. Cold joints tend to be of high resistance and may have a bad effect on the circuit. See figure for proper application of solder to contact pins.



Method of Applying Solder  
to Contact Pins

## WIRE PREPARATION

The correct preparation and tinning of wire prior to soldering it to a component is one of the basic steps in securing a good soldered connection. Wire strippers must be adjusted so that none of the strands of wire are cut or damaged in any way. If the wire is damaged, it might ultimately cause unit failure in the finished installation.

When stranded conductors are stripped, the strands have a tendency to unwind. If this condition occurs, the strands should be twisted back into their former position prior to tinning. After the wire has been stripped and all of the frayed strands are twisted back into place, it is ready for tinning.

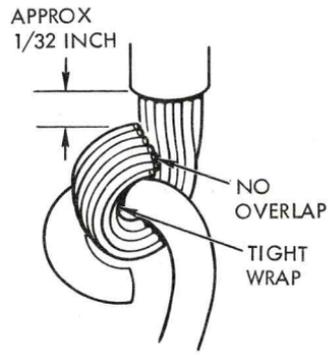
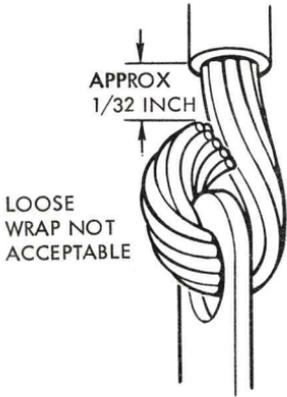
A small amount of solder should be applied to the tip of the iron. The wire is then placed on top of this solder and allowed to heat. When the wire has reached the temperature of the iron, solder will flow into its strands. At this time, a small amount of solder is applied to the wire and not to the iron. Solder is then allowed to flow until the wire has absorbed enough to tin every strand. Only enough to accomplish this purpose must be used. Too much solder will increase the diameter of the wire and will prevent it from passing through the hole in the lug. Too much solder will also make it hard to form around the lug. Too little solder will allow the strands to fray and will result in a poor connection.

To prevent the wire from separating from the terminal under vibration and shock conditions, the following precautions should be observed:

1. The wire lead must be protected from damage during installation. Sharp bends should be avoided.
2. The lead must be wrapped sufficiently around the terminal. The lead wrap should be at least a three-quarters turn but not in excess of one complete turn.
3. The lead must allow a small degree of flexibility.

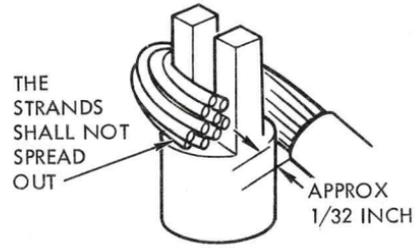
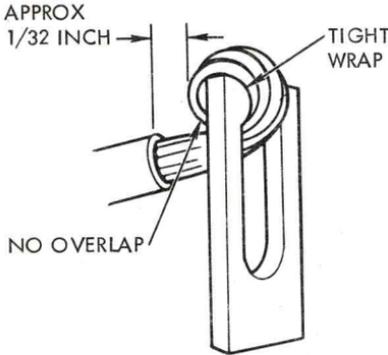
Typical methods of wrapping are shown in the figure.

METHODS OF WRAPPING WIRE AROUND TERMINALS OR SPLICES



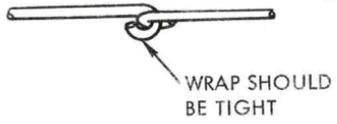
HOOK TERMINAL

FLAT TERMINAL WHEN APPROACHED FROM THE END

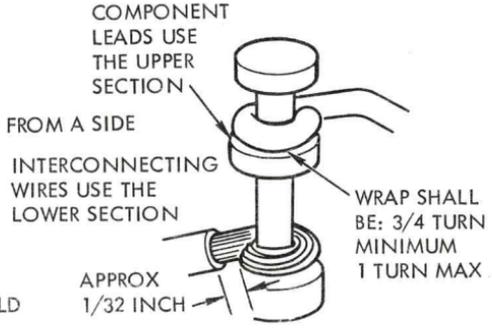


BOTH PRONGS OF A BIFURCATED TERMINAL

FLAT TERMINAL WHEN APPROACHED FROM A SIDE



HOOK SPLICE



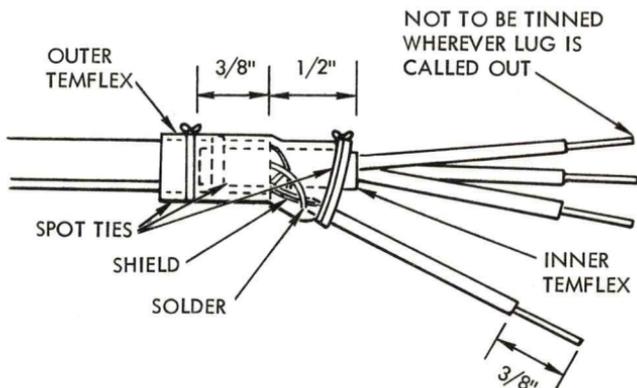
TURRET TERMINALS

## SHIELDED WIRE PREPARATION

Shielded wire is often used in instrumentation circuits and requires special preparation; i. e., one end of the shield of this type of wire being grounded by pigtailling, while the other end is terminated by insulating it from possible grounding.

In the pigtailling operation, the outer covering of the shielded wire is carefully removed, with care being taken not to damage the shield. The shield is then pushed back from the conductor or conductors, and the strands of the shield are carefully separated with a scribe. The inner conductor is then worked through the shield at the point where the strands are most separated, and the shield is bent to one side. The shield is next cut to approximately  $3/8$  inch. Using a heat shunt, the shield is then soldered to the ground wire.

As shown in the figure, a piece of Temflex is inserted over the conductor or conductors and tied. A larger piece of Temflex is installed over the entire connection and tied.

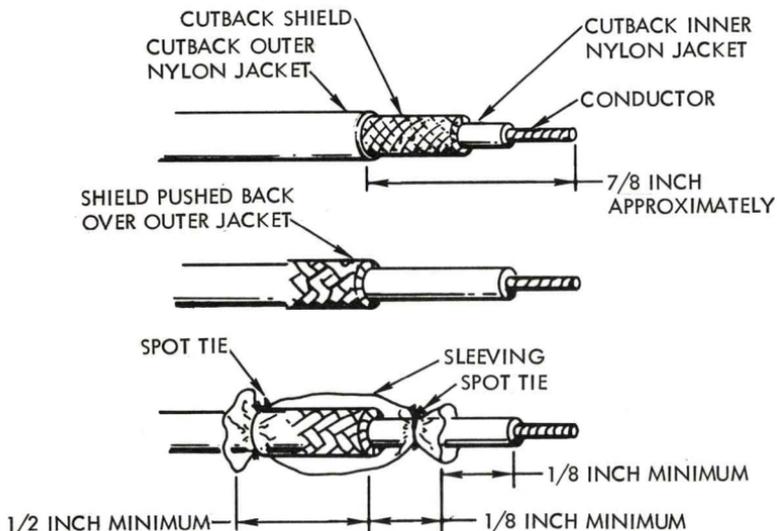


Shielded Wire Preparation

## TERMINATING UNGROUNDED SHIELD

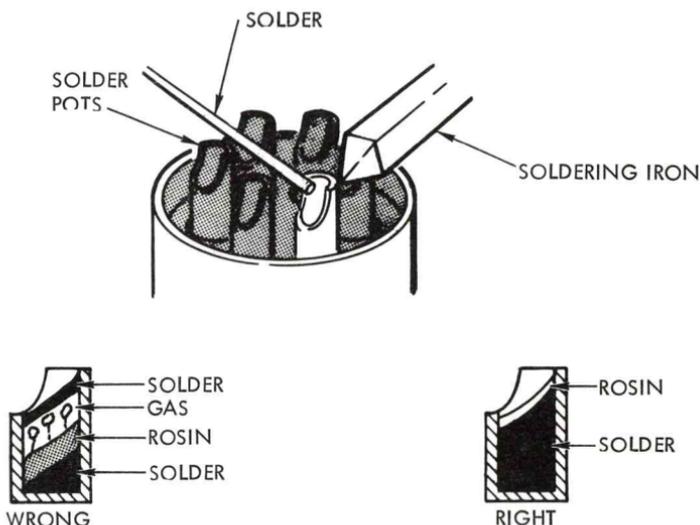
One method of so terminating an ungrounded shield is shown in the figure and consists of the following steps:

1. The outer nylon jacket is cut back about 7/8 inch from the end of the wire.
2. The metal shield is cut back as shown below, care being taken not to damage the inner nylon jacket.
3. The desired length of inner nylon jacket is then removed, using the correct wire stripper.



## CONNECTOR PREPARATION

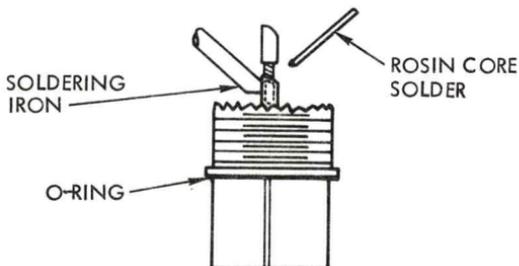
The most commonly used connectors in electronic assemblies are Cannon and Winchester plugs and receptacles. The major cause of failure in these connectors is poorly soldered wires. Special care should be taken to fill the solder pots of these connectors and to prevent the rosin flux from sinking to the bottom and taking up space that should be filled with solder. A poorly filled solder pot is subject to cracking under vibration. The wire may come loose, resulting in a poor electrical connection that might ultimately result in the failure of a whole unit. To obtain a correctly filled solder pot, solder must be fed slowly. See figure for correct method of preparing connector for soldering.



## JOINING CABLE TO CONNECTOR

To properly solder a cable to a connector, the following procedure is recommended:

1. Strip the wire and insert it in the pot. When bottomed, approximately 1/32 inch of the wire should be exposed above the pot (see figure). Cut wire to fit.
2. Install insulation tubing above the exposed end of the wire.
3. Tin the entire length of the stripped wire that is to be inserted in the pot of the connector. The insulation must not be discolored or curled by this operation.
4. Insert a small piece of solder in the pot of the connector.
5. Place the iron tip on the back of the pot. When the solder melts and bubbles, insert the conductor into the pot until it is bottomed. If necessary, apply a small amount of solder to the joint (see figure).
6. Remove the iron and hold the conductor steady until the solder cools and hardens. The contour of the individual strands of wire should be easily seen when the solder has cooled.
7. Clean the joint using an acid brush dipped in Isopropyl Alcohol to remove flux residues.
8. Slip the insulation tubing over the soldered connection.



Joining Cables to Connectors

XVII. USEFUL MISCELLANEOUS INFORMATION

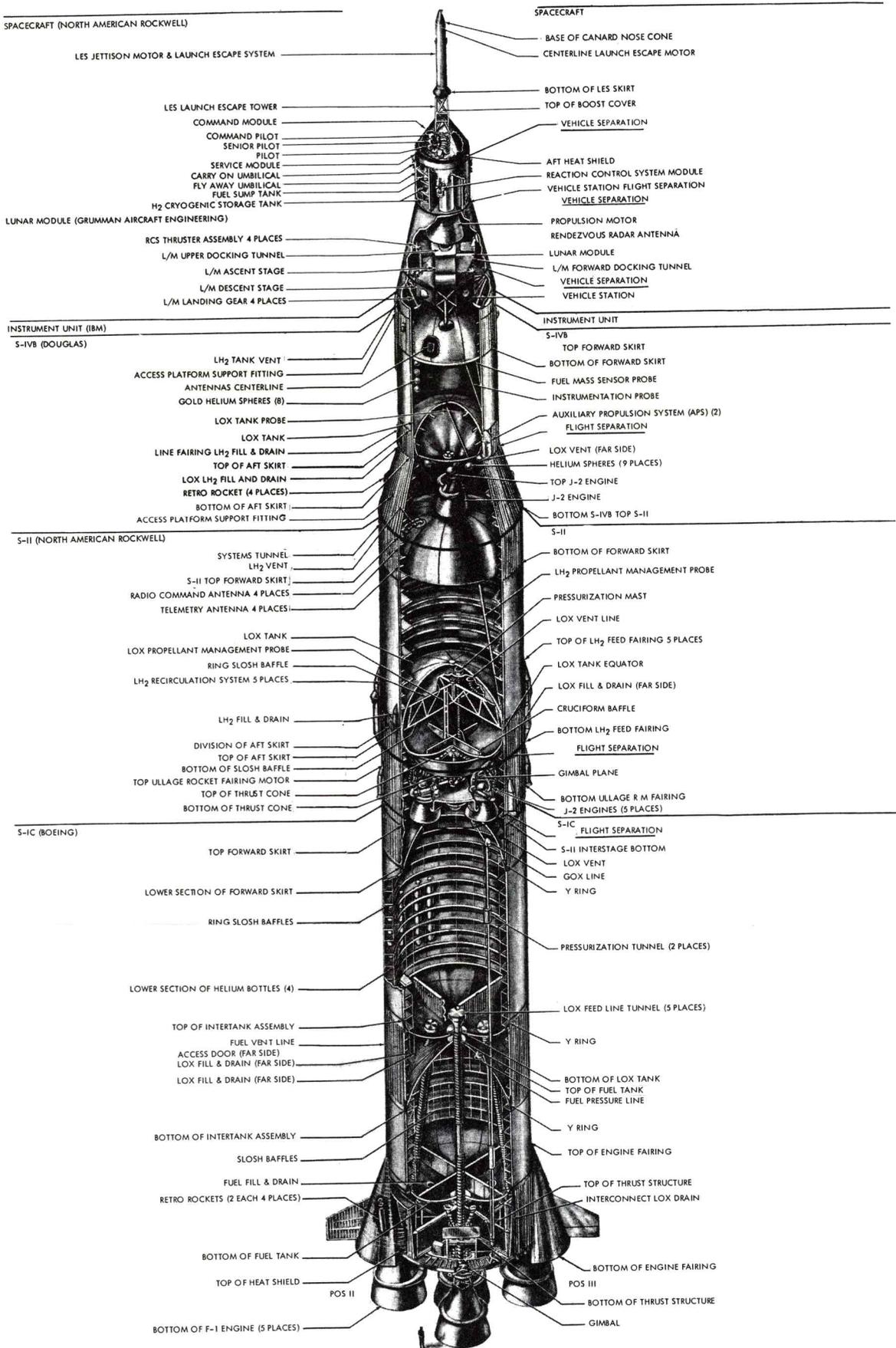
XVII. USEFUL MISCELLANEOUS INFORMATION

Data to be Provided Later

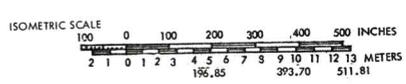
XVIII. APPENDIXES

APPENDIX - GLOSSARY

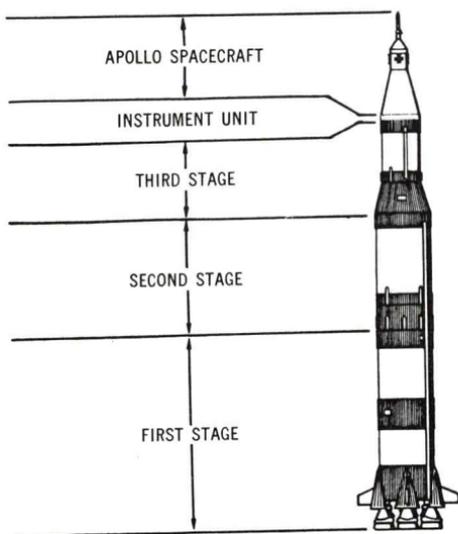
The Saturn S-II stage will provide the second-stage thrust for the Saturn V launch vehicle that will propel three astronauts to the moon by 1970 in the Apollo spacecraft. The Saturn V is often described as the earth-escape launch vehicle for Project Apollo, manned lunar landing. This vehicle is comprised of the S-IC (first stage), the S-II (second stage), the S-IVB (third stage), and the launch vehicle instrument unit (IU). The payload of this launch vehicle is the Apollo spacecraft, which comprises the command module, the service module, the lunar excursion module, the launch escape system, and the spacecraft adapter.



NOTE: S-IC STAGE ROTATED COUNTER CLOCKWISE FOR CLARITY



## SATURN V

**PHYSICAL CHARACTERISTICS**

	DIAMETER	HEIGHT	WEIGHT
OVERALL VEHICLE	33 ft.	364 ft.*	6,100,000 lb. (total liftoff)
FIRST STAGE	33 ft.	138 ft.	300,000 lb. (dry)
SECOND STAGE	33 ft.	81 ft. 7 in.	95,000 lb. (dry)**
THIRD STAGE	21 ft. 8 in.	58 ft. 7 in.	34,000 lb. (dry)**
INSTRUMENT UNIT	21 ft. 8 in.	3 ft.	4,500 lb.
APOLLO SPACECRAFT		80 ft.	95,000 lb.

\*SINCE INDIVIDUAL STAGE DIMENSIONS OVERLAP IN SOME CASES, OVERALL VEHICLE LENGTH IS NOT THE SUM OF INDIVIDUAL STAGE LENGTHS

\*\*INCLUDES AFT INTERSTAGE WEIGHT

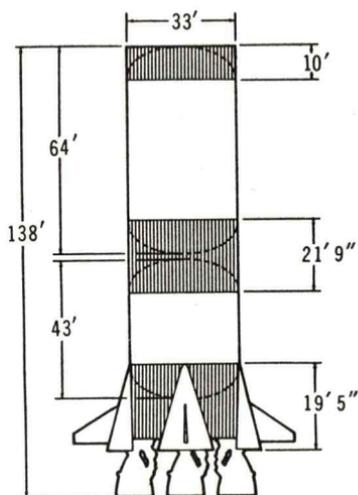
**PROPULSION SYSTEMS**

- FIRST STAGE** —Five bipropellant F-1 engines developing 7,500,000 lb. thrust  
RP-1 Fuel—203,000 gal. (1,359,000 lb.), LOX—331,000 gal. (3,133,000 lb.)
- SECOND STAGE**—Five bipropellant J-2 engines developing more than 1,000,000 lb. thrust  
LH<sub>2</sub>—260,000 gal. (153,000 lb.), LOX—83,000 gal. (789,000 lb.)
- THIRD STAGE** —One bipropellant J-2 engine developing up to 225,000 lb. thrust  
LH<sub>2</sub>—63,000 gal. (37,000 lb.), LOX—20,000 gal. (191,000 lb.)

**CAPABILITY**

- FIRST STAGE** —Operates about 2.5 minutes to reach an altitude of about 200,000 feet (38 miles) at burnout
- SECOND STAGE**—Operates about 6 minutes from an altitude of about 200,000 feet to an altitude of 606,000 feet (114.5 miles)
- THIRD STAGE** —Operates about 2.75 minutes to an altitude of about 608,000 feet (115 miles) before second firing and 5.2 minutes to translunar injection
- PAYLOAD**—250,000 lb. into a 115 statute-mile orbit

## S-IC FIRST STAGE



WEIGHT: 300,000 lb. (dry)  
 4,792,000 lb. (loaded)  
 DIAMETER: 33 ft.  
 HEIGHT: 138 ft.  
 BURN TIME: About 2.5 min.  
 VELOCITY: 6,000 miles per hour at burnout (approx.)  
 ALTITUDE AT BURNOUT: About 38 miles

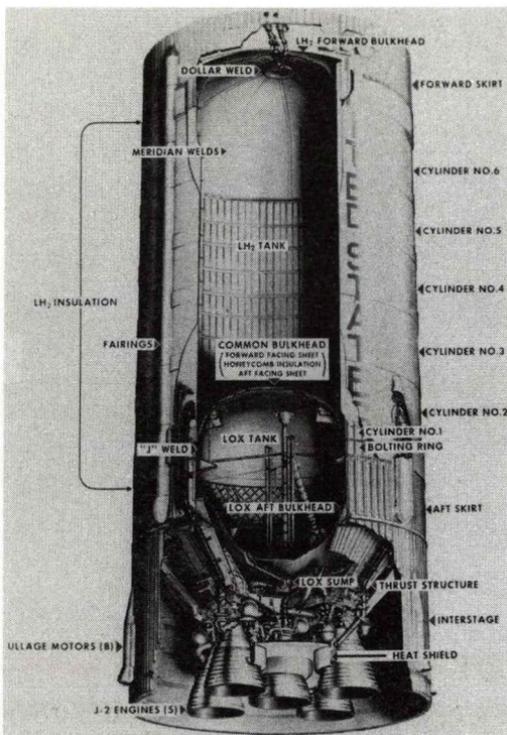
**MAJOR STRUCTURAL COMPONENTS**

THRUST STRUCTURE  
 FUEL TANK  
 INTERTANK  
 LOX TANK  
 FORWARD SKIRT

**MAJOR SYSTEMS**

PROPULSION: Five bipropellant F-1 engines  
 Total thrust: 7.5 million lb.  
 Propellant: RP-1—203,000 gal. or 1,359,000 lb.  
 LOX—331,000 gal. or 3,133,000 lb.  
 Pressure: Control—1.27 cubic feet of gaseous nitrogen at 3,250 psig  
 Fuel pressurization—124 cubic feet or 636 lb. of gaseous helium at 3,100 psig  
 LOX pressurization—gaseous oxygen converted from 6,340 pounds of LOX by the engines  
 HYDRAULIC: Power primarily for engine start and for gimbaling four outboard engines  
 ELECTRICAL: Two 28 VDC batteries, basic power for all electrical functions  
 INSTRUMENTATION: Handles approx. 900 measurements  
 TRACKING: ODOP Transponder

## S-II SECOND STAGE



WEIGHT: 95,000 lb. (dry)  
 1,037,000 lb. (loaded)  
 DIAMETER: 33 ft.  
 HEIGHT: 81 ft. 7 in.  
 BURN TIME: 6 min. approx. (actually 395 sec.)  
 VELOCITY: 15,300 miles per hour at burnout (approx.)  
 ALTITUDE AT BURNOUT: 114.5 miles

**MAJOR STRUCTURAL COMPONENTS**

AFT INTERSTAGE	THRUST STRUCTURE	COMMON BULKHEAD	LH <sub>2</sub> FORWARD BULKHEAD
AFT SKIRT	AFT LOX BULKHEAD	LH <sub>2</sub> CYLINDER WALLS	FORWARD SKIRT

**MAJOR SYSTEMS**

**PROPULSION:** Five J-2 engines

Thrust: More than 1,000,000 lb. (225,000 maximum each engine)

Propellant: LH<sub>2</sub>—260,000 gal. (153,000 lb.)

LOX—83,000 gal. (789,000 lb.)

**ELECTRICAL:** 6 electrical bus systems, four 28-volt DC flight batteries, and motor-operated power transfer switches

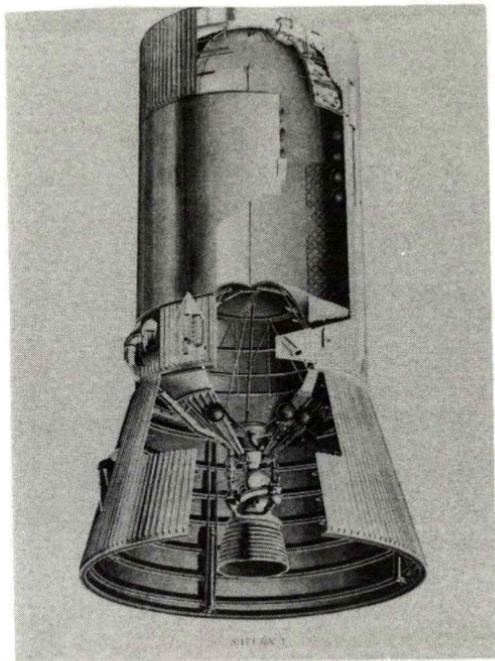
**ORDNANCE:** Provides, in operational sequence, ignition of eight ullage motors before ignition of five main engines, explosive separation of second stage interstage skirt, explosive separation of second stage from third stage, and ignition of four retrorockets to decelerate second stage for complete separation

**MEASUREMENT:** Instrumentation, telemetry, and radio frequency subsystems

**THERMAL CONTROL:** A ground-operated system that provides proper temperature control for equipment containers in the forward and aft skirt

**FLIGHT CONTROL:** Gimbaling of the four outboard J-2 engines as required for thrust vector control, accomplished by hydraulic-powered actuators which are electrically controlled from signals initiated in the flight control computer of the instrument unit (atop the Saturn V third stage)

## S-IVB THIRD STAGE



**WEIGHT:** 34,000 lb. (dry) including 7,700-lb. aft interstage  
262,000 lb. (loaded)

**DIAMETER:** 21 ft. 8 in.

**HEIGHT:** 58 ft. 7 in.

**BURN TIME:** 1st burn—2.75 min. (approx.)

2nd burn—5.2 min. (approx.)

**VELOCITY:** 1st burn—17,500 miles per hour at burnout (approx.)

2nd burn—24,500 miles per hour (approx. typical lunar mission escape velocity)

**ALTITUDE AT BURNOUT:** 115 miles after 1st burn and into a translunar injection on 2nd burn

**MAJOR STRUCTURAL COMPONENTS**

AFT INTERSTAGE	THRUST STRUCTURE	COMMON BULKHEAD
AFT SKIRT	PROPELLANT TANK	FORWARD SKIRT

**MAJOR SYSTEMS**

**PROPULSION:** One bipropellant J-2 engine

Total Thrust: 225,000 lb. (maximum)

Propellants: LH<sub>2</sub>—63,000 gal. (37,000 lb.)

LOX—20,000 gal. (191,000 lb.)

**HYDRAULIC:** Power for gimbaling J-2 engine

**ELECTRICAL:** One 56 VDC and three 28 VDC batteries, providing basic power for all electrical functions

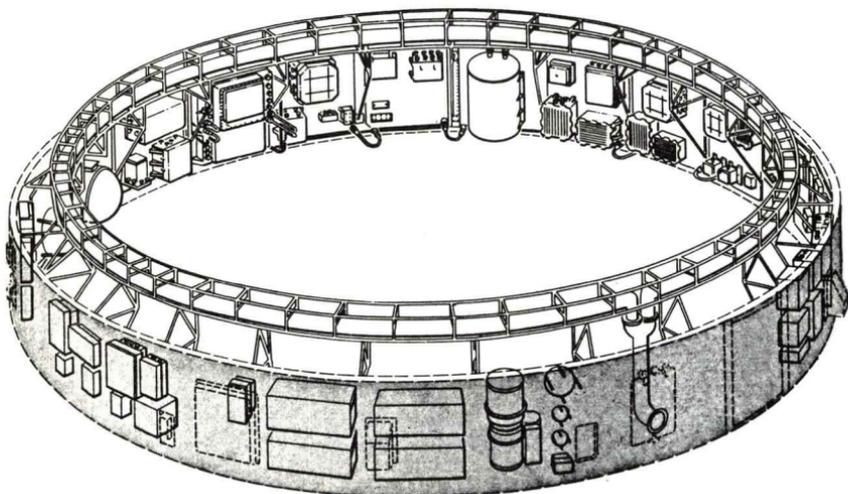
**TELEMETRY AND INSTRUMENTATION:** Five modulation subsystems, providing transmission of flight data to ground stations

**ENVIRONMENTAL CONTROL:** Provides temperature-controlled environment for components in aft skirt, aft interstage, and forward skirt

**ORDNANCE:** Provides explosive power for stage separation, retrorocket ignition, ullage rocket ignition and jettison, and range safety requirements

**FLIGHT CONTROL:** Provides stage attitude control and propellant ullage control

## INSTRUMENT UNIT



DIAMETER: 260 in.  
 HEIGHT: 36 in.  
 WEIGHT: 4,500 lb. (approx.)

**MAJOR SYSTEMS**

**ENVIRONMENTAL CONTROL SYSTEM:** Provides cooling for electronic modules and components within the IU and forward compartments of third stage

**GUIDANCE AND CONTROL SYSTEM:** Determines course of Saturn V through space and adapts that course to fulfill mission requirements

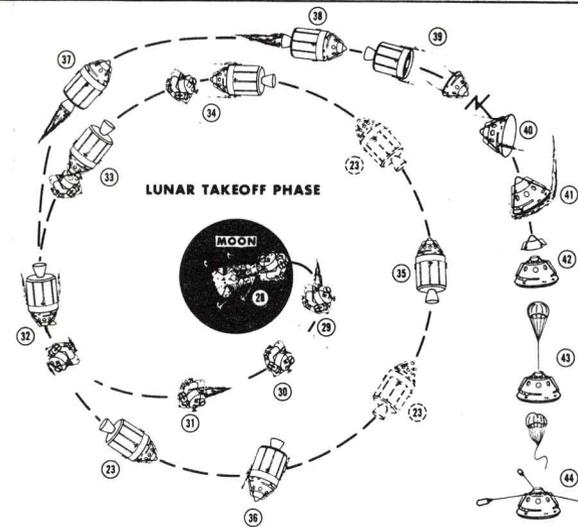
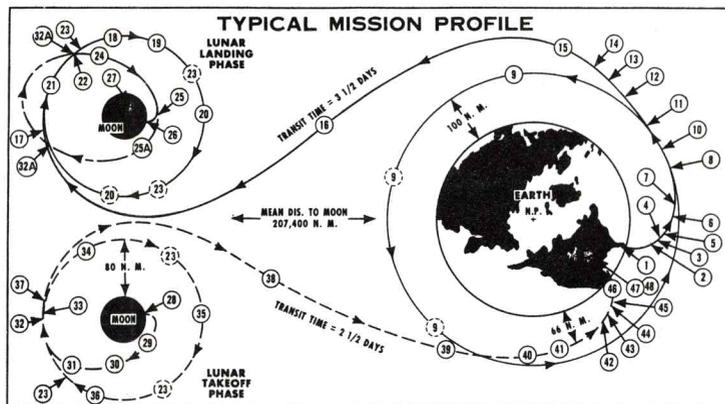
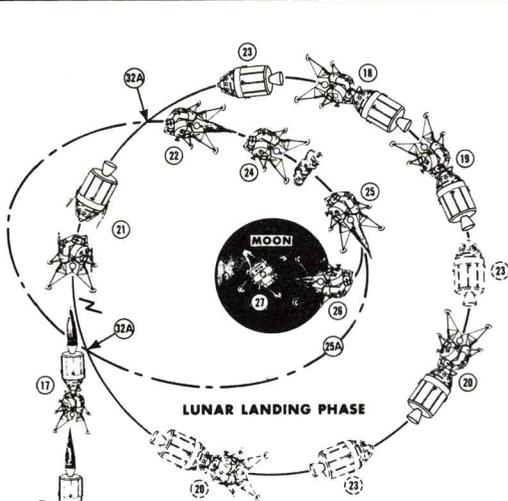
**INSTRUMENTATION SYSTEM:** Measures vehicle conditions and reactions during mission and transmits this information to ground for subsequent analysis, as well as providing for ground station-to-vehicle communication

**ELECTRICAL SYSTEM:** Provides basic operating power for all electronic and electrical equipment in the IU; also monitors vehicle performance and may initiate automatic mission abort if an emergency arises

**STRUCTURAL SYSTEM:** Serves as a load bearing part of the launch vehicle, supporting both the components within the IU and the spacecraft; composed of three 120-degree segments of thin-wall aluminum alloy face sheets bonded over a core of aluminum honeycomb about an inch thick

# SATURN V APOLLO

## LUNAR ORBITAL RENDEZVOUS MODE



### SEQUENCE OF OPERATIONS\*

1. S-IC STAGE IGNITION & VEHICLE LAUNCH
2. S-IC STAGE CUTOFF & JETTISON (IGNITE S-IC RETRO & S-II ULLAGE ROCKETS)
3. S-II STAGE IGNITION & THRUST BUILDUP
4. JETTISON S-II AFT INTERSTAGE (AT APPROX. FULL THRUST)
5. LAUNCH ESCAPE SYSTEM JETTISON (AFTER FULL S-II THRUST & VEHICLE STABILIZATION)
6. S-II STAGE CUTOFF & JETTISON (IGNITE S-II RETRO & S-IVB ULLAGE ROCKETS)
7. S-IVB STAGE IGNITION & ORBITAL VELOCITY BUILDUP
8. INSERTION INTO 100 N. M. (185KM) EARTH PARKING ORBIT & S-IVB ENGINE CUTOFF
9. EARTH PARKING ORBIT COAST (CHECKOUT CREW & EQUIPMENT)
10. IGNITE ULLAGE ROCKETS, S-IVB RE-IGNITION & THRUST BUILDUP TO ESCAPE VELOCITY
11. INJECTION INTO EARTH-MOON TRANSIT & S-IVB ENGINE CUTOFF
12. JETTISON FORWARD SECTION OF I.U./APOLLO INTERSTAGE ADAPTER
13. CSM SEPARATION FROM LEM/I.U./S-IVB & CSM TURN AROUND
14. CSM DOCKING TO LEM/I.U./S-IVB
15. JETTISON AFT APOLLO ADAPTER SECTION & I.U./S-IVB
16. MIDCOURSE CORRECTION [IGNITION (S) & CUTOFF (S) OF SM PROPULSION]\*
17. SM IGNITION & BRAKING INTO LUNAR PARKING ORBIT, ENGINE CUTOFF
18. LUNAR PARKING ORBIT COAST (CHECKOUT CREW, EQUIPMENT & LEM)

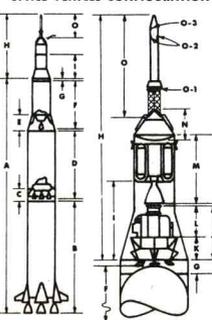
19. CREW TRANSFER (2 MEN) FROM CM TO LEM
20. PRE-DESCENT LEM CHECKOUT & LANDING SITE RECONNAISSANCE
21. SEPARATE LEM FROM CSM & TURN AROUND LEM TO DESCENT ATTITUDE
22. LEM LANDING STAGE IGNITION & BURNING TO DESCENT ELLIPSE
23. CSM CONTINUES IN LUNAR PARKING ORBIT (1 MAM)
24. LANDING STAGE PROP. CUTOFF & COAST VIA ELLIPTICAL ORBIT TO NEAR LUNAR SURFACE
25. LEM LANDING STAGE RE-IGNITION & BRAKING OUT OF ELLIPTICAL ORBIT
26. LEM HOVER, TRANSLATION, DESCENT MANEUVERS & LUNAR LANDING
27. LUNAR STAY (SCIENTIFIC EXPLORATION, EXPERIMENTS, & SAMPLE GATHERING)
28. LEM LUNAR LAUNCH STAGE IGNITION & LAUNCH (LEAVE LANDING STAGE ON MOON)
29. LUNAR LAUNCH STAGE POWERED ASCENT TO HOHMANN TRANSFER ELLIPSE
30. LUNAR LAUNCH STAGE PROP. CUTOFF & COAST TO LUNAR ORBIT VIA HOHMANN ELLIPSE\*
31. MIDCOURSE CORRECTION [IGNITION (S) & CUTOFF (S) OF MAIN PROPULSION]\*
32. MAIN ENGINE FIRING INTO CIRCULAR ORBIT, ENGINE CUTOFF, RENDEZVOUS & DOCKING
33. TRANSFER OF CREW (2 MEN) & SCIENTIFIC MATERIAL FROM LUNAR LAUNCH STAGE TO CM
34. JETTISON LEM LAUNCH STAGE (CONTINUES IN LUNAR ORBIT)
35. CHECKOUT OF CREW & CSM PRIOR TO LUNAR ORBIT ESCAPE
36. CSM ASSUME ATTITUDE FOR LUNAR ORBIT ESCAPE

37. SM IGNITION, INJECTION OF CSM INTO MOON-EARTH TRANSIT, ENGINE CUTOFF
38. MIDCOURSE CORRECTION [IGNITION (S) & CUTOFF (S) OF SM PROPULSION]\*
39. CM SEPARATION AND JETTISON OF SM
40. CM ESTABLISH RE-ENTRY ATTITUDE
41. CM EARTH ATMOSPHERE RE-ENTRY & AERODYNAMIC MANEUVER TO NEAR LANDING SITE
42. JETTISON FWD. COMPARTMENT HEAT SHIELD (AT 50,000 FT.)
43. DROGUE CHUTE DEPLOYMENT (BY MORTAR AT 25,000 FT.)
44. PILOT CHUTE DEPLOYMENT (BY MORTAR AT 15,000 FT.) & DROGUE CHUTE RELEASE
45. MAIN CHUTE DEPLOYMENT (REEFED CONDITION)
46. FINAL DESCENT WITH FULL CHUTE
47. EARTH LANDING AND MAIN CHUTE RELEASE
48. LAND RECOVERY

### ALTERNATE EMERGENCY PROCEDURE

- IF LEM CHECKOUT INDICATES LANDING NOT POSSIBLE, STEPS 25 THRU 32 ARE OMITTED AND THE FOLLOWING STEPS ARE TAKEN TO GET TO NO. 33:
- 25A. LEM CONTINUES IN ELLIPTICAL ORBIT COAST
  - 32A. RENDEZVOUS & DOCKING AT POINT OF ELLIPTICAL & CIRCULAR ORBITS INTERSECTION

### SPACE VEHICLE CONFIGURATION



### TECHNICAL DATA\*

DESCRIPTION	MISSION	WEIGHT (LBS) #	LENGTH (FT.)	DIAMETER (FT.)	ENGINE TYPE	TOTAL THRUST (LBS.)	LIQUID PROPELLANT CAPACITY (LBS.)	PHYSICAL DATA		APPROXIMATE VELOCITIES REQUIRED			
								EARTH	MOON	MPH	KNOTS		
A. 3 STAGE SATURN V LAUNCH VEHICLE	PAYLOAD TO PARKING ORBIT & ESCAPE VELOCITY	408.6 K	281.0	VARIABLE	5 F-1, 6 J-2	7,500 K (SEA LEVEL)	5,360 K	MEAN DIAM. IN MILES	4,875	1,877	INJECTION INTO 100 N. M. EARTH ORBIT	17,400	15,100
B. S-IC BOOSTER (SEE NOTE B-1)	INITIAL LIFT-OFF	287.0 K	128.0	33.0	5 F-1 LOX/SP-1	7,500 K (SEA LEVEL)	4,400 K	STATUTE	7,917	2,161	INJECTION INTO EARTH - MOON TRANSIT	24,300	21,100
C. S-IC/S-II INTERSTAGE ADAPTER	TRANSMITS THRUST FORCES FROM S-IC TO S-II	13.8 K	18.3	33.0	---	---	---	SURFACE GRAVITY	1 G	1/6 G	INJECTION INTO MOON-EARTH TRANSIT	5,100	4,400
D. S-II SECOND STAGE (SEE NOTE B-2)	VELOCITY BUILDUP FOR ORBITAL INJECTION	75.0 K	81.5	33.0	5 J-2 LOX/H <sub>2</sub>	1,000 K (VACUUM)	930 K	ATMOSPHERE	---	---	INJECTION INTO MOON-EARTH TRANSIT	5,100	4,400
E. S-II/S-IVB INTERSTAGE SHROUD	TRANSMITS THRUST FORCES FROM S-IC & S-II TO S-IVB	7.4 K	19.0	21.6 TO 33.0	---	---	---	TEMPERATURE IN SUN ("F)	MEAN +312*	---	EARTH ATMOSPHERE RE-ENTRY	24,400	21,200
F. S-IVB THIRD STAGE (SEE NOTE B-A,B)	APOLLO INJECTION INTO EARTH ORBIT AND EARTH-MOON TRANSIT	21.9 K	36.6	21.6	1 J-2 LOX/H <sub>2</sub>	200 K (VACUUM)	230 K	IN SHADOW	MEAN -243*	---	---	---	---
G. LAUNCH VEHICLE INSTRUMENT UNIT (I. U.)	GUIDANCE & CONTROL OF LAUNCH VEHICLE	3.3 K	3.0	31.6	---	---	---	---	---	---	---	---	---
H. APOLLO SPACECRAFT	LUNAR BRAKING, ORBIT, LANDING, LAUNCH & EARTH RETURN	56.8 K	78.9	VARIABLE	3 HYPERGOLIC STORABLES**	---	---	---	---	---	---	---	---
I. I.U./APOLLO INTERSTAGE ADAPTER	TRANSMITS LAUNCH VEHICLE THRUST TO CSM, HOUSES & SUPPORTS LEM	---	---	12.8 TO 21.6	---	---	---	---	---	---	---	---	---
J. LUNAR EXCURSION MODULE (LEM)	MANNED LUNAR LANDING AND TAKE OFF	---	---	14	2 HYPERGOLIC STORABLES	---	---	---	---	---	---	---	---
K. LEM LUNAR LANDING STAGE (SEE NOTE B-A,C)	LUNAR ORBIT(S) BRAKING, LUNAR HOVERING, TRANSLATION, DESCENT & LANDING	30.0 K	49.9	14	1 HYPERGOLIC STORABLE	10 K (VACUUM)	---	---	---	---	---	---	---
L. LEM LUNAR LAUNCH STAGE (SEE NOTE B-A)	LUNAR LAUNCH & INJECTION INTO LUNAR ORBIT	---	---	---	1 HYPERGOLIC STORABLE	3 K	---	---	---	---	---	---	---
M. SERVICE MODULE (SM) (SEE NOTE B-A,B)	MIDCOURSE CORRECTIONS, LUNAR BRAKING & ESCAPE PROPULSION	---	---	12.8	1 HYPERGOLIC STORABLE	23 K	---	---	---	---	---	---	---
N. COMMAND MODULE (CM)	MANNED LUNAR ORBIT & EARTH RETURN, MAIN APOLLO CONTROL	---	---	12.8	NONE	---	---	---	---	---	---	---	---
O. APOLLO LAUNCH ESCAPE SYSTEM (LES)	CREW ESCAPE DURING ABORT	6.6 K	33.2	2.2	3 SOLID FUEL MOTORS	---	---	---	---	---	---	---	---
Q-1 LAUNCH ESCAPE MOTOR	PULLS CM CLEAR OF ABORTED LAUNCH VEHICLE	---	---	---	SOLID FUEL	150 K FOR 3+ SECS.	---	---	---	---	---	---	---
Q-2 TOWER JETTISON MOTOR	JETTISONS TOWER AFTER SUCCESSFUL LAUNCH OR ABORT	---	---	---	SOLID FUEL	33 K FOR 1.3 SECS.	---	---	---	---	---	---	---
Q-3 PITCH MOTOR	PROVIDES TURN DIRECTION FOR LES TOWER OR LES/CM	---	---	---	SOLID FUEL	5 K FOR .3 SECS.	---	---	---	---	---	---	---
LOX VEHICLE (TOTAL)	MANNED LUNAR LANDING AND RETURN	6,000 K	360.0	MAX 33.0	14 MAIN PROPUL. ENGINES	---	---	---	---	---	---	---	---

\* UNDERLINED WEIGHTS INCLUDE LIQUID PROPELLANTS; OTHERS ARE DRY K=1000

- NOTES:
1. COAST PERIODS ARE BETWEEN POSITIONS 8 & 10, 11 & 16, 16 & 17, 17 & 23, 24 & 25, 30 & 31, 31 & 32, 35 & 37, 37 & 38, 38 & 41. (NO MAIN PROPULSION SYSTEM IN OPERATION).
  2. ULLAGE ROCKET FIRING REQUIRED BEFORE IGNITIONS 3, 7, AND 10 TO FORCE PROPELLANTS TO BOTTOM OF TANKS BEFORE MAIN PROPULSION IGNITION
  3. MULTIPLE RESTARTS (AS REQUIRED DURING COAST PERIODS FOR TRAJECTORY CORRECTIONS).
  4. \*\* FULL AND OXIDIZER BI-PROPELLANT, STORABLE AT NORMAL TEMPERATURES, THAT IGNITES SPONTANEOUSLY WHEN MIXED.
  5. AN OPTIMUM FLIGHT PATH USING AN ELLIPTICAL COASTING TRANSFER WITH POWERED FLIGHT AT LAUNCH AND TERMINAL POINTS ONLY (VS. CONTINUOUS BURN) TO CONSERVE PROPELLANTS.
  6. --- INDICATES SCALE CHANGES IN STAGE AND MODULE SKETCHES.
  7. \* THESE DIAGRAMS HAVE BEEN PURPOSEFULLY ALTERED IN SCALE AND PERSPECTIVE TO BETTER SHOW CONFIGURATIONS AND OPERATIONAL SEQUENCE, AND ARE FOR INFORMATIONAL PURPOSES ONLY. FOR CLARITY'S SAKE, VERY LITTLE CONSIDERATION HAS BEEN GIVEN TO RELATIVE MOTIONS AND POSITIONS OF THE EARTH VS. THE MOON DURING ELAPSED TIME INTERVALS SHOWN. THIS CHART REPRESENTS ONE OF SEVERAL TYPICAL PROFILES CURRENTLY BEING CONSIDERED AND IS SUBJECT TO CONTINUOUS CHANGE. ALL TECHNICAL DATA SHOWN IS APPROXIMATE.
  8. PROPULSION STG. CAPABLE OF (A) RESTART (B) GIMBALLING (C) THROTTLING



MARSHALL SPACE FLIGHT CENTER  
M-C-P-500a JUNE 15, 1963  
PREPARED BY: E. E. ASBOTT ILLUSTRATOR: JOE MADDOX

