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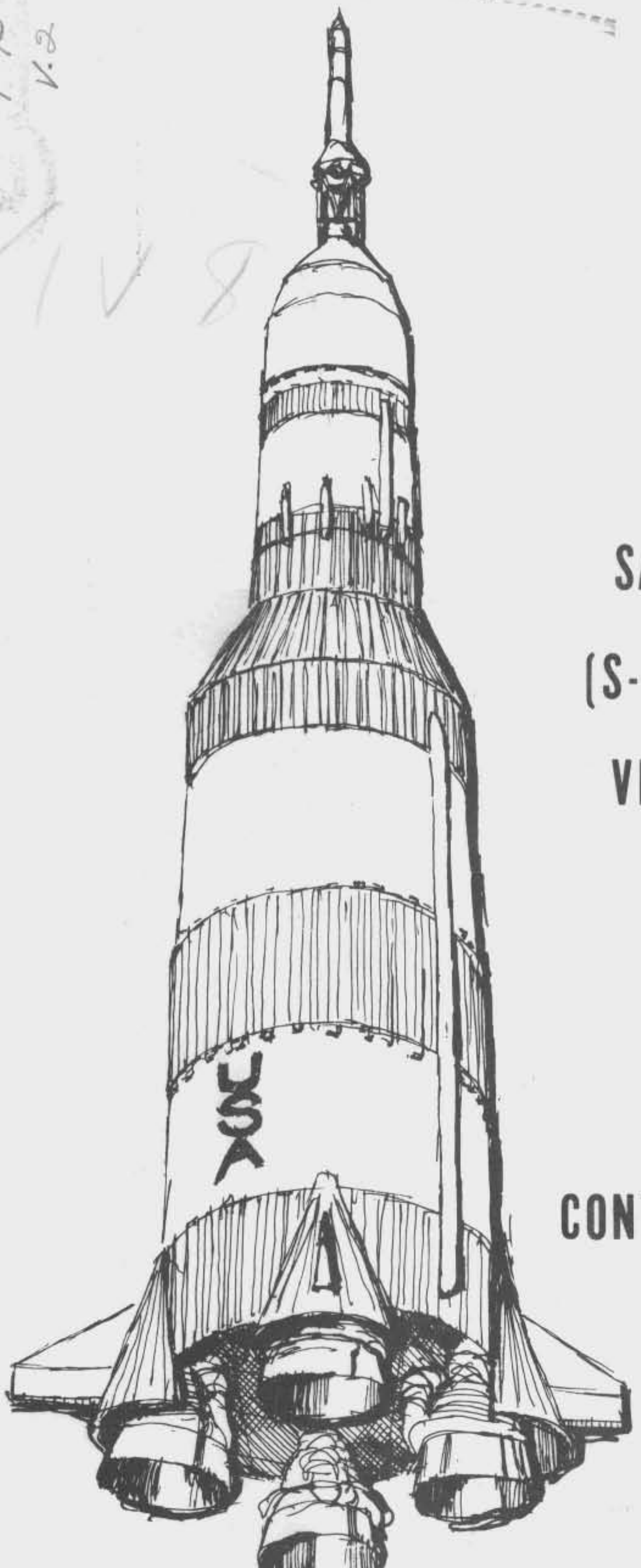
D5-17009-2
VOLUME II



APPENDICES

SATURN V DERIVATIVE (S-IC/S-IVB/I.U.) LAUNCH VEHICLE SYSTEM STUDY

SEPTEMBER 15, 1969

CONTRACT NO. NAS 8-30506

DOCUMENT NO. D5-17009-2

VOLUME II

TITLE: APPENDICES - SATURN V DERIVATIVE (S-IC/S-IVB/IU)
LAUNCH VEHICLE SYSTEM STUDY

CONTRACT NO. NAS8-30506

SEPTEMBER 15, 1969

THE BOEING COMPANY SPACE DIVISION LAUNCH SYSTEMS BRANCH

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APPENDIX A

S-IC STAGE DATA

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Appendix A, Section 1

S-IC Back-up Data

A.1 S-IC DESIGN CHANGE/REQUIREMENTS MATRIX

The correlations between S-IC design changes, the INT-20 requirements necessitating the changes, and the impact on the S-IC contract end item (CEI) specification are shown in Table A-1.

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TABLE A-1. S-IC DESIGN CHANGE/REQUIREMENTS MATRIX

STRUCTURES SUBSYSTEM CHANGES	CHANGE DESCRIPTION REFERENCE (D5-17009-2)	SUPPORTING DATA REFERENCE (D5-17009-3, APPENDIX A)	INT-20 REQUIREMENT	CEI SPECIFICATIONS IMPACT (CEI PARAGRAPH)
Forward Skirt				3.1.1 Functional Characteristics 3.1.1.1.1 Support and boost of upper vehicle 3.1.2.8.3 Temperature and pressure 3.1.2.8.4 Aerodynamic and structural loads 3.2.1 Interface requirements
No change required	4.2.2.1.a.1	2.1.2.2	Revised loads and environment	
Oxidizer Tank				
Add inboard suction fitting cover	4.2.2.1.a.2	2.1.3.1.b	No. 5 engine LOX duct deleted	3.3.1.2.1.2 Oxidizer tank 3.1.1.2.1 Stage mass properties
Delete LOX standpipe	4.2.2.1.a.2	2.1.3.1.a	Standpipe not required (Cost reduction)	3.1.1.2.1 Stage mass properties
Add support ring	4.2.2.1.a.2	2.1.3.1.a	Provide cruciform support and maintain existing bulkhead fitting geometry	3.3.1.2.1.2 Oxidizer tank 3.1.1.2.1 Stage mass properties
No change required	N/A	2.1.3.2	Revised tank loads and environment	3.1.2.8.3 Temperature and pressure 3.1.2.8.4 Aerodynamic and structural loads 3.1.2.8.1 Vibration, acoustics and shock
Intertank Structure				
No change required	N/A	2.1.4	Revised loads and environment	3.1.2.8.1 Vibration, acoustics and shock 3.1.2.8.4 Aerodynamic and structural loads
Fuel Tank				
Add inboard fuel suction elbow covers	4.2.2.1.a.4(a)	2.1.5.1	No. 5 engine fuel suction ducts deleted	3.1.1.2.6 Fuel fill and drain systems 3.3.1.2.1.4 Fuel tank 3.1.1.2.1 Stage mass properties
Add inboard LOX tunnel cover	4.2.2.1.a.4(b)	2.1.5.1	No. 5 engine LOX suction duct deleted. Cover for personnel safety and to construct gas flow	3.3.1.2.1.4 Fuel tank 3.1.1.2.1 Stage mass properties
Revise base gores	4.2.2.1.a.4(c)	2.1.5.2.c	Increased hoop compression loads	3.1.2.8.3 Temperature and pressure 3.1.1.2.1 Stage mass properties
Revise instrumentation cover	4.2.2.1.a.4(d)	-	Relief pressure switch added for revised prepressurization schedule	-
No change required		2.1.5.2	Revised tank loads and environment	3.1.2.8.3 Temperature and pressure 3.1.2.8.1 Vibration, acoustics and shock 3.1.2.8.4 Aerodynamic and structural loads

TABLE A-1 (Continued)

STRUCTURES SUBSYSTEM CHANGES	CHANGE DESCRIPTION REFERENCE (D5-17009-2)	SUPPORTING DATA REFERENCE (D5-17009-3, APPENDIX A)	INT-20 REQUIREMENT	CEI SPECIFICATION IMPACT (CEI PARAGRAPH)
Thrust Structure				
Delete No. 5 engine support structure	4.2.2.1.a.5(a)	2.1.6.1	No. 5 engine deleted	3.1.1 Functional characteristics 3.1.1.2.1 Stage mass properties 3.1.1.2.2.5 Structural support for engines 3.3.1.1.1.2 Engine location 3.3.1.2.1.5 Thrust structure 3.2.1 Interface requirements
Delete No. 5 engine fuel suction duct support links	4.2.2.1.a.5(b)	-	No. 5 engine fuel suction ducts deleted	3.1.1.2.1 Stage mass properties
No change required	N/A	2.1.6.3	Revised loads and environment	3.1.2.8.1 Vibration, acoustics and shock 3.1.2.8.3 Temperature and pressure 3.1.2.8.4 Aerodynamic and structural loads
Heat Shield				
Revise heat shield panel configuration	4.2.2.1.a.6	2.1.7	No. 5 engine heat shield penetrations deleted	3.1.1.2.1 Stage mass properties 10.1.7 Static firing head shield 3.2.1 Interface requirements
Delete No. 5 engine flame curtain	4.2.2.1.a.6	-	No. 5 engine deleted	
Revise heat shield support structure	4.2.2.1.a.6	2.1.7	Small panel support requirements deleted	3.1.1.2.1 Stage mass properties
No change required	N/A	2.1.7	Revised thermal environment	3.1.2.8.3 Temperature and pressure 3.1.2.8.1 Vibration, acoustics and shock 3.1.2.8.3.3 Base region

TABLE A-1 (Continued)

PROPULSION/MECHANICAL SUBSYSTEM CHANGES	CHANGE DESCRIPTION REFERENCE (D5-17009-2)	SUPPORTING DATA REFERENCE (D5-17009-3, APPENDIX A)	INT-20 REQUIREMENT	CEI SPECIFICATIONS IMPACT (CEI PARAGRAPH)
Oxidizer Fill and Drain System				
No change required	-	2.2.2	Increased ullage volume	3.1.1.2.3 Oxidizer fill, feed and drain systems
Oxidizer Feed System				
Delete inboard LOX suction duct, prevalve and PVC	4.2.2.1.b.1(b)	2.2.3.1	No. 5 engine deleted	3.1.1.2.3 Oxidizer fill, feed and drain systems 3.2.1 Interface requirements 3.1.1.2.1 Stage mass properties
Add inboard LOX interconnect spool support adapter and closure plates	''	2.2.3.1	LOX interconnect system retained for LOX fill conditioning, circulation and drain	3.1.1.2.1 Stage mass properties
Delete LOX cutoff sensors at engine positions 2, 4 & 5	''		No. 5 engine LOX feed system deleted No. 2 & 4 engine early cutoff	3.1.1.1.4.1 Propulsion thrust termination
Add redundant LOX cutoff sensors at engine positions 1 and 3	''	2.2.3.2	Retain LOX depletion cutoff logic (2 out of 4 voting)	3.1.1.1.4.1 Propulsion thrust termination 3.1.2.7.2.3 Redundancies
Oxidizer Interconnect System				
Replace position 2, normally closed, interconnect valve with duct segment (spool)	4.2.2.1.b.1(c)(1)	2.2.4.1	Retain system performance characteristics and reliability	3.2.1 Interface requirements 3.1.1.2.1 Stage Mass properties
Add temperature transducer in LOX interconnect system	''		To monitor system operation	3.1.1.2.18.4 Data transmitted 3.1.1.2.22.2 Hardware data signals
Oxidizer Bubbling System				
Delete bubbling line to No. 5 engine	4.2.2.1.b.1(c)(2)	2.2.5	No. 5 engine deleted	3.2.1 Interface requirements 3.1.1.2.1 Stage mass properties
Oxidizer Pressurization System				
Delete GOX return line from engine interface to GOX manifold	4.2.2.1.b.1(d)	2.2.6.1		3.2.1 Interface requirements 3.1.1.2.1 Stage mass properties
Add closure plate to GOX manifold	''			3.1.1.2.1 Stage mass properties
Replace the LOX tank pre-press and relief switches with similar switches of higher pressure setting	4.2.2.1.b.1(d)	2.2.6.2	To meet F-1 engine start NPSH with increased ullage required for INT-20 1.25:1 thrust to weight ratio	3.2.1 Interface requirements

PROPULSION/MECHANICAL SUBSYSTEM CHANGES	CHANGE DESCRIPTION REFERENCE (D5-17009-2)	SUPPORTING DATA REFERENCE (D5-17009-3, APPENDIX A)	INT-20 REQUIREMENT	CEI SPECIFICATIONS IMPACT (CEI PARAGRAPH)
Fuel Fill and Drain System				
Lengthen fuel loading probe	4.2.2.1.b.2(a)	2.2.7.1	Increased ullage volume	3.1.1.2.6.1.1 Fuel loading measurements 3.1.1.2.1 Stage mass properties
Fuel Feed System				
Delete all inboard fuel feed components (ducts, prevalves, PVC) from fuel tank elbow to engine interface	4.2.2.1.b.2(b)	2.2.7.2	No. 5 engine deleted	3.1.1.2.6 Fuel fill, feed and drain systems 3.2.1 Interface requirements 3.1.1 2.1 Stage mass properties
Fuel Pressurization System				
Delete helium supply and return pressurization ducts from helium manifold to engine interface	4.2.2.1.b.2(c)	2.2.7.3		3.2.1 Interface requirements 3.1.1.2.1 Stage mass properties
Add closure plate at helium manifold		2.2.7.3		3.1.1.2.1 Stage mass properties
Resize helium flow control orifice plates		2.2.7.4	To meet F-1 engine start NPSH and tank structural requirements during flight	
Increase the prepressurization relief pressure switch setting and add a relief pressure switch with a higher setting. Replace relief valve with existing similar valve which has a higher mechanical relief pressure setting	4.2.2.1.b.2.(c)	2.2.7.4	Increased ullage for 1.25:1 thrust to weight ratio	3.2.1 Interface requirements
Control Pressure System				
Delete control pressure system components for No. 5 engine prevalves and No. 2 interconnect valve	4.2.2.1.b.3(a)	2.2.8.1	No. 5 engine LOX and fuel feed system deleted No. 2 interconnect valve deleted	3.1.1.2.1 Stage mass properties
Turbopump LOX Seal Purge System				
Delete LOX seal purge line from inboard engine interface to purge manifold	4.2.2.1.b.3(c)(1)	2.2.8.2	No. 5 engine deleted	3.2.1 Interface requirements 3.1.1.2.1 Stage mass properties

TABLE A-1 (Continued)

PROPULSION/MECHANICAL SUBSYSTEM CHANGES	CHANGE DESCRIPTION REFERENCE (D5-17009-2)	SUPPORTING DATA REFERENCE (D5-17009-3, APPENDIX A)	INT-20 REQUIREMENT	CEI SPECIFICATIONS IMPACT (CEI PARAGRAPH)
LOX Dome and GG Purge Delete LOX dome and GG purge line from inboard engine interface to purge manifold	4.2.2.1.b.3(c)(3)	2.2.8.2	No. 5 engine deleted	3.2.1 Interface requirements 3.1.1.2.1 Stage mass properties
Engine Cocoon Conditioning Purge Delete conditioning purge line from inboard engine interface to manifold	4.2.2.1.b.3(c)(4)	2.2.8.2	No. 5 engine deleted	3.2.1 Interface requirements 3.1.1.2.1 Stage mass properties
Thrust OK Checkout Delete CALIPS line from inboard engine interface to manifold	4.2.2.1.b.3(c)(5)	2.2.8.2	No. 5 engine deleted	3.2.1 Interface requirements 3.1.1.2.1 Stage mass properties
Thrust Chamber Prefill Delete prefill line from inboard engine interface to manifold	4.2.2.1.b.3(c)(6)	2.2.8.2	No. 5 engine deleted	3.2.1 Interface requirements 3.1.1.2.1 Stage mass properties
POGO Suppression Delete POGO suppression line from inboard engine interface to manifold	4.2.2.1.b.3(c)(7)	2.2.8.2	No. 5 engine deleted	3.1.1.2.1 Stage mass properties
Fluid Power System Delete inboard engine hydraulic supply and return lines from inboard engine interface to manifolds Add closure plates to manifolds	4.2.2.1.b.4(a)	2.2.8.3	No. 5 engine deleted	3.2.1 Interface requirements 3.1.1.2.1 Stage mass properties
Thrust Vector Control No change	4.2.2.1.b.4(b)	2.2.8.4		
Engine and Related Components Delete inboard engine, loose equipment, thermal insulation, static firing GN_2 purge, engine attachment and support hardware	4.2.2.1.b.5		INT-20 configuration - 4 engine S-IC	3.1.1 Functional characteristics 3.1.1.2.1 Stage mass properties 3.2.1 Interface requirements 3.3.1.1.2 Engine location

TABLE A-1 (Continued)

ELECTRICAL/ELECTRONIC SUBSYSTEM CHANGES	CHANGE DESCRIPTION REFERENCE (D5-17009-2)	SUPPORTING DATA REFERENCE (D5-17009-3, APPENDIX A)	INT-20 REQUIREMENT	CEI SPECIFICATIONS IMPACT (CEI PARAGRAPH)
Power Generation & Distribution				
No change required	N/A	2.3.1	Revise distribution to accommodate circuitry changes	
S-IC/S-IVB Interface				
Delete thrust OK and add simulated S-II/S-IVB separation measurements	4.2.2.1.c.2	2.3.2.1	Minimize I.U. impact and facilitate reversibility	3.2.1 Interface requirements
Lengthen interface cables	4.2.2.1.c.2	2.3.2.2	Different S-IVB interface location	
Sequence and Control				
Deactivate center engine circuitry	4.2.2.1.c.3(a)		Center engine deleted	3.2.1 Interface requirements
Provide sequenced engine cutoff	4.2.2.1.c.3(a) 4.2.2.1.c.3(b)	2.3.3.1.a	To avoid exceeding structural acceleration limit	3.1.1.1.4.1 Propulsion thrust termination
Provide "G" limit engine cutoff	4.2.2.1.c.3(a) 4.2.2.1.c.3(b)	2.3.3.1.b 2.3.3.1.c	Provides optimum stage performance and cutoff mode versatility	3.1.1.1.4.1 Propulsion thrust termination
Provide redundant LOX level sensors for engines 1 & 3	4.2.2.1.c.3(a)	2.3.3.1.d 2.3.3.1.f	To maintain LOX depletion cutoff 2 of 4 voting logic	3.1.2.7.2.3 Redundancies
Provide reverse sequence engine cutoff	4.2.2.1.c.3(a) 4.2.2.1.c.3(b)	2.3.3.1.e 2.3.3.1.f 2.3.3.1.g	Provides optimum performance for single engine cutoff	3.1.1.1.4.1 Propulsion thrust termination
Revise fuel tank vent pressure switch circuitry	4.2.2.1.c.3(a) 4.2.2.1.c.3(b)	2.3.3.2	Revised prepressurization schedule	
Emergency Detection System				
No change required	N/A	2.3.4	Requirements are not changed	
Range Safety System				
No change required	N/A	2.3.5	Requirements are not changed	

TABLE A-1 (Continued)

ELECTRICAL/ELECTRONIC SUBSYSTEM CHANGES	CHANGE DESCRIPTION REFERENCE (D5-17009-2)	SUPPORTING DATA REFERENCE (D5-17009-3, APPENDIX A)	INT-20 REQUIREMENT	CEI SPECIFICATIONS IMPACT (CEI PARAGRAPH)
Separation & Ordnance System				
Lengthen interface cabling	4.2.2.1.c.6	2.3.6	Different S-IVB interface location	3.2.1 Interface requirements
Propellant Loading System				
No change required	N/A	2.3.7	Increased ullage	
Measuring System				
Add 19 measurements	4.2.2.1.c.8(a)	2.3.8	To monitor revised stage environment	
Deactivate 39 measurements	4.2.2.1.c.8(a)	2.3.8	Center engine and associated hardware deleted	3.1.1.2.18.4 Data transmitted
Electrical Network				
Revise distributor wiring and add relay card	4.2.2.1.c.9(a) thru (g)	2.3.9.2	To implement system changes with minimal impact and to facilitate reversibility	
Revise electrical cablin	4.2.2.1.c.9(h)	2.3.9.1	To implement system changes with minimal impact and to facilitate reversibility	

2.0 DESIGN DATA, TRADES AND RATIONALE

2.1 STRUCTURES SUBSYSTEMS

2.1.1 Loads and Environment

The loads and environment used in establishing and evaluating the S-IC stage baseline structural configuration defined in D5-17009-2, Section 4.2.2.1.a are included in this section. The applicable rationale and assumptions are also shown. This data encompasses and supplements the vehicle technical data included in D5-17009-2, Section 4.1.

2.1.1.1 Stage Shear

The baseline INT-20 vehicle ground wind shear distribution is shown in D5-17009-2, FIGURE 4.1.6.2-1*. The ground wind shear for the S-IC stage corresponding to a 99.9% pre-launch wind was conservatively assumed to act for all INT-20 conditions.

2.1.1.2 Stage Moment

The baseline INT-20 vehicle bending moment distribution for ground wind, max $q\alpha$, on pad, rebound, and maximum acceleration conditions are shown in FIGURE 4.1.6.2-2*, FIGURE 4.1.6.3-5*, TABLE 4.1.6.2-1*, TABLE 4.1.6.2-III and TABLE 4.1.6.3-III* of D5-17009-2, respectively.

2.1.1.3 Stage Longitudinal Force

The baseline INT-20 vehicle longitudinal force distribution for on pad, rebound, max $q\alpha$, and maximum acceleration conditions are shown in FIGURES 4.1.6.3-3* through 4.1.6.3-7 of D5-17009-2. These values are based on acceleration data developed during the Phase I study effort. The revised accelerations developed during Phase II per FIGURE A-23 will change these values slightly. However, the impact will not be significant for this study.

2.1.1.4 Stage Combined Loads

a. Compressive loads

The combined compressive loads per linear inch of stage circumference due to moment, longitudinal force and minimum tank ullage pressure are calculated in TABLES 4.1.6.2-1, 4.1.6.2-III, 4.1.6.3-1 and 4.1.6.3-III of D5-17009-2. Values are shown for on pad, rebound, max $q\alpha$ and maximum acceleration conditions. The maximum combined ultimate compressive loads are shown in D5-17009-2, FIGURE 4.1.6.3-1.

2.1.1.4 (Continued)

b. Tension loads

The combined tension loads per linear inch of stage circumference due to moment, longitudinal force and maximum tank ullage pressure are calculated in TABLES 4.1.6.2-II, 4.1.6.2-IV, 4.1.6.3-II and 4.1.6.3-IV of D5-17009-2. Values are shown for on pad, rebound, max $q\alpha$ and maximum acceleration conditions. The maximum combined tension loads are shown in D5-17009-2, FIGURE 4.1.6.3-3.

2.1.1.5 S-IC Tank Pressures

a. Baseline flight pressures

S-IC propellant tanks will be subjected to higher flight pressure loadings on INT-20 than on Sat V. The reason being that INT-20 will experience higher acceleration due to the reduced vehicle weight and relatively higher propellent levels during flight due to the lower four engine burnrate. The tanks do however have a margin of safety for Sat V pressures. Considerable effort was extended during the Phase I and Phase II study efforts to assure that the increased baseline INT-20 pressures would not exceed the capability.

The Phase I tank pressure studies were based on simplified analysis methods which did not include all engine performance characteristics or 3-Sigma dispersions. The techniques used would generally be adequate for a preliminary design. The Phase I analysis did show the actual tank pressures very close to the capability; therefore in consideration of the impact of a possible tank redesign it was decided that a detailed tank pressure evaluation was warranted during the Phase II activity.

Saturn V methods and computer programs were used for the Phase II INT-20 tank pressure study. The technique consists of a series of iterations involving ullage pressures, performance parameters, propellant levels, and structural and systems capabilities. The result is a combination of ullage pressure schedules, propellant loads, accelerations and other parameters based on the stage capability. Two iterations were performed for INT-20. These iterations are discussed in the following paragraphs:

1. First iteration

(a) First iteration stage performance

The Mark VII A computer program used for Sat V was modified to simulate an INT-20 vehicle with a liftoff acceleration of 1.25 g's and a 2-2 engine cutoff sequence limiting the vehicle acceleration

2.1.1.5 (Continued)

(a) to 4.68 g's at cutoff of each engine pair. The 1.25 g acceleration after completion of the slow release (.625 seconds after hold down arm release, HDAR) determined the total propellant load. The propellant loads (T = -7 seconds) considered are presented in TABLE A-11. The first stage dry weight used was 256,620 pounds and the total upper stage weight used was 405,837 pounds.

The following assumptions were included in the Mark VII A simulation:

(1) Rocketdyne F-1 engine tag values (1522 K Nominal, 1544 K at HDAR).

(2) Standard F-1 engine tag value climb out.

(3) Two degree engine cant after 20 seconds of flight.

(4) Sat V Lox and Fuel Tank ullage pressure schedules (it was determined that revised schedules for INT-20 would have no significant impact on the Mark VII A run).

(5) Gradual release mechanism after hold down arm release.

(6) Depletion and timer cutoff systems presently used on Sat V.

The following three different cases were simulated within the 2-2 cutoff sequence. TABLE A-11 shows propellant loads, load levels, ullage volumes, and propellant densities for each case.

(1) Case 1: First pair cutoff by timer at 137.325 seconds and 4.31 g's. Second pair cutoff by timer at 219.25 seconds and 4.31 g's.

(2) Case 2: First pair cutoff by timer at 137.325 seconds and 4.31 g's. Second pair cutoff by Lox depletion at 216.098 seconds and 4.496 g's.

(3) Case 3: First pair cutoff by timer at 137.375 seconds and 4.31 g's, second pair cutoff by fuel depletion at 214.884 seconds and 4.496 g's.

All timer cutoff accelerations were limited to 4.31 g's because of a ± 3-sigma acceleration band of ± 0.37 g's estimated from timer cutoffs of the S-IC stages. This will limit the INT-20 acceleration to 4.68 g's up to the improbable event of a +0.37 g acceleration over nominal at

TABLE A-II. INT-20 PROPELLANT LOADS, FIRST ITERATION

	Case I Timer cutoff of 2nd Engine Pair	Case II LOX Depletion of 2nd Engine Pair	Case III Fuel Depletion of 2nd Engine Pair
LOX Load (lb.)	3,045,980	3,002,660	3,067,476
Fuel Load (lb.)	1,313,818	1,354,785	1,293,137
LOX Level (Sta. No.)	1421.8 in.	1413.0 in.	1426.3 in.
Fuel Level (Sta. No.)	651.1 in.	665.0 in.	644.4 in.
LOX Ullage Vo. (%)	10.5%	11.8%	9.9%
Fuel Ullage Vol. (%)	10.9%	8.1%	12.3%
LOX Den. (lb./ft.^{3})	71.0	71.0	71.0
Fuel Den. (lb./ft.^{3})	50.1	50.1	50.1

2.1.1.5 (Continued)

the time of timer cutoff. Similarily, the Lox and fuel depletion cutoffs of the second pair of engines were limited to 4.496 g's because of the ± 3-sigma acceleration band of ±0.184 g's estimated from level cutoffs of the S-IC stages. This will limit the INT-20 vehicle acceleration to 4.68 g's up to the improbable event of a +3-sigma acceleration of 0.184 over nominal at the time of a depletion cutoff.

Time history plots of INT-20 vehicle mass, vehicle thrust, acceleration, altitude, velocity, and propellant levels resulting from the first iteration Mark VIIA computer run for the three cases mentioned above are shown in FIGURES A-1 thru A-11. Acceleration and propellant level 3-sigma dispersions estimated for INT-20 based on S-IC dispersion studies are also shown where applicable. The altitude and velocity data are subject to possible revisions by a more comprehensive 6-D trajectory program.

(b) First iteration ullage pressures

The Lox and Fuel ullage pressures for INT-20 have been increased over Sat V values for engine start and during early flight (to T + 50 seconds) because of NPSH requirements due to reduced INT-20 propellant heads. The INT-20 ullage pressures (PSIA and PSIG) and the ambient pressures are shown in FIGURES A-12 thru A-16. The revised pressure schedules and systems changes are discussed in detail in D5-17009-2, Section 4.2.2.1.b.1.(d) and 4.2.2.1.b.2(c) and Section 2.2.6 and 2.2.7.4 of APPENDIX A.

(c) First iteration total pressure

Total tank pressure is a combination of ullage pressure, liquid head and acceleration. Three-sigma dispersion liquid head and acceleration effects are taken into account by considering the worst of the following three possibilities:

(1) Nominal liquid head and acceleration
(2) +3-Sigma Liquid head and -3-Sigma Acceleration
(3) -3-Sigma Liquid head and +3-Sigma Acceleration

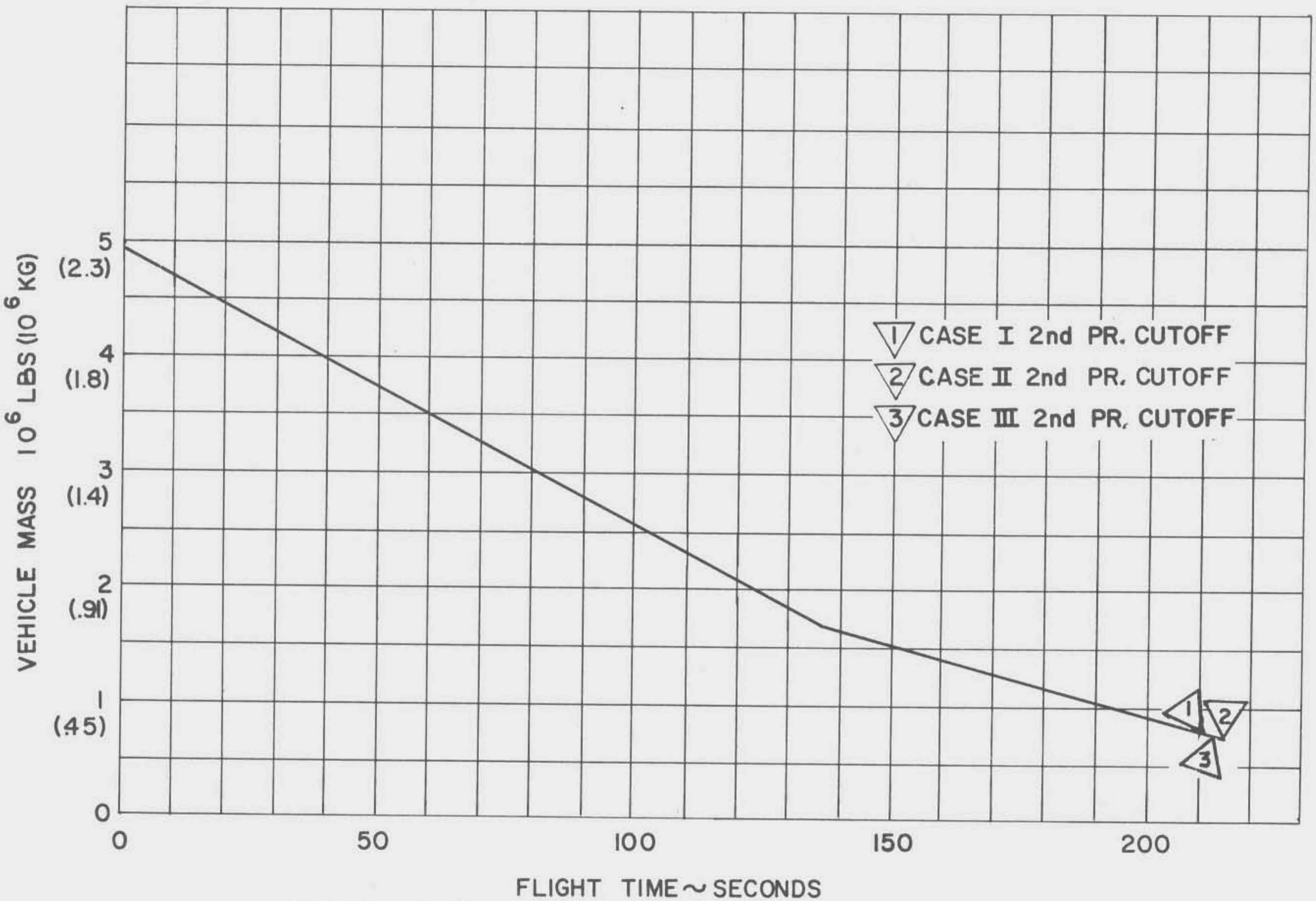


FIGURE A-1. VEHICLE MASS (INT-20), FIRST ITERATION

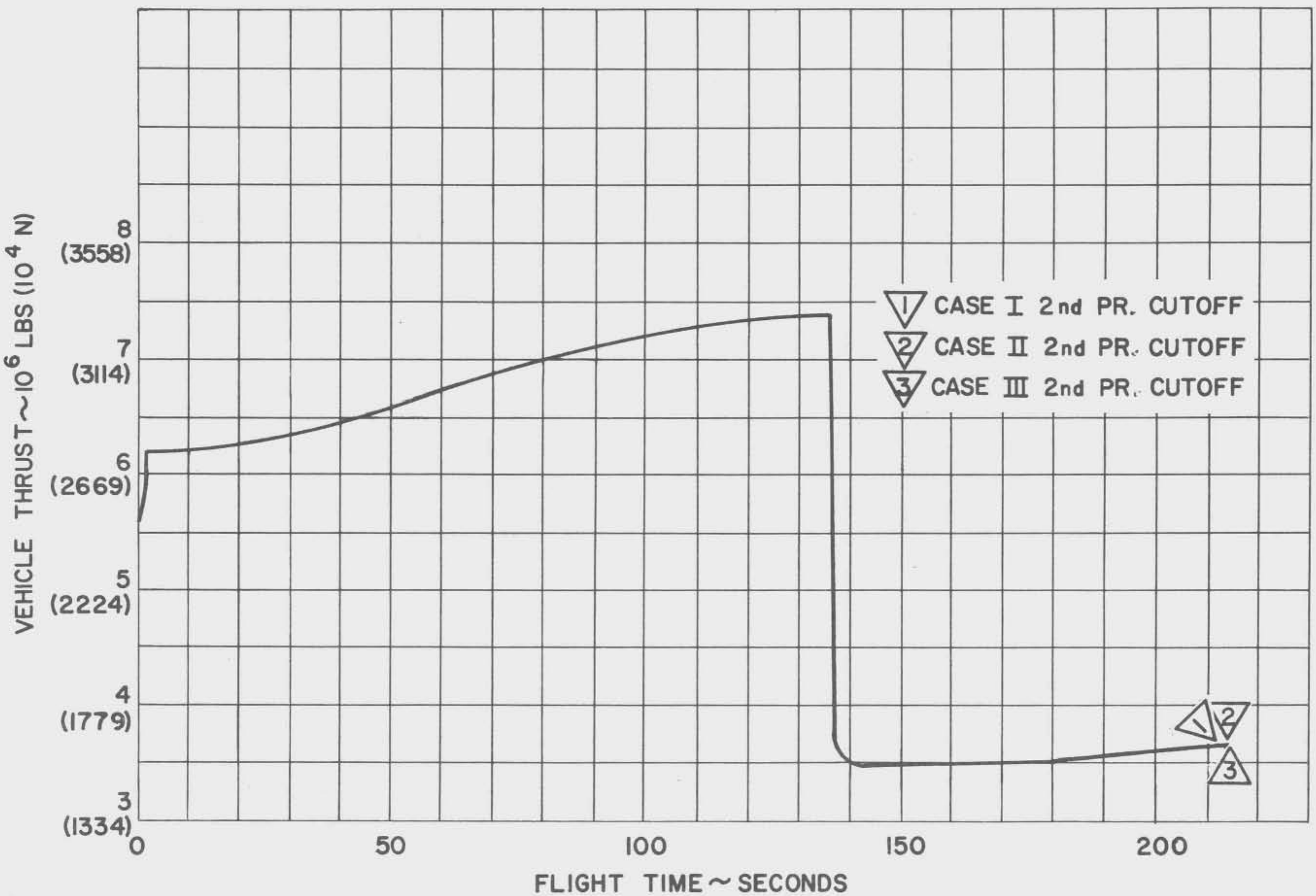


FIGURE A-2. VEHICLE THRUST (INT - 20), FIRST ITERATION

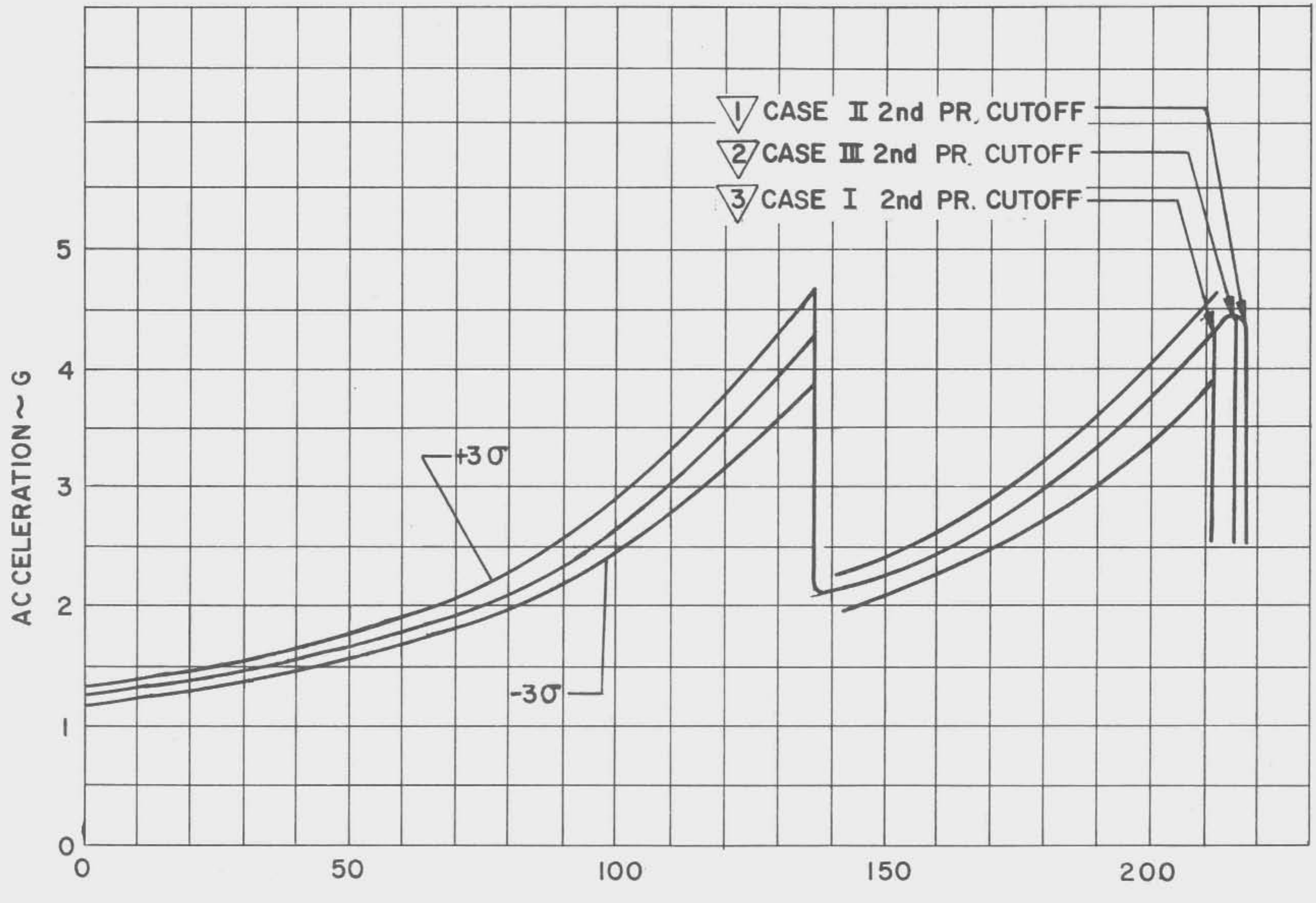


FIGURE A-3. VEHICLE ACCELERATION (INT-20), FIRST ITERATION

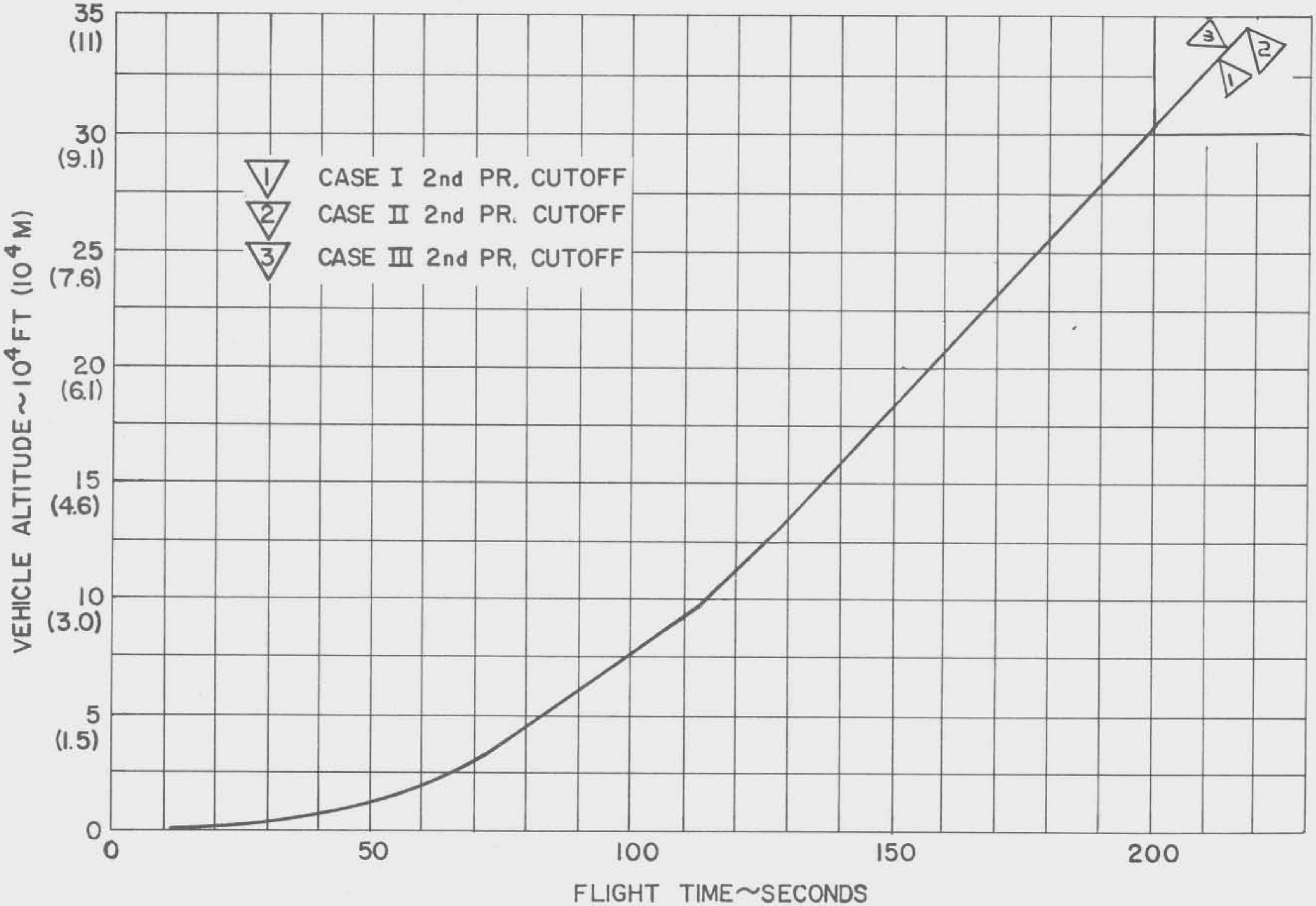


FIGURE A-4. VEHICLE ALTITUDE (INT-20), FIRST ITERATION

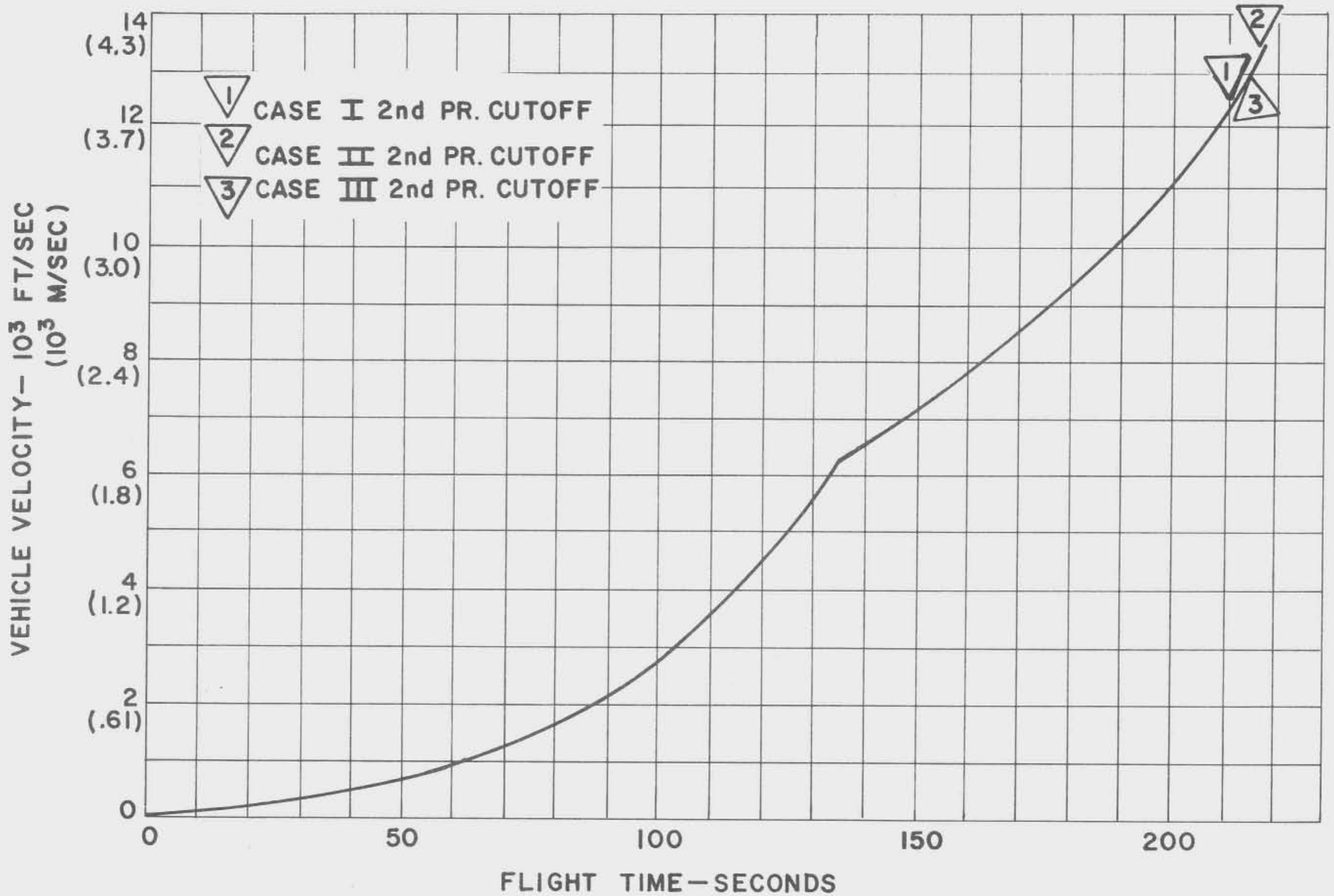


FIGURE A-5. VEHICLE VELOCITY (INT-20), FIRST ITERATION

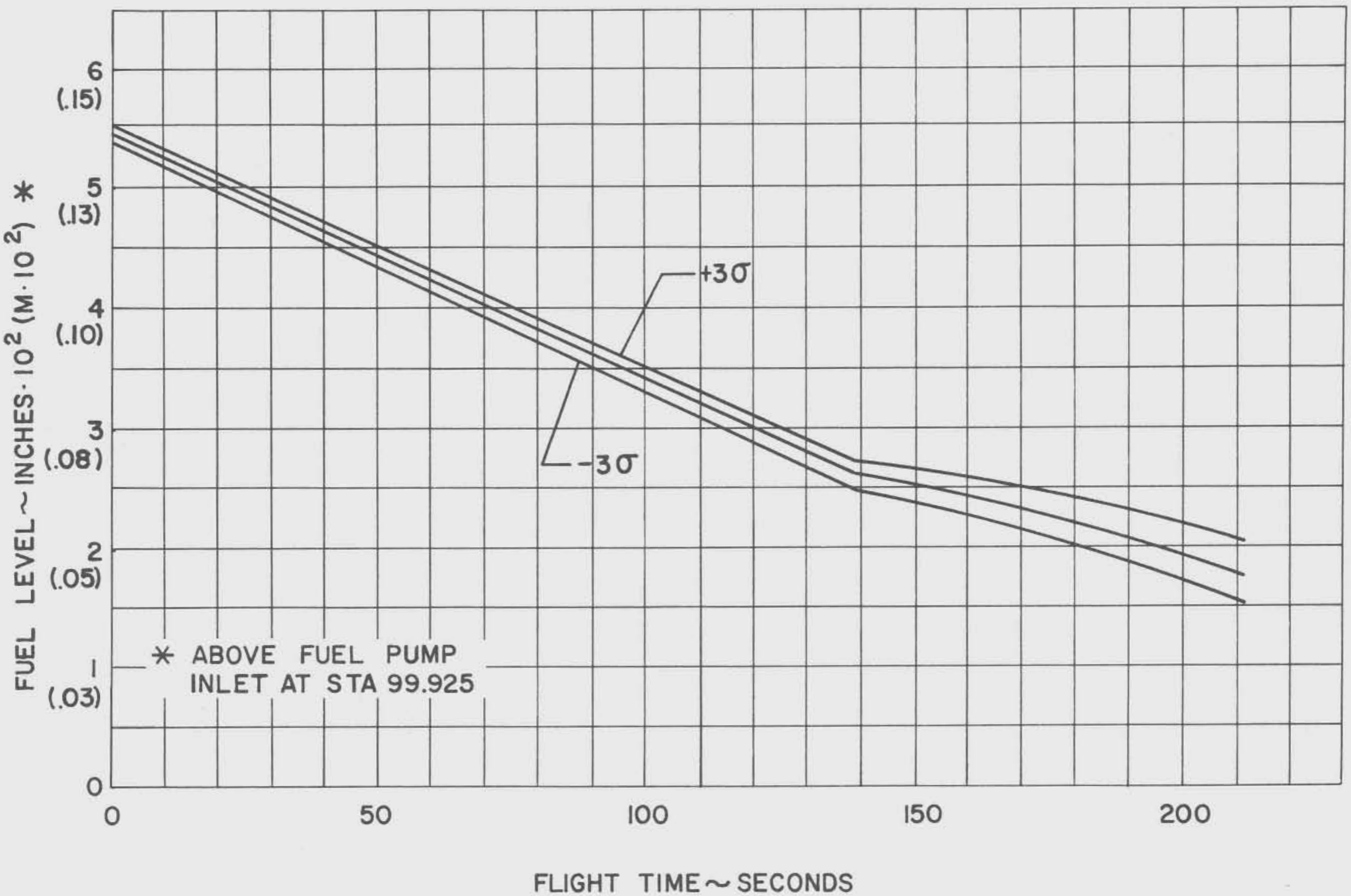


FIGURE A-6. FUEL LEVEL-CASE I (INT-20), FIRST ITERATION

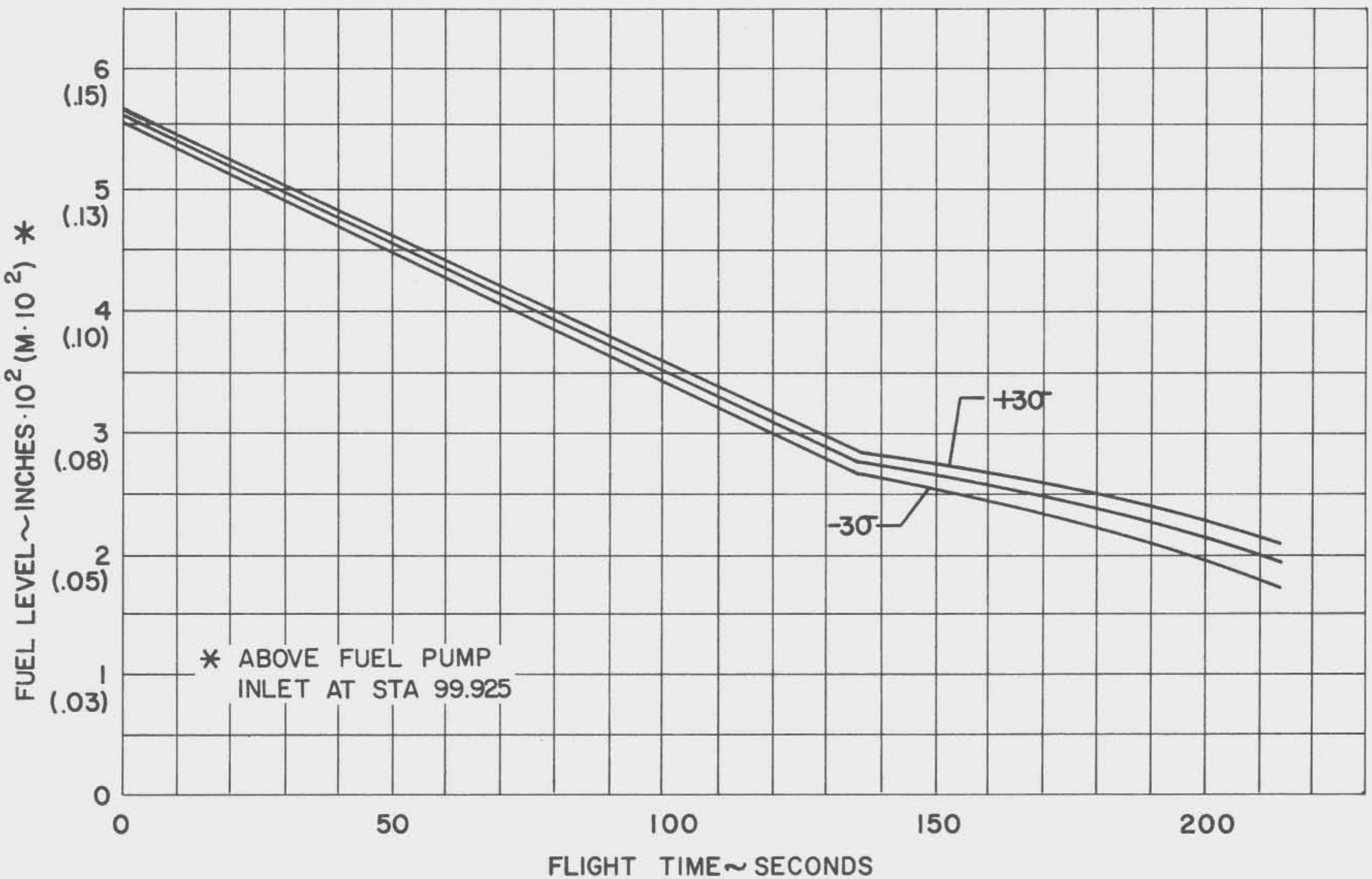


FIGURE A-7. FUEL LEVEL - CASE II (INT-20), FIRST ITERATION

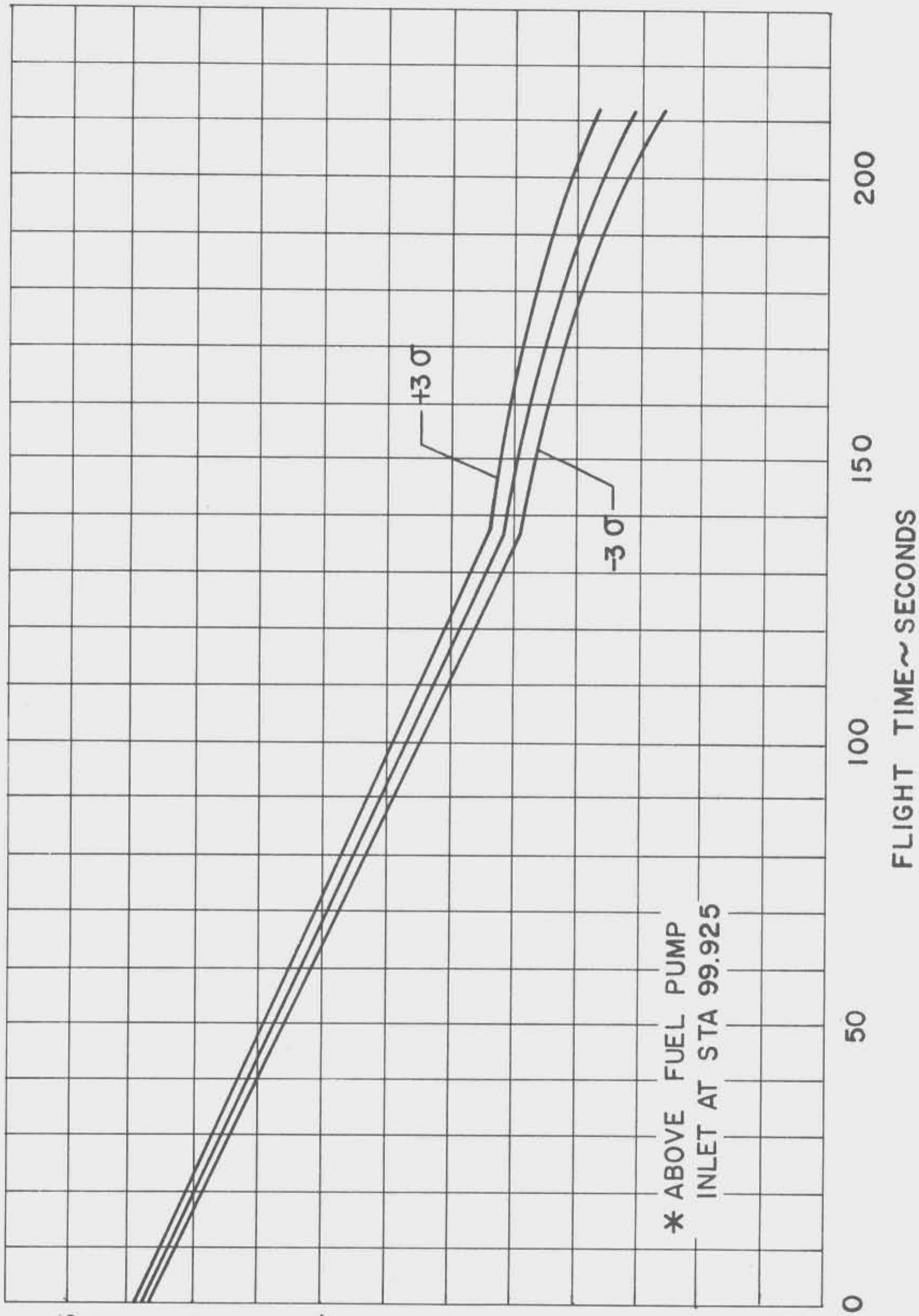
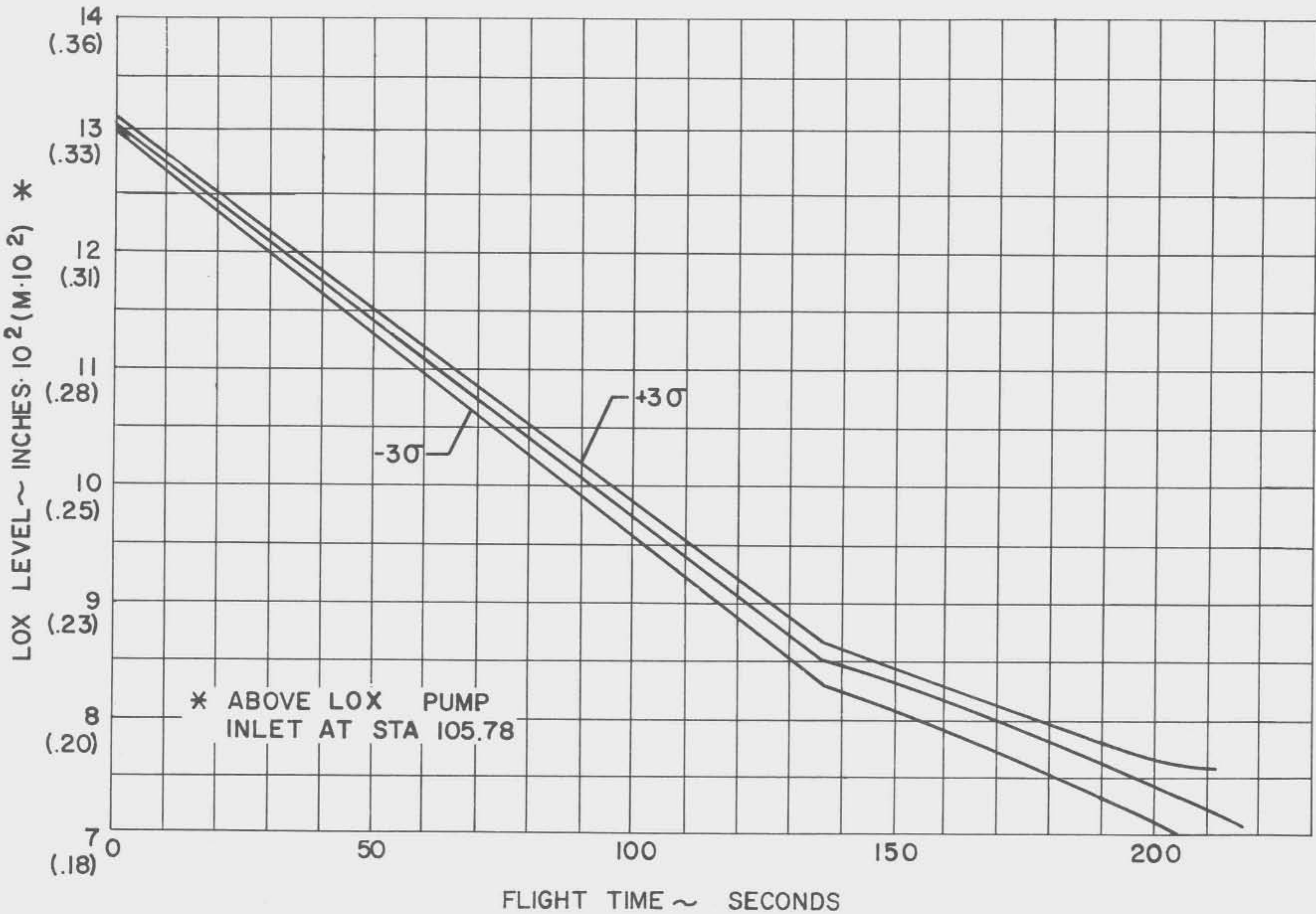


FIGURE A-8. FUEL LEVEL - CASE III (INT-20), FIRST ITERATION



FIGURUE A-9. LOX LEVEL-CASE I (INT-20), FIRST ITERATION

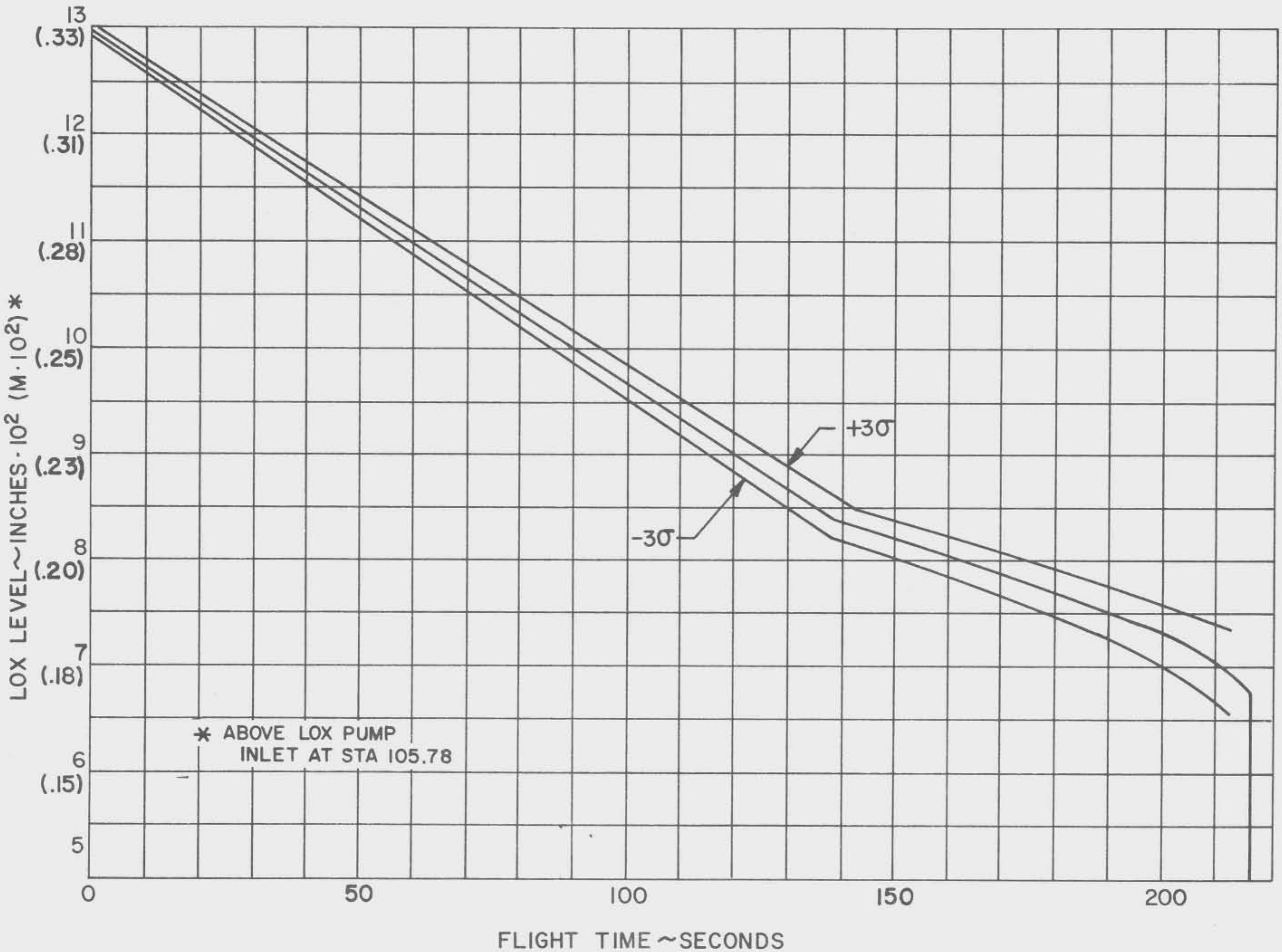


FIGURE A-10. LOX LEVEL - CASE II (INT-20), FIRST ITERATION

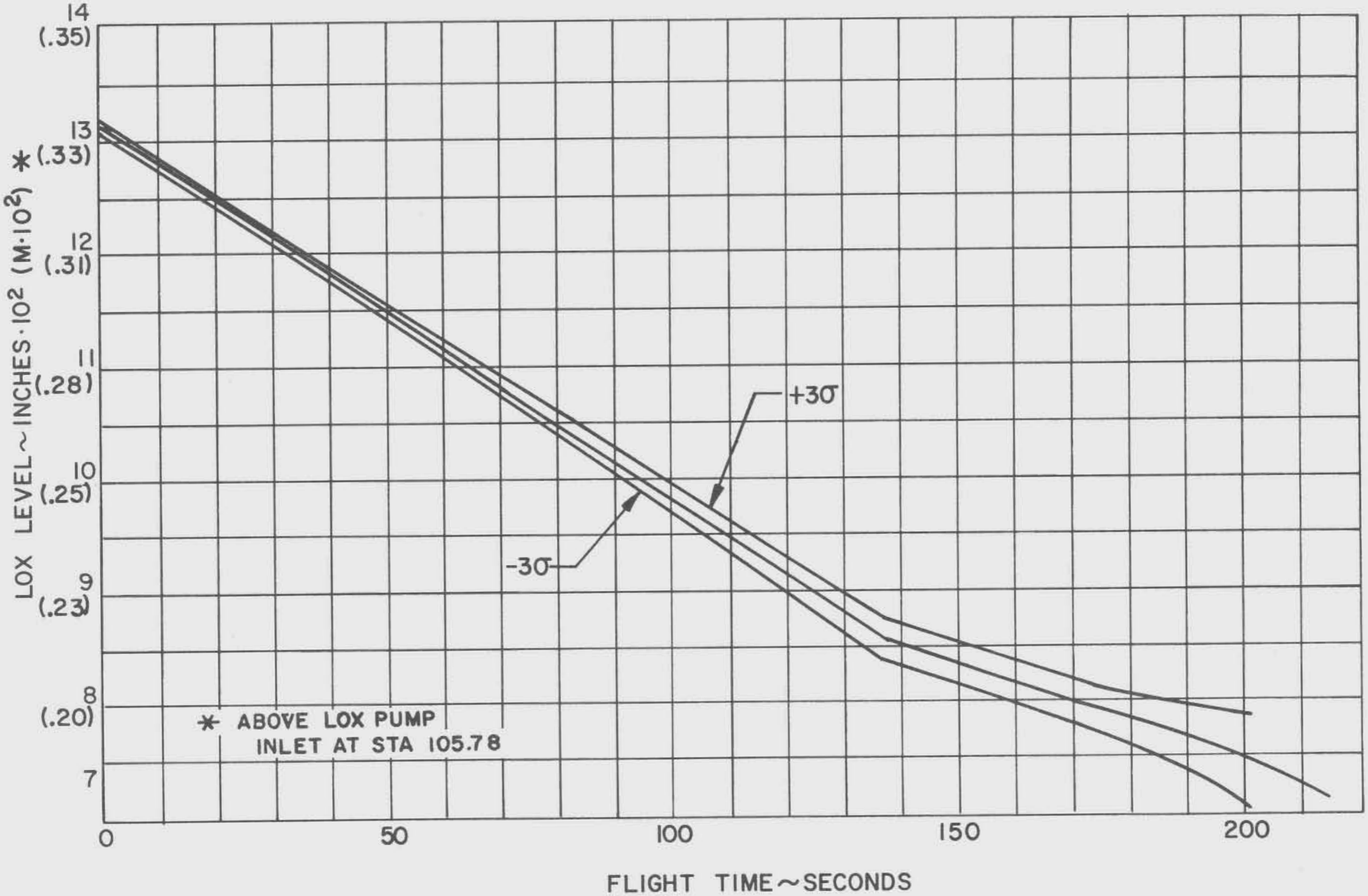


FIGURE A-11. LOX LEVEL - CASE III (INT-20), FIRST ITERATION

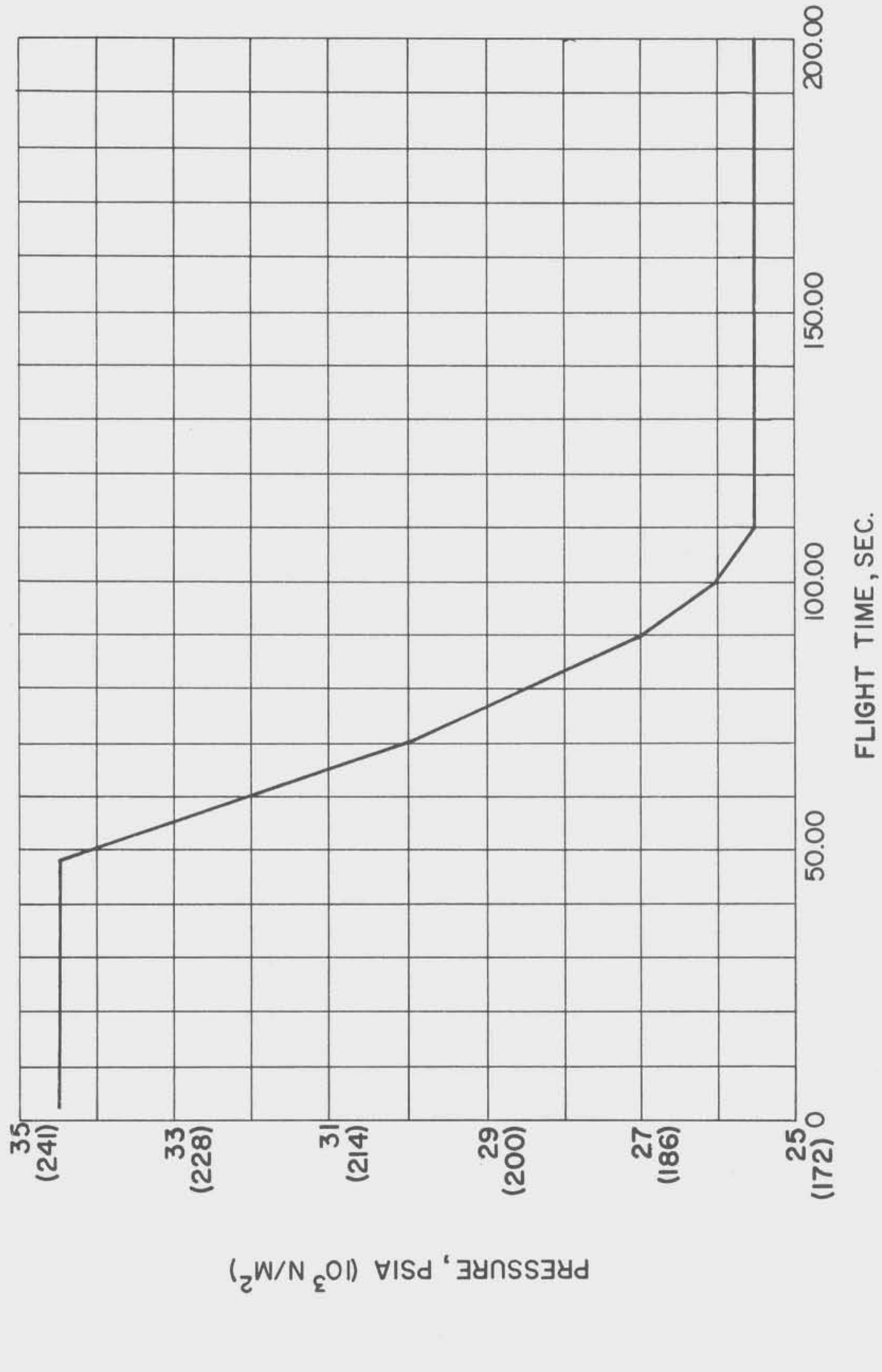


FIGURE A-12. MAXIMUM LOX ULLAGE PRESSURE (INT-20)

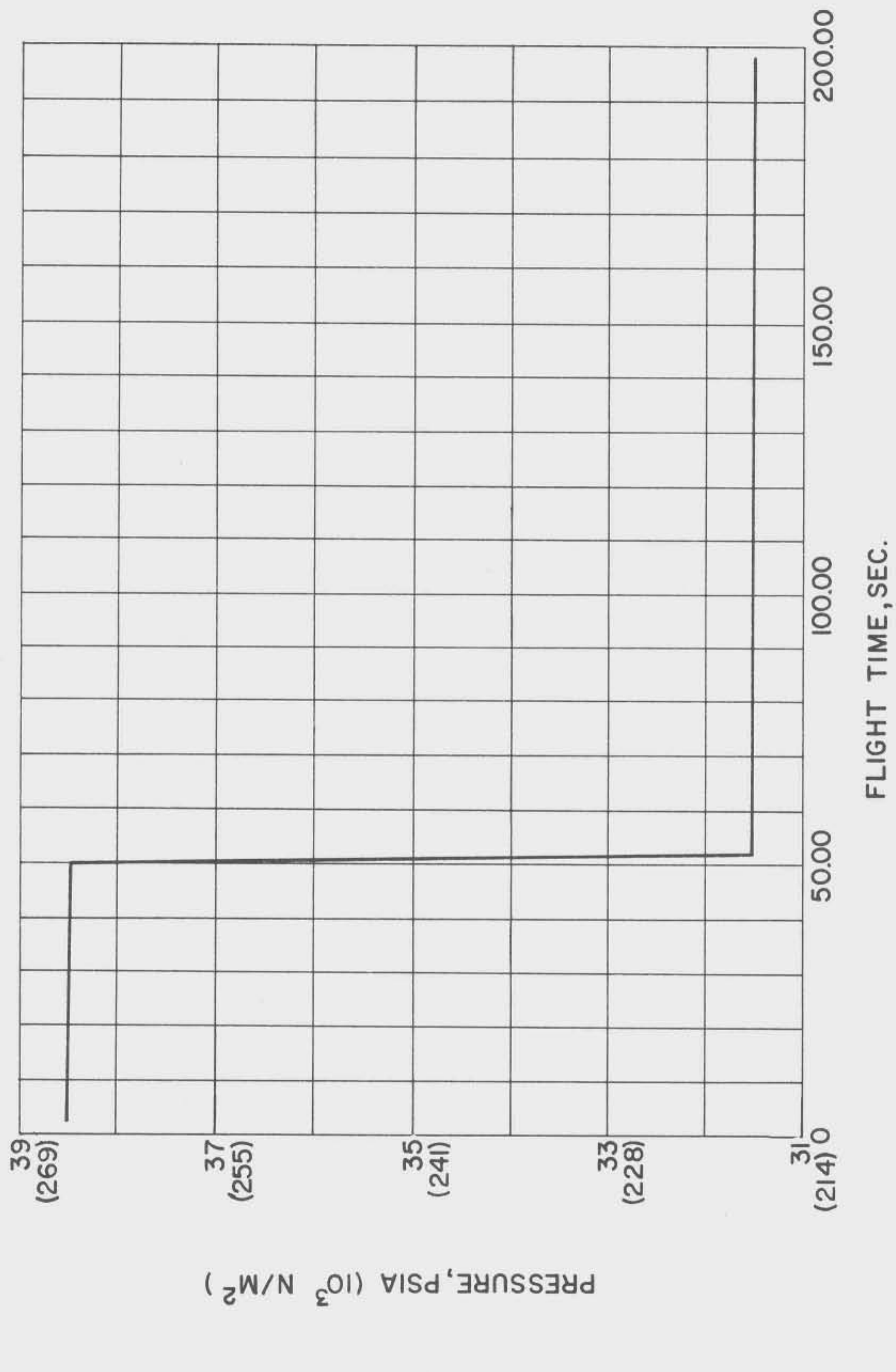


FIGURE A-13. MAXIMUM FUEL ULLAGE PRESSURE (INT-20)

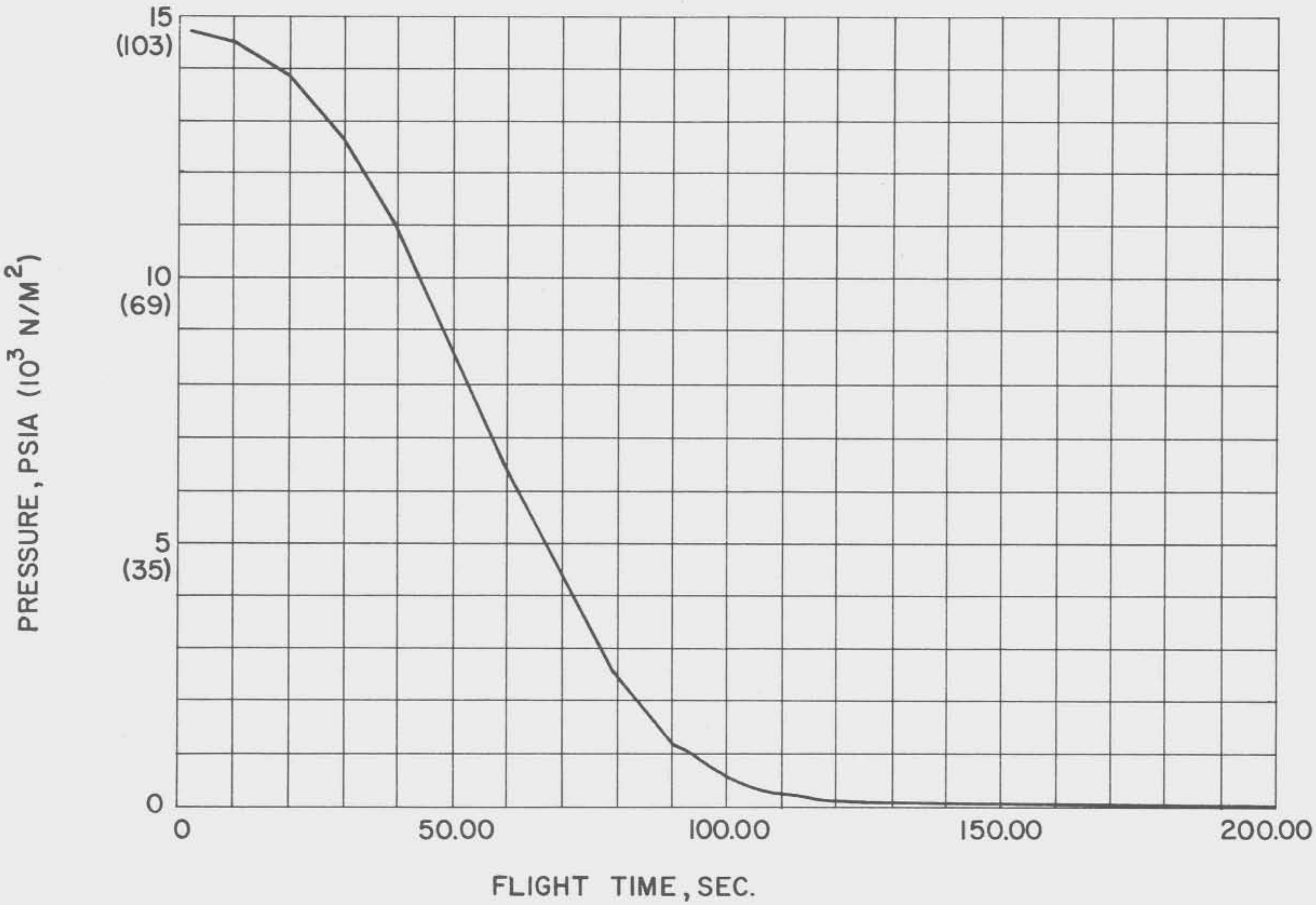


FIGURE A-14. AMBIENT PRESSURE (INT-20)

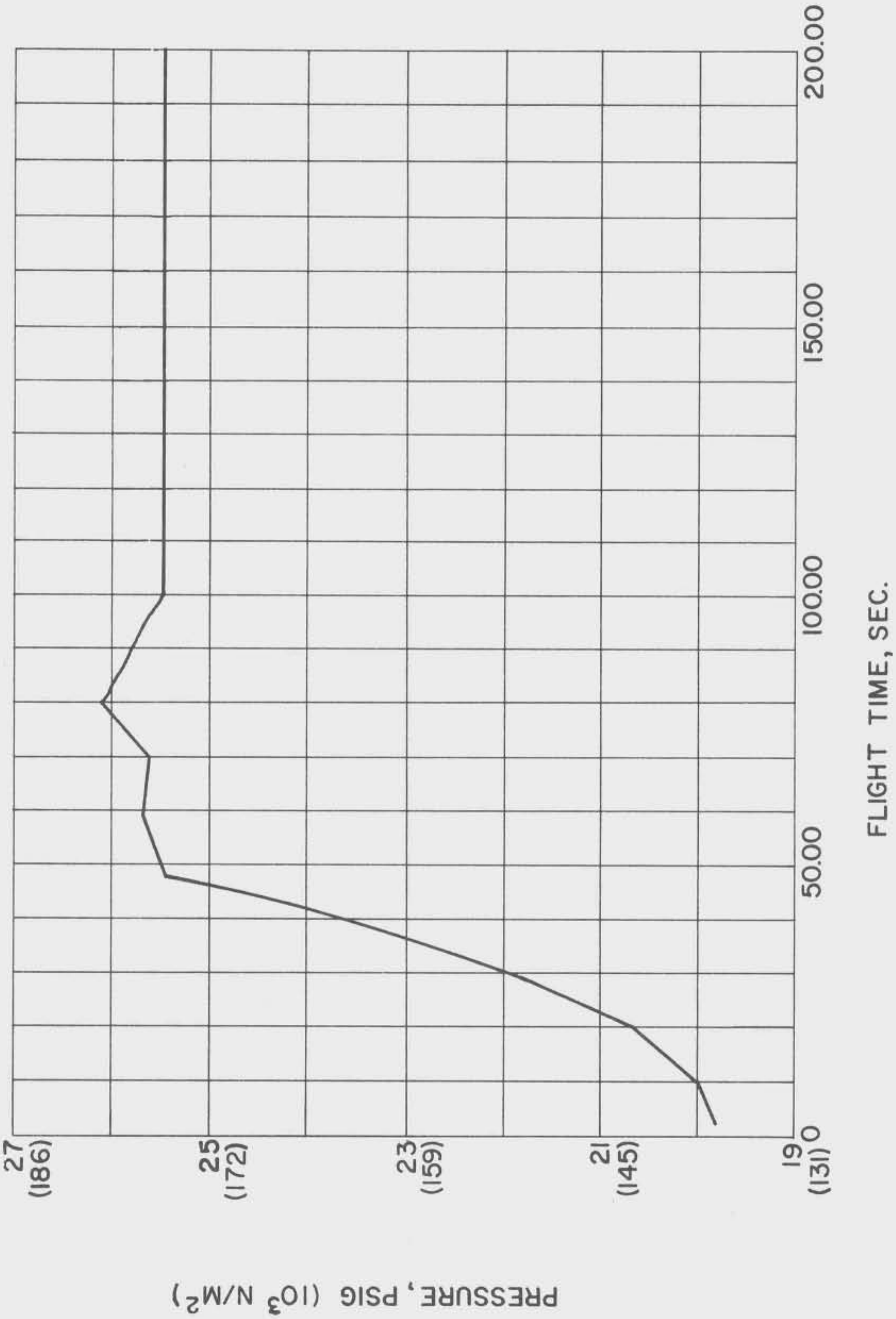


FIGURE A-15. DIFFERENTIAL LOX ULLAGE PRESSURE (INT-20)

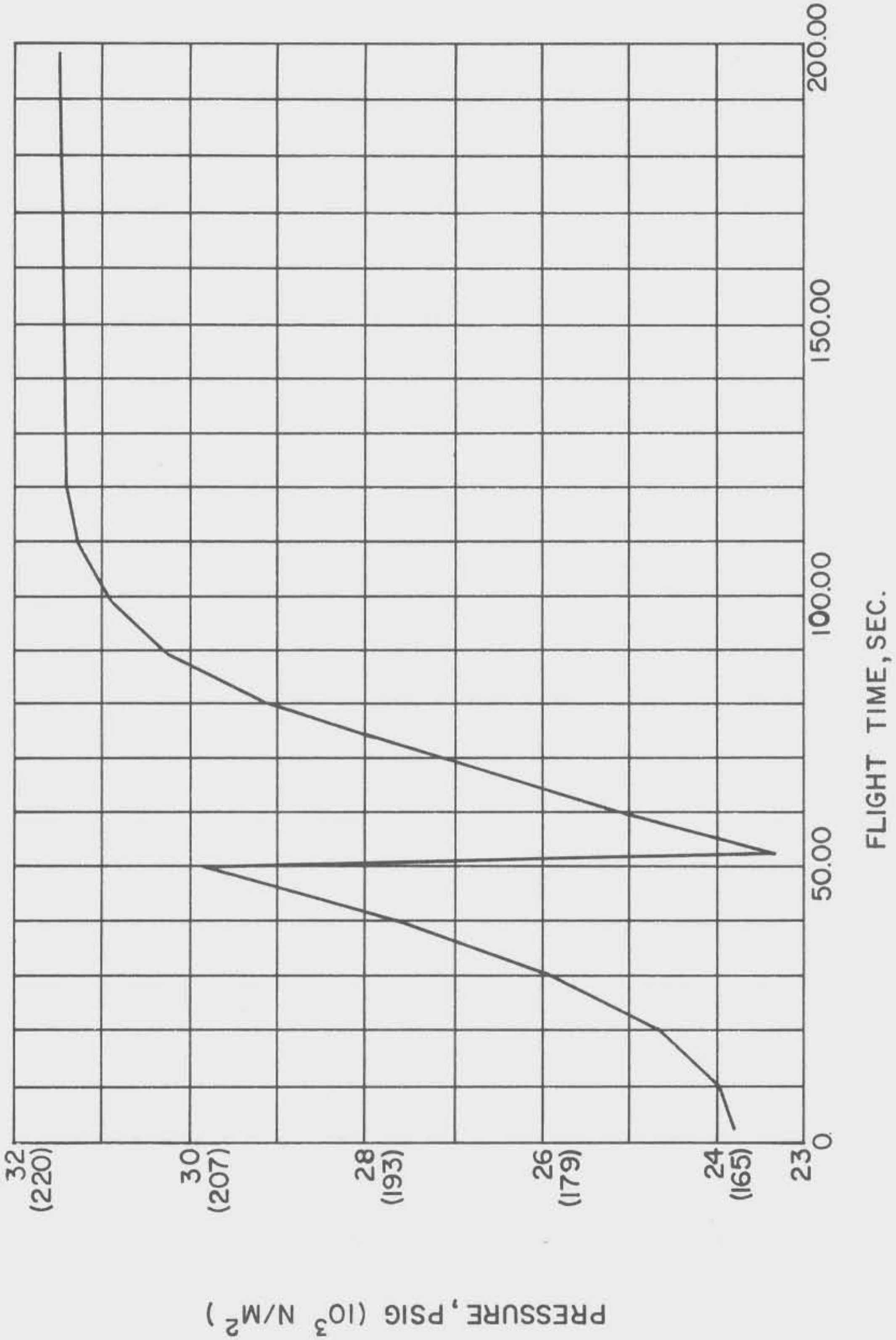


FIGURE A-16. DIFFERENTIAL FUEL ULLAGE PRESSURE (INT-20)

2.1.1.5 (Continued)

Total INT-20 maximum tank bottom pressures for the first iteration ullage pressures and the three first iteration performance cases were calculated to be as shown below:

LOX TANK	MAXIMUM PRESSURE (PSIG)*		
	CASE I	CASE II	CASE III
Nominal	60.2	59.1	60.8
+3 -σ Liquid Level	59.2	58.3	59.6
-3 -σ Liquid Level	59.5	59.1	61.0

* Capability = 59.6 PSIG

FUEL TANK	MAXIMUM PRESSURE (PSIG)*		
	CASE I	CASE II	CASE III
Nominal	48.8	50.3	48.1
+3 -σ Liquid Level	48.7	50.2	48.2
-3 -σ Liquid Level	48.2	50.1	47.4

* Capability = 49.3 PSIG

As indicated above, the first iteration Lox tank bottom pressure would exceed the capability for Cases I and III. The fuel tank capability would be exceeded for Case II. These results, however, serve as a basis for determining requirements for the second tank pressure study iteration.

Lox and fuel first iteration tank pressure envelopes, bottom pressures and lower tangent point pressures for performance Case I with maximum ullage pressures and all other parameters nominal are shown in FIGURES A-17 thru A-22.

2. Second iteration

Evaluation of tank bottom pressures for the three performance cases considered for the first iteration indicated that acceptable tank pressures could be obtained in both tanks by revising the Case I propellant load. For the second iteration, 14300 pounds of fuel was added and 26200 pounds of Lox was subtracted from the Case I propellant load. The S-IC dry weight was increased by 8500 pounds for the second iteration to reflect the later baseline INT-20 configuration definition.

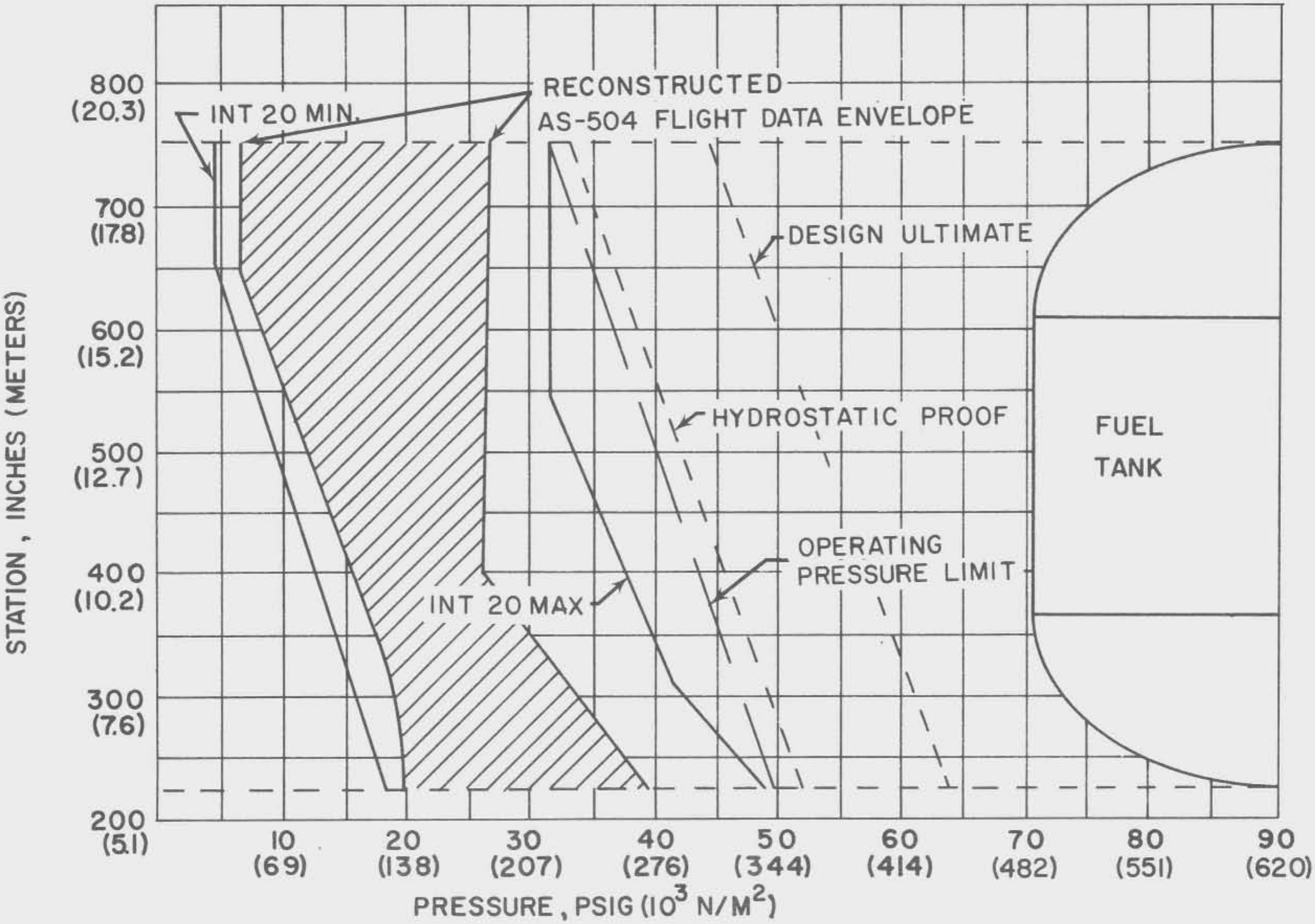


FIGURE A-17. FUEL TANK PRESSURE ENVELOPE - CASE I (INT 20), FIRST ITERATION

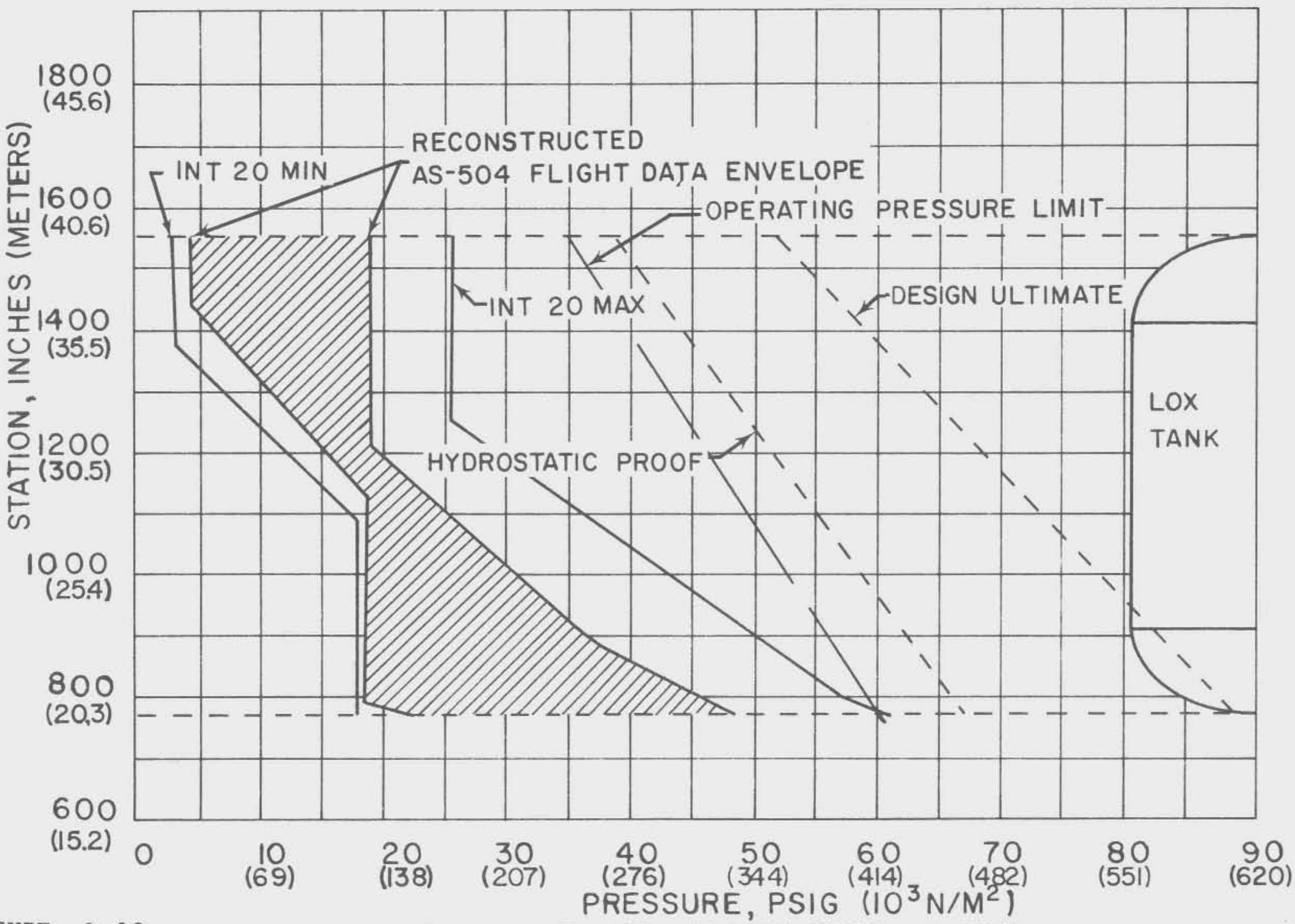


FIGURE A-18. LOX TANK PRESSURE ENVELOPE CASE I (INT-20), FIRST ITERATION

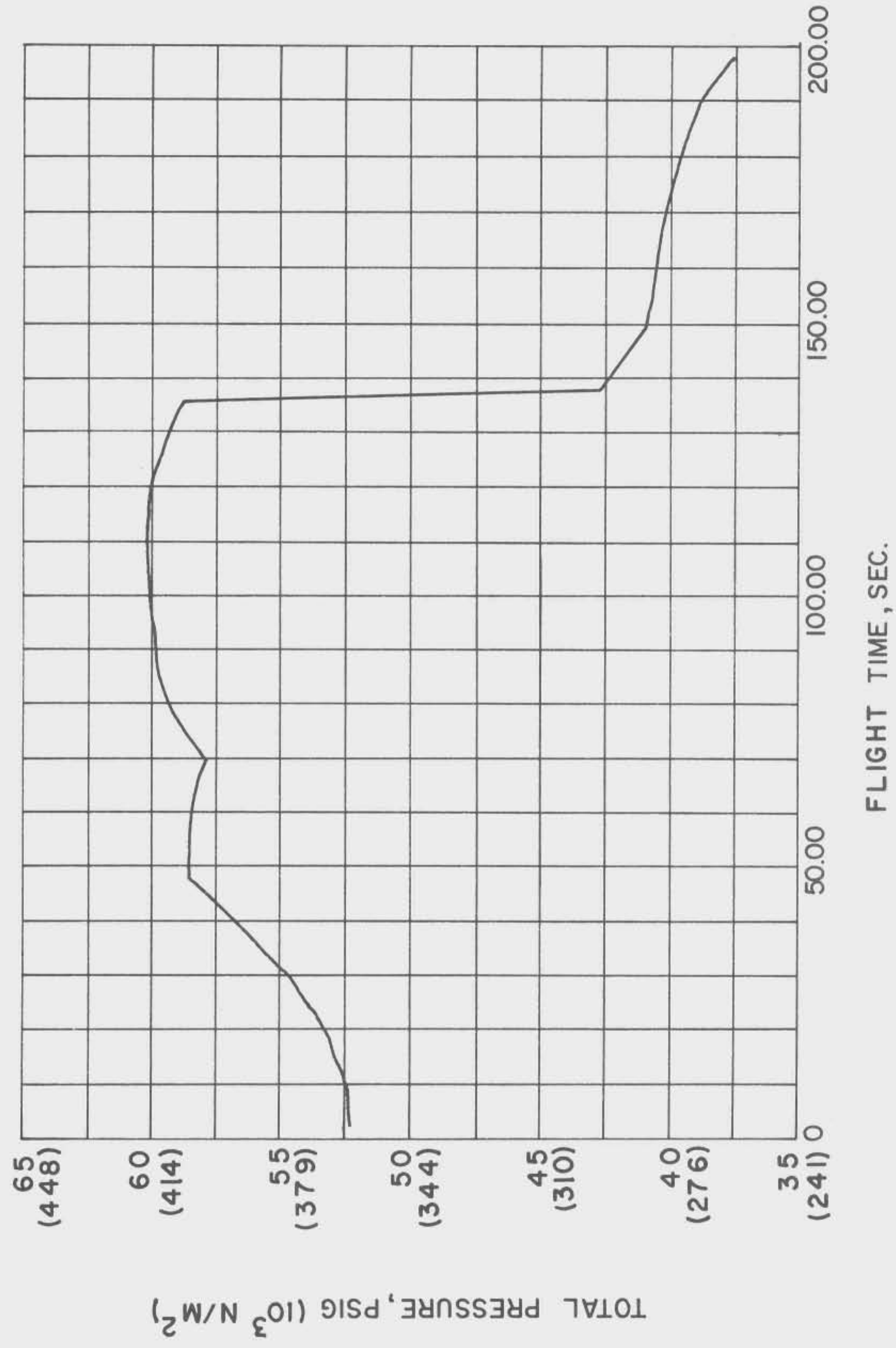


FIGURE A-19. LOX TANK BOTTOM PRESSURE - CASE I (INT-20), **FLIGHT ITERATION**

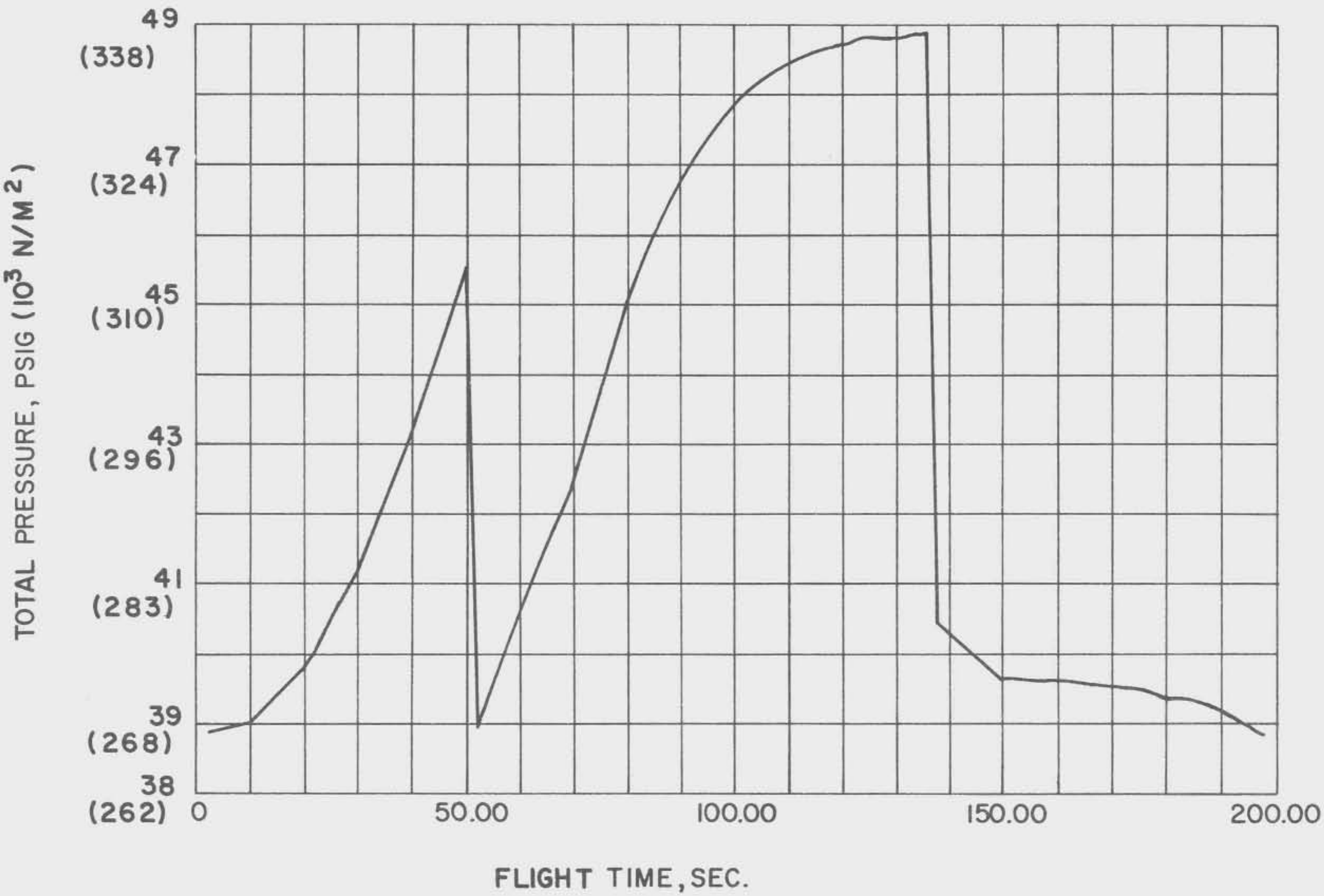


FIGURE A-20. FUEL TANK BOTTOM PRESSURE-CASE I (INT-20), FIRST ITERATION

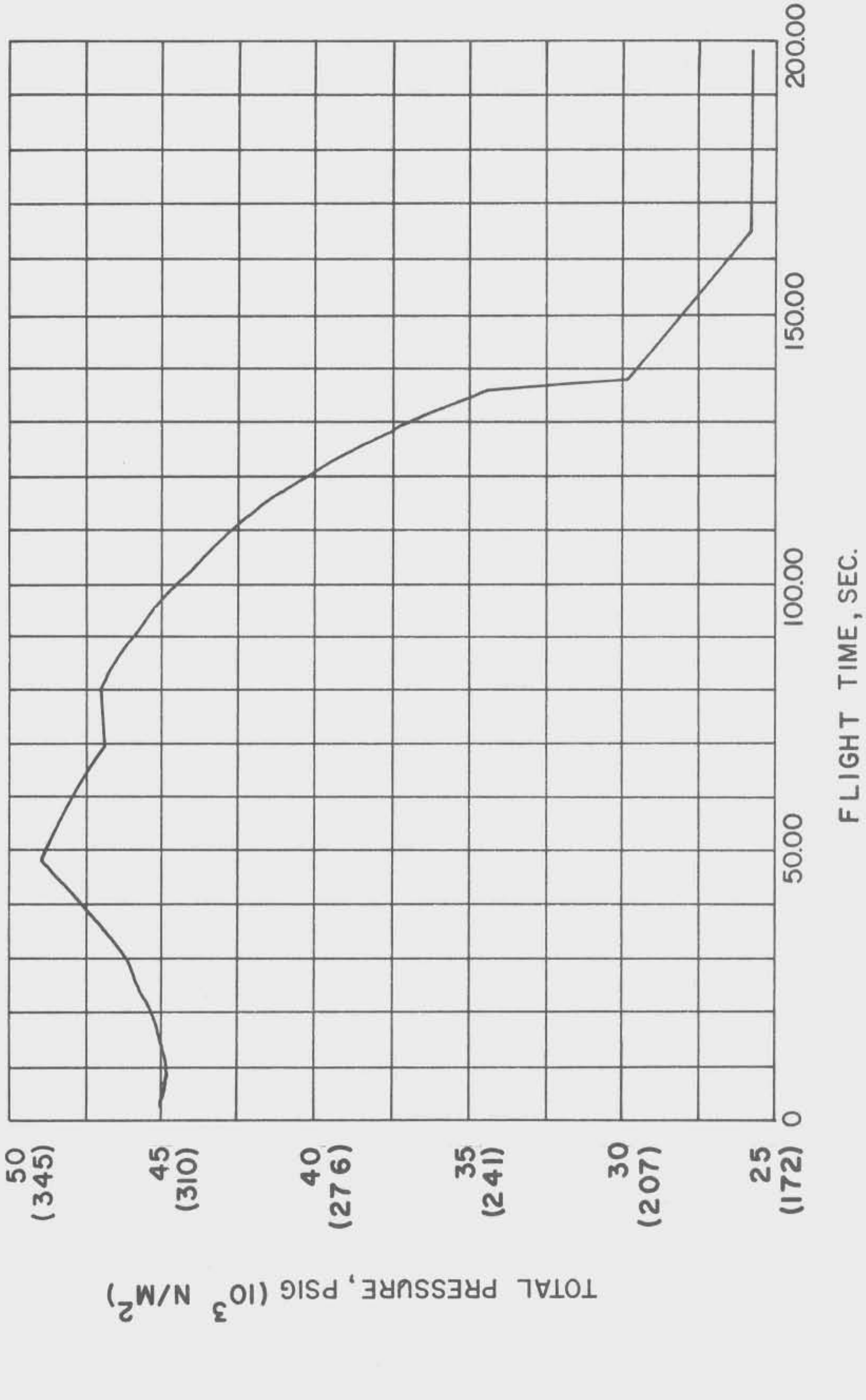


FIGURE A-21. LOX TANK STATION 912 PRESSURE-CASE I (INT-20), FIRST ITERATION

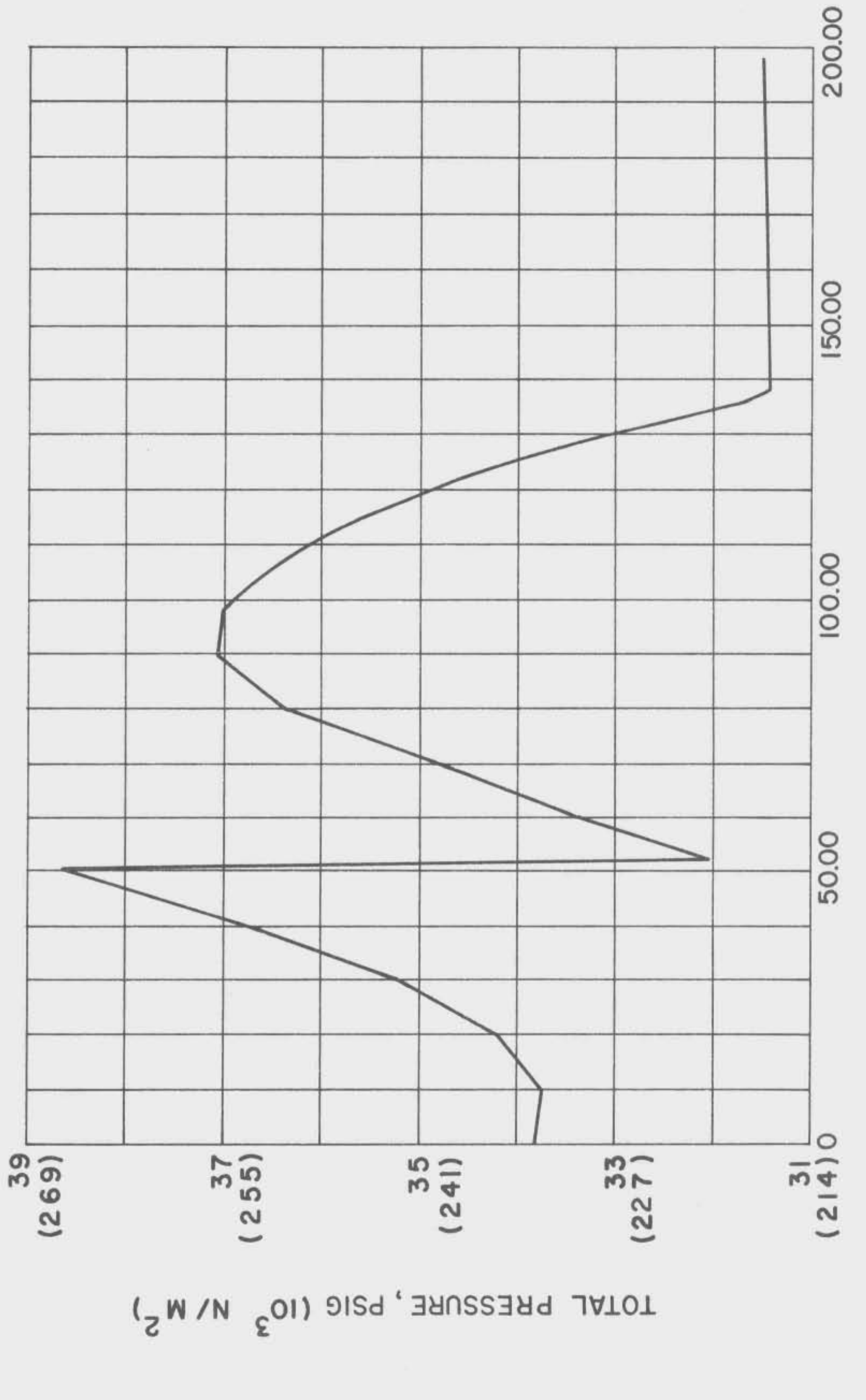


FIGURE A-22. FUEL TANK STATION 365 PRESSURE-CASE I (INT-20) FIRST ITERATION

2.1.1.5 (Continued)

2. For the second iteration, it was assumed that a timer cutoff based on real time acceleration inputs from the I U would be used for both engine pairs to significantly reduce the 3-sigma cutoff acceleration variation. It was assumed that this mode would allow a 4.68 g limit at cutoff for nominal and 3-sigma conditions.

(a) Second iteration stage performance

A second Mark VII A computer run was not considered necessary due to the preliminary nature of this study. The second iteration modifications were incorporated by extrapolating from the first iteration Mark VII A run. Only one case was considered. Propellant loads (T = -7 seconds) for the second iteration were as follows:

Lox Load	=	3,019,780 Lbs.
Lox Level	=	STA 1417 $\pm$ 4
Lox Ullage	=	11.2%
Fuel Load	=	1,328,118 Lbs.
Fuel Level	=	STA 656$\pm$2
Fuel Ullage	=	9.9%

Time history plots of second iteration propellant levels and acceleration are shown in FIGURES A-23 thru A-25. Three-sigma dispersions are also shown.

(b) Second iteration ullage pressures

The ullage pressures were not changed for the second iteration. The first iteration pressures shown in FIGURES A-12 thru A-16 also apply for the second iteration.

(c) Second iteration total pressure

Total second iteration maximum tank bottom pressures were calculated to be as shown below. The 3-sigma dispersion impact was considered in the same manner as for the first iteration.

LOX TANK	MAX PRES (PSIG)*
Nominal	59.3
+3 $-\sigma$ Liquid Level	58.4
+3 $-\sigma$ Liquid Level	59.5

* Capability = 59.6 PSIG

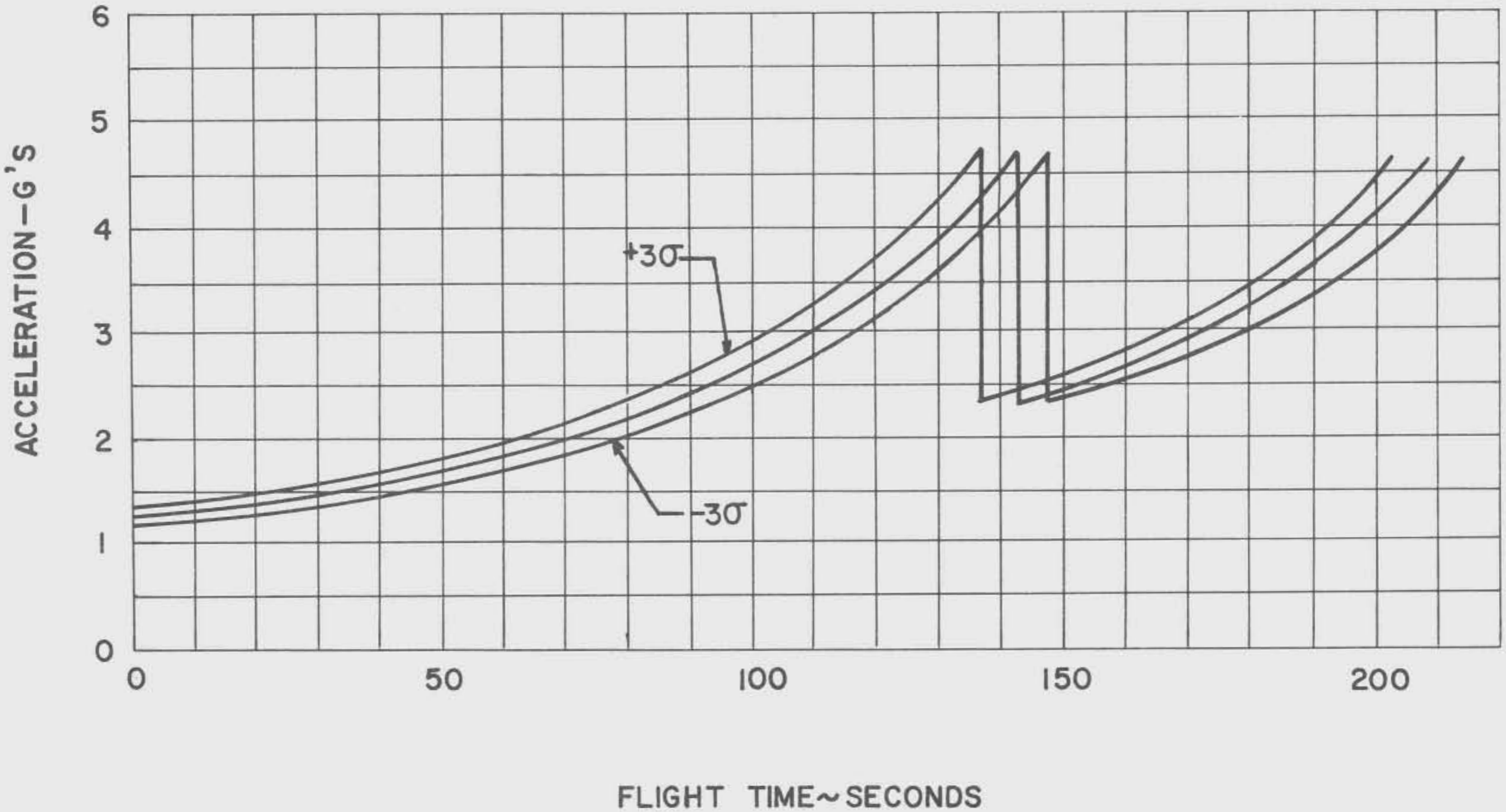


FIGURE A-23. VEHICLE ACCELERATION (INT-20), SECOND ITERATION

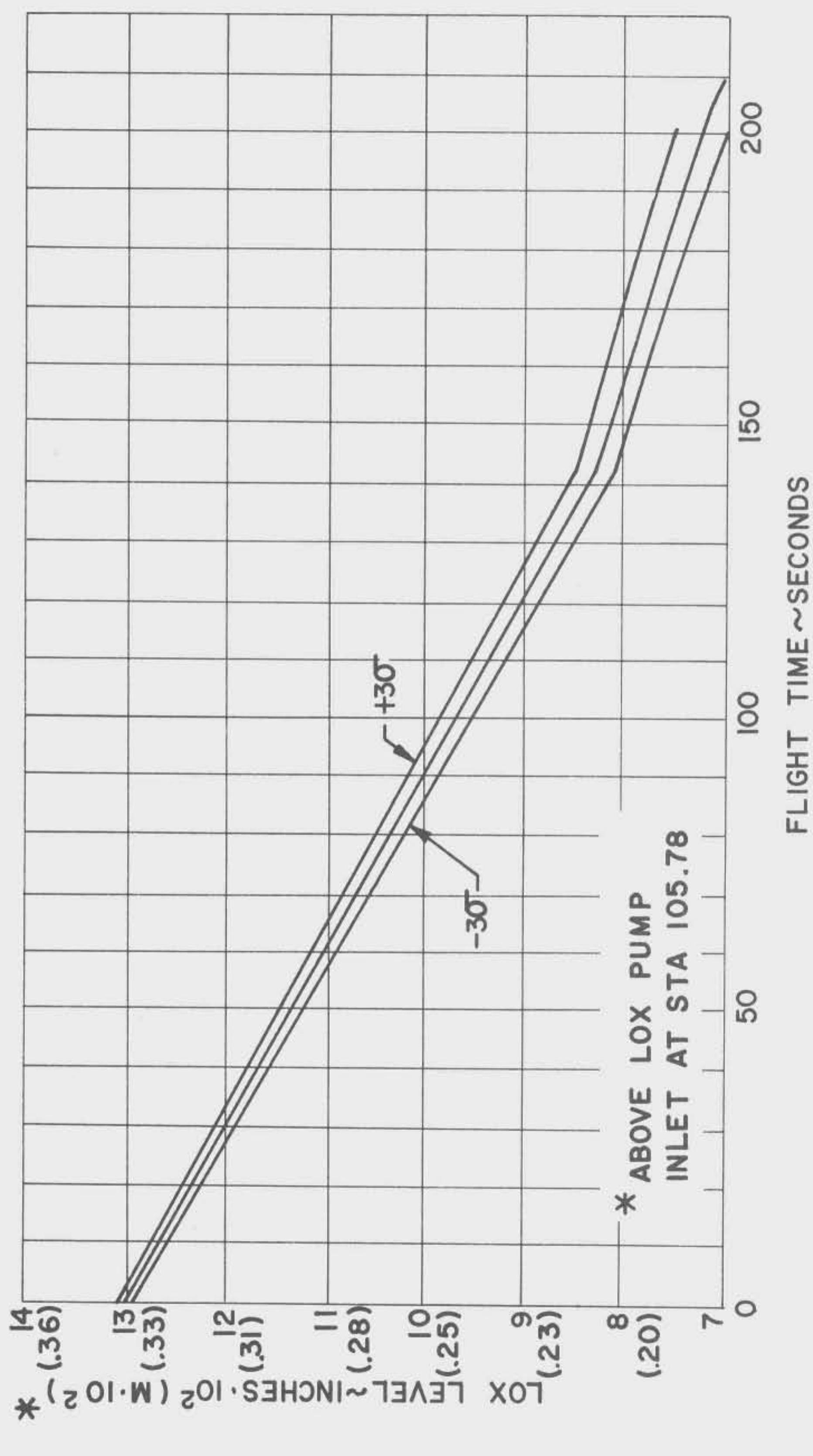


FIGURE A-24. LOX LEVEL (INT-20), SECOND ITERATION

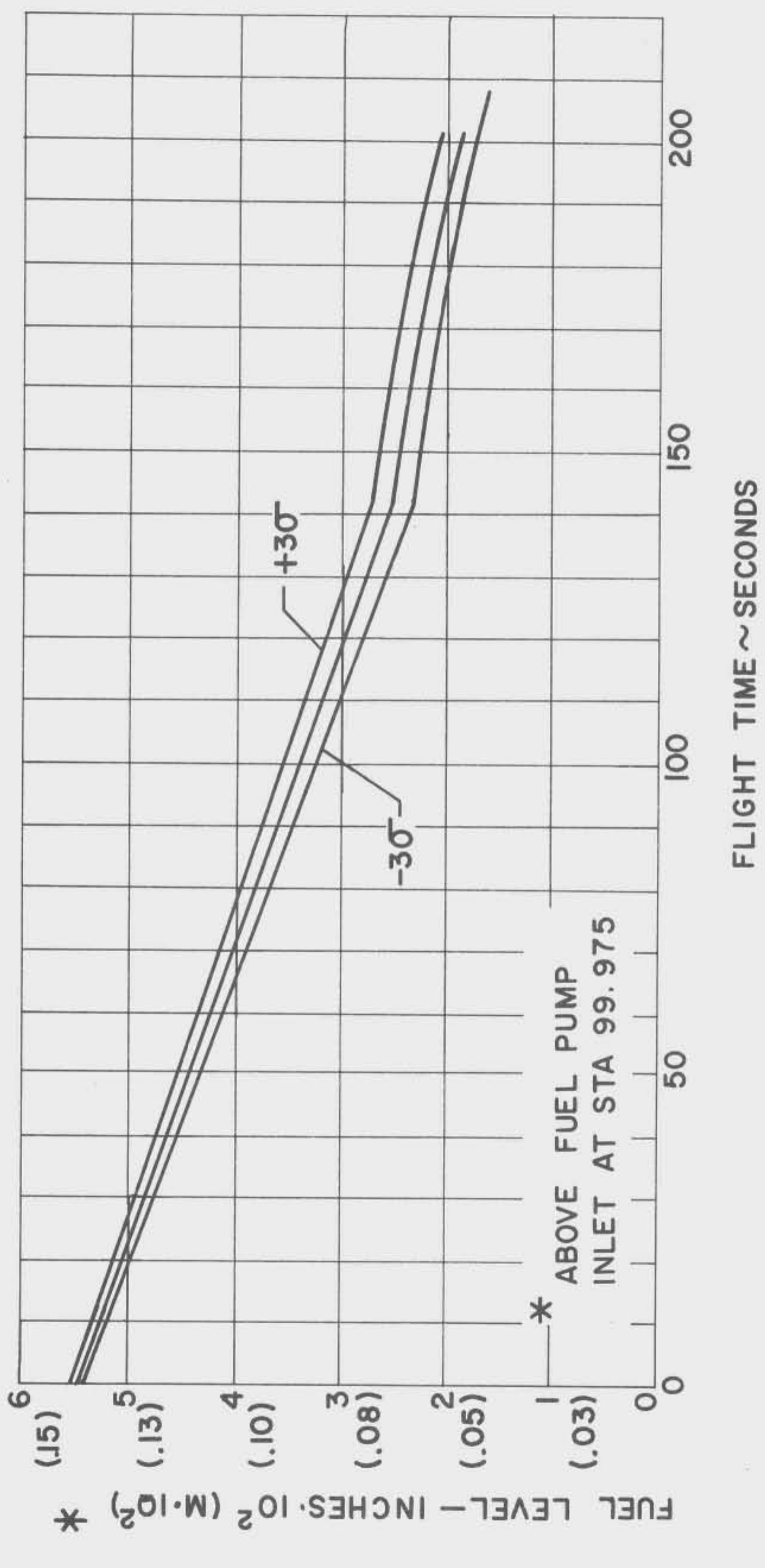


FIGURE A-25. FUEL LEVEL (INT-20), SECOND ITERATION

2.1.1.5 (Continued)

(c)

FUEL TANK	MAX PRES (PSIG)*
Nominal	49.2
+3 -σ Liquid Level	48.9
-3 -σ Liquid Level	48.2

* Capability = 49.3 PSIG

As indicated above, the second iteration Lox and Fuel Tank pressures are within the structural capability for the INT-20 baseline mission. However, little flexibility in varying parameters which could increase tank pressures exists for INT-20. This situation is discussed further in the following paragraph: Second iteration nominal Lox and Fuel Tank bottom pressures versus time are shown in FIGURE A-26.

b. Reduced payload flight pressures

The margins of safety in the propellant tanks due to tank bottom pressures during flight are very small for the baseline INT-20. For this reason, caution must be exercised when considering optional missions and payloads which would increase critical accelerations and propellant levels such that the tank pressure capabilities would be exceeded.

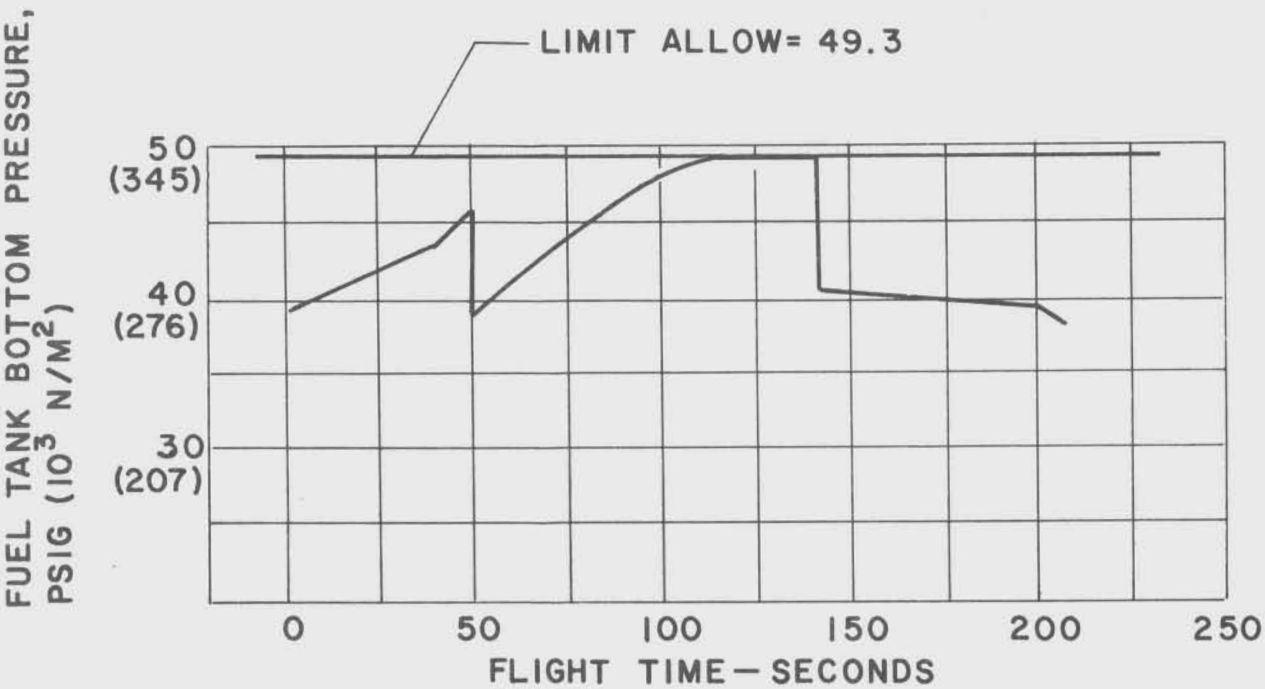
1. Big G and retrofit payloads

The baseline Big G and retrofit missions have smaller payloads than the INT-20 baseline. The reduced payloads are compensated for by S-IC propellant ballast in order to maintain a 1.25 thrust to weight ratio at liftoff. Because of the INT-20 tank pressure restrictions, these missions were investigated to determine the impact of the added propellant ballast on tank pressures.

For the retrofit mission, 6600 pounds of propellant ballast will be added. For the baseline Big G mission, the payload will be reduced by 14,706 pounds. However, 10,050 pounds will be compensated for by the LES and only 4656 pounds by additional propellant ballast. Inspection of the resulting additional liquid heads (less than 1 inch) indicated that the S-IC could accommodate the additional propellant ballast for retrofit and baseline Big G missions. The maximum resulting tank bottom pressures (3-sigma dispersions considered) are 49.3 PSI and 59.6 PSI in the fuel and Lox tanks, respectively.

2. Other reduced payloads

For large payload reductions (greater than about 7000 pounds) compensative variation in parameters other than increased thrust to weight ratios or



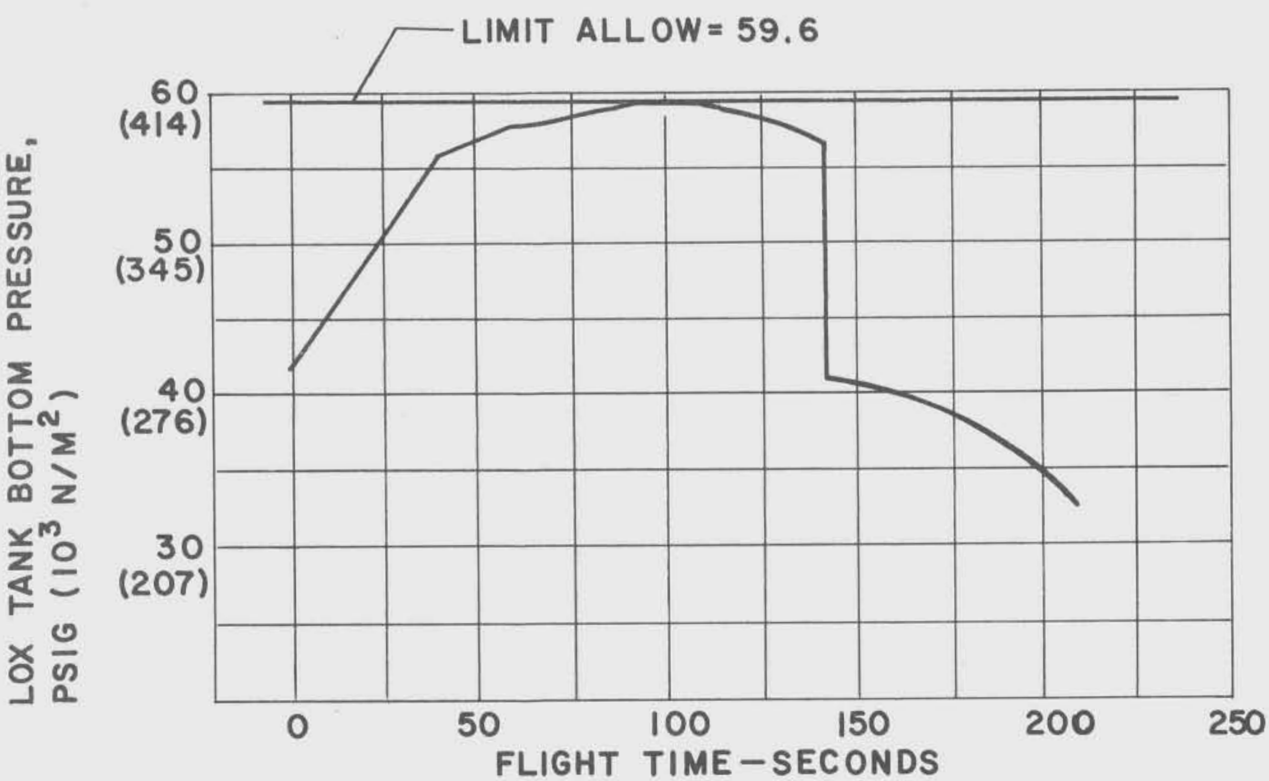


FIGURE A-26. TANK BOTTOM PRESSURE, SECOND ITERATION

2.1.1.5 (Continued)

2. additional S-IC propellant ballast must be used to avoid exceeding tank capabilities. This point is illustrated in FIGURE A-27 which shows that capabilities would be exceeded in both tanks if compensative propellant ballast (82000 pounds with 30% in fuel tank and 70% in Lox tank) were added for a 50000 pound payload mission. A similar situation would result if the same mission were flown with no compensative ballast and a higher thrust to weight ratio because relative higher accelerations would be incurred.

   Final resolution of the tank pressure restrictions for small payloads is outside of the scope of this study. However, several alternatives were considered and are listed below:

   (a) Reduce ullage pressure

   Reduction in ullage pressures was determined to be technically undesirable. (See Section 2.2.6.2 of APPENDIX A).

   (b) Cutoff first engine pair early

   This alternative has potential but would require a detailed investigation to establish correlation between payload capability and acceptable tank pressures.

   (c) Allow 1.25 factor of safety

   This is possible as potential reduced payload missions could be high energy, unmanned missions.

   (d) Add dead weight ballast

   Additional dead weight ballast for small payloads would entail a significant design effort.

   (e) Redesign tanks

   Tank redesign for increased aft bulkhead pressure capability would necessitate an increase in hydrostatic proof pressure which would impact the design conditions for other tank components or require change in hydrostatic test procedures.

   (f) Add ballast to upper stages

   This would impact S-IV B requirements.

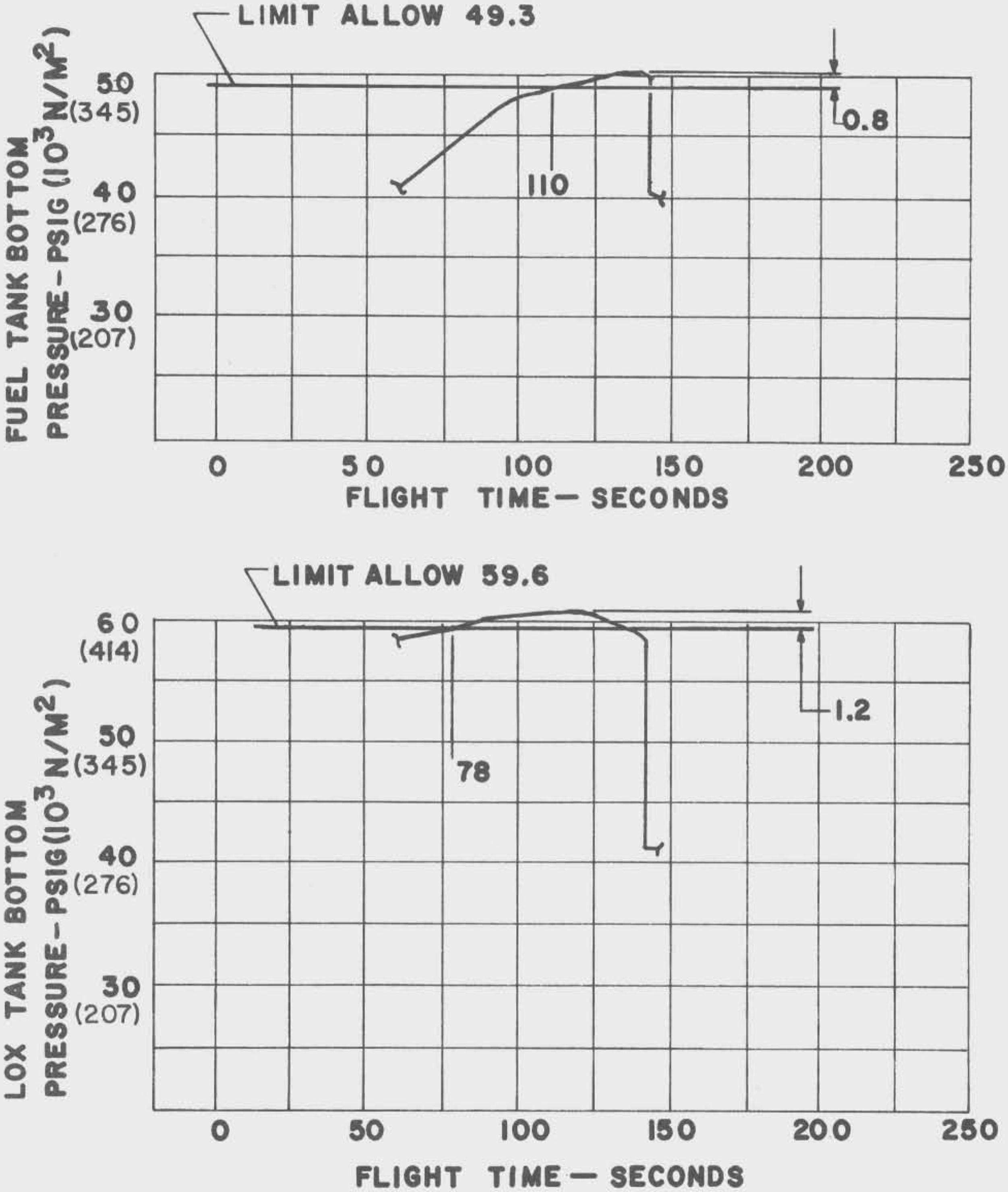


FIGURE A-27. TANK BOTTOM PRESSURE- 82000 LB BALLAST

2.1.1.5 (Continued)

(g) Re-Orifice F-1 engine to reduce thrust

A Mark VII A computer run was made for a 50000 pound payload and a reduced thrust as required to maintain a 1.25 thrust to weight ratio. All other parameters were the same as for the second iteration pressure studies. The resulting maximum Lox and fuel bottom pressures were not significantly reduced.

c. Rebound and liftoff tank pressures

The maximum tank pressures for these conditions occur at the apex of the lower bulkheads. Pressures on the lower heads are a combination of dynamic pressure, static head pressure due to propellant level, and ullage pressure. Lox and Fuel Tank liftoff and rebound pressures are shown in TABLE A-III. The values shown are for the first iteration pressure study. Corresponding values for the second iteration study were not calculated because of the adequate first iteration margins of safety.

d. Tank hoop compression loads

The S-IC propellant tank lower bulkheads are subject to hoop compression loads during fill and towards the end of flight. The bulkheads are relatively flat near the apex such that, when the liquid level is low and acceleration is high, the bulkheads tend to compress in the upper area as shown in FIGURE A-28. Liquid head, acceleration and ullage pressure, which are the contributors to hoop compression loads, are shown for INT-20 in FIGURES A-23, A-24, A-25, A-73 and A-76. The net hoop compression loads are higher for INT-20 than for Sat V.

2.1.1.6 Vibration and Acoustic Loads

The maximum INT-20 acoustic environment will be less than the corresponding Sat V environment as shown in FIGURE 4.1.3.1-1*. Component vibration is basically proportional to the acoustic excitation. Therefore, INT-20 vibration and acoustic loads will be less for INT-20 than for Sat V.

2.1.1.7 Acceleration Loads

INT-20 Vehicle acceleration versus flight time is shown in FIGURE A-23. INT-20 acceleration will be relatively higher than for Sat V.

2.1.1.8 Slosh Loads

Propellant slosh loads are influenced by lateral vehicle acceleration. The predicted maximum lateral acceleration for INT-20 (0.21 g) is less than that used for Sat V slosh loads calculations (0.50 g). INT-20 slosh loads will therefore be

TABLE A-III. INT-20 TANK PRESSURES AT LIFTOFF AND REBOUND

Condition	Tank	Ullage (Max) (psia)	Static Head (psia)	Dynamic (psia)	Total (psig)	Capability (psig)
Emergency Rebound	LOX	34.5	26.2	8.3	54.3	59.6
	Fuel	38.5	12.2	2.0	38.0	49.3
Lift-Off	LOX	34.5	26.2	10.9	56.9	59.6
	Fuel	33.5	12.2	9.6	45.6	49.3

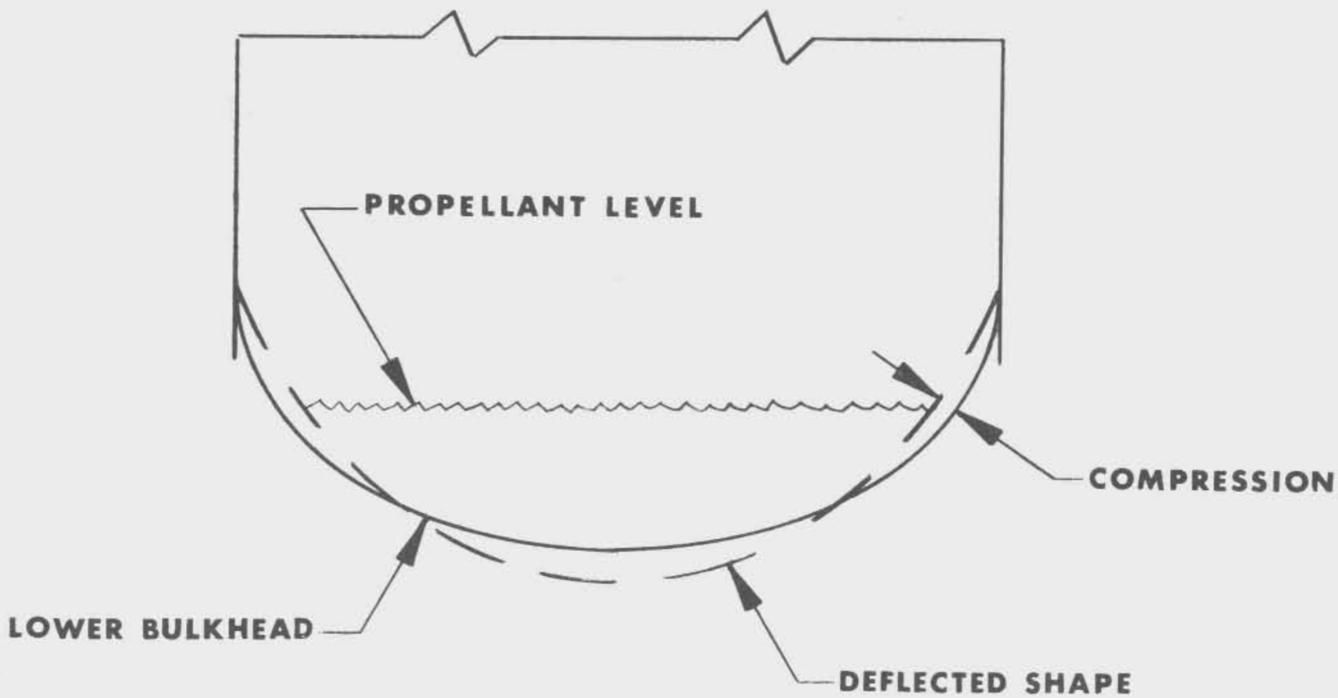


FIGURE A-28. LOWER BULKHEAD HOOP COMPRESSION

2.1.1.8 (Continued)

be less than for Sat V.

2.1.1.9 Aerodynamic Loads

The only increased aerodynamic loading for INT-20 will be a negative lateral aerodynamic pressure on the forward skirt due to the conical shaped S-IVB Aft Interstage. FIGURE A-29 shows the aerodynamic pressure distribution along the INT-20 vehicle and illustrates the spike at the S-IC/S-IVB interface.

2.1.1.10 Forward Skirt Temperatures

INT-20 thermal data and comparative INT-20 and Sat V thermal responses of the forward skirt skin and hat sections are shown in FIGURES A-30 thru A-35. Temperature gradients are shown for the clean body areas and the region of maximum protuberance heating. The forward skirt was assumed to be uninsulated and painted black. The INT-20 temperature data was calculated using existing Sat V computer programs with INT-20 trajectory data. The Sat V temperature data shown is the most recent published data for AS-511. The forward skirt temperatures are in general approximately 50°F higher for INT-20 than for Sat V.

2.1.1.11 Base Heat Shield Temperatures

The base heat shield thermal environment established for INT-20 is expected to be close to actual and only moderately conservative. The INT-20 incident radiation is shown in FIGURE A-36. It was based on AS-504 which flew a similar trajectory. During the first 100 seconds of flight the level was increased over AS-504 data because deletion of the center engine increases the form factor to the center of the heat shield. After recirculation becomes established this effect will be negated by the fully expanded plume and the forward flow of burning exhaust cases. Some conservation was included since the four engine plume will have less total energy than a five engine plume. Gas recovery temperatures established for INT-20 (FIGURE A-37) are maximum Sat V flight data with 50°F added after T + 80 seconds. The convective coefficient of heat transfer for INT-20 (FIGURE A-38) is the current S-IC design curve which has worked well in flight reconstructions.

All three environment figures were correlated with altitude to account for trajectory differences between INT-20 and Sat V. The radiant level and convective coefficient were reduced by one-half at the first two engine cutoff.

The time-temperature history of a typical section of the heat shield when subjected to INT-20 thermal environment is shown in FIGURE A-39. Comparitive Sat V (AS 511) values are shown in FIGURE A-40. A cross-section of the heat shield panel showing the points of interest is illustrated in FIGURE A-41. Bondline and forward surface temperatures run higher on later S-IC stages (AS 510 and on) due

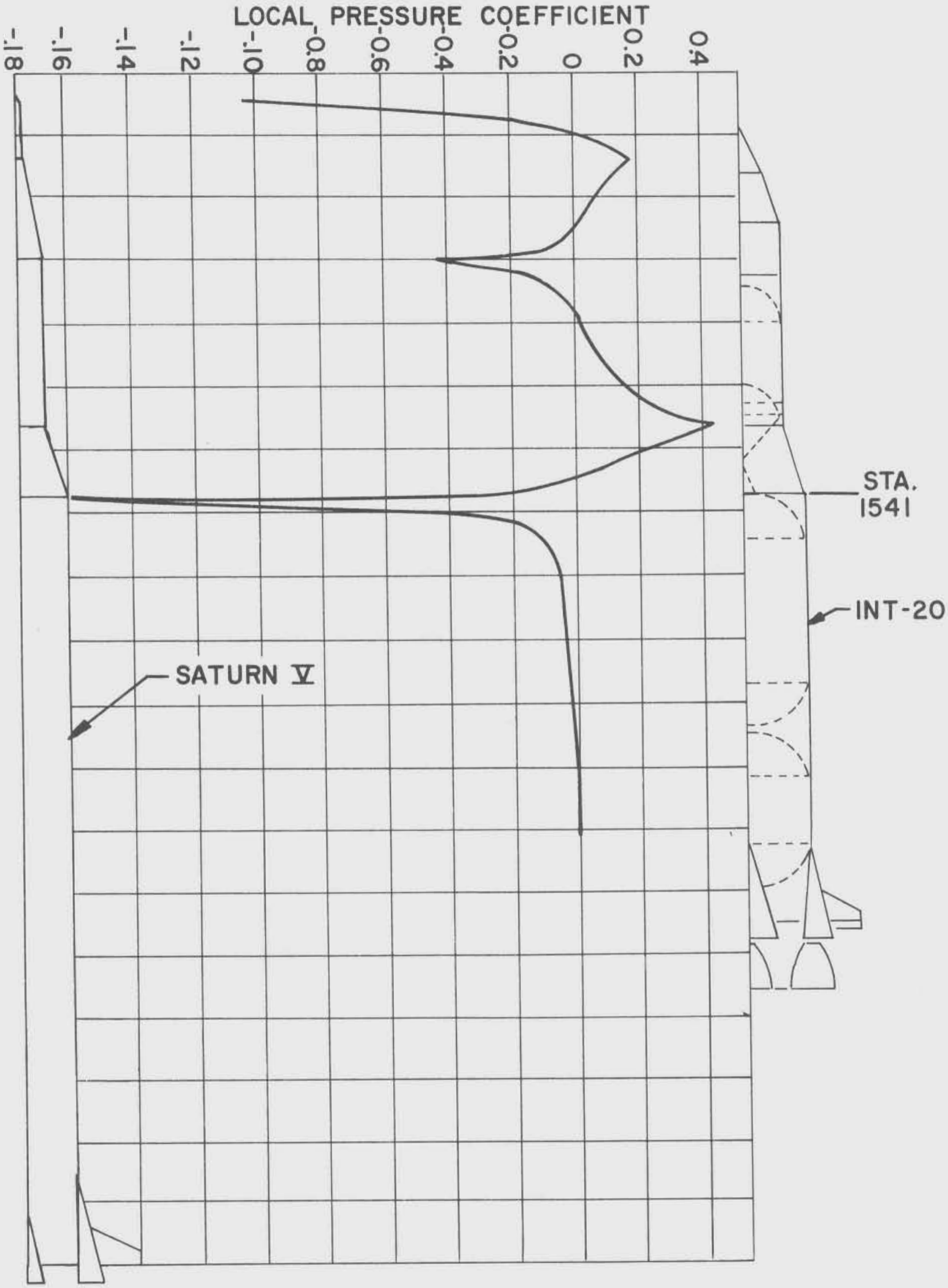


FIGURE A-29. **FORWARD SKIRT LATERAL AERODYNAMIC PRESSURE DISTRIBUTION (INT-20)**

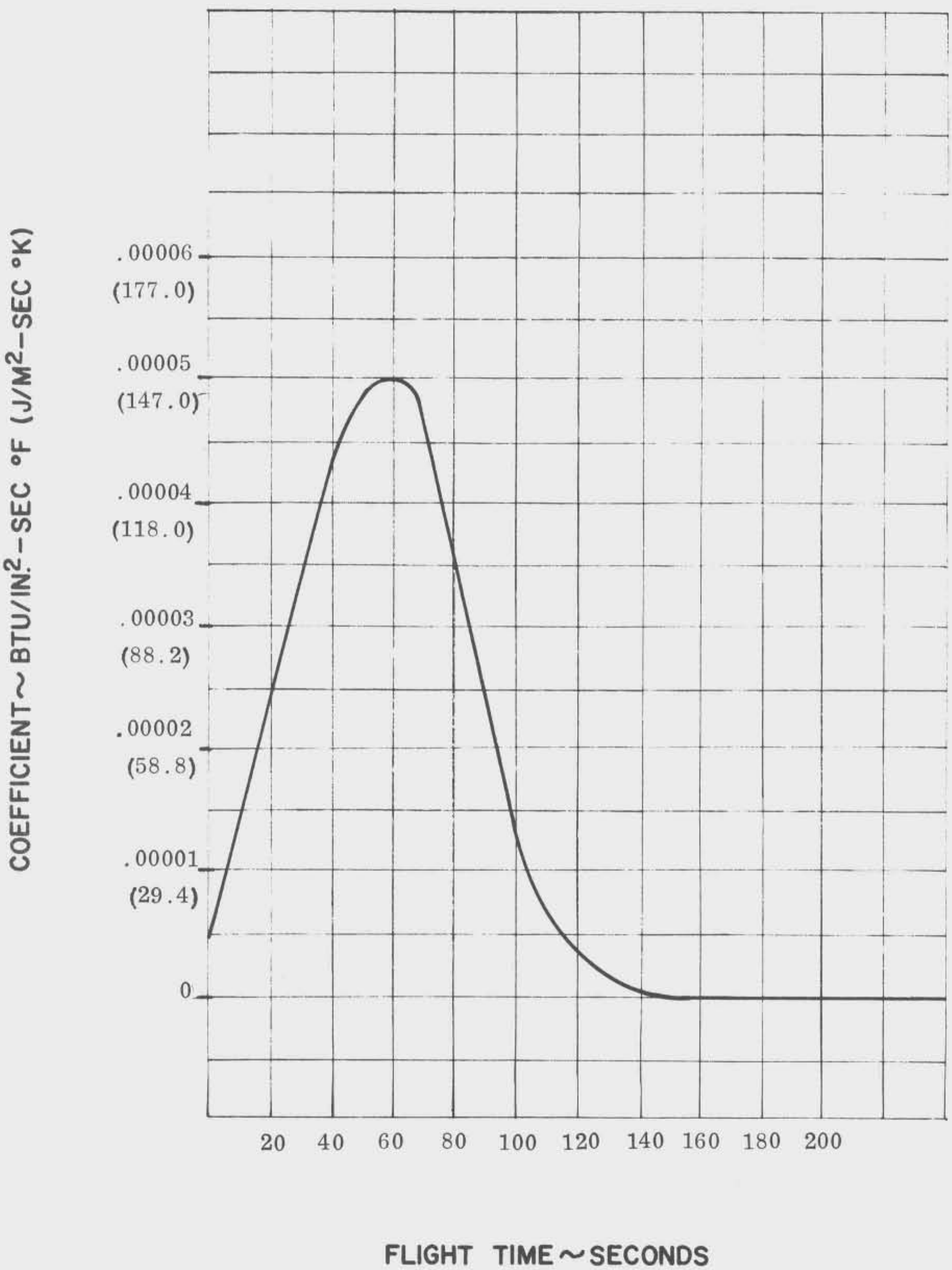


FIGURE A-**30.** FORWARD SKIRT SLIP FLOW CONVECTIVE HEAT TRANSFER COEFFICIENT (INT-20)

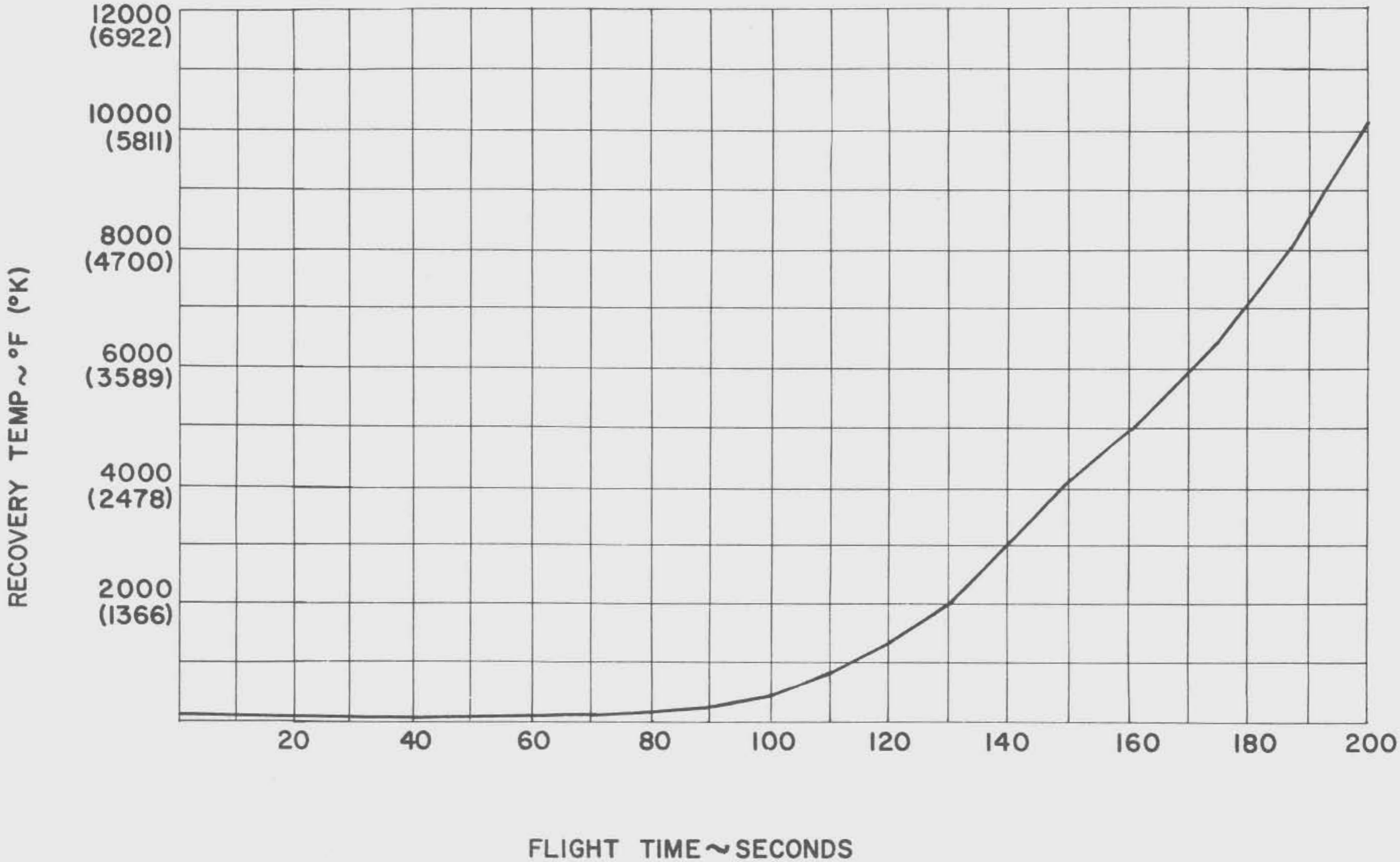


FIGURE A-31. FORWARD SKIRT RECOVERY TEMPERATURE (INT-20)

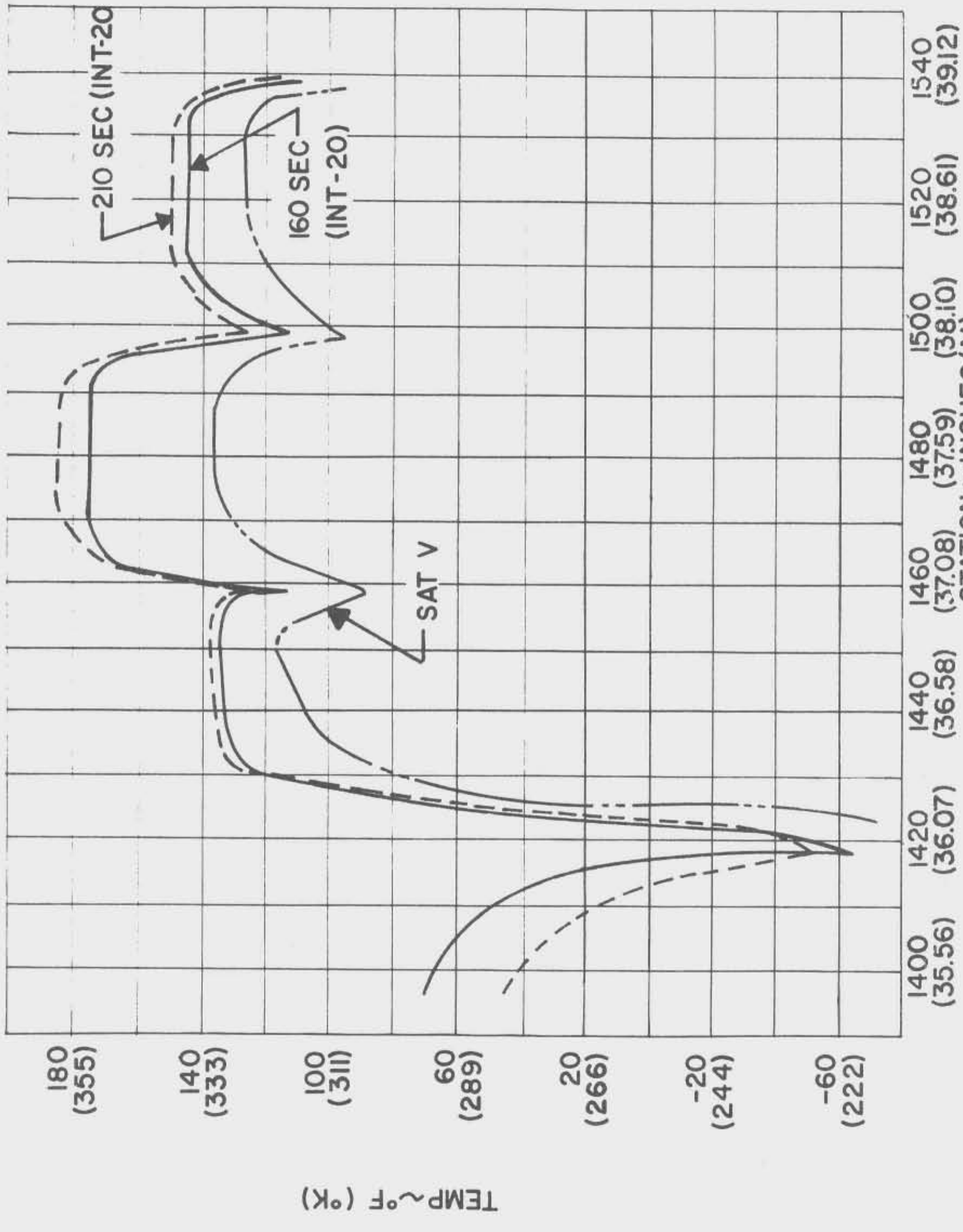


FIGURE A-32. FORWARD SKIRT SKIN CLEAN BODY TEMP GRADIENT (INT-20 & SAT V)

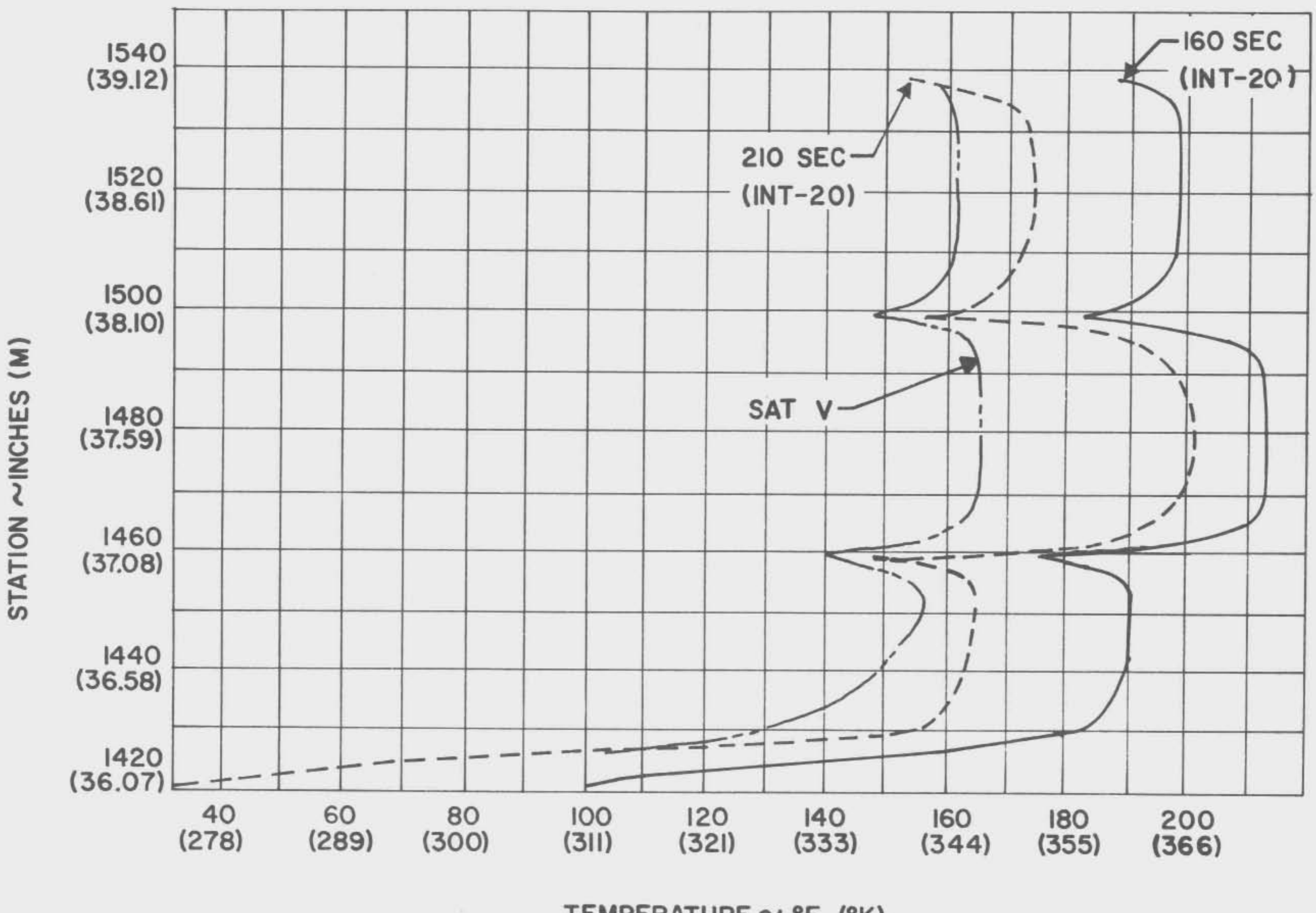


FIGURE A- 33. FORWARD SKIRT HAT SECTION CLEAN BODY TEMP GRADIENT (INT-20 & SAT V)

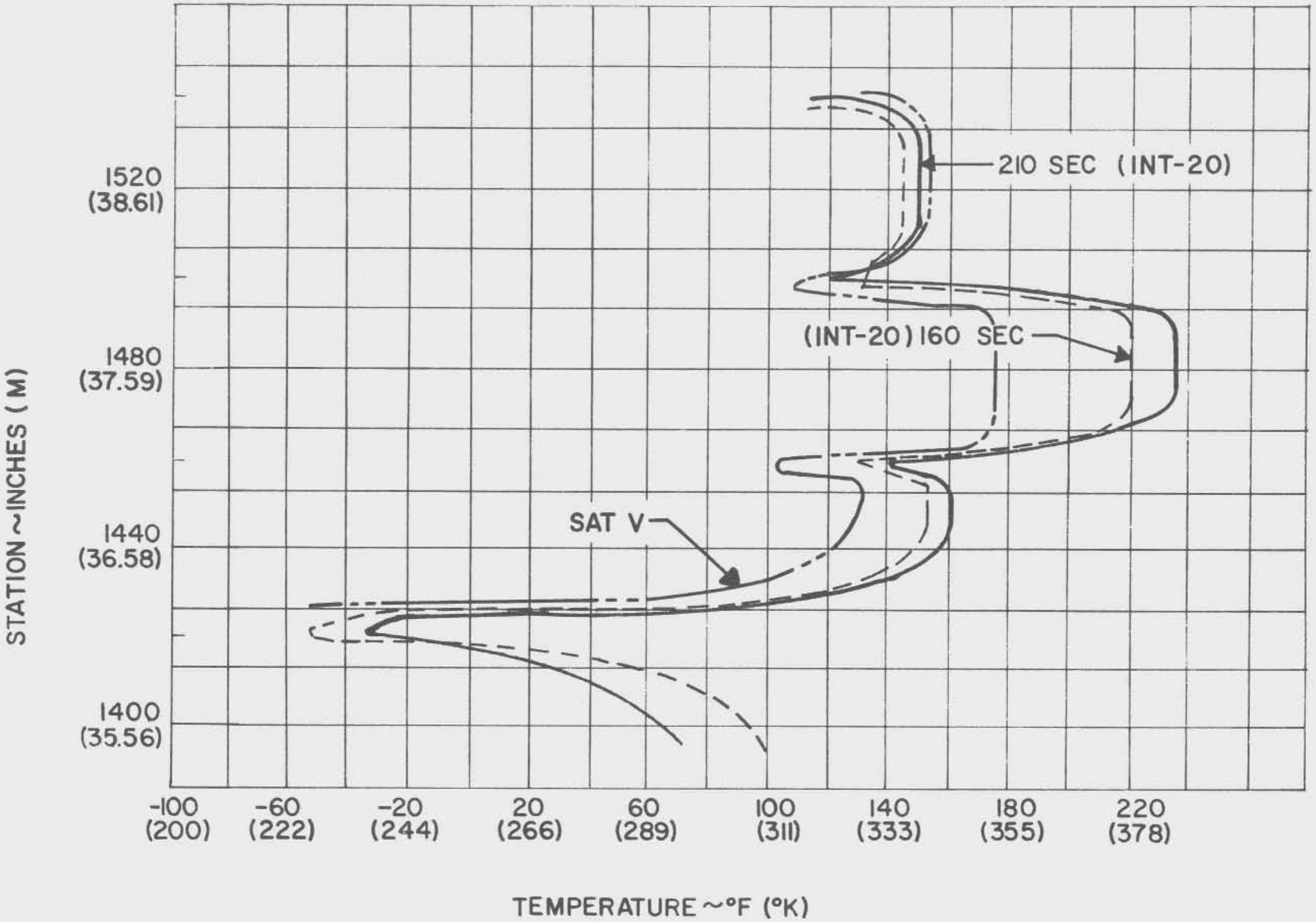


FIGURE A-34. FORWARD SKIRT SKIN MAX PROTUBERANCE TEMP GRADIENT (INT-20 & SAT V)

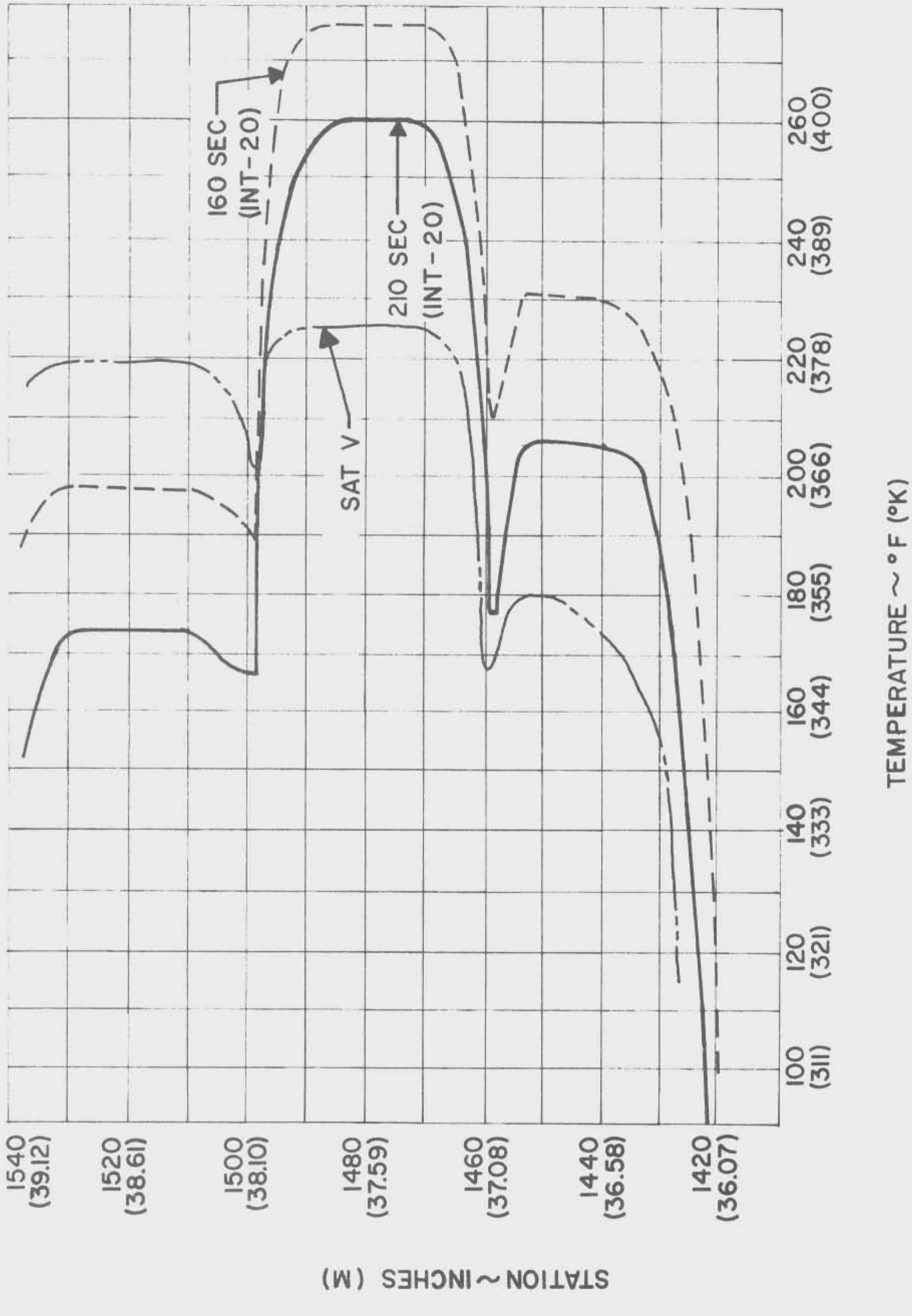


FIGURE A-35. FORWARD SKIRT HAT SECTION MAX PROTUBERANCE TEMP GRADIENT (INT-20 & SAT V)

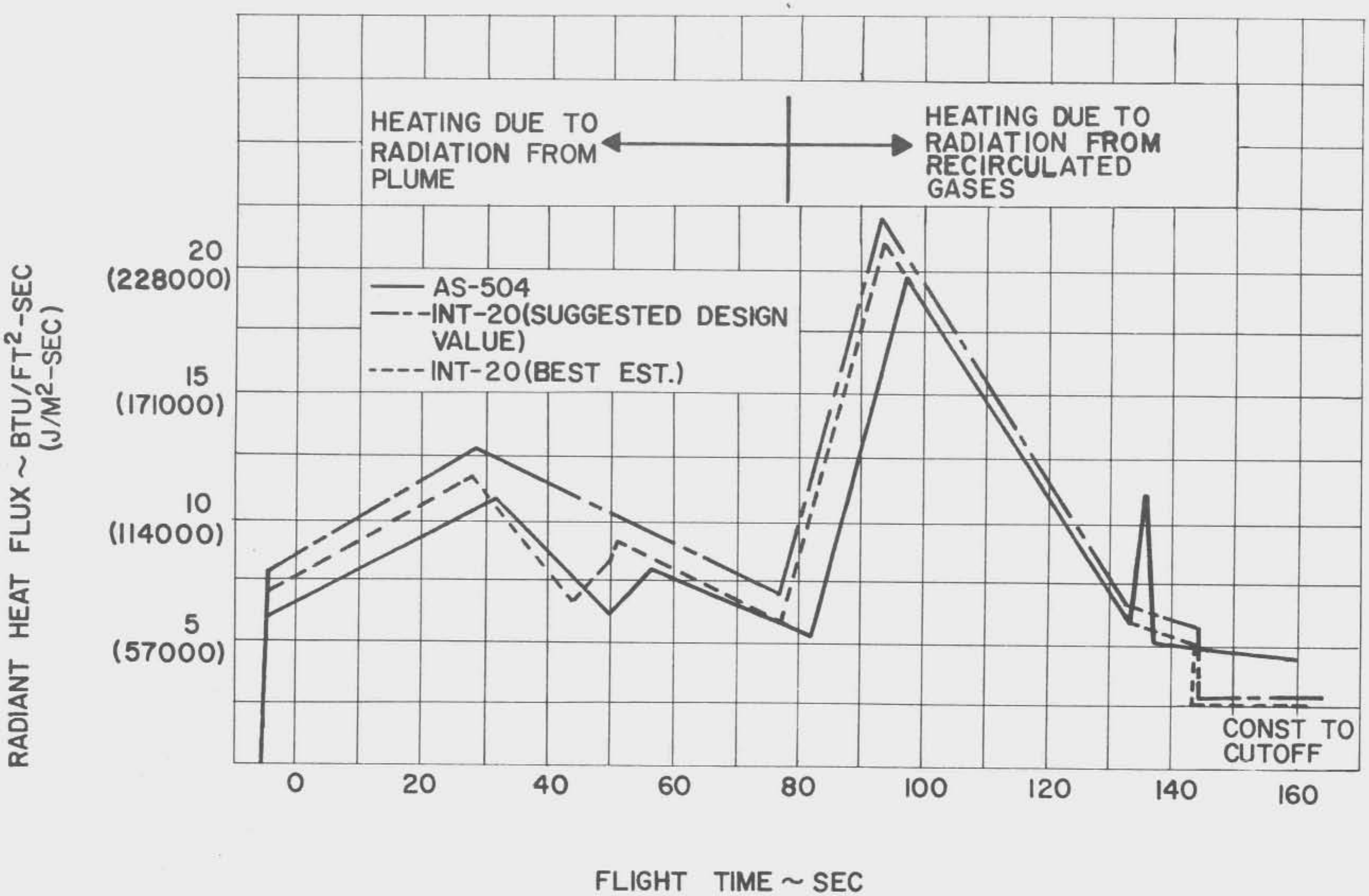


FIGURE A-36. BASE REGION RADIANT HEAT FLUX (INT-20 & SAT V)

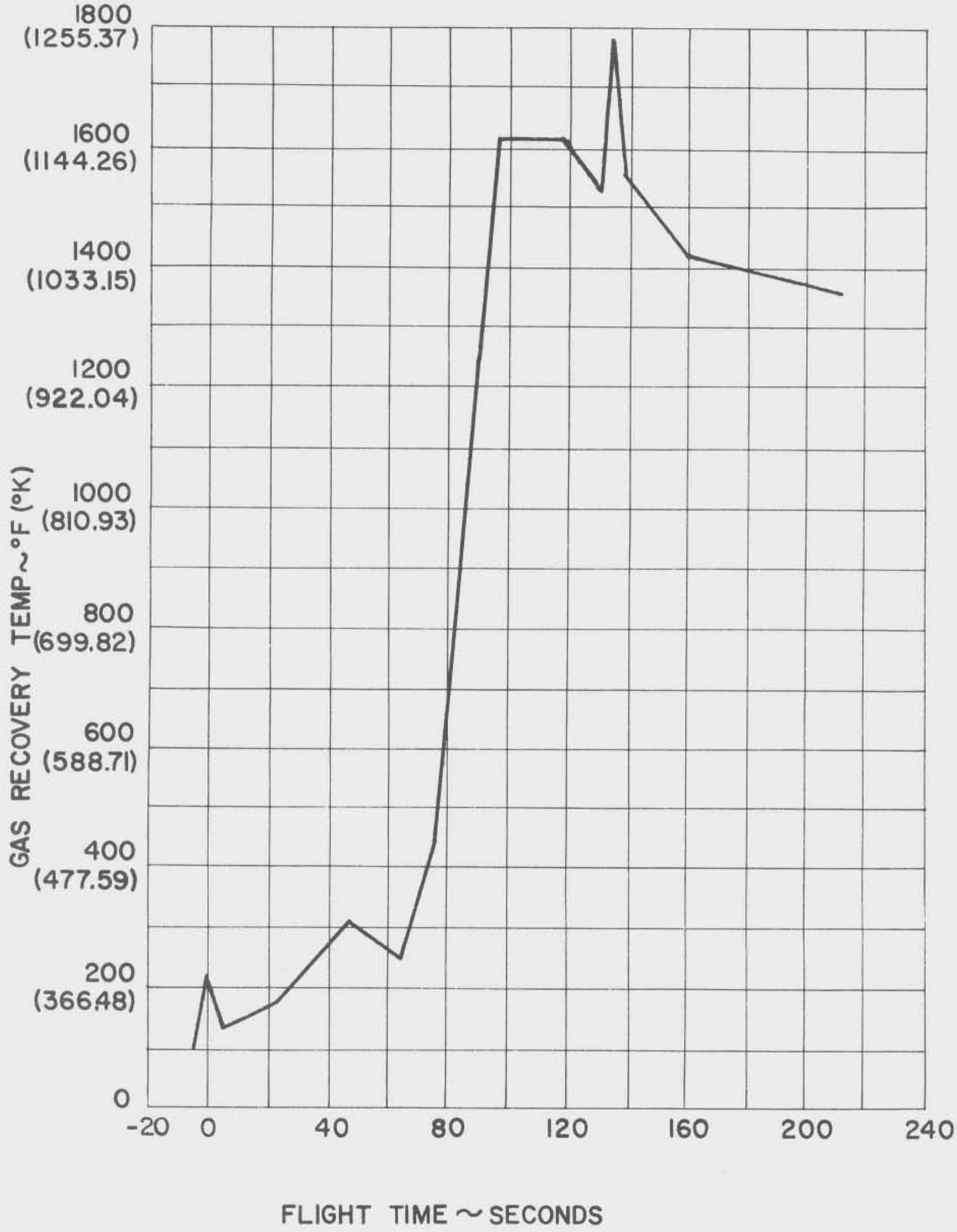


FIGURE A-37. BASE REGION GAS TEMPERATURE (INT-20)

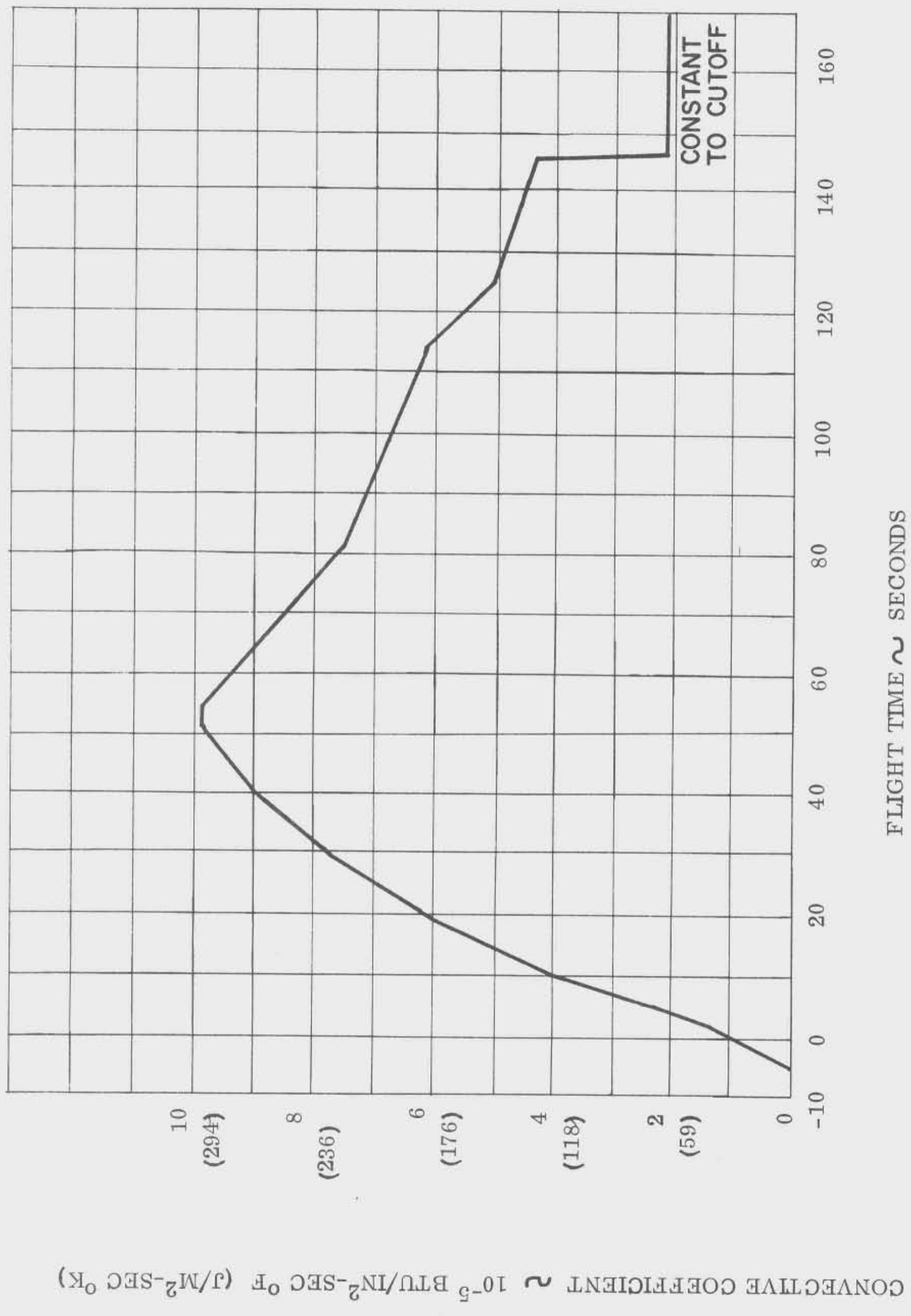


FIGURE A-38. BASE REGION CONVECTIVE COEFFICIENT (INT-20)

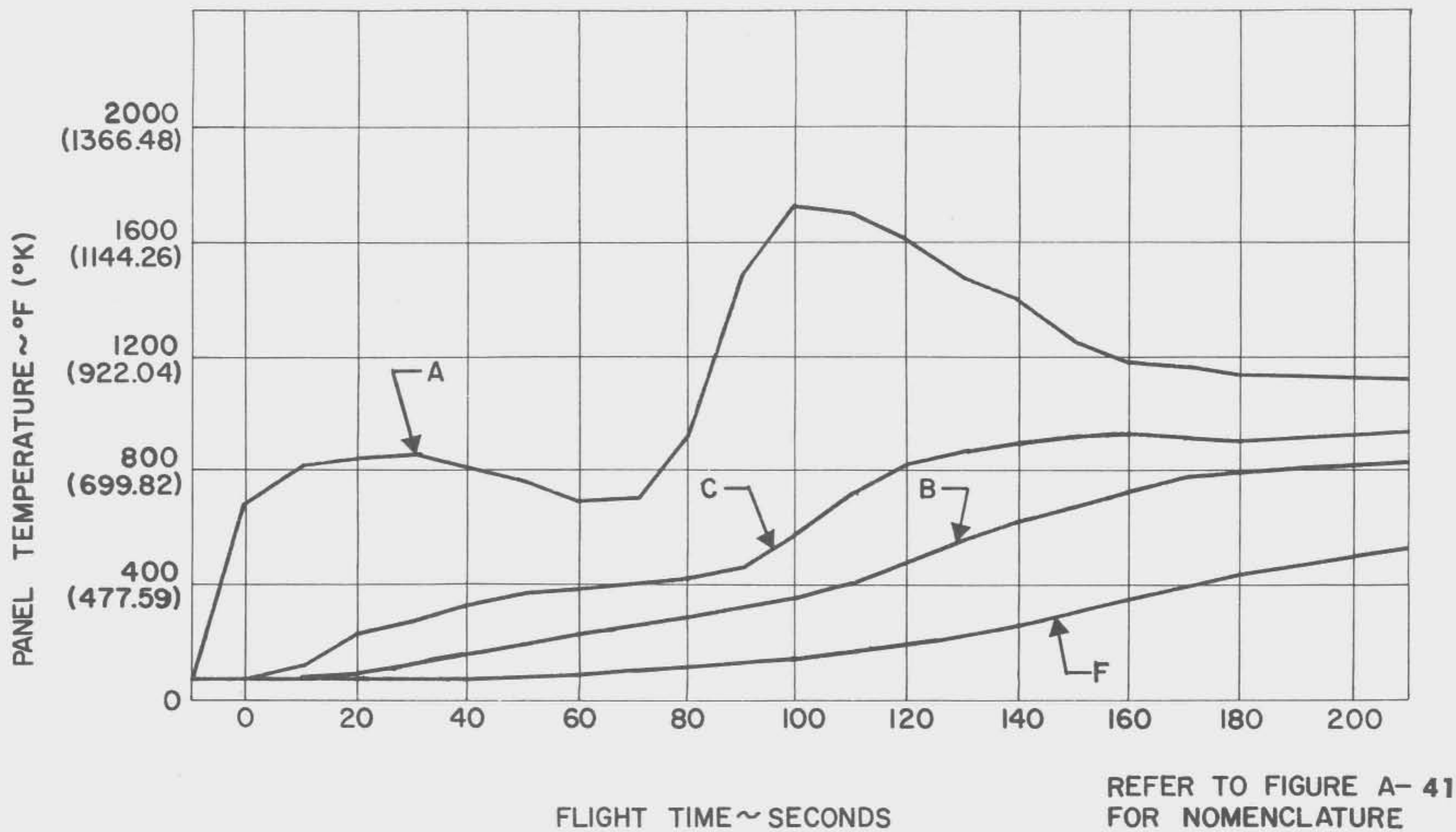
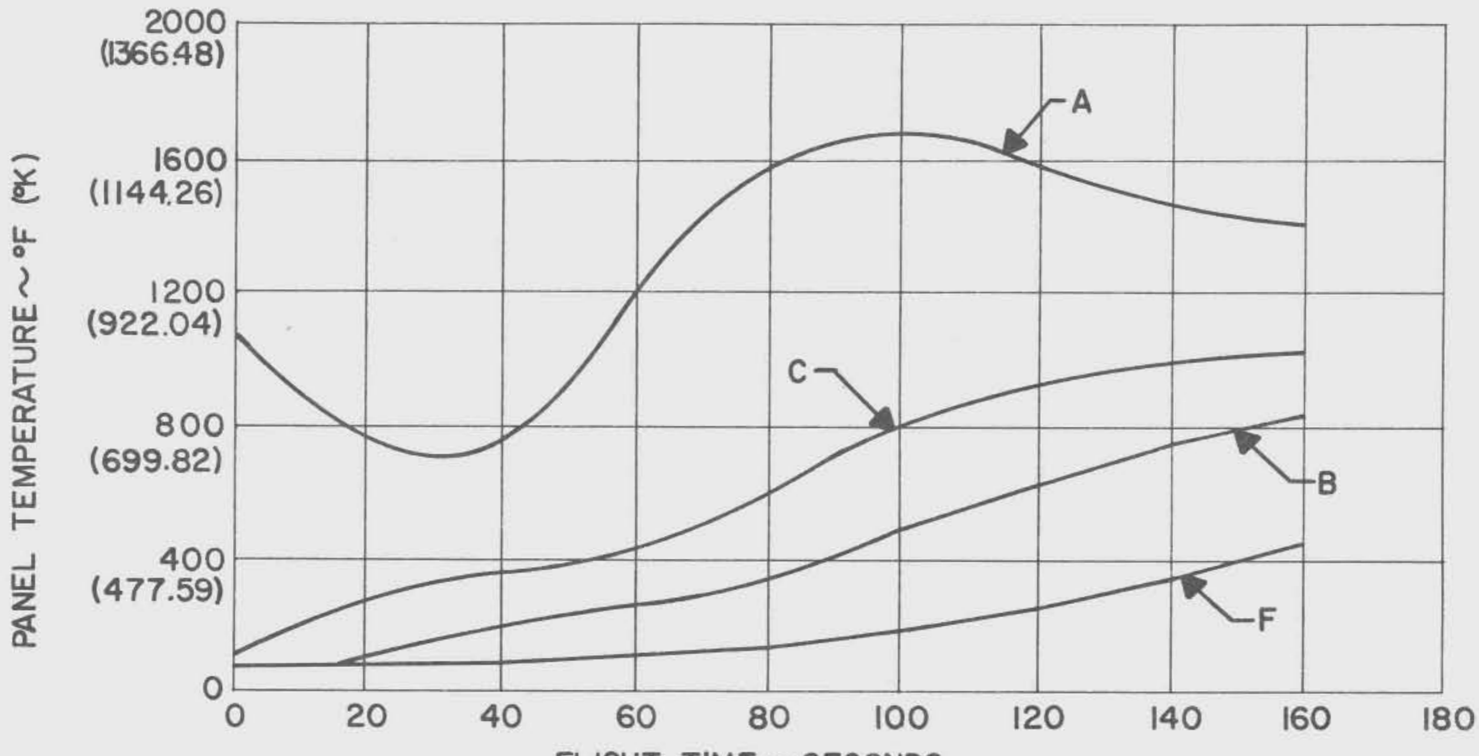


FIGURE A-39. BASE HEAT SHIELD PANEL TEMPERATURE (INT-20)



REFER TO FIGURE A-41 FOR NOMENCLATURE

FIGURE A-40. BASE HEAT SHIELD PANEL TEMPERATURE (SAT V)

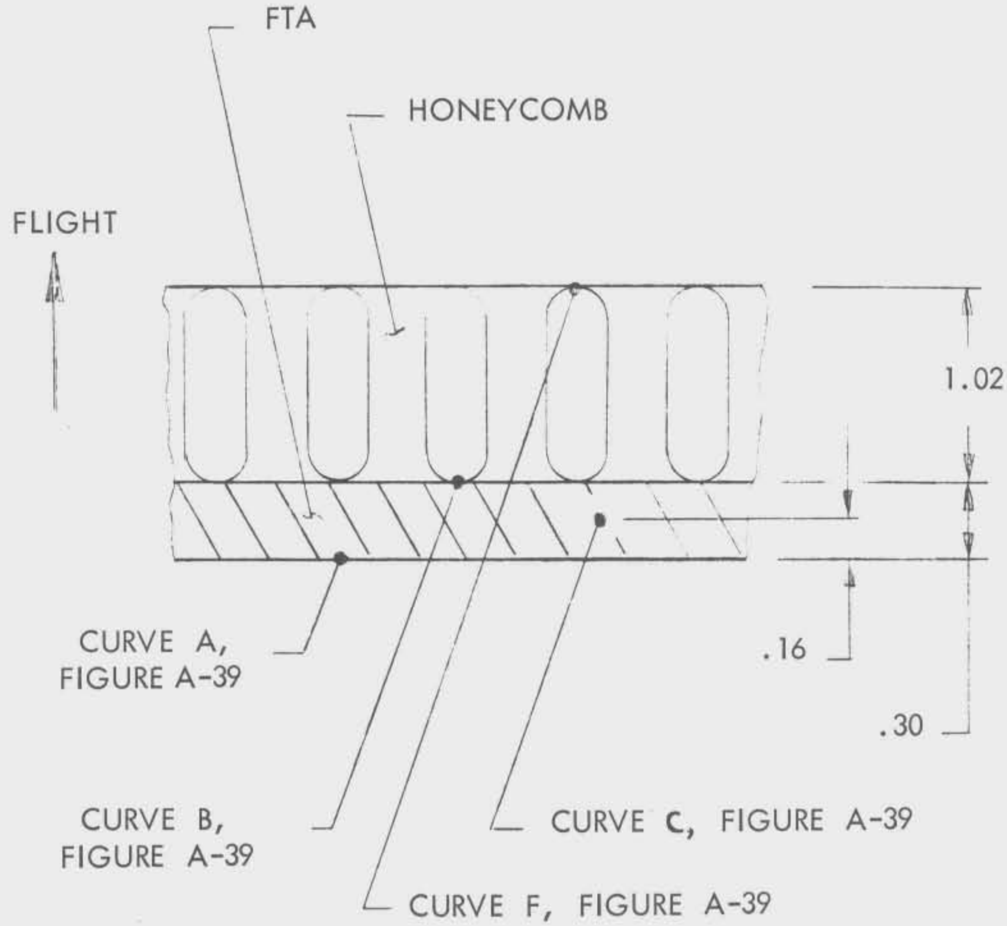


FIGURE A-41. HEAT SHIELD PANEL CROSS-SECTION (INT-20)

2.1.1.11 (Continued)

to the use of FTA-442A heat shield material which has more strength but less thermal resistance than the M31 material used on early S-IC stages. INT-20 temperatures are also increased over Sat V values due to the longer run and soak time.

Time - temperature data for the heat shield attach points and back up structure for INT-20 and comparative Sat V values (AS 511) are shown in FIGURES A-42 & A-43, respectively. A cross-section view with points of interest indicated is shown in FIGURE A-44.

2.1.1.12 Cutoff and Separation Loads

a. Cutoff

A simulation of the INT-20 vehicle during final two engine shutdown was run. The thrust decay curves taken from AS 505 flight data were assumed to be representative for INT-20. The resulting INT-20 accelerations were found to be less severe than the corresponding values for AS 505 outboard engine cutoff. At no point did any acceleration induced by the decay transient exceed the steady state acceleration level prior to shutdown.

b. Separation

The loading effects of propellant residuals impacting upon the forward tank bulkheads during separation will be different for INT-20 than for Sat V because of the increased INT-20 residuals and the 2-2 INT-20 engine cutoff sequence. TABLE A-IV is a comparison of the factors which relate to this condition.

The analysis required to accurately determine the resultant bulkhead loads is outside the scope of this preliminary study because of the complexity of the impact phenomenom. A simplified assessment performed for this study indicated that the critical resultant bulkhead loads for INT-20 with four retro-rockets would be slightly higher than for Sat V but would probably be acceptable. A factor of safety less than 1.4 could result but a reduced factor was considered acceptable after separation. Preliminary indications are that the INT-20 bulkhead loads resulting if eight retro-rockets were used would be significantly greater than Sat V loads and could be un-acceptable. A simple test in which a scaled-down model of the tank bulkhead is subjected to fluid impingement would be required for a detailed analysis in order to establish hydro-dynamic parameters.

2.1.2 Forward Skirt

Refer to D5-17009-2, Section 4.2.2.1.a.1 for the baseline forward skirt configuration definition.

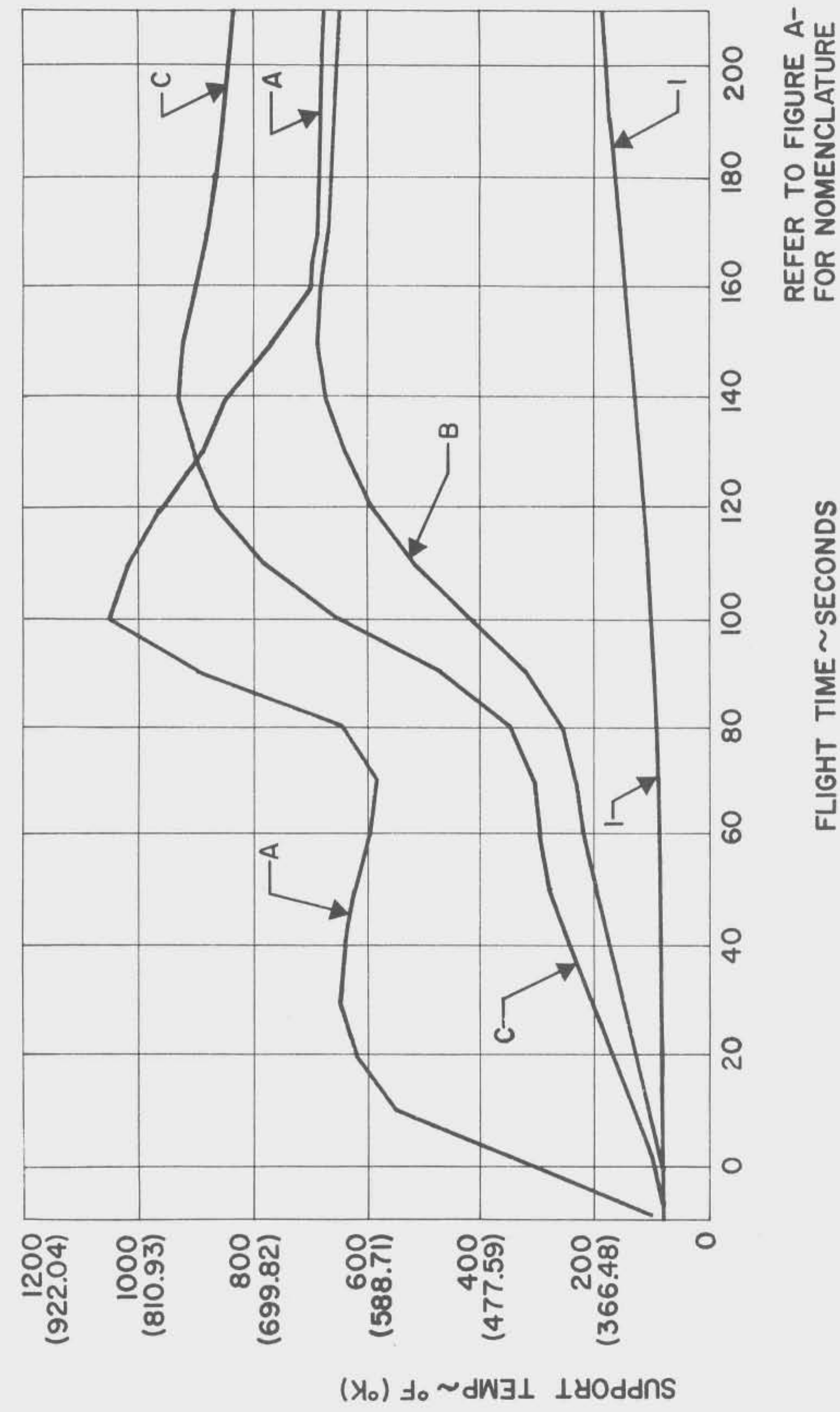


FIGURE A-42. BASE HEAT SHIELD SUPPORT TEMPERATURE (INT-20)

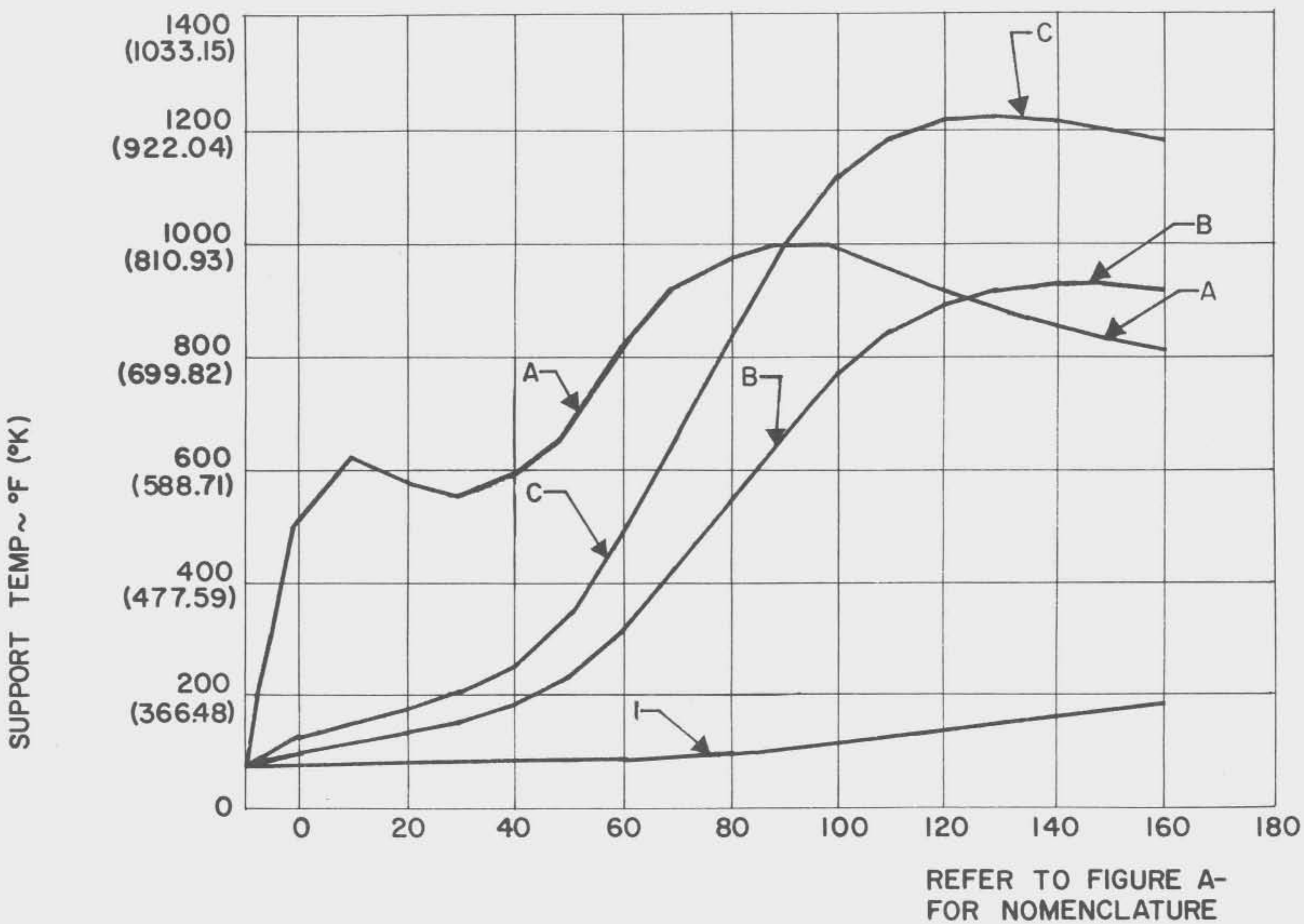


FIGURE A-43. BASE HEAT SHIELD SUPPORT TEMPERATURE (SAT V)

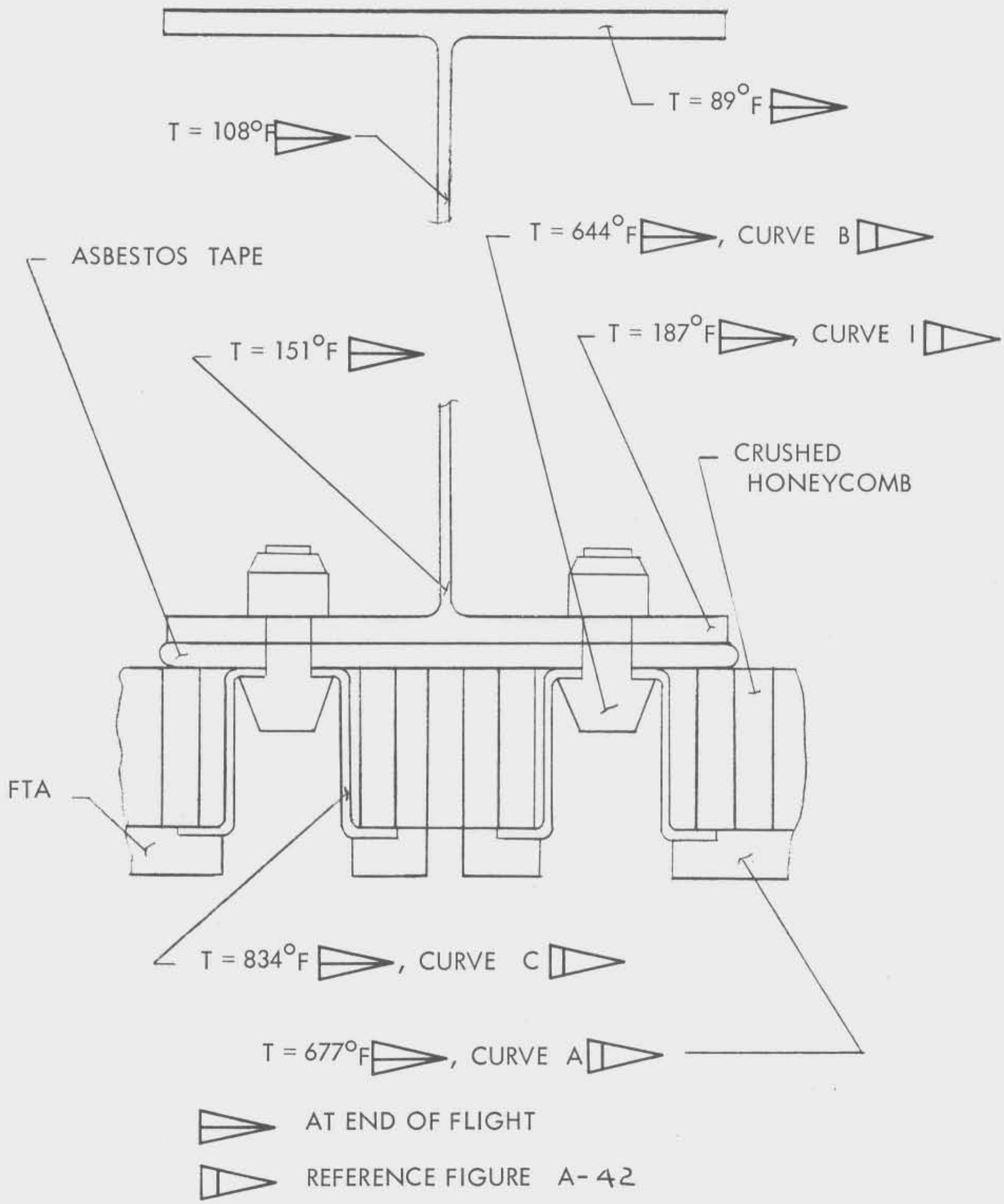


FIGURE A-44. HEAT SHIELD SUPPORT CROSS-SECTION (INT-20)

TABLE A-IV. S-IC Separation Conditions

	CONDITION	FUEL TANK RESIDUALS (pounds)	LOX TANK RESIDUALS (pounds)	No. of Retro Rockets	1-4 Engine Cutoff	2-2 Engine Cutoff	STAGE WT. (Less Propellant Tank Residuals) -pounds
VII A MARK A BOOST TRAJECTORY RUNS	SAT V S-IC (S-IC-4)	29,224	4,482	8	X		359,890
	INT-20 Baseline (Study Phase I) Criteria	30,400	25,100	8		X	327,180
	First Interation (Timed Cutoff) CASE I	49,600	76,200	8		X	"
	First Iteration CASE II (LOX depletion cutoff)	78,600	14,500	8		X	"
	First Iteration CASE III (Fuel depletion cutoff)	20,900	77,800	8		X	"
	Second Iteration (Programmed time to g limit cutoff)	49,700	45,700	8		X	"

2.1.2.1 S-IC/S-IVB Interface

a. Discussion

McDonnell Douglas was assigned responsibility for selecting the S-IC/S-IVB interface configuration by the program manager during the study proposal activity. The reason being that the S-IC is handled from the forward skirt and hence required configuration changes would probably be more cost effective if made to the S-IVB. The objective of our study effort was to establish a basis upon which to build a coordinated Boeing/McDonnell Douglas interface definition and implementation plan and to establish preliminary configurations which could be used by Michoud Engineering for evaluation.

In order to evaluate potential S-IC/S-IVB interface configurations, it was necessary to identify the existing Saturn V configuration of both stages in the interface area. The configurations are shown in FIGURE A-45. Basically, the interface areas of both stages are similar in that they are made up of built-up rings consisting of inboard and outboard chords, webs, stiffeners and splices. The S-IC interface ring has 96 ring stiffeners, 6 chord splices and 12 web splices. The S-IVB interface ring has 132 ring stiffeners and 6 frame splices. There are 216 1/2 inch diameter interface bolts on a 199.17 radius bolt circle and 288 3/8 inch diameter interface bolts on a 196.875 radius for the existing S-IC and S-IVB, respectively. The S-IC has 216 forward skirt skin stringers while the S-IVB has 144 aft interstage skin stringers. There are four retro-rocket adapters on the S-IVB in the interface area. The S-IC has three alignment pin receptacles.

b. Trades

Several S-IC/S-IVB interface alternatives were studied and coordinated between Boeing and McDonnell Douglas.

2.1.2.1 (Continued)

1. Continuous Adapter Ring

   (D5-17009-2, FIGURE 4-1)

2. Modified Direct Interface which uses a modification of the existing S-IC interface bolt pattern consisting of 130 1/2 inch diameter bolts and 28 3/8 inch diameter bolts (D5-17009-2, FIGURE 4.2.2.1-2 and McDonnell Douglas Drawing IT16648.)

3. Increased Modified Direct Interface which uses a modification of the existing S-IC interface bolt pattern consisting of 192 1/2 inch diameter bolts (FIGURE A-46.)

4. Segmented, Non-Continuous Adapter Ring (McDonnell Douglas Drawing IT16648.)

5. Compatible Direct Interface which uses an interface bolt pattern compatible with the existing bolt patterns of both stages. It consists of 66 1/2 inch diameter bolts and 84 3/8 inch diameter bolts (Mc Donnell Douglas Drawing IT16648).

All of the above methods were evaluated from cost, manufacturing and structural viewpoints. Two of the methods were determined to be the most feasible. They are the continuous adapter ring (Method 1) and the modified direct interface (Method 2).

The increased modified direct interface (Method 3), with 192 1/2 inch diameter bolts, has more structural capability than the Method 2 configuration. However preliminary analysis indicated the additional capability was not required for INT-20 loads. The non-continuous adapter interface (Method 4) has less capability than the continuous adapter ring and was determined not acceptable from a structural standpoint. It would also probably require a restraining storage fixture for the components. The compatible direct interface (Method 5) could be used after the existing bolt patterns were drilled in each stage. However, this method is undersirable because of the preponderance of unused holes and the close proximity of holes to structural features. In addition, retrofit and conversion to add the compatible interface holes would require the S-IC work to be performed in the Michoud VAB or at KSC.

c. Selected interface description

   Method 1 (continuous adapter ring) was selected for the retrofit and baseline configurations. Method 2 (modified direct interface) could be used as an alternate for the baseline configuration.

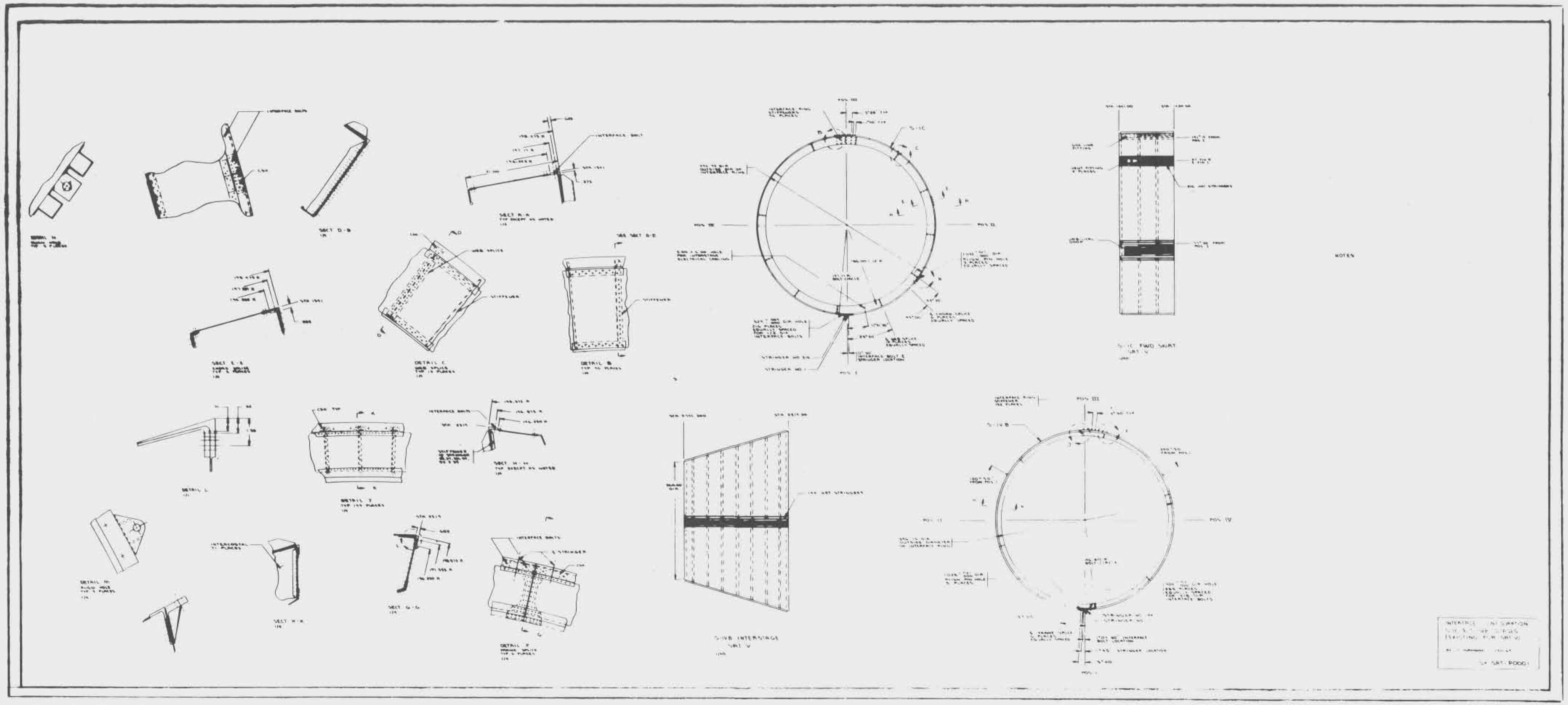


FIGURE A-45.

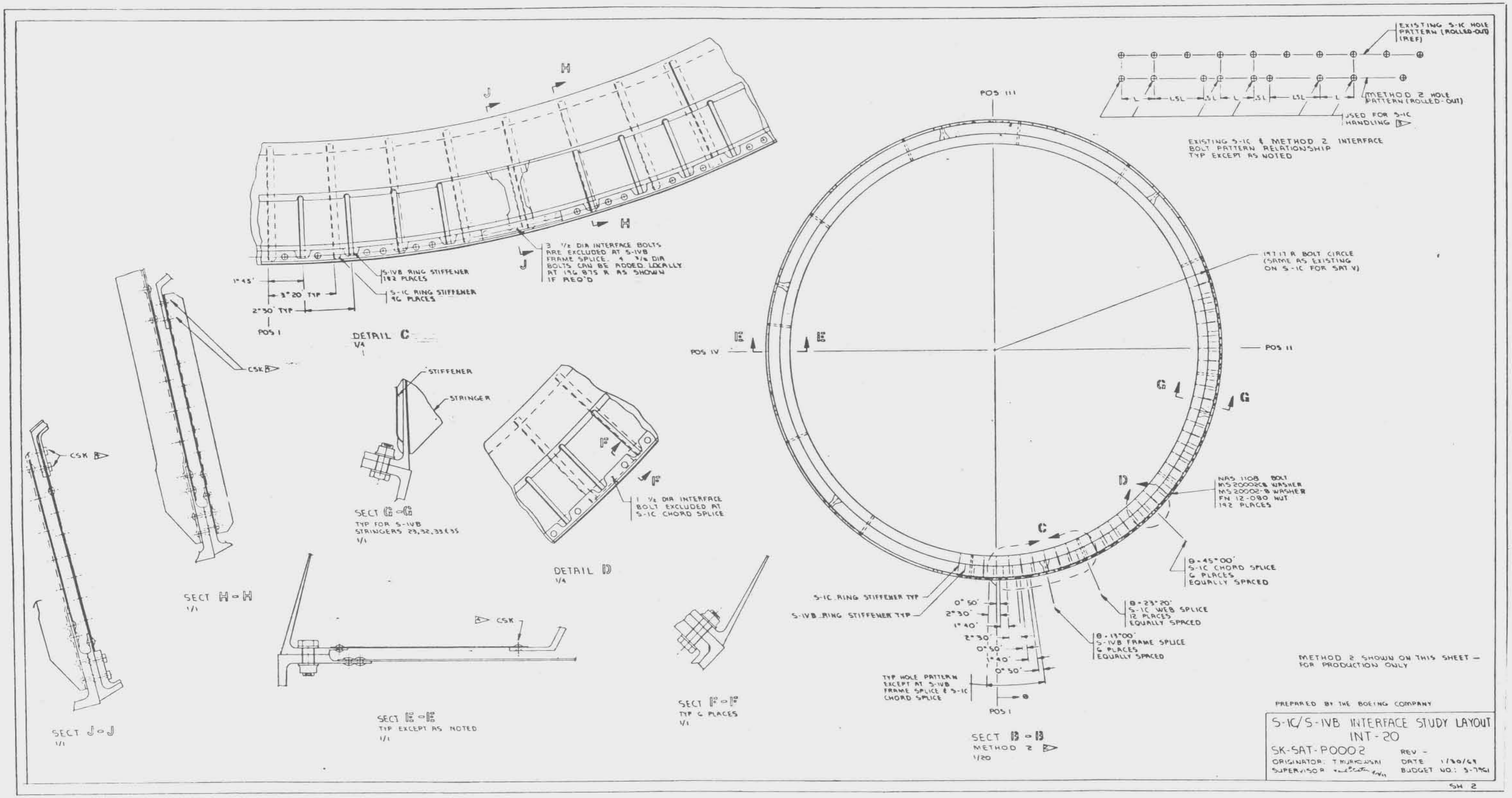

EXISTING S-IC HOLE PATTERN (ROLLED-OUT) (REF)
METHOD 2 HOLE PATTERN (ROLLED-OUT)
USED FOR S-IC HANDLING
EXISTING S-IC & METHOD 2 INTERFACE BOLT PATTERN RELATIONSHIP TYP EXCEPT AS NOTED
POS III
POS II
POS IV
POS I
197.17 R BOLT CIRCLE (SAME AS EXISTING ON S-IC FOR SAT V)
NAS 1108 BOLT
MS 20002C8 WASHER
MS 20002-8 WASHER
FN 12-080 NUT
192 PLACES
θ = 45°00' S-IC CHORD SPLICE 6 PLACES EQUALLY SPACED
θ = 23°20' S-IC WEB SPLICE 12 PLACES EQUALLY SPACED
θ = 13°00' S-IVB FRAME SPLICE 6 PLACES EQUALLY SPACED
S-IC RING STIFFENER TYP
S-IVB RING STIFFENER TYP
TYP HOLE PATTERN EXCEPT AT S-IVB FRAME SPLICE & S-IC CHORD SPLICE
SECT B-B
METHOD 2
1/20
METHOD 2 SHOWN ON THIS SHEET — FOR PRODUCTION ONLY
3 1/2 DIA INTERFACE BOLTS ARE EXCLUDED AT S-IVB FRAME SPLICE. 4 3/8 DIA BOLTS CAN BE ADDED LOCALLY AT 196.875 R AS SHOWN IF REQ'D
S-IVB RING STIFFENER 192 PLACES
S-IC RING STIFFENER 96 PLACES
1°45'
3°20' TYP
2°30' TYP
DETAIL C
1/4
STIFFENER
STRINGER
SECT G-G
TYP FOR S-IVB STRINGERS 23, 32, 33 & 35
1/1
1 1/2 DIA INTERFACE BOLT EXCLUDED AT S-IC CHORD SPLICE
DETAIL D
1/4
CSK
SECT H-H
1/1
SECT J-J
1/1
SECT E-E
TYP EXCEPT AS NOTED
1/1
SECT F-F
TYP 6 PLACES
1/1
PREPARED BY THE BOEING COMPANY
S-IC/S-IVB INTERFACE STUDY LAYOUT
INT-20
SK-SAT-P0002
REV -
ORIGINATOR: T MURKOWSKI
DATE 1/30/69
SUPERVISOR
BUDGET NO.: 5-7961
SH 2

FIGURE A-46.

2.1.2.1 (Continued)

c. Method 1 consists of adding a 5 inch deep channel adapter ring which is compatible with the existing interfaces of both the S-IC and S-IVB. It will attach to the Saturn V interface bolt patterns on both stages. The ring could be a continuous weldment or fabricated as a mechanical assembly.

Method 2 consists of using a direct interface and modifying the existing S-IC interface bolt pattern. The modified hole pattern will use 130 of the existing 216 1/2 inch diameter S-IC bolt locations and add 28 new 3/8 inch diameter bolt locations in local area. The modification to the S-IC pattern was required to avoid interference with S-IVB ring stiffeners, splices and retro-adapters.

The alignment provisions are basically the same for Methods 1 and 2. The three S-IC alignment receptacles will be retained. Alignment pins and fittings will be required on the S-IVB at suitable locations.

No modifications will be required to the S-IC handling ring for either Method 1 or 2. For Method 1, the S-IC forward area is unchanged. For Method 2, 130 of the existing handling bolt locations remain unchanged. Preliminary assessment indicates the S-IC stage for INT-20 can be handled using only these 130 handling bolts. However, additional handling holes could be added to the S-IC if subsequent detailed analysis indicates the necessity.

d. Interface cost and task study

A preliminary Michoud operations exercise was run to determine the cost factors and to identify major tasks peculiar to the adapter ring and direct interface methods.

1. Non-recurring operations and costs

(a) Adapter ring

Tooling costs for the adapter ring are estimated at $45,000 for direct labor and material. This includes:

(1) Extrusion die
(2) Stretch form tooling
(3) Stress relieve fixture
(4) Drill fixture
(5) Transportation dolly
(6) Assembly fixture

2.1.2.1 (Continued)

(b) Direct interface

Existing S-IC/S-II and S-IVB/S-II interface tool masters would be used to generate a new S-IC/S-IVB interface control master from which transfer gages could be made for both Boeing and McDonnell Douglas. The new master and transfer gages would be supplied by McDonnell Douglas as both the existing tool masters are located in California. The estimated cost of the new gages, drill plate fabrication and the Michoud Assembly fixture changes is essentially the same as for the adapter ring tooling.

2. Recurring costs

Recurring costs for six adapter ring segments is estimated at $2,166 using roll forming or $2,486 using stretch forming processing. This costs includes the drilling of the interface holes in the segments but does not include assembly of the segments into a structural ring. The cost of the hole drilling is about 50% of the total parts cost. There would be no delta recurring cost impact on the S-IC for the direct interface method.

3. Other factors

The modified direct interface would destroy reversibility in the S-IVB aft frame. Retrofit or conversion of the S-IC using the direct interface would require removal of the handling ring. This can be accomplished only in the vertical position at the Michoud VAB or at KSC.

4. Conclusion

The modified direct interface method would be preferable if retrofit of existing stages was unlikely and if conversion decisions could be made prior to drilling the interface hole patterns. These qualifications limit the flexibility of the direct interface method.

Although the adapter ring imposes a moderate added recurring cost, it has a number of inherent advantages which relate to avoidance of potential costs. These advantages are:

(a) No change to existing interface requirements for stage tooling, processing or inspection for either stage.

(b) Retrofit and production configuration could be identical.

(c) Flexibility of reversibility is maximized.

(d) Avoids control requirements for more than one interface configuration.

(e) Avoids revision to S-IC handling.

2.1.2.2 Forward Skirt Structural Assessment

Beam column computer programs which simulate the S-IC forward and S-II aft structure are presently used for S-IC forward skirt analysis. The program inputs are column loads, section properties, material properties, thermal deflections, structural misalignments, and ring and skin spring constants. The outputs are internal loads, deflections and stresses. For INT-20, it was decided that new programs which simulate the S-IVB Aft Interstage were outside the scope of this study and were not necessary for a preliminary assessment of the forward skirt for INT-20 loads.

The preliminary forward skirt structural assessment conducted for this study consisted of comparing the corresponding INT-20 and Sat V loads and extrapolating the impact of the INT-20 loads from the existing Sat V analysis. The contributing INT-20 forward skirt loads are vehicle combined axial loads, lateral aero-dynamic pressure, forward skirt temperature gradients and a radial kick load at the S-IC/S-IVB interface due to the conical S-IVB Aft Interstage.

a. Axial loads impact

The forward skirt axial loads will be considerably lower for INT-20 than for Sat V because of the smaller upper stage and payload weights.

The maximum combined compressive loads for Sat V and INT-20 are as follows:

Nc (Max - INT-20)	=	2312 LB/IN	(ULT)	(Section 2.1.1.4, Appendix A)
Nc (Max - Sat V)	=	6845 LB/IN	(ULT)	(S-IC-4 & ON)

b. Lateral aerodynamic pressure impact

The aerodynamic pressure spike at the S-IC/S-IVB interface as discussed in Section 2.1.1.9 of Appendix A will produce an internal forward skirt pressure for INT-20 which could be as high as 6.0 PSIG. This condition does not exist on Sat V. The magnitude of the impact of the internal pressure was investigated by conservatively assuming that the 6.0 PSI pressure was uniformily distributed between STA 1541 and the next lower intermediate forward skirt ring at STA 1500.

(1) STA 1541 impact

The resultant radial force at STA 1541 was calculated as follows:

$$H \text{ (Radial - STA 1541)} = \frac{1.4\ (P)\ (L)}{2}$$

$$= \frac{1.4\ (6.0)\ (41)}{2} = 172 \text{ LB/IN (ULT)}$$

2.1.2.2 (Continued)

b. (1) This induced radial load will produce the following radial deflection at STA 1541:

$$\Delta R = \frac{H \; R^2}{A \; E} \qquad \text{(A = STA 1541 Fwd Skirt Ring Area)}$$

$$= \frac{172 \; (198)^2}{3.7 \; (10 \times 10^6)} = .182 \text{ inch}$$

(2) Skin - stringer impact

The maximum skin-stringer deflection and moment due to the internal pressure were calculated as follows. Simple supports were assumed.

$$\Delta R = \frac{5 \, WL^4 \; (1.4) \; (b)}{384 \; EI} \qquad \text{(b = 5.76 effective Sat V beam - Column width)}$$

$$= \frac{5(5.76) \, (41)^4 \; (1.4) \, (6)}{384 \, (10 \times 10^6) \, (.82)}$$

$$= .216 \text{ inch}$$

$$M = \frac{WL^2}{8} \, (1.4)$$

$$= \frac{6.0 \; (41)^2 \; (1.4)}{8}$$

$$= 1770 \text{ IN-LB/IN (ULT)}$$

c. Radial kick load impact

The conical S-IVB aft interstage has a slope of 16.5^0. This results in a radial component of the maximum combined axial compressive load of 690 LB/IN (ULT) at STA 1541. The resulting radial deflection at STA 1541 was calculated as follows:

$$\Delta R = \frac{H \, R^2}{A \, E} \qquad \text{(A = Combined S-IVB and S-IC Ring areas)}$$

$$= \frac{690 \; (198)^2}{6.2 \, (10 \times 10^6)} = .435 \text{ inch}$$

2.1.2.2 (Continued)

d. Temperature gradient impact

Axial temperature gradients as discussed in Section 2.1.1.10 of Appendix A produce local bending in the forward skirt. Maximum uninsulated Sat V (S-IC-4 & on) forward skirt expansion due to temperature gradient is .09 inch. Sat V thermal expansion at STA 1541 is .01 inch. The estimated INT-20 expansions due to temperature gradient are .12 inch maximum and .013 inch at STA 1541. The increased INT-20 temperatures will also cause a 5% material property loss.

e. Net INT-20 forward skirt loads impact

(1) STA 1541

The total INT-20 forward skirt maximum axial load is 2312 LB/IN (ULT). The total moment at STA 1541 due to the above conditions was calculated as follows:

$$\text{Total } \Delta R = .630 \text{ Inch}$$

$$\text{Max Moment} = 2312\ (.630)$$

$$= 1460 \text{ IN-LB/IN (ULT)}$$

The magnitude of the impact of these loads was determined by applying them to the leg of the S-IC interface ring outer chord which is .375 inch thick. The following calculations show that the resulting stresses will be within the structural capability.

$$fc = P/A = \frac{2312}{.375} = 6150 \text{ PSI (ULT)}$$

$$fb = \frac{6\ M}{b\ T^2\ (M.R)}$$ (M.R. = Modules of Rupture for Plastic bending)

$$= \frac{6\ (1460)}{(.375)^2\ (1.4)} = 44500 \text{ PSI (ULT)}$$

$$f \text{ (Total)} = 51000 \text{ PSI (ULT)}$$

$$F \text{ (Allow)} = 65000 \text{ PSI}$$

(2) Skin - stringer

Maximum outboard skin-stringer deflection for Sat V (S-IC-4 & on) occurs at STA 1520. This location was therefore investigated for INT-20 loads. The outboard deflection at STA 1541 due to the INT-20 radial kick load was also assumed to act at STA 1520. An

2.1.2.2 (Continued)

(2) axial load induced radial deflection of .05 inch was assumed to act at STA 1520 for INT-20. This was arrived at by multiplying the ratio of INT-20 to Sat V axial loads times the total Sat V deflection at STA 1520 minus the thermal deflection. The following calculations, which use the beam-column properties used for Sat V analyses, show that skin-stringer stresses for INT-20 will be within the structural capability.

$$\Delta R = .821 \text{ Inch}$$

$$\text{Max Moment} = .821(2312) + 1770$$
$$= 3670 \text{ IN-LB/IN (ULT)}$$

$$\text{Axial load} = 2312 \text{ LB/IN (ULT)}$$

$$\text{Effective Beam Width} = 5.76 \text{ Inch}$$

$$I = .82 \text{ IN}^4$$
$$A = 1.384 \text{ IN}^2$$
$$c = .517$$

$$fc = \frac{P}{A} + \frac{Mc}{I}$$

$$= \frac{2312\,(5.76)}{1.384} + \frac{3670\,(5.76)\,(.517)}{.82}$$

$$= 23000 \text{ PSI (ULT)}$$

$$Fc \text{ (Allow)} = 35400 \text{ PSI}$$

f. S-IC/S-IVB interface assessment

1. Modified direct interface

A very conservative analysis of the modified direct interface bolts was performed to establish structural acceptability. The following assumptions were made:

(a) A 3/8 inch bolt with a 9 inch spacing was assumed critical.

(b) The maximum combined tension load of 121 lb/in at STA 1541 (FIGURE 4-9*, D5-17009-2) was assumed to act concurrently with the maximum bolt shear.

2.1.2.2 (Continued)

(c) Ground shear of 38000 lb (Section 2.1.1.1 of Appendix A) was assumed.

(d) The total net STA 1541 radial deflection of .630 inch and the total S-IC and S-IVB ring areas of 6.2 IN^2 were assumed to influence bolt shear.

The following calculations show that the interface bolts will be structurally acceptable:

$$\text{Bolt Tension} = 121(9) = 1090 \text{ Lb/Bolt}$$

$$R_T = \frac{1090}{12700} = .086$$

$$\text{Bolt Shear} = \frac{38000\,(9)}{\pi(198)} + \frac{.63(6.2)(9)(10\times10^6)}{198^2}$$

$$= 9500 \text{ Lb/Bolt}$$

$$R_S = \frac{9500}{10500} = .905$$

M.S. (Conservative)

$$= \frac{.98}{.905} - 1 = .07$$

g. Adapter ring

The adapter ring is .50 inch thick as compared to the S-IC interface ring leg which is .375 in thick. Since the loads for these two components will be approximately the same it is concluded that the adapter ring will also be structurally acceptable.

2.1.3 Oxidizer Tank

Refer to D5-17009-2, Section 4.2.2.1.a.2 for baseline oxidizer tank configuration definition.

2.1.3.1 Trade Studies

Oxidizer tank design changes will be required in the area of the inboard lox suction fitting due to the deletion of the inboard lox suction duct. Trade studies were performed to determine whether or not to delete the lox standpipe and to determine the configuration of the suction fitting cover.

2.1.3.1 (Continued)

a. Lox standpipe

The primary considerations in determining whether or not to delete the standpipe for INT-20 were cost and ease of reversibility. The estimated cost saving if the standpipe were deleted is $10000.00. Reversibility can be maintained if the standpipe were deleted because it is designed to be able to be installed or removed after tank assembly. It was therefore concluded that the standpipe should be deleted for INT-20.

b. Suction fitting cover

Two cover configurations (D5-17009-2, FIGURE 4.2.2.1-3) were evaluated. Method 1 used a constant thickness flat plate. Method 2 used a flat plate with a floating flange of the same configuration presently used for hydrostatic test. Although Method 1 would be the most cost effective, stress analysis showed that it would be structurally unacceptable. Method 2, which required no analysis as hydrostatic proof pressures are not changed for INT-20, was therefore selected.

The fitting computer analysis used for Sat V bulkhead fittings was used for the Method 1 configuration analysis. The computer runs for the two critical fitting cross-sections are shown in FIGURES A-47 thru A-54. The results are tabulated in TABLE A-V . A general discussion of the computer program and the output terminology is contained in D5-12284-6, Section 6. The critical area for the Method 1 configuration was the cover attach bolts. The bolt analysis is as follows:

H 9 (Shear at bolts)

= 4780 LB/IN (For Pressure = 59.6)

Bolt Spacing = 1.89 IN

Bolt Shear = 1.89(1.4)(4780)

= 12700 LB/Bolt (ULT)

Allowable bolt shear = 11100 Lb/Bolt (Min. Section)

2.1.3.2 Oxidizer Tank Structural Assessment

a. Lox tank skins and Y-rings

Tank skin and Y-ring loads consist of axial loads and internal pressure. Critical conditions occur during hydrostatic proof test and flight. For hydrostatic test, proof pressures are unchanged for INT-20.

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* INPUT DATA

R(J) =	13.615	R(I) =	11.500	R(H) =	N/A	R(G) =	N/A	R(F) =	N/A	R(E) =	11.500
R(A) =	11.000	R(B) =	N/A	R(D) =	10.737	R(O) =	10.737	R(P) =	10.737	R(Q) =	9.9750
R(1) =	280.00	R(2) =	280.00	R(M) =	N/A						
E(1) =	-0.1150E-01	E(2) =	N/A	E(3) =	N/A	E(4) =	N/A	E(5) =	N/A	E(6) =	-0.2360
EC(1)=	N/A	EC(2)=	N/A	E(9) =	0.3750	E(10)=	0	E(M) =	2.1400	E(F) =	N/A
T(S) =	0.4620	T(A1)=	0.6600	T(A2)=	N/A	T(A3)=	N/A	T(A4)=	N/A	T(A5)=	N/A
T(C1)=	N/A	T(C2)=	N/A	T(P) =	0.7500	T(M) =	N/A				
P =	57.900	EXT L=	N/A	P(C1)=	N/A	P(C2)=	N/A	F =	N/A		
E(S) =	0.1060E 08	E(A1)=	0.1060E 08	E(A2)=	N/A	E(A3)=	N/A	E(A4)=	N/A	E(A5)=	N/A
E(C1)=	N/A	E(C2)=	N/A	E(R) =	0.1060E 08	E(E) =	0.1060E 08				
U(S) =	0.3300	U(A1)=	0.3300	U(A2)=	N/A	U(A3)=	N/A	U(A4)=	N/A	U(A5)=	N/A
U(C1)=	N/A	U(C2)=	N/A	U(R) =	0.3300	U(E) =	0.3300				
I(R) =	9.9400	I(E) =	0.5360E-01	M(RP)=	N/A	M(EP)=	N/A	F(P) =	N/A	F(EP)=	N/A
A(R) =	6.5200	A(E) =	1.1430	THETA=	0	T =	0				
(FA)S=	0.6300E 05	(FA)1=	0.6300E 05	(FA)2=	N/A	(FA)3=	N/A	(FA)4=	N/A	(FA)5=	N/A
FA)C1=	N/A	FA)C2=	N/A	(FA)R=	0.6300E 05	(FA)E=	0.6300E 05				
M(R) =	1.5000	C5 =	2.1400	C6 =	2.1400	C7 =	0.3750	C8 =	0.3750		

* CUNNINGHAM COEFFICIENTS

PHI(0)=	0.0486	S=	2.1787	W(C)=	5.4935	X(C)=	3.7504	X(D)=	8.5861

FIGURE A-47.

BULKHEAD FITTING STRESS ANALYSIS

THE BOEING COMPANY ** SATURN BOOSTER BRANCH

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* INFLUENCE MATRIX

H(01)	H(02)	M(01)	M(02)	H(09)	M(09)	H(10)	M(10)	CONST
0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	-8.4066E-07	0.	0.
0.	0.	0.	0.	0.	0.	0.	-1.7934E-05	1.2915E-02

* MEMBRANE FORCES N(PHI)

8.1060E 03	8.1060E 03	0.	0.	0.	0.	0.	0.

* SHEARING FORCES V(J)

0.	0.	0.	0.	0.	0.	3.0343E 02	2.8878E 02

FIGURE A-48.

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* INFLUENCE MATRIX

H(01)	H(02)	M(01)	M(02)	H(09)	M(09)	H(10)	M(10)	CONST
-2.1649E-05	9.6906E-06	-1.5743E-05	0.	0.	0.	0.	0.	-4.5297E-03
1.1473E-05	-1.2101E-05	0.	2.5824E-07	1.1156E-06	-2.5824E-07	0.	0.	5.0356E-03
-1.2260E-05	0.	-3.8089E-04	2.6696E-04	0.	0.	0.	0.	-2.8234E-02
-3.6346E-06	2.5824E-07	3.1606E-04	-2.8681E-04	2.3417E-06	1.0942E-06	0.	0.	2.7553E-02
0.	1.1156E-06	0.	2.3417E-06	-4.4732E-05	7.3755E-05	9.5160E-06	-7.6097E-05	-3.1839E-02
0.	-2.5824E-07	0.	1.0942E-06	7.3755E-05	-2.0402E-04	0.	2.0293E-04	6.1522E-02
0.	0.	0.	0.	9.5160E-06	0.	-1.0357E-05	0.	5.7798E-05
0.	0.	0.	0.	-7.6097E-05	2.0293E-04	0.	-2.2086E-04	-4.6698E-02

* SOLUTION VECTOR

H(01)	H(02)	M(01)	M(02)	H(09)	M(09)	H(10)	M(10)
9.9882E 01	-1.8926E 02	3.3883E 01	-5.2831E 01	1.2646E 03	-7.8377E 02	1.1564E 03	-9.4439E 02

* DEFLECTIONS AND ROTATIONS

DEFL(SE)= 1.3502E-02 ROTN(SE)= -4.2158E-03
DEFL(A10)= 1.3502E-02
ROTN(A10)= -4.2158E-03
DEFL(RC)= 1.1087E-02 ROTN(RC)= -4.0219E-03 DEFL(RO)= 1.2036E-02 ROTN(RO)= -4.0219E-03
DEFL(MHP)= 1.3584E-03

FIGURE A-49.

CASE NO. LLCS01, 1 ANNULAR RINGS, MNHOLE,PLATE

* STRESS COMPUTATIONS

* SHELL STRESSES AND MARGINS OF SAFETY

MERIDIONAL DIRECTION
F(EAD)= 1.7761E 04 F(EOB)= 9.5246E 02 MS(EO)= 2.4246E 00

* ANNULAR RING STRESSES AND MARGINS OF SAFETY

MERIDIONAL DIRECTION

	* A1 *
F(OAD)=	1.2433E 04
F(OIB)=	8.3312E 02
MS(OI)=	3.8504E 00
F(IAD)=	1.1995E 04
F(IIB)=	7.2770E 02
MS(II)=	4.0480E 00

HOOP DIRECTION

	* A1 *
F(OAD)=	1.4615E 04
F(OIB)=	1.3581E 03
MS(OI)=	3.0593E 00
F(IAD)=	1.5053E 04
F(IIB)=	1.4635E 03
MS(II)=	2.9305E 00

* RING STRESSES AND MARGINS OF SAFETY

HOOP DIRECTION
F(RAD)= 1.0945E 04 F(ROB)= -8.4966E 03 F(RIB)= 8.4966E 03 MS(RI)= 1.0930E 01 MS(RO)= 2.7930E 00
F(EAD)= 9.5965E 02 F(EOB)= -1.4889E 03 F(EIB)= 1.4889E 03 MS(EI)= 1.9114E 03 MS(EO)= 3.1271E 01

* MANHOLE COVER PLATE STRESSES AND MARGINS OF SAFETY

MERIDIONAL DIRECTION
F(PAD)= 1.5418E 03 F(POB)= 2.7161E 03 MS(PO)= 1.7792E 01

FIGURE A-50.

BULKHEAD FITTING STRESS ANALYSIS THE BOEING COMPANY ** SATURN BOOSTER BRANCH

DEC 1, 1964 PAGE 1

CASE NO. LLCS07, 1 ANNULAR RINGS, MNHOLE,PLATE

* INPUT DATA

R(J) =	13.615	R(I) =	11.500	R(H) =	N/A	R(G) =	N/A	R(F) =	N/A	R(E) =	11.500
R(A) =	11.000	R(B) =	N/A	R(D) =	10.737	R(O) =	10.737	R(P) =	10.737	R(Q) =	9.9750
R(1) =	280.00	R(2) =	280.00	R(M) =	N/A						
E(1) =	0.3600E-01	E(2) =	N/A	E(3) =	N/A	E(4) =	N/A	E(5) =	N/A	E(S) =	0.6180
EC(1)=	N/A	EC(2)=	N/A	E(9) =	0.3750	E(10)=	0	E(M) =	1.3720	E(F) =	N/A
T(S) =	0.4620	T(A1)=	0.7450	T(A2)=	N/A	T(A3)=	N/A	T(A4)=	N/A	T(A5)=	N/A
T(C1)=	N/A	T(C2)=	N/A	T(P) =	0.7500	T(M) =	N/A				
P =	57.900	EXT L=	N/A	P(C1)=	N/A	P(C2)=	N/A	F =	N/A		
E(S) =	0.1060E 08	E(A1)=	0.1060E 08	E(A2)=	N/A	E(A3)=	N/A	E(A4)=	N/A	E(A5)=	N/A
E(C1)=	N/A	E(C2)=	N/A	E(R) =	0.1060E 08	E(E) =	0.1060E 08				
U(S) =	0.3300	U(A1)=	0.3300	U(A2)=	N/A	U(A3)=	N/A	U(A4)=	N/A	U(A5)=	N/A
U(C1)=	N/A	U(C2)=	N/A	U(R) =	0.3300	U(E) =	0.3300				
I(R) =	2.6230	I(E) =	0.5360E-01	M(RP)=	0	M(EP)=	0	F(P) =	0	F(EP)=	0
A(R) =	4.1830	A(E) =	1.1440	THETA=	0	T =	0				
(FA)S=	0.6300E 05	(FA)1=	0.6300E 05	(FA)2=	N/A	(FA)3=	N/A	(FA)4=	N/A	(FA)5=	N/A
FA)C1=	N/A	FA)C2=	N/A	(FA)R=	0.6300E 05	(FA)E=	0.6300E 05				
M(R) =	1.5000	C5 =	1.3720	C6 =	1.3720	C7 =	0.3750	C8 =	0.3750		

* CUNNINGHAM COEFFICIENTS

PHI(0)=	0.0486	S=	2.1787	W(C)=	5.4935	X(C)=	3.7504	X(D)=	8.5861

FIGURE A-51.

CASE NO. LLCS07, 1 ANNULAR RINGS, MNHOLE, PLATE

* INFLUENCE MATRIX

H(01)	H(02)	M(01)	M(02)	H(09)	M(09)	H(10)	M(10)	CONST
0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	-8.4066E-07	0.	0.
0.	0.	0.	0.	0.	0.	0.	-1.7934E-05	1.2915E-02

* MEMBRANE FORCES N(PHI)

8.1060E 03	8.1060E 03	0.	0.	0.	0.	0.	0.

* SHEARING FORCES V(J)

0.	0.	0.	0.	0.	0.	3.0343E 02	2.8878E 02

FIGURE A-52.

BULKHEAD FITTING STRESS ANALYSIS THE BOEING COMPANY ** SATURN BOOSTER BRANCH

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CASE NO. LLCS07, 1 ANNULAR RINGS, MNHOLE,PLATE

* INFLUENCE MATRIX

H(01)	H(02)	M(01)	M(02)	H(09)	M(09)	H(10)	M(10)	CONST
-2.0394E-05	8.5849E-06	-1.5743E-05	0.	0.	0.	0.	0.	-5.7356E-03
1.0164E-05	-1.3372E-05	0.	-2.5627E-06	6.1162E-06	2.5627E-06	0.	0.	2.6453E-02
-2.3324E-05	0.	-2.8860E-04	1.8561E-04	0.	0.	0.	0.	6.1453E-02
7.9109E-06	-2.5627E-06	2.1975E-04	-2.0280E-04	5.6893E-06	4.1467E-06	0.	0.	-4.2631E-02
0.	6.1162E-06	0.	5.6893E-06	-4.8450E-05	7.0408E-05	9.5077E-06	-7.6097E-05	-7.3396E-02
0.	2.5627E-06	0.	4.1467E-06	7.0408E-05	-2.0707E-04	0.	2.0293E-04	3.9350E-02
0.	0.	0.	0.	9.5077E-06	0.	-1.0348E-05	0.	0.
0.	0.	0.	0.	-7.6097E-05	2.0293E-04	0.	-2.2086E-04	-4.7931E-02

* SOLUTION VECTOR

H(01)	H(02)	M(01)	M(02)	H(09)	M(09)	H(10)	M(10)
6.3677E 02	6.7157E 02	-9.4351E 01	2.6440E 02	4.6472E 03	4.7431E 02	4.2696E 03	-9.4837E 02

* DEFLECTIONS AND ROTATIONS

```
DEFL( SE)=  9.8003E-03 ROTN( SE)= -2.6642E-03
DEFL(A10)=  9.8003E-03
ROTN(A10)= -2.6642E-03
DEFL( RC)=  1.0740E-02 ROTN( RC)= -4.0931E-03 DEFL( RO)=  8.2105E-03 ROTN( RO)= -4.0931E-03
DEFL(MHP)=  1.0030E-03
```

FIGURE A-53.

```
BULKHEAD FITTING STRESS ANALYSIS                         THE BOEING COMPANY ** SATURN BOOSTER BRANCH
DEC  1, 1964                                                                                   PAGE11
CASE NO. LLCS07, 1 ANNULAR RINGS, MNHOLE,PLATE

* STRESS COMPUTATIONS

* SHELL STRESSES AND MARGINS OF SAFETY

  MERIDIONAL DIRECTION
  F(EAD)=   1.8922E 04  F(EIB)=   2.6522E 03  MS(EI)=   2.0449E 00

* ANNULAR RING STRESSES AND MARGINS OF SAFETY

  MERIDIONAL DIRECTION
                * A1                   *
  F(OAD)=   1.1735E 04
  F(OOB)=   2.3825E 03
  MS(OO)=   3.7285E 00
  F(IAD)=   1.1782E 04
  F(IOB)=   2.8582E 03
  MS(IO)=   3.6028E 00

  HOOP DIRECTION
                * A1                   *
  F(OAD)=   1.1503E 04
  F(OOB)=   1.3578E 01
  MS(OO)=   4.4727E 00
  F(IAD)=   1.1456E 04
  F(IIB)=   4.6216E 02
  MS(II)=   4.3553E 00

* RING STRESSES AND MARGINS OF SAFETY

  HOOP DIRECTION
  F(RAD)=   1.0602E 04  F(ROB)=  -5.5439E 03  F(RIB)=   5.5439E 03  MS(RI)=   8.1217E 00  MS(RO)=   3.4061E 00
  F(EAD)=   3.5434E 03  F(EOB)=  -1.5153E 03  F(EIB)=   1.5153E 03  MS(EI)=   2.3870E 01  MS(EO)=   1.2835E 01

* MANHOLE COVER PLATE STRESSES AND MARGINS OF SAFETY

  MERIDIONAL DIRECTION
  F(PAD)=   5.6929E 03  F(POB)=   2.6737E 03  MS(PO)=   7.4277E 00
```

FIGURE A-54.

TABLE A-V. LOWER LOX CLOSURE ANALYSIS RESULTS, METHOD 1

CASE	LOCATION	MERIDIONAL STRESS		HOOP STRESS		EXTERNAL LOAD		MAX. TOTAL STRESS		Hq	Mq
		fd	fb	fd	fb	fd	fb	fd	fb		
LLCS01	Shell	17,761	953	-	-	-	-	17,761	953	1265	-784
	Annulus	12,433	-833	15,003	-1464	-	-	15,053	-1464		
	Boss Ring	-	-	10,945	-8497	-	-	10,945	-8497		
	Plate	1542	2716	-	-	-	-	1542	2716		
LLCS07	Shell	18,922	-2652	-	-	-	-	18,922	-2652	4647	474
	Annulus	11,782	2858	11,456	-462	-	-	11,782	2858		
	Boss Ring	-	-	10,602	-5544	-	-	10,602	-5544		
	Plate	5693	2674	-	-	-	-	5693	2674		

NOTES:

Internal Pressure = 57.9 PSI
Stresses are in PSI (Limit)
H Force in LB/Inch of Circumference
M Force in IN-LO/Inch of Circumference
Negative Sign Denotes Compression in Outer Fibers
Hq & Mq act at the Boss Ring/Cover Plate Interface

2219 - T87 Aluminum =
F_{tu} = 63,000 PSI
F_{ty} = 50,000 PSI

2.1.3.2

a. For flight, the maximum axial load will be significantly reduced and the maximum pressure slightly increased for INT-20 as shown below:

For Sat V (S-IC-4 & on)

Nc (STA 1401 Aft) = 6600 Lb/In (ULT)
P (Bottom) = 56.8 PSIG

For INT-20 (Sections 2.1.1.4 & 2.1.1.5.a.2.(c) of APPENDIX A)

Nc (STA 1401 Aft) = 1230 Lb/In (ULT)
P (Bottom) = 59.5 PSI

The net result will obviously be a reduced loading for INT-20.

b. Lox tank bulkheads

1. Membrane and weld lands

The tank bulkhead membrane and weld lands are designed for hydrostatic proof pressures which will not be changed for INT-20.

2. Lox tank fittings

The majority of the upper and lower lox tank fittings are critical for proof pressure and hence will not be impacted for INT-20. Three upper fittings and two lower fittings are critical for external loads plus flight or static firing pressure on Sat V. The acoustic and vibration environment for INT-20 is the same as or less than for Sat V. Hence the external fitting loads for INT-20 will not be increased. The design flight pressure for the upper bulkhead is the ullage pressure towards the end of flight which is the same for Sat V and INT-20. It was therefore concluded that all of the upper lox fittings will be acceptable for INT-20.

The two lower fittings critical for flight are the lox fill and drain fitting and the center lox suction fitting. The minimum factor of safety for these fittings for Sat V (S-IC-5 & on) is 1.64. The maximum lox tank bottom pressure will increase from 56.8 PSIG on Sat V to 59.5 PSIG on INT-20. Assuming that the factor of safety is proportional to pressure, the predicted factor of safety for INT-20 will be 1.56.

3. Lox tank hoop compression

An analysis of the lox tank for INT-20 loads showed that the lower bulkhead will be structurally acceptable for INT-20 hoop compression without revision. Although hoop compression loads (Section 2.1.1.5.d of Appendix A) will be higher for INT-20 than for Sat V, the tank capability will not be exceeded. The same computer analysis used for Sat V was used for the INT-20

2.1.3.2 (Continued)

3. assessment. The technique and terminology is discussed in D5-12284-6, Section 7. The INT-20 computer output is included in FIGURES A-55 thru A-57. The resulting INT-20 hoop compression loads versus location and comparative Sat V values are shown in FIGURE A-58. TABLE A-V1 shows the correlation between ultimate hoop compression loads and capabilities. Areas of interest are illustrated in FIGURE A-59 .

c. Lox tank baffles

1. Cruciform baffle

The lox cruciform baffle is loaded by fluid lateral slosh, fluid vortex slosh, vehicle acceleration, and vibration. The only one of these contributors to increase for INT-20 is acceleration. The net result of these loads for INT-20 was not investigated in detail. However, a factor of safety of 2.05 exists for Sat V (S-IC-4 & on) and it was concluded that at least a 1.4 factor of safety will exist for INT-20.

2. Ring baffle

The design loads for the ring baffles occur during hydrostatic test and flight. No load changes will occur during hydrostatic test for INT-20. For flight; slosh, vibration, acceleration, tank pressure, and helium bottle loads act on the lox tank ring baffles. The minimum ring baffle factors of safety for Sat V (S-IC-4 & on) are 1.50 in the helium bottle area and 1.67 in other areas. Based on a preliminary investigation of the Sat V stress analysis and an assessment of the INT-20 loads impact, it was concluded that the ring baffles would have at least a 1.4 factor of safety for INT-20.

2.1.4 Intertank

Contributors to intertank loading are longitudinal force, drag force, bending moment, shear, temperature and internal pressure. None of these items will be greater for INT-20 than for Sat V. Therefore, there will be no impact on the intertank for INT-20.

2.1.5 Fuel Tank

Refer to D5-17009-2, Section 4.2.2.1.a.4 for the baseline fuel tank configuration definition.

```
CASE  B86666 C R.BLAIN 5-7351 8403
TITLE BULKHEAD HOOP LOADS $                                   MARCH 5 1969
ONE   INPUT(GAMMA,G,PO)$
      PRINT(GAMMA,G,PO)$
      INPUT(YO) $
      PRINT(YO)$
      START(I,1,10)$
      II=FLOAT(I)$
      PHI=9.0 + II   $
      A=198.0$
      B=140.0$
      COS=COSN(PHI*0.01745)$
      SIN=SINE(PHI*0.01745)$
      COT=COS/SIN$
      SR=(1.0-(1.0/(1.0+(((B/A)*COT)**2))))**0.50$
      Y=(B*SR)$
      Y1=140.0-Y$
      CON1=(((A**2)*(SIN**2))+((B**2)*(COS**2)))**0.50$
      CON2=1.0/CON1$
      CON3=CON1/(2.0*(B**2))$
      CON4=CON2-CON3$
      CON5=(A**2)*(CON4)$
      CON6=(G*GAMMA)/(2.0*(B**4)*(SIN**2))$
      CON7=CON1**3$
      CHECK=(Y1-YO)$
      BRANCH(CHECK,TWO,TWO,THREE)$
TWO   CON8=PO+(G*GAMMA*(YO-Y1))$
      CON9=(B*(Y1**2))-((Y1**3)/3.0)$
      NHOOP=(CON8*CON5)-(CON6*CON9*CON7)$
      PRINT(PHI,Y,NHOOP)$
      BRANCH(FOUR)$
THREECON10=(B*(YO**2))-((YO**3)/3.0)$
      NHOOP=(PO*CON5)-(CON6*CON10*CON7)$
      PRINT(PHI,Y,NHOOP)$
FOUR  REPEAT(I,81)$
      BRANCH(ONE)$
      END$

      EXECUTION
```

FIGURE A-55.

2

OUTPUT

GAMMA	5.740000E-02	G	1.450000E 00	PO	1.870000E 01	
YO	5.690000E 02					
PHI	1.000000E 01	Y	1.358414E 02	NHOOP	8.766938E 03	
PHI	2.000000E 01	Y	1.244817E 02	NHOOP	7.479327E 03	
PHI	3.000000E 01	Y	1.084512E 02	NHOOP	5.743959E 03	
PHI	4.000000E 01	Y	9.022748E 01	NHOOP	3.910182E 03	
PHI	5.000000E 01	Y	7.145327E 01	NHOOP	2.214501E 03	
PHI	6.000000E 01	Y	5.293341E 01	NHOOP	7.842250E 02	t = 2
PHI	7.000000E 01	Y	3.491590E 01	NHOOP	-3.246107E 02	
PHI	8.000000E 01	Y	1.734676E 01	NHOOP	-1.096300E 03	
PHI	9.000000E 01	Y	2.416869E-02	NHOOP	-1.538947E 03	
GAMMA	5.740000E-02	G	1.680000E 00	PO	2.160000E 01	
YO	5.020000E 02					
PHI	1.000000E 01	Y	1.358414E 02	NHOOP	9.284280E 03	
PHI	2.000000E 01	Y	1.244817E 02	NHOOP	7.902117E 03	
PHI	3.000000E 01	Y	1.084512E 02	NHOOP	6.041974E 03	
PHI	4.000000E 01	Y	9.022748E 01	NHOOP	4.079241E 03	
PHI	5.000000E 01	Y	7.145327E 01	NHOOP	2.265977E 03	t = 4
PHI	6.000000E 01	Y	5.293341E 01	NHOOP	7.358960E 02	
PHI	7.000000E 01	Y	3.491590E 01	NHOOP	-4.539849E 02	
PHI	8.000000E 01	Y	1.734676E 01	NHOOP	-1.289760E 03	
PHI	9.000000E 01	Y	2.416869E-02	NHOOP	-1.782924E 03	
GAMMA	5.740000E-02	G	1.900000E 00	PO	2.350000E 01	
YO	4.360000E 02					
PHI	1.000000E 01	Y	1.358414E 02	NHOOP	9.412820E 03	
PHI	2.000000E 01	Y	1.244817E 02	NHOOP	7.986226E 03	
PHI	3.000000E 01	Y	1.084512E 02	NHOOP	6.069859E 03	
PHI	4.000000E 01	Y	9.022748E 01	NHOOP	4.051697E 03	
PHI	5.000000E 01	Y	7.145327E 01	NHOOP	2.189463E 03	
PHI	6.000000E 01	Y	5.293341E 01	NHOOP	6.172168E 02	t = 6
PHI	7.000000E 01	Y	3.491590E 01	NHOOP	-6.104039E 02	
PHI	8.000000E 01	Y	1.734676E 01	NHOOP	-1.483015E 03	
PHI	9.000000E 01	Y	2.416869E-02	NHOOP	-2.016238E 03	
GAMMA	5.740000E-02	G	2.300000E 00	PO	2.350000E 01	
YO	3.660000E 02					
PHI	1.000000E 01	Y	1.358414E 02	NHOOP	9.496134E 03	
PHI	2.000000E 01	Y	1.244817E 02	NHOOP	8.007648E 03	
PHI	3.000000E 01	Y	1.084512E 02	NHOOP	6.014973E 03	
PHI	4.000000E 01	Y	9.022748E 01	NHOOP	3.923915E 03	
PHI	5.000000E 01	Y	7.145327E 01	NHOOP	1.998717E 03	
PHI	6.000000E 01	Y	5.293341E 01	NHOOP	3.716899E 02	t = 8
PHI	7.000000E 01	Y	3.491590E 01	NHOOP	-9.082153E 02	
PHI	8.000000E 01	Y	1.734676E 01	NHOOP	-1.837757E 03	
PHI	9.000000E 01	Y	2.416869E-02	NHOOP	-2.440423E 03	
GAMMA	5.740000E-02	G	2.980000E 00	PO	2.350000E 01	
YO	2.970000E 02					
PHI	1.000000E 01	Y	1.358414E 02	NHOOP	9.571859E 03	
PHI	2.000000E 01	Y	1.244817E 02	NHOOP	7.999292E 03	
PHI	3.000000E 01	Y	1.084512E 02	NHOOP	5.903738E 03	
PHI	4.000000E 01	Y	9.022748E 01	NHOOP	3.715341E 03	
PHI	5.000000E 01	Y	7.145327E 01	NHOOP	1.706660E 03	
PHI	6.000000E 01	Y	5.293341E 01	NHOOP	6.759903E 00	t = 10
PHI	7.000000E 01	Y	3.491590E 01	NHOOP	-1.344062E 03	
PHI	8.000000E 01	Y	1.734676E 01	NHOOP	-2.353142E 03	
PHI	9.000000E 01	Y	2.416869E-02	NHOOP	-3.055484E 03	
GAMMA	5.740000E-02	G	3.670000E 00	PO	2.350000E 01	
YO	2.290000E 02					
PHI	1.000000E 01	Y	1.358414E 02	NHOOP	9.418506E 03	
PHI	2.000000E 01	Y	1.244817E 02	NHOOP	7.763632E 03	
PHI	3.000000E 01	Y	1.084512E 02	NHOOP	5.572152E 03	
PHI	4.000000E 01	Y	9.022748E 01	NHOOP	3.298730E 03	
PHI	5.000000E 01	Y	7.145327E 01	NHOOP	1.220804E 03	t = 1

FIGURE A-56.

PHI	6.000000E 01	Y	5.293341E 01	NHOOP	-5.410319E 02	
3 PHI	7.000000E 01	Y	3.491590E 01	NHOOP	-1.960592E 03	
PHI	8.000000E 01	Y	1.734676E 01	NHOOP	-3.060879E 03	
PHI	9.000000E 01	Y	2.416869E-02	NHOOP	-3.893201E 03	
GAMMA	5.740000E-02	G	4.680000E 00	PO	2.350000E 01	
YO	1.680000E 02					
PHI	1.000000E 01	Y	1.358414E 02	NHOOP	8.952875E 03	
PHI	2.000000E 01	Y	1.244817E 02	NHOOP	7.226632E 03	
PHI	3.000000E 01	Y	1.084512E 02	NHOOP	4.958968E 03	
PHI	4.000000E 01	Y	9.022748E 01	NHOOP	2.626826E 03	
PHI	5.000000E 01	Y	7.145327E 01	NHOOP	5.071047E 02	
PHI	6.000000E 01	Y	5.293341E 01	NHOOP	-1.294691E 03	t = 13
PHI	7.000000E 01	Y	3.491590E 01	NHOOP	-2.772855E 03	
PHI	8.000000E 01	Y	1.734676E 01	NHOOP	-3.971746E 03	
PHI	9.000000E 01	Y	2.416869E-02	NHOOP	-4.964166E 03	
GAMMA	5.740000E-02	G	2.600000E 00	PO	2.350000E 01	
YO	1.290000E 02					
PHI	1.000000E 01	Y	1.358414E 02	NHOOP	5.592481E 03	
PHI	2.000000E 01	Y	1.244817E 02	NHOOP	4.555750E 03	
PHI	3.000000E 01	Y	1.084512E 02	NHOOP	3.189323E 03	
PHI	4.000000E 01	Y	9.022748E 01	NHOOP	1.778979E 03	
PHI	5.000000E 01	Y	7.145327E 01	NHOOP	4.941075E 02	
PHI	6.000000E 01	Y	5.293341E 01	NHOOP	-5.969092E 02	
PHI	7.000000E 01	Y	3.491590E 01	NHOOP	-1.485299E 03	t = 16
PHI	8.000000E 01	Y	1.734676E 01	NHOOP	-2.192666E 03	
PHI	9.000000E 01	Y	2.416869E-02	NHOOP	-2.434302E 03	
GAMMA	5.740000E-02	G	3.130000E 00	PO	2.350000E 01	
YO	9.500000E 01					
PHI	1.000000E 01	Y	1.358414E 02	NHOOP	5.274311E 03	
PHI	2.000000E 01	Y	1.244817E 02	NHOOP	4.209402E 03	
PHI	3.000000E 01	Y	1.084512E 02	NHOOP	2.815720E 03	
PHI	4.000000E 01	Y	9.022748E 01	NHOOP	1.388252E 03	
PHI	5.000000E 01	Y	7.145327E 01	NHOOP	9.424681E 01	
PHI	6.000000E 01	Y	5.293341E 01	NHOOP	-1.006996E 03	t = 18
PHI	7.000000E 01	Y	3.491590E 01	NHOOP	-1.555718E 03	
PHI	8.000000E 01	Y	1.734676E 01	NHOOP	-1.718228E 03	
PHI	9.000000E 01	Y	2.416869E-02	NHOOP	-1.775150E 03	
GAMMA	5.740000E-02	G	3.930000E 00	PO	2.350000E 01	
YO	5.100000E 01					
PHI	1.000000E 01	Y	1.358414E 02	NHOOP	4.490816E 03	
PHI	2.000000E 01	Y	1.244817E 02	NHOOP	3.421465E 03	
PHI	3.000000E 01	Y	1.084512E 02	NHOOP	2.038900E 03	
PHI	4.000000E 01	Y	9.022748E 01	NHOOP	6.418087E 02	
PHI	5.000000E 01	Y	7.145327E 01	NHOOP	2.011753E 02	t = 20
PHI	6.000000E 01	Y	5.293341E 01	NHOOP	-1.738924E 02	
PHI	7.000000E 01	Y	3.491590E 01	NHOOP	-4.739649E 02	
PHI	8.000000E 01	Y	1.734676E 01	NHOOP	-6.644381E 02	
PHI	9.000000E 01	Y	2.416869E-02	NHOOP	-7.296015E 02	
GAMMA	5.740000E-02	G	4.680000E 00	PO	2.350000E 01	
YO	0.					
PHI	1.000000E 01	Y	1.358414E 02	NHOOP	3.144094E 03	
PHI	2.000000E 01	Y	1.244817E 02	NHOOP	2.749174E 03	
PHI	3.000000E 01	Y	1.084512E 02	NHOOP	2.207357E 03	
PHI	4.000000E 01	Y	9.022748E 01	NHOOP	1.624392E 03	t = 2
PHI	5.000000E 01	Y	7.145327E 01	NHOOP	1.079347E 03	
PHI	6.000000E 01	Y	5.293341E 01	NHOOP	6.218636E 02	
PHI	7.000000E 01	Y	3.491590E 01	NHOOP	2.804101E 02	
PHI	8.000000E 01	Y	1.734676E 01	NHOOP	7.043679E 01	
PHI	9.000000E 01	Y	2.416869E-02	NHOOP	-4.743252E-01	

LINES PRINTED 160
CARDS READ 59

FIGURE A-57.

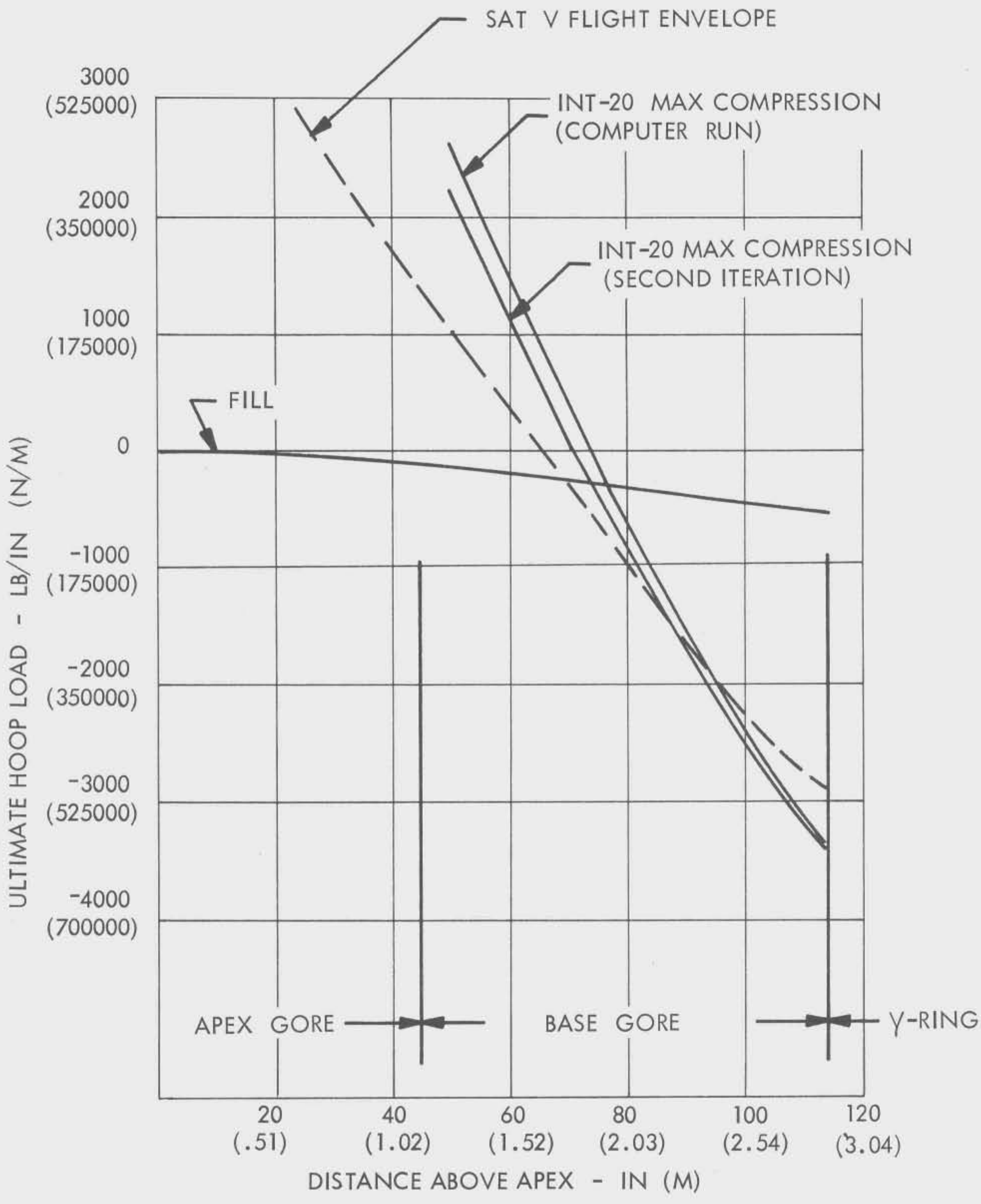


FIGURE A-58. LOX TANK HOOP COMPRESSION LOADS

TABLE A-VI. LOX TANK HOOP COMPRESSION SUMMARY (INT-20)

Panel No.	Distance Above Apex (Midpoint)	N_c (ULT) Capability LB/IN	N_c (ULT) Actual - Second Iteration LB/IN
I	109.1	3550	3130
II	101.1	3200	2580
III	93.4	2825	2030
IV	85.3	2350	1330
V	76.8	1775	580
VI	58.1	450	200

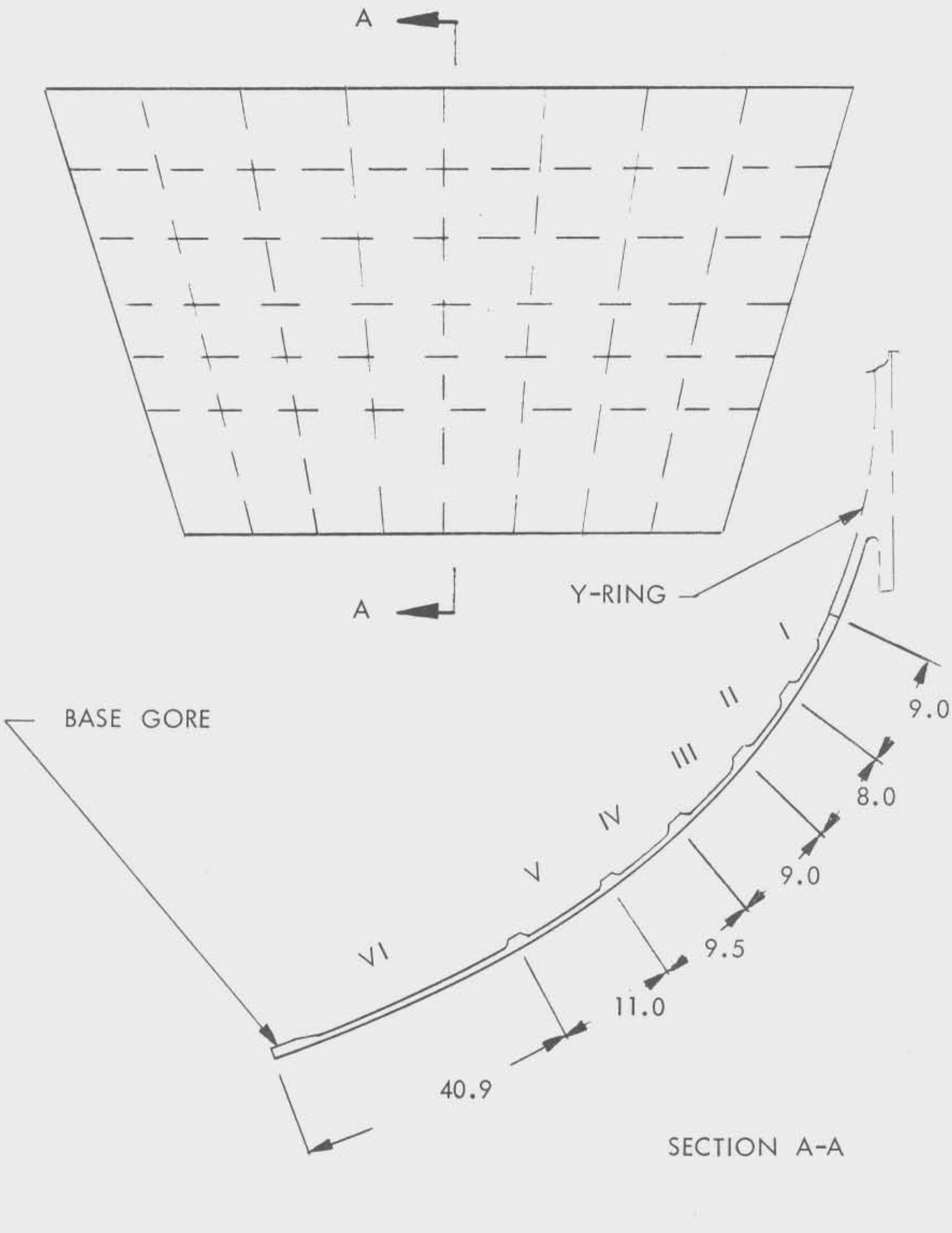


FIGURE A-59. LOX TANK LOWER BASE GORE

2.1.5.1 Trade Studies

A trade study was performed to determine whether to make the inboard fuel suction closures at the suction elbows or to delete the elbows and provide the closures at the suction fittings. The factors leading to the decision to add the closures at the suction elbows were as follows:

(1) No additional analysis would be required as the fitting configuration with the elbows retained will be the same as for Sat V hydrostatic test.

(2) Adding a flat plate cover directly to the inboard lox suction fitting proved to be structurally unacceptable (Section 2.1.3.1.b of Appendix A). A similar result was anticipated for the fuel suction fitting.

(3) The trapped fuel will be insignificant.

A study was not performed to determine the gas flow through an open inboard lox tunnel or to establish tunnel cover design requirements. However, it was considered good design practice to provide a cover for the tunnel to prevent unrestricted gas flow and for safety reasons.

2.1.5.2 Fuel Tank Structural Assessment

a. Fuel tank skins and Y-rings

Tank skin and Y-ring loads consist of axial loads and internal pressure. Critical conditions occur during hydrostatic test and flight. Proof pressures are unchanged for INT-20 hydrostatic test. The maximum axial load will be significantly reduced and the maximum pressure slightly increased for INT-20 during flight as shown below:

<u>For Sat V</u> (S-IC-4 & on)

Nc (STA 602 Aft) = 7528 Lb/In (ULT)
P (Bottom) = 43.2 PSIG

<u>For INT-20</u> (Sections 2.1.1.4 & 2.1.1.5.a.2.(c) of APPENDIX A)

Nc (STA 602 Aft) = 4940 Lb/In (ULT)
P (Bottom) = 49.2 PSIG

The net result will obviously be a reduced loading for INT-20.

2.1.5.2 (Continued)

b. Fuel tank bulkheads

1. Membrane and weld lands

The tank bulkhead membrane and weld lands are designed for hydrostatic proof pressures which will not be changed for INT-20.

2. Fuel tank fittings

Most of the fuel tank fittings are critical for proof pressure and hence will not be impacted for INT-20. Three upper fittings and six lower fittings are critical for external loads plus flight or static firing pressure on Sat V. Since the acoustic and vibration environment is not increased for INT-20 the external fitting loads will not increase. The design flight pressure for the upper bulkhead is the ullage pressure towards the end of flight which is the same for Sat V and INT-20. It was therefore concluded that all of the upper fuel fittings will be acceptable for INT-20.

The minimum Sat V (S-IC-5 & on) factors of safety for the six lower fuel fittings which are critical for external loads plus pressure on Sat V are as follows:

Inboard suction Ftg: F.S. = 1.47 (Flight)
Outboard suction Ftg: F.S. = 1.52 (Flight)
Electrical Ftg: F.S. = 1.50 (Flight)
Inboard Tunnel Ftg: F.S. = 1.83 (Static Test)
Emergency Drain Ftg: F.S. = 1.50 (Static Test)
Outboard Tunnel Ftg: F.S. = 1.57 (Static Test)

The maximum fuel tank bottom pressure will increase from 43.2 PSIG on Sat V to 49.2 PSIG on INT-20. The inboard fuel suction fitting was concluded to be acceptable for INT-20 because the external fitting loads will be significantly reduced over Sat V values due to deletion of the fuel suction duct for INT-20. The high factor of safety for the inboard tunnel fitting for Sat V insures that it also will be acceptable for INT-20. Standard Sat V fitting analysis techniques would probably show the remaining four lower fittings marginal for INT-20 pressures combined with Sat V external loads (probably conservative). However, based on an assessment of fitting stress influencing factors and existing fitting structural test results, it was concluded that a 1.4 factor of safety could be shown for these fittings for INT-20.

2.1.5.2 (Continued)

c. Fuel tank hoop compression

Analysis of the fuel tank for INT-20 hoop compression loads (Section 2.1.1.5.d of Appendix A) showed that the existing lower bulkhead capability would be exceeded. The lower fuel base gore segments were therefore revised for INT-20 to increase the thickness in the critical area near the Y-ring as discussed in D5-17009-2, Section 4.2.2.1.a.4.(c).

The revised base gores were analyzed for INT-20 hoop compression loads using the same computer analysis used for Sat V. The technique and terminology is discussed in D5-12284-6, Section 7. The computer output for INT-20 is included in FIGURES A-60 thru A-64. The resulting INT-20 hoop compression loads versus location and comparative Sat V values are shown in FIGURE A-65. TABLE A-VII shows the correlation between ultimate hoop compression loads and capabilities for the revised INT-20 configuration and the existing Sat V configuration. Areas of interest are illustrated in FIGURE A-66

3. Fuel loading probe support

The fuel loading probe will be lengthened 14 inches for INT-20 (D5-17009-2, Section 4.2.2.1.b.2.(a)). Consequently, the fuel loading probe support bracket load will be increased from 1800 pounds for Sat V to 2300 pounds for INT-20. Preliminary assessment indicates that the probe support will be structurally acceptable for this increased load.

d. Fuel tank baffles

1. Cruciform baffle

The fuel cruciform baffle is loaded by slosh pressure, vibration, and vehicle acceleration. The only one of these contributors to increase for INT-20 is acceleration. The net impact of the loads for INT-20 was not investigated in detail. However, the minimum factor of safety for Sat V is 1.57 and it was concluded that a 1.4 factor of safety will be maintained for INT-20.

2. Ring baffle

The design loads for the ring baffles occur during hydrostatic test and flight. No load changes will occur during hydrostatic test for INT-20. During flight the rings have slosh, vibration, and vehicle motion loads in addition to tank pressure. Preliminary assessment of the Sat V fuel tank ring baffle analysis indicated that relatively low factors of safety exist in two areas for Sat V. A 1.47 factor of safety exists in the critical inboard ring baffle chord for Sat V due to hoop tension resulting from internal pressure and bending due to slosh. Maximum slosh occurs at the fuel surface where the internal

```
CASE  B86666 C R.BLAIN 5-7351 8403
TITLE BULKHEAD HOOP LOADS $                                        MARCH 5 1969
 ONE  INPUT(GAMMA,G,P0)$
      PRINT(GAMMA,G,P0)$
      INPUT(Y0) $
      PRINT(Y0)$
      START(I,1,10)$
      II=FLOAT(I)$
      PHI=9.0 + II  $
      A=198.0$
      B=140.0$
      COS=COSN(PHI*0.01745)$
      SIN=SINE(PHI*0.01745)$
      COT=COS/SIN$
      SR=(1.0-(1.0/(1.0+(((B/A)*COT)**2))))**0.50$
      Y=(B*SR)$
      Y1=140.0-Y$
      CON1=(((A**2)*(SIN**2))+((B**2)*(COS**2)))**0.50$
      CON2=1.0/CON1$
      CON3=CON1/(2.0*(B**2))$
      CON4=CON2-CON3$
      CON5=(A**2)*(CON4)$
      CON6=(G*GAMMA)/(2.0*(B**4)*(SIN**2))$
      CON7=CON1**3$
      CHECK=(Y1-Y0)$
      BRANCH(CHECK,TWO,TWO,THREE)$
 TWO  CON8=P0+(G*GAMMA*(Y0-Y1))$
      CON9=(B*(Y1**2))-((Y1**3)/3.0)$
      NHOOP=(CON8*CON5)-(CON6*CON9*CON7)$
      PRINT(PHI,Y,NHOOP)$
      BRANCH(FOUR)$
THREECON10=(B*(Y0**2))-((Y0**3)/3.0)$
      NHOOP=(P0*CON5)-(CON6*CON10*CON7)$
      PRINT(PHI,Y,NHOOP)$
 FOUR REPEAT(I,81)$
      BRANCH(ONE)$
      END$

      EXECUTION
```

FIGURE A-60.

OUTPUT

GAMMA	4.070000E-02	G	1.780000E 00	P0	0.
Y0	2.950000E 02				
PHI	1.000000E 01	Y	1.358414E 02	NHOOP	2.797506E 03
PHI	2.000000E 01	Y	1.244817E 02	NHOOP	2.283851E 03
PHI	3.000000E 01	Y	1.084512E 02	NHOOP	1.606285E 03
PHI	4.000000E 01	Y	9.022748E 01	NHOOP	9.063180E 02
PHI	5.000000E 01	Y	7.145327E 01	NHOOP	2.682573E 02
PHI	6.000000E 01	Y	5.293341E 01	NHOOP	-2.733960E 02
PHI	7.000000E 01	Y	3.491590E 01	NHOOP	-7.136344E 02
PHI	8.000000E 01	Y	1.734676E 01	NHOOP	-1.062539E 03
PHI	9.000000E 01	Y	2.416869E-02	NHOOP	-1.338819E 03
GAMMA	4.070000E-02	G	1.780000E 00	P0	1.950000E 01
Y0	2.950000E 02				
PHI	1.000000E 01	Y	1.358414E 02	NHOOP	5.406435E 03
PHI	2.000000E 01	Y	1.244817E 02	NHOOP	4.565080E 03
PHI	3.000000E 01	Y	1.084512E 02	NHOOP	3.437921E 03
PHI	4.000000E 01	Y	9.022748E 01	NHOOP	2.254217E 03
PHI	5.000000E 01	Y	7.145327E 01	NHOOP	1.163886E 03
PHI	6.000000E 01	Y	5.293341E 01	NHOOP	2.426185E 02
PHI	7.000000E 01	Y	3.491590E 01	NHOOP	-4.809537E 02
PHI	8.000000E 01	Y	1.734676E 01	NHOOP	-1.004091E 03
PHI	9.000000E 01	Y	2.416869E-02	NHOOP	-1.339212E 03
GAMMA	4.070000E-02	G	2.080000E 00	P0	0.
Y0	2.550000E 02				
PHI	1.000000E 01	Y	1.358414E 02	NHOOP	2.815946E 03
PHI	2.000000E 01	Y	1.244817E 02	NHOOP	2.272626E 03
PHI	3.000000E 01	Y	1.084512E 02	NHOOP	1.558938E 03
PHI	4.000000E 01	Y	9.022748E 01	NHOOP	8.250010E 02
PHI	5.000000E 01	Y	7.145327E 01	NHOOP	1.579403E 02
PHI	6.000000E 01	Y	5.293341E 01	NHOOP	-4.090816E 02
PHI	7.000000E 01	Y	3.491590E 01	NHOOP	-8.743156E 02
PHI	8.000000E 01	Y	1.734676E 01	NHOOP	-1.251768E 03
PHI	9.000000E 01	Y	2.416869E-02	NHOOP	-1.564394E 03
GAMMA	4.070000E-02	G	2.080000E 00	P0	1.950000E 01
Y0	2.550000E 02				
PHI	1.000000E 01	Y	1.358414E 02	NHOOP	5.424875E 03
PHI	2.000000E 01	Y	1.244817E 02	NHOOP	4.553856E 03
PHI	3.000000E 01	Y	1.084512E 02	NHOOP	3.390574E 03
PHI	4.000000E 01	Y	9.022748E 01	NHOOP	2.172900E 03
PHI	5.000000E 01	Y	7.145327E 01	NHOOP	1.053569E 03
PHI	6.000000E 01	Y	5.293341E 01	NHOOP	1.069329E 02
PHI	7.000000E 01	Y	3.491590E 01	NHOOP	-6.416349E 02
PHI	8.000000E 01	Y	1.734676E 01	NHOOP	-1.193320E 03
PHI	9.000000E 01	Y	2.416869E-02	NHOOP	-1.564787E 03
GAMMA	4.070000E-02	G	2.630000E 00	P0	0.
Y0	2.150000E 02				
PHI	1.000000E 01	Y	1.358414E 02	NHOOP	2.987702E 03
PHI	2.000000E 01	Y	1.244817E 02	NHOOP	2.372668E 03
PHI	3.000000E 01	Y	1.084512E 02	NHOOP	1.568982E 03
PHI	4.000000E 01	Y	9.022748E 01	NHOOP	7.471902E 02
PHI	5.000000E 01	Y	7.145327E 01	NHOOP	3.048965E 00
PHI	6.000000E 01	Y	5.293341E 01	NHOOP	-6.305542E 02
PHI	7.000000E 01	Y	3.491590E 01	NHOOP	-1.156595E 03
PHI	8.000000E 01	Y	1.734676E 01	NHOOP	-1.595597E 03
PHI	9.000000E 01	Y	2.416869E-02	NHOOP	-1.977969E 03
GAMMA	4.070000E-02	G	2.630000E 00	P0	1.950000E 01
Y0	2.150000E 02				
PHI	1.000000E 01	Y	1.358414E 02	NHOOP	5.596631E 03
PHI	2.000000E 01	Y	1.244817E 02	NHOOP	4.653898E 03
PHI	3.000000E 01	Y	1.084512E 02	NHOOP	3.400618E 03

FIGURE A-61.

3

PHI	4.000000E 01	Y	9.022748E 01	NHOOP	2.095090E 03
PHI	5.000000E 01	Y	7.145327E 01	NHOOP	8.986777E 02
PHI	6.000000E 01	Y	5.293341E 01	NHOOP	-1.145397E 02
PHI	7.000000E 01	Y	3.491590E 01	NHOOP	-9.239142E 02
PHI	8.000000E 01	Y	1.734676E 01	NHOOP	-1.537150E 03
PHI	9.000000E 01	Y	2.416869E-02	NHOOP	-1.978363E 03
GAMMA	4.070000E-02	G	3.300000E 00	P0	0.
Y0	1.750000E 02				
PHI	1.000000E 01	Y	1.358414E 02	NHOOP	3.030047E 03
PHI	2.000000E 01	Y	1.244817E 02	NHOOP	2.348616E 03
PHI	3.000000E 01	Y	1.084512E 02	NHOOP	1.464055E 03
PHI	4.000000E 01	Y	9.022748E 01	NHOOP	5.661824E 02
PHI	5.000000E 01	Y	7.145327E 01	NHOOP	-2.429269E 02
PHI	6.000000E 01	Y	5.293341E 01	NHOOP	-9.333556E 02
PHI	7.000000E 01	Y	3.491590E 01	NHOOP	-1.515346E 03
PHI	8.000000E 01	Y	1.734676E 01	NHOOP	-2.018183E 03
PHI	9.000000E 01	Y	2.416869E-02	NHOOP	-2.481754E 03
GAMMA	4.070000E-02	G	3.300000E 00	P0	1.950000E 01
Y0	1.750000E 02				
PHI	1.000000E 01	Y	1.358414E 02	NHOOP	5.638976E 03
PHI	2.000000E 01	Y	1.244817E 02	NHOOP	4.629846E 03
PHI	3.000000E 01	Y	1.084512E 02	NHOOP	3.295691E 03
PHI	4.000000E 01	Y	9.022748E 01	NHOOP	1.914082E 03
PHI	5.000000E 01	Y	7.145327E 01	NHOOP	6.527018E 02
PHI	6.000000E 01	Y	5.293341E 01	NHOOP	-4.173411E 02
PHI	7.000000E 01	Y	3.491590E 01	NHOOP	-1.282665E 03
PHI	8.000000E 01	Y	1.734676E 01	NHOOP	-1.959736E 03
PHI	9.000000E 01	Y	2.416869E-02	NHOOP	-2.482148E 03
GAMMA	4.070000E-02	G	4.660000E 00	P0	0.
Y0	1.200000E 02				
PHI	1.000000E 01	Y	1.358414E 02	NHOOP	2.883163E 03
PHI	2.000000E 01	Y	1.244817E 02	NHOOP	2.096200E 03
PHI	3.000000E 01	Y	1.084512E 02	NHOOP	1.087600E 03
PHI	4.000000E 01	Y	9.022748E 01	NHOOP	7.846735E 01
PHI	5.000000E 01	Y	7.145327E 01	NHOOP	-8.221535E 02
PHI	6.000000E 01	Y	5.293341E 01	NHOOP	-1.594050E 03
PHI	7.000000E 01	Y	3.491590E 01	NHOOP	-2.264324E 03
PHI	8.000000E 01	Y	1.734676E 01	NHOOP	-2.781034E 03
PHI	9.000000E 01	Y	2.416869E-02	NHOOP	-2.759283E 03
GAMMA	4.070000E-02	G	4.660000E 00	P0	1.950000E 01
Y0	1.200000E 02				
PHI	1.000000E 01	Y	1.358414E 02	NHOOP	5.492092E 03
PHI	2.000000E 01	Y	1.244817E 02	NHOOP	4.377430E 03
PHI	3.000000E 01	Y	1.084512E 02	NHOOP	2.919236E 03
PHI	4.000000E 01	Y	9.022748E 01	NHOOP	1.426367E 03
PHI	5.000000E 01	Y	7.145327E 01	NHOOP	7.347520E 01
PHI	6.000000E 01	Y	5.293341E 01	NHOOP	-1.078036E 03
PHI	7.000000E 01	Y	3.491590E 01	NHOOP	-2.031643E 03
PHI	8.000000E 01	Y	1.734676E 01	NHOOP	-2.722587E 03
PHI	9.000000E 01	Y	2.416869E-02	NHOOP	-2.759676E 03
GAMMA	4.070000E-02	G	2.620000E 00	P0	0.
Y0	1.100000E 02				
PHI	1.000000E 01	Y	1.358414E 02	NHOOP	1.478339E 03
PHI	2.000000E 01	Y	1.244817E 02	NHOOP	1.053803E 03
PHI	3.000000E 01	Y	1.084512E 02	NHOOP	5.113216E 02
PHI	4.000000E 01	Y	9.022748E 01	NHOOP	-2.959184E 01
PHI	5.000000E 01	Y	7.145327E 01	NHOOP	-5.112175E 02
PHI	6.000000E 01	Y	5.293341E 01	NHOOP	-9.244434E 02
PHI	7.000000E 01	Y	3.491590E 01	NHOOP	-1.285799E 03
PHI	8.000000E 01	Y	1.734676E 01	NHOOP	-1.357641E 03
PHI	9.000000E 01	Y	2.416869E-02	NHOOP	-1.347023E 03

FIGURE A-62.

GAMMA	4.070000E-02	G	2.620000E 00	P0	1.950000E 01
Y0	1.100000E 02				
PHI	1.000000E 01	Y	1.358414E 02	NHOOP	4.087268E 03
PHI	2.000000E 01	Y	1.244817E 02	NHOOP	3.335033E 03
PHI	3.000000E 01	Y	1.084512E 02	NHOOP	2.342958E 03
PHI	4.000000E 01	Y	9.022748E 01	NHOOP	1.318308E 03
PHI	5.000000E 01	Y	7.145327E 01	NHOOP	3.844113E 02
PHI	6.000000E 01	Y	5.293341E 01	NHOOP	-4.084290E 02
PHI	7.000000E 01	Y	3.491590E 01	NHOOP	-1.053118E 03
PHI	8.000000E 01	Y	1.734676E 01	NHOOP	-1.299194E 03
PHI	9.000000E 01	Y	2.416869E-02	NHOOP	-1.347416E 03
GAMMA	4.070000E-02	G	3.160000E 00	P0	0.
Y0	8.500000E 01				
PHI	1.000000E 01	Y	1.358414E 02	NHOOP	1.352856E 03
PHI	2.000000E 01	Y	1.244817E 02	NHOOP	8.948537E 02
PHI	3.000000E 01	Y	1.084512E 02	NHOOP	3.146952E 02
PHI	4.000000E 01	Y	9.022748E 01	NHOOP	-2.579423E 02
PHI	5.000000E 01	Y	7.145327E 01	NHOOP	-7.642606E 02
PHI	6.000000E 01	Y	5.293341E 01	NHOOP	-1.144124E 03
PHI	7.000000E 01	Y	3.491590E 01	NHOOP	-1.084627E 03
PHI	8.000000E 01	Y	1.734676E 01	NHOOP	-1.056590E 03
PHI	9.000000E 01	Y	2.416869E-02	NHOOP	-1.048326E 03
GAMMA	4.070000E-02	G	3.160000E 00	P0	1.950000E 01
Y0	8.500000E 01				
PHI	1.000000E 01	Y	1.358414E 02	NHOOP	3.961785E 03
PHI	2.000000E 01	Y	1.244817E 02	NHOOP	3.176084E 03
PHI	3.000000E 01	Y	1.084512E 02	NHOOP	2.146331E 03
PHI	4.000000E 01	Y	9.022748E 01	NHOOP	1.089957E 03
PHI	5.000000E 01	Y	7.145327E 01	NHOOP	1.313681E 02
PHI	6.000000E 01	Y	5.293341E 01	NHOOP	-6.281091E 02
PHI	7.000000E 01	Y	3.491590E 01	NHOOP	-8.519460E 02
PHI	8.000000E 01	Y	1.734676E 01	NHOOP	-9.981422E 02
PHI	9.000000E 01	Y	2.416869E-02	NHOOP	-1.048719E 03
GAMMA	4.070000E-02	G	4.010000E 00	P0	0.
Y0	5.500000E 01				
PHI	1.000000E 01	Y	1.358414E 02	NHOOP	1.061687E 03
PHI	2.000000E 01	Y	1.244817E 02	NHOOP	5.627692E 02
PHI	3.000000E 01	Y	1.084512E 02	NHOOP	-6.055715E 01
PHI	4.000000E 01	Y	9.022748E 01	NHOOP	-6.657664E 02
PHI	5.000000E 01	Y	7.145327E 01	NHOOP	-7.309128E 02
PHI	6.000000E 01	Y	5.293341E 01	NHOOP	-6.623169E 02
PHI	7.000000E 01	Y	3.491590E 01	NHOOP	-6.278750E 02
PHI	8.000000E 01	Y	1.734676E 01	NHOOP	-6.116448E 02
PHI	9.000000E 01	Y	2.416869E-02	NHOOP	-6.068609E 02
GAMMA	4.070000E-02	G	4.010000E 00	P0	1.950000E 01
Y0	5.500000E 01				
PHI	1.000000E 01	Y	1.358414E 02	NHOOP	3.670616E 03
PHI	2.000000E 01	Y	1.244817E 02	NHOOP	2.843999E 03
PHI	3.000000E 01	Y	1.084512E 02	NHOOP	1.771079E 03
PHI	4.000000E 01	Y	9.022748E 01	NHOOP	6.821330E 02
PHI	5.000000E 01	Y	7.145327E 01	NHOOP	1.647160E 02
PHI	6.000000E 01	Y	5.293341E 01	NHOOP	-1.463024E 02
PHI	7.000000E 01	Y	3.491590E 01	NHOOP	-3.951943E 02
PHI	8.000000E 01	Y	1.734676E 01	NHOOP	-5.531972E 02
PHI	9.000000E 01	Y	2.416869E-02	NHOOP	-6.072545E 02
GAMMA	4.070000E-02	G	4.670000E 00	P0	0.
Y0	3.500000E 01				
PHI	1.000000E 01	Y	1.358414E 02	NHOOP	7.278372E 02
PHI	2.000000E 01	Y	1.244817E 02	NHOOP	2.106858E 02
PHI	3.000000E 01	Y	1.084512E 02	NHOOP	-4.275880E 02
PHI	4.000000E 01	Y	9.022748E 01	NHOOP	-4.340138E 02

FIGURE A-63.

5

PHI	5.000000E 01	Y	7.145327E 01	NHOOP	-3.635939E 02
PHI	6.000000E 01	Y	5.293341E 01	NHOOP	-3.294708E 02
PHI	7.000000E 01	Y	3.491590E 01	NHOOP	-3.123376E 02
PHI	8.000000E 01	Y	1.734676E 01	NHOOP	-3.042639E 02
PHI	9.000000E 01	Y	2.416869E-02	NHOOP	-3.018841E 02
GAMMA	4.070000E-02	G	4.670000E 00	P0	1.950000E 01
Y0	3.500000E 01				
PHI	1.000000E 01	Y	1.358414E 02	NHOOP	3.336766E 03
PHI	2.000000E 01	Y	1.244817E 02	NHOOP	2.491916E 03
PHI	3.000000E 01	Y	1.084512E 02	NHOOP	1.404048E 03
PHI	4.000000E 01	Y	9.022748E 01	NHOOP	9.138857E 02
PHI	5.000000E 01	Y	7.145327E 01	NHOOP	5.320348E 02
PHI	6.000000E 01	Y	5.293341E 01	NHOOP	1.865437E 02
PHI	7.000000E 01	Y	3.491590E 01	NHOOP	-7.965685E 01
PHI	8.000000E 01	Y	1.734676E 01	NHOOP	-2.458163E 02
PHI	9.000000E 01	Y	2.416869E-02	NHOOP	-3.022777E 02

LINES PRINTED 237
CARDS READ 73

FIGURE A-64.

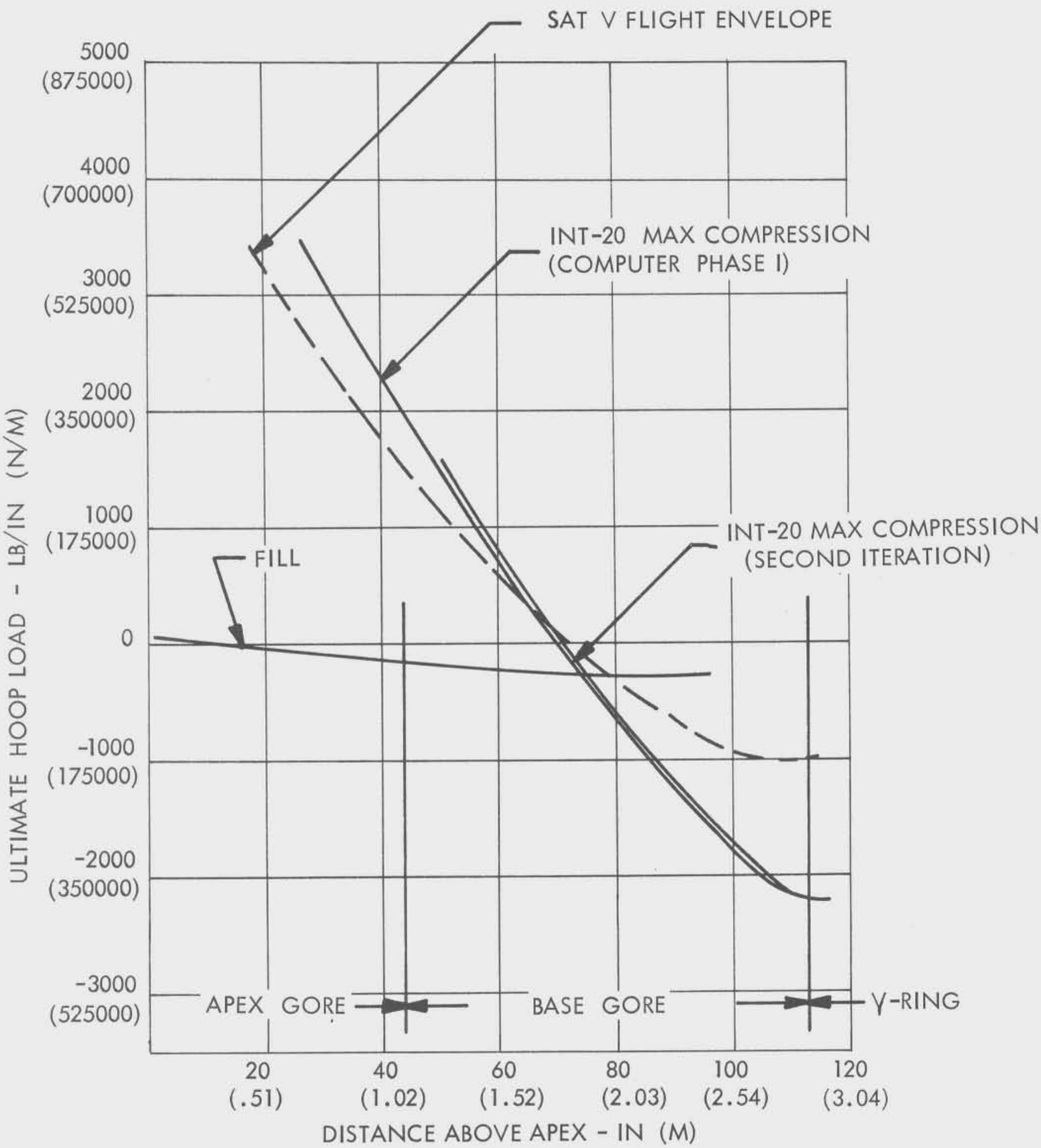


FIGURE A-65. FUEL TANK HOOP COMPRESSION LOADS

TABLE A-VII. FUEL TANK HOOP COMPRESSION SUMMARY (INT-20)

Panel No.	Distance Above Apex (Midpoint)	Nc (ULT) Capability LB/IN		Nc (ULT) Actual - Second Iteration LB/IN
		Sat V	INT-20	
I	107.3	1750	2168	2100
II	96.5	1400	3033	1570
III	84.9	1000	1724	910
IV	70.5	500	500	300
V	53.5	250	250	250

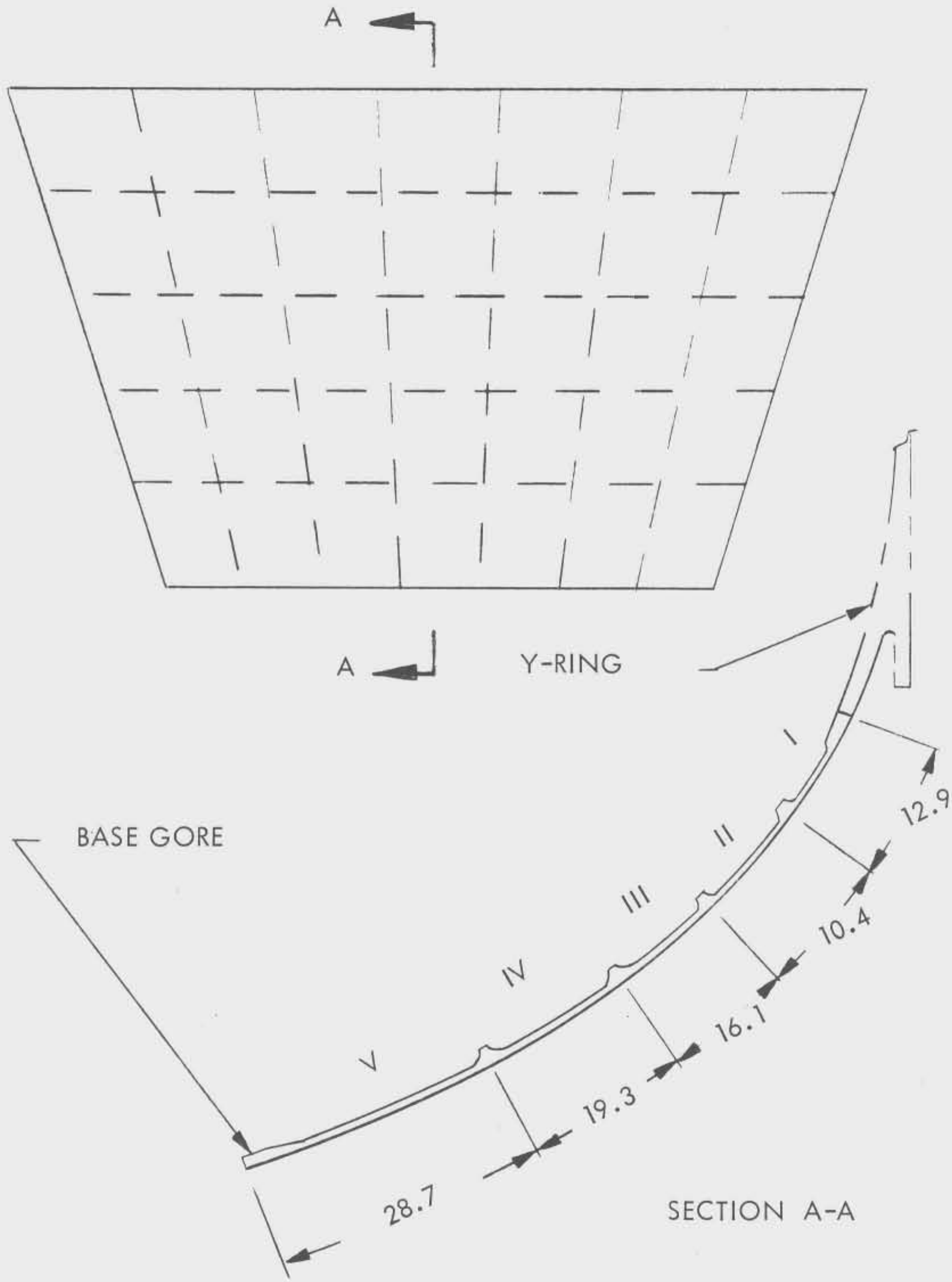


FIGURE A-66. FUEL TANK LOWER BASE GORE

2.1.5.2 (Continued)

2. pressure acting is ullage pressure. Since ullage pressure is not changed for INT-20 at the critical time period it was concluded that this factor of safety would not be significantly reduced for INT-20.

A 1.44 factor of safety exists in a bolt attaching the ring baffle diagonal strut between STA 404 and 365 for Sat V. An assessment of the Sat V analysis for this bolt indicated inherent conservatism in the analysis. It was concluded that a 1.4 factor of safety would be maintained for INT-20.

All other component margins of safety for Sat V are sufficient to assure acceptability for INT-20.

2.1.6 Thrust Structure

Refer to D5-17009-2, Section 4.2.2.1.a.5 for the baseline thrust structure configuration definition.

2.1.6.1 Trade Studies

The inboard Lox interconnect spool will be supported by a new support adapter which attaches to the inboard propellant duct support structure for INT-20 (D5-17009-2, Section 4.2.2.1.b.1 (b)). Some consideration was given to deleting the inboard propellant duct support structure for INT-20 and providing a truss support for the interconnect spool. However, after evaluating the design effort and qualification testing required for the new truss it was decided to retain the inboard propellant duct support structure. This is also consistent with INT-20 reversibility guidelines.

Consideration was also given to simplifying the thrust structure cross beam as significantly lower loads will develope for INT-20 due to deletion of the center engine. However, this was judged to be outside the scope of this study and inconsistent with INT-20 reversibility guidelines.

2.1.6.2 Slow Release System

The difference between total liftoff thrust and total liftoff weight for Sat V with a thrust to weight ratio of 1.25 is 1.5×10^6 pounds. For INT-20 the difference is 1.2×10^6 pounds. Therefore, fewer slow release devices will be required for INT-20 than for Sat V. Although, the number has not been established for INT-20, the capability of reducing the quantity of slow release devices exists (D5-17009-2, Section 4.2.2.1.a.5. (c)).

2.1.6.3 Thrust Structure Structural Assessment

Reduced thrust structure axial loads due to the lower INT-20 upper stage weight and reduced total thrust due to deletion of the center engine assure that the thrust structure will be acceptable for INT-20.

2.1.7 Heat Shield

Refer to D5-17009-2, Section 4.2.2.1.a.6 for the baseline heat shield configuration definition.

2.1.7.1 Trade Studies

Three heat shield configurations were evaluated for INT-20 (D5-17009-2, FIGURE 4.2.2.1-10).

2.1.7.1 (Continued)

a. Heat shield method 1

Method 1 considered changes to both the panels and support structure. New panel configurations, some of which are larger than those qualified for Sat V, would be required in the vacant curtain area. Major support modifications would also be required.

b. Heat shield method 2

Method 2 minimized required panel changes. No new panel configurations would be required because standard square panels will be used. Although support structure modification would be extensive, only one new part would be required. Existing beam and attach bracket configurations would be used.

c. Heat shield method 3

Method 3 minimized support structure changes. However, new large panel configurations which are unqualified would be required.

d. Conclusion

The major cost drivers for heat shield panels were found to be edge trimming, attachment provisions, and new panel tooling. These cost factors outweigh required support structure changes. Based on these cost considerations and the fact that panels which are larger than those used on Sat V would probably require qualification testing, Method 2 was selected for INT-20.

2.1.7.2 Heat Shield Structural Assessment

a. Heat shield panel

Base heat shield loads and environment are essentially the same for Sat V and INT-20 except for the longer INT-20 burn time and the increased base heating for INT-20. Maximum heat shield forward surface temperature, will be approximately 100°F hotter for INT-20 than for Sat V (AS 510 & on). Refer to Section 2.1.1.11 of Appendix A.

Extensive heat shield testing has been performed for Sat V. Test specimens which were mechanically delaminated to the crushed core and subjected to combined heat and vibration were not detrimentally affected even though the forward surface temperature reached 750°F in the delaminated areas. Some test specimens were run through more than one Sat V cycle and the total test time was greater than the INT-20 burn time. It was therefore concluded that the heat shield would be structurally acceptable for INT-20 and that sufficient test data existed to preclude the requirement for an

2.1.7.2 (Continued)

a. INT-20 heat shield qualification test.

b. Heat shield support structure

INT-20 heat shield support structure temperatures will not be appreciably increased over Sat V (AS 510 & on) values. Refer to Section 2.1.1.11 of Appendix A. The revised center area support structure grid for INT-20 is the same configuration and uses the same components used in adjacent areas for Sat V. Since heat shield loads are basically uniform, the INT-20 support system is essentially the same configuration and subjected to the same loads as proven Sat V configurations.

c. CEI impact

CEI requirements presently limit the maximum forward surface temperature to 300°F which will be exceeded for INT-20. The CEI will be revised to limit the support structure temperature to 300°F and to allow local hot spots on the panels provided that the heat shield function is not compromised. INT-20 heat shield environment will not exceed these revised requirements.

2.2 PROPULSION/MECHANICAL SUBSYSTEMS

2.2.2 Oxidizer Fill and Drain

The INT-20 criteria (S-IC propellant load data for the baseline mission) located the LOX level at station 1404.0, at T = 0. The second iteration S-IC boost trajectory run and associated propellant load analysis established the LOX level at station 1405.0 at T = 0. See Paragraph 2.1.1.5.a.2(a) of Appendix A. The pre-ignition level for LOX is determined by adding thrust buildup and hold down volume for engines #1 through #4. The resulting nominal LOX preignition level is at station 1417.0. Applying S-IC three-sigma deviations to the LOX volume yields a level of 1417 $\pm$4.0 inches.

The LOX loading probe sensing element of the existing S-IC has an operative sensing range between station 1400.5 and 1483.0 (FIGURE A-67). Therefore the minimum LOX loading level 1413.0 will be 12.5 inches above the lower sensing limit of the present loading probe.

If the above minimum LOX loading level is not significantly reduced (ullage volume increased) by mission adaptation loading requirements, the present LOX loading probe is acceptable for INT-20 without change.

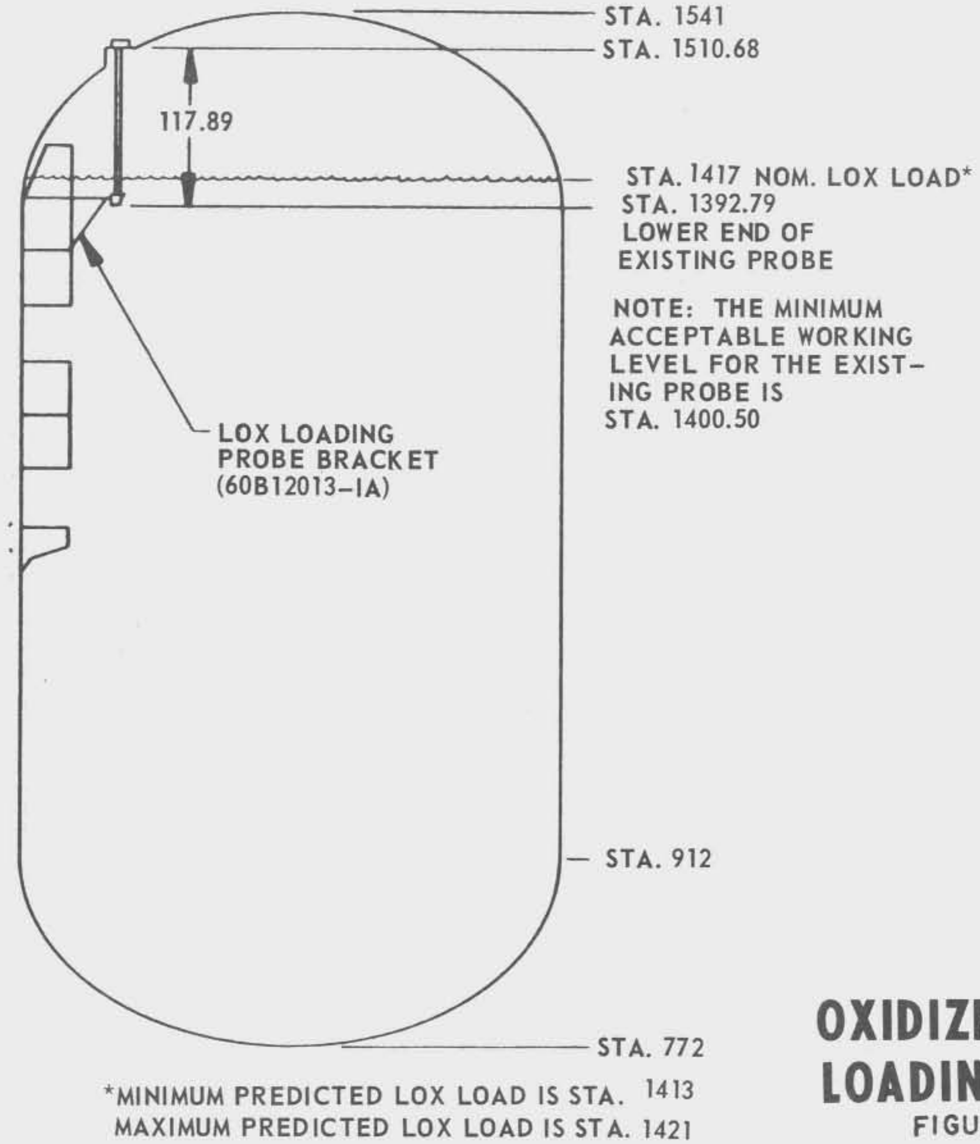
2.2.3 Oxidizer Feed System

2.2.3.1 Center Engine Lox Duct Configuration

Two Lox delivery system configuration change concepts were investigated. These were: (a) total deletion of the center Lox feed system, except for the Lox interconnect spool, as reported in D5-17009-2, paragraph 4.2.2.1.b.1.(b). (b) deletion of the center Lox prevalves and the pressure-volume compensator (PVC) duct only.

The factors considered in the above configuration trade were, system performance, revesibility, weight and cost. Total deletion of the No. 5 Engine Lox Feed System (concept a) was selected for the following reasons:

(a1) Deletion of the Lox suction duct will not affect the performance of the engines No. 1 through No. 4 during Lox fill, standby, flight nor drain. A minor configuration change of the Lox interconnect system required for satisfactory compatable system performance is discussed under a following paragraph, 2.2.4.1.



OXIDIZER TANK
LOADING PROBE
FIGURE A-67

2.2.3.1 (Continued)

(a_2) Reversibility (the ability to remove or reinstall the LOX suction duct on assembled stages) is possible with minor changes to existing tooling. Geometry layouts, FIGURES A-68 and A-69 were prepared to verify this capability.

(a_3) Deletion of the duct and its residual Lox volume will result in a weight savings of approximately 10,000 pounds.

(a_4) Deletion of the duct represents a significant cost reduction for production INT-20 stages.

Concept (b) has the advantage of simplified conversion (reversibility). The following disadvantages, however are inherent in this configuration:

(b_1) LOX geysering in the retained center engine suction duct during flight is probable. The effects of geysering on the outboard engine Lox supply flow is analytically not predictable.

(b_2) Bosses in the suction duct represents additional possible leak points.

(b_3) Retention of the center engine Lox duct represents added weight and cost.

In both configurations the center engine Lox interconnect spool must be retained A spool support adapter (to replace the prevalve) can be installed on the existing center engine propellant duct support structure. D5-17009-2, paragraph 4.2.2.1(b) defines the adapter, its support interface, and the closure plates required to seal the upper and lower ends of the interconnect spool. Existing seals can be used with appropriately designed closure plates.

The existing center engine propellant line support structure and its interface for the Lox duct support is retained. Although this structure is moderately complex, costly to fabricate and structurally excessive for the interconnect spool support, a redesign of the support frame would be inconsistant with the minimum change and reversibility guidelines. The interconnect system change definition and design trade factors are noted in paragraph 2.2.4.1 of APPENDIX A.

2.2.3.2 Lox Cut-Off Sensors

The primary cut-off mode for engines #2, #4 and #1, #3 for the INT-20 will be by programmed time to "g" limit command from the Instrument Unit (IU). The existing S-IC employs Lox depletion as the primary outboard engine cut-off initiation mode. Each outboard engine Lox supply fitting at the tank has an optical cut-off sensor.

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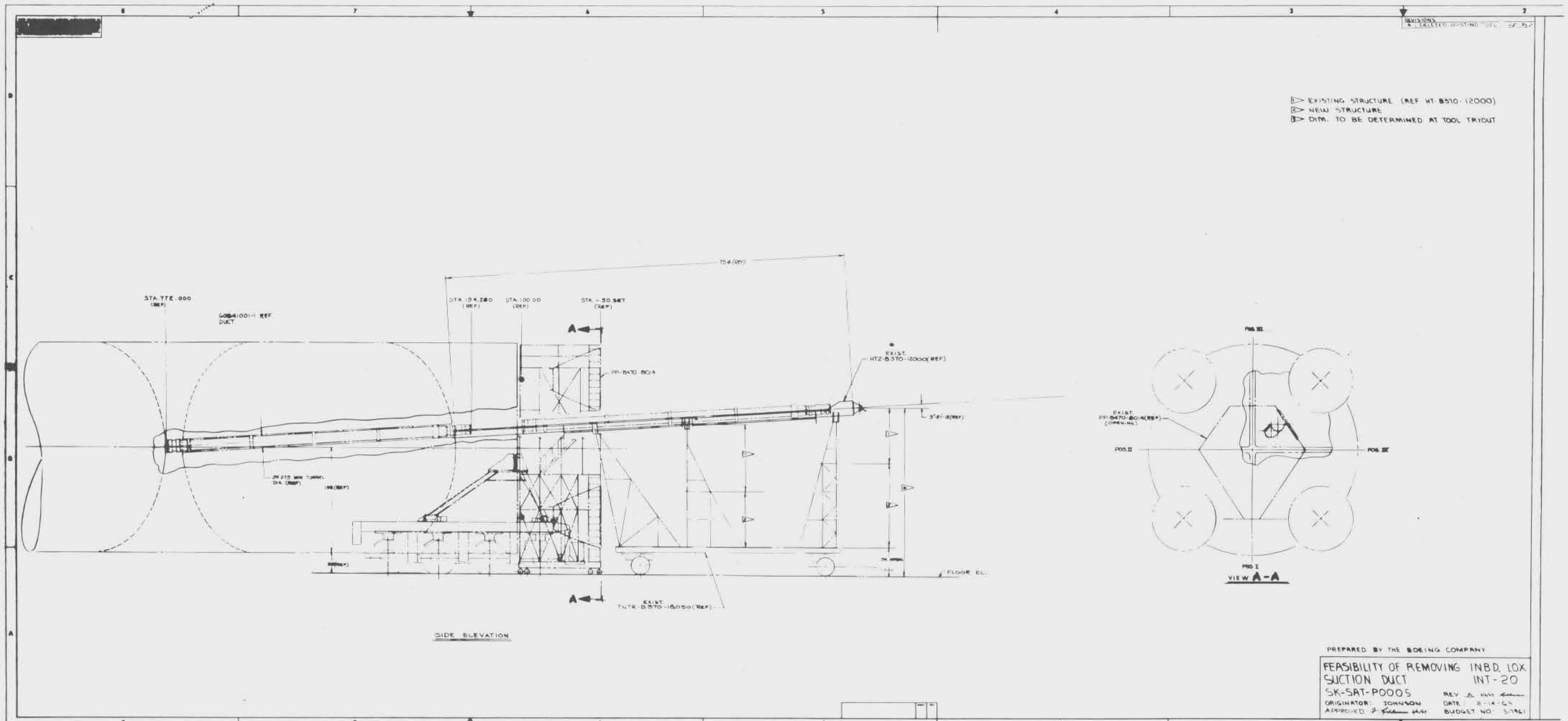


[redacted]
EXISTING STRUCTURE (REF HT-B310-12000)
NEW STRUCTURE
DIM. TO BE DETERMINED AT TOOL TRYOUT
FLOOR EL.
SIDE ELEVATION
VIEW A-A
PREPARED BY THE BOEING COMPANY
FEASIBILITY OF REMOVING INBD. LOX
SUCTION DUCT INT-20
SK-SAT-P0005 REV A
ORIGINATOR: JOHNSON DATE 2-14-64
APPROVED BUDGET NO: 5-7961

FIGURE A-68

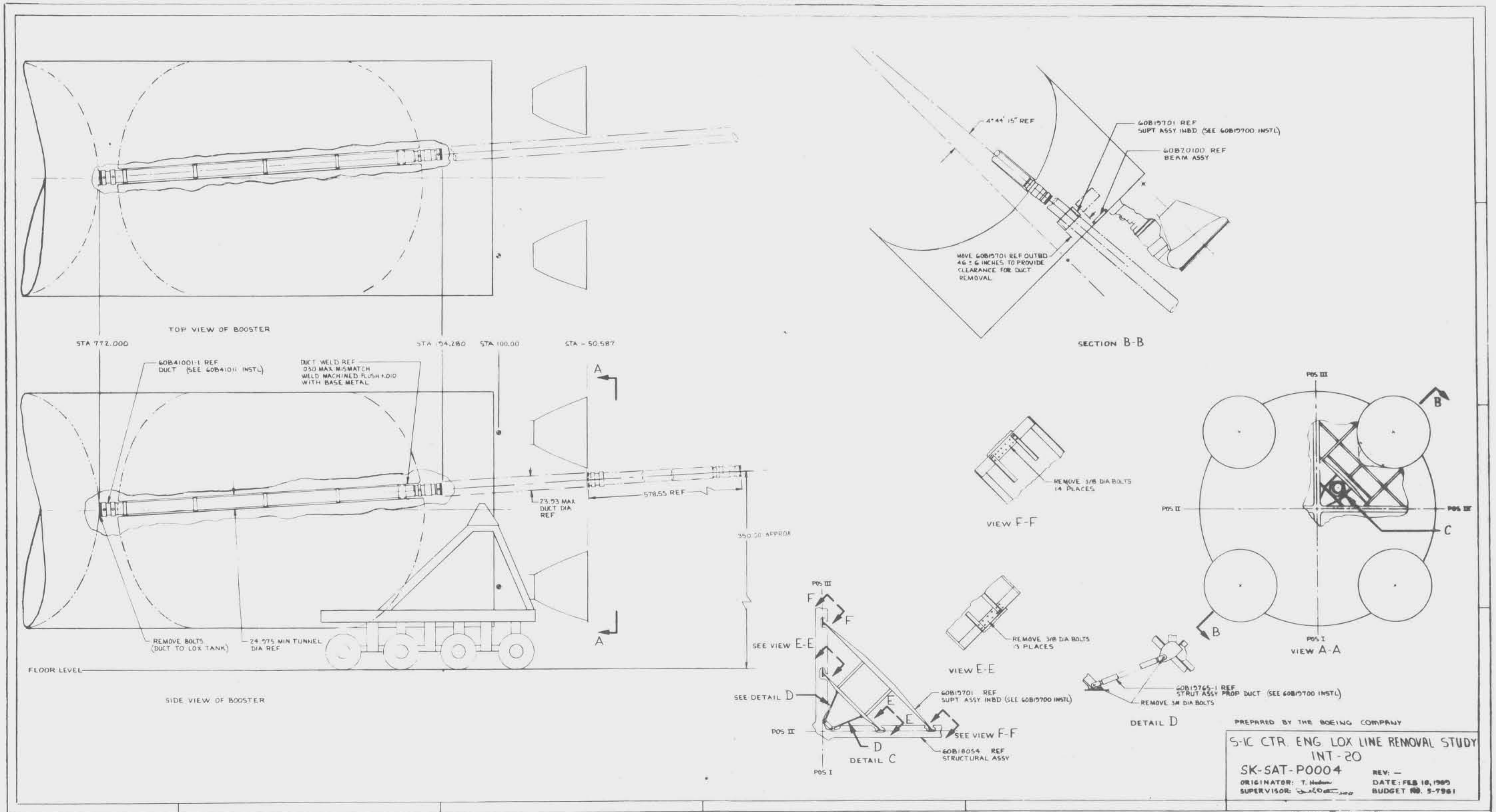

TOP VIEW OF BOOSTER
STA 772.000
STA 154.280
STA 100.00
STA - 50.587
60B41001-1 REF
DUCT (SEE 60B41011 INSTL)
DUCT WELD REF
.050 MAX MISMATCH
WELD MACHINED FLUSH ±.010
WITH BASE METAL
23.53 MAX
DUCT DIA
REF
578.55 REF
350.00 APPROX
REMOVE BOLTS
(DUCT TO LOX TANK)
24.775 MIN TUNNEL
DIA REF
FLOOR LEVEL
SIDE VIEW OF BOOSTER
4°44' 15" REF
60B15701 REF
SUPT ASSY INBD (SEE 60B15700 INSTL)
60B20100 REF
BEAM ASSY
MOVE 60B15701 REF OUTBD
46 ± 6 INCHES TO PROVIDE
CLEARANCE FOR DUCT
REMOVAL
SECTION B-B
REMOVE 3/8 DIA BOLTS
14 PLACES
VIEW F-F
REMOVE 3/8 DIA BOLTS
13 PLACES
VIEW E-E
POS III
POS II
POS IV
POS I
VIEW A-A
SEE VIEW E-E
SEE DETAIL D
60B15701 REF
SUPT ASSY INBD (SEE 60B15700 INSTL)
SEE VIEW F-F
60B18054 REF
STRUCTURAL ASSY
DETAIL C
60B15765-1 REF
STRUT ASSY PROP DUCT (SEE 60B15700 INSTL)
REMOVE 3/4 DIA BOLTS
DETAIL D
PREPARED BY THE BOEING COMPANY
S-IC CTR. ENG. LOX LINE REMOVAL STUDY
INT-20
SK-SAT-P0004
REV: —
ORIGINATOR: T. Hudson
DATE: FEB 10, 1969
SUPERVISOR:
BUDGET NO. 5-7961

FIGURE A-69

2.2.3.2 (Continued)

"Two-out-of-four" voting circuit logic is used to initiate the outboard engines cut-off sequence. The retention of an equivalent Lox depletion capability, as a backup cut-off system, on the INT-20 is considered consistant with Sat V criteria and mandatory for crew safety.

The changes defined in D5-17009-2, paragraph 4.2.2.1 (b) provide the required sensors for a Lox depletion cut-off system to back up a programmed cut-off of the sustainer engines #1 and #3. Qualified 60B41008-5 sensors can be installed in an existing boss on the #1 and #3 engine Lox ducts. This boss, however, is located approximately 23.9 inches below the retained cut-off sensor in the Lox suction fitting. See D5-17009-2, FIGURE 4.2.2.1-16. This downstream location of the added snesors is predicted to be acceptable.

Lox depletion cut-off circuitry is not provided for engines #2 and #4. The depletion sensors in the #2 and #4 suction fitting are therefore deleted. In the event of reversed sequence cut-off, initiated by a premature cut-off of either #1 or #3 engine, the sustainer engines must be programmed for early cut-off prior to possible Lox depletion.

2.2.4 Oxidizer Conditioning System

2.2.4.1 Lox Interconnect System

Deletion of the #5 engine Lox suction duct necessitates a change in the Lox Interconnect System, (D5-17009-2, FIGURE 4-17). A decision to replace the normally closed valve at engine position #2 (Fin B) with a spool as shown in D5-17009-2 FIGURE 4.2.2.1-18 is based on the following examination of the interconnect system functions:

FIGURE 4.2.2.1-17 of D5-17009-2 is a schematic of the existing S-IC LOX Interconnect System with the INT-20 changes noted. The figure includes critical elevations of the system components. Interconnect valves at positions #1, #5 and #4 are of the normally "open" type, whereas, the valve at position #2 is normally "closed."

For Lox fill and standby operation the interconnect valves are in their normal position. Existing S-IC two line bubbling causes Lox circulation "up" line #1 and "down" line #2, "up" line #3 and "down" lines #4 and #5. During flight all interconnect valves are "closed" to isolate the #5 suction line. During suction line drain, all the interconnect valves are "open."

The possibility of using the existing S-IC Interconnect System with the #5 engine suction duct deleted was investigated. Two problems with such an arrangement are evident. The first problem is as follows:

2.2.4.1 (Continued)

During Lox loading the existing two line bubbling would be used. This would give circulation in lines #3 and #4, and lines #1 and #2. However there would be no flow in the interconnect line between suction line #2 and the position #5 line spool. An elevation view of this interconnect section is shown by FIGURE A- . During loading, part of the position #5 spool and part of the interconnect duct would become filled with Gox (vapor) as shown in FIGURE A-70 . The rest of the interconnect duct and spool would be filled with saturated Lox. This would probably not cause a problem during loading and standby. However, during flight, with the valve at position #5 in the closed position a problem would exist. Continued boiling during flight may cause excessive pressures in this unvented section of the interconnect. This condition could be avoided by leaving the interconnect at position #5 open for flight. This is not acceptable, however, because the Gox (vapor) would change the natural frequency of the suction line #3 and may cause a POGO problem.

Another alternate would be to leave the interconnect valve at suction line #2 open for flight. However, if this were done, it is likely that the Gox cavity would form in the position #5 part of the interconnect duct and change the natural frequency of suction line #2. A third alternate would be to leave both interconnect valves at positions #2 and #5 open for flight. This would eliminate Gox in the interconnect duct because it could escape into the suction lines. However, this open interconnect would dynamically couple suction lines #2 and #3.

The second problem associated with the use of the existing interconnect system configuration for INT-20 with the engine #5 suction duct removed is: If the interconnect valve at the suction line #5 position were inadvertently closed after Lox loading, it would only be a matter of time until the interconnecting duct would rupture due to overpressure.

The defined interconnect system changes for INT-20, i.e., replacement of the position #2 interconnect valve with a spool eliminates the above problems and provides for the existing basic S-IC system functions as follows:

(a_1) During fill, standby and drain operations all three remaining interconnect valves will be in their normal "open" position.

(a_2) During flight all three valves will be held "closed" to isolate the four suction lines.

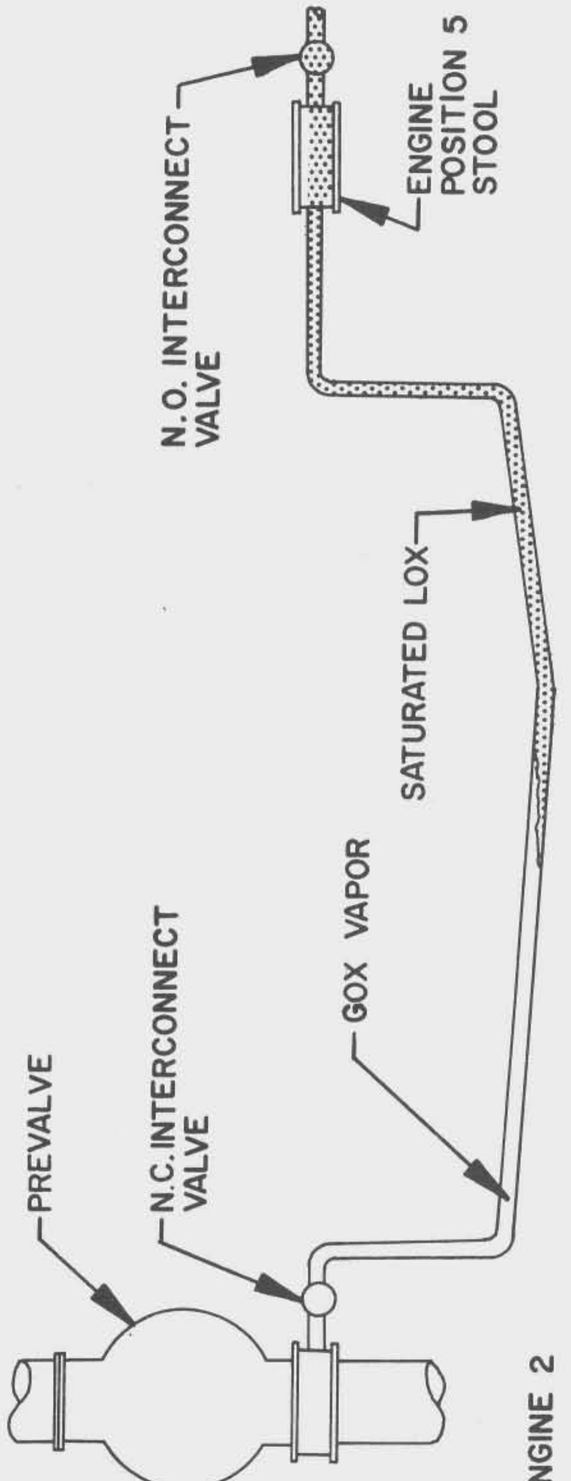


FIGURE A-70 SCHEMATIC OF INTERCONNECT DUCT BETWEEN ENGINE POSITIONS 2 AND 5

2.2.4.1 (Continued)

(a_3) During thermal pumping there will be Lox flow in all interconnect ducts. This will eliminate the possibility of Gox buildup. There would be "up" flow in the position #1 and #3 lines, and "down" flow at the position #2 and #4. The down flow at position #2 would be spit between the position #1 and #3 ducts. This circulation pattern is different from the existing S-IC, where all the "down" flow in the #2 duct goes "up" in duct #1. No potential problem has been identified with this predicted flow change. Proper circulation characteristics should however be demonstrated during the first Lox loading of this system. A temperature probe is specified in the #5 position spool to allow evaluation of the circulation characteristics at this location. Consideration should be given to demonstrating the predicted satisfactory circulation characteristics on the S-IC-T (appropriately configurated to be representative of the INT-20 #5 position duct and interconnect system.)

In summary the defined changes and preliminary supporting analyses of the interconnect system with the INT-20 Lox feed system configuration indicates that:

(b_1) The Lox conditioning system will operate satisfactorily.

(b_2) The Lox emergency bubbling system will operate satisfactorily.

(b_3) Geysering after #2 and #4 engine cut-off does not appear to be a problem because the Lox suction line pressure will increase much faster than any conceivable suction line temperature rise, i.e., the Lox in the suction lines will always be subcooled.

(b_4) Vortexing will not be a problem. Although this item was not evaluated at depth, it is not apparent that a vortexing problem would exist.

(b_5) The POGO suppression system will work, i.e., its S-IC functional characteristics should not be affected by the defined changes to the Lox feed and interconnect systems.

2.2.5 Lox Bubbling System

Elimination of the center engine bubbling system branch line is defined by D5-17009-2 paragraph 4.2.2.1 (c) (2). Removal of the #5 engine position LOX feed duct eliminates the need for the emergency bubbling supply to the center engine Lox spool. To maintain the same helium flow per duct to the four remaining ducts as now specified for the S-IC, adjustment and recalibration of the ground supply (GSE)

2.2.5 (Continued)

system regulator is required. See D5-17009-2 paragraph 4.2.2.2.a.1 (c).

2.2.6 Oxidizer Pressurization System

2.2.6.1 Center Engine Gox Return Line Elimination

Removal of the center engine Gox return line is necessary to prevent the need for closure of this branch line aft of the base heat shield plane. Termination of the center engine Gox return branch at the manifold flange further permits the elimination of potential leak points and the removal of the bolted-on duct support bracketry. Elimination of unused system components from the stage will reduce hardware and installation costs for the production INT-20 stage. No dynamic load problems are apparent. The existing seal at the manifold flange can be used with an appropriately designed closure plate.

2.2.6.2 Oxidizer Tank Pressure Control System

The S-IC-11 oxidizer tank prepressurization requires revision to accomodate the increased ullage requirements for the baseline INT-20. The defined minimum Lox tank level at station 1413.0 with the S-IC prepress lower limit of 24.2 PSIA will not satisfy the engine (gas generator) start pressure requirement. FIGURE A-71 relates the S-IC and INT-20 Lox and fuel pressure switch settings to F-1 engine start pressure requirements. FIGURE A-72 relates the engine start requirements to INT-20 ullage pressures.

The requirement to increase the INT-20 prepressurization switch settings necessitate changes in other related pressure control and relief system components. The Lox tank pressurization schedule for INT-20 is shown by FIGURE A-73 . No change requirement is apparent, from a preliminary analyses, for the Gox flow control (GFC) system. The INT-20 system regulating characteristics of the GFC valve are expected to be somewhat different from a 5 engine supplied S-IC system. Pressure regulation is however predicted to be within the valve specification range shown by FIGURE A-73.

Revision to the mechanical relief valve is not required. In fact a change to the existing 23.5 - 25.5 PSIG control range is not permissible. The upper limit is constrained by the Lox tank structural capability. Lowering of the mechanical relief operating pressure band is highly undesirable because it would increase the probability of maximum tank pressure regulation by overboard venting (relief valve cycling.) A change of the Lox relief valve pressure switch setting however is required to maintain an acceptable differential between the revised prepressurization switch and the relief valve switch pressure control as shown in FIGURE A- 73 .

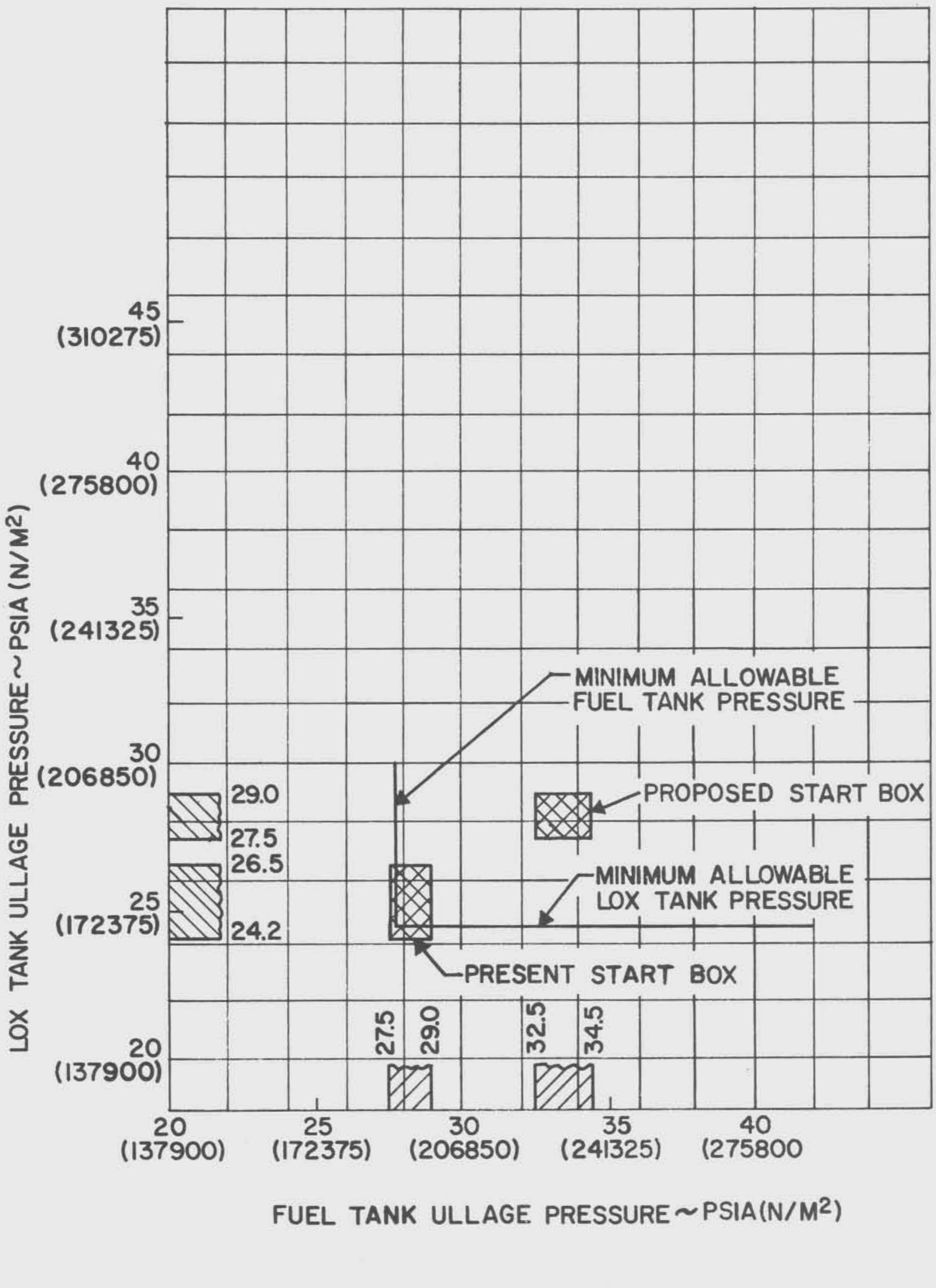
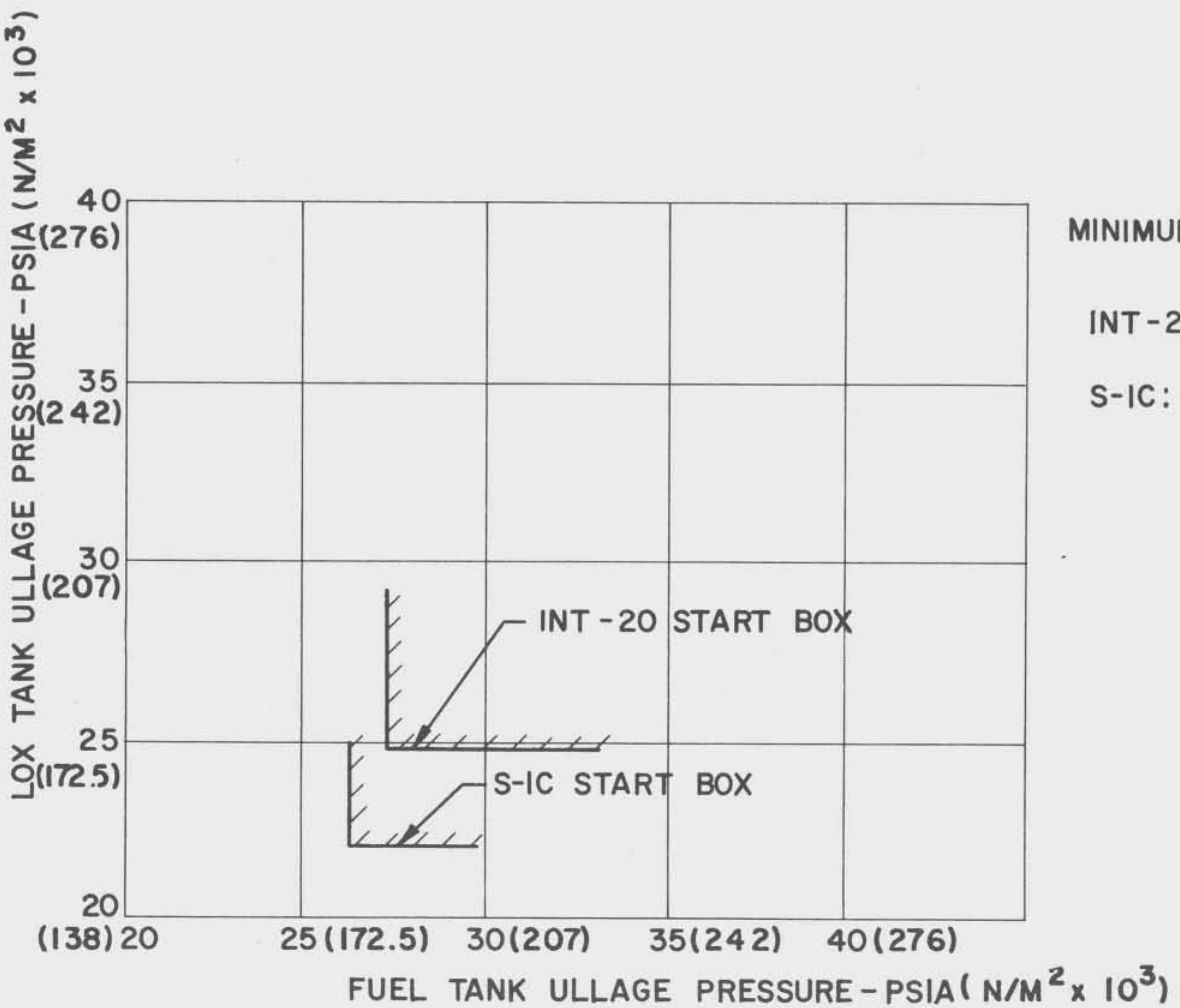


FIGURE A-71 PRESTART ULLAGE PRESSURE REQUIREMENTS (INT-20)



MINIMUM PROPELLANT LOAD

		STA. NO.
INT-20:	LOX	1413
	FUEL	654
S-IC:	LOX	1475.65
	FUEL	690.28

FIGURE A-72 INT-20 AND S-IC MINIMUM PRESTART ULLAGE PRESSURE REQUIREMENTS

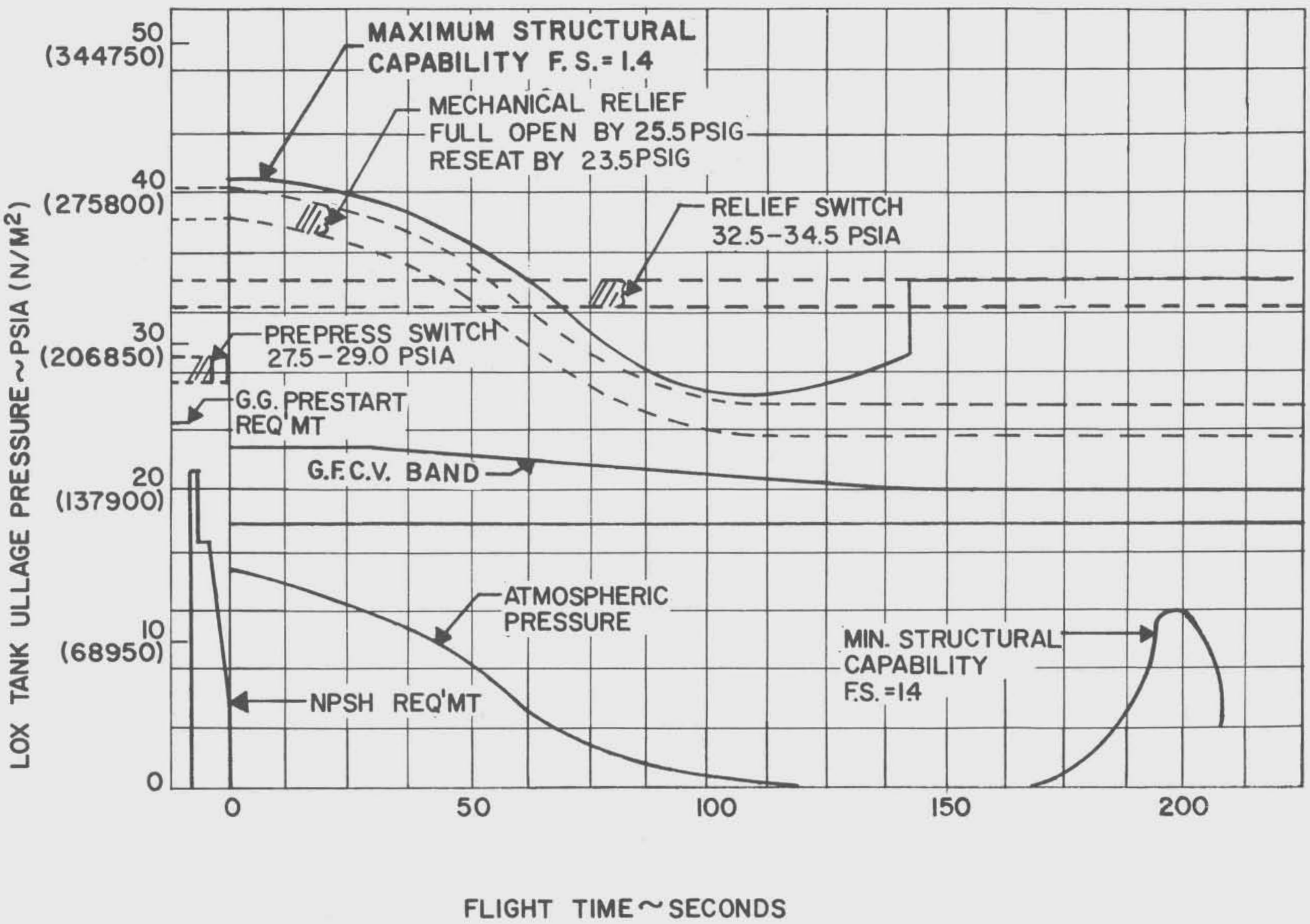


FIGURE A-73 LOX TANK ULLAGE PRESSURE SCHEDULE (INT-20)

2.2.6.2 (Continued)

The above system pressure values should be considered preliminary. An objective of the study was to permit the use of pressure settings of existing qualified switches. More detailed analysis may disclose system requirements which dictate the use of different pressure settings.

Another relief Lox tank pressure system which merits consideration would be to activate the mechanical operation of the second relief valve, which is not used during flight. This could provide a redundant all mechanical relief system, operative prior to and throughout flight, and would permit the deletion of the relief pressure switch.

2.2.7 Fuel System

2.2.7.1 Fuel Fill and Drain

Because of the INT-20 increased ullage volume, the fuel loading probe will be lengthened 14" (D5-17009-2 FIGURES 4.2.2.1-22 and -23). The change, in essence, lengthens the probe stillwell 14". The electronics package will remain unchanged.

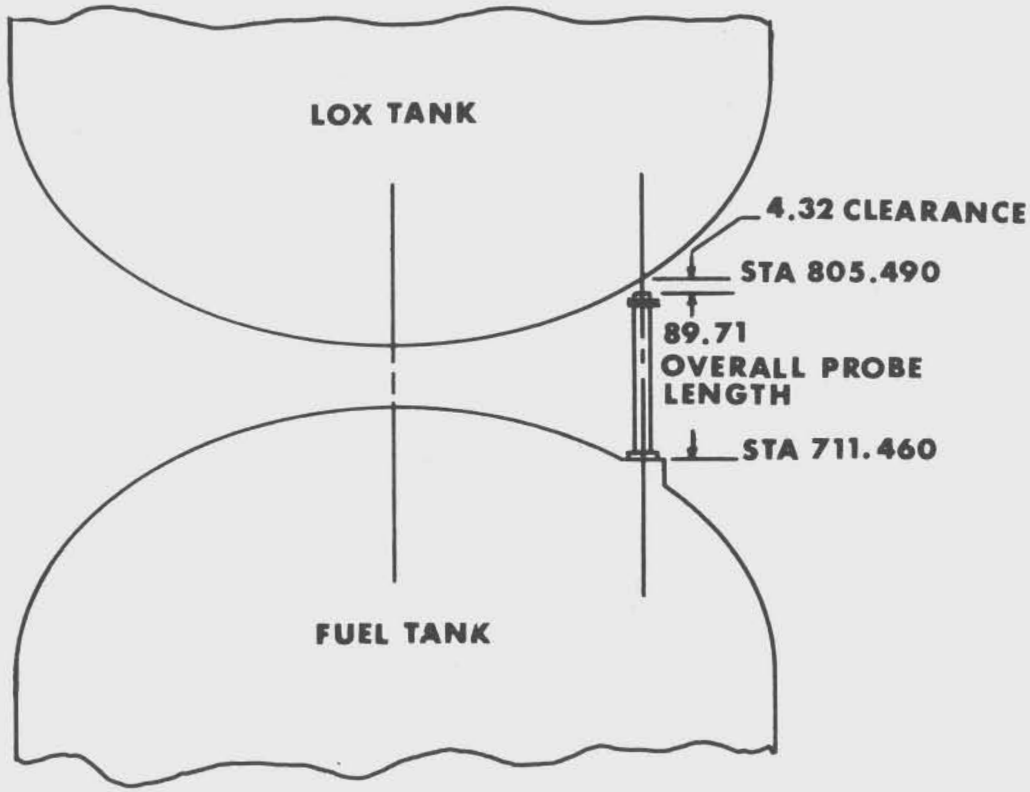
The lengthened probe will require a vibration requalification test only. A clearance study (FIGURE A-74) demonstrates that the lengthened probe can be removed without interference with the aft Lox bulkhead.

The increased loading probe length was established initially using nominal engine performance data (1522K). In subsequent studies, using actual performance data (approx. 1531K) it was determined that additional propellants would be required to satisfy the 1.25 thrust to weight ratio. See para. 2.1.1.5.a.2(a) APPENDIX A. Based on this higher fuel loading level (Sta. 656$\pm$2") use of the existing S-IC fuel loading probe will be re-evaluated during the INT-20 design definition phase.

2.2.7.2 Fuel Feed System

All inboard fuel feed system hardware aft of the fuel suction elbows will be deleted. This hardware (PVC ducts, suction ducts and prevalves) is very costly and not required for system performance. Deletion of this hardware also represents a weight savings and reduces the number of possible leak points.

The inboard fuel suction elbows were not deleted in order that the existing elbow to tank structural configuration be retained. Closure plates and existing seals will be used to seal the downstream end of the fuel elbows. The inboard fuel elbows will act as reservoirs from which fuel cannot be drained. The quantity of fuel, however, contained in these elbows is considered insignificant.



LENGTHENED FUEL PROBE CLEARANCE FIGURE A-74

2.2.7.3 Center Engine Helium Return Line Elimination

Removal of the center engine Helium supply and return lines is necessary to prevent the need for closure of these branch lines aft of the heat shield plane. Termination of the center engine Helium supply and return branches at the manifold flange further permits the elimination of potential leak points and the removal of the bolted-on duct support bracketry. Elimination of unused system components from the stage will reduce hardware and installation costs from the production INT-20 stage.

FIGURE A-75 shows the portion of the remaining Helium supply and return manifolds associated with the center engine. The configuration as defined in D5-17009-2 must be re-evaluated during the design definition phase. A dynamics assessment of the defined change revealed that the first lateral mode of the section of manifold mounted on the cross-beam couples with the first lateral mode of the cantilevered duct segment which is supported by the torsional stiffness of the cross-beam mounted manifold duct. Firm loads were not determined by the preliminary study. However, during the design definition phase, firm loads will be established and the following action taken, as required.

If the loads are not considered excessive, the defined change will be used.

If the loads are excessive, then the following changes will be incorporated:

a. Baseline Configuration

   Replace 60B49605-1 and 603-1 with manifold segments that do not include center engine branches.

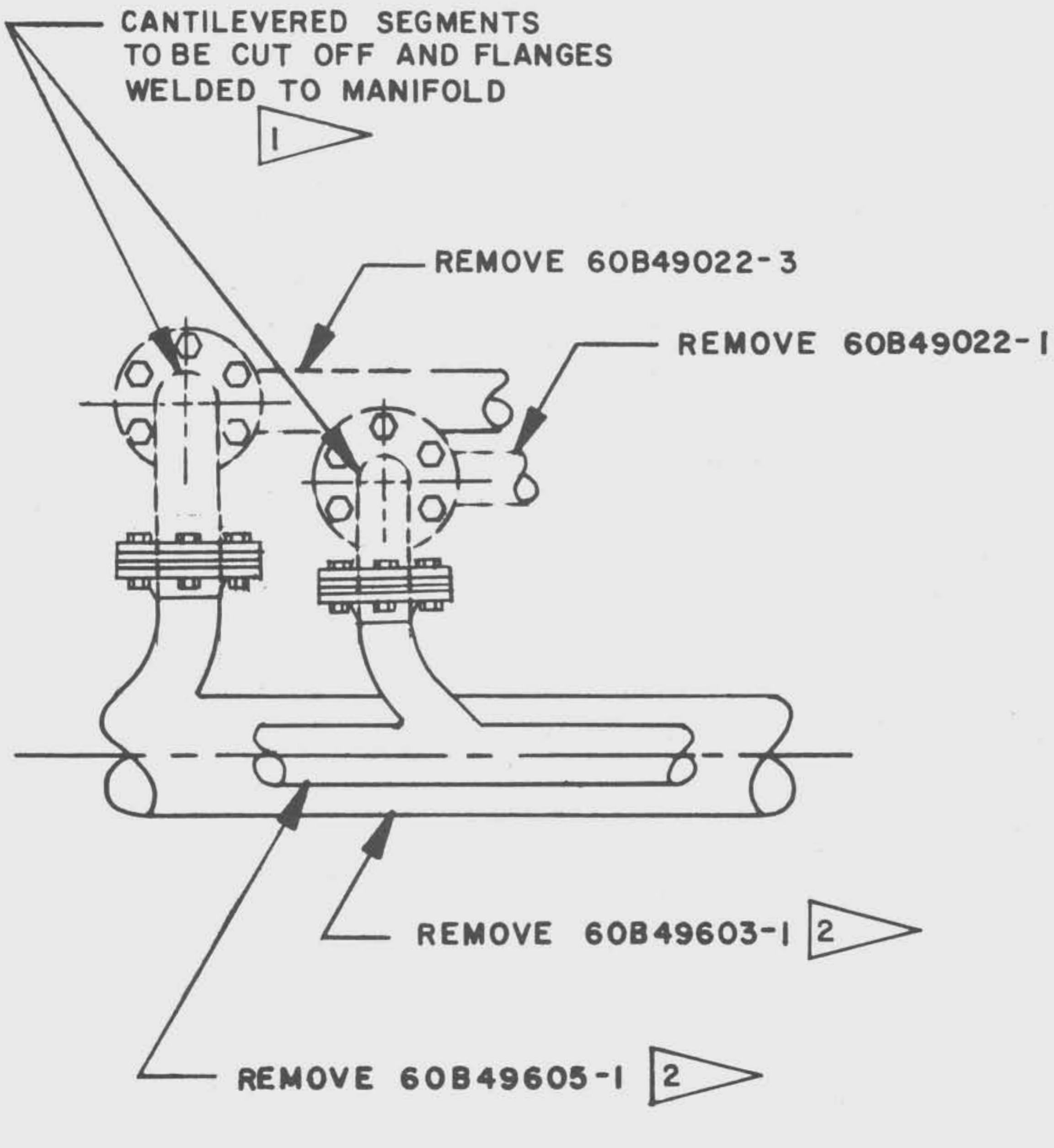
b. Retrofit Configuration

   Shorten the length of the cantilevered branches as shown in FIGURE A-75.

2.2.7.4 Fuel Pressurization System

The S-IC-11 fuel tank pressurization system requires revision to accommodate the increased ullage requirements for the baseline INT-20. The defined minimum fuel level at Station 640 will not satisfy the engine (gas generator) start pressure requirements using the present S-IC prepress lower limit of 27.5 PSIA. FIGURE A-71 relates the S-IC and INT-20 Lox and fuel static head plus prepress to F-1 engine start pressure requirements. FIGURE A-72 relates the engine start requirements to INT-20 ullage pressures.

The requirement to increase the INT-20 prepressurization switch settings necessitate changes in other related pressure control and relief system components. The fuel tank pressurization schedule for INT-20 is shown in FIGURE A-76 . Changes in the mechanical fuel relief valve and relief pressure switch settings are required to maintain an acceptable differential between these devices and the revised



1 RETROFIT CONFIGURATION

2 REPLACE WITH PLAIN DUCT (PROD. CONFIGURATION)

FUEL PREPRESSURIZATION SYSTEM FIGURE A-75

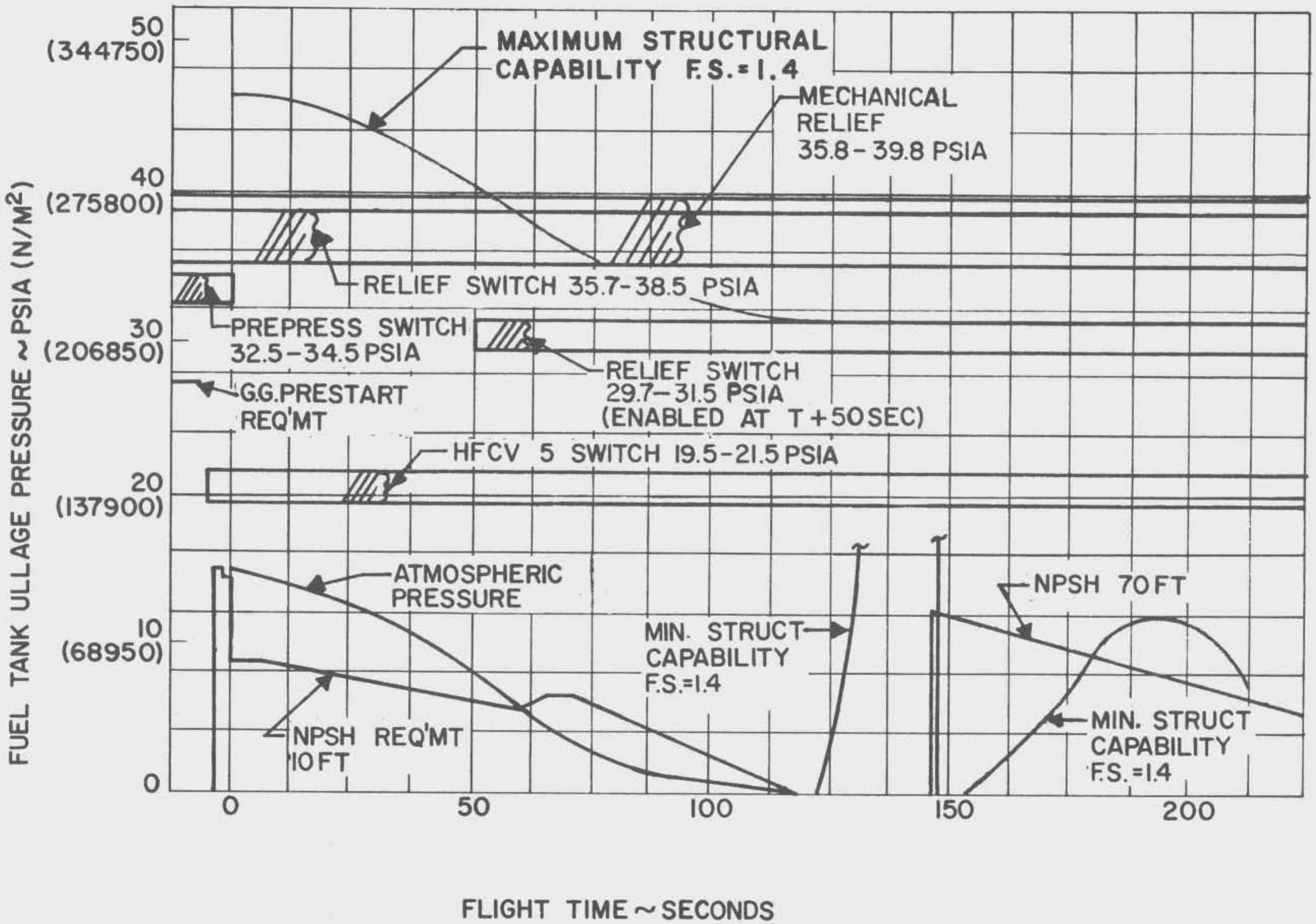


FIGURE A-76 FUEL TANK ULLAGE PRESSURE SCHEDULE (INT-20)

2.2.7.4 (Continued)

prepressurization switch. FIGURE A-76 illustrates the INT-20 fuel pressurization system prepress and relief device operating bands. FIGURE A-76 also shows the installation of a fourth pressure switch (35.7 to 38.5 psia). This switch was added to give redundancy to the mechanical relief valve (35.8 to 39.8 psia) while the vehicle is on the pad and during early part of flight. The existing -27 pressure switch (29.7 - 31.5 psia) will be inhibited until T+50. From T+50 until end of flight, however, the switch will be the primary relief mechanism. The number 5 Helium flow control valve pressure switch (19.5 to 21.5 psia) will remain unchanged. All the above hardware has been qualified with the exception of the new prepress switch (32.5 to 34.5 psia). This switch can be manufactured as a modification of an existing switch and qualified by similarity.

The above system pressure values should be considered preliminary. An objective of the study was to permit the use of pressure settings of existing qualified switches. More detailed analysis may disclose system requirements which dictate the use of different pressure settings.

Helium flow control valve orifice sizes and operating times will be established during the design definition phase. At that time the S-IC Fuel Tank Pressurization System Program will be run using INT-20 design and performance parameters. Also, during the design definition phase, consideration should be given to the development of a psig mechanical relief valve. This would eliminate the need for the -27 pressure switch and the components required to enable that switch during flight.

2.2.8 Auxiliary Systems

Of the three auxiliary systems; Control Pressure System, Environmental Control System and Engine Support and Purge Systems, only the Control Pressure and Engine Support and Purge Systems require changes.

2.2.8.1 Control Pressure System

The control pressure system provides a pressure supply and distribution system for command operation of various pneumatic onboard valves and to supply storage for the engine purge systems (D5-17009-2, FIGURE 4.2.2.1-26). A ground distribution system actuates those valves which function only prior to lift-off or during captive firing. These valves are controlled with 750 psi GN_2 routed directly from the GSE source thru the Aft No. 1 umbilical plate to the valves. There are three such valves: a normally closed fuel fill and drain valve, a normally closed Lox fill and drain valve and a normally closed Lox interconnect valve (D5-17009-2, FIGURE 4.2.2.1-26). Venting these systems and thus closing the valves is accomplished back thru the ground support equipment.

The vent lines from the prevalve 3 way control valves are used as a back-up system during static firing (D5-17009-2, FIGURE 4.2.2.1-27). A GSE pressure source at the Aft Umbilical No. 3 can be used to close the prevalves in the event of an

2.2.8.1 (Continued)

electrical power failure.

The deletion of the center engine prevalves and the No. 2 Lox interconnect valve on INT-20 has been defined previously. Deletion of these valves was used as justification for the removal of their associated control systems.

All associated changes to GSE are defined in D5-17009-2 paragraph 4.2.2.2.

2.2.8.2 Engine Support Purge Systems

The engine support and purge systems consist of the following:

Turbopump Oxidizer Seal purge
Lox Dome and Gas Generator Lox Injector Purge
Engine Cocoon Thermal Conditioning purge
Thrust OK Checkout
Thrust Chamber Prefill
POGO Suppression

The above systems are illustrated in D5-17009-2, FIGURES 4.2.2.1-28, -30 and -33. These support and purge systems are common to all fine engines. Each system consists of a manifold mounted in the thrust structure with branch lines to each engine.

Because of the similarity in design, the following is applicable to all of the above: Deletion of the center engine precludes the need for these systems to that position. Deletion of the branch lines also reduces the number of possible leak points and reduces the fabrication and installation costs associated with those lines. Removal of the lines also eliminates base heat shield penetrations and special line support structure. The deletion of the center engine portion of these systems does not effect the remainder of the on-board systems which support the outboard engines. Minor GSE/ESE orifice and regulator calibration changes as defined in D5-17009-2 paragraph 4.2.2.2.a.3(a) and (b) will be required.

A preliminary examination of the dynamic loading of the capped center engine branch "stubs" showed no excessive loads. These results were attributed to the following:

The cantilevered "stubs" are very short.
The "stub" is a bulkhead mounted fitting.

2.2.8.3 Fluid Power System

Hydraulic power is required at each engine to actuate certain components which are necessary to complete the start sequence. Engine generated hydraulic power is not available until mainstage has been reached.

A ground hydraulic pumping unit provides hydraulics to the aft umbilical plate No. 2. Stage mounted supply and return manifolds supply the fluid to the vacinity of the five engines where branch lines distribute it to the individual engines (D5-17009-2, FIGURE 4.2.2.1-34).

With the deletion of the center engine, the ground supply and return branch lines to that position are no longer required. Deletion of these lines from the engine interface to the manifolds is defined for INT-20. The manifolds will be closed using simple flat closure plates and the existing seals.

Deletion of the branch lines reduce the number of possible leak points and reduces the associated fabrication and installation costs. Removal of these lines eliminate the base heat shield penetrations and associated branch line bracketry.

The deletion of the center engine portion of this system does not effect the remainder of the onboard system which supports the outboard engines. The deletion of one engine should have a favorable impact on the flow demands upon the ground hydraulic pumping unit during the start sequence. A preliminary examination of the dynamic loading of the capped center engine branch "stubs" showed no excessive loads.

2.2.8.4 Thrust Vector Control System

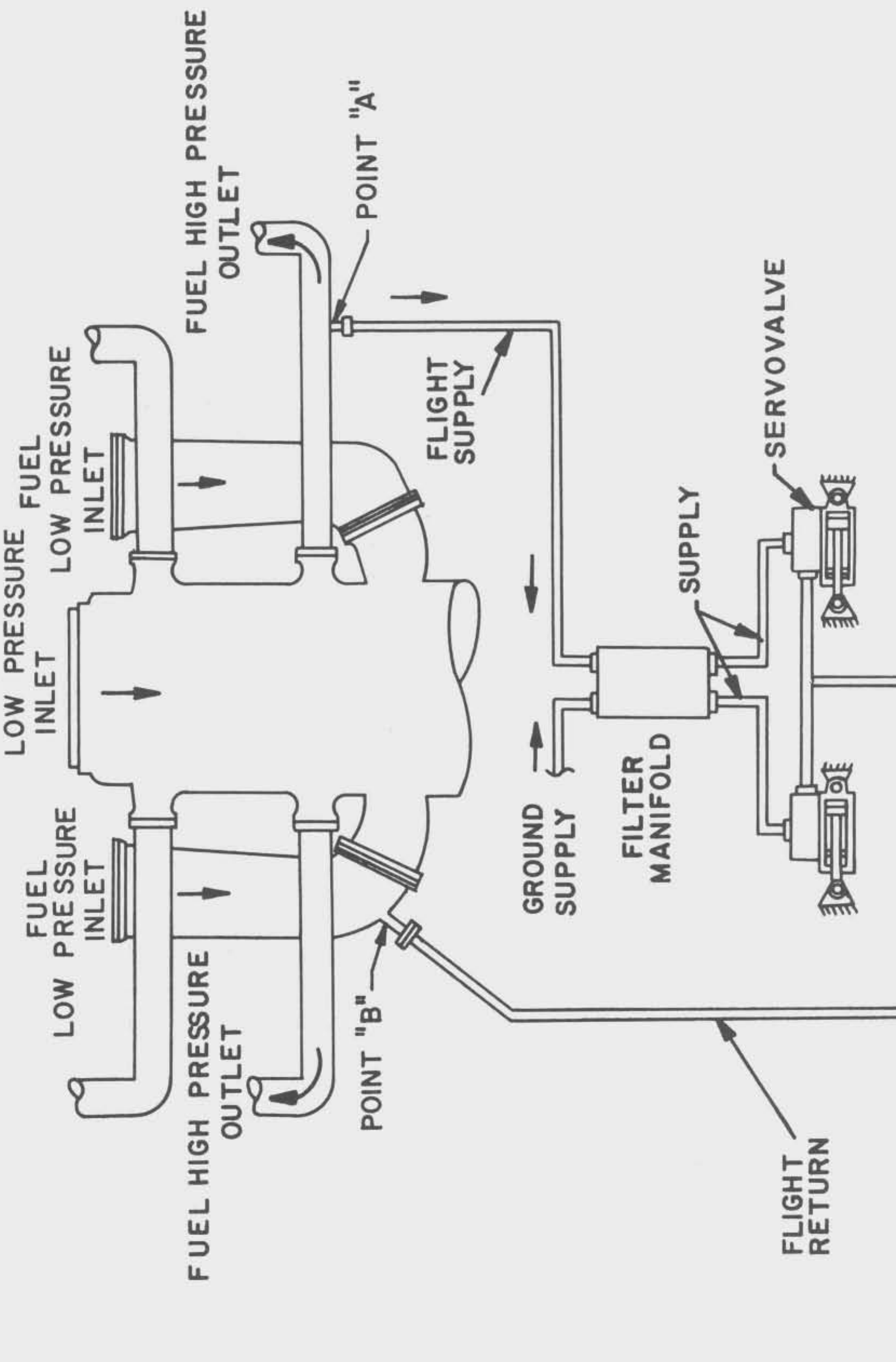
a. Design impact

The Propulsion/Mechanical elements of the thrust vector control system are mounted directly to the engine. They consist of the filter manifold, the servo-actuators, the associated interconnecting ducts and the supply and return ducting between this system and the respective engine systems (FIGURE A-77). The thrust vector control system, however, is installed only on outboard engines. Deletion of the center engine, therefore, has no impact on the design parameters of this system.

b. Flight Impact

INT-20 flight conditions however, required study of the thrust vector control system. The nominal INT-20 flight profile calls for engines 2 and 4 to shut down at T + 146 sec. and engines 1 and 3 to shut down at T + 211 sec. Such a sequence results in the absence of hydraulic supply pressure to the servoactuators of engines 2 and 4 for the last 65 sec of flight. The following questions then required answers:

Will engines 2 and 4 be subject to free, unrestrained oscillations (flopping) for the last 65 seconds of flight?



THRUST VECTOR CONTROL SYSTEM

FIGURE A-77

2.2.8.4 (Continued)

What effect will steering command signals have on engines 2 and 4 after T + 146 seconds?

1. Dynamic influence

A dynamics study identified the maximum force (worse case) on any one actuator of a shut down engine to be 19,500 lbs. This force is a result of engine C.G and longitudional acceleration, PVC duct spring rates, lateral acceleration, recirculation and aerodynamic loads.

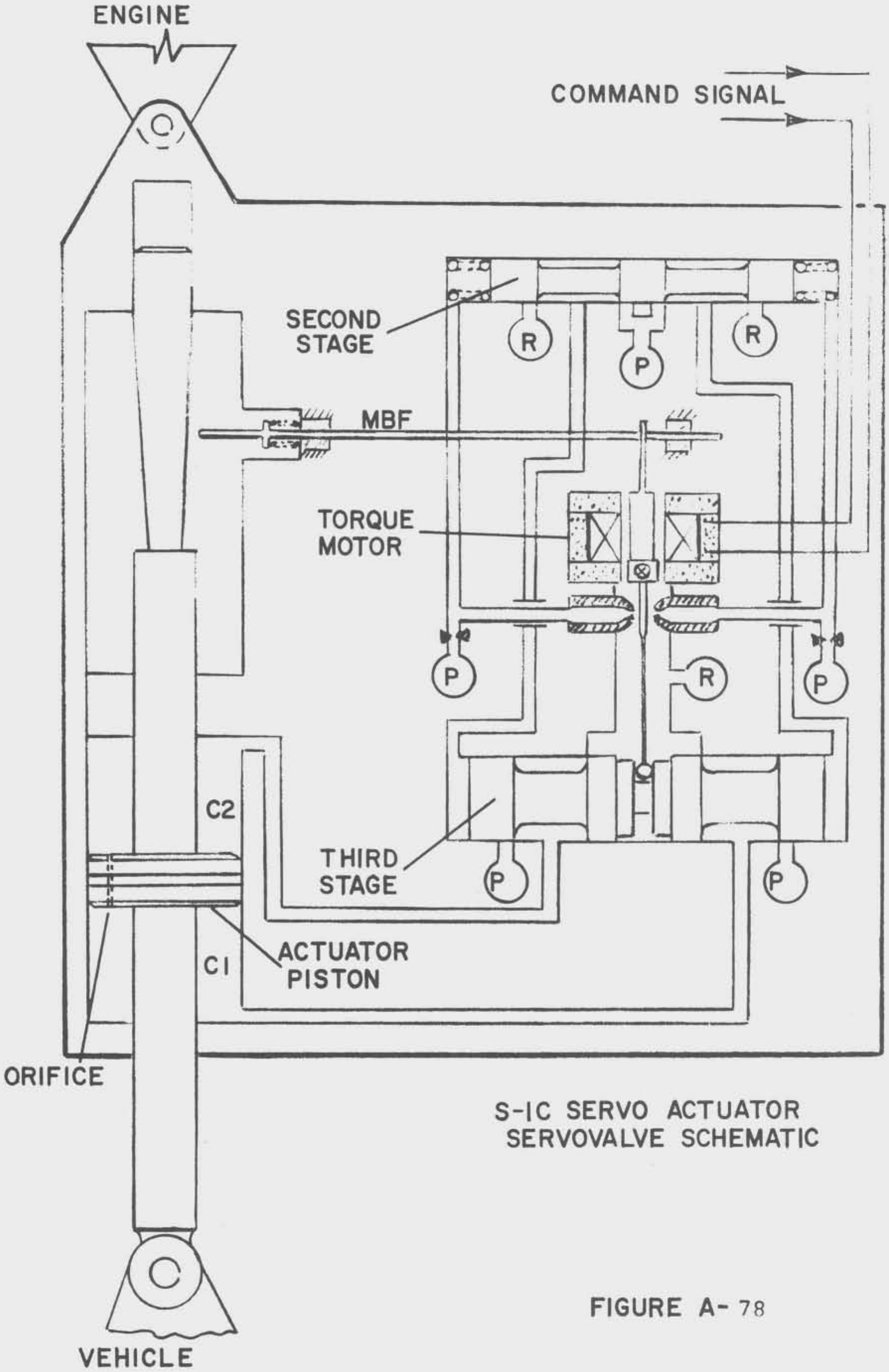
2. Hydraulic system influence

FIGURE A-77 illustrates that supply pressure (Point A) and return pressure (Point B) equalize in an engine that has been shut down. FIGURE A-77 also illustrates that both the supply and return ducts will remain flooded after shut-down.

FIGURE A-**78** illustrates the internal interrelation between the servo-actuator and its servovalve. This figure illustrates that, with the system flooded and the third stage spool in the neutral position, servo-actuator travel can only occur due to leakage flow thru the piston orifice and the third stage spool.

With the engine shut down, P and R are equal as illustrated in FIGURE A-78 . With P and R equal, no flow exists and movement of the flapper by steering command signal will have no effect on the second stage spool. With the second stage spool centered, and the second to third stage ports flooded, the third stage is "locked-up." Thus, with the exception of leakage flow explained above, the servoactuator will be hydralically constrained.

FIGURE A-79 relates external actuator loads to $\triangle$B (flopping). This figure illustrates that with the maximum predicted external actuator load (19,500 lbs.) the engine gimbal rate will be .4 degrees per second. FIGURE A-79 was plotted from calculations based on piston orifice size and third stage spool leakage rates. This gimbal rate is considered too small to present a loads problem.



S-IC SERVO ACTUATOR SERVOVALVE SCHEMATIC

FIGURE A- 78

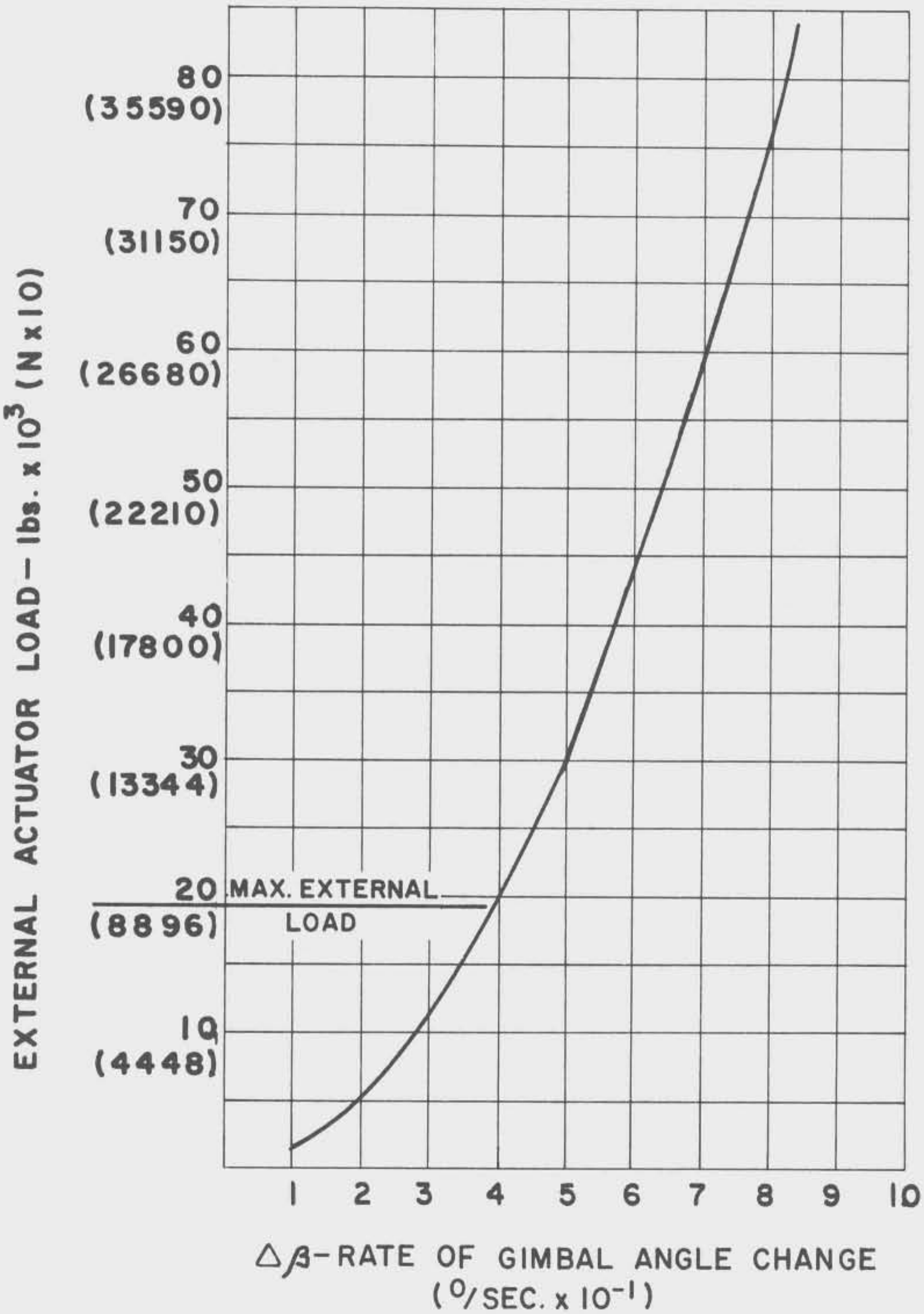


FIGURE A– 79 EXTERNAL ACTUATOR LOAD
VS
RATE OF GIMBAL ANGLE CHANGE

2.3 ELECTRICAL/ELECTRONIC SUBSYSTEMS

2.3.1 Power Generation and Distribution

The present S-IC batteries provide a specified voltage output for a minimum of 640 ampere-minutes. Approximately 52.5 ampere-minutes are utilized during activation. The maximum battery load is less than 50 amperes. Therefore, for power change over at T-50 seconds and a 211 second flight, a maximum of 217.5 ampere-minutes are required per battery. A total of 587.5 ampere-minutes are available, leaving a minimum of 370 ampere-minutes per battery. Therefore, the present batteries are sufficient.

2.3.2 S-IC/S-IVB Interface

2.3.2.1 Functional

Deletion of the Engine No. 5 Thrust OK measurements and addition of the simulated S-II/S-IVB separation indication were requested by IBM. Deleting the Thrust OK measurement distributor wiring provides a normal indication to the I.U. (simulates a normally energized NC relay contact.) Therefore, no change is required to the I.U. circuitry. The simulated S-II/S-IVB separation indication is utilized to perform switching functions in the I.U. Test and checkout capability is provided by the separation simulate relay (2K50). These changes are implemented with minimal impact.

The S-IC functional interface with the S-IVB has been investigated to the extent to determine that compatability can be achieved. Detail pin-function identification and compatible connector selections are considered a design detail beyond the scope of this preliminary study. This level of interface definition will be accomplished during the Design Definition Phase.

2.3.2.2 Cabling

The S-IVB interface connectors are located approximately 208 inches higher than the present S-II interface connectors. Also, the S-IVB interface is located near position II instead of the S-IC position I location. Therefore, an additional 36 feet of cabling is required to cross the S-IVB interstage shroud and circumference from position I to position II.

2.3.3 Sequence and Control

2.3.3.1 Engine Cutoff Circuitry

The engine cutoff circuitry requirements are determined by stage performance which has not presently been uniquely defined. Therefore, the design approach is to provide maximum versatility with minimum impact. The proposed circuitry is dependent upon I.U. generated cutoff commands. The method utilized by the I.U. to generate these cutoff commands does not affect the S-IC circuitry. The proposed circuitry provides for sequenced engine cutoff, "g" limit cutoff commands, redundant LOX sensors for engines 1 and 3, and a reverse engine cutoff sequence.

a. Sequenced Engine Cutoff

The INT-20 vehicle experiences a high rate of acceleration. The predicted flight profile indicates that two S-IC engines must be cutoff during the launch phase to avoid exceeding a 4.68 "g" longitudinal acceleration limit. The two engine cutoff will occur at approximately 146 seconds. Engines 2 and 4 have been selected to be cut off at this time. The acceleration again approaches 4.68 "g" at approximately 211 seconds, at which time the S-IC launch phase is terminated. Either "g" limit or programmed cutoff commands can be utilized for engine cutoff.

b. G Limit Cutoff Command

For this mode, the I.U. determines actual acceleration and calculates time to "g" limit. The cutoff command is initiated at some delta time prior to actual "g" limit. The delta time is dependent upon the acceleration measurement accuracy and cutoff delay time. Assuming the acceleration can be determined more accurately than predicted, this approach provides maximum possible vehicle performance. Therefore, utilization of this method is proposed for engines 2 and 4 cutoff. The accuracy, timing and performance will be precisely defined during the design phase.

The same "g" limit flight program routine can be utilized for engines 1 and 3 cutoff at approximately 211 seconds. This provides cutoff mode versatility and "g" limit back-up for possible LOX depletion cutoff. A LOX depletion cutoff can be utilized, depending upon the amount of propellant initially loaded. Therefore, the proposed citcuitry provides for a "g" limit cutoff of engines 1 and 3. This cutoff mode is also required for utilization of the reverse engine cutoff sequence.

2.3.3.1 (continued)

c. Programmed Cutoff Command

For this mode, the vehicle acceleration is predicted within 3 sigma limits. The I.U. initiates a programmed cutoff command to assure the "g" limit is not exceeded (+3 sigma level at 4.68 "g"). The cutoff command would be initiated at a nominal 4.31 "g" level, which occurs at approximately 137 seconds. This results in a loss of performance with respect to nominal (4.68 "g" level of 146 seconds). The primary advantage of utilizing a programmed cutoff command is simplification of the I.U. programming.

Although utilization of a programmed cutoff command is not presently proposed, a programmed cutoff command may be required as backup for the "g" limit cutoff command. This requirement is dependent upon I.U. single point critical failure modes and will be determined during the design phase. S-IC circuitry would not be affected, since the same switch selector channels would be used for the backup commands.

d. LOX Depletion Cutoff Circuitry

LOX level sensors for engines 2 and 4 would not indicate depletion, since these engines are normally cutoff at approximately 146 seconds. To maintain the present LOX depletion cutoff two-of-four voting logic, redundant sensors are added for engines 1 and 3 and sensors are deleted for engines 2 and 4. The two-of-four voting logic and propellant depletion enable are required to reduce the possibility of premature engine cutoff due to spurious LOX sensor indications.

e. Reverse Engine Cutoff Sequence

A reverse engine cutoff sequence is utilized in the event of engines 1 or 3 cutoff prior to two engine cutoff. The I.U. detects the engine out condition and switches the two engine cutoff command to the opposite engine. Without the reverse sequence, the launch would be terminated at the two engine cutoff command by two adjacent engines out cutoff. Detection of the engine out condition requires a minimal change in the I.U. circuitry.

In the event the reverse engine cutoff sequence is utilized, the I.U. must initiate cutoff of engines 2 and 4 prior to possible LOX depletion. A LOX depletion cutoff capability does not presently exist for engines 2 and 4. Redundant sensors and logic can be implemented for engines 2

2.3.3.1 e. (continued)

and 4 if the performance loss due to early flight termination is unacceptable. The performance will be analyzed during the design phase.

f. Alternate Design Approach

The reverse engine cutoff sequence switching logic can be implemented in the S-IC. This approach would simplify the I.U. change, particularly if programmed engine cutoff commands are utilized. Due to relay usage considerations, it would be advantageous to incorporate the engine 2 and 4 LOX depletion capability with the reverse sequence switching logic. A functional block diagram of this circuit configuration is shown in Figure A-80. Although this approach is not presently proposed, it should be reconsidered if programmed cutoff commands are utilized.

g. Additional Considerations

The proposed engine cutoff circuitry is based on the assumption that three engine operation is feasible. This assumption will be verified during the design phase. The circuitry change required to eliminate single engine cutoff is minimal and could easily be incorporated.

The proposed reverse engine cutoff sequence is based on the assumption that LOX depletion can be predicted with reasonable accuracy. LOX depletion would be greatly increased by a rupture of a LOX duct, which would also result in single engine cutoff. Engine cutoff would stop the depletion, if the rupture were below the prevalve. If the rupture were above the prevalve, a catastrophic condition would probably exist prior to depletion. Therefore, the assumption is considered to be valid.

2.3.3.2 Fuel Tank Vent and Relief Circuitry

Implementation of the fuel tank vent and relief circuitry is a straight forward result of the proposed pressure schedule requirements. The fuel tank vent and relief solenoid valve draws a maximum of 1.5 amperes through approximately 165 feet of wiring (0.85 ohms), resulting in a maximum supply voltage drop of 1.275 volts. An equivalent return voltage drop would result in exceeding the 2.0 volt maximum S-IC design criteria. Therefore, the stage skin is utilized for the return path.

The inhibit relay contacts are rated for 2 amperes resistive load. This rating is sufficient for activation of the solenoid, but is not sufficient for deactivation of the solenoid. The relay should not be used to deactivate the solenoid during

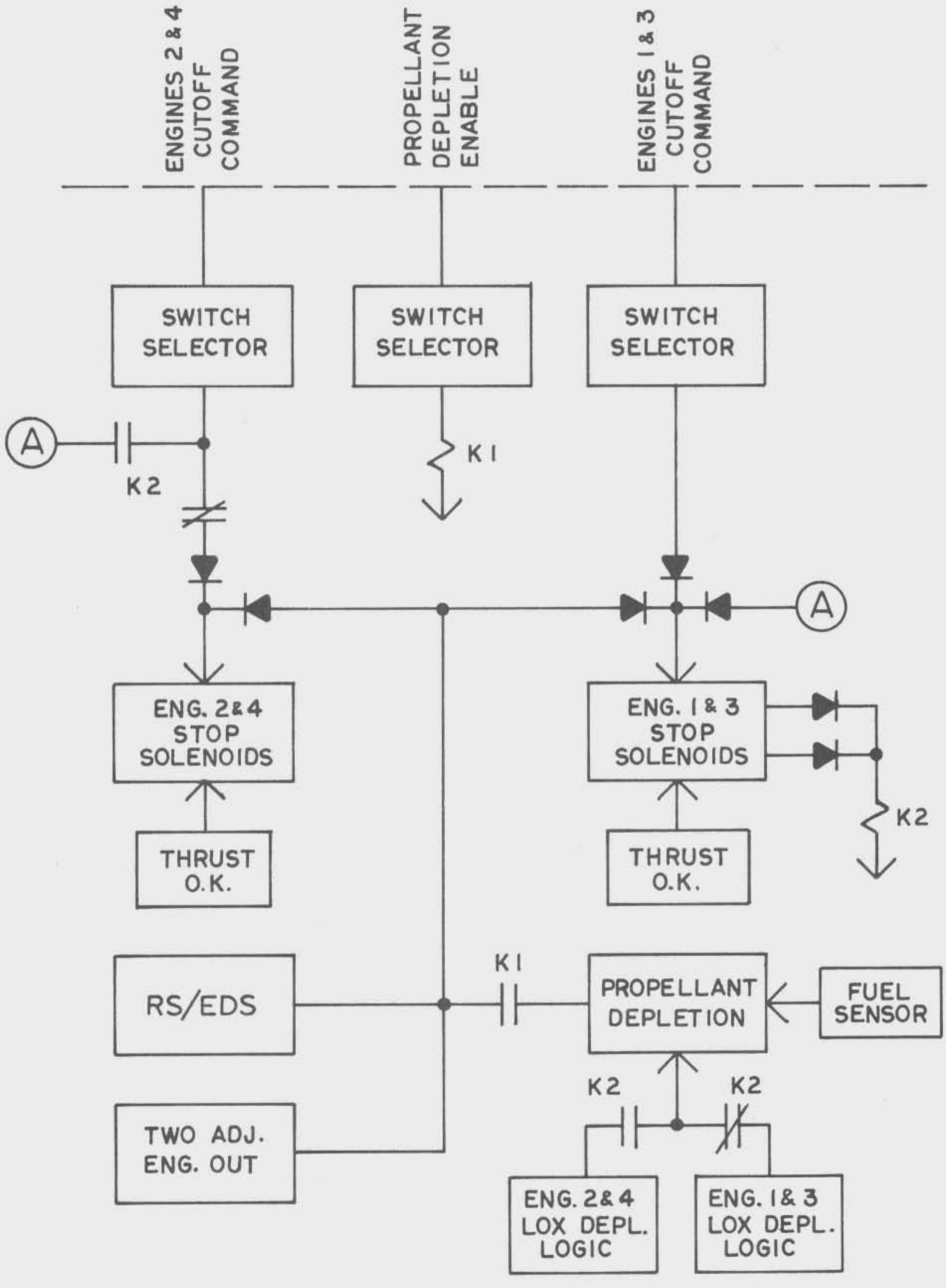


FIGURE **A-80**
ALTERNATE ENGINE CUTOFF
CIRCUITRY FUNCTIONAL DIAGRAM

2.3.3.2 (Continued)

test and checkout. Since the relay is a latching type, there is no problem during flight.

2.3.4 Emergency Detection System

No design changes are required.

2.3.5 Range Safety System

No design changes are required.

2.3.6 Separation and Ordnance System

Coordination with Mc Donnell-Douglas indicates system components can be installed utilizing existing S-IVB mounting provisions. Also, the existing cables between EBW Detonators and Firing Units are long enough for the new installation. The interface cables are lengthened 18 feet because of the additional height of the S-IVB interstage shroud.

2.3.7 Propellant Loading System

No design changes are required for the electronics, although the fuel loading probe is revised to accommodate required levels.

2.3.8 Measuring System

The addition of 19 measurements is recommended for the first two stages. These measurements are required to verify predicted heat shield and Lox interconnect spool temperature, tank and gimbal block vibration, and intertank strain environments. The 39 measurements deleted are no longer required, primarily due to deletion of the center engine. TABLE A-VIII lists the deleted measurements and instrumentation. A complete Instrumentation Program and Components List has been prepared.

Additional changes to the measurement program should be considered to provide POGO related data. These changes are shown in TABLE A-IX. The changes have not been included in the proposed measurement program because the POGO phenomena is not considered to be unique to the INT-20 configuration. Any measurements required to monitor INT-20 unique POGO phenomena will be added during the design phase.

TABLE A-VIII

DELETED INSTRUMENTATION

MEASUREMENT/COMPONENT	INSTALLATION/PART NUMBER
A4-120 [1] Accelerometer	60B67279 60B67520-1
A5-120 [1] Acceleration	60B67280 60B67520-1
C3-105 DC Amplifier	[2] 60B73113-71
C6-105 DC Amplifier	[2] 60B73113-73
C196-115 Temperature Gage DC Amplifier	60B70014 60B72067-5 60B73113-61
C201-115 Temperature Gage DC Amplifier	60B71121-5 60B72067-5 60B73113-63
C242-105 DC Amplifier	[2] 60B73113-137
C342-115 Temperature Gage DC Amplifier	60B41014 60B72099-1 60B73113-151
C343-115 Temperature Gage DC Amplifier	60B41014 60B72099-1 60B73113-151
D3-105	[2]
D4-105	↑
D7-105	|
D8-105	|
D9-105	|
D10-105	|
D13-105	↓
D126-105	[2]

TABLE A-VIII
(continued)

MEASUREMENT/COMPONENT	INSTALLATION/PART NUMBER
D131-115 Pressure Transducer	60B71121 60B72200-3
F44-105 DC Converter	▷2 60B73138-1
K4-115	▷3
K6-105	▷2
K7-105	↕
K8-105	↕
K9-105	↕
K10-105	↕
K15-105	▷2
K45-115	▷3
K46-115	↕
K47-115	↕
K56-115	↕
K105-115	↕
K106-115	↕
K111-115	↕
K112-115	↕
K113-115	↕
K114-115	↕
K173-115	↕
K174-118	▷3
T1-105 Tachometer Pulse Converter	▷2 60B73156-1

TABLE A-VIII
(continued)

1. Measurement not required for INT-20 performance analysis.

2. Measurement provided by engine manufacturer.

3. Switch/relay is an integral part of another stage system.

TABLE A-IX

POGO RELATED MEASUREMENT PROGRAM CHANGES

ADDITIONAL MEASUREMENTS

MEASUREMENT/COMPONENT	TM CHANNEL/PART NUMBER
E90-115	AP1B0-04-00-00
Accelerometer	60B72192-1
D170-119	AP1B0-26-00-00
Pressure Transducer	60B72091-1
DC Amplifier	60B73113-49
D171-117	AP1B0-27-00-00
Pressure Transducer	60B72200-1

REVISED TELEMETRY CHANNELS

MEASUREMENT	FROM	TO
XD4-101	AP1A0V13-01-00	AP1A0V15-00-00
XD4-102	AP1A0-13-02-00	AP1A0-16-00-00
XD4-103	AP1A0-13-03-00	AP1A0-17-00-00
XD4-104	AP1A0-13-04-00	AP1A0-18-00-00
VXD127-115	AP1B0V13-08-00	AP1A0V26-00-00

2.3.9 Electrical Networks

2.3.9.1 Cabling

Unused cabling is coiled and stowed to implement system changes with minimum impact and to facilitate configuration reversibility. If the unused cable branches were deleted, 19 additional cables would have to be documented. These cables would also have to be modified if an INT-20 configuration were retrofitted to a SAT-V configuration. If the reversibility requirement is limited with respect to the number of vehicles, the cost effectiveness of this approach should be reconsidered during the design phase. A complete Cable Interconnection Diagram has been prepared.

2.3.9.2 Electrical Distributors

System changes are implemented by adding/deleting distributor wiring to minimize the change impact and facilitate configuration reversibility. Wiring changes to ground unused telemetry channels and implement additional measurements have been defined, but are not shown in the Electrical Schematics.

APPENDIX A

3.0 PARTS ADD AND DELETE LISTING

This section contains a listing of all significant parts added, deleted or revised for INT-20. Included are part quantity per stage and weights of the affected components.

3.1 STRUCTURES SUBSYSTEMS

3.1.1 Forward Skirt

DELETIONS	WT	ADDITIONS	WT
		Revise S-IC Interface Bolt Pattern (See Method 2 of FIGURE 4.2.2.1-2)	NIL
Total Wt.			0

Total Wt. 0

3.1.2 Oxidizer Tank

DELETIONS	WT	ADDITIONS	WT
LOX Standpipe Assy (60B41271-5) 1 each	171.5	Inbd. LOX Suction Fitting Closure Cover with Floating Flange (See Method 2 of FIGURE 4.2.2.1-3) 1 each	44.1
		Cruciform Support Ring (See Method 2 of FIGURE 4.2.2.1-3) 1 each	7.1
Total Wt.	-171.5		51.2

Total Wt. -120.3

3.1.3 Intertank

No additions or deletions are required.

APPENDIX A

3.1.4 Fuel Tank

DELETIONS	WT	ADDITIONS	WT
		Inbd. Fuel Suction Elbow Closure (See FIGURE 4.2.2.1-4) 2 each	15.4
		Inbd. LOX Tunnel Cover (See FIGURE 4.2.2.1-4) 1 each	11.7
		Tunnel Cover Attach Hardware	
		(NAS 1306 bolt) 3 each	NIL
		(MBN10E-6 nut plate) 3 each	NIL
		(MS20002-7 washer) 3 each	NIL
		Revise Lower Fuel Base Gore Segment (See FIGURE 4.2.2.1-5) 8 places	300
		Revise 60B24510-3, Upper Fuel Instrumentation Cover (See FIGURE 4.2.2.1-6) 1 each	0.5
		Nutplate (60B12012-5) 1 each	0.1
		Insert (MS21209F1-15) 4 each	NIL

Total Wt. 0 327.7

Total Wt. +327.7

APPENDIX A

3.1.5 Thrust Structure

DELETIONS	WT	ADDITIONS	WT
Center Engine Supt. Strut (60B19001-1) 2 each	186.8		
Strut Insulation (60B19006-1, -3) 2 each	6.4		
Strut Fitting (60B18916-1) 2 each	18.6		
Support Strut Attach Hardware			
(MBB30B-20-44 bolt) 2 each	NIL		
(MBN10FC20 nut) 2 each	NIL		
(NAS 1587-20C Washer) 2 each	NIL		
(NAS 1587-20 Washer) 2 each	NIL		
Center Engine Adapter Fitting (60B18910-1) 1 each	83.5		
Inbd. Fuel Suction Duct Supt. Link (60B19769-1) 8 each	21.6		

APPENDIX A

3.1.5 (Continued)

DELETIONS	WT	ADDITIONS	WT
Support Link Attach Hardware			
(60B32020-8C20 bolt) 8 each	NIL		
(60B32020-8C34 bolt) 8 each	NIL		
(60B32023-8C nut) 16 each	NIL		
(MS20002-8 washer) 16 each	NIL		
(MS20002-8C washer) 16 each	NIL		
Total Wt.	-316.9		0

Total △ Wt. -316.9

3.1.6 Heat Shield

DELETIONS	WT	ADDITIONS	WT
Flight Heat Shield Panel - 1 each except as noted		Flight Heat Shield Panel (60B20210-17) 6 each	392.4
(60B20632-17)	18.3		
(60B20243-17)	14.4	Static Firing Honey- comb Heat Shield Panel (60B20210-1) 6 each	-
(60B20244-17)	14.8		
(60B20413-17)	7.4		

APPENDIX A

3.1.6 (Continued)

DELETIONS	WT	ADDITIONS	WT
(60B20631-17)	39.8	Static Firing Steel Back-up Heat Shield Panel	-
(60B20407-17)	51.4	(60B20422-1)	
(60B20414-17)	16.1	6 each	
(60B20245-17)	4.8	Heat Shield Supt. Beam	
(60B20241-17)	4.7	1 each	
(60B20240-17)	6.3	(60B20140-1)	6.1
(60B20242-17)	12.4	(60B20150-1)	4.9
(60B20630-17)	19.1	(60B20200-1)	19.8
(60B20411-17)	5.5		
(60B20411-18)	5.5	Support Beam Attach Fitting	5.2
(60B20403-17) 2 each	75.2	(60B20199-1) 2 each	
Static Firing Honeycomb Heat Shield Panel — 1 each except as noted		Support Beam Attach Clip (60B20327-1, -2) 2 each	0.4
(60B20411-17, -18)	-		
(60B20408-1)	-	Support Beam Attach Doubler	NIL
(60B20405-1)	-	(60B20195-1, -3) 2 each	
(60B20413-1)	-	Support Beam Attach Splice	0.4
(60B20414-1)	-	(60B20193-1, -3) 2 each	

APPENDIX A

3.1.6 (Continued)

DELETIONS	WT	ADDITIONS	WT
(60B20407-1)	-	Support Beam Attach Channel	0.4
(60B20404-1)	-	(60B20030-1, -2) 1 each	
(60B20403-1) 2 each	-	Inconel Support Bracket (See FIGURE 4.2.2.1-12) 1 each	10.8
Static Firing Steel Back-up Heat Shield Panel - 1 each except as noted			
(60B20454-1, -3)	-		
(60B20455-1, -3)	-		
(60B20011-1)	-		
(60B20013-1)	-		
(60B20014-1)	-		
(60B20431-1)	-		
(60B20458-1)	-		
(60B20015-1)	-		
(60B20459-1)	-		
(60B20426-1)	-		
(60B20012-1)	-		
(60B20010-1)	-		
(60B20562-1) 2 each	-		

APPENDIX A

3.1.6 (Continued)

DELETIONS	WT	ADDITIONS	WT
Center Engine Flame Curtain Assembly (60B20508-1) 1 each	110.0		
Heat Shield Support Beam - 1 each			
(60B20170-1)	3.3		
(60B20542-3, -4)	9.8		
(60B20226-3, -5)	12.3		
(60B20226-1)	6.2		
(60B20160-1)	1.7		
(60B20123-1)	23.5		
(60B20180-1)	26.0		
Support Beam Attach Clip			
(60B20227-1) 2 each	0.2		
(60B20227-3) 4 each	0.4		
(60B20227-5) 6 each	0.6		
(60B20132-1) 1 each	0.1		
(60B20137-1, -2) 1 each	0.2		

APPENDIX A

3.1.6 (Continued)

DELETIONS	WT	ADDITIONS	WT
(60B20102-1, -2) 1 each	0.2		
(60B20605-1) 4 each	0.4		
(60B20543-1) 8 each	0.8		
(60B20129-1, -3) 2 each	0.8		
(60B20105-1) 2 each	0.2		
(60B20131-1) 2 each	0.2		
Support Beam Attach Doubler (60B20145-1) 3 each	NIL		
Support Beam Attach Filler			
(60B20135-1) 1 each	0.3		
(60B20146-1) 2 each	0.2		
Support Beam Attach Bracket (60B20629-1) 4 each	1.2		
Support Beam Attach Fitting (60B20198-1, -2) 1 each	2.7		

APPENDIX A

3.1.6 (Continued)

DELETIONS	WT	ADDITIONS	WT
Support Beam Attach Washer			
(60B20550-1, -2) 2 each	NIL		
(60B20550-3) 4 each	NIL		
Heat Shield Stiffener			
(60B20465-1) 1 each	3.4		
(60B20466-1) 1 each	2.3		

Total Wt. -502.7 440.4

Total Δ Wt. -62.3

3.2 PROPULSION AND MECHANICAL SUBSYSTEMS

3.2.1 Oxidizer System

3.2.2 Oxidizer Fill and Drain (60B41012)

No change.

APPENDIX A

3.2.3 Oxidizer Feed System (60B41014)

DELETIONS	WT	ADDITIONS	WT
Inbd. LOX Prevalve (20M32010)	390.0	Inbd. LOX Interconnect Spool Supt. Adapter (FIGURE 4.2.2.1-15)	175
LOX Cutoff Sensor (60B41008-3) 3 each	3	LOX Cutoff Sensor (60B41008-5) 2 each	2
* Inbd. LOX Suction Duct Assy. (60B41011-3)	1272.0	Plug (MC238C12W) 2 each	NIL
Plug (MC238C8W) 2 each	NIL		
Inbd. PVC Duct (20M02002)	500.0		
Seals (60B41149-65 & -77) 1 each	5.6		
Total Wt.	-2170.6		177

Total △ Wt. -1993.6

* Deletion of this duct will result in a LOX reduction of 8350 lbs.

3.2.4 Oxidizer Conditioning System

APPENDIX A

3.2.5 LOX Interconnect System (60B41014)

DELETIONS	WT	ADDITIONS	WT
Engine Position 2 Interconnect Valve (60B41136-3)	28	New Interconnect Spool (FIGURE 4.2.2.1-18)	7

Total Wt. -28 7

Total △ Wt. -21

3.2.6 LOX Bubbling System (60B41221)

DELETIONS	WT	ADDITIONS	WT
Tube Assemblies (60B41221-45 & -37)	.4	Cap (MC177D4W)	NIL
Union (MC160D4W)	NIL	Plug (MC238C4W)	NIL
Adapter (MC237D4W)	NIL		
Check Valve (60B41028-3)	.5		
Union Orifice (60B41046-9)	NIL		

Total Wt. -.9

Total △ Wt. -.9

APPENDIX A

3.2.7 Oxidizer Pressurization (60B51400)

DELETIONS	WT	ADDITIONS	WT
Tube Assembly (60B51404-1)	29.0	GOX Manifold Assy. Closure (FIGURE 4.2.2.1-21, Item 1)	2.7
Seal (60B41149-11)	.4		
Bracket (60B51443-1)	.5		
Roller Assembly (60B51416-1) 2 each (60B51416-3)	2.3		
Roller (60B51417-1) 6 each	1.7		
Bushing (60B51418-1) 4 each (60B51418-3) 2 each	.4		
Pressure Switch (60B49030-25)	3.5	Pressure Switch (60B49030-21)	3.5
Pressure Switch (60B49030-27)	3.5	Pressure Switch (60B49030-XX, new dash no.)	3.5

Total Wt. -41.3 9.7

Total Wt. -31.6

3.2.8 Fuel System

3.2.9 Fuel Fill and Drain (60B43014)

DELETIONS	WT	ADDITIONS	WT
Fuel Loading Probe (60B43006-25F)	23.0	Lengthen Loading Probe (FIGURE 4.2.2.1-23	27.0

Total Wt. 23.0 27.0

Total Wt. +4.0

APPENDIX A

3.2.10 Fuel Feed System (60B43014)

DELETIONS	WT	ADDITIONS	WT
Inbd. Fuel Prevalves (20M32011-1) 2 each	175.0		
Inbd. Fuel Suction Ducts (60B43001-1) 2 each	159.0		
Inbd. Fuel PVC Ducts (20M02003-1)	300.0		
Seals (60B43063-39) 4 each	.6		
Seals (60B43063-37) 2 each	.6		
Support (60B49360-1)	9.0		

Total Wt. -644.2

Total Wt. -644.2

3.2.11 Fuel Pressurization System (60B49600)

DELETIONS	WT	ADDITIONS	WT
Inbd. Helium Supply Line (60B49022-1)	12.0	Helium Manifold Closures (FIGURE 4.2.2.1-21, Items 2 & 3)	3.0
Inbd. Helium Return Line (60B49002-3)	7.2	Orifice (60B49510-XX)*	-
Seal (60B41149-5, -9) 1 each	.6	Orifice (60B49510-XX)*	-
Orifice (60B49510-11)	-	Orifice (60B49510-XX)* 3 each	-
Orifice (60B49510-13)	-		
Orifice (60B49510-15) 3 each	-	Pressure Switch (60B49030-XX)*	3.5
Pressure Switch (60B49030-21)	3.5	Pressure Switch (60B49030-33)	3.5
Total Wt.	-23.3	* New dash number as required.	10

Total Wt. -13.3

APPENDIX A

3.2.12 Auxiliary Systems

3.2.13 Control Pressure Subsystem (60B52500)

DELETIONS	WT	ADDITIONS	WT
Flight - Onboard			
Inboard GN_2 Supply Lines (60B52500-101, -103, -105, -107, -109, -113)	2.0	Cap (MC177D6W)	NIL
Inboard GN_2 Supply Line Tee (MC158D6) 2 each	.1		
Inboard Supply Solenoid Valve (60B52101-3 and -7) 1 each	2.5		
Ground - Onboard			
Inboard GN_2 Supply Lines (60B41223-139, -141, -169, -170, -171)	.9	Cap (MC177D8W)	NIL
Inboard GN_2 Supply Line Unions (MC160D6) & (MC169D12W) 1 each	NIL		
Inboard GN_2 Supply Line Tee (MC162D6)	NIL		

Total Wt. -5.5

Total Δ Wt. -5.5

APPENDIX A

3.2.14 Environmental Control System

No change.

3.2.15 Engine Support Purge Systems

3.2.16 Turbopump Oxidizer Seal (60B37601)

DELETIONS	WT	ADDITIONS	WT
Orifice Adapter Assy. (60B37616-3)	.2	Plug (MC238C8W)	NIL
Tube Assemblies (60B37601-173, -145, -147, & -181)	3.0		
Bulkhead Elbow Assembly (MC165D8)	.1		
Union Assembly (MC160D8W) 2 each	NIL		
Fitting Assembly (60B37618-3)	3.9		

Total Wt. -7.2

Total Δ Wt. -7.2

APPENDIX A

3.2.17 Radiation Calorimeter Purge System (First Flight Stages Only)

DELETIONS	WT	ADDITIONS	WT
		Tube Assemblies (60B37601-173, -145, and -147)	3.0
		Bulkhead Elbow Assy. (MC165D8)	.1
		Union Assembly (MC160D8W) 2 each	NIL
		New Line Segment (FIGURE 4-28)	.9

Total Wt. 4.0

Total △ Wt. +4.0

3.2.18 LOX Dome and Gas Generator LOX Injector Purge System (60B37600)

DELETIONS	WT	ADDITIONS	WT
Inbd. GN_2 Supply Lines (60B37600-623, -625, -627)	6.2	Plug (MC238C16W)	NIL
Adapter Orifice (60B37614-9)	.5		
Union Assembly (MC160D16UW) 2 each	.4		

APPENDIX A

3.2.18 (Continued)

DELETIONS	WT	ADDITIONS	WT
Inboard GN_2 Supply Fitting (60B37637-3)	4.1		

Total Wt. -11.2

Total Δ Wt. -11.2

3.2.19 Engine Cocoon Thermal Conditioning Purge System (60B37602)

DELETIONS	WT	ADDITIONS	WT
Orifice, Reducer (60B37622-3)	.4	Plug (MC238C16W)	NIL
Tube Assemblies (60B37602-407, -413, -125)	5.1		
Union Assemblies (MC160D08W) 2 each	NIL		
Fitting Assembly (60B37621-5)	2.2		

Total Wt. -7.7

Total Δ Wt. -7.7

APPENDIX A

3.2.20 Thrust OK Checkout System (60B37600)

DELETIONS	WT	ADDITIONS	WT
Tube Assemblies (60B37600-73, -79, -81, -83, -109)	1.0	Cap (MC177D4W)	NIL
Hose Assembly (MBH30A-04A-0175)	NIL		
Unions (MC160D4W) 3 each	NIL		
Elbows (MC160D4) 2 each	NIL		

Total Wt. -1.0

Total Δ Wt. -1.0

3.2.21 Thrust Chamber Prefill System (60B37550)

DELETIONS	WT	ADDITIONS	WT
Supply Tube Assembly (60B37550-115, -145)	1.8	Plug (MC238C16W)	NIL
Orifice (60B37525-9)	.4		
Union Assembly (60B37656-1)	.1		
Fitting Assembly (60B37621-3)	3.0		

Total Wt. -5.3

Total Δ Wt. -5.3

APPENDIX A

3.2.22 POGO Suppression System (60B41340)

DELETIONS	WT	ADDITIONS	WT
Orifice (60B41354-1)	.1	Plug (MC238C6W)	NIL
Adapter (MC237C4W)	NIL		
Union (MC160C4W) 3 each	NIL		
Helium Supply Tube Assemblies (60B41344-11, -29, -31, -33)	2.6		
Reducer (MC247CS-4)	NIL		
Nut (MC124C8WU)	NIL		
Check Valve (60B41319-3)	2.0		

Total Wt. -4.7

Total Δ Wt. -4.7

3.2.23 Flight Control Subsystem

The flight control subsystem is made up of the fluid power system and the thrust vector control system.

APPENDIX A

3.2.24 Fluid Power System (60B82000)

DELETIONS	WT	ADDITIONS	WT
H/S Penetration Tube (60B82024-1) (60B82085-3C)	 19.3 20.0	Inboard Hydraulic Supply and Return Closures (FIGURE 4.2.2.1-21, Item 4)	2.2
Flex Tube Assembly (60B82013-1F & -3F)	 10.0		
Bracket Cap (60B82094-1A) 10 each	 2.0		
Cushion Bracket (60B82095) 10 each (60B82096) 10 each	 1.1 .2		
Bolt, Nut, Washer (NAS 1304-8W) 20 each (MS21042-4) 20 each (AN960C416) 40 each	 NIL NIL NIL		

Total Wt. -51.6 2.2

Total Δ Wt. -49.4

3.2.25 Thrust Vector Control System (60B8400)

No change.

APPENDIX A

3.2.26 Engine and Related Components (60B37450)

DELETIONS	WT	ADDITIONS	WT
F-1 Engine & Loose Equipment (104001)	19,260		
F-1 Engine Thermal Insulation (145011), (145021)			
Center Engine Support Strut to Engine Attach Pin (60B84001-1B) 2 ea.	1.0		
Center Engine Support Strut to Engine Attach Nut (60B84005-1A) 2 ea.	1.2		
Center Engine Support Strut to Engine Attach Washer and Pins			
(60B84007-1A) 2 each	NIL		
(MS24665-379) 2 each	NIL		
(MS24665-375) 2 each	NIL		
(60B84090-1) 4 each	NIL		
Center Engine Gimbal Block to Stage Attach Bolt (MBB30M-14-56) 8 each	8.0		
Center Engine Gimbal Block to Stage Attach Nut (MBN10B-14) 8 each	1.6		
Center Engine Gimbal Block to Stage Attach Washer (NAS1587-14) 8 each	NIL		
(NAS1587-14C) 8 each	NIL		

Total Wt. -19,271.8

Total Δ Wt. -19,271.8

3.3 ELECTRICAL/ELECTRONIC SUBSYSTEMS

3.3.1 Power Generation and Distribution

No additions, deletions, or revisions are required.

3.3.2 S-IC/S-IVB Interface

Revisions	Wt.	Revisions	Wt.
Cable Assembly 120W3 (60B55303-1)	+9.040	Cable Assembly 120W45 (60B55345-1)	+2.916
Cable Assembly 120W4 (60B55304-1)	+6.998	Cable Assembly 120W46 (60B55346-1)	+2.916
Cable Assembly 120W5 (60B55305-1)	+4.666	Cable Assembly 120W47 (60B55347-1)	+2.333
Cable Assembly 120W13 (60B55315-1)	+5.216		
Total Wt.	+25.290		+8.165
Total △ Wt.	+34.085		

3.3.3 Sequence and control

Deletions	Wt.	Additions	Wt.
LOX Level Sensor (60B41008-3) 3 each	-3.000	LOX Level Sensor (60B41008-5)	+1.000
		Printed Wiring Assembly (60B62100-5)	N/A
Total Wt.	-3.000		+1.000
Total △ Wt.	-2.000		

3.3.3 (Continued)

Revisions	Wt.	Revisions	Wt.
Cable Assembly 115W16 (60B55016-1)	+0.433	Junction Box Assembly 118A100 (60B57877-1)	+0.001
Cable Assembly 118W16 (60B55295-1)	+0.649	Cable Assembly 118W14 (60B55294-1)	+4.765
Total Wt.	+1.082		+4.766
Total △ Wt.	+5.848		

3.3.4 Emergency Detection System

No additions, deletions, or revisions are required.

3.3.5 Range Safety System

No additions, deletions, or revisions are required.

3.3.6 Separation and Ordinance System

Revisions	Wt.	Revisions	Wt.
Cable Assembly 120W10 (60B55310-1)	+2.268	Cable Assembly 120W39 (60B55339-1)	+1.166
Total Wt.	+2.268		+1.166
Total △ Wt.	+3.4.34		

3.7 Propellant Loading System

No additions, deletions, or revisions are required.

3.3.8 Measuring System

Deletions	Wt.	Additions	Wt.
Accelerometer (60B67520-1) 2 each	-2.044	Resistance Thermometer (60B72067-5)	+0.500
Temperature Gage (60B72067-5) 2 each	-1.000	Radiation Calorimeter (60B72065-1) 2 each	+1.000
Temperature Gage (60B72099-1) 2 each	-0.400	Thermocouple (60B71141-11)	+0.603
Pressure Transducer (60B72200-3)	-0.500	Thermocouple (60B71141-13) 4 each	+1.208
DC Amplifier (60B73113-61)	N/A	Accelerometer (60B72192-7)	+0.800
DC Amplifier (60B73113-71)	N/A	Accelerometer (60B72192-11) 2 each	+1.600
DC Amplifier (60B73113-73)	N/A	Zone Box (60B67608-1) 4 each	+0.408
DC Amplifier (60B73113-137)	N/A	Zone Box (60B67608-3)	+0.102
DC Amplifier (60B73113-15) 2 each	N/A	DC Amplifier (60B73113-21) 2 each	N/A
DC Converter (60B73138-1)	N/A	DC Amplifier (60B73113-33)	N/A
Tachometer Pulse Converter (60B73156-1)	N/A	DC Amplifier (60B73113-45)	N/A

3.3.8 (Continued)

Deletions	Wt.	Additions	Wt.
		DC Amplifier (60B73113-85) 2 each	N/A
		DC Amplifier (60B73113-115) 8 each	N/A
		Cable Assembly	+ 6.000
		Cable Assembly	+27.000
		Cable Assembly	+15.000
		Cable Assembly	+ 2.000
Total Wt.	-3.944		+56.221
Total △ Wt.	+52.277		

Additional parts required for first two stages only.

Revisions	Wt.	Revisions	Wt.
Measuring Rack 115A500 (60B70995-1)	+2.077	Cable Assembly 115W58 (60B55058-1)	+1.297
Measuring Rack 115A501 (60B70995-3)	-2.076	Cable Assembly 115W59 (60B55059-1)	+1.054
Measuring Rack 115A502 (60B70995-5)	+6.228	Cable Assembly 115W68 (60B55068-1)	+2.025
Measuring Rack 115A503 (60B70995-7)	+4.154	Cable Assembly 115W80 (60B55080-1)	+2.611

3.3.8 (Continued)

Revisions	Wt.	Revisions	Wt.
Measuring Rack 115A504 (60B70995-9)	-5.661	Cable Assembly 115W81 (60B55081-1)	+1.064
Measuring Rack 115A505 (60B70995-11)	-3.117	Cable Assembly 115W82 (60B55082-1)	+2.359
Cable Assembly 115W86 (60B55086-1)	+0.436	Cable Assembly 118W53 (60B55297-1)	+1.428
Cable Assembly 115W94 (60B55094-1)	+0.756		
Total Wt.	+6.949		+11.838
Total △ Wt.	+18.787		

3.3.9 Electrical Network

Revisions	Wt.	Revisions	Wt.
Sequence and Control Distributor 115A2 (60B62028-9)	+0.140	Measuring Distributor 115A7 (60B62032-9)	+0.170
Propulsion Distributor 115A3 (60B62029-11)	+0.170	Measuring Disbutor 115A8 (60B62033-9)	-0.146
Timer Distributor 115A4 (60B62030-5)	+0.049	Thrust OK Distributor 115A9 (60B62295-5)	-0.194
Total Wt.	+0.359		-0.170
Total △ Wt.	+0.189		

MSFC FORM 422 (VERTICAL) (AUGUST 1960)

APPLICATION		PART No.	MF
NEXT ASSY	USED ON		

REVISIONS

SYM	DESCRIPTION	DATE	APPROVAL

PRELIMINARY

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON: FRACTIONS DECIMALS ANGLES	ORIGINAL DATE OF DRAWING 6-23-69 DRAFTSMAN / CHECKER TRACER / CHECKER ENGINEER / ENGINEER	INSTRUMENTATION PROGRAM AND COMPONENTS LIST INT-20	GEORGE C. MARSHALL SPACE FLIGHT CENTER NATIONAL AERONAUTICS AND SPACE ADMINISTRATION HUNTSVILLE, ALABAMA
MATERIAL	SUBMITTED		
HEAT TREATMENT	APPROVED	SCALE NONE / CODE IDENT NO. 14981 / DWG SIZE A	60B57500
FINAL PROTECTIVE FINISH		UNIT WT .000	SHEET A-188 OF

MSFC FORM 422-8 (VERTICAL) (NOVEMBER 1962) CONTINUATION SHEET

REVISIONS			
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CODE IDENT NO	DWG SIZE	60B57500
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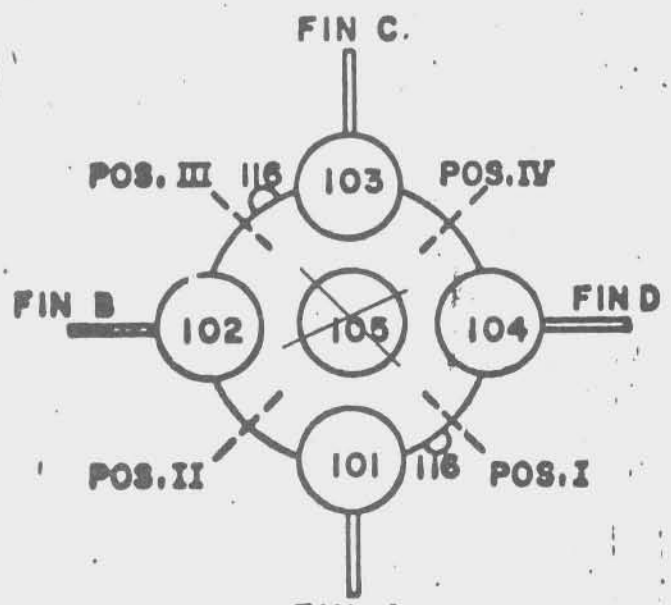
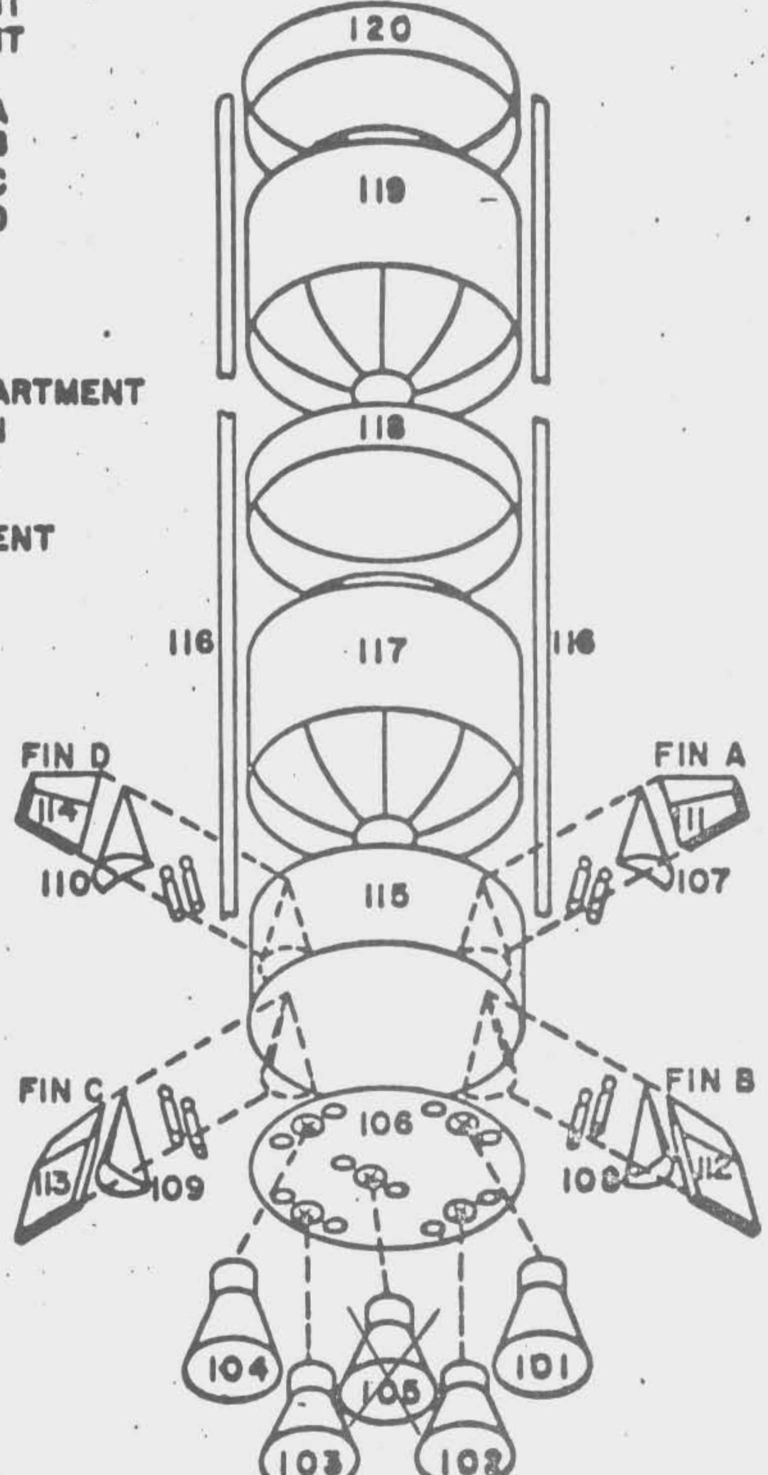
UNIT NO.	AREA DEFINITION
101	ENGINE 1 COMPARTMENT
102	ENGINE 2 COMPARTMENT
103	ENGINE 3 COMPARTMENT
104	ENGINE 4 COMPARTMENT
105	ENGINE 5 COMPARTMENT
106	AFT HEAT SHIELD
107	ENGINE FAIRING, FIN A
108	ENGINE FAIRING, FIN B
109	ENGINE FAIRING, FIN C
110	ENGINE FAIRING, FIN D
111	FIN A
112	FIN B
113	FIN C
114	FIN D
115	THRUST FRAME COMPARTMENT
116	CABLE/PRESSURIZATION TUNNEL AREAS
117	FUEL TANK AREA
118	INTERTANK COMPARTMENT
119	LOX TANK
120	INTERSTAGE AREA



VIEW LOOKING FORWARD



INSTRUMENTATION PROGRAM AND COMPONENTS LIST

SYSTEM SATURN VEHICLE INT-20

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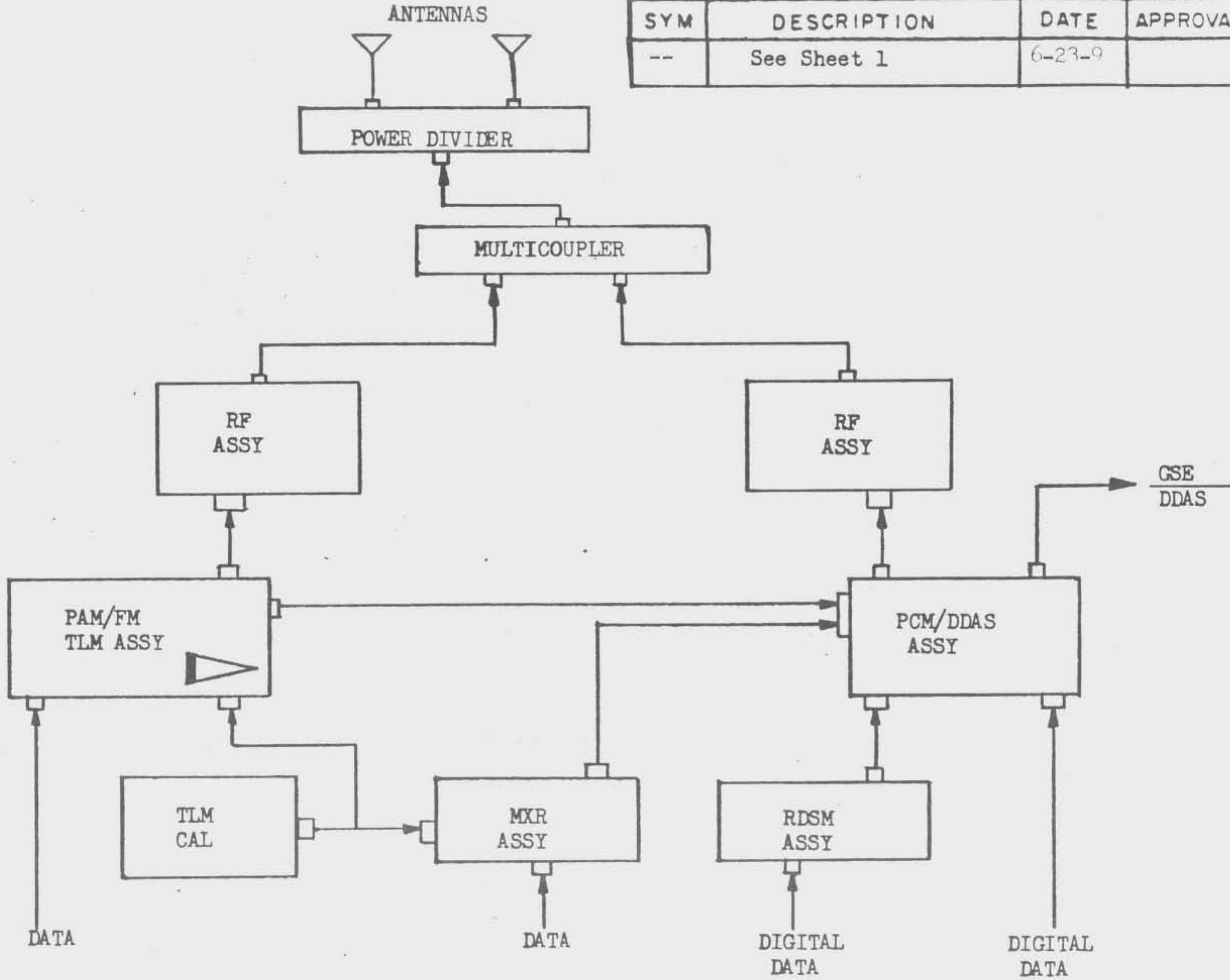

PAM DATA IS TRANSMITTED ONLY VIA THE PCM/DDAS ASSEMBLY.

TELEMETRY SYSTEM FLOW DIAGRAM

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GENERAL NOTES:

1. MEASURING SYSTEMS DESIGNATION

The following letters symbolize the corresponding systems, (Parameters) within this list:

LETTER	SYSTEM (PARAMETERS)
A	Acceleration
B	Acoustic
C	Temperature
D	Pressure
E	Vibration
F	Flow Rate
G	Position
H	Guidance and Control Signal
K	Signals
L	Liquid Level
M	Voltage, Current and Frequency
N	Miscellaneous
R	Angular Velocity
S	Strain
T	RPM
V*	Electrical Support Equipment, (ESE), Measurements
X*	Auxiliary Display Measurements
	**Miscellaneous Equipment
	**RF & TLM Equipment

* Measurements required for real time display @ the launch site are as follows:

a. An "X" prefix is added to the measurement number of each measurement which is routed from the PCM Ground Station through the Launch Vehicle ESE to KSC/LVO-1 equipment for real time analog recordings.

b. A "V" prefix is added to the measurement number of each measurement (analog or discrete) which is routed from the PCM Ground Station to the Launch Vehicle ESE for real time display or distribution to equipment other than KSC/LVO-1 analog recorders. In general, these "V" measurements are displayed on ESE panels by lights and meters, but in some cases are distributed to special operational systems display equipment.

c. A "VX" prefix is added to the measurement number of each measurement which is distributed by the Launch Vehicle ESE to both KSC/LVO-1 analog recorders and ESE panels or other display equipment.

** These sections list the names and part numbers of equipment required for the flight instrumentation.

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2. COLUMN IDENTIFICATION

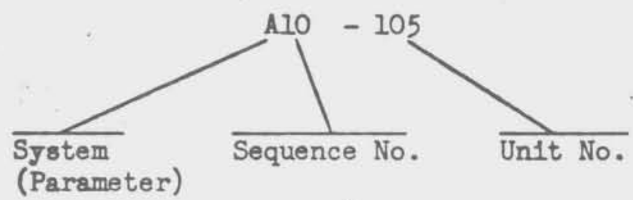
Line

The number listed in this column is used only for computer input control of IP&C information.

Measurement No.

Each measurement is identified in the following manner:

Measurement No.



A. The letter designates the parameter.
B. Each measurement of a parameter is numbered in sequence.
C. A dash follows the basic measurement number: The following numeral shows the unit, or area of the vehicle in which the measurement originates.
D. An added prefix letter "V" or "X" indicates an electrical support equipment or auxiliary display measurement specially handled at KSC. (See Sheet 5)

Measurement Name and/or Component

The measurement name serves to explain the type of measurement and indicate the system on which it is made.

Components, listed below the measurement name identify hardware necessary to make the measurement.

Range or Part No.

The range identifies the expected upper and lower values over which the transducer is to sense the physical phenomenon.

The part number identifies the components named in the measurement name and/or component column.

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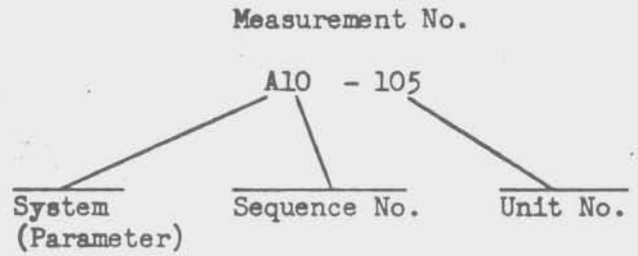
2. COLUMN IDENTIFICATION

Line

The number listed in this column is used only for computer input control of IP&C information.

Measurement No.

Each measurement is identified in the following manner:



A. The letter designates the parameter.
B. Each measurement of a parameter is numbered in sequence.
C. A dash follows the basic measurement number: The following numeral shows the unit, or area of the vehicle in which the measurement originates.
D. An added prefix letter "V" or "X" indicates an electrical support equipment or auxiliary display measurement specially handled at KSC. (See Sheet 5)

Measurement Name and/or Component

The measurement name serves to explain the type of measurement and indicate the system on which it is made.

Components, listed below the measurement name identify hardware necessary to make the measurement.

Range or Part No.

The range identifies the expected upper and lower values over which the transducer is to sense the physical phenomenon.

The part number identifies the components named in the measurement name and/or component column.

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Flt. Per

Flight Period: 1. Ignition of engine cutoff. 2. Engine cutoff to loss of telemetry signals.

% Pos. Error

This column lists an estimated % possible end to end error which is associated with this measurement.

Telemeter Channel

This column contains an alpha-numeric code assigning each measurement to a specific telemetry channel. Refer to telemetry code explanation following the "NOTES" section.

Res.

This column identifies the SCO frequency response in cycles per second, assuming a modulation index of 5 unless a note of exception is made, or is the multiplexer sampling rate in samples per second.

Flt. Cal.

This column shows whether or not a measurement TLM channel is calibrated during flight.

Req.

The number in the "REQ" column referring to the measurement requesters is no longer used.

3. Measurement numbers in parentheses indicate that they share the same telemeter channel as the measurement number under which they appear.

4. Measurement locations are approximate.

5. Transducer disconnected from telemetry and connected to static firing measuring system for static firing.

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6. Transducer furnished by engine manufacturer.
7. Measurement switched to PCM telemeter for pre-flight checkout (DDAS).
8. Measurement switched off PCM telemeter to accommodate those measurements switched in for pre-flight checkout.
9. Measurement switched to umbilical cable for test and checkout.
10. Measurement switched off telemeter approximately 1 second prior to outboard engine cutoff.
11. Measurement switched on telemeter approximately 1 second prior to outboard engine cutoff.
12. Transducer is integral part of prevalve assembly.
13. Measurement requires eleven sensor segments 60B72068-1.
14. Measurement requires eight sensor segments 60B72068-1.
15. Measurement switched off PCM telemeter and grounded for pre-flight checkout.

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TELEMETRY CHANNEL ASSIGNMENT CODE

The telemetry channel assignment for a measurement is defined by an alphanumeric code which requires 14 columns or less. This code is defined as follows:

1. PCM/FM Telemetry Channel Assignments:

A. Column 1

Column 1 contains a letter that designates the stage of the vehicle from which a measurement is telemetered as follows:

A S-1C
B S-11
C S-1VB
D Instrument Unit
G S-1B
E Ground DDAS

B. Columns 2 and 3

Columns 2 and 3 contain a letter and a number which serves to identify the RF data link as well as the type and sequential number of the primary telemeter which utilizes the link. The letter P designates a PCM/FM type telemeter.

C. Columns 4 and 5

Columns 4 and 5 contain a letter and number which serve the dual purpose of defining a multiplexer (physically) and a part of the PCM programming format (address).

1) Physical Relationship:

A multiplexer is an "AO" multiplexer physically if it is defined as AO" in the PCM programming format in the normal flight mode. A given multiplexer can be AO,A1,A2,A3,BO,B1,B2, or B3 depending on how the multiplexers are programmed in the normal flight mode.

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2) PCM Programming Format:

The letters "A" and "B" each define one-half of the PCM wavetrain (group). "A" and "B" operate at a basic rate of 3600 words/second and are interlaced for 7200 words/second in the PCM format. The numbers 0,1,2, and 3 are used with the letters A and B to define a part of the PCM programming format as follows:

A0	12	or	120 samples/second
B0	12	or	120 samples/second
A1	4	or	40 samples/second
A2	4	or	40 samples/second
A3	4	or	40 samples/second

D. Column 6

Column 6 contains a letter or dash (-) to indicate whether or not the assigned measurement is at anytime switched to another channel or address.

A dash (-) indicates that no switching occurs; the letter V indicates that switching does occur. The remarks column and/or General Note Section of the IP&CL defines the exact switching condition. These switching conditions include, but are not limited to: FM/FM to DDAS for prelaunch checkout, inflight switching including flight period switching, power transfers and PCM mode shifts.

E. Columns 7 and 8

Columns 7 and 8 contain the numbers 01 through 27 which identifies a main channel of a Model 270 multiplexer or the equivalent PCM address for digital data.

F. Column 9

Column 9 contains a letter or dash (-) to identify the type multiplexing or measurement routing as follows:

G	Discrete measurement routed direct to PCM/DDAS Model 301 assembly.
J	Discrete measurement routed to Number 1 Model 410 multiplexer.
K	Discrete measurement routed to Number 2 Model 410 multiplexer.
L	Analog measurement routed to a remote low level sub-multiplexer.
R	Discrete measurement routed to a remote digital sub-multiplexer.
H	Analog measurement routed to a remote high level sub-multiplexer.
Dash	Analog measurement routed directly to a Model 270 multiplexer.

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F. Column 9 (continued)

U Discrete measurement routed directly to a Model 270 multiplexer. (In this case bit identification will be contained in columns 13 & 14. This includes, but is not restricted to, measurements routed through discrete summing devices.)

G. Columns 10 and 11

Columns 10 and 11 contain the numbers 00 through 10 which identify Model 270 multiplexer sub-channels or the equivalent PCM address for digital data. The 00 indicates all ten sub-channels or frames are used.

H. Columns 12

Column 12 contains a dash (-) for separation.

I. Columns 13 and 14

Columns 13 and 14 contains the numbers 00 through 10 which identifies a particular digital bit. The 00 indicates all 10 bits are used.

Note: The numbers 01 and 10 correspond to the Most Significant Bit (2^9) through the Least Significant (2^0), i.e., MSB=Bit 01, LSB=Bit 10.

2. PAM/FM/FM Telemetry Channel Assignments:

A. Column 1

Column 1 contains a letter that designates the stage of the vehicle from which a measurement is telemetered as follows:

A S-1C
B S-11
C S-1VB
D Instrument Unit
G S-1B
E Ground DDAS

B. Columns 2 and 3

Columns 2 and 3 contain a letter and a number which serves to identify the RF data link as well as the type and sequential number of the primary telemeter which utilizes the link. The letter F is used to designate FM/FM telemeter.

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C. Columns 4 and 5

Columns 4 and 5 contain a letter and a number which physically identifies a multiplexer. A multiplexer is physically identifies as "AO" if it is defined as "AO" in the PCM programming format in the normal flight mode. A given multiplexer can be AO,A1,A2,A3,BO,B1,B2 or B3 depending on how the multiplexers are programmed in the normal flight mode. When there is no inflight transmission via PCM/FM, these columns contain "-X" which identifies the 70KC±30% Sub-Carrier Band used. In either case the multiplexers are always assigned to channel X.

D. Column 6

Column 6 contains a letter or dash (-) to indicate whether or not the assigned measurement is at anytime switched to another channel or address.

A dash (-) indicates that no switching occurs; the letter V indicates that switching does occur. The remarks column and/or General Notes Section of the IP&CL defines the exact switching condition.

E. Columns 7 and 8

Columns 7 and 8 contain the numbers 01 through 27 which identifies a main channel of a Model 270 multiplexer.

F. Column 9

Column 9 contains a letter or dash (-) to identify the type multiplexing as follows:

L	Analog measurement routed to a remote low level sub-multiplexer.
H	Analog measurement routed to a remote high level sub-multiplexer.
Dash	Analog measurement routed directly to a Model 270 multiplexer.

G. Columns 10 and 11

Columns 10 and 11 contain the numbers 00 through 10 which identify Model 270 multiplexer sub-channels. The 00 indicates no sub-multiplexing.

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3. FM/FM Telemeter Channel Assignments:

A. Column 1

Column 1 contains a letter that designates the stage of the vehicle from which a measurement is telemetered as follows:

A S-1C
B S-11
C S-1VB
D Instrument Unit
G S-1B
E Ground DDAS

B. Columns 2 and 3

Columns 2 and 3 contain a letter and a number which serves to identify the RF data link as well as the type and sequential number of the primary telemeter which utilizes the link. The letter F is used to designate FM/FM Telemeter.

C. Column 4

Column 4 contains a letter or dash (-) to indicate whether or not the assigned measurement is switched to another channel. A dash (-) indicates that no switching occurs; the letter V indicates that switching does occur. The remarks column and/or General Notes Section of the IP&CL defines the exact switching condition.

D. Columns 5 and 6

Columns 5 and 6 contain the numbers 01 through 18 which identify the IRIG Bands used.

4. SS/FM Telemeter Channel Assignments:

A. Column 1

Column 1 contains a letter that designates the stage of the vehicle from which a measurement is telemetered as follows:

A S-1C
B S-11
C S-1VB
D Instrument Unit
G S-1B
E Ground DDAS

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B. Columns 2 and 3

Columns 2 and 3 contain a letter and a number which serves to identify the RF data link as well as the type and sequential number of the primary telemeter which utilizes the link. The letter S is used to designate SS/FM Telemeter.

C. Column 4

Column 4 contains a letter or dash (-) to indicate whether or not the assigned measurement is switched to another channel. A dash (-) indicates that no switching occurs; the letter V indicates that switching does occur. The remarks column and/or General Notes Section of the IP&CL defines the exact switching condition.

D. Columns 5 and 6

Columns 5 and 6 contain the numbers 01 through 15 which identify the input channels to the SS/FM telemeter.

Note: When measurements are routed directly to the SS/FM telemeters, only 6 columns are required to identify the channel assignment. However, when a slow speed multiplexer assembly is used, 13 columns are required. In this application, columns 7 through 13 are as follows:

E. Column 7

Column 7 contains the letter W which is used to designate a slow speed multiplexer assembly.

F. Column 8

Column 8 contains the numbers 1 or 2 to provide a sequential numerical identification of slow speed multiplexer assemblies on a given stage.

G. Column 9

Column 9 contains a dash (-) for separation.

H. Columns 10 and 11

Columns 10 and 11 contain the numbers 01 through 16 which identifies a main channel of the slow speed multiplexer assembly.

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I. Column 12

Column 12 contains a letter or number to identify the type of multiplexer or measurement routing used on a main channel as follows:

D 4 sub-channels (3 seconds out of 12 for each measurement)
E 2 sub-channels (6 seconds out of 12 for each measurement)
Y 5 sub-channels (2.4 seconds out of 12 for each measurement)
O measurement routed through slow speed multiplexer assembly without multiplexing.

J. Column 13

Column 13 contains the numbers 1 through 5 which identify the sub-channel used. This column contains the number 0 when a measurement is routed through a slow speed multiplexer assembly without being multiplexed.

Note: For the application where a slow speed multiplexer assembly is applied to an FM/FM Telemeter Channel, the code requires 13 columns as follows:

K. Columns 1 through 6

Column 1 contains a letter that designates the stage of the vehicle from which a measurement is telemetered as follows:

A S-1C
B S-11
C S-1VB
D Instrument Unit
G S-1B
E Ground DDAS

Columns 2 and 3

Columns 2 and 3 contain a letter and number which serves to identify the RF data link as well as the type and sequential number of the primary telemeter which utilizes the link. The letter F is used to designate FM/FM Telemeter.

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Column 4

Column 4 contains a letter or dash (-) to indicate whether or not the assigned measurement is switched to another channel. A dash (-) indicates that no switching occurs; the letter V indicates that switching does occur. The remarks column and/or General Notes Section of the IP&CL defines the exact switching condition.

Columns 5 and 6

Columns 5 and 6 contain the numbers 01 through 18 which identify the IRIG Bands used.

Column 7

Column 7 contains the letter W which is used to designate a slow speed multiplexer assembly.

Column 8

Column 8 contains the numbers 1 or 2 to provide a sequential numerical identification of slow speed multiplexer assemblies on a given stage.

Column 9

Column 9 contains a dash (-) for separation.

Columns 10 and 11

Columns 10 and 11 contain the numbers 01 through 16 which identifies a main channel of the slow speed multiplexer assembly.

Column 12

Column 12 contains a letter to identify the type of multiplexer used on main channel as follows:

D 4 sub-channels (3 seconds out of 12 for each measurement)
E 2 sub-channels (6 seconds out of 12 for each measurement)
Y 5 sub-channels (2.4 seconds out of 12 for each measurement)

Columns 13

Column 13 contains the numbers 1 through 5 which identify the sub-channel used.

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PCM TELEMETER CHANNEL CODE EXAMPLES

Description / Column	1	2	3	4	5	6	7	8	9	10	11	12	13	14
12 SPS discrete through RDSM	A	P	1	B	0	-	1	9	R	0	4	-	0	1
12 SPS direct to 270 multiplexer	A	P	1	B	0	-	0	4	-	0	1	-	0	0
120 SPS direct to 270 multiplexer	A	P	1	B	0	-	0	5	-	0	0	-	0	0
12 SPS switching required	A	P	1	B	0	V	0	6	-	0	2	-	0	0
40 SPS discrete direct to 301 assembly	A	P	1	B	1	-	0	7	G	0	0	-	0	0
120 SPS discrete direct to 301 assembly	A	P	1	B	0	-	0	8	G	0	0	-	0	5

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PAM, FM/FM, SS/FM TELEMETER CHANNEL CODE EXAMPLES

Description / Column	1	2	3	4	5	6	7	8	9	10	11	12	13	14
PAM/FM/FM, 12SPS direct to 270 multiplexer, no switching	A	F	1	A	1	-	0	3	-	0	8			
PAM/FM/FM, 120SPS direct to 270 multiplexer, no switching	A	F	1	A	1	-	2	3	-	0	0			
FM/FM, no switching	A	F	1	-	0	3								
FM/FM, switching required	A	F	1	V	0	3								
FM/FM, slow speed multiplexer assembly, 4 sub-channels, no sw.	A	F	1	-	1	5	W	1	-	1	6	D	4	
SS/FM, direct no switching	A	S	1	-	0	7								
SS/FM, direct switching required	A	S	1	V	0	7								
SS/FM, through slow speed multiplexer assembly continuous channel	A	S	1	-	0	9	W	1	-	0	9	0	0	
SS/FM, slow speed multiplexer assembly, 4 sub-channels no sw.	A	S	1	-	1	5	W	1	-	1	6	D	4	
SS/FM, slow speed multiplexer assembly, 4 sub-channels sw. req.	A	S	1	V	1	5	W	1	-	1	6	D	4	

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INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM ACCELERATION   VEHICLE INT-20

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LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND OR COMPONENT	RANGE AND OR PART NUMBER	FLT PER	% POS ERR	TELEMETER CHANNEL	RES.	FLT CAL.	REQ	REMARKS
10	A1-118	ACCELERATION, LONG.	-2.5 TO 5.0 G	1	5	AF1-03	11	Y		ON STA 757 RING FRAME
11				2		AP1B0V07-02-00				SEE NOTE 7
20		ACCEL 118A489	60B72192-9							INSTL DWG 60B67471

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INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM TEMPERATURE VEHICLE INT-20

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LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND OR COMPONENT	RANGE AND OR PART NUMBER	FLT PER	% POS ERR	TELEMETER CHANNEL	RES.	FLT CAL	REQ	REMARKS
10 11 40	C3-101	TEMP TURBINE MANIFOLD DC AMPL ASSY	-15 TO 1100 C 60B73113-71	1	5	AP1B0-07-03-00	12	Y		SEE NOTE 6 RACK ASSY 60B70995-5
10 11 40	C3-102	TEMP TURBINE MANIFOLD DC AMPL ASSY	-15 TO 1100 C 60B73113-71	1	5	AP1B0V08-03-00	12	Y		SEE NOTE 6 AND 15 RACK ASSY 60B70995-7
10 11 40	C3-103	TEMP TURBINE MANIFOLD DC AMPL ASSY	-15 TO 1100 C 60B73113-71	1	5	AP1B0V09-03-00	12	Y		SEE NOTES 6 AND 8 RACK ASSY 60B70995-9
10 11 40	C3-104	TEMP TURBINE MANIFOLD DC AMPL ASSY	-15 TO 1100 C 60B73113-71	1	5	AP1B0-11-03-00	12	Y		SEE NOTE 6 RACK ASSY 60B70995-1
10 11 20 40	C4-119	TEMP LOX BULK TEMP GAGE 119A400 DC AMPL ASSY	-190 TO -165 C 60B72067-1 60B73113-49	1	5	AP1B0-11-10-00	12	Y		AT CRUCIFORM BAFFLE INSTL DWG 60B67508 RACK ASSY 60B70995-3
10 11 40	XC6-101	TEMP OXIDIZER PUMP BRG NO.1 DC AMPL ASSY	-15 TO 205 C 60B73113-73	1	5	AP1A0V01-07-00	12	Y		SEE NOTES 5,6 RACK ASSY 60B70995-5
10 11 40	XC6-102	TEMP OXIDIZER PUMP BRG NO.1 DC AMPL ASSY	-15 TO 205 C 60B73113-73	1	5	AP1A0V02-07-00	12	Y		SEE NOTES 5,6 RACK ASSY 60B70995-7

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MSFC FORM 422 B (HORIZONTAL) (NOVEMBER 1962) CONTINUATION SHEET

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM TEMPERATURE VEHICLE INT-20

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LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND OR COMPONENT	RANGE AND/OR PART NUMBER	FLT PER	% POS ERR	TELEMETER CHANNEL	RES	FLT CAL	REQ	REMARKS
10 11 40	XC6-103	TEMP OXIDIZER PUMP BRG NO.1 DC AMPL ASSY	-15 TO 205 C 60B73113-73	1	5	AP1A0V03-07-00	12	Y		SEE NOTES 5,6 RACK ASSY 60B70995-9
10 11 40	XC6-104	TEMP OXIDIZER PUMP BRG NO.1 DC AMPL ASSY	-15 TO 205 C 60B73113-73	1	5	AP1A0V04-07-00	12	Y		SEE NOTES 5,6 RACK ASSY 60B70995-1
10 11 20 40	C26-106	TEMP HT SHIELD T CAL CALORIMETER 115A742 DC AMPL ASSY	0 TO 40 BTU/FT2 SEC 60B72063-1 60B73113-85	1 2	5	AP1B0-11-08-00	12	Y		120 IN. RADIUS POS II FACING AFT INSTL DWG 60B70123 RACK ASSY 60B70995-7
10 11 12 20 30 40	C50-106	TEMP GAS AFT. HEAT SHIELD TEMP GAGE ASSY 106A441 ZONE BOX ASSY 115A748 DC AMPL ASSY	0 TO 1750 C 60B71141-9 60B67608-3 60B73113-45	1	5	AP1B0V10-02-00	12	Y		120 IN. RAD POS II 0.25 IN. AFT. HEAT SHIELD SEE NOTE 8 INSTL DWG 60B70123 INSTL DWG 60B70123 RACK ASSY 60B70995-7
10 11 12 20 30 40	C52-106	TEMP GAS AFT. HEAT SHIELD TEMP GAGE ASSY 106A443 ZONE BOX ASSY 115A750 DC AMPL ASSY	0 TO 1750 C 60B71141-11 60B67608-3 60B73113-45	1	5	AP1B0V09-02-00	12	Y		120 IN. RAD POS II 2.4 IN. AFT HT SHIELD SEE NOTE 15 INSTL DWG 60B70123 INSTL DWG 60B70123 RACK ASSY 60B70995-7
10 11 20 30 40	C67-120	TEMP SKIN INTERNAL TEMP GAGE ASSY 120A471 ZONE BOX ASSY 120A420 DC AMPL ASSY	-50 TO 200 C 60B67609-1 60B67608-1 60B73113-123	1 2	5	AP1B0V10-08-00	12	Y		7 IN. FWD UPPER END CONDUIT SEE NOTE 15 INSTL DWG 60B70577 INSTL DWG 60B70577 RACK ASSY 60B70995-3
	C61-106	TEMP HEAT SHIELD RCAL CALORIMETER 106453 DC AMPL ASSY	0 TO 20 BTU/FT2 SEC 60B72065-1 60B73113-85	1	5	APIA0-04-03-00	12	Y		120 IN. RAD POS II FACING AFT.

CODE IDENT NO.	DWG SIZE	60B57500
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LSB 139 (6/66)

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM TEMPERATURE VEHICLE INT-20

REVISION			
SYM	DESCRIPTION	DATE	APPROVAL
-	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND OR COMPONENT	RANGE AND OR PART NUMBER	FLT PER	% POS ERR	TELEMETER CHANNEL	RES.	FLT. CAL.	REQ	REMARKS
10 11 12 13 20 30 40	C107-115	TEMP AMB THRUST FRAME COMPARTMENT TEMP GAGE ASSY 115A607 ZONE BOX ASSY 115A435 DC AMPL ASSY	-50 TO 1000 C 60B71141-29 60B67608-1 60B73113-23	1 2	5	AP1A0-10-10-00	12	Y		60 IN. FWD OF HEAT SHIELD AT POS II 80 IN. RADIUS FROM VEHICLE CENTERLINE INSTL DWG 60B71087 INSTL DWG 60B71087 RACK ASSY 60B70995-7
10 11 12 20 40	XC125-119	TEMP GAS HELIUM TANK TEMP GAGE 119A416 DC AMPL ASSY	-235 TO 125 C 60B72067-7 60B73113-67	1 2	5	AP1B0-14-10-00	12	Y		INSIDE FIRST HELIUM BOTTLE FROM POS I TOWARD FIN A INSTL DWG 60B67509 RACK ASSY 60B70995-3
10 11 12 13 20 40	C126-119	TEMP GAS HELIUM TANK TEMP GAGE 119A423 DC AMPL ASSY	-235 TO 125 C 60B72067-7 60B73113-67	1 2	5	AP1A0V02-08-00	12	Y		INSIDE FIRST HELIUM BOTTLE FROM POS I TOWARD FIN D SEE NOTE 9 INSTL DWG 60B67509 RACK ASSY 60B70995-3
10 11 12 13 20 40	C127-115	TEMP GOX INLET VALVE TEMP GAGE 115A755 DC AMPL ASSY	-100 TO 260 C 60B72067-5 60B73113-69	1	5	AP1B0V09-01-00	12	Y		INLET OF GOX CONTROL VALVE OF LOX TANK PRESSURIZATION SYSTEM SEE NOTE 15 INSTL DWG 60B70159 RACK ASSY 60B70995-11
10 11 12 13 20 40	C128-118	TEMP HELIUM INLET CONTROL VALVE TEMP GAGE 118A487 DC AMPL ASSY	-235 TO 40 C 60B72099-1 60B73113-53	1	5	AP1A0-04-08-00	12	Y		INLET OF HELIUM CONT VALVE OF THE FUEL TANK PRESSURIZATION SYSTEM INSTL DWG 60B71229 RACK ASSY 60B70995-3

CODE IDENT NO	DWG SIZE	60B57500
14981	A	SHEET 22

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM TEMPERATURE VEHICLE INT-20

REVISION			
SYM.	DESCRIPTION	DATE	APPROVAL
--	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND/OR COMPONENT		RANGE AND/OR PART NUMBER	FLT PER.	% POS. ERR.	TELEMETER CHANNEL	RES.	FLT CAL.	REQ.	REMARKS
	C161-106	Temp Heat Shield Int.		-20 to 55°C	1	5	AP1A0-05-03-00	12	Y		120 In. RAD Pos III
		Temp Gage Assy	106A452	60B71141-13	2						Between Structure
		Zone Box Assy	115A761	60B67608-1							and Insulation
		DC Ampl Assy		60B73113-33							
	C162-115	Temp Heat Shield		-20 to 30°C	1	5	AP1A0-06-03-00	12	Y		120 In. RAD Pos III
		Forward Surface			2						
		Temp Gage Assy.	115A610	60B71141-13	1						
		Zone Box Assy	115A447	60B67608-1	2						
		DC Ampl Assy		60B73113-21							

CODE IDENT. NO.	DWG SIZE	60B57500
14981	A	SHEET 23

MSFC FORM 422 B (HORIZONTAL) (NOVEMBER 1962) CONTINUATION SHEET

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SYSTEM TEMPERATURE VEHICLE INT-20

REVISION			
SYM	DESCRIPTION	DATE	APPROVAL
-	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND OR COMPONENT	RANGE AND/OR - PART NUMBER	FLT PER	% POS ERR	TELEMETER CHANNEL	RES.	FLT CAL	REQ	REMARKS
10	C149-106	TEMP HEAT SHIELD T CAL	0 TO 50	1	5	AP1B0V09-04-00	12	Y		253 IN. RAD FIN LINE
11			BTU/FT2 SEC	2						D SEE NOTE 8
20		CALORIMETER 110A443	60B72063-3							INSTL DWG 60B70118
40		DC AMPL ASSY	60B73113-85							RACK ASSY 60B70995-3
10	C188-115	TEMP AMB SUCTION LINE	-50 TO 1000 C	1	5	AP1A0-06-10-00	12	Y		10 IN. FWD HT SHIELD
11				2						4 EACH TEMP GAGES
12										CONNECTED IN PARALLEL
13										AROUND ENG NO. 1
14										SUCTION LINE
20		TEMP GAGE ASSY 115A612	60B71141-29							INSTL DWG 60B67117
21		TEMP GAGE ASSY 115A900	60B71141-29							INSTL DWG 60B67117
22		TEMP GAGE ASSY 115A901	60B71141-29							INSTL DWG 60B67117
23		TEMP GAGE ASSY 115A902	60B71141-29							INSTL DWG 60B67117
30		ZONE BOX ASSY 115A448	60B67608-1							INSTL DWG 60B67117
40		DC AMPL ASSY	60B73113-23							RACK ASSY 60B70995-5
10	C189-115	TEMP AMB SUCTION LINE	-50 TO 1000 C	1	5	AP1A0-07-10-00	12	Y		10 IN. FWD HT SHIELD
11				2						4 EACH TEMP GAGES
12										CONNECTED IN PARALLEL
13										AROUND ENG NO. 2
14										SUCTION LINE
20		TEMP GAGE ASSY 115A613	60B71141-29							INSTL DWG 60B67117
21		TEMP GAGE ASSY 115A903	60B71141-29							INSTL DWG 60B67117
22		TEMP GAGE ASSY 115A904	60B71141-29							INSTL DWG 60B67117
23		TEMP GAGE ASSY 115A905	60B71141-29							INSTL DWG 60B67117
30		ZONE BOX ASSY 115A449	60B67608-1							INSTL DWG 60B67117
40		DC AMPL ASSY	60B73113-23							RACK ASSY 60B70995-7
10	C190-115	TEMP AMB SUCTION LINE	-50 TO 1000 C	1	5	AP1A0-08-10-00	12	Y		10 IN. FWD HT SHIELD
11				2						4 EACH TEMP GAGES
12										CONNECTED IN PARALLEL
13										AROUND ENG NO. 3
14										SUCTION LINE
20		TEMP GAGE ASSY 115A614	60B71141-29							INSTL DWG 60B67117
21		TEMP GAGE ASSY 115A906	60B71141-29							INSTL DWG 60B67117
22		TEMP GAGE ASSY 115A907	60B71141-29							INSTL DWG 60B67117
23		TEMP GAGE ASSY 115A908	60B71141-29							INSTL DWG 60B67117
30		ZONE BOX ASSY 115A450	60B67608-1							INSTL DWG 60B67117
40		DC AMPL ASSY	60B73113-23							RACK ASSY 60B70995-11

CODE IDENT NO	DWG SIZE	60B57500
14981	A	SHEET 24

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INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM TEMPERATURE VEHICLE INT-20

REVISION			
SYM	DESCRIPTION	DATE	APPROVAL
-	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND OR COMPONENT	RANGE AND OR PART NUMBER	FLT PER	% POS ERR	TELEMETER CHANNEL	RES.	FLT CAL	REQ	REMARKS
10	C191-115	TEMP AMB SUCTION LINE	-50 TO 1000 C	1	5	AP1A0-09-10-00	12	Y		10 IN. FWD HT SHIELD
11				2						4 EACH TEMP GAGES
12										CONNECTED IN PARALLEL
13										AROUND ENG NO. 4
14										SUCTION LINE
20		TEMP GAGE ASSY 115A615	60B71141-29							INSTL DWG 60B67117
21		TEMP GAGE ASSY 115A909	60B71141-29							INSTL DWG 60B67117
22		TEMP GAGE ASSY 115A910	60B71141-29							INSTL DWG 60B67117
23		TEMP GAGE ASSY 115A911	60B71141-29							INSTL DWG 60B67117
30		ZONE BOX ASSY 115A451	60B67608-1							INSTL DWG 60B67117
40		DC AMPL ASSY	60B73113-23							RACK ASSY 60B70995-1
10	C192-115	TEMP FUEL SUCTION LINE	0 TO 25 C	1	5	AP1A0-06-01-00	12	Y		ENGINE NO. 1 INLET
11		INTERNAL								
20		TEMP GAGE 115A452	60B72067-5							INSTL DWG 60B70014
40		DC AMPL ASSY	60B73113-61							RACK ASSY 60B70995-5
10	C194-115	TEMP FUEL SUCTION LINE	0 TO 25 C	1	5	AP1A0-07-01-00	12	Y		ENG NO. 3 INLET
11		INTERNAL								
20		TEMP GAGE 115A454	60B72067-5							INSTL DWG 60B70014
40		DC AMPL ASSY	60B73113-61							RACK ASSY 60B70995-11
10	VXC197-115	TEMP LOX SUCTION LINE	-185 TO - 155C	1	5	AP1B0-14-08-00	12	Y		AT SPOOL APPROX 90
11		ENG NO. 1								IN. ABOVE PUMP INLET
20		TEMP GAGE 115A790	60B72067-5							INSTL DWG 60B71086
40		DC AMPL ASSY	60B73113-63							RACK ASSY 60B70995-5
10	VXC198-115	TEMP LOX SUCTION LINE	-185 TO - 155C	1	5	AP1B0-16-08-00	12	Y		AT SPOOL APPROX 90
11		ENG NO. 2								IN. ABOVE PUMP INLET
20		TEMP GAGE 115A791	60B72067-5							INSTL DWG 60B71086
40		DC AMPL ASSY	60B73113-63							RACK ASSY 60B70995-7

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CODE IDENT NO	DWG SIZE	60B57500
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MSFC FORM 422 B (HORIZONTAL) (NOVEMBER 1962) CONTINUATION SHEET

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM TEMPERATURE VEHICLE INT-20

REVISION			
SYM	DESCRIPTION	DATE	APPROVAL
–	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND OR COMPONENT	RANGE AND OR PART NUMBER	FLT PER	% POS ERR	TELEMETER CHANNEL	RES.	FLT CAL	REQ	REMARKS
10	VXC199-115	TEMP LOX SUCTION LINE	-185 TO - 155C	1	5	AP1B0-13-09-00	12	Y		AT SPOOL APPROX 90
11		ENG NO. 3								IN. ABOVE PUMP INLET
20		TEMP GAGE 115A792	60B72067-5							INSTL DWG 60B71086
40		DC AMPL ASSY	60B73113-63							RACK ASSY 60B70995-11
10	VXC200-115	TEMP LOX SUCTION LINE	-185 TO - 155C	1	5	AP1B0-15-09-00	12	Y		AT SPOOL APPROX 90
11		ENG NO. 4								IN. ABOVE PUMP INLET
20		TEMP GAGE 115A793	60B72067-5							INSTL DWG 60B71086
40		DC AMPL ASSY	60B73113-63							RACK ASSY 60B70995-1
10	C203-115	TEMP AMB THRUST FRAME	-60 TO 50 C	1	5	AP1B0V10-04-00	12	Y		STA 142 POS III 140
11		COMPARTMENT		2						IN. RAD SEE NOTE 15
20		TEMP GAGE ASSY 115A724	60B71141-31							INSTL DWG 60B67010
30		ZONE BOX ASSY 115A719	60B67608-5							INSTL DWG 60B67010
40		DC AMPL ASSY	60B73113-41							RACK ASSY 60B70995-11
10	C205-115	TEMP AMB THRUST FRAME	-60 TO 50 C	1	5	AP1B0-11-04-00	12	Y		STA 142 POS I 140 IN.
11		COMPARTMENT		2						RAD
20		TEMP GAGE ASSY 115A726	60B71141-31							INSTL DWG 60B67010
30		ZONE BOX ASSY 115A721	60B67608-5							INSTL DWG 60B67010
40		DC AMPL ASSY	60B73113-41							RACK ASSY 60B70995-3
10	C206-120	TEMP AMB INTERSTAGE	-100 TO 25 C	1	5	AP1B0V08-08-00	12	Y		STA 1500 46 DEGREES
11		AREA								FROM FIN A TOWARD FIN
12										B 176 IN. RAD
13										SEE NOTE 15
20		TEMP GAGE 120A495	60B72067-5							INSTL DWG 60B70549
40		DC AMPL ASSY	60B73113-143							RACK ASSY 60B70995-3

CODE IDENT NO	DWG SIZE	60B57500
14981	A	SHEET 26

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LSB 13911 (6-66)

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM TEMPERATURE VEHICLE INT-20

REVISION			
SYM	DESCRIPTION	DATE	APPROVAL
-	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME - AND OR COMPONENT	RANGE AND OR PART NUMBER	FLT PER	% POS ERR	TELEMETER CHANNEL	RES.	FLT CAL	REQ	REMARKS
10	C208-120	TEMP AMB INTERSTAGE	-100 TO 25 C	1	5	AP1B0V09-08-00	12	Y		STA 1500 36 DEGREES
11		AREA								FROM FIN A TOWARD FI'
12										D 176 IN. RAD
13										SEE NOTE 8
20		TEMP GAGE 120A497	60B72067-5							INSTL DWG 60B70549
40		DC AMPL ASSY	60B73113-143							RACK ASSY 60B70995-3
10	C211-119	TEMP LOX TANK ULLAGE	-190 TO 250 C	1	5	AP1B0-11-01-00	12	Y		IN TOP OF LOX TANK
11										
20		TEMP GAGE 119A433	60B72067-9							INSTL DWG 60B67510
40		DC AMPL ASSY	60B73113-55							RACK ASSY 60B70995-3
10	C219-115	TEMP HT EXCH HELIUM	-20 TO 350 C	1	5	AP1A0-06-08-00	12	Y		DOWNSTREAM OF HEAT
11		MANIFOLD OUTLET		2						EXCHANGER
20		TEMP GAGE 115A934	60B72099-1							INSTL DWG 60B70026
40		DC AMPL ASSY	60B73113-131							RACK ASSY 60B70995-11
10	C220-117	TEMP FUEL TANK ULLAGE	-70 TO 120 C	1	5	AP1A0-08-08-00	12	Y		APPROX 12 IN. FROM
11				2						LOX LINE NO. 1 TOWARD
12										FIN D STA 699
20		TEMP GAGE 117A435	60B72067-11							INSTL DWG 60B67447
40		DC AMPL ASSY	60B73113-91							RACK ASSY 60B70995-3
10	XC242-101	TEMP ENVIRONMENT ENG	-30 TO 260°C	1	5	AP1B0-07-05-00	12	Y		SEE NOTE 6
11		NO. 1								
40		DC AMPL ASSY	60B73113-137							RACK ASSY 60B70995-5
10	XC242-102	TEMP ENVIRONMENT ENG	-30 TO 260°C	1	5	AP1B0-08-05-00	12	Y		SEE NOTE 6
11		NO. 2								
40		DC AMPL ASSY	60B73113-137							RACK ASSY 60B70995-7
10	XC242-103	TEMP ENVIRONMENT ENG	-30 TO 260°C	1	5	AP1B0V09-05-00	12	Y		SEE NOTE 6 AND 15
11		NO. 3								
40		DC AMPL ASSY	60B73113-137							RACK ASSY 60B70995-9

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LSB 1391(6-66)

CODE IDENT NO	DWG SIZE	60B57500
14981	A	SHEET 27

MSFC FORM 422 B (HORIZONTAL) (NOVEMBER 1962) CONTINUATION SHEET

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM TEMPERATURE VEHICLE INT-20

REVISION			
SYM	DESCRIPTION	DATE	APPROVAL
-	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND OR COMPONENT	RANGE AND OR PART NUMBER	FLT PER	% POS ERR	TELEMETER CHANNEL	RES	FLT CAL	REQ	REMARKS
10	XC242-104	TEMP ENVIRONMENT ENG	-30 TO 260°C	1	5	AP1B0-10-05-00	12	Y		SEE NOTE 6
11		NO. 4								
40		DC AMPL ASSY	60B73113-137							RACK ASSY 60B70995-1
10	C300-117	TEMP FUEL DENSITY	0 TO 38 C	1		AP1B0-20-01-00	12	Y		THREE TEMP GAGES IN
11		DETERMINATION NO. 1								SERIES
20		TEMP GAGE 117A1	60B72067-11							INSTL DWG 60B64983
21		TEMP GAGE 117A2	60B72067-11							INSTL DWG 60B64983
22		TEMP GAGE 117A3	60B72067-11							INSTL DWG 60B64983
40		DC AMPL ASSY	60B73113-147							RACK ASSY 60B70995-11
10	C301-117	TEMP FUEL DENSITY	0 TO 38 C	1		AP1B0-20-02-00	12	Y		THREE TEMPERATURE
11		DETERMINATION NO. 2								GAGES IN SERIES
20		TEMP GAGE 117A4	60B72067-11							INSTL DWG 60B64983
21		TEMP GAGE 117A5	60B72067-11							INSTL DWG 60B64983
22		TEMP GAGE 117A6	60B72067-11							INSTL DWG 60B64983
40		DC AMPL ASSY	60B73113-147							RACK ASSY 60B70995-11
10	C302-117	TEMP FUEL DENSITY	0 TO 38 C	1		AP1B0-20-09-00	12	Y		THREE TEMPERATURE
11		DETERMINATION NO. 3								GAGES IN SERIES
20		TEMP GAGE 117A7	60B72067-11							INSTL DWG 60B64983
21		TEMP GAGE 117A8	60B72067-11							INSTL DWG 60B64983
22		TEMP GAGE 117A9	60B72067-11							INSTL DWG 60B64983
40		DC AMPL ASSY	60B73113-147							RACK ASSY 60B70995-11

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LSB 1391(6/66)

CODE IDENT NO	DWG SIZE	60B57500
14981	A	SHEET 28

MSFC. FORM 422-8 (HORIZONTAL) (NOVEMBER 1962) CONTINUATION SHEET

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM TEMPERATURE VEHICLE INT-20

REVISION			
SYM.	DESCRIPTION	DATE	APPROVAL
--	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND/OR COMPONENT	RANGE AND/OR PART NUMBER	FLT. PER.	% POS. ERR.	TELEMETER CHANNEL	RES.	FLT. CAL.	REQ.	REMARKS
	C326-115	Temp #1 LOX Prevalve Eng #2	-190 to -160C	1 2	5	AP1B0-07-08-00	12	Y		Top Transducer
		Temp Gage 115A896	60B72099-1							Instl Dwg 60B41014
		DC Ampl Assy	60B73113-151							Rack Assy 60B70995-11
	XC327-115	Temp #2 LOX Prevalve Eng #2	-190 to -160C	1 2	5	AP1B0-12-03-00	12	Y		Second from top
		Temp Gage 115A897	60B72099-1							Instl Dwg 60B41014
		DC Ampl Assy	60B73113-151							Rack Assy 60B70995-11
	C330-115	Temp #1 LOX Prevalve Eng #4	-190 to -160C	1 2	5	AP1B0-12-08-00	12	Y		Top Transducer
		Temp Gage 115A997	60B72099-1							Instl Dwg 60B41014
		DC Ampl Assy	60B73113-151							Rack Assy 60B70995-3
	XC331-115	Temp #2 LOX Prevalve Eng No. 4	-190 to -160C	1 2	5	AP1B0-12-07-00	12	Y		Second from top
		Temp Gage 115A998	60B72099-1							Instl Dwg 60B41014
		DC Ampl Assy	60B73113-151							Rack Assy 60B70995-1
	C334-115	Temp #1 LOX Prevalve Eng #1	-190 to -160C	1 2	5	AP1B0-12-04-00	12	Y		Top Transducer
		Temp Gage 115A892	60B72099-1							Instl Dwg 60B41014
		DC Ampl Assy	60B73113-151							Rack Assy 60B70995-5
	XC335-115	Temp #2 LOX Prevalve Eng #2	-190 to -160C	1 2	5	AP1B0-12-01-00	12	Y		Second from top
		Temp Gage 115A893	60B72099-1							Instl Dwg 60B41014
		DC Ampl Assy	60B73113-151							Rack Assy 60B70995-5
	C338-115	Temp #1 LOX Prevalve Eng #3	-190 to -160C	1 2	5	AP1B0-12-06-00	12	Y		Top Transducer
		Temp Gage 115A993	60B72099-1							Instl Dwg 60B41014
		DC Ampl Assy	60B73113-151							Rack Assy 60B70995-11

CODE IDENT. NO.	DWG SIZE	60B57500
14981	A	SHEET 29

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM PRESSURE VEHICLE INT-20

REVISION			
SYM	DESCRIPTION	DATE	APPROVAL
-	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND OR COMPONENT	RANGE AND OR PART NUMBER	FLT PER	% POS ERR	TELEMETER CHANNEL	RES.	FLT CAL	REQ	REMARKS
10 11	D3-101	PRESS., LOX PUMP DISCHARGE NO. 2	0-2000 PSIA	1	5	AP1B0-13-07-00	12	Y		SEE NOTE 6
10 11	D3-102	PRESS., LOX PUMP DISCHARGE NO. 2	0-2000 PSIA	1	5	AP1B0-14-07-00	12	Y		SEE NOTE 6
10 11	D3-103	PRESS., LOX PUMP DISCHARGE NO. 2	0-2000 PSIA	1	5	AP1B0-15-07-00	12	Y		SEE NOTE 6
10 11	D3-104	PRESS., LOX PUMP DISCHARGE NO. 2	0-2000 PSIA	1	5	AP1B0-16-07-00	12	Y		SEE NOTE 6
10 11	XD4-101	PRESS., FUEL PUMP INLET NO. 1	0 TO 200 PSIA	1	5	AP1A0V13-01-00	12	Y		SEE NOTE 6 AND 9
10 11	XD4-102	PRESS., FUEL PUMP INLET NO. 1	0 TO 200 PSIA	1	5	AP1A0-13-02-00	12	Y		SEE NOTE 6
10 11	XD4-103	PRESS., FUEL PUMP INLET NO. 1	0 TO 200 PSIA	1	5	AP1A0-13-03-00	12	Y		SEE NOTE 6
10 11	XD4-104	PRESS., FUEL PUMP INLET NO. 1	0 TO 200 PSIA	1	5	AP1A0-13-04-00	12	Y		SEE NOTE 6

CODE IDENT NO	DWG SIZE	60B57500
14981	A	SHEET 31

MSFC FORM 422 B (HORIZONTAL) (NOVEMBER 1962) CONTINUATION SHEET

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM PRESSURE VEHICLE INT-20

REVISION			
SYM	DESCRIPTION	DATE	APPROVAL
-	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND OR COMPONENT	RANGE AND OR PART NUMBER	FLT PER	% POS ERR	TELEMETER CHANNEL	RES.	FLT CAL	REQ	REMARKS
10 11	D7-101	PRESS.,FUEL PUMP DISCHARGE NO. 2	0 TO 2500 PSIA	1	5	AP1A0-06-06-00	12	Y		SEE NOTE 6
10 11	D7-102	PRESS.,FUEL PUMP DISCHARGE NO. 2	0 TO 2500 PSIA	1	5	AP1A0-07-06-00	12	Y		SEE NOTE 6
10 11	D7-103	PRESS.,FUEL PUMP DISCHARGE NO. 2	0 TO 2500 PSIA	1	5	AP1A0-08-06-00	12	Y		SEE NOTE 6
10 11	D7-104	PRESS.,FUEL PUMP DISCHARGE NO. 2	0 TO 2500 PSIA	1	5	AP1A0-09-06-00	12	Y		SEE NOTE 6
10 11	D8-101	PRESS., COMBUSTION CHAMBER	0-1500 PSIA	1	.5	AF1-11 AP1B0V07-10-00	110	N		SEE NOTE 6 AND 7
10 11	D8-102	PRESS., COMBUSTION CHAMBER	0-1500 PSIA	1	.5	AF1-12 AP1B0V08-01-00	160	N		SEE NOTE 6 AND 7
10 11	D8-103	PRESS., COMBUSTION CHAMBER	0-1500 PSIA	1	.5	AF1-13 AP1B0V09-03-00	220	N		SEE NOTE 6 AND 7
10 11	D8-104	PRESS., COMBUSTION CHAMBER	0-1500 PSIA	1	.5	AF1-14 AP1B0V09-04-00	330	N		SEE NOTE 6 AND 7

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LSB 1391(6/66)

CODE IDENT NO	DWG SIZE	60B57500
14981	A	SHEET 32

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM PRESSURE VEHICLE INT-20

REVISION			
SYM	DESCRIPTION	DATE	APPROVAL
-	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND OR COMPONENT	RANGE AND OR PART NUMBER	FLT PER	% POS ERR	TELEMETER CHANNEL	RES	FLT CAL	REQ	REMARKS
10 11	D9-101	PRESS., GAS GENERATOR COMB. CHAMBER	0-1500 PSIA	1	5	AP1A0-01-01-00	12	Y		SEE NOTE 6
10 11	D9-102	PRESS., GAS GENERATOR COMB. CHAMBER	0-1500 PSIA	1	5	AP1A0-02-01-00	12	Y		SEE NOTE 6
10 11	D9-103	PRESS., GAS GENERATOR COMB. CHAMBER	0-1500 PSIA	1	5	AP1A0-03-01-00	12	Y		SEE NOTE 6
10 11	D9-104	PRESS., GAS GENERATOR COMB. CHAMBER	0-1500 PSIA	1	5	AP1A0-04-01-00	12	Y		SEE NOTE 6
10 11	D10-101	PRESS., TURBINE OUTLET	0-100 PSIA	1	5	AP1A0-06-07-00	12	Y		SEE NOTE 6
10 11	D10-102	PRESS., TURBINE OUTLET	0-100 PSIA	1	5	AP1A0-07-07-00	12	Y		SEE NOTE 6
10 11	D10-103	PRESS., TURBINE OUTLET	0-100 PSIA	1	5	AP1A0-08-07-00	12	Y		SEE NOTE 6
10 11	D10-104	PRESS., TURBINE OUTLET	0-100 PSIA	1	5	AP1A0-09-07-00	12	Y		SEE NOTE 6

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CODE IDENT NO.	DWG SIZE	60B57500
14981	A	SHEET 33

MSFC FORM 422 B (HORIZONTAL) (NOVEMBER 1962) CONTINUATION SHEET

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM PRESSURE VEHICLE INT-20

REVISION			
SYM	DESCRIPTION	DATE	APPROVAL
-	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND OR COMPONENT	RANGE AND OR PART NUMBER	FLT PER	% POS ERR	TELEMETER CHANNEL	RES	FLT CAL	REQ	REMARKS
10 11	D13-101	PRESS., OXIDIZER PUMP BEARING JET	0-1000 PSIA	1	5	AP1A0-01-10-00	12	Y		SEE NOTE 6
10 11	D13-102	PRESS., OXIDIZER PUMP BEARING JET	0-1000 PSIA	1	5	AP1A0-02-10-00	12	Y		SEE NOTE 6
10 11	D13-103	PRESS., OXIDIZER PUMP BEARING JET	0-1000 PSIA	1	5	AP1A0-03-10-00	12	Y		SEE NOTE 6
10 11	D13-104	PRESS., OXIDIZER PUMP BEARING JET	0-1000 PSIA	1	5	AP1A0-04-10-00	12	Y		SEE NOTE 6
10 11 20 40	D16-101	PRESS., ENG GIMBAL SYS SUPPLY PRESS. TRANS. 101A449 DC AMPL ASSY	0-2500 PSIA 60B72075-3 60B73112-3	1	5	AP1A0-05-04-00	12	Y		DOWNSTREAM SIDE INSTL DWG 60B70841 RACK ASSY 60B70995-5
10 11 20 40	D16-102	PRESS., ENG GIMBAL SYS SUPPLY PRESS. TRANS. 102A426 DC AMPL ASSY	0-2500 PSIA 60B72075-3 60B73112-3	1	5	AP1A0-06-04-00	12	Y		DOWNSTREAM SIDE INSTL DWG 60B70842 RACK ASSY 60B70995-7
10 11 20 40	D16-103	PRESS., ENG GIMBAL SYS SUPPLY PRESS. TRANS. 103A426 DC AMPL ASSY	0-2500 PSIA 60B72075-3 60B73112-3	1	5	AP1A0-07-04-00	12	Y		DOWNSTREAM SIDE INSTL DWG 60B70843 RACK ASSY 60B70995-9

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LSB 1391 (9/66)

CODE IDENT NO	DWG SIZE	60B57500
14981	A	SHEET 34

MSFC FORM 422 B (HORIZONTAL) (NOVEMBER 1962) CONTINUATION SHEET

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM PRESSURE VEHICLE INT-20

REVISION SYM	DESCRIPTION	DATE	APPROVAL
-	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND OR COMPONENT	RANGE AND OR PART NUMBER	FLT PER	% POS ERR	TELEMETER CHANNEL	RES.	FLT. CAL.	REQ	REMARKS
10 11 20 40	D16-104	PRESS., ENG GIMBAL SYS SUPPLY PRESS. TRANS. 104A426 DC AMPL ASSY	0-2500 PSIA 60B72075-3 60B73112-3	1	5	AP1A0-08-04-00	12	Y		DOWNSTREAM SIDE INSTL DWG 60B70844 RACK ASSY 60B70995-1
10 11 20 40	D21-101	PRESS. DIFF, PITCH ACTUATOR PRESS. TRANS. 101A454 DC AMPL ASSY	+/- 2500 PSID 60B72077-3 60B73112-1	1	5	AP1B0-24-00-00	120	Y		APPROX STA 75 INSTL DWG 60B84131 RACK ASSY 60B70995-1
10 11 20 40	D21-102	PRESS. DIFF, PITCH ACTUATOR PRESS. TRANS. 102A431 DC AMPL ASSY	+/- 2500 PSID 60B72077-3 60B73112-1	1	5	AP1B0V07-06-00	12	Y		APPROX STA 75 SEE NOTE 15 INSTL DWG 60B84131 RACK ASSY 60B70995-7
10 11 20 40	D21-103	PRESS. DIFF, PITCH ACTUATOR PRESS. TRANS. 103A431 DC AMPL ASSY	+/- 2500 PSID 60B72077-3 60B73112-1	1	5	AP1A0-11-00-00	120	Y		APPROX STA 75 INSTL DWG 60B84131 RACK ASSY 60B70995-9
10 11 20 40	D21-104	PRESS. DIFF, PITCH ACTUATOR PRESS. TRANS. 104A431 DC AMPL ASSY	+/- 2500 PSID 60B72077-3 60B73112-1	1 2	5	AP1B0V08-06-00	12	Y		APPROX STA 75 SEE NOTE 15 INSTL DWG 60B84131 RACK ASSY 60B70995-1
10 11 20 40	D22-101	PRESS. DIFF, YAW ACTUATOR PRESS. TRANS. 101A455 DC AMPL ASSY	+/- 2500 PSID 60B72077-3 60B73112-1	1 2	5	AP1A0-27-00-00	120	Y		APPROX STA 75 INSTL DWG 60B84131 RACK ASSY 60B70995-5
10 11 20 40	D22-102	PRESS. DIFF, YAW ACTUATOR PRESS. TRANS. 102A432 DC AMPL ASSY	+/- 2500 PSID 60B72077-3 60B73112-1	1 2	5	AP1B0V09-06-00	12	Y		APPROX. STA. 75 SEE NOTE 15 INSTL DWG 60B84131 RACK ASSY 60B70995-7

CODE IDENT NO	DWG SIZE	60B57500
14981	A	SHEET 35

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MSFC FORM 422 B (HORIZONTAL) (NOVEMBER 1962) CONTINUATION SHEET

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM PRESSURE   VEHICLE INT-20

REVISION			
SYM	DESCRIPTION	DATE	APPROVAL
-	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND OR COMPONENT	RANGE AND OR - PART NUMBER	FLT. PER	% POS ERR.	TELEMETER CHANNEL	RES.	FLT CAL.	REQ	REMARKS
10 11 20 40	D22-103	PRESS. DIFF, YAW ACTUATOR PRESS. TRANS. 103A432 DC AMPL ASSY	+/- 2500 PSID 60B72077-3 60B73112-1	1 2	5	AP1A0-12-00-00	120	Y		APPROX STA 75 INSTL DWG 60B84131 RACK ASSY 60B70995-9
10 11 20 40	D22-104	PRESS. DIFF, YAW ACTUATOR PRESS. TRANS. 104A432 DC AMPL ASSY	+/- 2500 PSID 60B72077-3 60B73112-1	1 2	5	AP1B0V10-06-00	12	Y		APPROX STA 75 SEE NOTE 8 INSTL DWG 60B84131 RACK ASSY 60B70995-1
10 11 20	D46-106	PRESS. DIFF HEAT SHIELD PRESS. TRANS. 115A627	+/-3 PSID 60B72201-1	1 2	5	AP1B0V07-02-00	12	Y		120 IN. RAD POS IV SEE NOTE 8 INSTL DWG 60B71587
10 11 20	D47-106	PRESS. DIFF HEAT SHIELD PRESS. TRANS. 115A628	+/-3 PSID 60B72201-1	1 2	5	AP1B0V08-02-00	12	Y		91 IN. RAD FIN LINE D SEE NOTE 15 INSTL DWG 60B71584
10 11 12 13 20	D67-115	PRESS.,GN2 SPHERES, PURGE SYSTEM PRESS. TRANS. 115A727	0 TO 3500 PSIA 60B72178-19	1	5	AP1A0V10-04-00	12	Y		IN MANF ASSY ON INTERMEDIATE RING APPROX STA 216 SEE NOTE 9 INSTL DWG 60B67008
10 11 20 40	D87-116	PRESS. HE. CONTROL VALVE INLET FUEL TANK PRESS. TRANS. 116A408 DC AMPL ASSY	0-3500 PSIA 60B72092-1 60B73112-3	1	5	AP1B0-16-10-00	12	Y		INSTL DWG 60B70672 RACK ASSY 60B70995-03
10 11 12 13 20	D88-115	PRESS., GN2 SPHERE CONT PRESS. SYS PRESS. TRANS. 115A464	0-3500 PSIA 60B72178-19	1	5	AP1A0V07-09-00	12	Y		IN MANF ASSY ON INTERMEDIATE RING APPROX STA 216 SEE NOTE 9 INSTL DWG 60B67008

CODE IDENT NO	DWG SIZE	60B57500
14981	A	SHEET 36

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MSFC FORM 422 B (HORIZONTAL) (NOVEMBER 1962) CONTINUATION SHEET

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM PRESSURE VEHICLE INT-20

REVISION SYM	DESCRIPTION	DATE	APPROVAL
-	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND/OR COMPONENT	RANGE AND/OR PART NUMBER	FLT PER	% POS ERR	TELEMETER CHANNEL	RES.	FLT CAL.	REQ	REMARKS
10 11 12 20	XD90-117	PRESS. FUEL TANK ULLAGE	0-45 PSIA	1 2	5	AP1B0V17-10-00	12	Y		RET. HE. INLET & VENT LINE. INSIDE TOP OF FUEL TANK SEE NOTE 9 INSTL DWG 60B67409
		PRESS. TRANS. 118A454	60B72199-5							
20		PRESS. TRANS. 120A478	60B72199-5							INSTL DWG 60B67408
10 11 20	XD94-119	PRESS. LOX TANK ULLAGE	0-45 PSIA	1 2	5	AP1B0V10-01-00	12	Y		BETWEEN GOX DISTR & VENT LINE SEE NOTE 9
		PRESS. TRANS. 120A478	60B72199-5							INSTL DWG 60B67408
10 11 12 13 20 40	XD95-119	PRESS. HE. STORAGE TANK	0-3500 PSIA	1 2	5	AP1B0V13-10-00	12	Y		INSIDE FIRST HE. BOTTLE FROM POS 1 TOWARD FIN A SEE NOTE 9
		PRESS. TRANS. 116A418	60B72092-1							INSTL DWG 60B70437
		DC AMPL ASSY	60B73112-3							RACK ASSY 60B70995-3
10 11 20	D97-115	PRESS. GOX CONTROL VALVE LOX TANK	0-1500 PSIA	1	5	AP1B0V08-01-00	12	Y		INLET OF VALVE SEE NOTE 8
		PRESS. TRANS. 115A582	60B72178-17							INSTL DWG 60B70159
10 11 20 40	D119-101	PRESS. DIFF ENG GIMBAL SYSTEM FILTER MANIFOLD	0-300 PSID	1 2	5	AP1A0-01-04-00	12	Y		
		PRESS. TRANS. 101A506	60B72077-5							INSTL DWG 60B70481
		DC AMPL ASSY	60B73113-139							RACK ASSY 60B70995-05
10 11 20 40	D119-102	PRESS. DIFF ENG GIMBAL SYSTEM FILTER MANIFOLD	0-300 PSID	1 2	5	AP1A0-02-04-00	12	Y		
		PRESS. TRANS. 102A466	60B72077-5							INSTL DWG 60B70841
		DC AMPL ASSY	60B73113-139							RACK ASSY 60B70995-07
10 11 20 40	D119-103	PRESS. DIFF ENG GIMBAL SYSTEM FILTER MANIFOLD	0-300 PSID	1 2	5	AP1A0-03-04-00	12	Y		
		PRESS. TRANS. 103A459	60B72077-5							INSTL DWG 60B70843
		DC AMPL ASSY	60B73113-139							RACK ASSY 60B70995-09

CODE IDENT NO	DWG SIZE	60B57500
14981	A	SHEET 37

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MSFC FORM 422 B (HORIZONTAL) (NOVEMBER 1962) CONTINUATION SHEET

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM PRESSURE VEHICLE INT-20

REVISION SYM	DESCRIPTION	DATE	APPROVAL
-	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND OR COMPONENT	RANGE AND OR PART NUMBER	FLT PER	% POS ERR	TELEMETER CHANNEL	RES.	FLT CAL.	REQ	REMARKS
10 11 20 40	D119-104	PRESS. DIFF ENG GIMBAL SYSTEM FILTER MANIFOLD PRESS. TRANS. 104A459 DC AMPL ASSY	0-300 PSID 60B72077-5 60B73113-139	1 2	5	AP1A0-04-04-00	12	Y		INSTL DWG 60B70844 RACK ASSY 60B70995-01
10 11 12 20	VXD124-115	PRESS. REGULATOR PURGE SYS PRESS. TRANS. 115A579	0-150 PSIA 60B72200-1	1	5	AP1A0-08-09-00	12	Y		STA 238, 8 IN. FROM COMPT SKIN ON GAS LINE INSTL DWG 60B67006
10 11 12 20	VXD125-115	PRESS. REGULATOR CONTROL PRESS. SYS PRESS. TRANS. 115A580	0-800 PSIA 60B72178-15	1	5	AP1A0-06-09-00	12	Y		IN MANF ASSY ON INTMED RING, APPROX STA 216 INSTL DWG 60B67008
10 11	D126-101	PRESS., ENG. CONTROL SYS RET.	0-500 PSIA	1	5	AP1A0-01-09-00	12	Y		SEE NOTE 6
10 11	D126-102	PRESS., ENG. CONTROL SYS RET.	0-500 PSIA	1	5	AP1A0-02-09-00	12	Y		SEE NOTE 6
10 11	D126-103	PRESS., ENG. CONTROL SYS RET.	0-500 PSIA	1	5	AP1A0-03-09-00	12	Y		SEE NOTE 6
10 11	D126-104	PRESS., ENG. CONTROL SYS RET.	0-500 PSIA	1	5	AP1A0-04-09-00	12	Y		SEE NOTE 6

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LSB 1391(16/91)

CODE IDENT NO	DWG SIZE	60B57500
14981	A	SHEET 38

MSFC FORM 422 B (HORIZONTAL) (NOVEMBER 1962) CONTINUATION SHEET

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM PRESSURE VEHICLE INT-20

REVISION			
SYM	DESCRIPTION	DATE	APPROVAL
–	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND OR COMPONENT	RANGE AND/OR PART NUMBER	FLT PER	% POS ERR	TELEMETER CHANNEL	RES.	FLT CAL.	REQ	REMARKS
10 11 12 20	VXD127-115	PRESS. LOX SUCTION LINE ENG NO. 1 PRESS. TRANS. 115A775	0-200 PSIA 60B72200-3	1	5	AP1B0V13-08-00	12	Y		AT SPOOL APPROX 90 IN. ABOVE PUMP INLET SEE NOTE 9 INSTL DWG 60B71086
10 11 20	VXD128-115	PRESS. LOX SUCTION LINE ENG NO. 2 PRESS. TRANS. 115A776	0-200 PSIA 60B72200-3	1	5	AP1B0-15-08-00	12	Y		AT SPOOL APPROX 90 IN. ABOVE PUMP INLET INSTL DWG 60B71086
10 11 20	VXD129-115	PRESS. LOX SUCTION LINE ENG NO. 3 PRESS. TRANS. 115A777	0-200 PSIA 60B72200-3	1	5	AP1B0-17-08-00	12	Y		AT SPOOL APPROX 90 IN. ABOVE PUMP INLET INSTL DWG 60B71086
10 11 20	VXD130-115	PRESS. LOX SUCTION LINE ENG NO. 4 PRESS. TRANS. 115A778	0-200 PSIA 60B72200-3	1	5	AP1B0-14-09-00	12	Y		AT SPOOL APPROX 90 IN. ABOVE PUMP INLET INSTL DWG 60B71086
10 11 12 20 40	D144-119	PRESS., HE. STORAGE TANK PRESS. TRANS. 116A419 DC AMPL ASSY	0-3500 PSIA 60B72092-1 60B73112-3	1 2	5	AP1A0-01-08-00	12	Y		INSIDE FIRST HELIUM BOTTLE FROM POS I TOWARD FIN D INSTL DWG 60B70437 RACK ASSY 60B70995-03
10 11 12 13 20	D145-115	PRESS., HE. INLET MANF PRESS. TRANS. 115A631	0-400 PSIA 60B72178-13	1 2	5	AP1A0-03-08-00	12	Y		IN HELIUM INLET MANF AHEAD OF HEAT EXCH HELIUM LINES APPROX STA 208 INSTL DWG 60B67108

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D5-17009-2

CODE IDENT NO	DWG SIZE	60B57500
14981	A	SHEET 39

BST (3/16/66)

MSFC FORM 422-B (HORIZONTAL) (NOVEMBER 1962) CONTINUATION SHEET

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM PRESSURE VEHICLE INT-20

REVISION			
SYM	DESCRIPTION	DATE	APPROVAL
-	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND/OR COMPONENT	RANGE AND/OR PART NUMBER	FLT PER	% POS ERR	TELEMETER CHANNEL	RES.	FLT CAL	REQ	REMARKS
10 11 20 40	D146-115	PRESS. FUEL SUCTION LINE INLET PRESS. TRANS. 115A912 DC AMPL ASSY	0-300 PSIA 60B72204-1 60B73112-3	1	5	AP1A0-24-00-00	120	Y		FUEL PUMP INLET DUCT NO. 1, ENG NO. 2 INSTL DWG 60B71527 RACK ASSY 60B70995-7
10 11 12 13 14 20	D152-117	PRESS.FUEL TANK ULLAGE PRESS. TRANS. 118A494	0-45 PSIA 60B72199-5	1 2	5	AP1A0-07-08-00	12	Y		TOP OF FUEL TANK, APPROX 22.5 DEGREES FROM POS I TOWARD FIN A, 96 IN. RAD FROM CL INSTL DWG 60B70178
10 11 12 13 20	D153-119	PRESS.LOX TANK ULLAGE PRESS. TRANS. 120A564	0-45 PSIA 60B72199-5	1 2	5	AP1A0-10-01-00	12	Y		TOP OF LOX TANK, 60 IN. RAD APPROX 22.5 DEG FROM POS III, TOWARD FIN B INSTL DWG 60B67409
10 11 12 20	D154-116	PRESS. HT EXCH HELIUM MANF OUTLET PRESS. TRANS. 117A439	0-200 PSIA 60B72200-3	1 2	5	AP1A0-05-08-00	12	Y		APPROX STA 276, ON HOT HELIUM DUCT, LOWER VERTICAL INSTL DWG 60B70061
10 11 12 20	D155-116	PRESS. HE. FLOW CONTROL VALVE OUTLET PRESS. TRANS. 116A423	0-400 PSIA 60B72178-13	1 2	5	AP1B0-15-10-00	12	Y		APPROX STA 602 ON COLD HELIUM DUCT, ELECTRICAL TUNNEL INSTL DWG 60B70135
10 11 12 20	D156-115	PRESS. GOX CONTROL VALVE SENSING LINE PRESS. TRANS. 115A864	0-45 PSIA 60B72199-5	1 2	5	AP1B0-07-01-00	12	Y		NEAR GOX CONTROL VALVE, IN GOX VALVE SENSING LINE INSTL DWG 60B70027

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LSB 1391(6/66)

CODE IDENT NO	DWG SIZE	60B57500
14981	A	SHEET 40

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM VIBRATION

VEHICLE INT-20

REVISION			
SYM.	DESCRIPTION	DATE	APPROVAL
--	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND/OR COMPONENT	RANGE AND/OR PART NUMBER	FLT. PER.	POS ERR	TELEMETER CHANNEL	RES.	FLT CAL	REQ	REMARKS
	E82-115	Vib. Long. Eng #1 Gimbal Block Accel. 115A728	0 to 5G 60B72192-11	1	10	AP1B0-01-00-00	120	Y		
	E92-117	Vib. Long. Aft Fuel Tank Blkhd Center Accel 117A425	0 to 5G 60B72192-11	1	10	AP1B0-02-00-00	120	Y		
	E93-119	Vib. Long. Aft LOX Tank Blkhd Center Accel 119A852	0 to 5G 60B72192-11	1	10	AP1B0-03-00-00	120	Y		

MSFC FORM 422 8 (HORIZONTAL) (NOVEMBER 1962) CONTINUATION SHEET

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM FLOW RATE VEHICLE INT-20

REVISION			
SYM	DESCRIPTION	DATE	APPROVAL
-	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND OR COMPONENT	RANGE AND OR PART NUMBER	FLT PER	% POS ERR	TELEMETER CHANNEL	RES.	FLT CAL	REQ	REMARKS
10 11 40	F44-101	FLOW RATE LOX HT EXCH INLET DC	0 TO 14 LB/SEC	1	5	AP1A0-13-06-00	12	Y		SEE NOTE 6
		DC CONVERTER	60B73138-1							RACK ASSY 60B70995-5
10 11 40	F44-102	FLOW RATE LOX HT EXCH INLET DC	0 TO 14 LB/SEC	1	5	AP1A0-13-07-00	12	Y		SEE NOTE 6
		DC CONVERTER	60B73138-1							RACK ASSY 60B70995-7
10 11 40	F44-103	FLOW RATE LOX HT EXCH INLET DC	0 TO 14 LB/SEC	1	5	AP1A0-13-08-00	12	Y		SEE NOTE 6
		DC CONVERTER	60B73138-1							RACK ASSY 60B70995-9
10 11 40	F44-104	FLOW RATE LOX HT EXCH INLET DC	0 TO 14 LB/SEC	1	5	AP1A0-13-09-00	12	Y		SEE NOTE 6
		DC CONVERTER	60B73138-1							RACK ASSY 60B70995-1

CODE IDENT NO.	DWG SIZE	60B57500
14981	A	SHEET 42

LSB 13916 (6/66)

MSFC FORM 422 B (HORIZONTAL) (NOVEMBER 1962) CONTINUATION SHEET

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM POSITION VEHICLE INT-20

REVISION			
SYM	DESCRIPTION	DATE	APPROVAL
-	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND OR COMPONENT	RANGE AND OR PART NUMBER	FLT PER	% POS ERR	TELEMETER CHANNEL	RES.	FLT CAL	REQ	REMARKS
10 11	G4-115	POSITION GOX FLOW CONTROL VALVE	0 TO 100%	1	5	AP1A0-09-01-69	12	Y		

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D5-17009-2

CODE IDENT NO	DWG SIZE	60B57500
14981	A	SHEET 43

LSB (391/6/69)

MSFC FORM 422 B (HORIZONTAL) (NOVEMBER 1962) CONTINUATION SHEET

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM SIGNALS VEHICLE INT-20

REVISION SYM	DESCRIPTION	DATE	APPROVAL
-	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND OR COMPONENT	RANGE AND OR PART NUMBER	FLT PER.	% POS ERR	TELEMETER CHANNEL	RES.	FLT CAL	REF	REMARKS
10 11	VK1-115	SWITCH SELECTOR OUTPUTS	ON-OFF	1 2		AP1B0-25-00-00	120	Y		
10	K2-115	FIRST MOTION	ON-OFF	1		AP1B0-22G00-05	120	N		
10	K3-115	OUTBD CUTOFF SIGNAL	ON-OFF	1		AP1B0-22G00-06	120	N		K175-115 IS REDUNDANT TO THIS MEAS.
10 11	K6-101	LIMIT SWITCH GAS GENERATOR VALVE	OPEN-CLOSED	1		AP1B0-13-04-00	12	Y		
10 11	K6-102	LIMIT SWITCH GAS GENERATOR VALVE	OPEN-CLOSED	1		AP1B0-14-04-00	12	Y		
10 11	K6-103	LIMIT SWITCH GAS GENERATOR VALVE	OPEN-CLOSED	1		AP1B0-15-04-00	12	Y		
10 11	K6-104	LIMIT SWITCH GAS GENERATOR VALVE	OPEN-CLOSED	1		AP1B0-16-04-00	12	Y		
10 11	K7-101	LIMIT SWITCH FUEL VALVE NO. 1	OPEN-CLOSED	1		AP1A0-01-05-00	12	Y		

CODE IDENT NO	DWG SIZE	60B57500
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LSB 1391(6/66)

MSFC FORM 422 B (HORIZONTAL) (NOVEMBER 1962) CONTINUATION SHEET

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM SIGNALS VEHICLE INT-20

REVISION SYM	DESCRIPTION	DATE	APPROVAL
-	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND OR COMPONENT	RANGE AND/OR PART NUMBER	FLT PER	% POS ERR	TELEMETER CHANNEL	RES.	FLT CAL.	REQ	REMARKS
10 11	K9-102	LIMIT SWITCH, LOX VALVE NO. 1	OPEN-CLOSED	1		AP1B0-14-06-00	12	Y		
10 11	K9-103	LIMIT SWITCH, LOX VALVE NO. 1	OPEN-CLOSED	1		AP1B0-15-06-00	12	Y		
10 11	K9-104	LIMIT SWITCH, LOX VALVE NO. 1	OPEN-CLOSED	1		AP1B0-16-06-00	12	Y		
10 11	K10-101	LIMIT SWITCH, LOX VALVE NO. 2	OPEN-CLOSED	1		AP1A0-01-06-00	12	Y		
10 11	K10-102	LIMIT SWITCH, LOX VALVE NO. 2	OPEN-CLOSED	1		AP1A0-02-06-00	12	Y		
10 11	K10-103	LIMIT SWITCH, LOX VALVE NO. 2	OPEN-CLOSED	1		AP1A0-03-06-00	12	Y		
10 11	K10-104	LIMIT SWITCH, LOX VALVE NO. 2	OPEN-CLOSED	1		AP1A0-04-06-00	12	Y		
10	VK11-118	LOX LEVEL CUTOFF NO. 1	ON-OFF	1		AP1B0-23G00-01	120	N		

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D5-17009-2

LSB 139(9/16/61)

CODE IDENT. NO	DWG SIZE	60B57500
14981	A	SHEET 46

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM SIGNALS VEHICLE INT-20

REVISION			
SYM	DESCRIPTION	DATE	APPROVAL
-	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND/OR COMPONENT	RANGE AND/OR PART NUMBER	FLT PER.	% POS ERR.	TELEMETER CHANNEL	RES.	FLT CAL.	REQ	REMARKS
10	VK12-118	LOX LEVEL CUTOFF NO. 2	ON-OFF	1		AP1B0-23G00-02	120	N		
10	VK13-118	LOX LEVEL CUTOFF NO. 3	ON-OFF	1		AP1B0-23G00-03	120	N		
10	VK14-118	LOX LEVEL CUTOFF NO. 4	ON-OFF	1		AP1B0-23600-04	120	N		
10	K17-115	IGNITION SIGNAL RETRO	ON-OFF	2		AP1B0-13U01-01	12	Y		
10 11	VK18-115	EBW VOLTAGE NO.1 (RETRO)	0 TO 5 V	2	5	AP1B0-14-01-00	12	Y		
10 11	VK19-115	EBW VOLTAGE NO. 2 (RETRO)	0 TO 5 V	2	5	AP1B0-15-01-00	12	Y		
10 11	K25-120	EBW VOLTAGE NO. 1 DESTRUCT	0 TO 5 V	1 2	5	AP1B0-16-01-00	12	Y		
10 11	K26-120	EBW VOLTAGE NO. 2 DESTRUCT	0 TO 5 V	1 2	5	AP1B0-17-01-00	12	Y		
10 11	VK27-120	EBW VOLTAGE NO. 1 SEPARATION	0 TO 5 V	2	5	AP1B0-13-05-00	12	Y		
10 11	VK28-120	EBW VOLTAGE NO. 2 SEPARATION	0 TO 5 V	2	5	AP1B0-14-05-00	12	Y		

CODE IDENT NO	DWG SIZE	60B57500
14981	A	SHEET 47

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LSB 109161 (9-66)

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM SIGNALS VEHICLE INT-20

REVISION			
SYM	DESCRIPTION	DATE	APPROVAL
-	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND OR COMPONENT	RANGE AND OR PART NUMBER	FLT PER	% POS ERR	TELEMETER CHANNEL	RES.	FLT CAL.	REQ	REMARKS
10 11	K30-120	FIRING SIGNAL SEPARATION	ON-OFF	2		AP1A0-09U04-01	12	Y		
10 11	K31-120	R/S NO. 1 CUTOFF AND DESTRUCT IND	ON-OFF	1 2		AP1A0-23-00-00	120	Y		
10 11	K32-120	R/S NO. 2 CUTOFF AND DESTRUCT IND	ON-OFF	1 2		AP1B0-06-00-00	120	Y		
10 11	VK33-115	THRUST OK PRESSURE SWITCH NO. 1 ENG NO. 1	ON-OFF	1		AP1B0-19R05-01	12	N		
10 11	VK34-115	THRUST OK PRESSURE SWITCH NO. 2 ENG NO. 1	ON-OFF	1		AP1B0-19R05-02	12	N		
10 11	VK35-115	THRUST OK PRESSURE SWITCH NO. 3 ENG NO. 1	ON-OFF	1		AP1B0-19R05-03	12	N		
10 11	VK36-115	THRUST OK PRESSURE SWITCH NO. 1 ENG NO. 2	ON-OFF	1		AP1B0-19R05-04	12	N		
10 11	VK37-115	THRUST OK PRESSURE SWITCH NO. 2 ENG NO. 2	ON-OFF	1		AP1B0-19R05-05	12	N		
10 11	VK38-115	THRUST OK PRESSURE SWITCH NO. 3 ENG NO. 2	ON-OFF	1		AP1B0-19R05-06	12	N		
10 11	VK39-115	THRUST OK PRESSURE SWITCH NO. 1 ENG NO. 3	ON-OFF	1		AP1B0-19R05-07	12	N		

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LSB 1391(6/66)

CODE IDENT NO	DWG SIZE	60B57500
14981	A	SHEET 48

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM SIGNALS VEHICLE INT-20

REVISION			
SYM	DESCRIPTION	DATE	APPROVAL
-	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND OR COMPONENT	RANGE AND OR PART NUMBER	FLT PER.	% POS. ERR	TELEMETER CHANNEL	RES.	FLT CAL	REQ	REMARKS
10 11	VK40-115	THRUST OK PRESSURE SWITCH NO. 2 ENG NO. 3	ON-OFF	1		AP1B0-19R05-08	12	N		
10 11	VK41-115	THRUST OK PRESSURE SWITCH NO. 3 ENG NO. 3	ON-OFF	1		AP1B0-19R05-09	12	N		
10 11	VK42-115	THRUST OK PRESSURE SWITCH NO. 1 ENG NO. 4	ON-OFF	1		AP1B0-19R05-10	12	N		
10 11	VK43-115	THRUST OK PRESSURE SWITCH NO. 2 ENG NO. 4	ON-OFF	1		AP1B0-19R06-01	12	N		
10 11	VK44-115	THRUST OK PRESSURE SWITCH NO. 3 ENG NO. 4	ON-OFF	1		AP1B0-19R06-02	12	N		
10 11 12	VK50-115	FUEL LEVEL UPPER CUTOFF SENSOR NO. 1	ON-OFF	1		AP1B0-21G00-07	120	N		
10 11 12	VK51-115	FUEL LEVEL UPPER CUTOFF SENSOR NO. 2	ON-OFF	1		AP1B0-21G00-08	120	N		

CODE IDENT NO	DWG SIZE	60B57500
14981	A	SHEET 49

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MSFC FORM 422 B (HORIZONTAL) (NOVEMBER 1962) CONTINUATION SHEET

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM SIGNALS VEHICLE INT-20

REVISION			
SYM	DESCRIPTION	DATE	APPROVAL
–	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND/OR COMPONENT	RANGE AND/OR PART NUMBER	FLT PER	% POS ERR	TELEMETER CHANNEL	RES.	FLT CAL	REQ	REMARKS
10 11	K52-115	FINAL THRUST OK CUTOFF ENG NO. 1	ON-OFF	1		AP1B0-19R04-05	12	N		
10 11	K53-115	FINAL THRUST OK CUTOFF ENG NO. 2	ON-OFF	1		AP1B0-19R04-06	12	N		
10 11	K54-115	FINAL THRUST OK CUTOFF ENG NO. 3	ON-OFF	1		AP1B0-19R04-07	12	N		
10 11	K55-115	FINAL THRUST OK CUTOFF ENG NO. 4	ON-OFF	1		AP1B0-19R04-08	12	N		
10 11	K57-115	FINAL LOX LEVEL CUTOFF OUTBOARD	ON-OFF	1		AP1B0-21G00-09	120	N		
10 11	VK59-118	HELIUM FLOW CONTROL VALVE NO. 1 OPEN	ON-OFF	1		AP1B0-19R10-01	12	N		
10 11	VK60-118	HELIUM FLOW CONTROL VALVE NO. 2 OPEN	ON-OFF	1		AP1B0-19R10-03	12	N		
10 11	VK61-118	HELIUM FLOW CONTROL VALVE NO. 3 OPEN	ON-OFF	1		AP1B0-19R10-05	12	N		
10 11	VK62-118	HELIUM FLOW CONTROL VALVE NO.4 OPEN	ON-OFF	1		AP1B0-19R10-07	12	N		

CODE IDENT NO	DWG SIZE	60B57500
14981	A	SHEET 50

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LSB 139 (9/16/66)

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM SIGNALS VEHICLE INT-20

REVISION			
SYM	DESCRIPTION	DATE	APPROVAL
-	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND/OR COMPONENT	RANGE AND/OR PART NUMBER	FLT. PER	% POS ERR	TELEMETER CHANNEL	RES.	FLT. CAL.	REQ	REMARKS
10 11	VK63-118	HELIUM FLOW CONTROL VALVE NO.5 OPEN	ON-OFF	1		AP1B0-19R10-09	12	N		
10 11	K64-120	LOX TANK VENT VALVE OPEN	ON-OFF	1		AP1B0V07U07-01	12	Y		SEE NOTE 8
10 11	K65-118	FUEL TANK VENT VALVE OPEN	ON-OFF	1		AP1B0V09U07-01	12	Y		SEE NOTE 8
10 11	K85-120	LOX TANK VENT VALVE CLOSED	ON-OFF	1		AP1B0V08U07-01	12	Y		SEE NOTE 15
10 11	K86-118	FUEL TANK VENT VALVE CLOSED	ON-OFF	1		AP1B0V10U07-01	12	Y		SEE NOTE 15
10 11	K87-118	HELIUM FLOW CONTROL VALVE NO. 1 CLOSED	ON-OFF	1		AP1B0-19R10-02	12	N		
10 11	VK88-118	HELIUM FLOW CONTROL VALVE NO. 2 CLOSED	ON-OFF	1		AP1B0-19R10-04	12	N		
10 11	VK89-118	HELIUM FLOW CONTROL VALVE NO. 3 CLOSED	ON-OFF	1		AP1B0-19R10-06	12	N		
10 11	VK90-118	HELIUM FLOW CONTROL VALVE NO. 4 CLOSED	ON-OFF	1		AP1B0-19R10-08	12	N		
10 11	VK91-118	HELIUM FLOW CONTROL VALVE NO. 5 CLOSED	ON-OFF	1		AP1B0-19R10-10	12	N		

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CODE IDENT. NO.	DWG SIZE	60B57500
14981	A	SHEET 51

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM SIGNALS VEHICLE INT-20

REVISION			
SYM	DESCRIPTION	DATE	APPROVAL
-	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND/OR COMPONENT	RANGE AND/OR PART NUMBER	FLT PER	% POS ERR	TELEMETER CHANNEL	RES.	FLT CAL	REQ	REMARKS
10 11 12	K92-115	ENGINE NO. 1 CUTOFF SIGNAL STOP SOLENOID NO. 1	ON-OFF	1		AP1B0-22G00-01	120	N		
10 11 12	K93-115	ENGINE NO. 2 CUTOFF SIGNAL STOP SOLENOID NO. 1	ON-OFF	1		AP1B0-22G00-02	120	N		
10 11 12	K94-115	ENGINE NO. 3 CUTOFF SIGNAL STOP SOLENOID NO. 1	ON-OFF	1		AP1B0-22G00-03	120	N		
10 11 12	K95-115	ENGINE NO. 4 CUTOFF SIGNAL STOP SOLENOID NO. 1	ON-OFF	1		AP1B0-22G00-04	120	N		
10 11	K97-115	LOX PREVALVE ENG NO. 1 OPEN	ON-OFF	1		AP1B0-13U02-01	12	Y		
10 11	K98-115	LOX PREVALVE ENG NO. 1 CLOSED	ON-OFF	1		AP1B0-13U03-01	12	Y		
10 11	K99-115	LOX PREVALVE ENG NO. 2 OPEN	ON-OFF	1		AP1B0-14U02-01	12	Y		
10 11	K100-115	LOX PREVALVE ENG NO. 2 CLOSED	ON-OFF	1		AP1B0-14U03-01	12	Y		
10 11	K101-115	LOX PREVALVE ENG NO. 3 OPEN	ON-OFF	1		AP1B0-15U02-01	12	Y		

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CODE IDENT NO	DWG SIZE	60B57500
14981	A	SHEET 52

MSFC FORM 422 B (HORIZONTAL) (NOVEMBER 1962) CONTINUATION SHEET

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM SIGNALS VEHICLE INT-20

REVISION			
SYM	DESCRIPTION	DATE	APPROVAL
-	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND OR COMPONENT	RANGE AND OR PART NUMBER	FLT PER.	% POS ERR	TELEMETER CHANNEL	RES.	FLT CAL	RFA	REMARKS
10 11	K102-115	LOX PREVALVE ENG NO. 3 CLOSED	ON-OFF	1		AP1B0-15U03-01	12	Y		
10 11	K103-115	LOX PREVALVE ENG NO. 4 OPEN	ON-OFF	1		AP1B0-16U02-01	12	Y		
10 11	K104-115	LOX PREVALVE ENG NO. 4 CLOSED	ON-OFF	1		AP1B0-16U03-01	12	Y		
10 11	K107-115	FUEL PREVALVE NO. 1 ENG NO. 2 OPEN	ON-OFF	1		AP1B0-07U09-01	12	Y		
10 11	K108-115	FUEL PREVALVE NO. 1 ENG NO. 2 CLOSED	ON-OFF	1		AP1B0V07U10-01	12	Y		SEE NOTE 8
10 11	K109-115	FUEL PREVALVE NO. 2 ENG NO. 2 OPEN	ON-OFF	1		AP1B0V08U09-01	12	Y		SEE NOTE 8
10 11	K110-115	FUEL PREVALVE NO. 2 ENG NO. 2 CLOSED	ON-OFF	1		AP1B0V08U10-01	12	Y		SEE NOTE 8

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LSB 1391(9/66)

CODE IDENT NO	DWG SIZE	60B57500
14981	A	SHEET 53

MSFC FORM 422 B (HORIZONTAL) (NOVEMBER 1962) CONTINUATION SHEET

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM SIGNALS VEHICLE INT-20

REVISION			
SYM	DESCRIPTION	DATE	APPROVAL
-	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND/OR COMPONENT	RANGE AND/OR PART NUMBER	FLT PER	% POS ERR	TELEMETER CHANNEL	RES.	FLT CAL	REQ	REMARKS
10 11	VK115-115	GOX FLOW CONTROL VALVE OPEN	ON-OFF	1		AP1B0-19R04-10	12	N		
10 11	VK116-115	GOX FLOW CONTROL VALVE CLOSED	ON-OFF	1		AP1B0-19R08-10	12	N		
10 11 12	VK120-120	FLD STRENGTH, LO LEVEL RANGE SAFETY COMMAND RECEIVER NO. 2	0 TO 5 VDC	1 2		AP1B0-11-02-00	12	Y		SEE NOTE 8
10	K124-120	LOX TANK VENT VALVE	OPEN-CLOSED	1		AP1B0-11-07-00	12	Y		

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MSFC FORM 422-B (HORIZONTAL) (NOVEMBER 1962) CONTINUATION SHEET

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM SIGNALS VEHICLE INT-20

REVISION			
SYM	DESCRIPTION	DATE	APPROVAL
-	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND/OR COMPONENT	RANGE AND/OR PART NUMBER	FLT PER	% POS. ERR.	TELEMETER CHANNEL	RES.	FLT CAL.	REQ	REMARKS
10 11 12	VK125-120	FLD STRENGTH, LO LEVEL RANGE SAFETY COMMAND RECEIVER NO. 1	0 TO 5 VDC	1 2		AP1B0-07-04-00	12	Y		
10 11	VK150-115	SWITCH SELECTOR REGISTER TEST	ON-OFF	1		AP1B0-21G00-01	120	N		
10 11 12	VK152-115	RETRO ROCKETS EBW FIRING UNIT NO. 1 PULSE SENSOR PULSE OK	ON-OFF	1		AP1B0-19R09-05	12	N		
10 11 12	VK153-115	RETRO ROCKETS EBW FIRING UNIT NO. 2 PULSE SENSOR PULSE OK	ON-OFF	1		AP1B0-19R09-06	12	N		
10 11 12	VK154-115	SEPARATION EBW FIRING UNIT NO. 1 PULSE SENSOR PULSE OK	ON-OFF	1		AP1B0-19R09-07	12	N		
10 11 12	VK155-115	SEPARATION EBW FIRING UNIT NO. 2 PULSE SENSOR PULSE OK	ON-OFF	1		AP1B0-19R09-08	12	N		
10 11 12	VK156-115	PD EBW FIRING UNIT NO. 1 PULSE SENSOR PULSE OK	ON-OFF	1		AP1B0-19R09-09	12	N		
10 11 12	VK157-115	PD EBW FIRING UNIT NO. 2 PULSE SENSOR PULSE OK	ON-OFF	1		AP1B0-19R09-10	12	N		

CODE IDENT NO	DWG SIZE	60B57500
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MSFC FORM 422-B (HORIZONTAL) (NOVEMBER 1962) CONTINUATION SHEET

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM SIGNALS VEHICLE INT-20

REVISION			
SYM	DESCRIPTION	DATE	APPROVAL
–	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND/OR COMPONENT	RANGE AND/OR PART NUMBER	FLT PER	% POS ERR	TELEMETER CHANNEL	RES.	FLT CAL.	REQ	REMARKS
10 11 12	VK158-118	HELIUM FLOW CONTROL VALVE NO. 2 OPEN COMMAND RECD	ON-OFF	1		AP1B0-19R09-01	12	N		
10 11 12	VK159-118	HELIUM FLOW CONTROL VALVE NO. 3 OPEN COMMAND RECD	ON-OFF	1		AP1B0-19R09-02	12	N		
10 11 12	VK160-118	HELIUM FLOW CONTROL VALVE NO. 4 OPEN COMMAND RECD	ON-OFF	1		AP1B0-19R09-03	12	N		
10 11 12	VK161-118	HELIUM FLOW CONTROL VALVE NO. 5 OPEN COMMAND RECD	ON-OFF	1		AP1B0-19R09-04	12	N		
10 11 12	K169-115	ENGINE NO. 1 CUTOFF SIGNAL STOP SOLENOID NO. 2	ON-OFF	1		AP1B0-21G00-03	120	N		
10 11 12	K170-115	ENGINE NO. 2 CUTOFF SIGNAL STOP SOLENOID NO. 2	ON-OFF	1		AP1B0-21G00-04	120	N		
10 11 12	K171-115	ENGINE NO. 3 CUTOFF SIGNAL STOP SOLENOID NO. 2	ON-OFF	1		AP1B0-21G00-05	120	N		
10 11 12	K172-115	ENGINE NO. 4 CUTOFF SIGNAL STOP SOLENOID NO. 2	ON-OFF	1		AP1B0-21G00-06	120	N		

CODE IDENT. NO.	DWG SIZE	60B57500
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MSFC FORM 422 B (HORIZONTAL) (NOVEMBER 1962) CONTINUATION SHEET

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM SIGNALS VEHICLE INT-20

REVISION			
SYM	DESCRIPTION	DATE	APPROVAL
-	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND OR COMPONENT	RANGE AND OR PART NUMBER	FLT PER	% POS ERR	TELEMETER CHANNEL	RES.	FLT CAL		REMARKS
10	K175-115	OUTBD C/O SIGNAL	ON-OFF	1		AP1A0-14-00-00	120	Y		REDUNDANT TO MEAS K3-115

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LSB 1391(9/66)

CODE IDENT NO	DWG SIZE	60B57500
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MSFC FORM 422 B (HORIZONTAL) (NOVEMBER 1962) CONTINUATION SHEET

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM LIQUID LEVEL VEHICLE INT-20

REVISION			
SYM	DESCRIPTION	DATE	APPROVAL
-	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND/OR COMPONENT	RANGE AND/OR PART NUMBER	FLT PER.	% POS ERR	TELEMETER CHANNEL	RES.	FLT CAL	REQ	REMARKS
10	L2-119	LOX LEVEL POSITION II		1		AP1B1-18G00-00	40	N		SEE NOTE 13
20		SENSOR SEGMENT 119A436	60B72068-1							INSTL DWG 60B71508
21		SPEC. SEGMENT	60B72068-27							INSTL DWG 60B71508
30		END CAP, AFT	60B72068-35							INSTL DWG 60B71508
40		ELECTRONICS 120A939	60B72068-7							INSTL DWG 60B71202
50		CABLE	60B72068-13							INSTL DWG 60B64985
10	L5-119	LOX LEVEL RESIDUAL		1		AP1B2-18G00-00	40	N		
20		SENSOR SEGMENT 119A439	60B72068-1							INSTL DWG 60B71508
21		SPEC. SEGMENT	60B72068-29							INSTL DWG 60B71508
30		END CAP, FWD	60B72068-35							INSTL DWG 60B71508
40		ELECTRONICS 120A942	60B72068-41							INSTL DWG 60B71202
50		CABLE	60B72068-17							INSTL DWG 60B64985
10	L6-117	FUEL LEVEL CENTER		1		AP1B3-18G00-00	40	N		SEE NOTE 14
20		SENSOR SEGMENT 117A415	60B72068-1							INSTL DWG 60B67445
21		SPEC. SEGMENT	60B72068-43							INSTL DWG 60B67445
30		END CAP, FWD	60B72068-35							INSTL DWG 60B67445
40		ELECTRONICS 115A967	60B72068-9							INSTL DWG 60B70774
50		CABLE	60B72068-11							INSTL DWG 60B70083
10	L10-119	SEGMENT IDENTIFICATION		1			12	N		
11		POS II DISCRETE BIT 4				AP1B0-19R03-06				
12		BIT 3				AP1B0-19R03-07				
13		BIT 2				AP1B0-19R03 08				
14		BIT 1				AP1B0-19R03 09				
10	L11-119	SEGMENT IDENTIFICATION		1			12	N		
11		FUEL DISCRETE BIT 4				AP1B0-19R03-02				
12		BIT 3				AP1B0-19R03-03				
13		BIT 2				AP1B0-19R03-04				
14		BIT 1				AP1B0-19R03-05				

CODE IDENT. NO	DWG SIZE	60B57500
14981	A	SHEET 58

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SYSTEM LIQUID LEVEL VEHICLE INT-20

REVISION			
SYM	DESCRIPTION	DATE	APPROVAL
–	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND OR COMPONENT	RANGE AND OR PART NUMBER	FLT PER	% POS ERR	TELEMETER CHANNEL	RES.	FLT CAL.	REQ	REMARKS
10 11 40	L13-119	LOX LEVEL TIME CORRELATION POS II TIME COPRELATION UNIT	0-5V 60B72147-1	1		AP1B0-20-04-00	12	Y		RACK ASSY 60B70995-03
10 11 40	L16-119	LOX LEVFL TIME CORRELATION RESIDUAL TIME CORRELATION UNIT	0-5V 60B72147-1	1		AP1B0-20-07-00	12	Y		RACK ASSY 60B70995-03
10 11 40	L17-117	FUEL LEVEL TIME CORRELATION CENTER TIME CORRELATION UNIT	0-5V 60B72147-1	1		AP1B0-20-08-00	12	Y		RACK ASSY 60B70995-03
10 11	L22-119	SEG IDENT RESIDUAL DISCRETE BIT 1		1		AP1B0-19R03-10	12	N		

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CODE IDENT NO	DWG SIZE	60B57500
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INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM ANGULAR VELOCITY VEHICLE INT-20

REVISION			
SYM	DESCRIPTION	DATE	APPROVAL
-	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND/OR COMPONENT	RANGE AND/OR PART NUMBER	FLT PER	% POS ERR	TELEMETER CHANNEL	RES.	FLT CAL	REQ	REMARKS
10 11 20	R4-120	ANGULAR VELOCITY PITCH RATE GYRO 120A590	+/- 10 DEG/SEC 60B72043-3	1 2	5	AF1-04 AP1B0V09-08-00	14	Y		INSTL DWG 60B67199 INSTL DWG 60B70998
10 11 20	R5-120	ANGULAR VELOCITY YAW RATE GYRO 120A591	+/- 10 DEG/SEC 60B72043-3	1 2	5	AF1-02 AP1B0V09-07-00	8	Y		INSTL DWG 60B67199 INSTL DWG 60B70998
10 11 20	R6-120	ANGULAR VELOCITY ROLL RATE GYRO 120A592	+/- 10 DEG/SEC 60B72043-3	1 2	5	AF1-05 AP1B0V08-04-00	20	Y		INSTL DWG 60B67199 INSTL DWG 60B70998

CODE IDENT NO	DWG SIZE	60B57500
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MSFC FORM 422-B (HORIZONTAL) (NOVEMBER 1962) CONTINUATION SHEET

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM STRAIN VEHICLE INT-20

REVISION			
SYM.	DESCRIPTION	DATE	APPROVAL
--	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND/OR COMPONENT	RANGE AND/OR PART NUMBER	FLT PER.	% POS ERR	TELEMETER CHANNEL	RES.	FLT CAL.	REQ.	REMARKS
10	S17-118	Strain Intertank Skirt	-800 Tens. to							This meas. monitored by
11		Long.	2200 Comp Uin/in							hardwire only. Approx.
12										Sta 790. 11 degrees
13										15 min from fin A
14										meas CW looking fwd.
15										See Note 16.
20		Strain Gage								Main Bridge
21		Bridge 118A455	60B72062-1							Instl Dwg 60B71206
10	S18-118	Strain Intertank Skirt	-800 Tens to							This meas monitored by
11		Long	2200 Comp Uin/in							hardwire only. Approx.
12										sta 790. 33 degrees
13										45 min from fin A.
14										See note 16.
20		Strain Gage								Main Bridge
21		Bridge 118A456	60B72062-1							Instl Dwg 60B71206
22		Strain Gage								Backup Bridge
23		Bridge 118A472	60B72062-1							Instl Dwg 60B71206
10	S19-118	Strain Intertank Skirt	-800 Tens to							This meas monitored
11		Long	2200 Comp Uin/in							by hardwire only.
12										Approx. sta 790. 56
13										degrees 15 min from
14										fin A. See Note 16.
20		Strain Gage								Main Bridge
21		Bridge 118A457	60B72062-1							Instl Dwg 60B71206
10	S20-118	Strain Intertank Skirt	-800 Tens to							This meas monitored
11		Long	2200 Comp Uin/in							by hardwire only.
12										Approx. sta 790. 78
13										degrees 45 min from
14										fin A. See Note 16.
20		Strain Gage								Main Bridge
21		Bridge 118A458	60B72062-1							Instl dwg 6071206
22		Strain Gage								Backup Bridge
23		Bridge 118A474	60B72062-1							Instl Dwg 60B71206

CODE IDENT. NO	DWG SIZE	60B57500
14981	A	SHEET 62

INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM STRAIN VEHICLE INT-20 -- SEE SHEET 1 6-23-69

Line	Measurement Number	Measurement Name and/or Component	Range and/or Part Number	Flt Per	Pos etc	Telemeter Channel	Res	Remarks
10	S21-118	Strain Intertank Skirt	-800 Tens to					This meas monitored
11		Long	2200 Comp Uin/in					by hardwire only.
12								Approx. sta 790. 101
13								degrees 15 min from
14								fin A. See Note 16.
20		Strain Gage						Main Bridge
21		Bridge 118A459	60B72062-1					Instl Dwg 60B71206
10	S22-118	Strain Intertank Skirt	-800 Tens to					This meas monitored
11		Long	2200 Comp Uin/in					by hardwire only.
12								Approx. sta 790. 123
13								degrees 45 min from
14								fin A. See Note 16.
20		Strain Gage						Main Bridge
21		Bridge 118A460	60B72062-1					Instl dwg 60B71206
22		Strain Gage						Backup Bridge
23		Bridge 118A476	60B72062-1					Instl Dwg 60B71206
10	S23-118	Strain Intertank Skirt	-800 Tens to					This meas monitored
11		Long	2200 Comp Uin/in					by hardwire only.
12								Approx. sta 790. 146
13								degrees 15 min from
14								fin A. See Note 16.
20		Strain Gage						Main Bridge
21		Bridge 118A461	60B72062-1					Instl Dwg 60B71206
10	S24-118	Strain Intertank Skirt	-800 Tens to					This meas monitored
11		Long	2200 Comp Uin/in					by hardwire only.
12								Approx sta 790. 168
13								degrees 45 min from
14								fin A. See Note 16.
20		Strain Gage						Main Bridge
21		Bridge 118A462	60B72062-1					Instl Dwg 60B71206
22		Strain Gage						Backup Bridge
23		Bridge 118A478	60B72062-1					Instl Dwg 60B71206

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SYSTEM STRAIN VEHICLE INT-20

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LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND/OR COMPONENT	RANGE AND/OR PART NUMBER	FLT. PER.	% POS. ERR.	TELEMETER CHANNEL	RES.	FLT CAL	REQ	REMARKS
10	S25-118	Strain Intertank Skirt	-800 Tens to							This meas monitored
11		Long	2200 Comp Uin/in							by hardwire only.
12										Approx. sta 790. 191
13										degrees 15 min from
14										fin A. See note 16.
20		Strain Gage								Main Bridge
21		Bridge 118A463	60B72062-1							Instl Dwg 60B71206
10	S26-118	Strain Intertank Skirt	-800 Tens to							This meas monitored
11		Long	2200 Comp Uin/in							by hardwire only.
12										Approx. sta 790. 213
13										degrees 45 min from
14										fin A. See Note 16.
20		Strain Gage								Main Bridge
21		Bridge 118A464	60B72062-1							Instl Dwg 60B71206
22		Strain Gage								Backup Bridge
23		Bridge 118A480	60B72062-1							Instl Dwg 60B71206
10	S27-118	Strain Intertank Skirt	-800 Tens to							This meas monitored
11		Long	2200 Comp Uin/in							by hardwire only.
12										Approx. sta 790. 236
13										degrees 15 min from
14										fin A. See Note 16.
20		Strain Gage								Main Bridge
21		Bridge 118A465	60B72062-1							Instl Dwg 60B71206
10	S28-118	Strain Intertank Skirt	-800 Tens to							This meas monitored
11		Long	2200 Comp Uin/in							by hardwire only.
12										Approx. sta 790. 258
13										degrees 45 min from
14										fin A. See note 16.
20		Strain Gage								Main Bridge
21		Bridge 118A466	60B72062-1							Instl Dwg 60B71206
22		Strain Gage								Backup Bridge
23		Bridge 118A482	60B72062-1							Instl Dwg 60B71206

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SYSTEM STRAIN VEHICLE INT-20

REVISION: SYM. -- | DESCRIPTION: SEE SHEET 1 | DATE: 6-23-69 | APPROVAL:

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND/OR COMPONENT	RANGE AND/OR PART NUMBER	FLT PER	% POS ERR	TELEMETER CHANNEL	RES.	FLT CAL	REQ	REMARKS
10	S29-118	Strain Intertank Skirt	-800 Tens to							This meas monitored
11		Long	2200 Comp Uin/in							by hardwire only.
12										Approx. sta 790. 281
13										degrees 15 min from
14										fin A. See Note 16.
20		Strain Gage								Main Bridge
21		Bridge 118A467	60B72062-1							Instl Dwg 60B71206
10	S30-118	Strain Intertank Skirt	-800 Tens to							This meas monitored
11		Long	2200 Comp Uin/in							by hardwire only.
12										Approx. sta 790. 303
13										degrees 45 min from
14										fin A.. See Note 16.
20		Strain Gage								Main Bridge
21		Bridge 118A468	60B72062-1							Instl Dwg 60B71206
22		Strain Gage								Backup Bridge
23		Bridge 118A484	60B72062-1							Instl Dwg 60B71206
10	S31-118	Strain Intertank Skirt	-800 Tens to							This meas monitored
11		Long	2200 Comp Uin/in							by hardwire only.
12										Approx. sta 790. 326
13										degrees 15 min from
14										fin A. See Note 16.
20		Strain Gage								Main Bridge
21		Bridge 118A469	60B72062-1							Instl Dwg 60B71206
10	S32-118	Strain Intertank Skirt	-800 Tens to							This meas monitored
11		Long	2200 Comp Uin/in							by hardwire only.
12										Approx. sta 790. 348
13										degrees 45 min from
14										fin A. See Note 16.
20		Strain Gage								Main Bridge
21		Bridge 118A470	60B72062-1							Instl Dwg 60B71206
22		Strain Gage								Backup Bridge
23		Bridge 118A486	60B72062-1							Instl Dwg 60B71206

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INSTRUMENTATION PROGRAM & COMPONENTS LIST

SYSTEM STRAIN VEHICLE INT-20

REVISION SYM.	DESCRIPTION	DATE	APPROVAL
--	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND/OR COMPONENT	RANGE AND OR PART NUMBER	FLT PER.	% POS ERR.	TELEMETER CHANNEL	RES.	FLT CAL.	REQ	REMARKS
10 11 12 20 21	S117-118	Strain Intertank Skirt Long Strain Gage Bridge 118A471	-800 (Tens) to 2200 (Comp) Uin/in. 60B72062-1	1 2	5	AP1A0-01-02-00	12	Y		Use backup bridge for S17-118
10 11 12 20 21	S119-118	Strain Intertank Skirt Long Strain Gage Bridge 118A473	-800 (Tens) to 2200 (Comp) Uin/in. 60B72062-1	1 2	5	AP1A0-01-03-00	12	Y		Use backup bridge for S19-118
10 11 12 20 21	S121-118	Strain Intertank Skirt Long Strain Gage Bridge 118A475	-800 (Tens) to 2200 (Comp) Uin/in 60B72062-1	1 2	5	AP1A0-02-02-00	12	Y		Use backup bridge for S21-118
10 11 12 20 21	S123-118	Strain Intertank Skirt Long Strain Gage Bridge 118A477	-800 (Tens) to 2200 (Comp) Uin/in 60B72062-1	1 2	5	AP1A0-10-03-00	12	Y		Use backup bridge for S23-118
10 11 12 20 21	S125-118	Strain Intertank Skirt Long Strain Gage Bridge 118A479	-800 (Tens) to 2200 (Comp) Uin/in 60B72062-1	1 2	5	AP1B0-11-06-00	12	Y		Use backup bridge for S25-118
10 11 12 20 21	S127-118	Strain Intertank Skirt Long Strain Gage Bridge 118A481	-800 (Tens) to 2200 (Comp) 60B72062-1	1 2	5	AP1B0-11-09-00	12	Y		Use backup bridge for S27-118

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SYSTEM STRAIN VEHICLE INT-20

REVISION SYM.	DESCRIPTION	DATE	APPROVAL
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LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND/OR COMPONENT	RANGE AND OR PART NUMBER	FLT. PER.	% POS. ERR.	TELEMETER CHANNEL	RES.	FLT CAL	REQ	REMARKS
10 11 12	S129-118	Strain Intertank Skirt Long	-800 (Tens) to 2200 (Comp)	1 2	5	AP1B0-20-10-00	12	Y		Use backup bridge for S29-118
20 21		Strain Gage Bridge 118A483	60B72062-1							
10 11 12	S131-118	Strain Intertank Skirt Long	-800 (Tens) to 2200 (Comp)	1 2	5	AP1A0-02-03-00	12	Y		Use backup bridge for S31-118
20 21		Strain Gage Bridge 118A485	60B72062-1							

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SYSTEM RPM

VEHICLE INT-20

REVISION			
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LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND OR COMPONENT	RANGE AND OR PART NUMBER	FLT PER.	% POS ERR.	TELEMETER CHANNEL	RES.	FLT CAL.	REQ	REMARKS
10 11 40	T1-101	TURBOPUMP RPM TACH PULSE CONV	0 TO 7000 RPM 60B73156-1	1	5	AF1-08 AP1B0V07-07-00	45	N		SEE NOTES 6 & 7 RACK ASSY 60B70995-05
10 11 40	T1-102	TURBOPUMP RPM TACH PULSE CONV	0 TO 7000 RPM 60B73156-1	1	5	AF1-07 AP1B0V08-09-00	35	N		SEE NOTES 6 & 7 RACK ASSY 60B70995-07
10 11 40	T1-103	TURBOPUMP RPM TACH PULSE CONV	0 TO 7000 RPM 60B73156-1	1	5	AF1-06 AP1B0V08-10-00	25	N		SEE NOTES 6 & 7 RACK ASSY 60B70995-09
10 11 40	T1-104	TURBOPUMP RPM TACH PULSE CONV	0 TO 7000 RPM 60B73156-1	1	5	AF1-09 AP1B0V10-02-00	60	N		SEE NOTES 6 AND 7 RACK ASSY 60B70995-01

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SYSTEM RF AND TELEMETRY VEHICLE INT-20

REVISION			
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LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND/OR COMPONENT	RANGE AND/OR PART NUMBER	FLT. PER.	% POS ERR	TELEMETER CHANNEL	RES.	FLT. CAL.	REQ	REMARKS
60 61		SYNC BUFFER UNIT 115A972	60B72146-1							
60		R/S ANTENNA 120A964	60B74941-1							
60		R/S ANTENNA 120A965	60B74941-1							
60 61		R/S HYBRID RING 120A968	60B74959-3							
60		R/S DIR COUP. 120A962	60B74960-1							
60		TLM ANTENNA 120A412	60B75121-1							
60		TLM ANTENNA 120A413	60B75121-1							
60 61		TLM MULTICOUPLER 120A407	60B75130-5							
60		TLM COAX SW 120A970	60B75140-1							
60 61		TLM POWER DIVIDER 120A409	60B75160-5							

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SYSTEM RF AND TELEMETRY VEHICLE INT-20

REVISION			
SYM	DESCRIPTION	DATE	APPROVAL
-	SEE SHEET 1	6-23-69	

LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND OR COMPONENT		RANGE AND OR PART NUMBER	FLT. PER	% POS ERR.	TELEMETER CHANNEL	RES.	FLT CAL.	REQ	REMARKS
60		TLM RF TERM.	120A938	60B75512-1							
60 61		PAM/FM TLM ASSY (F1+P1)	115A400	60B76310-3							
60 61		MODEL 270 (MXR) (P1)	115A403	60B76369-3							
60		RF ASSY (P1)	120A405	60B76470-1							244.3 MC
60		RF ASSY (F1)	120A400	60B76470-5							256.2 MC
60 61		DC POWER ISOLATOR	115A414	60B76503-3							STA 152.50
60 61		PCM/DDAS ASSY (P1)	115A404	60B76601-11							
60 61		SUB-MXR ASSY REMOTE DIGITAL	115A413	60B76676-1							
60		R/S DECODER	120A958	50M10698							
60		R/S DECODER	120A959	50M10698							
60 61		DIGITAL COMMAND RECEIVER	120A986	50M10986							

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SYSTEM RF AND TELEMETRY VEHICLE INT-20

REVISION			
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LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND OR COMPONENT	RANGE AND OR PART NUMBER	FLT PER	% POS ERR.	TELEMETER CHANNEL	RES.	FLT CAL.	REQ	REMARKS
60 61	-	DIGITAL COM- 120A987 MAND RECEIVER	50M10986							
60		TLM CALIBRATOR 115A406	50M12011-3							

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CODE IDENT. NO.	DWG SIZE	60B57500
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SYSTEM MISCELLANEOUS EQUIP. VEHICLE INT-20

REVISION			
SYM	DESCRIPTION	DATE	APPROVAL
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LINE	MEASUREMENT NUMBER	MEASUREMENT NAME AND/OR COMPONENT	RANGE AND/OR PART NUMBER	FLT PER	% POS ERR	TELEMETER CHANNEL	RES.	FLT CAL.	REQ	REMARKS
70 71		SELECTOR (SEL) 115A959 RACK ASSY	60B72084-1							CONTAINS ONE MEAS CALIBRATOR 60B73059-1
70 71		SEL RACK ASSY 115A960	60B72084-1							CONTAINS ONE MEAS CALIBRATOR 60B73059-1
70 71		SEL RACK ASSY 115A961	60B72084-1							CONTAINS ONE MEAS CALIBRATOR 60B73059-1
70 71		SEL RACK ASSY 115A965	60B72084-1							CONTAINS ONE MEAS CALIBRATOR 60B73059-1
70		MEAS RACK SEL 115A957	60B73020-1							
70 71		MEAS RACK ASSY 115A500 MEAS CALIBRATOR	60B73024-1 60B73059-1							
70 71		MEAS RACK ASSY 115A501 MEAS CALIBRATOR	60B73024-1 60B73059-1							
70 71		MEAS RACK ASSY 115A502 MEAS CALIBRATOR	60B73024-1 60B73059-1							
70 71		MEAS RACK ASSY 115A503 MEAS CALIBRATOR	60B73024-1 60B73059-1							
70 71		MEAS RACK ASSY 115A504 MEAS CALIBRATOR	60B73024-1 60B73059-1							
70 71		MEAS RACK ASSY 115A505 MEAS CALIBRATOR	60B73024-1 60B73059-1							

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APPLICATION		PART No.	MF	REVISIONS			
NEXT ASSY	USED ON			SYM	DESCRIPTION	DATE	APPROVAL

PRELIMINARY

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	ORIGINAL DATE OF DRAWING 4-28-69		INTERMEDIATE 20 S-IC STAGE END ITEM TEST PLAN		GEORGE C. MARSHALL SPACE FLIGHT CENTER NATIONAL AERONAUTICS AND SPACE ADMINISTRATION HUNTSVILLE, ALABAMA
TOLERANCES ON: FRACTIONS — DECIMALS — ANGLES —	DRAFTSMAN S. Edwards	CHECKER [illegible]			
MATERIAL —	TRACER [illegible]	CHECKER			
	ENGINEER [illegible]	ENGINEER [illegible]			
HEAT TREATMENT —	SUBMITTED		CODE IDENT. 14981	DWG SIZE	66B10920
FINAL PROTECTIVE FINISH —	APPROVED		SCALE	A	SHEET 1 OF 150

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LIST OF FIGURES

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1.0 INTRODUCTION

1.1 PURPOSE

The purpose of the End Item Test Plan is to present the requirements for testing the assembled Intermediate 20 S-IC Stage prior to delivery to the procuring agency.

This document is prepared in accordance with Contract Document NPC 200-2 and submitted in accordance with Contract Document.

1.2 SCOPE

This document contains level one test requirements for the completed Intermediate 20 S-IC Stage. The tests required for acceptance of the Intermediate 20 S-IC by Stage Contract End Item Specification Part II are identified by an asterisk preceding requirements.

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2.0 GENERAL TEST DESCRIPTION

The End-Item Test Plan provides for testing the Intermediate 20 S-IC Stage after it has been completely assembled. The description of the individual tests specified in the following sections include the functional characteristics to be tested along with the nominal and tolerance values to be used.

Testing on the stages will be performed in accordance with approved procedures satisfying the requirements of this plan. The procedures to be used and their applicable configurations are identified by the appropriate Test Documentation Index.

Time and cycle recording equipment will be in operation at all times SE or stage power is applied.

The stage structure system will not be tested by this plan as it must be acceptable prior to Level I checkout.

2.1 TEST PHASES - INTERMEDIATE 20 S-IC STAGE

End item testing of the completed Stage will be accomplished in the five phases shown diagramatically in figure 2-1. The nomenclature and a brief description of each test phase is as follows:

a. The MANUFACTURING CHECKOUT phase is the test performed on the completed stage prior to shipment to the static test stand. The test requirements for this phase are specified in section 3.

b. The PRE-STATIC CHECKOUT phase is the final test of the completed stage at the static test stand to verify readiness for static firing. The test requirements for this phase are specified in section 4.

c. The STATIC FIRING test phase consists of the countdown for and the actual firing of the stage at the static test stand and the monitoring of stage systems operation during this interval. The test requirements for this phase are specified in section 5.

d. The POST FIRING EVALUATION checkout phase is the test performed after static firing and prior to the shipment of the stage to Michoud for Post Static Checkout. This phase verifies the integrity of the stage for shipment. The test requirements for this phase are specified in section 5.

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2.1 (continued)

e. The POST STATIC CHECKOUT phase is the final test performed on the stage after refurbishment prior to shipment to KSC, to verify the readiness of the stage for shipment. The test requirements for this phase are specified in section 4.

2.2 TEST PHASES - REFURBISHED S-IC STAGE TO INTERMEDIATE 20 CONFIGURATION

End Item Testing of the refurbished S-IC Stage to Intermediate 20 configuration will be accomplished in one of the two test flows as shown in Figure 2.1. If a refurbished S-IC is one of the first two Intermediate 20 Stages, it will be Static Fired as part of developmental testing to prove the design. The refurbished S-IC testing will start with the PRE-STATIC CHECKOUT phase (Reference 2.1.b). After two Intermediate 20 S-IC Stages have been Static Fired, the refurbished S-IC Intermediate 20 Stage testing will start with the POST STATIC CHECKOUT phase (reference 2.1.e).

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2.2 UNMOUNTED FLIGHT HARDWARE

The requirements for items of Intermediate 20 S-IC unmounted flight hardware and their availability and use during level one testing are as follows:

a. Fins and Fairings - will be shipped to KSC where they will be mated to stage.

b. Engine Pyrotechnics - will be available at the static firing sites and installed during preparations for static firing tests; are replaced by substitutes and simulators (see 2.3) at all other times.

c. Flight Batteries - not available during level one testing; installed just prior to stage launch at KSC; are simulated by jumper cables and telemetry termination modules during ground checkout.

d. Engine Skirt Extensions - will be installed prior to and removed after static firing; will be mated to the stage engines at KSC.

e. Retro-rockets, retro-rocket CDF Manifold and Ordnance, and retro-rocket pyrogen initiators - not available during level one checkout; installed on the stage at KSC; initiators replaced by pulse sensors at all other times.

f. Flight heat shield -

(1) In Static Firing the Static Firing heat shield will be installed and the flight heat shield instrumentation will be terminated with telemetry termination module.

(2) During refurbishment the static firing heat shield will be removed and the non-instrumented panels of the flight heat shield will be installed.

(3) In PSC the flight heat shield instrumentation will be terminated with telemetry termination modules.

(4) The instrumented heat shield panels will be installed at KSC.

g. Range Safety and Stage Separation Systems Ordnance Devices - not available during level one testing for safety reasons; installed on the Stage at KSC; are replaced by EBW pulse sensors (see 2.3) during level one test.

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2.3 LIST OF SIMULATORS

The following is a list of simulators, cables, and terminations that will be used during level one test:

a. Upper Stage Substitutes - consists of a drawer in the SE that will be connected and removed along with the rest of the SE at each test site; used to complete signal paths to Stage switch selector engine gimballing position indications, etc.

b. Battery jumper cables - consists of jumper cables from a ground power supply to each of the stage main battery busses; are used in place of flight batteries in consideration of total power requirements during checkout at each test location; installed when SE is hooked up. These cables are slung between the stage and ground, and do not go through umbilical connections.

c. Turbine Exhaust and Gas Generator Igniter Substitutes - consists of plugs to the engine openings which have the capability of providing electrical simulation of the actual igniters; installed during pre-static checkout and remain on the stage at all times except for actual static firings and launchings.

d. Hypergol Cartridge Simulator - consists of an attachment (with pneumatics) to the hypergol container on the F-1 Engine; provides simulation of hypergol installed, not installed, and ruptured; installed prior to Engine Systems Tests at each test site and removed following Simulated Static Firing or Simulated Flight Tests.

e. Launch Equipment Electrical Simulator (LEES) - consists of electrical networks and timers that can be installed in the SE; provides capability of making the S-IC Stage act as a completed Intermediate20 V Vehicle;installed only for simulated static firing and simulated flight tests during each test phase.

f. Stage Separation Simulator - consists of equipment to provide the capability of electrical stage separation simulation; installed on SE only during Post Static Checkout for the simulated flight test.

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2.3 (continued)

g. Telemetry Channel Termination Modules - Several groups of telemetry channel terminations are provided to maintain the integrity of the telemetry during test and checkout. These are generally removed from the stage as flight hardware is installed. The flows for the various groups are as follows:

(1) Terminations installed on the stage during connection of SE and removed at completion of PSC prior to shipment of stage to KSC.

Flight Batteries
Flight Heat Shield
Interstage Ambient Temperature

(2) Termination modules used at the static firing site - installed for Static Firing; removed during installation of SE for refurbishment checkout.

Pump Bearing

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3.0 MANUFACTURING CHECKOUT REQUIREMENTS

This section specifies the test requirements for the assembled Intermediate 20 S-IC stage prior to shipment to the static test stand.

3.1 DC END TO END RESISTANCE

Measure and record the stage DC resistance through access points located near position I aft and position III forward.

3.2 TELEMETRY ANTENNAS

Perform system test to comply with requirements of paragraph 4.16.

3.3 RANGE SAFETY ANTENNAS

Perform system test to comply with requirements of paragraph 4.26

3.4 ENVIORNMENTAL CONTROL

Perform system test to comply with requirements of paragraphs 4.4.1, 4.4.3, 4.4.4, 4.4.5, and 4.4.6.

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4.0 PRE STATIC/POST STATIC CHECKOUT REQUIREMENTS

This section specifies test requirements for Pre Static Checkout and Post Static Checkout. The following list delineates the prerequisites for the performance of each test or test block The list reflects only the minimum safety and technical restrictions on the checkout sequence and the actual order of performance is to be determined by the test conductor in view of these restrictions.

	PARAGRAPHS	PREREQUISITES
4.1	Receiving Inspection	None
4.2	Stage Installation	4.1
4.3	Stage Connection	4.2
4.4	Forward Environmental Control	4.2
4.5	AFT Environmental Control	4.2
4.6	Bus Resistance	4.2
4.7	Critical Power Distribution	4.6
4.8	Power Application	4.7
4.9	Power Removal	4.8
4.10	Power Transfer	4.8
4.11	Bus Voltage	4.8
4.12	Stage Sequencing	4.19
4.13	Stage Separation	4.12
4.14	Engine Cutoff	4.12
4.15	Electrical Heaters	4.23 (C6-101 thru -104)
4.16	Telemetry Antennas	4.2
4.17	Strain Gage Pressure Transducer	4.11, 4.19
4.18	Liquid Level Initialization	4.11
4.19	PCM/DDAS and PCM/FM	Pre - 4.11 Post - 4.11, 4.16
4.20	Measurement Power	None
4.21	FM/FM	Pre - 4.11 Post - 4.11, 4.16
4.22	RACS	4.19
4.23	Measurement Profile	4.17, 4.22
4.24	DC Signal Conditioner	None
4.25	Spurious Emissions	4.8, 4.16
4.26	Range Safety Antennas	4.2
4.27	Command Receiver	4.19
4.28	Range Safety Systems	Pre - 4. 27 Post - 4. 26, 4.27
4.29	Hydraulics	4.8
4.30	Hydraulic Checkout Valve	4.8
4.31	Thrust Vector Control	4.29.1, .2, .3, .4, .5
4.32	GN_2 Control System	4.8, 4.34
4.33	GN_2 Purge System	4.8
4.34	Pressure Switches	4.8
4.35	LOX Dome Purge	4.8
4.36	Prefill	4.35

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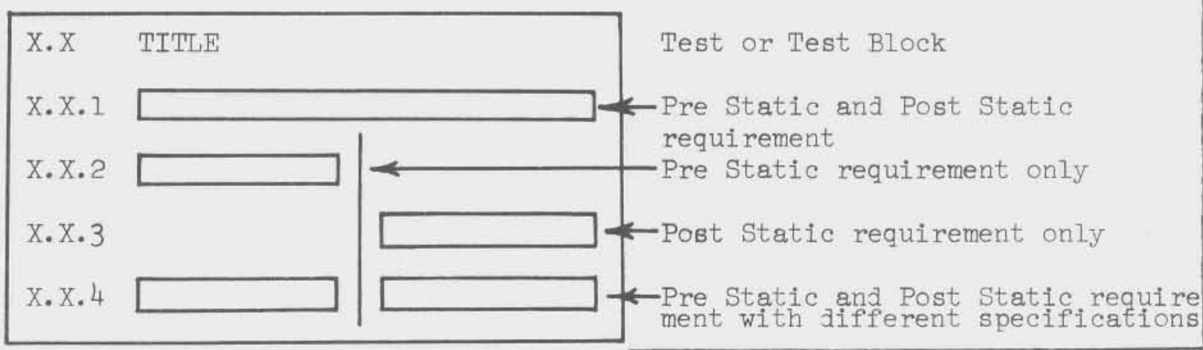
4.0 (Continued)

4.37	Cocoon Purge	4.8
4.38	GOX Flow Control Valve	4.42
4.39	LOX Pressurization High Pressure	None
4.40	LOX Pressurization Low Pressure	4.39
4.41	Fuel Pressurization	4.32
4.42	LOX Tank	4.18,4.34,4.40,4.49
4.43	Fuel Tank	4.18,4.34,4.41,4.50
4.44	Thrust Chamber	None
4.45	Turbine Exhaust	None
4.46	Turbopump Torque	None
4.47	Engine Components	4.29.1,.2,.3,.4,.5,4.32, 4.37
4.48	Stage Components General	4.15,4.32,4.34,4.40,4.41
4.49	Stage Components - GN_2	4.32
4.50	Stage Components - Helium	4.32,4.41
4.51	Electromagnetic Compatibility Conducted	4.9,4.10,4.13,4.14,4.15, 4.21,4.23,4.28,4.33,4.35, 4.36,4.37,4.42,4.43,4.47
4.52	Overall Test - General	Pre - 4.9,4.10,4.13,4.14, 4.15,4.23,4.28,4.33,4.35, 4.36,4.37,4.42,4.43,4.47, 4.48,4.49,4.50 Post - 4.51
4.53	Overall Test - LOX Pressure	Pre - 4.34,4.49 Post - 4.18,4.34,4.40,4.49
4.54	Overall Test - Fuel Pressure	Pre - 4.34,4.49 Post - 4.18,4.34,4.41,4.50
4.55	Engine Alignment	None
4.56	Disconnect from Facility	None
4.57	Shipping Inspection	Pre - 4.56 Post - 4.56,4.58
4.58	Stage Weighing	4.56
4.59	Remove from Test Facility	Pre - 4.56 Post - 4.57

A special format is used in this section. The following illustration defines the format.



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4.1 RECEIVING INSPECTION

4.1.1 The Intermediate 20 S-IC Stage shall be mounted horizontally on its' transporter when it arrives at the test stand/test cell. A visual inspection of the stage will be made for apparent damage, for verification of stage component status including instrument canister covers installed, assurance that all interstage cables are properly mated and to verify that stage openings are protected to maintain the required cleanliness levels.

4.1.2 The transporter mounted propellant tank pressure control and monitor system shall have maintained the fuel and LOX tanks under positive pressure during transit.

Verify desiccant filters installed on propellant tanks.

4.1.3 A continuity check of stage lines and cables will be accomplished to verify stage assembly and insure readiness for testing. This includes a visual check for disconnected "B" nuts and flange bolts, defective fasteners, and damage to shielding and insulation.

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4.2 INSTALLATION IN TEST FACILITY

4.2.1 The stage and transporter shall be positioned adjacent to the stand. The LOX and fuel tank pressure shall be monitored to determine that they are above 2.0 PSIG. The transporter mounted propellant tank pressure control and monitor system shall be disconnected. The stage shall be lifted and rotated to a vertical position. Then it shall be lowered into the test stand. The holddown support horizontal load supports shall be connected to the stage attach fittings. The LOX and fuel tanks shall be maintained at a positive pressure. The forward stabilization system shall be installed.

The stage and transporter shall be positioned in the test cell.

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4.3 CONNECTION TO TEST FACILITY

4.3.1 SE cleanliness shall be verified by an analysis of gas from the SE prior to connecting to the Intermediate 20 S-IC Stage. Lines from SE, at the SE/Stage Interface, for the stage LOX, control and helium areas shall be blown down and given hydrocarbon content determination, dew-points analysis and particle count sampling per MSFC-SPEC-164. Lines at the SE/Stage Interface for the Stage fuel areas shall be blown down and given dewpoint analysis and particle count sampling. Hydraulic lines shall receive contamination level sampling per 60B32086. A visual inspection to verify that contamination prevention covers and seals are installed on the SE and Stage and to verify from records that Stage and SE cleanliness requirements have been met shall be conducted after Stage installation in the test stand/test cell. Stage to SE connection will be made to provide pneumatic power, electrical power and electrical control to the systems and components.

4.3.2 Personnel platforms and bulkhead protective covers will be installed in the forward skirt and intertank area and access ladders will be installed in the thrust structure. The work platforms, both internal and external, will be placed into position relative to the Stage.

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4.4 FORWARD ENVIRONMENTAL CONTROL

4.4.1 Verify FECU is operating anytime power is applied to telemetry transmitters or LOX loading electronics and when LOX is onboard.

4.4.2 Verify FECU is capable of providing conditioned air at the following pressure and temperature as measured at the ground side of umbilical:

a. 0.32 to 2.0 PSIG

b. 65 ± 5°F (Used when LOX is not onboard)
80 ± 10°F (Used when LOX is loaded)

4.4.3 *Verify temperature of conditioned air provided by the FECU does not exceed 65°F as measured at the umbilical.

4.4.4 *After FECU output temperature verification, verify pressure at umbilical simulator coupling 55YC1 is within ± 20% of graph value, Figure 4-1, corresponding to an input flowrate of not less than 10 lb/min. Record pressure measured at umbilical.

4.4.5 *After FECU output temperature verification, verify pressure at umbilical simulator coupling 55YC2 is within ± 20% of graph value, Figure 4-1, corresponding to an input flowrate of not less than 5 lb/min. Record pressure measured at umbilical

4.4.6 With canister covers installed and FECS operating, verify flow out of each canister outlet.

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4.5 AFT ENVIRONMENTAL CONTROL

4.5.1 Verify AECU is operating when LOX is loaded.

4.5.2 Verify AECU is capable of providing conditioned air or GN_2 to maintain temperature at battery location in thrust structure at $75 \pm 15^{\circ}F$.

4.5.3 Verify AECU provides flow by feeling for flow from each orifice outlet.

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4.6 STAGE RESISTANCE

4.6.1 Prior to connection of Support Equipment to the stage, measure the resistance between each stage bus and stage common, and between each of the stage busses. Record all measurements and evaluate data for indications of any possible short circuits in stage wiring between busses and common, or between busses.

4.6.2 After connection of Support Equipment to the stage, but prior to application of stage power, repeat the stage bus resistance measurements. Record all measurments and evaluate data for indications of any possible short circuits in stage and support equipment wiring between busses and common or between busses.

4.6.3 After the support equipment has been connected to the stage, measure the resistance of the aft compartment thermistors at the GSE and the ambient temperature of the aft compartment. Verify that the measured resistance values are within + 150 ohms of a value which is four times the resistance taken from the Temperature Resistance Characteristic curve at the measured aft compartment temperature. See Figure 4-2.

4.6.4 * Verify Wind Load Measurement strain bridge DC resistance is 350 ± 7 ohms. With support equipment connected, verify continuity of each measurement.

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4.7 CRITICAL POWER DISTRIBUTION

4.7.1 With stage power off remove power connectors from the following stage components.

a. FM/FM assembly 115A400
b. PCM/DDAS assembly 115A404
c. F1 RF assembly 120A409
d. P1 RF assembly 120A405
e. DC Power Isolator 115A414
f. Remote Digital Submultiplexer 115A413
g. PCM multiplexer 115A403
h. Range Safety Receiver 120A986
i. Range Safety Receiver 120A987
j. Range Safety Decoder 120A958
k. Range Safety Decoder 120A959
l. Measuring Power Supply 115A11
m. Measuring Power Supply 115A12
n. LOX Residual Electronics 120A942
o. LOX level Electronics 120A939
p. LOX Loading Electronics 120A943
q. Fuel Level Electronics 115A967
r. Fuel Loading Electronics 115A966
s. LOX Cutoff Sensors 118A1 thru 118A5
t. LOX Cutoff Sensor 118A36
u. Fuel Cutoff Sensor 115A76

4.7.2 Apply stage power systematically to each component listed in 4.7.1 and verify each connector provides 28 ± 4 VDC of proper polarity at only the correct pin location. Reference paragraph 4.8 for power application requirements.

4.7.3 With stage power off reinstall power connectors removed in 4.7.1 above.

4.7.4 With stage power off install power interrupt units to the following components.

a. LOX Residual Electronics 120A942
b. LOX Level Electronics 120A939
c. LOX Loading Electronics 120A943
d. Fuel Level Electronics 120A967
e. Fuel Loading Electronics 120A966
f. LOX Cutoff Sensor 118A1 thru 118A5
g. LOX Cutoff Sensor 118A36
h. Fuel Cutoff Sensor 118A76
i. Rate Gyros 120A590, 120A591, and 120A592

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4.8 POWER APPLICATION

4.8.1 *Apply power to Stage Status Bus 1D119, verify bus voltage is 28.0 $\pm$ 4.0 VDC and monitor stage discrete indications for correct response.

4.8.2 *Verify that all direct connected loads are switched off and apply power to External Busses 1D111 and 1D211. Verify busses 1D111, 1D211, 1D11, 1D119 and 1D21 voltages are 28.0 $\pm$ 1.0 VDC and monitor stage discrete indications for correct response.

4.8.3 *Apply power to Measuring Power Supplies, verify bus 1D29 voltage is 28.0 $\pm$ 1.0 VDC and monitor stage discrete indications for correct response. Verify busses 1D81 and 1D82 voltages are 5.00 $\pm$ 0.05 VDC.

4.8.4 *Apply power to stage measuring RACKS, verify bus 1D23 voltage is 28.0 $\pm$ 1.0 VDC and monitor stage discrete indications for correct response.

4.8.5 *Apply power to subsidary bus 1D28, verify bus voltage is 28.0 $\pm$ 1.0 VDC and monitor stage discrete indications for correct response.

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4.9 POWER REMOVAL

Remove power from the stage using the following sequence after verifying that the stage is on external power.

4.9.1 Remove power to subsidary bus 1D28, verify voltage is 0.0 $\pm$ 1.0 VDC and monitor stage discrete indications for correct response.

4.9.2 Remove power from Measuring Power Supplies, verify that bus 1D29 voltage is 0.0 $\pm$ 1.0 VDC and that busses 1D81 and 1D82 voltage is 0.0 $\pm$ 1.0 VDC Monitor stage discrete indications for correct response.

4.9.3 Remove power from stage measuring RACKS, verify bus 1D23 voltage is 0.0 $\pm$ 1.0 VDC and monitor stage discrete indications for correct response.

4.9.4 Verify that all direct connected loads are off. Remove power from external busses 1D111 and 1D211, verify voltages are 0.0 $\pm$ 1.0 VDC and monitor stage discrete indications for correct response. Verify busses 1D11, 1D21, 1D10, and 1D20 voltages are 0.0 $\pm$ 1.0 VDC.

4.9.5 Remove power from stage status bus 1D119, verify bus voltage is 0.0 $\pm$ 1.0 and monitor discrete indications for correct response.

4.9.6 Remove power from stage main bus 1D110 and verify zero voltage.

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4.10 POWER TRANSFER

The requirements of 4.8 (Power Application) will be accomplished immediately prior to execution of this paragraph.

4.10.1	Apply power to Telemetry Calibrator, F1 Telemetry, and P1 Telemetry. Monitor stage discrete indications for correct response.	*Apply power to Telemetry Calibrator, F1 Telemetry, and P1 Telemetry. Monitor stage discrete indications for correct response.

4.10.2 *With the stage on external power apply power to stage battery busses 1D10 and 1D20, verify bus voltages are 28.0 + 4.0/-2.0 VDC. Monitor stage discrete indications for correct response.

4.10.3 *Command power transfer switch to internal position with all stage systems on except Range Safety, monitor stage discrete indications for correct response.

4.10.4 *Remove power from stage external busses 1D111 and 1D211, verify voltages are 0.0 + 1.0 VDC. Verify busses 1D81 and 1D82 voltages are 5.00 ± 0.05 VDC, buss 1D119 voltage is 28.0 + 4.0 VDC and all other buss voltages are 28.0 ± 1.0 VDC. Monitor stage discrete indications for correct response.

4.10.5 *Apply power to stage external busses 1D111 and 1D211, verify voltages are 28.0 + 4.0/-2.0 VDC.

4.10.6 *Command power transfer switch to external position with all stage systems on except Range Safety. Monitor stage discrete indications for correct response.

4.10.7 *Remove power from stage internal busses 1D10 and 1D20, and verify 1D10, 1D20, 1D12, and 1D22 voltages are 0.0 ± 1.0 VDC. Verify busses 1D81 and 1D82 voltages are 5.00 ± 0.05 VDC, buss 1D119 voltage is 28.0 ± 4.0 VDC, and all other buss boltages are 28.0 ± 1.0 VDC. Monitor stage discrete indications for correct response.

4.10.8	Remove power to Telemetry Calibrator, F1 Telemetry, and P1 telemetry. Monitor stage discrete indications for correct response.	*Remove power to Telemetry Calibrator, F1 Telemetry, and P1 Telemetry. Monitor stage discrete indication for correct response.

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4.11 BUS VOLTAGE

4.11.1 *With the stage on external power, verify bus voltage levels as follows:

a. Verify busses 1D119, 1D111, 1D211, 1D11, 1D21, 1D23, and 1D29 voltage levels are 28.0 ± 1.0 VDC.
b. Verify busses 1D81 and 1D82 voltage levels are 5.00 + 0.05 VDC.
c. Verify busses 1D10, 1D20, 1D12, and 1D22 voltage levels are 0.0 ± 1.0 VDC.

4.11.2 *With the stage on internal power, verify bus voltage levels as follows;

a. Verify busses 1D119, 1D10, 1D20, 1D11, 1D21, 1D23, 1D29, 1D12, and 1D22 voltage levels are 28.0 + 1.0 VDC.
b. Verify busses 1D81 and 1D82 voltage levels are 5.00 ± 0.05 VDC.
c. Verify busses 1D111 and 1D211 voltage levels are 0.0 ± 1.0 VDC.

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4.12 STAGE SEQUENCING

4.12.1 *With a Stage Select command, set all ones Logic in the Input Register and verify the Verification Register contains all zeros logic.

4.12.2 *With all ones logic in the Input Register, command Switch Selector reset and verify the Verification Register contains all ones logic.

4.12.3 *Verify no switch selector response when an all ones logic is set in the Input Register without Stage Select command.

4.12.4 *With stage select commands, set primary address codes of switch selector functions in the Input Register and verify correct Verification Register logic. With Read commands verify correct switch selector output for the following functions:

a. Telemetry calibrate
b. Telemetry calibrate reset.
c. Enable engine out (thrust not OK)
d. Helium flow control valve #2
e. Helium flow control valve #3
f. Helium flow control valve #4
g. Two-Four engine cutoff
h. Two-Four engine cutoff backup
i. Enable One-Three engine cutoff
j. Enable One-Three engine cutoff backup
k. Arm EBW firing units (Sep. and Retro.)
l. Arm EBW firing units backup (Se. and Retro.)
m. Fire EBW firing units (Sep. and Retro.)
n. Fire EBW firing units backup (Sep. and Retro.)
o. Enable auto. abort (two adjacent engines out)
p. Command One-Three engine cutoff
q. Command One-Three engine cutoff backup
r. Enable fuel vent and relief pressure switch

4.12.5 *With stage select commands, set complement address codes of switch selector functions in the Input Register and verify correct Verifications Register logic. With Read commands verify correct switch selector inputs for the same functions specified in 4.12.4 above.

4.12.6 *Verify switch selector telemetry calibrate reset capability by sequence and control distributor reset command with lift off relay energized.

4.12.7 *Verify switch selector telemetry calibrate reset does not reset other switch selector outputs with liftoff relay energized.

4.12.8 *Verify sequence and control distributor reset command does not reset telemetry calibrate command with liftoff relay de-energized.

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4.13 STAGE SEPARATION

4.13.1 *Verify the two separation EBW firing units and the two retro-rocket EBW firing units monitor measurements indicate 4.2 ± .4 VDC within 1.5 seconds after a primary ARM command.

4.13.2 *Verify the two separation EBW firing units and the two retro-rocket EBW firing units monitor measurements indicate 4.2 ± .4 VDC within 1.5 seconds after a backup ARM command.

4.13.3 *Verify the No.1 separation and retro-rocket EBW firing units produce pulse accept indications and monitor measurements indicating less than 0.6 VDC upon receipt of the primary FIRE Command.

4.13.4 *Verify the No.2 separation and retro-rocket EBW firing units produce pulse accept indications and monitor measurements indicating less than 0.6 VDC upon receipt of the backup FIRE command.

4.13.5 *With EBW firing units unarmed verify pulse accept indications are not produced upon receipt of a FIRE command.

4.13.6 *Verify EBW firing unit monitor measurements indicate less than 0.6 VDC within 20 seconds after removal of an ARM command.

4.13.7 *Verify the primary liftoff relay inhibits arming No.1 separation and retro-rocket EBW firing units.

4.13.8 *Verify the backup liftoff relay inhibits arming No.2 separation and retro-rocket EBW firing units.

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4.14 ENGINE CUTOFF

Verify all possible combinations of cutoff signals and enable in each mode of engine cutoff. Verify engine cutoff does not occur without all correct signals and enables.

4.14.1 *Support Equipment - Verify support equipment commands cutoff each engine.

4.14.2 *Thrust Not OK - Verify engine cutoff does not occur by any one thrust not OK signal. Verify two thrust not OK signals on the same engine cutoff their corresponding engine.

4.14.3 *One/Three LOX Level - Verify engine cutoff does not occur by any one dry LOX Level sensor. Verify two dry outboard LOX level sensors cutoff engines 1 and 3.

4.14.4 *One/Three Fuel Level - Verify engines1 and 3 cutoff by any one dry fuel level sensor. Verify two dry fuel level sensors cutoff engines 1 and 3.

4.14.5 *Command One/Three Cutoff - Verify engines 1 and 3 cutoff occurs by either primary or backup IU One/Three commands.

4.14.6 *One/Three LOX Level Backup - Verify engine cutoff does not occur by any one dry LOX level sensors. Verify two dry LOX level sensors cut off engines 1 and 3.

4.14.7 *One/Three Fuel Level Backup - Verify engines 1 and 3 cut off by any one dry fuel level sensor. Verify two dry fuel level sensors cut off engines 1 and 3.

4.14.8 *Command Two/Four Cutoff - Verify engines 2 and 4 cutoff occurs by either primary or backup IU Two/Four commands.

4.14.9 *Instrument Unit/EDS - Verify engine cutoff does not occur by any one IU command. Verify two IU commands cutoff all engines.

4.14.10 *Range Safety - Verify engine cutoff does not occur by any one Range Safety cutoff command. Verify two Range Safety cutoff commands cutoff all engines

4.14.11 *Adjacent Engine Out - Verify engine cutoff does not occur by any one outboard engine out. Verify two adjacent outboard engines out cutoff all remaining engines.

4.14.12 *In any mode of cutoff utilizing series relay contacts, verify each contact for correct response.

4.14.13 *Verify Engine Cutoff timers function within the following tolerences:

a.	Outboard LOX Level	1.200 + 0.034 seconds
b.	Outboard LOX Level Backup	1.200 ∓ 0.034 seconds
c.	Outboard Fuel Level	2.100 ∓ 0.052 seconds
d.	Outboard Fuel Level Backup	2.100 ∓ 0.052 seconds
e.	Thrust Not Ok	0.044 ∓ 0.010 seconds

4.14.14 Verify the Static Test Stop Solenoid Backup valves open when de-energized.

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4.15 ELECTRICAL HEATERS

4.15.1 *Verify LOX Fill and drain valve heater current is 1.75 + 0.5 AMPS/Valve when heaters are on and thermostats turn heaters on at 50°F or above and turn heaters off at 150°F or below.

4.15.2 *Verify thermostats for servoaccelerometer heaters located in unit 118 turn heaters on at 100°F or above and turn heaters off at 200°F or below.

4.15.3 *Verify turbopump bearing heater current is 12.5 + 2.5 AMPS/ENG when heaters are on and thermostats turn heaters on at 65°F or above and turn heaters off at 180°F or below.

4.15.4 *Verify thermostats for servo-accelerometer heaters located in unit 120 turn heaters on at 100°F or above and turn heaters off at 200°F or below.

4.15.5 *Verify thermostats for rate gyro heaters turn heaters on at 50°F or above and turn heaters off at 130°F or below.

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4.16 TELEMETRY ANTENNAS

4.16.1 With the coaxial switch de-energized, verify the VSWR measured at the output of the multi-coupler is 2.0: 1 or less at frequencies of 256.2 MHz ± 25.6 KHz and 244.3 MHz ± 24.4 KHz.

4.16.2 With the coaxial switch energized and umbilical and auxiliary outputs terminted, verify the VSWR measured at the output of the multicoupler is 2.0:1 or less at frequencies of 256.2 MHz ± 25.6 KHz and 244.3 ± 24.4 KHz.

4.16.3 With the coaxial switch energized, apply 256.2 MHz ± 25.6 KHz to the Fl link input. Verify the attenuation measured at the umbilical and auxiliary outputs is 28.5 db maximum.

4.16.4 *Verify the VSWR of each antenna, as measured at the antenna input connector is 2.0:1 or less at frequencies of 256.2 MHz and 25.6 KHz and 244.3 MHz ± 24.4 KHz.

4.16.5 *Verify the attenuation of the antenna system is within the limits of, and does not exceed (by more than 1 db) the values recorded during the subsystem bench test performed prior to installation.

4.16.6 *Verify the input VSWR of the Fl telemetry link is 2.0:1 or less at a frequency of 256.2 MHz ± 25.6 KHz.

4.16.7 *Verify the input VSWR of the Pl telemetry link is 2.0:1 or less at a frequency of 244.3 MHz ± 24.4 KHz.

4.16.8 *Verify the phasing of the antenna feed cables is ± 15 electrical degrees or less.

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4.17 STRAIN GAGE PRESSURE TRANSDUCER

With stage system pressure at ambient, obtain calibration data for Boeing strain gage pressure transducers during Level I checkout per the following criteria.

4.17.1 Record Run Mode, High and Low calibrate modes of amplifier inputs (transducer output) and DDAS output. Record multiplexer zero DC offset.

4.17.2 Multiply each amplifier input value by nominal gain of 125 and where applicable add 2.50 VDC. Record each value plus DC offset as stage computed values.

4.17.3 Verify each computed value is within ± 0.050 VDC of its' corresponding measured DDAS output.

4.17.4 Verify computed Run mode values for D119-101 thru D119-104 are within ± 0.360 VDC of ODIS Run estimate values. Verify computed Run mode values for remaining measurements are within ± 0.150 VDC of ODIS Run estimate values.

4.17.5 Compute ODIS data as follows:

a. HCHP = Computed Stage High
b. LCHP = Computed Stage Low
c. RUNMDE = Computed Stage Run

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4.18 LIQUID LEVEL INITIALIZATION

4.18.1 Verify or adjust alignment of the LOX level electronics with associated probes to obtain the following indications:

a. Run mode discrete reads 0000
Continuous reads 0000110010 ± 2 counts

b. LO CAL mode discrete reads 0101
Continuous reads 00001001010 ± 4 counts

c. HI CAL mode discrete reads 1011
Continuous reads 1100111110 ± 24 counts

4.18.2 Verify or adjust alignment of LOX residual electronics with associated probe to obtain the following indications.

a. Run mode discrete reads 0000
Continuous reads 0011011101 ± 4 counts

b. LO CAL mode discrete reads 0101
Continuous reads 0011110101 ± 4 counts

c. HI CAL mode discrete reads 1011
Continuous reads 1111101001 + 21/- 24 counts

4.18.3 Verify LOX and fuel loading alignment of electronics with associated probes per the following indications.

a. Run mode

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4.18.3 (Continued)

Continuous indication
Cycle between full scale and zero.
Reference voltage indication is 20.0 ± 0.1 VDC.
Lock indication is 5.0 ± 0.5 VDC.
Overfill sensor indicates out of liquid.

b. LO CAL

Continuous indication is 6.0 ± 0.2 VDC.
Reference is 20.0 ± 0.1 VDC.
Lock indication is 0.0 ± 0.5 VDC.

c. HI CAL

Overfill sensor indicates in liquid.

NOTE: Fuel loading probe will have to be modified and requirements may change by new design.

4.18.4 Verify or adjust alignment of fuel level electronics with associated probes to obtain the following indications:

a. Run mode discrete reads 0000
Continuous reads 0 000 110 010 ± 2 counts

b. LO CAL mode discrete reads 0101
Continuous reads 0 001 001 001 ± 4 counts

c. HI CAL mode discrete reads 1011
Continuous reads 1 100 110 010 ± 24 counts

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4.19 PCM/FM AND PCM/DDAS

4.19.1 *Verify the PCM/FM RF assembly power output is 25 ± 10 watts.

4.19.2 *Verify the PCM/FM upper bandedge is 244.33600 MHz ± 27.40 KHz and lower bandedge is 244.26400 MHz ± 27.40 KHz. Verify the bandedge difference is 72 KHz ± 6 KHz.

4.19.3 *Verify the PCM/DDAS 600 KHz VCO signal strength is greater than 5.0 volts peak-to-peak.

4.19.4 *Verify the PCM/DDAS clock rate is 72000 ± 25 Hz.

4.19.5 Verify the PCM/DDAS upper bandedge is 635 KHz ± 10 KHz and lower bandedge is 565 KHz ± 10 KHz. Verify bandedge difference is 70 ± 10 KHz.

4.19.6 Verify one master frame of AO multiplexer data in the PCM/DDAS wavetrain occurs in 83.333 ms ± 0.029 ms. Verify one master frame of BO multiplexer data in the PCM/DDAS wavetrain occurs in 83.333 ms ± 0.029 ms.

4.19.7 *Verify the PCM/DDAS multiplexer identification and reference format is as follows: Note: Errors are not allowed in sync. checks.

(a) Channel 28A and 28B

Frames 1-9, 11-19, 21-29 ..... 0 000 011 000 ± 4 counts
Frame 10, 20, 30 .... 1 111 100 111 ∓ 4 counts

(b) Channel 29A

Frames 1-30 .... 1 111 100 111 ± 4 counts

4.19.8 *Verify the PCM/DDAS sync and identification format is as follows without errors:

(a) Channel 29B

Frames 1-29 .... 1 011 011 110
Frame 30 .... 0 100 100 001

(b) Channel 30A

Frames 1-29 .... 1 010 001 001
Frame 30 .... 0 101 110 110

(c) Channel 30B

Frames 1-29 .... 1 100 000 110
Frame 30 .... 0 011 111 001

4.19.9 *Verify the PCM/DDAS system provides inflight calibration, with respect to multiplexers, that is within ± 45 millivolts of the five standard calibration levels.

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4.19.10 *Verify the PCM/DDAS system provides inflight calibration, with respect to pre-sampling filter channels, that is within ± 150 millivolts of the five standard calibration levels. Voltage transients on the calibration waveforms may be ignored.

4.19.11 *Verify the PCM/DDAS system provides linearity with respect to all pre-sampling filter and non-pre-sampling filter channels per the following voltages.

MULTIPLEXER INPUT (VDC)	PRE-SAMPLING FILTER CHANNEL DDAS OUTPUT (VDC)	NON-PRE-SAMPLING FILTER CHANNEL OUTPUT
0.000 ± .002	0.000 ± 0.075	0.000 ± 0.035
1.250 ± .002	1.250 ± 0.085	1.250 ± 0.035
2.500 ± .002	2.500 ± 0.094	2.500 ± 0.035
3.750 ± .002	3.750 ± 0.104	3.750 ± 0.035
5.000 ± .002	5.000 ± 0.113	5.000 ± 0.035

4.19.12 *Verify the external calibrator preflight calibration levels are within ± 20 millivolts of the five standard calibration levels.

4.19.13 *Verify the PCM/DDAS system provides multiplexer repetition rates of 3600 ± 1.75 pps for each multiplexer.

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4.20 MEASUREMENT POWER

Adjust stage measurement power supplies if required by paragraph 4.19.7 per the following:

4.20.1 With stage instrumentation systems on, verify 115A11 measurement voltage at telemetry calibrator input is 5.00 ± 0.010 VDC. If the measured voltage is out of tolerance, adjust 115A11 power supply to obtain 5.000 ± 0.005 VDC at calibrator input.

4.20.2 With stage instrumentation systems on verify 115A12 measurement voltage at Power Distributor is 5.000 ± .010 VDC. If the measured voltage is out of tolerance, adjust 115A12 power supply to obtain 5.000 ± 0.005 VDC.

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4.21 FM/FM

4.21.1 *Verify the FM/FM RF assembly power output is 25 ± 10 watts.

4.21.2 *Verify the FM/FM center frequency is 256.2000 MHz ± 25.62 KHz.

4.21.3 *Verify SCO Linearity is 1% of it's design bandwidth for five constant input levels supplied by the airborne telemetry calibrator in the preflight mode. Verify that each SCO bandedge is within the limits of ± 1 Hz (or ± 1% of its bandwidth whichever is greater).

4.21.4 *Verify the pre-emphasis of each SCO is ± 10% of the amplitude obtained for a comparable deviation produced by a reference signal generator at the RFTE.

4.21.5 *Verify the response of each SCO to inflight calibration mode is within + 100 MV of corresponding values obtained from static (preflight) input levels supplied by the airborne telemetry calibrator.

4.21.6 *Verify the response of SCO measurements through the F1 RF assembly as follows:

a. Verify the response of each measurement (except tachometer measurements) is within ± 3% of the corresponding PCM/RF response in High and Low Calibrate modes. Verify at least 1.0 volt difference in response to High and Low Calibrate modes for each measurement.

b. Verify the response of each tachometer measurement to High Calibrate mode is 100 Hz ± 3 Hz.

4.21.7 *Verify the telemetry inflight calibration sequence occurs as follows:

Cal Period 1 - No Calibration
Cal Period 2 - Link F1 SCO Calibration -
- Mux Ao Internal Calibration
Cal Period 3 - Mux Ao filter Calibration
Cal Period 4 - No Calibration
Cal Period 5 - Mux Bo internal Calibration
Cal Period 6 - Mux Bo filter Calibration

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4.22 RACS VERIFICATION

4.22.1 Establish profiles for DDAS measurements with RAC's capability by averaging 32 samples of each measurement when all measurements are switched as follows:

a. Run mode to high calibrate mode
b. Run mode to low calibrate mode
c. High calibrate mode to run mode

4.22.2 Command each measurement individually to the switching modes of 4.22.1 above. Verify Rate Gyro measurements are within ± 3.0 percent full scale of the corresponding switching mode profile. Verify other measurements are within ± 0.8 percent full scale of their correspond switching mode profile.

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4.23 MEASUREMENT PROFILE

4.23.1 *Read all stage measurements as follows:

a. Monitor flight instrumentation available through DDAS.

b. Monitor flight instrumentation available through hardwire.

c. Monitor LOX Loading measurements.

d. Monitor Fuel Loading measurements.

4.23.2 *Verify stage measurements as follows with exceptions and considerations of paragraph 4.23.3.

a. Verify measurements with RACS capability in high calibrate mode are within ± 2 percent full scale of bench established predicted values, or corrected values established by approved Level I calibration procedures.

b. Verify measurements with RACS capability in low calibrate mode are within ± 2 percent full scale of bench established predicted values, or corrected values established by approved Level I calibration procedures.

c. Verify measurements in run (ambient) mode are within ± 5.0 percent full scale of bench established predicted values, or corrected values established by approved Level I calibration procedures.

4.23.3 *As a special case the following exceptions and considerations are acceptable.

a. Analog K measurements derived from 28 volts through voltage divider networks are acceptable when they are within ± 10 percent full scale of predicted values.

b. Verify LOX cutoff, Fuel cutoff, and Thrust OK measurements are identical to predicted values for 32 out of 32 samples.

c. Time correlation measurements are acceptable if the voltage difference of 2 samples taken 10 milliseconds apart is greater than 0.50 volts and less than 0.75 volts.

d. Rate gyro measurements deviate from high and low calibrate mode predicted values as follows:

(1) High calibrate decreases 85 millivolts for each volt decrease at calibrate input and increases 85 millivolts for each volt increase at calibrate input.

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4.23.3 (Continued)

(2) Low calibrate increases 85 millivolt for each volt decrease at calibrate input and decreases 85 millivolts for each volt increase in calibrate input.

(3) Rate Gyro measurements are acceptable when they are within ± 3% full scale of bench or corrected values.

e. Verify LOX and Fuel Loading Electronics measurements as follows:

(1) Verify continuous voltage measurements are within ± 1 percent full scale of predicted values.

(2) Verify reference voltage measurements are within ± 0.5 percent full scale of predicted values.

(3) Verify lock indication measurements are within ± 10 percent full scale of predicted values.

(4) Verify overfill indication measurements are identical to predicted values for 32 out of 32 samples.

f. Strain gage pressure measurements are acceptable with the following consideration known as the Delta Function.

R1, H1 and L1 and Run, High, and Low calibrate predicted values (ODIS data).

R2, H2, and L2 and Run, High, and Low calibrate actual measured values.

(1) For acceptance R2 must equal R1 within ± 0.250 VDC.

(2) R2-R1 defines Δ

(3) For acceptance H2 must equal H1 plus Δ within ± 0.100 VDC.

(4) For acceptance L2 must equal L1 plus Δ within ± 0.100 VDC.

g. In the event that engine strain gage pressure measurements are not acceptable with Delta Function considerations using ODIS predicted values, engine log book calibration data will be used in computing Delta Functions.

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4.23.3 Continued

h. Differential pressure measurements D119-101 through D119-104 are acceptable when run mode values are within ±.36 VDC of predicted values.

4.23.4 *Verify LOX and fuel loading measurements respond to RACS commands without a PTCS Inhibit and do not respond to RACS commands with PTCS Inhibit applied.

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4.24 DC SIGNAL CONDITIONER ADJUST

Adjust any DC signal conditioner found out of tolerance in paragraph 4.23 to ± .5% of full scale of bench test values.

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4.25 SPURIOUS EMISSIONS

4.25.1 . *Measure antenna conducted emissions of the following transmitters over a frequency range of 0.150 MHz to 10,000 MHz.

a. FM/FM telemetry transmitter
b. PCM/FM telemetry transmitter

Verify power levels of harmonic and spurious emissions appearing outside a 1.0 MHz ($\pm$ 500 KHz) bandwidth are down from the unmodulated carrier by an amount determined by the following equation; where P is the measured power level in watts of the transmitter fundamental frequency:

$$db = 55 + 10 \, Log_{10} P$$

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4.26 RANGE SAFETY ANTENNAS

4.26.1 *Verify the VSWR of each Range Safety Antenna as measured at the antenna input connector is 1.5:1.0 or less at 450 MHz ± .03 MHz.

4.26.2 *Verify the attenuation of the antenna subsystem is within the limits of and does not exceed (by more than 1 db) the values recorded during the subsystem bench test performed prior to installation of the stage.

4.26.3 *Verify the input VSWR of the Range Safety Antenna Subsystem as measured at the receiver input connection is 1.5:1.0 or less at 450 MHz ± .03 MHz.

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4.27 COMMAND RECEIVER

4.27.1 *System RF Threshold Sensitivity - Verify that the RF threshold level does not exceed 5 microvolts at the receiver input, for both "Arm and Cutoff" and "Propellant Dispersion" commands transmitted with ± 60 KHz deviation.

4.27.2 *System Deviation Threshold Sensitivity - Verify that the deviation threshold level does not exceed ± 50 KHz, for both "Arm and Cutoff" and "Propellant Dispersion" commands transmitted at an RF level of 150 microvolts at receiver input.

4.27.3 *Limiter Test Voltage - Measure and record the low level signal strength values corresponding to receiver input RF levels successively incremented at 5 dbm intervals from -120 dbm to -40 dbm. Repeatability based on two runs shall be within ± 3% full scale.

4.27.4 *RF Bandwidth - Verify that the RF bandwidth is 340 + 30 KHz at the -3 db level centered at 450 MHz ± 34 KHz and 1.2 MHz maximum at the -60 db level.

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4.28 RANGE SAFETY SYSTEMS

4.28.1 *Apply external power to range safety systems and verify correct response.

4.28.2 *Operate each range safety system individually in the closed loop (coaxial cable) external power mode. Verify firing unit arming and adequate firing pulses occur for each system interrogated with a correct sequence of A/FCO and PD commands at an RF level of -93 $\pm$ 3 dbm.

4.28.3 *Verify firing unit arming and adequate firing pulses do not occur when each system is interrogated at RF levels of -53 $\pm$ 3 dbm under each of the following conditions:

(a) Controller inhibits ON
(b) A/FCO and PD commands out of sequence
(c) Incorrect address codes
(d) Incorrect function commands

4.28.4 *With range safety systems on external power apply power to stage internal busses. Transfer range safety systems to internal power and verify correct response.

4.28.5 *Operate each range safety system simultaneously in the open loop (antenna) internal power mode. Verify engine cutoff firing unit arming and adequate firing pulses occur when both systems are interrogated with a correct sequence of A/FCO and PD commands.

4.28.6 *Verify EBW firing unit monitor measurements indicate 4.2 $\pm$ .4 VDC within 1.5 seconds of an A/FCO command.

4.28.7 *Verify EBW firing unit monitor measurements indicate less than 0.6 VDC within 20 seconds after removal of an A/FCO command.

4.28.8 *Command both Range Safety Receivers to external power closed loop modes with inhibits off. Command all stage RF systems on in the open loop mode.

4.28.9 *Interrogate the Range Safety System at RF levels of -93 $\pm$ 3 dbm at receiver inputs. Verify correct responses for A/FCO and PD commands transmitted in sequence with correct address codes.

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4.28.10 *Interrogate the Range Safety System at RF levels of -93 $\pm$ 3 dbm at receiver inputs. Verify no system response for non-functional commands.

4.28.11 *Interrogate the Range Safety System at RF levels of -53 $\pm$ 3 dbm at receiver inputs. Verify no system response with commands transmitted with incorrect codes. Verify proper response for functional commands transmitted out of sequence.

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4.29 HYDRAULICS

4.29.1 Verify stage and ground hydraulic systems cleanliness prior to admitting hydraulic fluid to servoactuator servovalves as follows. Open servoactuator pre-filtration bypass valve on each servoactuator, apply ground hydraulic fluid to the stage and inspect hydraulic systems for leakage, adjust ground hydraulic pressure to provide maximum flow through stage but do not exceed 2100 PSIG at hydraulic supply umbilical, allow hydraulic fluid to flush stage and ground hydraulic systems for 30 minutes minimum, take fluid samples from each stage hydraulic filter manifold assembly and SE supply and return line and perform contamination analysis per 60B32086, and upon successful contamination analysis, remove hydraulic pressure and close servoactuator prefiltration bypass valves.

4.29.2 *After stage and ground hydraulic systems cleanliness verification, verify no external fluid leakage from hydraulic supply and return line connections with 2000 + 50 PSIG at F-1 engine 4-way control valves or 2050 + 50 PSIG at hydraulic supply umbilical. Six (6) drops of fluid per minute from either servoactuator piston rod seal under static conditions is acceptable. If servoactuator rod seal leakage is excessive, cycle servoactuator 100 cycles at $\frac{1}{2}$ cps and + $\frac{1}{2}$ degree amplitude. Reject servoactuator only if leakage during 100 cycles exceed ten (10) drops per seal. (Servoactuator leakage requirements apply with at least 1400 PSIG supply pressure and 20 PSIG return pressure).

4.29.3 *After stage and ground hydraulic systems cleanliness verification, verify no external fluid leakage from return line connections with 475 + 50 PSIG at stage return umbilical.

4.29.4 Verify no trapped air in servoactuator filter manifold pressure transducers and systems "A" hydraulic pressure transducers.

4.29.5 Verify pressure at each F-1 engine station 109 interface is 1500 + 100 PSIG with 1550 + 50 PSIG at hydraulic supply umbilical.

4.29.6 Verify hydraulic flow rate to the stage does not exceed 119 GPM with 1750 + 50 PSIG at hydraulic supply umbilical and servoactuator mid stroke locks removed.

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4.29.7 *During the hydraulic flushing operations with 270 GPM minimum hydraulic flow to the stage, verify pressure drop across each stage filter manifold assembly does not exceed 20 PSID.

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4.30 HYDRAULIC CHECKOUT VALVE

4.30.1 *Verify hydraulic checkout valves travel time from ground position to engine position is between 0.5 and 3.5 seconds and from engine position to ground position is between 0.5 and 3.5 seconds when commanded with 28 +2/-4 VDC. Hydraulic pressure must not be applied to the stage during this test.

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4.31 THRUST VECTOR CONTROL

4.31.1 *Verify servoactuator position potentiometer wiper to supply voltage ratio is 0.500 ± 0.004 with servoactuator mid stroke locks installed.

4.31.2	After locks on null test, verify servoactuator hydraulic null (servoactuator mid-stroke locks removed, 1750 ± 50 PSIG hydraulic pressure at supply umbilical, and no current to the servoactuator) is within 0.08 degree of the locks on null position using mechanical position indicator.	
4.31.3	Verify gimbal clearance between moving and stationary stage and facility components as F-1 engines are gimballed through maximum gimbal angles. The end of stroke position shall be 5.17 ± 0.05 degrees with respect to the locks on midstroke position.	*Verify gimbal clearance between moving and stationary stage and SE components as F-1 engines are gimballed through maximum gimbal angles.
4.31.4		*After gimbal clearance demonstration, verify servoactuator cutoff signal is between 12.9 and 14.8 VDC with 28 ± 1.5 VDC applied to each end of servoactuator position potentiometer primary element and servoactuator positioned at 3.00 ± .01 degrees extend and retract.

4.31.5 *After locks on null test, verify servoactuator position potentiometer wiper to supply voltage ratio is 0.500 ± 0.015 with servoactuator mid stroke locks removed, 1700 ± 50 PSIG hydraulic pressure at F-1 engine 4-way control valves or 1750 ± 50 PSIG at hydraulic supply umbilical and zero current input to servoactuator servo-valves.

4.31.6 *After gimbal clearance demonstration, verify servoactuator polarity, gain, linearity and hysteresis are within tolerance per Figure 4-3.

4.31.7 *After gimbal clearance demonstration, verify threshold current (change in current input required to cause the servoactuator position potentiometer wiper to supply voltage ratio to change by 0.005) does not exceed one (1) milliampere with 1700 ± 50 PSIG hydraulic pressure at F-1 engine 4-way control valves. or 1750 ± 50 PSIG at hydraulic supply umbilical.

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4.31.8 *After gimbal clearance demonstration, verify servoactuator step response for 0.5 and 3.0 degree step inputs are within tolerance per Figures 4-4 and 4-5 respectively.

4.31.9 After gimbal clearance demonstration, verify pitch servoactuators at engines 1 and 4 and yaw servoactuators at engines 1 and 2 retract and pitch servoactuators at engines 2 and 3 and yaw servoactuators at engines 3 and 4 extend with a positive signal applied from the SE gimbal controller.

4.31.10 *After gimbal clearance demonstration, verify amplitude ratio and phase shift of each servoactuator for frequency functions shown in Figure 5-7 are within the limits of Figures 5-8 and 5-9 respectively. Use the same gimbal program that will be used for static firing.

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4.32. GN_2 CONTROL

4.32.1 It should be noted in all test procedures applying pressure to the GN_2 control system that the GN_2 purge system will also be pressurize through the bypass check valve and the LOX turbopump seal purge will flow.

4.32.2 Verify remotely no audible GN_2 leakage from low pressure system at 750 ± 50 PSIG with 800 PSIG minimum in high pressure system.

4.32.3 *Verify relief valve relieving pressure is 950 ± 50 PSIG and reseating pressure is not below 845 PSIG by pressurizing the high pressure system to 1000 PSIG minimum and then using an external GN_2 source pressurize low pressure system until relief valve relieves but do not exceed 1000 PSIG.

4.32.4 *After relief valve functional test, verify the total external leakage from the relief valve does not exceed 32 SCIM GN_2, with 750 ± 50 PSIG in low pressure system and 800 PSIG minimum in high pressure system.

4.32.5 *After relief valve functional test, verify GN_2 control vent valve seat leakage does not exceed 5 SCIM with 750 ± 50 PSIG in low pressure system and 800 PSIG minimum in high pressure system.

4.32.6 After relief valve functional test, verify remotely no audible GN_2 leakage from high pressure system at 3250 ± 50 PSIG.

4.32.7 *After relief valve functional test, verify regulator output is 750 ± 50 PSIG with high pressure system pressure varied from 1000 to 3250 PSIG.

4.32.8 *After low pressure system audible leak test, verify no external GN_2 leakage with leak detector solution from low pressure system at 750 ± 50 PSIG with 800 PSIG minimum in high pressure system.

4.32.9 *After high pressure system audible leak test, verify no external GN_2 leakage with leak detector solution from high pressure system at 1500 ± 100 PSIG.

4.32.10 *After high pressure system leak test, verify the fill valve seat leakage does not exceed 5 SCIM GN_2 with 1500 ± 100 PSIG in high pressure system.

4.32.11 *After relief valve functional test, verify control solenoid valves seat leakage does not exceed 5 SCIM GN_2 per valve as measured from the valve vent ports with the valves actuated and deactuated with 750 ± 50 PSIG in low pressure system and 800 PSIG minimum in high pressure system.

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4.32.12 Verify remotely no audible GN_2 leakage from ground GN_2 control lines at 750 ± 25 PSIG.

4.32.13 *After ground GN_2 control lines audible leak test, verify no external GN_2 leakage with leak detector solution from ground GN_2 control lines at 750 ± 25 PSIG.

4.32.14 Verify remotely no audible leakage from Thrust OK pressure switch calibration lines at 1240 ± 30 PSIG.

4.32.15 After regulator output test and thrust OK pressure switch calibration line audible leak test, verify thrust not OK control of prevalves by simulating thrust OK through calips lines for four engines and issue thrust not OK cutoff enable command. Verify prevalves for engine with thrust not OK condition close. Repeat this test allowing each engine to have a thrust not OK condition.

4.32.16 After thrust not OK control of prevalves test, verify no external GN_2 leakage with leak detector solution from thrust OK pressure switch calibration lines disconnected for that test at 1240 ± 30 PSIG.

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4.33 GN_2 PURGE

4.33.1 *Verify relief valve relieving pressure is 110 ± 5 PSIG and reseating pressure is not below 100 PSIG by pressurizing the high pressure system to 125 PSIG minimum and then using an external GN_2 source pressurize low pressure system until relief valve relieves but do not exceed 125 PSIG.

4.33.2 *After relief valve functional test, verify external leakage from regulator assembly does not exceed 10 SCIM GN_2 with 250 ± 50 PSIG in high pressure system and 85 ± 10 PSIG in low pressure system.

4.33.3 *Verify no external GN_2 leakage with leak detector solution from the low pressure system at 85 ± 10 PSIG with 95 PSIG minimum in high pressure system.

4.33.4 After relief valve functional test, verify no audible GN_2 leakage from high pressure system at 3250 ± 50 PSIG.

4.33.5 *After relief valve functional test, verify regulator output is 85 ± 10 PSIG with high pressure system pressure varied from 400 to 3250 PSIG.

4.33.6 *After high pressure system audible leak test, verify no external GN_2 leakage with leak detector solution from high pressure system at 1500 ± 100 PSIG.

4.33.7 *After high pressure system leak test, verify fill valve seat leakage does not exceed 5 SCIM GN_2 with 1500 ± 100 PSIG in high pressure system.

4.33.8 *After high pressure system leak test, verify fill bypass check valve seat leakage does not exceed 5 SCIM GN_2 with 1500 ± 100 PSIG in high pressure system.

4.33.9 *After regulator output test, verify positive flow from each F-1 engine GN_2 overboard drain with low pressure system at 85 ± 10 PSIG and 95 PSIG minimum in high pressure system.

4.33.10 *After regulator output test, verify positive flow from calorimeter purge housing (first flight stages only).

4.33.11 *Verify no external GN_2 leakage with leak detector solution from hazardous gas detection system in forward skirt area at 20 ± 2 PSIG.

4.33.12 *Verify no external GN_2 leakage with leak detector solution from hazardous gas detection system in aft compartment at 20 ± 2 PSIG.

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4.33.13		*Verify flow from each line of hazardous gas detected system in forward skirt area with 20 $\pm$ 2 PSIG applied to system.
4.33.14		*Verify flow from each line of hazardous gas detection system in aft compartment with 20 $\pm$ 2 PSIG applied to system.
4.33.15	After regulator output test, verify GN_2 purge pressure measured at station 116 for each engine is 80 $^{+15}_{-20}$ PSIG with high pressure system pressure varied from 400 PSIG minimum to 2760 to 3300 PSIG maximum.	
4.33.16		*With the turbopump LOX seal purge flowing, verify no external GN_2 leakage using leak detector solution from fittings and joints downstream of bearing coolant control valve at 10 $\pm$ 1 PSIG. The engine valves vent system must be isolated from the overboard drain system during this test. Pressure in the drain system must not be allowed to exceed 15 PSIG since damage to drain line bellows can result.

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4.34 PRESSURE SWITCHES

4.34.1 Verify remotely no audible leakage from thrust OK pressure switch calibration lines at 1240 ± 30 PSIG.

4.34.2 *After audible leak test, verify no external GN_2 leakage with leak detector solution from thrust OK pressure switch calibration lines at 1240 ± 30 PSIG.

4.34.3 *After leak test of calibration lines, verify thrust OK pressure switches actuation pressure is 995 to 1125 PSIG while increasing pressure from 0 to 1240 + 30 PSIG and actuation/deactuation differential pressure is 50 to 100 PSI using calibration port while decreasing pressure from 1240 ± 30 to 0 PSIG. Perform this test three times.

4.34.4 Verify no external GN_2 leakage with leak detector solution from LOX tank pressure switch calibration lines at 35.2 to 39.3 PSIA. | *Verify no external GN_2 leakage with leak detector solution from LOX tank pressure switch calibration lines at 29.4 to 32.1 PSIA.

4.34.5 *After leak test of calibration lines, verify LOX tank prepressurization pressure switch actuation pressure is 27.2 to 29.6 PSIA, deactuation pressure is 26.9 PSIA minimum, and actuation/deactuation differential pressure is 0.3 to 2.3 PSI using calibration port without exceeding 39.3 PSIA. Perform this test three times.

4.34.6 Verify LOX tank prepressurization pressure switch actuation pressure is 28.0 to 29.0 PSIA, deactuation pressure is 27.5 PSIA minimum and actuation/deactuation differential pressure is 0.5 PSI minimum using systems port. Perform this test three times.

4.34.7 *After leak test of calibration lines, verify LOX tank vent and relief pressure switch actuation pressure is 32.2 to 35.1 PSIA, deactuation pressure is 31.9 PSIA minimum, and actuation/deactuation differential pressure is 0.3 to 1.8 PSI using calibration port without exceeding 39.3 PSIA. Perform this test three times.

4.34.8 Verify LOX tank vent and relief pressure switch actuation pressure is 33.0 to 34.5 PSIA, deactuation pressure is 32.5 PSIA minimum, and actuation/deactuation differential pressure is 0.5 PSI minimum using systems port. Perform this test three times.

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4.34.9 After leak test of calibration lines, verify LOX tank high set point pressure switch actuation pressure is 33.6 to 36.9 PSIA, deactuation pressure is 33.3 PSIA minimum, and actuation/deactuation differential pressure is 0.3 to 2.2 PSI using calibration port without exceeding 39.3 PSIA. Perform this test three times.

4.34.10 Verify LOX tank high set point pressure switch actuation pressure is 34.5 to 36.2 PSIA, deactuation pressure is 34.0 PSIA minimum, and actuation/deactuation pressure is 0.5 PSI minimum using systems port. Perform this test three times.

4.34.11 After leak test of calibration lines, verify LOX tank high set relief pressure switch actuation pressure is 35.2 to 39.3 PSIA, deactuation pressure is 34.9 PSIA minimum and actuation/deactuation differential pressure is 0.3 to 2.8 PSI using calibration port without exceeding 39.3 PSIA. Perform this test three times.

4.34.12 Verify LOX tank high set relief pressure switch actuation pressure is 36.2 to 38.5 PSIA, deactuation pressure is 35.7 PSIA minimum, and actuation/deactuation differential pressure is 0.5 PSI minimum using systems port. Perform this test three times.

4.34.13 Verify no external GN_2 leakage with leak detector solution from fuel tank pressure switch calibration lines at 35.2 to 39.3 PSIA.

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4.34.14 *After leak test of calibration lines, verify fuel tank pressurization pressure switch actuation pressure is 19.3 to 22.0 PSIA, deactuation pressure is 19.0 PSIA minimum and actuation/deactuation differential pressure is 0.3 to 1.8 PSI using calibration port without exceeding 39.3 PSIA. Perform this test three times.

4.34.15 After leak test of calibration lines, verify fuel tank prepressurization pressure switch is 32.2 to 35.1 PSIA, deactuation pressure is 31.9 PSIA minimum, and actuation/deactuation differential pressure is 0.3 to 1.8 PSI using calibration port without exceeding 39.3 PSIA. Perform this test three times.

4.34.16 Verify fuel tank prepressurization pressure switch actuation pressure is 33.0 to 34.5 PSIA, deactuation pressure is 32.5 PSIA minimum, and actuation/deactuation differential pressure is 0.5 PSI minimum using systems port. Perform this test three times.

4.34.17 After leak test of calibration lines, verify fuel tank pressurization pressure switch actuation pressure is 29.4 to 32.1 PSIA, deactuation pressure is 29.1 PSIA minimum and actuation/deactuation differential pressure is 0.3 to 1.8 PSI using calibration port without exceeding 39.3 PSIA. Perform this test three times.

4.34.18 Verify fuel tank pressurization pressure switch actuation pressure is 30.2 to 31.5 PSIA, deactuation pressure is 29.7 PSIA minimum, and actuation/deactuation differential pressure is 0.5 PSI minimum using systems port. Perform this test three times.

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4.34.19 After leak test of calibration lines, verify fuel tank vent and relief pressure is 35.2 to 39.3 PSIA, deactuation pressure is 34.9 PSIA minimum and actuation/deactuation differential pressure is 0.3 to 2.8 PSI using calibration port without exceeding 39.3 PSIA. Perform this test three times.

*After leak test of calibration lines, verify fuel tank vent and relief pressure switch actuation pressure is 29.4 to 32.1 PSIA, deactuation pressure is 29.1 PSIA minimum and actuation/deactuation differential pressure is 0.3 to 1.8 PSI using calibration port without exceeding 39.3 PSIA. Perform this test three times.

4.34.20 Verify fuel tank vent and relief pressure switch actuation pressure is 36.2 to 38.5 PSIA, deactuation pressure is 35.7 PSIA minimum and actuation/deactuation differential pressure is 0.5 PSI minimum using systems port. Perform this test three times.

4.34.21 After leak test of calibration lines, verify fuel tank vent and relief pressure is 35.2 to 39.3 PSIA, deactuation pressure is 34.9 PSIA minimum and actuation/deactuation differential pressure is 0.3 to 2.8 PSI using calibration port without exceeding 39.3 PSIA. Perform this test three times.

4.34.22 Verify fuel tank vent and relief pressure switch actuation pressure is 36.2 to 38.5 PSIA, deactuation pressure is 35.7 PSIA minimum, and actuation/deactuation differential pressure is 0.5 PSI minimum using systems port. Perform this test three times.

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4.35 LOX PURGE

4.35.1 Either the prevalves and interconnect valve number three or engine main valves must be closed when operating LOX dome purge to prevent negative pressure in the LOX tank.

4.35.2 *Verify no external GN_2 leakage with leak detector solution under flow conditions from the LOX dome purge lines with low LOX dome purge operating with 120 to 220 PSIG at station 116. During this test verify primary seal leakage through monitor ports of bolted flanges does not exceed 0.25 SCIM GN_2.

4.35.3	Verify LOX Dome purge pressure at station 116 is between 120 and 220 PSIG and flow through all system lines.	Verify LOX Dome purge pressure at station 116 is 130 $\pm$ 5 PSIG and flow through all system lines.
4.35.4	Verify high LOX dome purge pressure at each engine station 116 interface is 600 PSIG minimum with a SE regulator setting such that lock-up pressure never exceeds 1200 PSIG.	
4.35.5	After high LOX dome purge station 116 pressure verification, verify absolute difference between any engine station 116 pressure and the average pressure at station 116 does not exceed 25 PSI.	

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4.36 PREFILL

4.36.1	With the thrust chamber prefill system filled with ethylene glycol solution, verify no external leakage from stage lines and thrust chamber tubes.	*Verify no external GN_2 leakage with leak detector solution from thrust chamber jacket prefill system line connections from umbilical to each F-1 engine fuel manifold inlet with approximately 40 PSIG at umbilical.
4.36.2	Verify flow out of each F-1 engine thrust chamber when thrust chamber jacket is filled to overflow with ethylene glycol solution.	*Verify flow from each F-1 engine thrust chamber with approximately 40 PSIG applied to thrust chamber jacket prefill umbilical.

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4.37 COCOON PURGE

4.37.1 *Verify no external GN_2 leakage with leak detector solution from thermal conditioning purge line connections from the umbilical to each F-1 engine location with approximately 20 PSIG at umbilical.

4.37.2 *Verify flow from each exit of the thermal conditioning purge with approximately 20 PSIG applied at umbilical.

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4.38 GOX FLOW CONTROL VALVE

4.38.1 *After tank leak test and protecting GFCV pilot aneroid, apply 1250 ± 50 PSIG to GFCV bias regulator checkout port (P_a) and verify the following:

a. Bias regulator pressure (P_d) is 520 ± 15 PSIG.

b. As pilot aneroid pressure is varied from 19.5 to 24.0 PSIA, the open position switch deactuates and the closed position switch actuates between 19.5 and 21.5 PSIA; the position potentiometer indicates valve movement, and sense pressure readings for delta pressures between bias and control pressure (P_d-P_c) of 100 and 200 PSID match vendor data within 0.3 PSI.

4.38.2 After GFCV functional test, verify GFCV bias regulator checkout port (P_a) seat leakage does not exceed 25 SCIM GN_2 with 6 to 12 PSIG in LOX tank.

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4.39 LOX PRESSURIZATION SYSTEM LEAK TEST (HIGH PRESSURE)

4.39.1 With the GFCV P_a checkout port check valve mechanically actuated and the downstream bias chamber bleed plugged to prevent duct pressure from entering the bias pressure area of the GFCV and GFCV P_c checkout port cap removed to vent control pressure area of the GFCV, verify remotely no audible GN_2 leakage from GOX ducts from the LOX inlet check valves on each F-1 engine dome to test flange connection at downstream side of GFCV at 1500 ± 50 PSIG.

4.39.2 *After high pressure audible leak test of lower GOX ducts, and with the GFCV P_a checkout port check valve mechanically actuated and the downstream bias chamber bleed plugged to prevent duct pressure from entering the bias pressure area of the GFCV and GFCV P_c checkout port cap removed to vent control pressure area of GFCV, verify no external GN_2 leakage using leak detector solution from the GOX ducts from the LOX inlet check valves on each F-1 engine dome to the test flange connection at downstream side of GFCV at 1000 ± 50 PSIG. Fuzz leakage is allowed at LOX bypass line to GOX return line joint on F-1 engine heat exchangers. During this test verify primary seal leakage through monitor ports of bolted flanges does not exceed 0.25 SCIM GN_2 with flowmeters.

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4.40 LOX PRESSURIZATION LEAK TEST (LOW PRESSURE)

4.40.1 Verify GFCV is protected from pilot aneroid chattering and excessive delta pressures between bias and control pressures (P_d and P_c) prior to applying pressure to the GOX ducts or bias regulator checkout port (P_a). If pressure to be applied to GOX ducts or P_a is between 200 and 350 PSIG, protect GFCV by removing control pressure checkout port (P_c) cap or apply pressure to pilot aneroid and maintain pressure between 19.5 and 24.0 PSIA. If pressure to be applied to GOX ducts or P_a is greater than 350 PSIG, apply pressure to pilot aneroid and maintain pressure between 19.5 and 24.0 PSIA.

4.40.2	After protecting GFCV, verify no audible GN_2 leakage from GOX ducts from GFCV and pressurization check valve to LOX tank at 350 ± 10 PSIG.	After protecting GFCV, verify no audible GN_2 leakage from GOX ducts from the LOX inlet check valve on each engine to the top of the LOX tank and LOX prepress line at 350 ± 10 PSIG.
4.40.3	*After protecting GFCV and lower GOX ducts leak test, verify no external GN_2 leakage with leak detector solution from GOX ducts from GFCV and prepress check valve to LOX tank at 300 + 10 PSIG. During this test verify primary seal leakage through monitoring ports of bolted flanges does not exceed 0.25 SCIM GN_2 with flowmeter. During this test verify bias regulator checkout port (P_a) seat leakage does not exceed 50 SCIM GN_2 with flowmeter	After protecting GFCV and 350 PSIG audible leak test of GOX ducts, verify no external GN_2 leakage with leak detector solution from GOX ducts from the LOX inlet check valve on each engine to the top of the LOX tank and LOX prepress line at 300 ± 10 PSIG. Fuzz leakage is allowable at LOX by-pass line to GOX return line joint on F-1 engine heat exchanger. During this test, verify primary seal leakage through monitoring ports of bolted flanges does not exceed 0.25 SCIM GN_2 with flowmeter. During this test verify bias regulator checkout port (P_a) seat leakage does not exceed 50 SCIM GN_2 with flowmeter.
4.40.4		Verify no external leakage (GN_2 and 1%, by volume, halogen gas) with halogen gas detectors from bellow and flex joints in GOX ducts at 300 ± 10 PSIG. After repairs leak test with leak detector solution and where applicable, leak test primary seals of bolted flanges with monitor ports with flowmeter.

4.40.5 *After GOX ducts leak test, verify prepress check valve seat leakage does not exceed 5 SCIM GN_2 with GOX ducts at $300 ^{+10}_{-50}$ PSIG.

4.40.6	With LOX 2 lb/sec prepress flowing (1200 ± 100 PSIG at DA4103) verify no external leakage with leak detector solution from LOX prepress lines from the umbilical to the LOX prepress check valve.	

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4.41 FUEL PRESSURIZATION

4.41.1 Verify remotely no audible leakage from helium high pressure system at 1400 ± 50 PSIG.

4.41.2 *After high pressure audible test, verify no external GN_2/He leakage with leak detector solution from helium high pressure system at 1400 ± 50 PSIG. During this test, verify primary seal leakage through monitor ports of bolted flanges does not exceed 0.25 SCIM GN_2/He with flowmeter.

4.41.3 *After helium high pressure system leak test, verify no external GN_2/He leakage with leak detector solution from pogo suppression lines downstream of pogo suppression system control valves under flowing conditions with 1400 ± 50 PSIG in helium high pressure system.

4.41.4 *After helium high pressure system leak test, verify helium fill check valve seat leakage does not exceed 10 SCIM GN_2/He with 1400 ± 50 PSIG in helium high pressure system.

4.41.5 *After helium high pressure system leak test, verify helium emergency dump valve seat leakage does not exceed 115 SCIM GN_2/He with 1400 ± 50 PSIG in helium high pressure system.

4.41.6 *With fuel one lb/sec prepress flowing, (600 ± 50 PSIG at DA4102), verify no external leakage with leak detector solution from fuel prepress lines from the umbilical to the fuel prepress check valve.

4.41.7 Verify remotely no audible leakage from pressurization low pressure system at 250 ± 10 PSIG with 260 PSIG minimum in helium high pressure system.

4.41.8 *After pressurization low pressurization system audible test, verify no external GN_2 leakage with leak detector solution from pressurization low pressure system and fuel prepress line at 200 ± 10 PSIG with 210 PSIG minimum in helium high pressure system. Fuzz leakage is allowable at helium bypass line to helium return line joint on F-1 engine heat exchangers. During this test, verify primary seal leakage through monitor ports of bolted flanges does not exceed 0.25 SCIM GN_2 with flowmeter.

4.41.9 *After leak tests, verify prepress check valve seat leakage does not exceed 4 SCIM GN_2 with 200 ± 10 PSIG in pressurization low pressure system and 210 PSIG minimum in helium high pressure system.

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4.41.10 — Verify no external leakage (GN_2 and 1% by volume, halogen gas) with halogen detectors from gimbal joints in pressurization low pressure system at 200 ± 10 PSIG with 210 PSIG GN_2 in helium high pressure system. After repairs, leak test with leak detector solution, and where applicable, leak test primary seals of bolted flanges with monitor ports with flowmeter.

4.41.11 Verify under flowing conditions with the helium bottles at 1400 ± 5 PSIG that the prevalve helium injection pressure is 140 ± 20 PSIG as measured at transducer location for D182-115.

*After pogo suppression system leak test, verify pressure at pressure transducer D182-115 location is 140 ± 20 PSIG with system flowing and 1400 ± 25 PSIG in helium high pressure system.

4.41.12 Verify helium flow control valve operation by cycling each valve three times with helium bottle pressure between 200 and 1000 PSIG helium or GN_2.

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4.42 LOX TANK SYSTEM LEAK TEST

4.42.1		*Verify LOX tank vent and relief valve mechanically relieves at 23.5 to 25.0 PSIG and reseats at 0.5 PSI below actual relief pressure but not less than 23.5 PSIG.

4.42.2 Verify remotely no audible GN_2 leakage from connections on LOX tank and between LOX tank and F-1 engine main Lox valves and LOX fill and drain ducts from LOX tank to umbilical at 18 ± 1 PSIG.

4.42.3 *After audible leak test, verify no external GN_2 leakage with leak detector solution from connections on LOX tank and between LOX tank and F-1 engine main LOX valves and LOX fill and drain ducts from LOX tank to umbilical at 12 ± 1 PSIG. During this test, verify primary seal leakage through monitor ports of bolted flanges does not exceed 0.25 SCIM GN_2 with flowmeter.

4.42.4 *After tank leak test, verify LOX tank pressure sense line to GFCV provides flow to GFCV with 12 ± 1 PSIG in LOX tank.

4.42.5 After audible leak test, verify no external leakage (GN_2 and 1% by volume, halogen gas) with halogen detectors from connections on LOX tank and between LOX tank and F-1 engine main LOX valves and LOX fill and drain ducts at 12 ± 1 PSIG. After repairs, leak test connections with leak detector solution, and where applicable, leak test primary seals of bolted flanges with monitor ports with flowmeter.

4.42.6 *After tank leak test, verify each LOX bubbling check valve seat leak does not exceed 5 SCIM GN_2 with 12 ± 1 PSIG in LOX tank.

4.42.7 *Verify audibly that LOX bubbling shutoff valve opens and closes when commanded.

4.42.8 *After tank leak test, verify no external GN_2/He leakage with leak detector solution from LOX bubbling lines from the umbilical to LOX bubbling check valves at 500 ± 25 PSIG.

4.42.9	After LOX bubbling lines 500 PSIG test and LOX bubbling check valve seat leakage test, verify no external leakage with leak detector solution from LOX bubbling line connections to LOX bubbling check valves with four (4) line LOX bubbling operating, (415 to 600 PSIG at umbilical).	*After LOX bubbling lines 500 PSIG test and LOX bubbling check valve seat leakage test, verify no external leakage with leak detector solution from LOX bubbling line connections to LOX bubbling check valves with 12 ± 1 PSIG in LOX tank.

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4.42.10 *After tank leak test, verify no external GN_2 leakage with leak detector solution from LOX tank vent ducts at 12 $\pm$ 1 PSIG

4.42.11 *After vent duct leak tests, verify each vent valve seat leakage does not exceed 290 SCIM GN_2 with 12 $\pm$ 1 PSIG in LOX tank.

4.42.12 *After fill and drain valve duct leak tests, verify each fill and drain valve seat leakage does not exceed 5 SCIM GN_2 with 12 $\pm$ 1 PSIG in LOX tank.

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4.43 FUEL TANK SYSTEMS LEAK TEST

4.43.1 Verify remotely no audible GN_2 leakage from connections on fuel tank and between fuel tank and F-1 engine main fuel valves at 15 ± 1 PSIG.

4.43.2 *After audible leak test, verify no external GN_2 leakage with leak detector solution from connections on fuel tank and between fuel tank and F-1 engine main fuel valves at 10 ± 1 PSIG. During this test, verify primary seal leakage through monitor ports of bolted flanges does not exceed 0.25 SCIM GN_2 with flowmeter.

4.43.3 After audible leak test, verify no external leakage (GN_2 and 1% by volume, halogen gas) with halogen detectors from connections on fuel tank and between fuel tank and F-1 engine main fuel valves and fuel fill and drain duct at 10 ± 1 PSIG. After repairs, leak test connections with leak detector solution, and where applicable leak test primary seals of bolted flanges with monitor ports with flowmeter.

4.43.4 *After tank leak test, verify no external GN_2 leakage with leak detector solution from fuel tank fill and drain duct at 10 ± 1 PSIG.

4.43.5 *After fill and drain valve duct leak test, verify fill and drain valve seat leakage does not exceed 5 SCIM GN_2 with 10 ± 1 PSIG in fuel tank.

4.43.6 *After tank leak test, verify no external GN_2 leakage with leak detector solution from fuel tank flight vent duct at 10 ± 1 PSIG.

4.43.7 *After flight vent duct leak test, verify flight vent and relief valve seat leakage does not exceed 60 SCIM GN_2 with 10 ± 1 PSIG in fuel tank.

4.43.8 After tank leak test, verify no external GN_2 leakage with leak detector solution from fuel tank auxiliary vent ducts at 10 ± 1 PSIG.

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4.43.9	After auxiliary vent ducts leak test, verify each auxiliary vent valve seat leakage does not exceed 60 SCIM GN_2 with 10 $\pm$ 1 PSIG in fuel tank.	
4.43.10		*Verify HFCV 5 opens when fuel pressurization switch deactuates and closes when it actuates (100 PSIG minimum in helium high pressure system). Use pressure switch calibration port for this test.
4.43.11.		*Verify HFCV 5 remains closed when Command Helium Flow Control Valve No. 5 inhibit relay is energized and fuel pressurization pressure switch is actuated and deactuated (100 PSIG minimum in helium high pressure system). Use pressure switch calibration port for this test.

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4.44 THRUST CHAMBER LEAK TEST

4.44.1 Verify no external GN_2 leakage with leak detector solution from connections on F-1 engine thrust chamber volumes at 10 ± 1 PSIG. During this test verify the following:

a. Primary seal leakage through monitor ports of bolted flanges does not exceed 0.25 SCIM GN_2 with flowmeter.

b. Each LOX dome purge check valve seat leakage does not exceed 10 SCIM GN_2 with flowmeter.

c. Each thrust chamber prefill check valve seat leakage does not exceed 50 SCIM GN_2 with flowmeter.

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4.45 TURBINE EXHAUST LEAK TEST

4.45.1 Verify no external GN_2 leakage with leak detector solution from connections on F-1 engine turbine exhaust volumes at 10 ± 1 PSIG. During this test verify the following:

a. Each GG injector purge check valve seat leakage does not exceed 25 SCIM GN_2 with flowmeter.

b. Primary seal leakage through monitor ports of GG ball valve to combustor, GG combustor to turbine inlet, heat exchanger to exhaust bolted flanges does not exceed 10 SCIM GN_2 with flowmeter.

c. Primary seal leakage through monitor ports of bolted flanges not mentioned in (b) does not exceed 0.25 SCIM GN_2 with flowmeter.

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4.46 TURBOPUMP TORQUE CHECK

4.46.1 Verify turbopump shaft break away and running torque does not exceed 20 foot pounds in each direction and that there is no scuffing, rubbing, or binding for each F-1 engine.

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4.47 ENGINE COMPONENTS

4.47.1 The low LOX dome purge must be on when engine main valves are cycled to maintain LOX dome cleanliness if engine flushing operations are complete. The prevalves and LOX interconnect valve number three must be closed when engine main valves are cycled with LOX dome purge operating.

4.47.2 Prior to conducting an engine components test, drain lines shall be attached downstream of the main fuel valves, upstream of the fuel GGBV's, and downstream of the engine checkout valve on the engine return line.

4.47.3 The hypergol simulators shall be installed and 100-150 psig GN_2 pressure shall be applied to the hypergol simulators. The hypergol installed lights shall come on.

4.47.4 With no hydraulic pressure to the stage, the facility stop backup valves shall be cycled closed, and back to open. The closed and open indications shall be obtained.

4.47.5 With a pressure of 1550 $\pm$ 50 psig, as measured at the hydraulic supply umbilical and the facility stop backup valves open, the 4-way valve start solenoids shall be energized. All engine MLV's, MFV's and GGBV's shall remain closed.

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4.47.6 With a pressure of 1550 $\pm$ 50 PSIG, as measured at the hydraulic supply umbilical, the facility stop backup valves closed, and the hypergol simulator supply off, the 4-way valve start solenoids shall be energized. All MLV's and GGBV's shall go open. The MFV's shall remain closed.

4.47.7 With a pressure of 1550 $\pm$ 50 PSIG, as measured at the hydraulic supply umbilical, hypergol simulator supply on, and the facility stop backup valves closed, the ignition sequencer shall be energized and all MLV's, MFV's and GGBV's shall go open. All engine stop solenoid backup valves shall be opened simultaneously and all engine propellant valves shall go closed. The time from engine stop solenoid backup valve open indication to GGBV open indication dropout shall be 150 ms, maximum for engines 1 and 3. The time from the last GGBV open indication dropout (from above) to engines 2 and 4 GGBV open indication dropout shall be 150 $\pm$ 50 ms.

4.47.8 With a pressure of 1550 $\pm$ 50 PSIG, as measured at the hydraulic supply umbilical, hypergol simulator supply on, and the facility stop backup valves closed, the ignition sequencer shall be energized, and all MLV's, MFV's and GGBV's shall go open. The launch sequencer cutoff button shall be depressed and all engine MLV's, MFV's and GGBV's shall go closed. Verify engine control valve start signal timing from T-0 is within the limits specified in Figure 46.

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4.47.9 With 1550 + 50 PSIG hydraulic pressure at the hydraulic supply umbilical or 1500 $\pm$ 50 PSIG at the 4-way control valves, perform a normal engine main valve opening and closing sequence and verify main valve timing is within limits specified in Figure 4-6. Perform this test three times.

4.47.10 With 1500 $\pm$ 50 PSIG hydraulic pressure at the engine 4-way control valves, perform an engine main valve opening and closing sequence using the redundant stop solenoid only and verify main valves open and close upon command and GG ball valve closing time from close command to open indication dropout does not exceed 300 milliseconds.

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4.48 STAGE COMPONENTS (GENERAL)

4.48.1 Voltage shall be applied to stage busses 1D119, 1D111, and 1D211. The output voltage on stage buss 1D119 shall be 28 ± 4 VDC and on stage busses 1D111, 1D211, 1D11 and 1D21 shall be 28 ± 1 VDC.

4.48.2 Power shall be applied to the stage instrumentation system and DDAS ON shall be verified.

4.48.3 The GN_2 purge system spheres shall be pressurized to 1500 ± 100 psig and the regulator outlet pressure shall be verified at 85 ± 10 psig.

4.48.4 Electrical power shall be applied to the LOX turbopump bearing heaters LOX fill and drain valve heaters and servo accelerometer heater. The heaters shall become warm to the touch.

4.48.5 A signal of 28 ± 0.5 VDC shall be applied to each of the five (5) LOX level sensors to simulate sensor "Wet" condition. Loss of the "Dry" indication shall occur.

4.48.6 A signal of 28 ± 0.5 VDC shall be applied to each of the two (2) fuel level sensors to simulate sensor "Wet" condition. Loss of the "Dry" indication shall occur.

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4.48.7 The fuel prepressurization system shall be confidence tested as follows:

a. Turn on fuel slow prepress and verify the following steady stage pressures:

DA3019	3500 + 200 PSIG
DA4116	3500 ∓ 500 PSIG
DA4102	200 ± 50 PSIG

b. Turn on fuel fast prepress and verify the following pressures:

DA3019	3500 + 200 PSIG
DA4116	3500 ∓ 500 PSIG
DA4102	less than 2300 PSIG (Pressure at DA4102 shall reach 90% of its steady state value within 3 seconds)

4.48.8 Turn on LOX 2 lb/sec prepressurization system and verify the following pressures:

DA3019	3500 + 200 PSIG
DA4114	3500 ∓ 500 PSIG
DA4115	3500 ∓ 500 PSIG
DA4103	less than 2300 PSIG (pressure at DA4103 shall reach 90% of its steady state value within 2 seconds)

4.48.9 Verify LOX interconnect valves 1, 3, and 4 do not open upon command with the stage on internal power and valves closed. Verify valves open when commanded using interconnect valve override function with the stage on internal power and valves closed.

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4.49 STAGE COMPONENTS (GN_2)

4.49.1	APPLY 1500 ± 100 PSIG in high pressure GN_2 control system spheres and verify the low pressure GN_2 control system regulation is 750 ± 50 PSIG.	
4.49.2	After regulator output test, verify control and timing of LOX vent valve. Maximum allowable opening time is 300 MS, open command to open indication. Maximum allowable closing time is 950 MS, close command to closed indication. (Ground control connected to stage control solenoid valve vent port.)	*After regulator output test, verify control and timing of LOX vent valve. Maximum allowable opening time is 300 MS, open command to open indication. Maximum allowable closing time is 535 MS, close command to closed indication.

4.49.3 *After regulator output test, verify control and timing of LOX vent and relief valve. Maximum allowable opening time is 300 MS, open command to open indication. Maximum allowable closing time is 535 MS,close command to closed indication.

4.49.4 *After regulator output test, verify control and timing of fuel vent and relief valve. Maximum allowable opening time is 200 MS, open command to open indication. Maximum allowable closing time is 400 MS, close command to closed indication.

4.49.5 *After regulator output test, verify control of the LOX interconnect valves 1, 3 and 4.

4.49.6 *After regulator output test, verify control and timing of LOX prevalves. Maximum allowable closing time is 650 to 1025 MS, close command to closed indication.

4.49.7 *After regulator output test, verify control and timing of fuel prevalves. Maximum allowable closing time is 1500 to 3000 MS, close command to closed indication.

4.49.8 *After ground GN_2 control lines leak tests, verify LOX fill and drain valves open when 750 ± 50 PSIG ground control pressure is applied.

4.49.9 *After ground GN_2 control lines leak tests, verify fuel fill and drain valve opens when 750 ± 50 PSIG ground control pressure is applied.

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4.49.10 After ground GN_2 control lines leak tests, verify auxiliary fuel vent and relief valves open when 750 ± 50 PSIG ground control pressure is applied and valve operating times. Maximum allowable opening time is 300 MS, open command to open indication. Maximum allowable closing time is 500 MS, close command to closed indication.

4.49.11 After ground GN_2 control lines leak tests, verify fuel emergency drain valve opens when 750 ± 50 PSIG ground control pressure is applied.

4.49.12 *After ground GN_2 control lines leak tests, verify LOX and fuel prevalves close when 750 ± 50 PSIG ground control pressure is applied.

4.49.13 After ground GN_2 control lines leak tests, verify LOX emergency dump valve opens when 750 ± 50 PSIG ground control pressure is applied.

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4.50 STAGE COMPONENTS (HELIUM)

4.50.1 *Verify helium emergency dump valve opens and closes when commanded (100 PSIG minimum in helium high pressure system).

4.50.2 *Verify control and timing of HFCV's 1 through 5 (200-1000 PSIA in helium high pressure system). Maximum allowable opening time is 500 MS, open command to open indication. Maximum allowable closing time is 200 MS, close command to close indication.

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4.51 ELECTROMAGNETIC COMPATIBILITY CONDUCTED

4.51.1

*Verify transients exceeding ± 10 volts 445 microsecond pulse widths do not occur on the following stage components as the stage is sequenced through a simulated countdown and flight. Transients detected from application or removal of power to components will be considered normal.

a. K4(K20-1)Fire EBW Firing Unit (Sep)
K1(K104)He Flow Control Valve No. 4
K2(K26)Engine 2-4 Cutoff
K3(K27)Enable Engine 1-3 Cutoff
K4(K10-1)Arm EBW Firing Unit (R&S)

b. K2(K47)Enable Engine Out
K4(K102)He Flow Control Valve No. 2
K5(K103)He Flow Control Valve No. 3
K_1(K18)LOX Level Cutoff Logic
K_2(K28)LOX Level Cutoff Logic

c. K_3(K38)LOX Level Cutoff Logic
K_3(K67)Cutoff Backup
K_{22}(K112)He Flow Valve No. 2
K_{23}(K113)He Flow Valve No. 3

d. K_{24}(K114)He Flow Valve No. 4
K_{25}(K115)He Flow Valve No. 5
K_{28}(K126)LOX Vent and Relief Valve
K_1(K61)Engine No. 1 LOX Prevalve
K_2(K62)Engine No. 2 LOX Prevalve

e. K_3(K63)Engine No. 3 LOX Prevalve
K_4(K64)Engine No. 4 LOX Prevalve
K_4(K8)Fuel Prop. Depletion
K_{21}(K1)Engine No. 1 Cutoff

f. K_{22}(K2)Engine No. 2 Cutoff
K_{23}(K3)Engine No. 3 Cutoff
K_{24}(K4)Engine No. 4 Cutoff
K_{32}(K121)LOX Interconnect Valve No. 1

g. K_{33}(K106)LOX Interconnect Over Ride
K_{34}(K123)LOX Interconnect Valve No. 3
K_{35}(K124)Thrust OK Logic Engine No. 4
K_{18}(K14)Thrust OK Logic Engine No. 4
K_4(K120)Lift Off
K_{30}(K130)Lift Off

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4.51.1 (Continued)

(Continued)

h. K_5(K37) Enable Engine Out
K_4(K17) Enable Engine 1-3 Cutoff
K_{16}(K29) EDS Engines Cutoff K_{12}(K39-2)
K_{11}(K39-1) EDS Engine Cutoff

i. Range Safety Decoder No. 1 A/FCO
Range Safety Decoder No. 2 A/FCO
K_4(K34) Thrust OK Logic Engine No. 4
K_3(K107) Engine 1-3 Cutoff backup

j. K_1(K117) Two Adjacent Engines Out
K_5(K70) Separation Arm No. 2
K_5(K90) Separation - Retro Fire No. 2
K_{19}(K79) EDS Engine Cutoff
K_{12}(K69) Range Safety Cutoff No. 3

4.51.2

*Verify transients exceeding +42/-14 volts 3 microseconds pulse widths from ground potential or zero volts do not occur on the following stage components as the stage is sequenced through a simulated countdown and flight. Transients detected from application or removal of power to components will be considered normal.

a. EBW Firing Unit No. 1 (Retro.) Arm
EBW Firing Unit No. 2 (Retro.) Arm
LOX Level Engine Cutoff Sensor No. 1
Range Safety Decoder No. 1 (DC Power)
EBW Firing Unit No. 1 (Range Safety) Arm

b. EBW Firing Unit No. 1 (Range Safety) Fire
EBW Firing Unit No. 2 (Range Safety) Arm
EBW Firing Unit No. 2 (Range Safety) Fire
Timer Distributor (+1D21 Power)
Switch Selector (DC Power)

c. Range Safety Decoder No. 2
EBW Firing Unit No. 1 (Separation) Arm
EBW Firing Unit No. 1 (Separation) Fire
EBW Firing Unit No. 2 (Separation) Arm
EBW Firing Unit No. 1 (Retro.) Fire

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4.52 OVERALL TEST GENERAL

4.52.1 All static firing and stage systems shall be checked under simulated static firing conditions. This test shall be performed before propellant loading as closely related as possible to the firing test to insure proper operation of equipment before the acutal firing attempt. A sequence per Figure 5-12 shall be performed with simulation as required to complete the sequence checks. This test shall be performed during the X-1 Day countdown procedure. Prior to Simulated Static Firing perform Flight Measurement Profile Test, per paragraph 4.23.2 only. Verify PCM/FM signal is adequate for sync and record all PCM/DDAS data during sequence of Fig. 5-12.

*After performing Flight Measurement Profile Test, paragraph 4.23.2 only verify PCM/FM signal is adequate for sync and record all PCM/FM data.

4.52.2 *Apply 1500 ± 100 PSIG in high pressure GN_2 control system sphere and verify the low pressure GN_2 control system regulation is 750 ± 50 PSIG.

4.52.3 *Apply 1500 ± 100 PSIG in high pressure GN_2 purge system sphere and verify the low pressure GN_2 purge system regulation is 85 ± 10 PSIG.

4.52.4 *With 750 ± 50 PSIG in the GN_2 Control System, verify the flight fuel tank vent and relief valve open position pickup occurs with 200 ms of its' open command. Verify the close position pickup occurs within 400 ms of the close command.

4.52.5 *Verify the fuel fill and drain valve opens with 750 ± 50 PSIG and closes with 0 ± 50 PSIG.

4.52.6 *Command wet simulation to each fuel cutoff sensor and verify loss of "dry" indications.

4.52.7 *Actuate the fuel tank vent and relief valve pressure switch and verify the fuel tank vent and relief valve opens. Deactuate and verify the fuel tank vent and relief valve closes.

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4.52.8 *Pressurize calibration port of fuel prepress pressure switch and verify switch actuation. Remove pressure and verify deactuation.

4.52.9 *With 750 ± 50 PSIG in the GN_2 control system, verify each of 2 LOX tank vent and relief valves open position pickup occurs within 300 MS of each corresponding open command. Verify each close position pickup occurs within 535 MS of each corresponding close command.

4.52.10 *Verify each of 3 LOX fill and drain valves open witn 750 ± 50 PSIG and close with 0 ± 50 PSIG.

4.52.11 *Command wet simulation to each of the 6 LOX level cutoff sensors and verify loss of dry indications.

4.52.12 *Actuate the LOX tank vent and relief pressure switch and verify the LOX tank vent and relief valve opens. Deactuate verify the LOX tank vent and relief valve closes.

4.52.13 *Pressurize calibration port of the LOX prepress pressure switch and verify switch actuation. Remove pressure and verify deactuation.

4.52.14 *Apply power to Range Safety, F1 and P1 Telemetry, Telemetry Calibrator, and internal busses 1D10 and 1D20. Command Range Safety and Stage transfer switch to internal power. Monitor stage discrete indications for correct response and verify 28 ± 1 VDC on stage busses 1D11, 1D12, 1D21, 1D22, 1D23, 1D28, and 1D29.

4.52.15 *Command Interconnect Valves 1, 3, and 4 closed with the stage on internal power. Verify Interconnect Valves 1, 3, and 4 closed position indications energized. Command Interconnect valves 1, 3, and 4 open and verify open position indications energized.

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4.52.16 *Apply 500 ± 50 VAC (60 cps) to each of 20 engine igniter simulators and verify loss of 1 igniter corresponding to each pair of simulators.

4.52.17 *With 1500 ± 50 PSIG in hydraulic control system command each engine 4-way control valve start solenoid.

a. Verify each main LOX valve close position dropout occurs within 155 ± 50 MS of each corresponding engine start command.

b. Verify each gas generator ball valve close position dropout occurs within 135 ± 25 MS of each corresponding engine start command.

c. Verify each main LOX valve open position pickup occurs within 300 ± 70 MS of each corresponding main LOX valve closed position dropout.

d. Verify each gas generator ball valve open position pickup occurs within 170 ± 50 MS of each corresponding gas generator ball valve closed position dropout.

e. Verify loss of 4 hypergol installed indications with 25 to 150 PSIG applied to each of 4 ignition monitor valves.

f. Verify each main fuel valve open position pickup occurs within 530 ± 100 MS of each corresponding main fuel valve closed position dropout.

g. Verify the second main fuel valve closed position dropout occurs within 100 MS of the first main fuel valve closed position dropout.

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4.52.18 *Actuate thrust OK switches from calibration port and verify 12 thrust OK pressure switch thrust OK indications.

4.52.19 *Ramp each engine at approximately $\frac{1}{4}$ degree/sec in the positive pitch and yaw directions until servo valve saturation and collect data. Repeat in the negative pitch and yaw directions and collect data.

4.52.20 *With 250 ± 50 PSIG in helium bottles command helium flow control valve 1 open and verify open indications.

4.52.21 *Command switch selector to open helium flow control valves 2, 3, and 4. Verify open position indications for each valve and 2.0 ± .4 VDC on measurement K1-115.

4.52.22 *Command switch selector to enable engine out by thrust not OK. Verify 2.0 ± 4 VDC on measurement K1-115.

4.52.23 *Command switch selector to calibrate telemetry. Verify 2.0 ± .4 VDC on measurement K1-115 and measurement calibration.

4.52.24 *Command switch selector to reset telemetry calibration and verify 2.0 ± .4 VDC on measurement K1-115.

4.52.25 *Command switch selector to cutoff the 2-4 engine (primary and backup). Verify for each command 20 ± 0.4 VDC on measurement K1-115.

4.52.26 *Command switch selector to enable 1-3 engine cutoff (primary and backup). Verify for each command 2.0 ± .4 VDC on measurement K1-115.

4.52.27 *Command switch selector to arm Sep. and Retro EBW firing units (primary and backup). Verify 4.2 ± .4 VDC on each EBW monitor measurement. Verify for each command 2.0 ± .4 VDC on measurement K1-115.

4.52.28 *Command switch selector to enable two adjacent engines out auto abort and verify 2.0 ± .4 VDC on measurement K1-115.

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4.52.29 *Command switch selector to fire Sep. and Retro EBW firing units (primary and backup). Verify pulse accept indications for each firing unit and verify for each command 2.0 ± .4 VDC on measurement K1-115.

4.52.30 *With 1500 ± 50 PSIG in hydraulic control system command each engine 4-way control valve stop solenoid.

a. Verify each main LOX valve open position dropout occurs for each corresponding engine stop command.

b. Verify each gas generator ball valve open position dropout occurs for each corresponding engine stop command.

c. Verify each main fuel valve open dropout occurs for each corresponding engine stop command.

d. Verify each main LOX valve close position pickup occurs for each corresponding open position dropout.

e. Verify each gas generator ball valve close position pickup occurs for each corresponding open position dropout.

f. Verify each main fuel valve close position pickup occurs for each corresponding open position dropout.

4.52.31 *Remove thrust OK switch calibration port porssure and verify 4 final thrust not OK indications. Verify 4 LOX and 4 fuel prevalve close indications occur for each corresponding open position dropout.

4.52.32 With other RF systems on, transmit range safety open loop arm command and verify 4.2 ± .4 VDC on EBW monitor measurements. Transmit PD command and verify EBW pulse accept indications.

4.52.33 *With Umbilical Carrier Simulators command forward and aft 1 and 2 electrical umbilicals to separate and verify correct response.

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4.53 OVERALL TEST LOX PRESSURE CONTROL

4.53.1 With both LOX auxiliary pressurizing boxes energized and LOX prepress valve open, actuate LOX TANK PREPRESS switch through calips port between T-9 and T-4.7 seconds and verify auxiliary pressurizing valves 1 and 2 and LOX prepress valve close. Remove pressure from calips port and verify valves open.

4.53.2 With both LOX auxiliary pressurizing boxes energized and LOX prepress valve open, actuate LOX TANK PREPRESS switch through calips port between T-4.7 and T-0 secconds and verify LOX auxiliary pressurizing valve 1 and 2 close and LOX prepress valve remains open. Remove pressure from calips port and verify LOX auxiliary pressurizing valve 1 and 2 open and LOX prepress valve remains open.

4.53.3 With both LOX auxiliary pressurizing boxes energized, actuate LOX TANK PRESSURIZATION switch through calips port between T-0 and T+14 seconds and verify LOX auxiliary pressurizing valves 1, 2 and 4 close. Remove pressure from calips port and verify valves open.

4.53.4 With both LOX auxiliary pressurizing boxes energized, actuate LOX TANK PRESSURIZATION switch through calips port between T+14 seconds and cutoff and verify LOX auxiliary pressurizing valves 1, 2, 3 and 4 close. Remove present from calips port and verify valves open.

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4.53.5 With both LOX auxiliary pressurizing boxes energized, actuate LOX TANK HIGH SET RELIEF switch through calips port between T 14 seconds and cutoff and verify LOX auxiliary pressurizing valves 1,2,3,4,7 and 8 close and LOX tank auxiliary vent and flight vent valves open. Remove pressure from calips port and verify pressurizing valves open and vent valves close.

4.53.6 *Verify LOX tank vent and relief valve opens when LOX tank vent and relief pressure switch actuates and closes when it deactuates (750 + 50 PSIG in GN_2 control low pressure system). Use pressure switch calibration port for this test.

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4.54 OVERALL TEST FUEL PRESSURE CONTROL

4.54.1 With both fuel auxiliary pressurizing boxes energized and fuel slow prepress valve open, actuate FUEL TANK PREPRESS switch through calips port between T-9 and T-2.75 seconds and verify fuel auxiliary pressurizing valve 1 and slow prepress valve close. Remove pressure from calips port and verify valves open.

4.54.2 With both fuel auxiliary pressurizing boxes energized and fuel fast prepress and fast extension prepress valves open, actuate FUEL TANK PREPRESS switch through calips port between T-2.75 and T-0 seconds and verify fuel auxiliary pressurinzing valve 1, fuel fast prepress valve and fuel fast extension prepress valve close. (Fast extension valve closes with switch actuated between T-2.70 and T-0 seconds.) Remove pressure from calips port and verify valves open.

4.54.3 With both fuel auxiliary pressurizing boxes energized and fuel flight and auxiliary vent valves closed, actuate FUEL TANK VENT AND RELIEF switch through calips port between T-0 seconds and cutoff and verify fuel auxiliary pressurizing valves 1 and 2 close and fuel tank flight and auxiliary vent valves (3) open. Remove pressure from calips port and verify pressurizing valves open and vent valves close.

*Verify flight vent and relief valve opens when fuel tank vent and relief high pressure switch actuates and closes when it deactuates (750 $\pm$ 50 PSIG in GN_2 control low pressure system). Use pressure switch calibration port for this test.

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4.54.4 *Verify flight vent and relief valve opens when fuel tank vent and relief low pressure switch actuates with an IU enable and closes when it deactuates.

4.54.5 *Verify flight vent and relief valve does not open by low pressure switch actuation without an IU enable.

4.54.6 With both fuel auxiliary pressurizing boxes energized and fuel flight and auxiliary vent valves closed, actuate FUEL TANK VENT AND RELIEF switch through calips port between T-0 seconds and cutoff and verify fuel auxiliary pressurizing valves 1 and 2 close and fuel tank flight and auxiliary vent valves (3) open. Remove pressure from calips port and verify pressurizing valves open and vent valves close.

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4.55 ENGINE TO STAGE ALIGNMENT

4.55.1 Either before or after captive firing, record data to determine the stage alignment in the test stand and the alignment of the engine center line through the center of the injector and the center of the engine exit plane with respect to vertical.

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4.56 DISCONNECT FROM TEST FACILITY

4.56.1 Prior to disconnecting the SE, the stage valves shall be monitored to verify that they are in the position required for transportation.

4.56.2	The LOX emergency drain line shall be removed and the opening at the tank capped.	
4.56.3	The propellant tanks shall be pressurized between 3 and 5 PSIG prior to disconnecting standby purge. The propellant tank pressure and control system shall be connected and made operable after stage removal from the test stand.	The desiccant filters shall be removed from the propellant tanks and the propellant tank pressure and control system connected and made operable.

4.56.4 During disconnect and removal of SE, care will be exercised to prevent contamination or damage to the stage connections. All special test fixtures, non-flight instrumentation, systems "A", hoses and adapters, and hydraulic lines connected directly to the stage and SE will be removed. The stage power transfer switch will be left in the external power position and all SE power supplies supplying power to the stage will be turned off. After all power is removed, the umbilital simulators will be relieved of pressure and removed. Stage and engine protective covers and closures will be installed. All work platforms will be removed.

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4.57 SHIPPING INSPECTION

4.57.1 An inspection shall be performed to verify stage component status, cables are properly mated, protective covers are installed and all stage openings are protected to maintain required cleanliness levels.

4.57.2 Verify propellant tanks are pressurized for transportation per 66B10952, Positive Pressurization Requirements.

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4.58 STAGE WEIGHING

4.58.1 *To determine the weight and center of gravity of the Intermediate 20 S-IC Stage, the Stage will be weighed until two successive weighings within ± 0.1 percent of each other are obtained. These weights will be used to calculate the Intermediate 20 S-IC Stage center of gravity. The stage may be weighed with desiccant filters installed on the propellant tanks or with the tanks pressurized and sealed.

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4.59 REMOVE FROM TEST FACILITY

4.59.1 In stage removal operations, the LOX and fuel tanks shall be maintained at a positive pressure. The horizontal load supports shall be removed from the stage attach fittings, and the forward stabilization system shall be removed from the forward handling ring. The standby preclamp shall be removed and the stage lifted from the test stand. The stage shall be rotated to the horizon and lowered to the transporter. The LOX Pump Seal Purge shall be maintained during stage rotation. The stage transporter mounted propellant tank monitor and control system shall be connected to the stage and the system made operable to maintain a positive pressure in the fuel and LOX tanks during transportation. The transporter support jacks will be removed and the Intermediate 20 S-IC will be transported from the test cell.

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5.0 STATIC FIRING REQUIREMENTS

5.1 STAGE PREPARATION FOR STATIC FIRING

To properly prepare the stage for static firing the following operations or functions shall be accomplished and/or verified. The normal sequence for accomplishing these events is depicted in Figure 5-1. As systems are activated the associated blueline parameters of Figure 5-2 shall be maintained within the tolerances specified.

5.1.1 The engines on the stage shall be serviced as follows:

a. The LOX Dome and Gas Generator LOX Injector shall be flushed with trichloroethylene.

b. The Thrust Chamber fuel jacket shall be flushed with trichloroethylene and leak checked.

c. The turbopump shaft breakaway and running torque shall be verified to be not greater than 20 foot lbs. as measurement on the torque pinion gear shaft in each direction.

d. The engine inlet screens shall be removed from the suction lines prior to static firing.

5.1.2 The forward environmental conditioning system shall be activated to provide conditioned air at 65 $\pm$ 5 degrees F prior to applying power to telemetry transmitters and LOX loading electronics.

5.1.3 The stage electrical power shall be applied.

5.1.4 The stage DDAS System shall be turned on.

5.1.5 The Purge and Control GN_2 spheres shall be pressurized to 1500 $\pm$ 100 PSIG.

5.1.6 The Servoactuator midstroke locks shall be removed.

5.1.7 To prepare the stage for fuel loading with all fuel prevalves closed the fuel tank vent valves shall be opened and the fuel emergency drain valve verified closed. To load fuel with the fuel prevalves open the Main LOX Valves, Main Fuel Valves, and Gas Generator Valves shall also be closed.

When fuel is present in the fuel suction ducts below the prevalves, stage hydraulic pressure shall be maintained at 1000 PSIG minimum and the LOX Turbopump Seal Purge shall be activated.

5.1.8 The fuel tank shall be filled such that a fuel loading probe voltage of (TBD) VDC is present prior to initiation of the firing command. Sample fuel during loading for particle count and density.

5.1.9 The fuel pump impeller backcasing instrumentation shall be primed to remove air from the lines.

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5.1.10 With fuel in the suction lines and the fuel system pressurized at 10 to 11 PSIG all line and tank connections shall be visually inspected for leakage.

5.1.11 Verify the LOX Interconnect Support Bracket Installation dimension specified on 60B41134 between the shear web and the edge of the support bracket is 3.25 ± .13 inches with the stage in vertical position before LOX loading. Record the results and if dimension is out of tolerance, readjust the support bracket to 3.25 ± .03 inches.

5.1.12 To prepare the stage for LOX loading, verify/accomplish the following:

a. The following valves shall be closed:

Main LOX Valves
Gas Generator Valves
Main Fuel Valves
Stage LOX Fill and Drain Valve No. 3
LOX Emergency Drain Valve
LOX Bubbling Shutoff Valve
Fuel Tank Auxiliary Vent and Relief Valves

b. The following valves shall be open:

LOX Prevalves
LOX Tank and Fuel Tank Flight Vent and Relief Valves

c. The following functions shall be activated:

LOX Fill and Drain Valve Heaters
Turbopump Heaters
Servo Accelerometer Heater
Aft Environmental Control Air Flow

d. The helium storage cylinders shall be pressurized to 1600 PSIG maximum.

5.1.13 As LOX Loading is commenced the forward environmental conditioning system shall be activated to provide conditioned air at 80 ± 10 degrees F.

5.1.14 The LOX tank shall be initially loaded at approximately 300 GPM until suction ducts are full and recirculation is established in ducts 1 thru 4 with the LOX interconnect valves in the normal position. When LOX is detected at the 90 inch point in the suction ducts, 2 line LOX bubbling shall be initiated and maintained until LOX recirculation has been established in suction ducts 1 thru 4. LOX recirculation is established when the nominal LOX suction duct temperature stabilizes below -285°F simultaneously in each duct after the LOX suction duct pressure is at least 20 PSIG. When suction ducts are half full the LOX tank vent valves shall be closed and the LOX ullage pressure maintained between 2 and 4 PSIG by cycling either vent valve until recirculation has been established in suction ducts 1 thru 4 at which time the LOX tank vent valves shall be opened. After recirculation has been established in ducts 1 thru 4 the fill rate may be increased to approximately 1500 GPM and continued at this rate until a minimum of 6.5% of the tank volume is filled. LOX may then be loaded at 10,000 GPM to

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5.1.14 Continued

approximately 95% of the tank volume. The loading rate shall then be reduced to approximately 1500 GPM to achieve and maintain a LOX loading probe voltage of (TBD). During all times LOX is loaded, 2 line LOX bubbling shall be used to re-establish thermal pumping if necessary.

5.1.15 With LOX in the suction lines and the LOX system pressurized at 7 to 8 PSIG, all line and tank connections shall be visually inspected for leakage.

5.1.16 Hypergol and the Gas Generator and Turbine Exhaust Igniters shall be installed in each engine.

5.1.17 Each engine fuel jacket shall be filled with ethylene glycol water prefill solution. Low LOX dome purge required during prefill operation.

5.1.18 Each outboard engine shall be gimballed $\pm \frac{1}{4}$ degree in pitch and yaw to verify that it is free and will gimbal correctly in each direction upon receiving a specific command. Low LOX dome purge required if engine filled with prefill solution.

5.1.19 After LOX loading is complete the helium cylinders shall be pressurized between 3000&3200 PSIG. The purge and control GN_2 spheres shall be pressurized between 2760&3300 PSIG.

5.1.20 The four stage hold down arms shall be preloaded to 588 ± 10 KIPS on the hold down arm actuator rods. The three stage forward stabilization fittings shall be preloaded to 40 ± 2 KIPS.

5.1.21 The POGO suppression system shall be activated for one minute to pre-charge the prevalves prior to the automatic sequence. Two line LOX bubbling shall be on during pre-charge operation to assure thermal pumping will not be interrupted.

5.1.22 Two line LOX bubbling shall be activated at or prior to T-10 minutes for final chill down of LOX suction ducts prior to ignition.

5.1.23 Prior to T-90 seconds (start of automatic sequence) the fuel auxiliary vent valves shall be closed, 4 line LOX bubbling shall be enabled, aft environmental switch over to GN_2 shall be accomplished to inert the aft section and power shall be applied to the following: +1D10 Bus, +1D20 Bus, S-IC Telemetry Calibrator, F1 RF Assembly and P1 RF Assembly.

5.1.24 LOX Tank Vent and Relief Valve and Fuel Tank Flight Vent Valve shall be cycled closed and then open. The LOX Tank Vent Valve shall be cycled closed open and closed.

5.1.25 LOX replenish shall be terminated at T-187 seconds.

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5.2 STATIC FIRING

5.2.1 (TBD) second duration static firing shall be accomplished. The (TBD) seconds shall be timed from simulated liftoff (T+0) to cutoff commands initiated.

5.2.2 When all preparations for static firing operations of paragraph 5.1 have been completed, blueline parameters of Figure 5-2 shall be verified to be within tolerance and a firing command signal initiated. During the ensuing automatic countdown and firing sequence the blueline parameters shall be monitored in accordance with Figure 5-2 and the performance parameters of paragraph 5.4 shall be recorded for post test evaluation.

5.2.3 Paragraph 5.4 establishes the criteria to verify satisfactory performance of the S-IC stage during the static firing. Data will be analyzed by the Test Evaluation team and the necessary graphs, tables and data format needed to support the performance requirements will be included in the static firing 5-day test report. A post test meeting will be held at MTF within seven days after the static firing and a verbal presentation to the customer will define the performance of each system in relation to the performance criteria. If all requirements of 5.4 have not been achieved, the exceptions will be listed with proposed course of action. The hardwire measuring system shall be the primary system for acceptance and performance data.

5.2.4 *Engine cutoff shall be initiated in accordance with the minimum firing duration and redline parameter directions of Figure 5-3.

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5.3 POST FIRING SECURING

5.3.1 Following engine cutoff the following operations shall be accomplished. The blueline parameters of Figure 5-2 shall be maintained within the limits specified until their associated systems are deactivated.

5.3.2 The LOX Dome Purge shall be initially maintained at an operating level of 600 PSIG minimum at station 116.

5.3.3 The Forward Environmental Conditioning System shall be verified to be providing condition air at 80 $\pm$ 10 degrees F.

5.3.4 The LOX and Fuel Tanks shall be vented to a small positive pressure utilizing the tank vent valves.

5.3.5 Upon indication that the stage has safely shutdown a reset command shall be provided.

5.3.6 Upon visual verification that engine cutoff is complete and that no residual fires or leaks are present in the engine area the LOX Dome Purge may be reduced and AFT Environmental may be switched from GN_2 to air.

5.3.7 The control and purge GN_2 storage spheres shall be pressurized to 1500 $\pm$ 100 PSIG.

5.3.8 LOX bubbling shall be initiated as necessary to suppress geysering in the LOX system until completion of LOX draining.

5.3.9 The helium storage cylinders shall be vented to a pressure of 57 to 50 PSIG.

5.3.10 The propellant tanks shall be drained and a positive pressure shall be maintained not exceeding 7 PSIG LOX and 9 PSIG Fuel throughout the drain operation. The LOX tank shall be purged with GN_2 (vent valves open) until the LOX Suction Ducts are at ambient temperature. Both tanks shall be maintained at a small positive pressure upon completion of all drain operations.

5.3.11 When the LOX tank is drained, the Aft Environmental Conditioning System may be deactivated and the Forward Environmental Conditioning System shall be adjusted to provide conditioned air at 65 $\pm$ 5 degrees F if power is applied to telemetry transmitters and LOX loading electronics. If the said electronics is not active the FECS may be secured.

5.3.12 Each engine shall be serviced as soon as possible after firing. The engine service requirements are as follows:

a. The low LOX Dome Purge and the Turbopump LOX Seal Purge and hydraulic pressure at 1500 $\pm$ 50 PSIG shall be maintained as required during Fuel and LOX draining. The LOX dome purge shall remain on for a minimum of one hour.

b. The Hypergol Manifold Assembly shall be purged, utilizing GN_2 at 150 $\pm$ 50 PSIG as measured at the CCP prior to removal of the spent cartridge.

5.3.12 Continued

c. The Residual Fuel shall be drained from each engine and the prefill solution shall be drained and purged from the stage prefill system.

d. The spent Pyrotechnic Igniters shall be removed and the protective closures shall be installed.

NOTE: All of the residual LOX in the engine LOX feed system shall be drained and/or allowed to boil off prior to complying with any of the following requirements.

e. The electrical power to the turbopump heaters shall be terminated.

f. The thrust chamber fuel jacket shall be leak checked and shall be flushed with trichloroethylene and purged with GN_2. The leak check shall verify no leakage from the thrust chamber fuel jacket.

g. The turbopump shall be preserved utilizing preservative fluid and GN_2. The GN_2 pressure shall be 35 $\pm$ 10 PSIG. This preservation requirement shall be accomplished within 72 hours of the time that fuel was last introduced into the turbopump lubrication system, or within the calendar day on which the 72 hours expires.

h. The turbopump pinion torque shall be measured, both breakaway and running, in both directions and verified to not exceed 20 foot lbs.

5.3.13 The GN_2 Purge and Control Systems shall be vented to atmospheric pressure.

5.3.14 The stage electrical equipment in both the forward and aft compartments may be turned off.

5.3.15 Protective closures shall be installed on each of the engines.

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL
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5.4 PERFORMANCE PARAMETERS

5.4.1 ENGINE PERFORMANCE

5.4.1.1 The stage shall demonstrate that the performance of each engine conforms to the following:

a. Engine thrust reduced to standard conditions at a T + 35 - 38 second time interval is within 15 KIPS of predicted thrust furnished by Rocketdyne and within the limits of 1500 to 1545 KIPS.

b. Gas generator total propellant flow rate reduced to standard conditions exceeds 170 lb/sec at T + 35 - 38 second time interval.

c. Turbine manifold torus temperature reduced to standard conditions at a T + 35 - 38 second time interval is within the limits of 1400 to 1610°F.

d. Fuel pump balance cavity pressure is within the limits of 200 to 300 psig from T + 0 to cutoff as recorded by measurement DA14-1 thru 4.

e. LOX pump seal cavity pressure does not exceed 8 psig at any time during the static firing operation as recorded by measurement DA13-1 thru 4.

A MSFC engine data reduction program past 516 provided 30 days prior to the scheduled static firing will be utilized to fulfill the requirements of (a), (b), and (c). Measurements required for program input are listed below.

MEASUREMENT NUMBER	MEASUREMENT DESCRIPTION
CA1A-1 and 4	Temp, fuel pump inlet No. 2
CA2-1 thru 4	Temp, turbine manifold torus
CA9-1 thru 4	Temp, turbine inlet
CA10-1 thru 4	Temp, turbine outlet
CA2000-1 thru 4	Temp, LOX suction line
DA1-1 thru 4	Press,fuel pump inlet No. 1
DA2-1 thru 4	Press,fuel pump inlet No. 2
DA3-1 thru 4	Press, LOX pump outlet No.1
DA4-1 thru 4	Press, LOX pump outlet No.2
DA5-1 thru 4	Press,fuel pump outlet No.1
DA6-1 thru 4	Press,fuel pump outlet No.2
DA7-1 thru 4	Press, combustion chamber
DA7A-1 thru 4	Press, combustion chamber
DA8-1 thru 4	Press, GG chamber
DA9-1 thru 4	Press, turbine outlet
DA33-1 thru 4	Press, turbine inlet
DA2000-1 thru 4	Press, LOX suction duct
FA1-1 thru 4	Flowrate, LOX to H.E.
TA1-1 thru 4	Speed, turbopump
Fuel density	
Ambient Pressure and Temperature	
DA2000B-1 thru 4	Press, LOX suction duct
TA1A-1 thru 4	Speed, Trubopump

REVISIONS			
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-			

?.4.1.2 The stage shall demonstrate that the engine sequence conforms to the following:

a. The F-1 engine start commands (4-way Control Valve Open Signal, Measurement KA6-1 thru 4) shall be given on an individual basis such that 90 kilo-pounds thrust (or 100 psig Combustion Chamber Pressure, Measurement DA7-1 thru 4) is targeted for the following times: (Ref. dwg. 60B37301)

Engine Position No. 1	T-2.660 sec.
Engine Position No. 3	T-2.660 sec.
Engine Position No. 2	T-2.360 sec.
Engine Position No. 4	T-2.360 sec.

b. The individual engine start command signal sequence shall be derived by combining the above requirements and the engine start times (the time required from 4-Way Control Valve Open Signal to 90 kilo-pounds thrust) obtained from the individual F-1 Engine Log Books.

c. The absolute difference between the time required from 4-Way Control Valve Open Signal to 90 kilo-pounds thrust obtained from the stage acceptance test, corrected to nominal prestart conditions, and the value predicted by the Engine Manufacturer shall not exceed 200 milliseconds.

d. Engine propellant valve potentiometer times shall be within the limits specified below:

VALVE OPENING TIMES	LIMITS (Milliseconds)	MEASUREMENT NUMBER
No. 1 Main LOX Valve	535 ± 85	GA1
No. 2 Main LOX Valve	535 ± 85	GA2
*Gas Generator Ball Valve	165 ± 40	KA1
No. 1 Main Fuel Valve	720 ± 110	GA3
No. 2 Main Fuel Valve	720 ± 110	GA4
VALVE CLOSING TIMES		
No. 1 Main LOX Valve	515 ± 85	GA1
No. 2 Main LOX Valve	515 ± 85	GA2
*Gas Generator Ball Valve	85 ± 15	KA1
No. 1 Main Fuel Valve	1160 ± 250	GA3
No. 2 Main Fuel Valve	1160 ± 250	GA4

Overlap: The time period from the point at which any main oxidizer valve reaches fully closed to the point at which any main fuel valve reaches fully closed shall be a minimum of 100 milliseconds. The main oxidizer valves shall reach closed prior to the main fuel valves.

*The gas generator valve times are switch to switch times.

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SYM	DESCRIPTION	DATE	APPROVAL

+.1.3 The following performance parameters are to be recorded during the Static Firing for use in post firing evaluation of F-1 Engine heat exchanger performance. Acceptable Helium heat exchanger effectiveness is defined by Figure 5-4. Acceptable LOX heat exchanger GOX outlet temperature is defined by 5-5. Acceptable LOX heat exchanger GOX outlet pressure is defined by Figure 5-6.

ENGINE HEAT EXCHANGER MEASUREMENT REQUIREMENTS

MEASUREMENT NUMBER	MEASUREMENT DESCRIPTION
DA37-1 thru 4	Pressure, Heat Exchanger Helium Outlet (4)
DA39-1 thru 4	Pressure, Heat Exchanger GOX Outlet (4)
CA4006-1 thru 4	Temperature, Heat Exchanger Helium Inlet (4)
CA4008-1 thru 4	Temperature, Heat Exchanger Helium Outlet (4)
CA4009-1 thru 4	Temperature, Heat Exchanger GOX Outlet (4)
FA1-1 thru 4	Flowrate, LOX Heat Exchanger (4) ▷1
DA4040-1 thru 4 DA4041-1 thru 4 CA4008-1 thru 4	Flowrate, Helium Heat Exchanger (4) ▷1

▷1 T + 30 to cutoff

,.4.2 THRUST VECTOR CONTROL SYSTEM

5.4.2.1 The TVC system shall demonstrate the capability of gimballing the four outboard engines in pitch, yaw and roll modes during the static firing in accordance with the gimbal program specified in Figure 5-7.

a. * Actuator Frequency Response

During $\pm$ 1/4° sine wave frequency sweep the amplitude ratio and phase shift shall be within the limits specified in Figure 5-8 and Figure 5-9 as derived from the measurements listed below.

b. * Actuator Step Response

During $\pm$ 2° step commands, the maximum rate of extension and retraction shall be 11.0 $\pm$ 2 degrees/second, as derived from the measurements listed below.

c. Position to Command Tolerance

The actuator steady state piston position shall be 0 $\pm$ 0.1 degrees with a 0 input command and 2 $\pm$ 0.5 degrees with a 2 degree step command as derived from the measurements listed below.

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL

5.4.2.1 (Continued)

TVC MEASUREMENT REQUIREMENTS

MEASUREMENT NUMBER	MEASUREMENT DESCRIPTION
GA10	Position, Pitch Actuator Piston
GA11	Position, Yaw Actuator Piston
HA1	Current, Pitch Actuator Servo Input
HA2	Current, Yaw Actuator Servo Input
MA1006	Amplifier Input, Pitch Actuator
MA1007	Amplifier Input, Yaw Actuator

5.4.3 PRESSURIZATION SYSTEMS

5.4.3.1 The LOX pressurization system shall maintain the LOX tank ullage pressure within the envelope of Figure 5-10 during onboard pressurization system operation.

5.4.3.2 The fuel pressurization system shall maintain the fuel tank ullage pressure within the envelope of Figure 5-11 from simulated liftoff to cutoff with the following helium control valve sequence:

Valve	Sequence	Measurement No.
No. 1	(To Be Added)	DI629
No. 2	(To Be Added)	DI631
No. 3	(To Be Added)	DI633
No. 4	(To Be Added)	DI635
No. 5	(To Be Added)	DI637

The helium containers will be pressurized within limits of 3000 to 3200 psia at T-2.75 seconds, as recorded by Measurement DA4001.

5.4.4 ELECTRICAL POWER SYSTEM

5.4.4.1 The stage shall demonstrate that the electrical power system is capable of maintaining the voltage requirements listed below while transferred to internal power.

BUSS	VOLTAGE	MEASUREMENT NO.
1D11	28 ± 1 VDC	MA1009
1D21	28 ± 1 VDC	MA1010

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL

5.4.5 CONTROL PRESSURE SYSTEM

5.4.5.1 The stage shall demonstrate the capability of the control pressure system to maintain control sphere pressure (Measurement DA4004) above 2000 psig after cutoff and the regulator outlet pressure (Measurement DA4006) shall not exceed 750 $\pm$ 50 psig at any time during the static firing operation.

5.4.6 GN_2 PURGE SYSTEM

5.4.6.1 The stage shall demonstrate the capability of the purge system to maintain purge sphere pressure (Measurement DA4005) between 3300 and 1000 PSIG from simulated liftoff to cutoff. The LOX pump seal purge regulator outlet pressure (Measurement DA4007) shall be maintained at 85$\pm$10 PSIG during static firing operation.

5.4.7 FLIGHT MEASUREMENTS SYSTEM

5.4.7.1 The Systems "A" and Systems "B" Measurements listed below shall be compared within the accuracies specified in the correlation accuracy column. The comparison shall be made by using the average of data points recorded during the T + 35 - 38 seconds time interval.

SYSTEMS "A"	SYSTEMS "B"	CORRELATION ACCURACY
CA2-1	C3-101	58°C.
CA2-2	C3-102	58°C.
CA2-3	C3-103	58°C.
CA2-4	C3-104	58°C.
CA4000	C125-119	17°C.
CA4001	C126-119	28°C.
CA2000-1	C197-115	1.7°C.
CA2000-2	C198-115	1.7°C.
CA2000-3	C199-115	1.7°C.
CA2000-4	C200-115	1.7°C.
DA4-1 thru DA4-4	D3-101 thru D3-104	1 125 PSI
DA1-1 thru DA1-4	D4-101 thru D4-104	1 10 PSI
DA6-1 thru DA6-4	D7-101 thru D7-104	1 175 PSI
DA7-1 thru DA7-4	D8-101 thru D8-104	1 105 PSI
DA8-1 thru DA8-4	D9-101 thru D9-104	1 105 PSI

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL
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5.4.7.1 Continued

SYSTEMS "A"	SYSTEMS "B"	CORRELATION ACCURACY
DA9-1 thru DA9-4	D10-101 thru D10-104	▷1 7 PSI
DA12-1 thru DA12-4	D13-101 thru D13-104	▷1 61 PSI
DA4005	D67-115	▷1 425 PSI
DA4019	D97-115	▷1 125 PSI
DA4001	D95-119	▷1 300 PSI
DA2001	D94-119	▷1 2.5 PSI
DA1000	D90-117	▷1 2.5 PSI
DA4004	D88-115	▷1 425 PSI
DA4007	D124-115	▷1 13 PSI
DA4006	D125-115	▷1 90 PSI
DA2000-1 thru DA2000-4	D127-115 thru D130-115	▷1 11 PSI
DA4002	D144-119	▷1 425 PSI
GA4000	G4-115	7%

▷1 Systems "B" reading shall have firing day pressure in PSI subtracted from reading.

4.7.2 Measurements that are inactive and will not be evaluated due to the following reasons are listed below:

(1) Disconnected from T.M. for hardwire monitoring
(2) Located on flight heat shields
(3) No aerodynamic heating effect
(4) Avoid static firing environment

C006-101	C052-106	K118-120
C006-102	C149-106	K119-120
C006-103	C026-106	M010-115
C006-104	D046-106	M011-115
	D047-106	C067-120
C050-106	K117-120	

5.4.7.3 The measurements listed in the S-IC IP&C list other than those listed in paragraph 5.4.7.2 above, shall be active and, shall transmit reasonable data during static firing.

5.4.7.4 Static Firing Measurement Systems Operation

a. PCM/FM

All multiplexer AO and BO pre-sampling filter channels that are programmed for inflight calibration shall exhibit inflight calibration within ± 26 counts (150) mv of the standard calibration levels. The measurements shall be made on the steady state portion of each calibration level. Voltage transients on the calibration waveforms are to be ignored.

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SYM	DESCRIPTION	DATE	APPROVAL

5.4.7.4 Continued

Multiplexer AO and BO shall exhibit inflight calibration levels within ± 19 counts (100) mv of the five standard calibration levels.

The encoding accuracy of the PCM system shall be checked to the tolerances listed below for the duration of the static firing:

Channels 28A, 28B

frames 1-9, 11-19, 21-29	0.000 ± 0.050 VDC
frames 10, 20, 30	5.000 ± 0.050 VDC

b. FM/FM Systems

Narrow-band IRIG channels that are programmed for inflight calibration shall exhibit inflight calibration that is within the following tolerances of the five calibration levels:

IRIG Channels 2, 3 . . . . . .± 150 mv
IRIG Channels 4-15 . . . . . .± 100 mv

Data points for evaluation of IRIG channels 2 and 3 shall be taken during the last 50 ms of each calibration level.

All narrow-band IRIG channels not programmed for inflight calibration shall retain uninterrupted data throughout inflight calibration.

c. Measurement Power

Measurement power busses 1D81 and 1D82 shall be 5.000 ± 0.050 VDC throughout static firing.

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL
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5.4.8 RANGE SAFETY SYSTEM

5.4.8.1 Range Safety Power - The Range Safety RF input to both Range Safety Systems shall be on and received at the range safety command receivers at a value sufficiently above the threshold to insure lock-in of the range safety receivers.

5.4.8.2 Range Safety Signal - The RF Signal reception of both receivers shall be uninterrupted throughout the static firing. The range safety commands will be initiated after engine cutoff and range safety pulse sensor signals shall be verified.

5.4.9 PROPELLANT LOADING SYSTEM

5.4.9.1 The two fuel loading probe measurements shall agree within 0.3 inches from loading probe lock-on signal until nominal fuel load is achieved and immediately prior to firing command.

FUEL LOADING MEASUREMENT REQUIREMENTS

MEASUREMENT NUMBER	MEASUREMENT DESCRIPTION
LA1023	Fuel Loading Probe
LA1023A	Fuel Loading Probe
MA1008	Reference Fuel Loading Probe
MA1008A	Reference Fuel Loading Probe

5.4.9.2 The two LOX loading probe measurements shall agree within 0.5 inches from loading probe lock-on signal until nominal LOX load is achieved and immediately prior to firing command.

LOX LOADING MEASUREMENT REQUIREMENTS

MEASUREMENT NUMBER	MEASUREMENT DESCRIPTION
LA2025	LOX Loading Probe
LA2025A	LOX Loading Probe
MA1001	Reference LOX Loading Probe
MA1001A	Reference LOX Loading Probe

5.4.10 COUNTDOWN AND SEQUENCE

5.4.10.1 The stage shall demonstrate the capability to properly function in its simulated KSC Launch Countdown mode as specified in Figure 5-12.

5.4.10.2 The stage shall demonstrate the capability of accepting switch selector input commands and sequencing the stage as specified in Figure 5-12.

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL

4.11 POGO SUPPRESSION SYSTEM

5.4.11.1 The stage shall demonstrate the capability to maintain the prevalve helium injection pressure within the limits shown in figure 5-13.

5.4.11.2 The stage shall demonstrate the capability to maintain helium in the prevalve cavity from T + 10 seconds until cutoff as indicated by an evaluation of prevalve temperature data. (Measurements CA2081-1 thru -4 , CA2082-1 thru -4).

POGO SUPPRESSION SYSTEM MEASUREMENT REQUIREMENTS

MEASUREMENT NUMBER	MEASUREMENT DESCRIPTION
D182-115	Pressure He Supply
CA2081-1 thru -4	Temperature No.1 Prevalve Cavity
CA2082-1 thru -4	Temperature No.2 Prevalve Cavity

5.4.12 KSC REDLINES

5.4.12.1 The stage shall demonstrate the capability to operate within KSC redlines. Evaluation shall be made using stage flight instrumentation data recorded from approximately firing command to ignition command.

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL

5.5 POST FIRING EVALUATION

5.5.1 All of the required tests and operations to be performed after the static firing are listed below. The list delineates the minimum safety and technical prerequisites for the performance of each of the individual tests. The actual order of performance is to be determined by the test conductor in view of these restrictions.

PARAGRAPH		PREREQUISITES
4.19	PCM/FM System	4.24
4.21	FM/FM System	4.24
4.23	Flight Measurement Profile	4.52
4.24	DC Signal Conditioner Adjust	4.52
4.29.2	Hydraulic System Leakage	4.52
4.29.6	Hydraulic System Flow Verification	4.29.2
4.31.2	TVC Locks Off Null	4.29.6
4.31.10	TVC Dry Run	4.29.2
4.42.2	LOX Tank Confidence	5.0
4.42.3	LOX Tank Leak Test	5.0
4.43.1	Fuel Tank Confidence	5.0
4.43.2	Fuel Tank Leak Test	5.0
4.52	Overall Test General	5.0

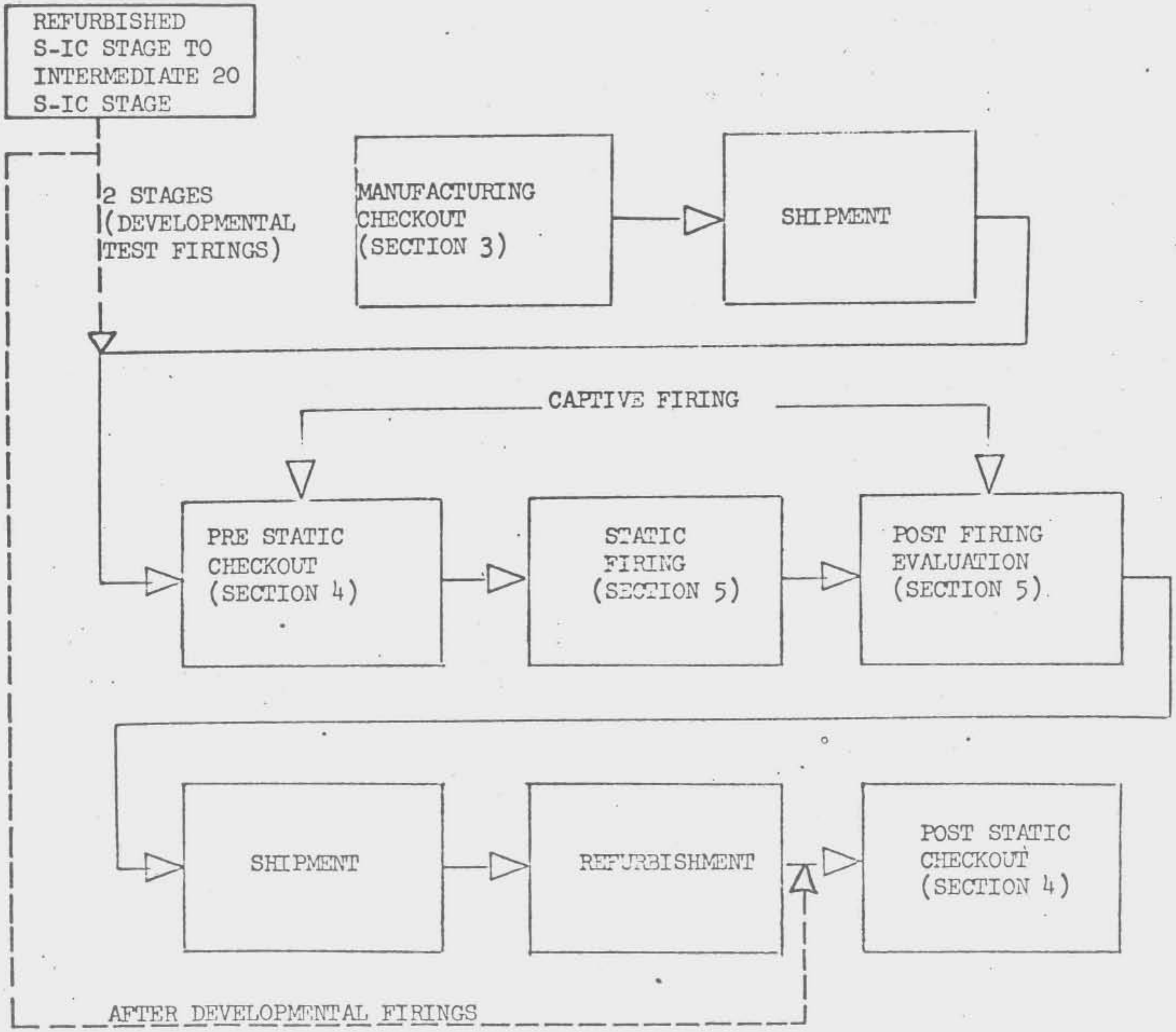


FIGURE 2-1

SEQUENCE OF TESTS FOR INTERMEDIATE 20 S-IC STAGES

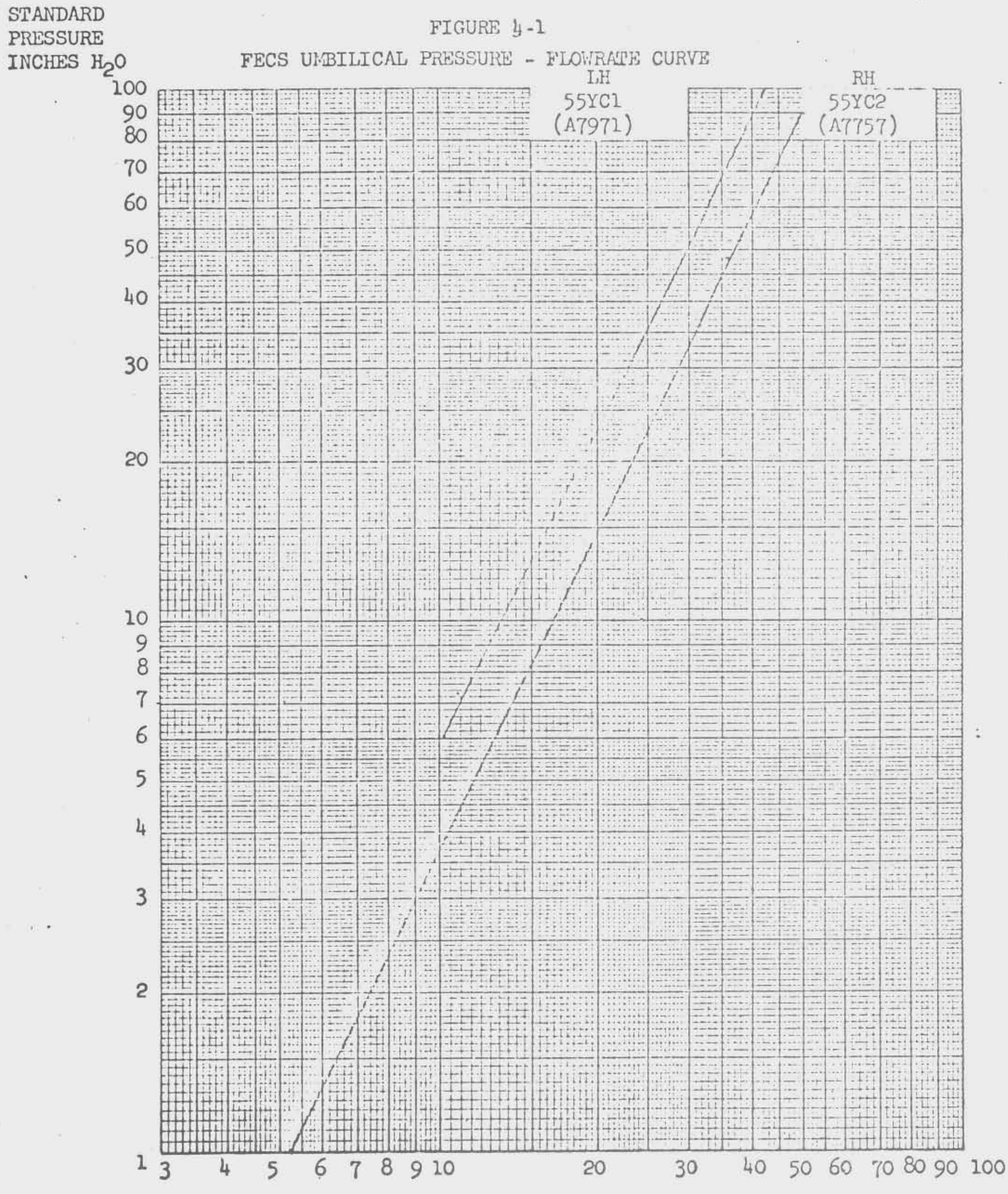
REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL

CODE IDENT NO	DWG SIZE	
14981	A	66B10920
		SHEET A-374

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL

FIGURE 4-1

FECS UMBILICAL PRESSURE - FLOWRATE CURVE

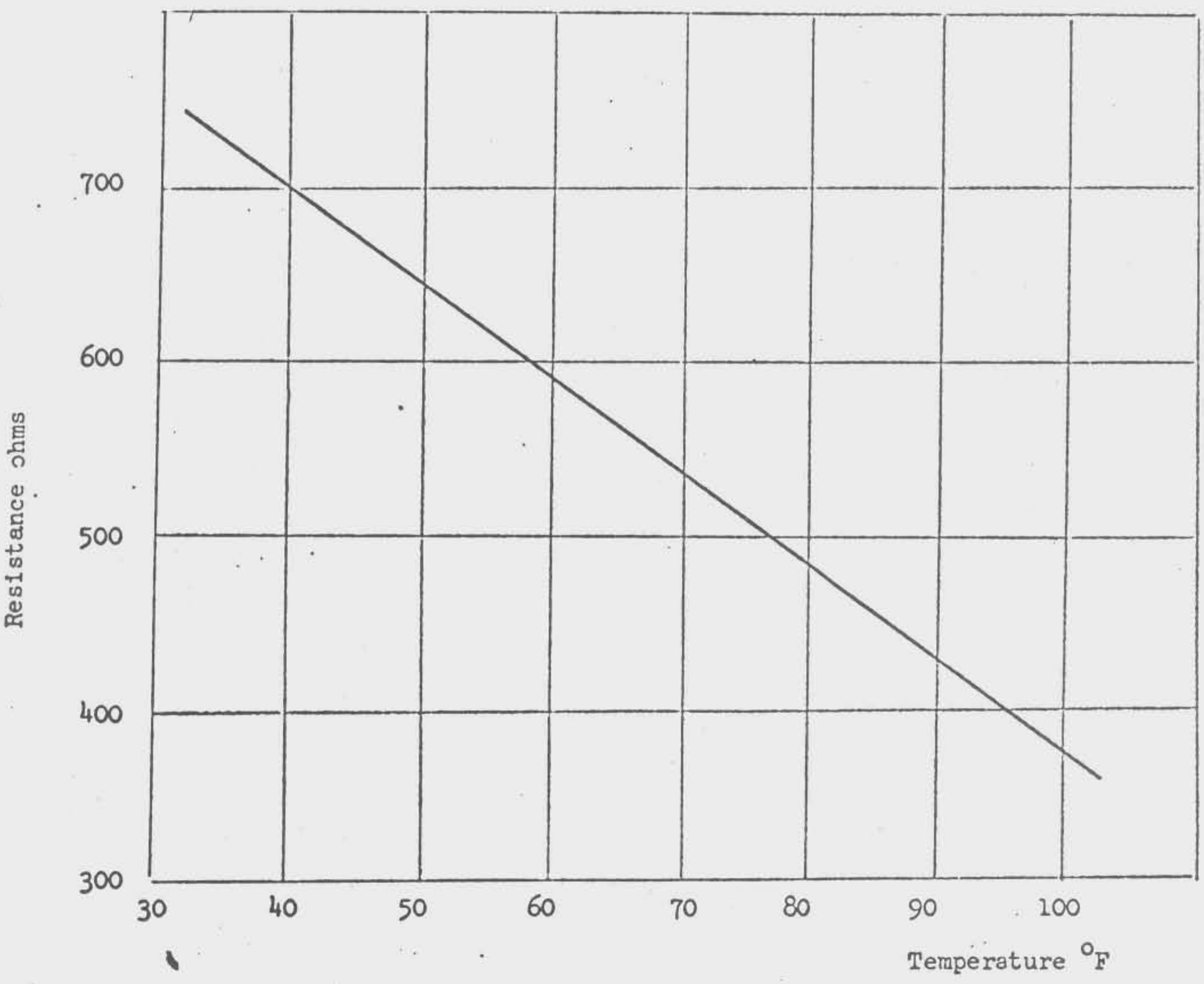


CODE IDENT NO	DWG SIZE	66B10920
14981	A	SHEET A-375

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL

FIGURE 4-2

AFT COMPARTMENT THERMISTOR
TEMPERATURE-RESISTANCE CHARACTERISTIC CURVE

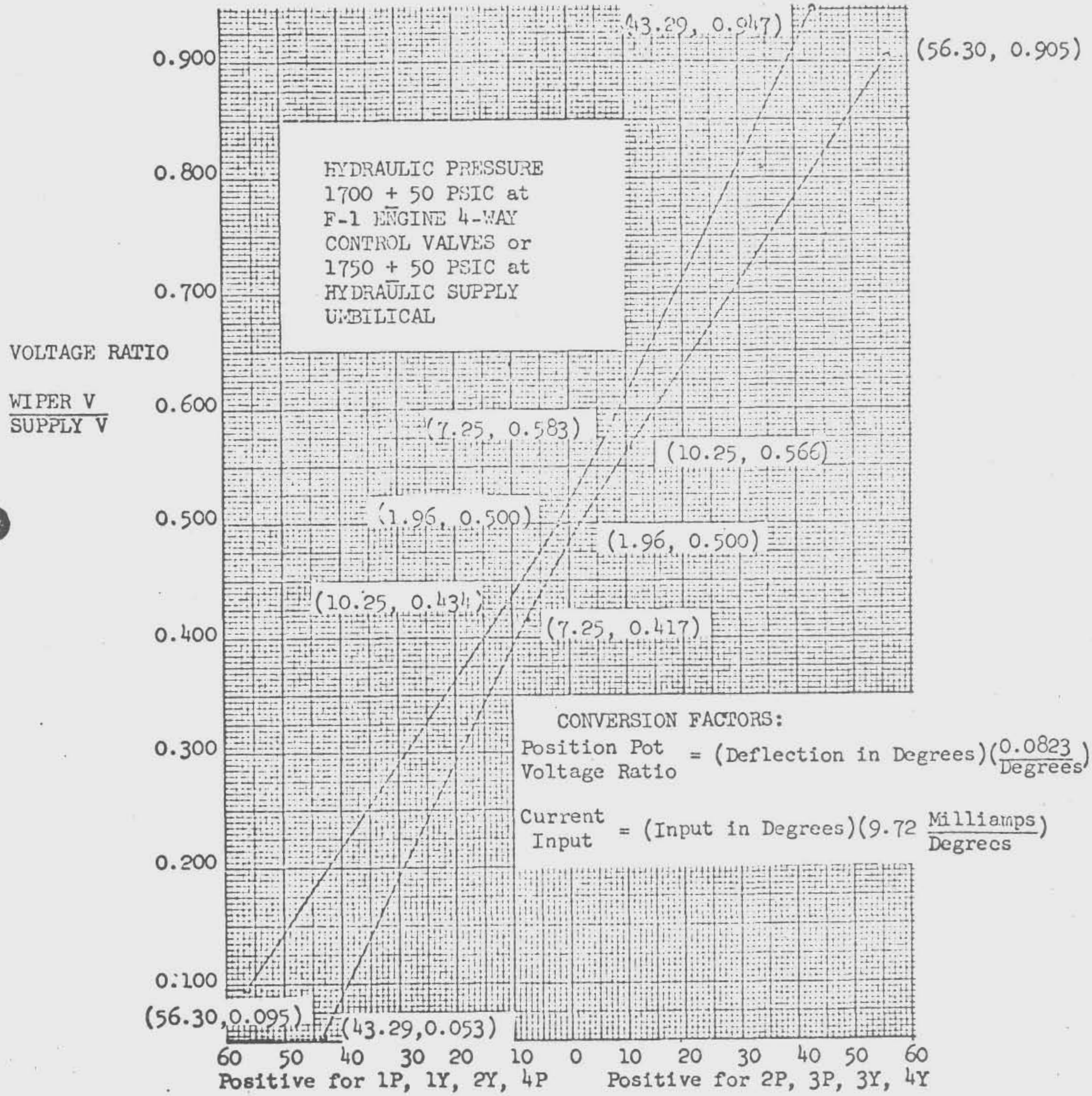


Resistance = $-5.50 \frac{\text{ohms}}{^{\circ}\text{F}}$ (meas. temp. °F) + 925 ohms

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL

FIGURE 4-3

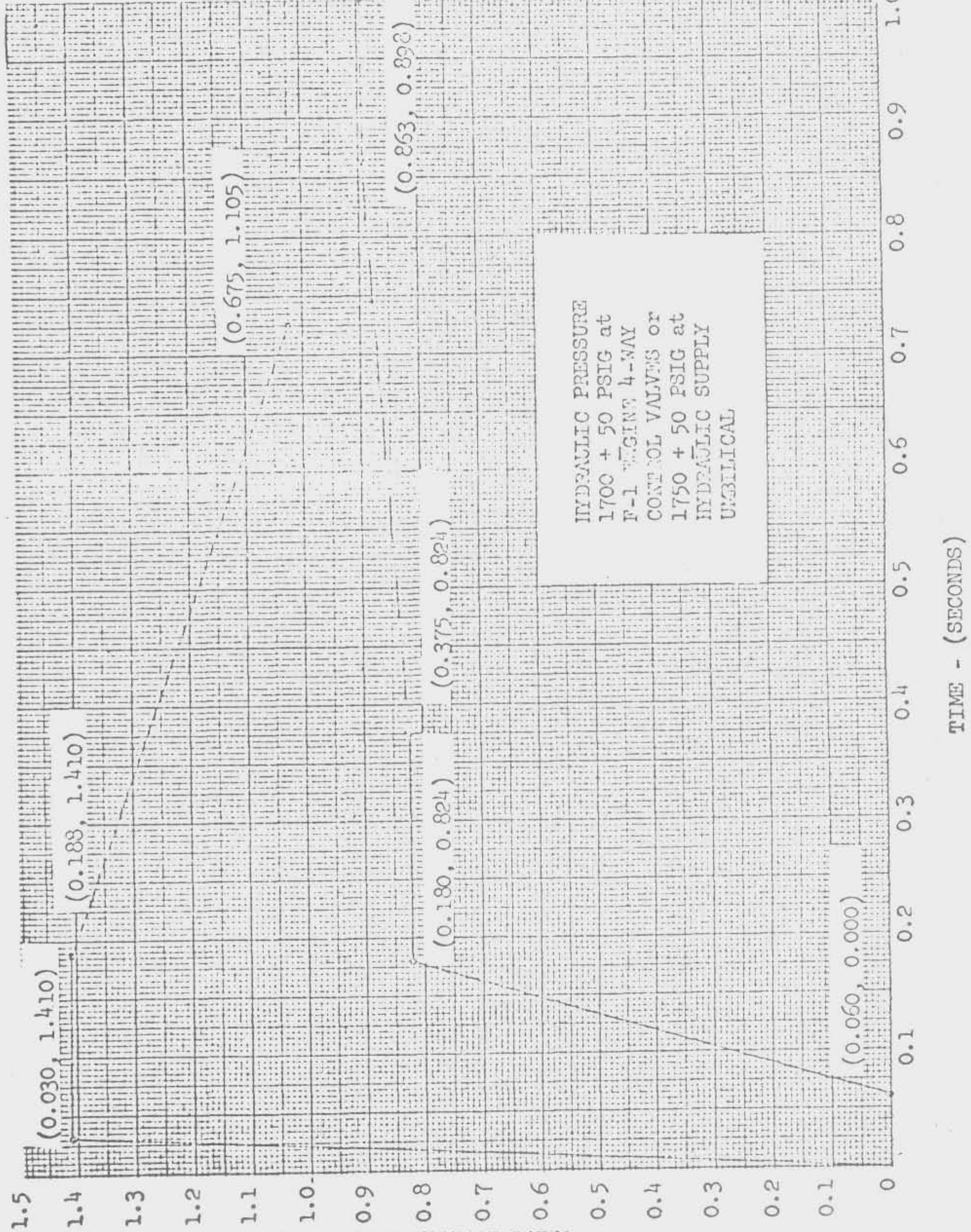
SERVOACTUATOR POLARITY, GAIN, LINEARITY AND HYSTERESIS ACCEPTABILITY LIMITS



CODE IDENT NO	DWG SIZE	
14981	A	66B10920
		SHEET A-377

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL

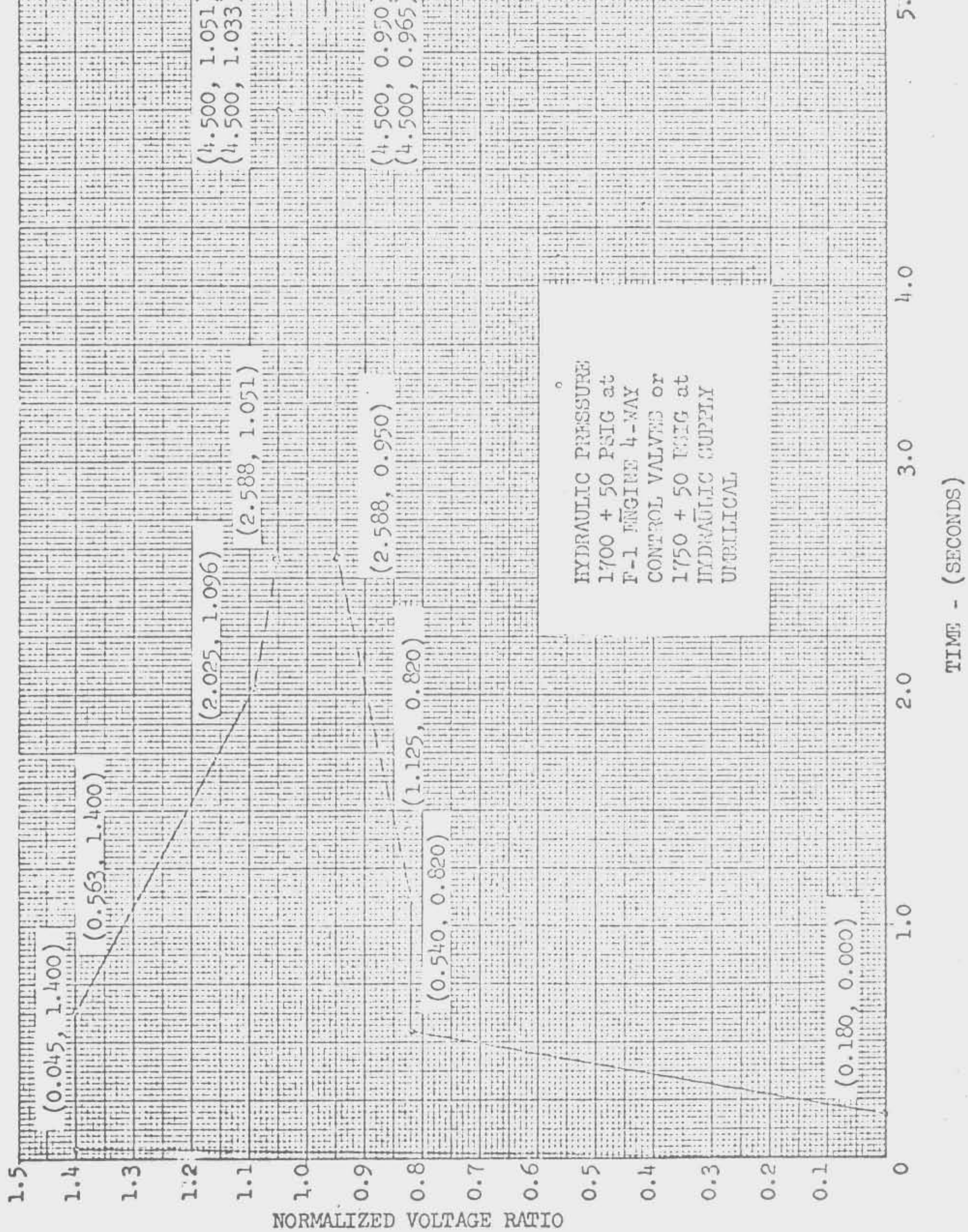
FIGURE 4-4
STEP RESPONSE - 0.5° STEP



CODE IDENT NO	DWG SIZE	66B10920
14981	A	SHEET A-378

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL

FIGURE 4-5
STEP RESPONSE - 3° STEP



REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL

FIGURE 4-6
(Sheet 1 of 1)
ENGINE START AND STOP SEQUENCE TIMES
(Timing specified in seconds)

A. Engine control valve start signal timing from T-0 must be within 0.20 seconds of times listed in 60B37301.

B. Engine main valve timing from control valve start signal to first motion (pot) and closed switch dropout (limit switch):

VALVES	LIMIT SWITCH	POTENTIOMETER
Main LOX Valves	.155 ± .050	.040 ± 025
GG Ball Valves	.145 ± .025	---
Main Fuel Valves	---	---

C. Engine main valve opening times:

VALVES	LIMIT SWITCH	POTENTIOMETER
Main LOX Valves	.300 ± .070	.525 ± .100
GG Ball Valves	.170 ± .050	---
Main Fuel Valves	.530 ± .100	.650 ± .100

D. Timing from No. 1 MFV to No. 2 MFV opening movement on each engine shall not exceed 0.100 seconds.

E. Engine main valve timing from control valve stop signal to first motion (pot) and open switch dropout (limit switch):

VALVES	LIMIT SWITCH	POTENTIOMETER
Main LOX Valves	.185 ± .075	.045 ± .040
GG Ball Valves	.050 ± .020	---
Main Fuel Valves	.125 ± .050	.035 ± .030

F. Engine main valve closing times:

VALVES	LIMIT SWITCH	POTENTIOMETER
Main LOX Valves	.300 ± .070	.525 ± .100
GG Ball Valves	.145 ± .030	---
Main Fuel Valves	.630 ± .120	.750 ± .100

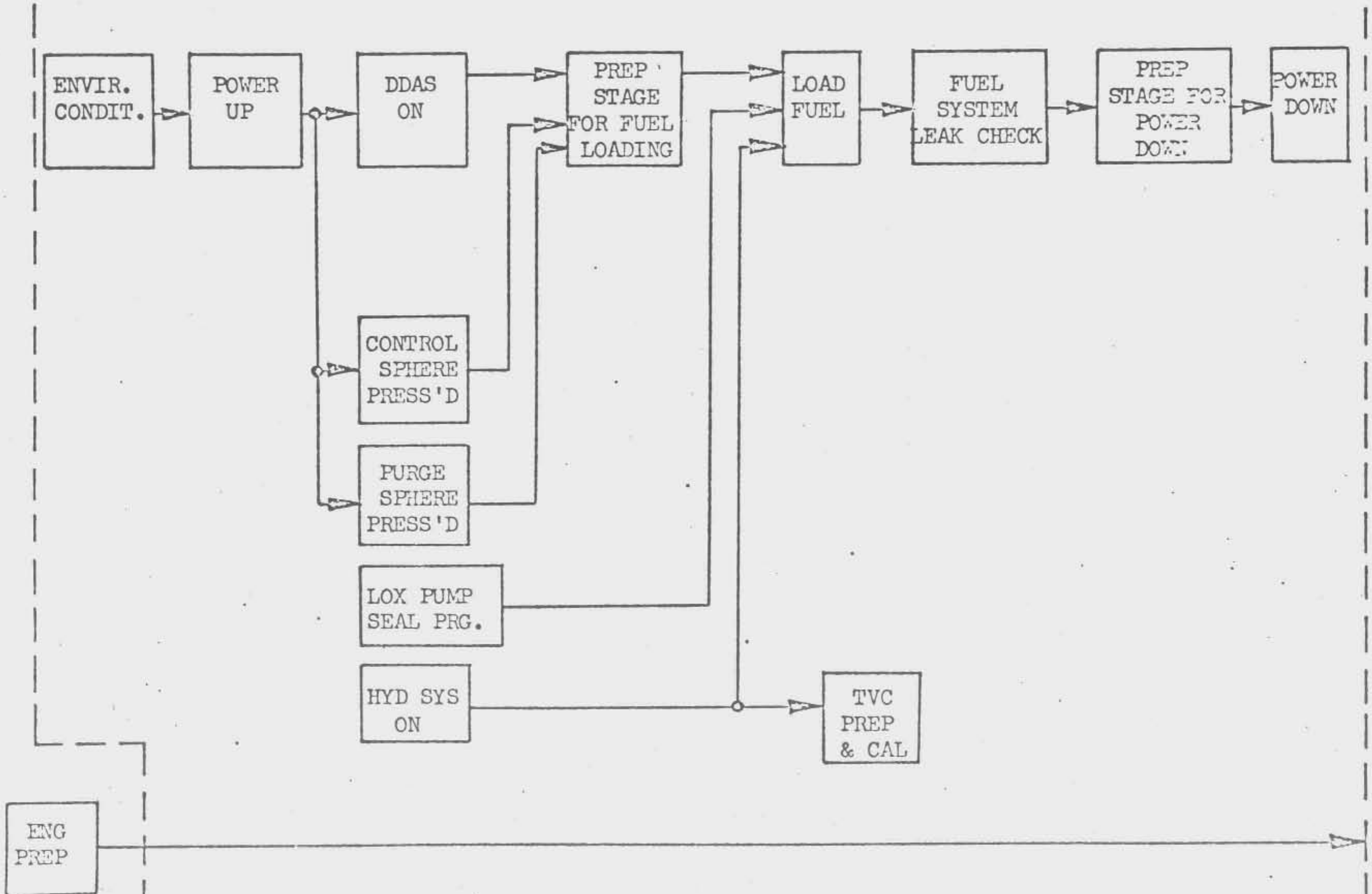
G. Time from Cutoff Start to facility stop backup valve open command is within .200 ± .050.

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL

FIGURE 5-1 (Sheet 1 of 2)

NORMAL STAGE PREPARATION FOR
STATIC FIRING SEQUENCE

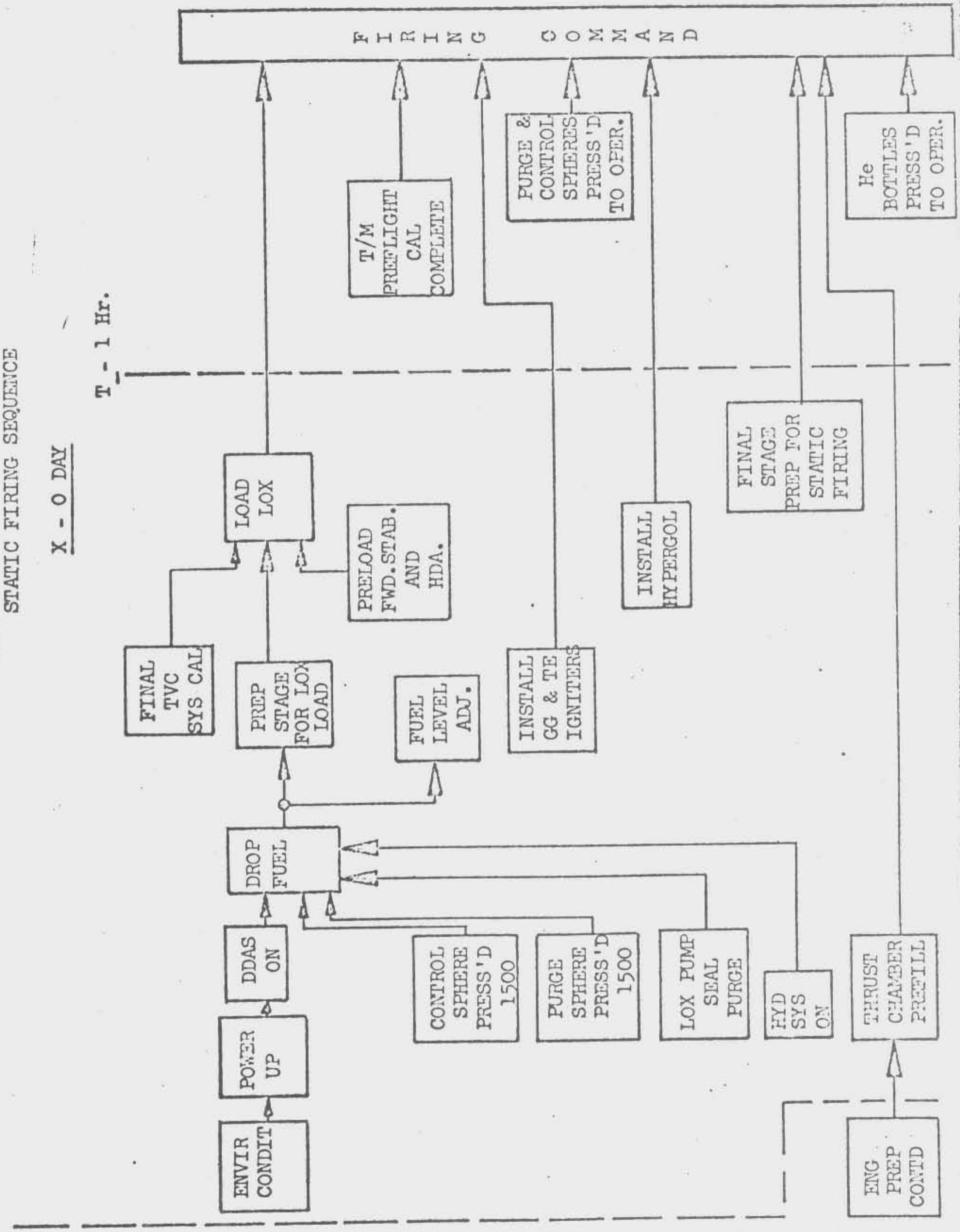
X - 1 DAY



REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL

FIGURE 5-1 (Sheet 2 of 2)

NORMAL STAGE PREPARATION FOR STATIC FIRING SEQUENCE



CODE IDENT NO	DWG SIZE	66B10920
14981	A	SHEET A-382

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL

FIGURE 5-2
BLUELINE PARAMETERS (Sheet 1 of 2)
A. PRE-IGNITION BLUELINE PARAMETERS

These blueline parameters are to be monitored prior to ignition command. The test conductor will be notified and a hold will be initiated if any of these exceed the specific conditions as noted.

NOMENCLATURE	MINIMUM	MAXIMUM	MEASUREMENT NO.
Pressure, Fuel Tank Ullage	(TBD) psig	(TBD) psig	DA1000
Pressure, LOX Tank Ullage	(TBD) psig	(TBD) psig	DA2001
Pressure, Fuel Pump Inlet No. 1	29 psig	---	DA1-1 thru 4
Pressure, Fuel Pump Inlet No. 2	29 psig	---	DA2-1 thru 4
Pressure, LOX Suction Line	60.0 psig	---	DA2000-1 thru 4
Pressure, LOX Pump Seal Cavity	---	6	DA13-1 thru 4
Pressure, Hydraulic Supply	1450 psig	1600 psig	DA3041
Pressure, Helium Container No. 2	3000 psig 1	1600 psig 2 3200 psig 1	DA4001
Pressure, Helium Container No. 3	3000 psig 1	1600 psig 2 3200 psig 1	DA4002
Pressure, Sphere Control System	2760 psig	3300 psig	DA4004
Pressure, Sphere Purge System	2760 psig	3300 psig	DA4005
Pressure, Regulator Control System	700 psig	800 psig	DA4006
Pressure, LOX Pump Seal Purge	60 psig	100 psig	DA4009-1 thru 4
Temperature, No. 1 Bearing	0°F.	---	CA3-1 thru 4
Temperature, LOX Suction Line	---	-275°F.	CA2000-1 thru 4
Temperature, Fwd. Canister	60°F. 3	70°F. 3	CA5135
Environmental System	70°F. 4	90°F. 4	
Temperature, LOX Prevalve Cavity 5			CA2081-1 thru 4 (Backup) CA2082-1 thru 4 (Primary)
Temperature, Hydraulic Return	60°F	130°F	(To be added)
Pressure, LOX Dome Purge	120 psig	1000 psig	DA4000-1 thru 4
Voltage, 1D11 and 1D21	24 VDC	30 VDC	MA1009 &MA1010

1 Effective after T-15 minutes
2 Effective prior to T-15 minutes
3 No LOX
4 LOX
5 Blueline is effective for 2 minutes from initiation of prevalve precharge. During this period indicated temperature shall rise from below -165°C to above -165°C.
6 Verify no liquid leakage exists until T-30 minutes.

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FIGURE 5-2
(Sheet 2 of 2)

B. MAINSTAGE BLUELINES

These blueline parameters shall be monitored during mainstage operation and test conductor shall be notified if any of these exceed the specified conditions as noted.

NOMENCLATURE	MINIMUM	MAXIMUM	MEASUREMENT NO.
Temperature, Fire Detect Harness Nos. 1 thru 4 Aft compartment	Sudden Rise		CA5105-1 thru 4

C. POST CUTOFF BLUELINES

These blueline parameters shall be monitored following cutoff and the test conductor shall be notified if any of these exceed the specified conditions as noted.

NOMENCLATURE	MINIMUM		MAXIMUM	MEASUREMENT NO.
Pressure, Sphere Control System	1200 psig	1▷	3300	DA4004
Pressure, Sphere Purge System	1200 psig	1▷	3300	DA4005

1▷ Effective from cutoff to cutoff + 30 minutes.

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FIGURE 5-3

REDLINE PARAMETERS

Redline Parameters will be monitored from ignition command (except as noted). Cutoff will be initiated only if both the primary measurement and the redundant measurement exceed the specified conditions. In the event either of the measurements is lost, the remaining measurement will become the Redline Measurement and if it exceeds the specified conditions, cutoff will be initiated. For time reference purposes, T + 0 is defined as simulated liftoff.

NOMENCLATURE	MINIMUM	MAXIMUM	MEASUREMENT NO.
1. Pressure, Fuel Pump Inlet No. 1 [20]	12 psig [1]	---	DA1-1 thru 4 [2]
2. Pressure, LOX Pump Discharge No.1	---	1700 psig	DA3-1 thru 4 [3]
3. Pressure, Fuel Pump Discharge No.1	---	2280 psig	DA5-1 thru 4 [4]
4. Pressure, LOX Pump Bearing Jet	200 psig [5]	540 psig	DA12-1 thru 4 [6]
5. Pressure, LOX Pump Seal Cavity	---	12 psig	DA13-1 thru 4 [7]
6. Pressure, Fuel Pump Balance Cavity	150 psig [8]	350 psig 400 psig	DA14-1 thru 4 [9]
7. Pressure, LOX Suction Line [20]	(TBD) [10] [19]	[18] ---	DA2000-1 thru 4 [11]
8. Pressure, Fuel Tank Ullage [20]	(TBD) [12] [13]	(TBD)	DA1000 [14]
9. Pressure, LOX Tank Ullage [20]	(TBD) [12] [13]	(TBD)	DA2001 [15]
10. Pressure, LOX Pump Seal Purge	30 psig	100 psig	DA4009-1 thru 4 [16]
11. Temperature, Turbine Manifold Torus	---	1775°F.	CA2-1 thru 4 [17]

[1] Effective from T + 0 to cutoff.

[2] Static Measurement DA2-1 thru 4; Pressure, Fuel Pump Inlet No. 2, is redundant.

[3] Static Measurement DA4-1 thru 4; Pressure, LOX Pump Discharge No. 2, is redundant.

[4] Static Measurement DA6-1 thru 4; Pressure, Fuel Pump Discharge No. 2, is redundant.

[5] Effective from T + 2 to cutoff.

[6] Static Measurement DA12A-1 thru 4; Pressure, LOX Pump Bearing Jet, is redundant.

[7] Static Measurement DA13A-1 thru 4; Pressure, LOX Pump Seal Cavity, is redundant.

[8] 150 psig minimum is effective from T + 0 seconds to cutoff.
350 psig maximum is effective from T + 4 seconds to cutoff.
400 psig maximum is effective from ignition command to T + 4 seconds.

[9] Static Measurement DA14A-1 thru 4; Pressure, Fuel Pump Balance Cavity, is redundant.

[10] Effective from T + 0 to cutoff.

[11] Static Measurement DA2000B-1 thru 4; Pressure, LOX Suction Line, is redundant.

[12] Effective T-9 to T-5.

[13] Effective T-5 to cutoff.

[14] Static Measurement DA1000A; Pressure, Fuel Tank Ullage, is redundant.

[15] Static Measurement DA2001A; Pressure, LOX Tank Ullage, is redundant.

[16] Static Measurement DA4009-1 thru 4; Pressure, LOX Pump Seal Purge, is redundant.

[17] Static Measurement CA9-1 thru 4; Temperature Turbine Inlet, is redundant. Maximum limit of 1540°F.

[18] LOX Suction Line Temp Below -293°F.

[19] LOX Suction Line Temp Above -293°F.

[20] Supplemental GN_2 from the facility source shall be supplied to the deficient pressurization system in the event that either the LOX or Fuel Tank ullage pressure or the turbopump LOX or Fuel Inlet pressure falls within $^{+1.0}_{-0.0}$ PSIG of the minimum redline limits.

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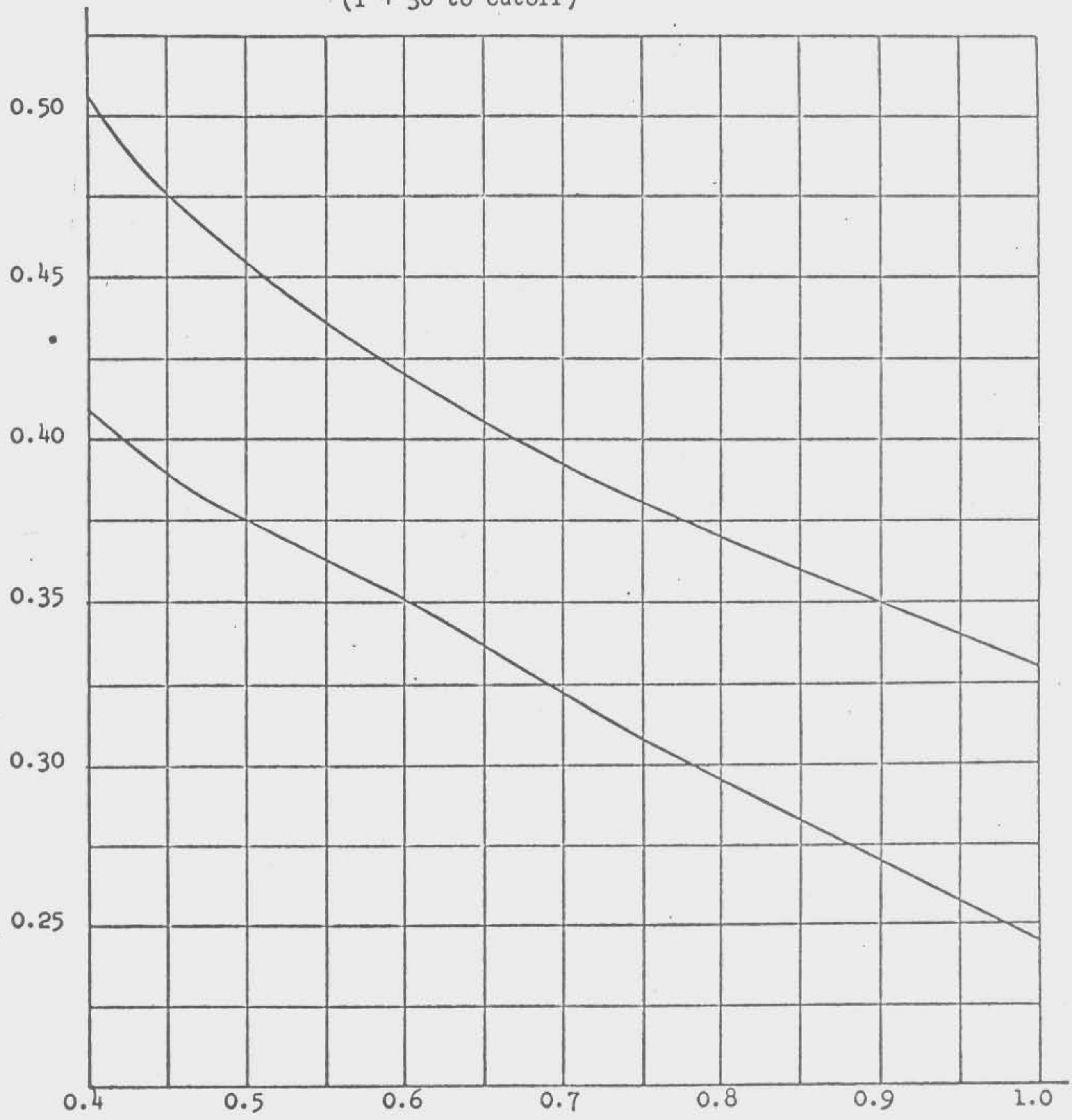
FIGURE 5-4

STEADY STATE HELIUM HEAT EXCHANGER PERFORMANCE
(T + 30 to Cutoff)



$$\text{Effectiveness} = \frac{T\ out - T\ in}{1150^{\circ}F - T\ in}$$

T out = Helium Outlet Temperature
T in = Helium Inlet Temperature

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FIGURE 5-5

STEADY STATE LOX HEAT EXCHANGER PERFORMANCE
(T + 30 to Cutoff)

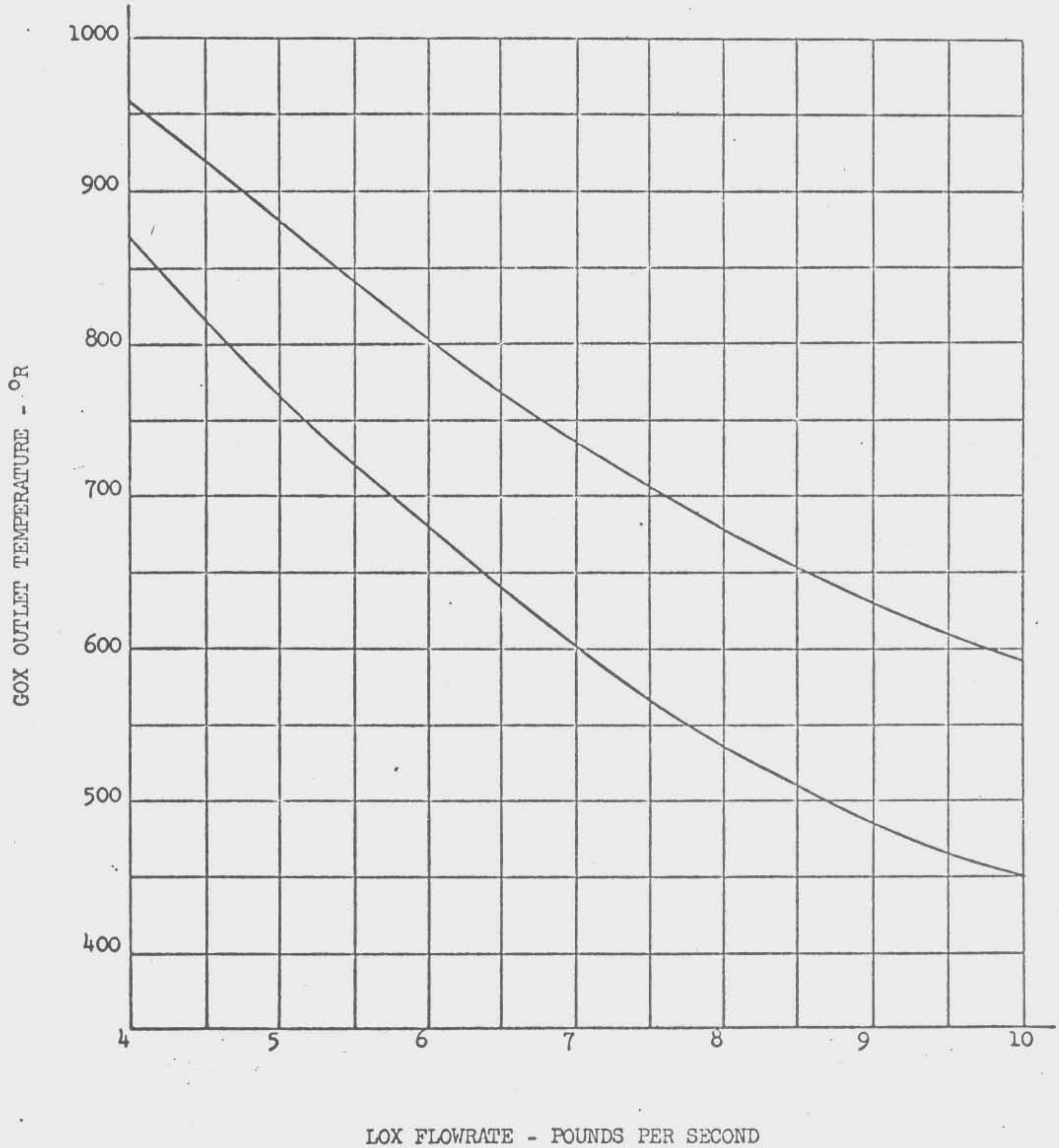

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FIGURE 5-6

STEADY STATE LOX HEAT EXCHANGER PERFORMANCE
(T + 30 to Cutoff)

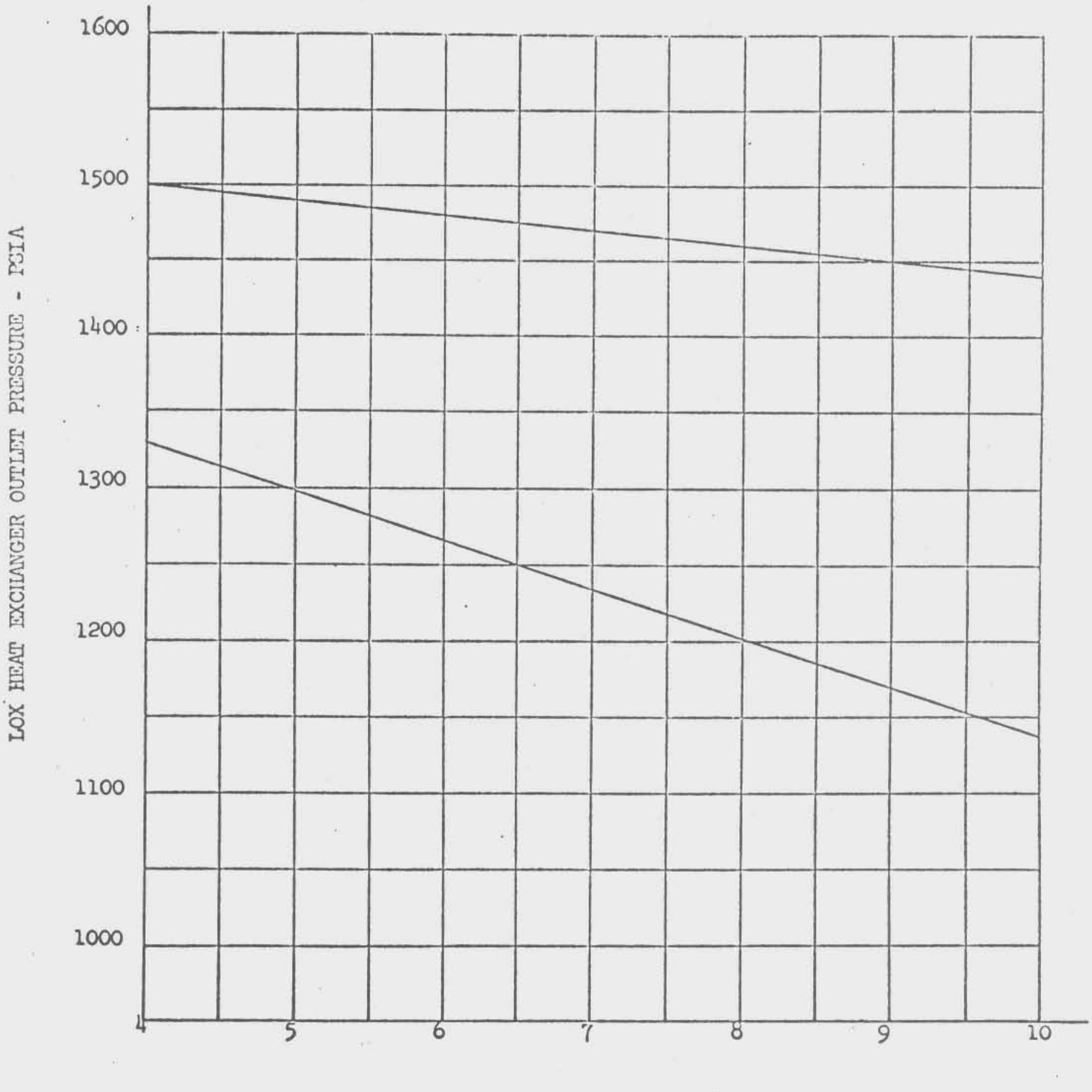

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FIGURE 5-7
(Sheet 1 of 2)
GIMBAL PROGRAM

PITCH AMPL (DEGREES)	YAW AMPL. (DEGREES)	FREQUENCY (HZ)	FUNCTION	NO. OF CYCLES
+2.0	0	-	STEP [1]	1 *
0	+2.0	-	STEP [1]	1 *
-2.0	0	-	STEP [1]	1
0	-2.0	-	STEP [1]	1
±0.25	0	1	Sine	5 ± 1*
±0.25	0	2	Sine	5 ± 1
±0.25	0	3	Sine	5 ± 1*
±0.25	0	4	Sine	5 ± 1
±0.25	0	5	Sine	5 ± 1*
±0.25	0	6	Sine	5 ± 1
±0.25	0	7	Sine	5 ± 1*
±0.25	0	8	Sine	5 ± 1*
±0.25	0	9	Sine	5 ± 1*
±0.25	0	10	Sine	5 ± 1*
±0.25	0	11	Sine	5 ± 1
±0.25	0	12	Sine	5 ± 1
±0.25	0	13	Sine	5 ± 1
±0.25	0	14	Sine	5 ± 1
±0.25	0	15	Sine	5 ± 1
0	±0.25	1	Sine	5 ± 1*
0	±0.25	2	Sine	5 ± 1
0	±0.25	3	Sine	5 ± 1*
0	±0.25	4	Sine	5 ± 1
0	±0.25	5	Sine	5 ± 1*
0	±0.25	6	Sine	5 ± 1
0	±0.25	7	Sine	5 ± 1*
0	±0.25	8	Sine	5 ± 1*
0	±0.25	9	Sine	5 ± 1*
0	±0.25	10	Sine	5 ± 1*
0	±0.25	11	Sine	5 ± 1
0	±0.25	12	Sine	5 ± 1
0	±0.25	13	Sine	5 ± 1
0	±0.25	14	Sine	5 ± 1
0	±0.25	15	Sine	5 ± 1
±1.00(Roll)	±1.00(Roll	0.5	Sine	3 ± 1

* Minimum Requirements

[1] Step amplitude shall be limited to ± 0.5 degree for dry run execution.

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Figure 5-7
(Sheet 2 of 2)

NOTES:

1. Initiate gimbal program at T + 3 seconds. T is simulated liftoff.

2. Gimbal functions shall be programmed such that no engine gimballing will occur during the following time-slice:

   T + 35 through T + 38

3. 500 milliseconds dwell at null between each set of constant waveforms and between completion of a waveform in one plane before command of a step or waveform in the other plane.

4. One second elapsed time between each step command (i.e., at null, command actuation from null, one second later command actuation to null, one second later command next step or sine function in whichever plane it is to occur.)

5. Complete gimbal program at T + 120 seconds or earlier.

6. All four engines at the outboard positions are to be gimballed simultaneously.

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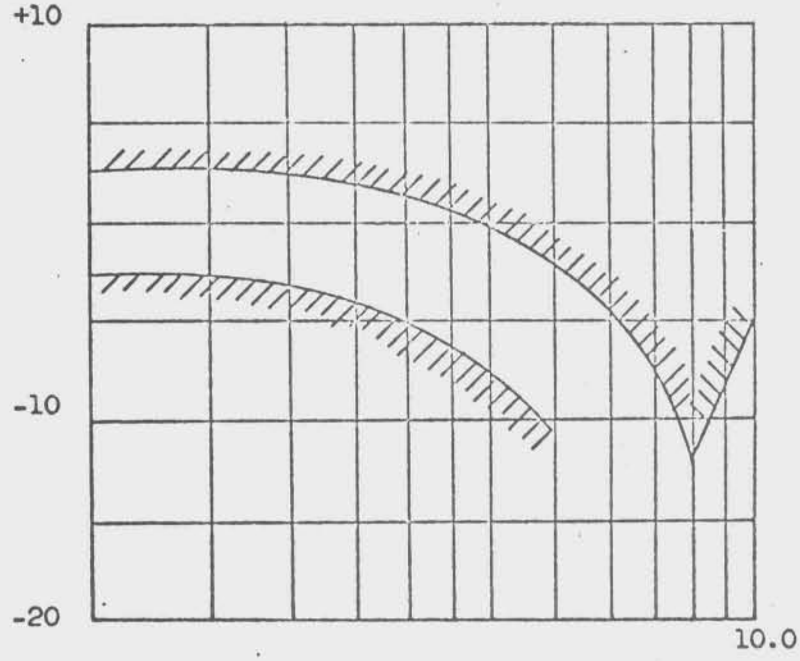
FIGURE 5-8

THRUST VECTOR CONTROL FREQUENCY RESPONSE
(Predicted piston position limits)



Notes:

1. Amplitude ratio - $\frac{\beta_p}{\beta_c}$

   β_p = servoactuator piston position

   β_c = commanded position

2. Commanded amplitude = $\pm 0.25^\circ$ (Sinusoidal)
3. Fluid temperature = 40 - 120°F
4. Notch frequency must be greater than 7 cps.

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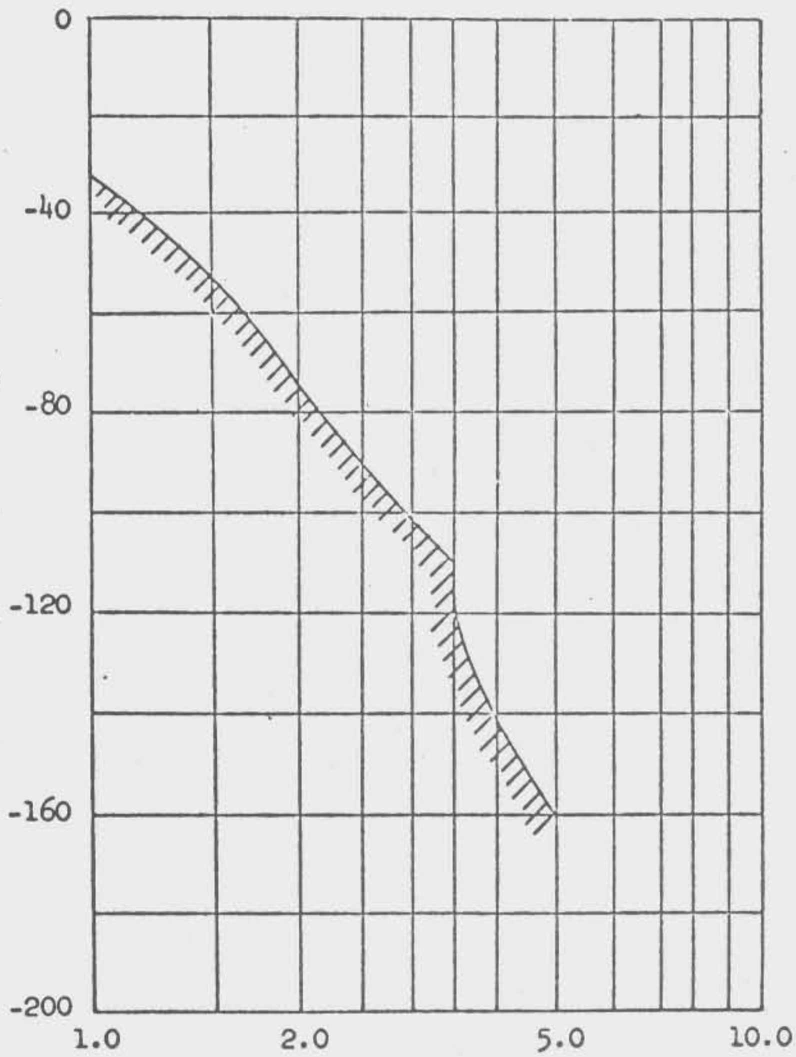
FIGURE 5-9

THRUST VECTOR CONTROL FREQUENCY RESPONSE
(Predicted piston position limits)

PHASE SHIFT



Notes:

1. Phase Shift $\beta_c - \beta_p$

   β_p = servoactuator piston position

   β_c = commanded position

2. Commanded amplitude = $\pm 0.25^\circ$ (sinusoidal)
3. Fluid temperature = 40 - 120°F

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FIGURE 5-10

LOX TANK ULLAGE PRESSURE LIMITS FOR
ACCEPTABLE GOX FLOW CONTROL VALVE PERFORMANCE

NOTE: GOOD ONLY FOR GFCV OPERATION

(TO BE EVALUATED AND POSSIBLY REVISED)

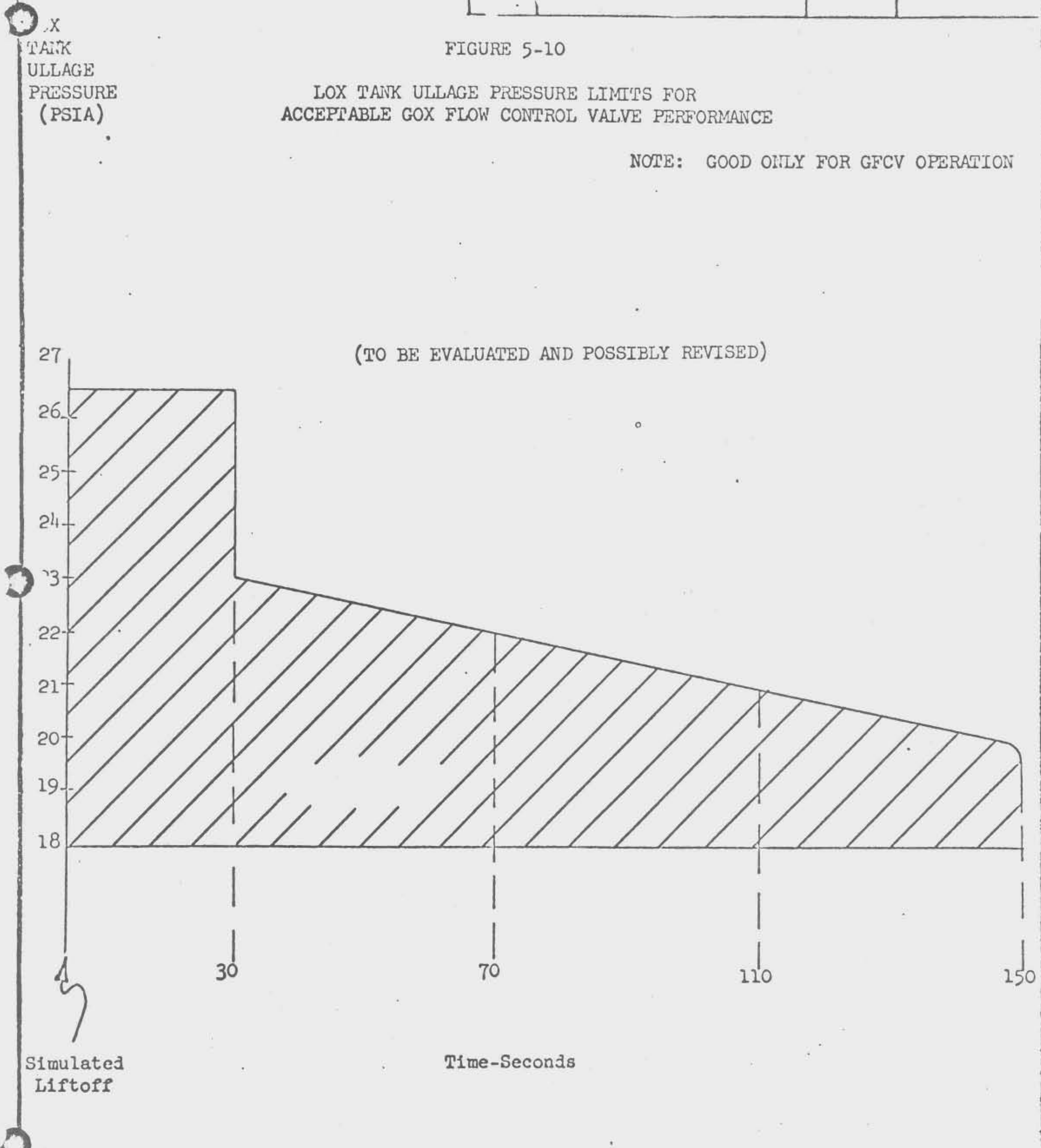

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FIGURE 5-11

FUEL TANK ULLAGE PRESSURE PERFORMANCE

(TO BE EVALUATED AND REVISED)

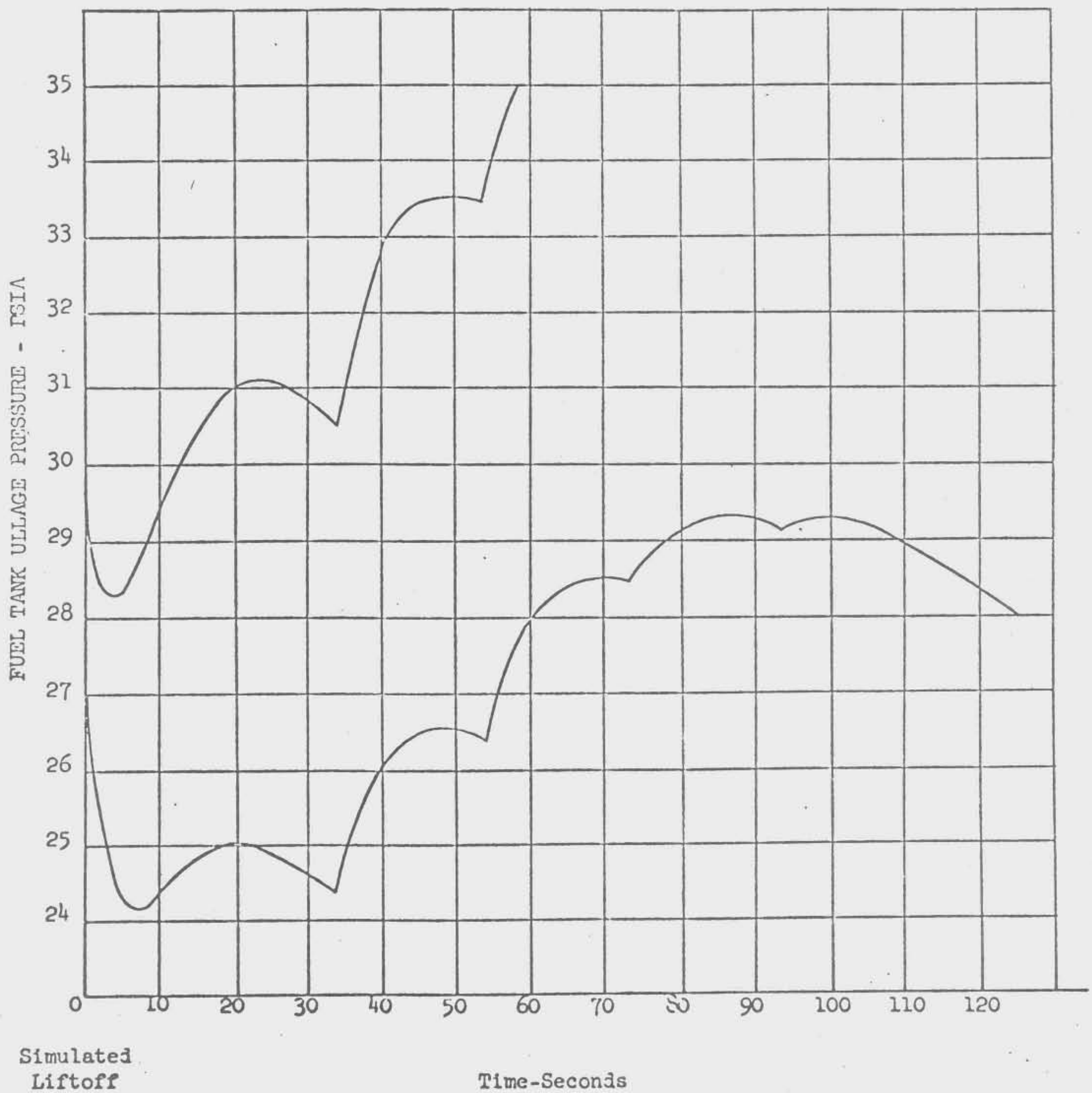

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FIGURE 5-12
(Sheet 1 of 14)
SEQUENCE REQUIREMENTS

1 Engine start times shall be within ±0.020 seconds of the times listed in 60B37301.

2 For simulated static firing verify position switch timing in accordance with Figure 4-6.

3 For simulated static firing maximum time for these events to occur is 5 seconds. This is due to venting through the thrust OK pressure switch calips lines.

4 HFCV's may cycle closed during simulated static firing due to low helium bottle pressure prior to electrical command.

5 For simulated static firing:
KDI 246 ON KDI 482 ON + .535 Max

6 Saturn V S-IC times to be evaluated and revised for Intermediate 20 S-IC.

* Ignore for simulated static firing.

FIGURE 5-12
(Sheet 2 of 14)

COMMANDS	RESULTS	INDICATION	TIME
Firing Command	Firing Command	KDI189 ON	KDI138 ON -1.050 MAX
Launch Sequencer T-90	Terminal Countdown Channel 1	KDI138 ON	T-90 (Definition
	Fuel Tank Flight Vent and Relief Valve Open	KDI222 OFF	KDI138 ON +.300 MAX
	Fuel Tank Flight Vent and Relief Valve Closed	KDI221 ON	KDI222 OFF+.400 MAX
	Start Fuel Tank Prepress	KDI228 ON	KDI221 ON +.050 MAX (6)
	Fuel Tank Prepress OK	KDI231 ON	Prior to T-25
Launch Sequencer T-72	Terminal Countdown Channel 2	KDI178 ON	T-72 (Definition)
	GSE LOX Bubbling Valve Open	KDI240 OFF	KDI178 ON +.100 MAX
	* LOX Bubbling 2 Lines	KDI243 OFF	KDI240 OFF+.050 MAX
	LOX Tank Vent and Relief Valve Open	KDI247 OFF	KDI182 ON +.450 MAX
	LOX Tank Vent and Relief Valve Closed	KDI246 ON	KDI182 ON +.600 MAX (5)
	Start LOX Prepress	KDI256 ON	KDI246 ON +.050 MAX (6)
	LOX Tank Prepress OK	KDI252 ON	Prior to T-25
Launch Sequencer T-30	Terminal Countdown Channel 3	KDI198 ON	T-30 (Definition)
	* Engine 1 Hydraulic Checkout Valve Grd. Pos.	KDI277 OFF	KDI198 ON +1.500 MAX
	Engine 2 Hydraulic Checkout Valve Grd. Pos.	KDI297 OFF	KDI198 ON +1.500 MAX
	Engine 3 Hydraulic Checkout Valve Grd. Pos.	KDI317 OFF	KDI198 ON +1.500 MAX
	Engine 4 Hydraulic Checkout Valve Grd. Pos.	KDI337 OFF	KDI198 ON +1.500 MAX

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FIGURE 12
(Sheet 3 of 14)

COMMANDS	RESULTS	INDICATION	TIME
	Engine 1 Hydraulic Checkout Valve Eng. Pos.	KDI260 ON	KDI277 OFF+.5 to 3.5
	Engine 2 Hydraulic Checkout Valve Eng. Pos.	KDI280 ON	KDI297 OFF+.5 to 3.5
	Engine 3 Hydraulic Checkout Valve Eng. Pos.	KDI300 ON	KDI317 OFF+.5 to 3.5
	Engine 4 Hydraulic Checkout Valve Eng. Pos.	KDI320 ON	KDI337 OFF+.5 to 3.5
	Power Changeover External	KDI194 OFF	KDI198 ON +.200 MAX
	Power Changeover Internal	KDI193 ON	KDI193 ON +.400 MAX
Launch Sequencer T-26	Terminal Countdown Channel 4	KDI218 ON	T-26 (Definition)
	Range Safety Command Receiver No. 1 Internal Power ON	KDI535 ON	KDI218 ON +.050 MAX
	Range Safety Command Receiver No. 2 Internal Power ON	KDI536 ON	KDI218 ON +.050 MAX
Launch Sequencer T-25	Terminal Countdown Channel 5	KDI238 ON	T-25 (Definition)
	LOX Prepress Test OK	KDI212 ON	KDI238 ON +5.000 MAX
	Fuel Prepress Test OK	KDI214 ON	KDI238 ON +.050 MAX
	* GSE LOX Dome and CG Purge High Open	KDI88 ON	KDI238 ON +.100 MAX
	* GSE LOX Dome and CG Purge High Pressure OK	KDI89 ON	Prior to T-10
	Ready for Ignition	KDI190 ON	Prior to T-10
Launch Sequencer T-18	Terminal Countdown Channel 7	KDI278 ON	T-18 (Definition)
	Safe and Armed Device Safe	KDI471 OFF	KDI278 ON +.100 MAX
	Safe and Armed Device Armed	KDI472 ON	KDI278 ON +.250 MAX
	LOX Interconnect Valve No. 1 Open	KDI200 OFF	KDI278 ON +1.500 MAX
	LOX Interconnect Valve No. 1 Closed	KDI201 ON	KDI278 ON +3.000 MAX
	LOX Interconnect Valve No. 3 Open	KDI206 OFF	KDI278 ON +1.500 MAX
	LOX Interconnect Valve No. 3 Closed	KDI207 ON	KDI278 ON +3.000 MAX
	LOX Interconnect Valve No. 4 Open	KDI208 OFF	KDI278 ON +1.500 MAX
	LOX Interconnect Valve No. 4 Closed	KDI209 ON	KDI278 ON +3.000 MAX
	Stage LOX Bubbling Valve Close Command	KDI244 OFF	KDI278 ON +3.000 MAX
Launch Sequencer T-17	Terminal Countdown Channel 8	KDI298 ON	T-17 (Definition)
Launch Sequencer T-15	Terminal Countdown Channel 9	KDI318 ON	T-15 (Definition)
	High Engine Area Purge Engine No. 1 Open	KDI152 ON	KDI318 ON +.100 MAX
	High Engine Area Purge Engine No. 2 Open	KDI153 ON	KDI318 ON +.100 MAX
	High Engine Area Purge Engine No. 3 Open	KDI154 ON	KDI318 ON +.100 MAX
	High Engine Area Purge Engine No. 4 Open	KDI155 ON	KDI318 ON +.100 MAX
Launch Sequencer T-10	Terminal Countdown Channel 10	KDI358 ON	T-10 (Definition)
	Hydraulic Unit Commit	KDI594 ON	KDI358 +.050 MAX

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COMMANDS	RESULTS	INDICATION	TIME
Launch Sequencer T-9	Terminal Countdown Channel 11	KDI378 ON	T-9 (Definition)
	Stage GN_2 1500 PSIG Enable	KDI511 ON	KDI378 ON + .250 MAX
	Ignition Start	KA2 ON	KDI378 ON + .050 MAX
	Igniter 480 Volts Applied	KDI217 ON	KDI378 ON + .300 MAX
	Igniter 480 Volts Applied	KDI217 OFF	KDI217 ON+100 ± .050
	Igniter Link Break Turbine Exhaust Engine 1	KA4-1 OFF	KDI378 ON +1.500 MAX
	Igniter Link Break Turbine Exhaust Engine 2	KA4-2 OFF	KDI378 ON +1.500 MAX
	Igniter Link Break Turbine Exhaust Engine 3	KA4-3 OFF	KDI378 ON +1.500 MAX
	Igniter Link Break Turbine Exhaust Engine 4	KA4-4 OFF	KDI378 ON +1.500 MAX
	Igniter Link Break Gas Generator Engine 1	KA10-1 OFF	KDI378 ON +1.500 MAX
	Igniter Link Break Gas Generator Engine 2	KA10-2 OFF	KDI378 ON +1.500 MAX
	Igniter Link Break Gas Generator Engine 3	KA10-3 OFF	KDI378 ON +1.500 MAX
	Igniter Link Break Gas Generator Engine 4	KA10-4 OFF	KDI378 ON +1.500 MAX
	All T. E. & G. G. Igniter Installed	KDI172 OFF	KDI378 ON +1.500 MAX
	Turbopump Heaters Enable	KDI210 OFF	KDI378 ON +1.500 MAX
	Engine Control Valve Open Engine 1	KA6-1 ON	1
	Engine Control Valve Open Engine 2	KA6-2 ON	1
	Engine Control Valve Open Engine 3	KA6-3 ON	1
	Engine Control Valve Open Engine 4	KA6-4 ON	1
2	Engine 1 GG Valve Closed	KDI272 OFF	KA6-1 ON +.155 ±.025
	Engine 2 GG Valve Closed	KDI292 OFF	KA6-2 ON +.155 ±.025
	Engine 3 GG Valve Closed	KDI312 OFF	KA6-3 ON +.155 ±.025
	Engine 4 GG Valve Closed	KDI332 OFF	KA6-4 ON +.155 ±.025
	Engine 1 GG Valve Open	KDI264 ON	KDI272 OFF +.165±.040
	Engine 2 GG Valve Open	KDI284 ON	KDI292 OFF +.165±.040
	Engine 3 GG Valve Open	KDI304 ON	KDI312 OFF +.165±.040
	Engine 4 GG Valve Open	KDI324 ON	KDI332 OFF +.165±.040
	No. 1 Main LOX Valve Closed Engine 1	KA37-1 OFF	KA6-1 ON + .155 NOM.
	No. 1 Main LOX Valve Closed Engine 2	KA37-2 OFF	KA6-2 ON + .155 NOM.
	No. 1 Main LOX Valve Closed Engine 3	KA37-3 OFF	KA6-3 ON + .155 NOM.
2	No. 1 Main LOX Valve Closed Engine 4	KA37-4 OFF	KA6-4 ON + .155 NOM.

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COMMANDS	RESULTS	INDICATION	TIME
2	No. 1 Main LOX Valve Open Engine 1	KA36-1 ON	KA37-1 OFF +.305 NOM.
	No. 1 Main LOX Valve Open Engine 2	KA36-2 ON	KA37-2 OFF +.305 NOM.
	No. 1 Main LOX Valve Open Engine 3	KA36-3 ON	KA37-3 OFF +.305 NOM.
	No. 1 Main LOX Valve Open Engine 4	KA36-4 ON	KA37-4 OFF +.305 NOM.
	No. 2 Main LOX Valve Closed Engine 1	KA39-1 OFF	KA6-1 ON +.155 NOM.
	No. 2 Main LOX Valve Closed Engine 2	KA39-2 OFF	KA6-2 ON +.155 NOM.
	No. 2 Main LOX Valve Closed Engine 3	KA39-3 OFF	KA6-3 ON +.155 NOM.
	No. 2 Main LOX Valve Closed Engine 4	KA39-4 OFF	KA6-4 ON +.155 NOM.
	No. 2 Main LOX Valve Open Engine 1	KA38-1 ON	KA39-1 OFF +.305 NOM.
	No. 2 Main LOX Valve Open Engine 2	KA38-2 ON	KA39-2 OFF +.305 NOM.
	No. 2 Main LOX Valve Open Engine 3	KA38-3 ON	KA39-3 OFF +.305 NOM.
	No. 2 Main LOX Valve Open Engine 4	KA38-4 ON	KA39-4 OFF +.305 NOM.
2	Hypergol Monitor Switch Engine 1	KA8-1 OFF	KA6-1 ON + 3.500 MAX
	Hypergol Monitor Switch Engine 2	KA8-2 OFF	KA6-2 ON +3.500 MAX
	Hypergol Monitor Switch Engine 3	KA8-3 OFF	KA6-3 ON +3.500 MAX
	Hypergol Monitor Switch Engine 4	KA8-4 OFF	KA6-4 ON +3.500 MAX
2	No. 1 Main Fuel Valve Closed Engine 1	KA41-1 OFF	KA8-1 OFF +.300 NOM.
	No. 1 Main Fuel Valve Closed Engine 2	KA41-2 OFF	KA8-2 OFF +.300 NOM.
	No. 1 Main Fuel Valve Closed Engine 3	KA41-3 OFF	KA8-3 OFF +.300 NOM.
	No. 1 Main Fuel Valve Closed Engine 4	KA41-4 OFF	KA8-4 OFF +.300 NOM.
	No. 1 Main Fuel Valve Open Engine 1	KA40-1 ON	KA41-1 OFF +.590 NOM
	No. 1 Main Fuel Valve Open Engine 2	KA40-2 ON	KA41-2 OFF +.590 NOM
	No. 1 Main Fuel Valve Open Engine 3	KA40-3 ON	KA41-3 OFF +.590 NOM
	No. 1 Main Fuel Valve Open Engine 4	KA40-4 ON	KA41-4 OFF +.590 NOM
	No. 2 Main Fuel Valve Closed Engine 1	KA43-1 OFF	KA8-1 OFF +.300 NOM.
	No. 2 Main Fuel Valve Closed Engine 2	KA43-2 OFF	KA8-2 OFF +.300 NOM.
	No. 2 Main Fuel Valve Closed Engine 3	KA43-3 OFF	KA8-3 OFF +.300 NOM.
	No. 2 Main Fuel Valve Closed Engine 4	KA43-4 OFF	KA8-4 OFF +.300 NOM.
2			

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FIGURE 5-12
(Sheet 6 of 14)

COMMANDS	RESULTS	INDICATION	TIME
2	No. 2 Main Fuel Valve Open Engine 1	KA42-1 ON	KA43-1 OFF +.590 NOM.
↓	No. 2 Main Fuel Valve Open Engine 2	KA42-2 ON	KA43-2 OFF +.590 NOM.
↓	No. 2 Main Fuel Valve Open Engine 3	KA42-3 ON	KA43-3 OFF +.590 NOM.
2	No. 2 Main Fuel Valve Open Engine 4	KA42-4 ON	KA43-4 OFF +.590 NOM.
	Engine No. 1 Thrust Not OK No. 1	KDI441 OFF	Prior to T-0
	Engine No. 1 Thrust Not OK No. 2	KDI442 OFF	Prior to T-0
	Engine No. 1 Thrust Not OK No. 3	KDI443 OFF	Prior to T-0
	Engine No. 2 Thrust Not OK No. 1	KDI444 OFF	Prior to T-0
	Engine No. 2 Thrust Not OK No. 2	KDI445 OFF	Prior to T-0
	Engine No. 2 Thrust Not OK No. 3	KDI446 OFF	Prior to T-0
	Engine No. 3 Thrust Not OK No. 1	KDI447 OFF	Prior to T-0
	Engine No. 3 Thrust Not OK No. 2	KDI448 OFF	Prior to T-0
	Engine No. 3 Thrust Not OK No. 3	KDI449 OFF	Prior to T-0
	Engine No. 4 Thrust Not OK No. 1	KDI450 OFF	Prior to T-0
	Engine No. 4 Thrust Not OK No. 2	KDI451 OFF	Prior to T-0
	Engine No. 4 Thrust Not OK No. 3	KDI452 OFF	Prior to T-0
	Thrust OK Pressure Switch No. 1 Engine 1	KA9-1 ON	Prior to T-0
	Thrust OK Pressure Switch No. 2 Engine 1	KA9-1A ON	Prior to T-0
	Thrust OK Pressure Switch No. 3 Engine 1	KA9-1B ON	Prior to T-0
	Thrust OK Pressure Switch No. 1 Engine 2	KA9-2 ON	Prior to T-0
	Thrust OK Pressure Switch No. 2 Engine 2	KA9-2A ON	Prior to T-0
	Thrust OK Pressure Switch No. 3 Engine 2	KA9-2B ON	Prior to T-0
	Thrust OK Pressure Switch No. 1 Engine 3	KA9-3 ON	Prior to T-0
	Thrust OK Pressure Switch No. 2 Engine 3	KA9-3A ON	Prior to T-0
	Thrust OK Pressure Switch No. 3 Engine 3	KA9-3B ON	Prior to T-0
	Thrust OK Pressure Switch No. 1 Engine 4	KA9-4 ON	Prior to T-0
	Thrust OK Pressure Switch No. 2 Engine 4	KA9-4A ON	Prior to T-0
	Thrust OK Pressure Switch No. 3 Engine 4	KA9-4B ON	Prior to T-0

COMMANDS	RESULTS	INDICATION	TIME
	Engine 1 All Thrust OK	KDI270 ON	Prior to T-0
	Engine 2 All Thrust OK	KDI290 ON	Prior to T-0
	Engine 3 All Thrust OK	KDI310 ON	Prior to T-0
	Engine 4 All Thrust OK	KDI330 ON	Prior to T-0
	All Engines Running	KA56 ON	Prior to T-0
	High Engine Area Purge Engine No. 1 Open	KDI152 OFF	KA56 ON +0.050 MAX
	High Engine Area Purge Engine No. 2 Open	KDI153 OFF	KA56 ON +3.000 ± .500
	High Engine Area Purge Engine No. 3 Open	KDI154 OFF	KA56 ON +0.050 MAX
	High Engine Area Purge Engine No. 4 Open	KDI155 OFF	KA56 ON +3.000 ± .500
	LOX Prepress Commit	KDI81 ON	T-4.7 ± .100 MAX △6
Launch Sequencer T-4	Terminal Countdown Channel 12	KDI338 ON	T-4 (Definition)
	Helium Flow Control Valve No. 1 Close Command	KDI655 OFF	T-2.75 ± .200 MAX △6
	Helium Flow Control Valve No. 1 Closed	KDI460 OFF	KDI655 OFF +.250 MAX △6
	Helium Flow Control Valve No. 1 Open	KDI629 ON	KDI655 OFF +.500 MAX △6
Switch Selector T-0	Multiple (Thrust Not OK) Engine C/O Enable	KDI666 ON	T-0 + .200
Launch Sequencer T-0	Terminal Countdown Channel 13	KDI418 ON	T-0 (Definition)
	POGO He Supply Valve 1 Open Command	KDI564 OFF	KDI418 ON +.050 MAX
	POGO He Supply Valve 2 Open Command	KDI565 OFF	KDI418 ON +.050 MAX
	Fuel Press Umbilical Shutoff Valve Closed	KDI456 On	KDI418 ON +.100 MAX
	Start Fuel Tank Prepress	KDI228 OFF	KDI418 ON +.050 MAX △6
	Fuel Prepress Vent Valve Open	KDI162 ON	KDI418 ON +.100 MAX
	Start LOX Prepress	KDI256 OFF	KDI418 ON +.050 MAX
	GSE LOX Prepress Line Vent Open	KDI552 On	KDI418 ON +.100 MAX △6
	Launch Commit	KDI196 ON	KDI418 ON +.050 MAX
	Liftoff	KDI197 ON	KDI418 ON +.050 MAX
Launch Sequencer T+2	Terminal Countdown Channel 14	KDI398 ON	T+2 (Definition)
Switch Selector T+20	Telemetry Calibrate	KDI666 ON	T+20 ± .200
Switch Selector T+25	Telemetry Calibrate	KDI666 ON	T+25 ∓ .200
Switch Selector T+34	Open Helium Flow Control Valve No. 2	KDI666 ON	T+34 ∓ .200 △6
	Helium Flow Control Valve No. 2 Closed	KDI630 OFF	KDI666 ON +.250 MAX △6
	Helium Flow Control Valve No. 2 Open	KDI631 On	KDI666 ON +.500 MAX △6
Launch Sequencer T+35	Terminal Countdown Channel 16	KDI458 ON	T+35 (Definition)
Switch Selector T+50	Enable Fuel Tank High Vent & Relief Pressure Switch	KDI( )	T+50 ± .200
Switch Selector T+54	Open Helium Flow Control Valve No. 3	KDI666 ON	T+54 ± .200 △6
	Helium Flow Control Valve No. 3 Closed	KDI632 OFF	KDI666 ON + .250 MAX △6
	Helium Flow Control Valve No. 3 Open	KDI633 ON	KDI666 ON + .500 MAX △6

REVISIONS: SYM | DESCRIPTION | DATE | APPROVAL

CODE IDENT NO 14981 | DWG SIZE A | 66B10920 | SHEET A-401

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL

FIGURE 5-12
(Sheet 8 of 14)

COMMANDS	RESULTS	INDICATION	TIME
Launch Sequencer T+55	Terminal Countdown Channel 17	KDI578 ON	T+55 (Definition)
Switch Selector T+74	Open Helium Flow Control Valve No. 4	KDI666 ON	T+74 +.200
	Helium Flow Control Valve No. 4 Closed	KDI634 OFF	KDI666 ON +.250 MAX
	Helium Flow Control Valve No. 4 Open	KDI635 ON	KDI666 ON +.500 MAX
Launch Sequencer T+75	Terminal Countdown Channel 19	KDI518 ON	T+75 (Definition)
Launch Sequencer T+94	Terminal Countdown Channel 20	KDI538 ON	T+94 (Definition)
	Helium Flow Control Valve No. 5 Closed	KDI636 OFF	KDI538 ON +.250 MAX
	Helium Flow Control Valve No. 5 Open	KDI637 ON	KDI538 ON +.500 MAX
Switch Selector T+109	Automatic Abort System Enabled	KDI666 ON	T+109 ±.200
Switch Selector T+110	Telemetry Calibrate	KDI666 ON	T+110 ±.200
Switch Selector T+115.2	Telemetry Calibrate	KDI666 ON	T+115.2 ±.200
Switch Selector T+119.5	Retro and Separation #1 EBW Firing Unit Armed	KDI666 ON	T+119.5 ±.200
Switch Selector T+119.6	Retro and Separation #2 EBW Firing Unit Armed	KDI666 ON	T+119.6 ±.200
Cutoff	Terminal Countdown Sequencer Cutoff	KDI478 ON	T+124.9 ±2
	Cutoff Start	KA55 ON	T+124.9 ±2
	Cutoff Complete	KDI432 ON	T+125 ±2
	POGO He Supply Valve 1 Closed Command	KDI564 ON	KDI432 ON +.100 MAX
	POGO He Supply Valve 2 Closed Command	KDI565 ON	KDI432 ON +.100 MAX
	Engine Control Valve Closed Engine 1	KA7-1 ON	KA55 ON+.050 MAX
	Engine Control Valve Closed Engine 2	KA7-2 ON	KDI432 ON +.050 MAX
	Engine Control Valve Closed Engine 3	KA7-3 ON	KA55 ON+.050 MAX
	Engine Control Valve Closed Engine 4	KA7-4 ON	KDI432 ON +.050 MAX
	All Engines Running	KA56 OFF	KA7-1 ON +.250 MAX
	Engine 1 All Thrust OK	KDI270 OFF	KA7-1 ON +.250 MAX
	Engine 2 All Thrust OK	KDI290 OFF	KA7-2 ON +.250 MAX
	Engine 3 All Thrust OK	KDI310 OFF	KA7-3 ON +.250 MAX
	Engine 4 All Thrust OK	KDI330 OFF	KA7-4 ON +.250 MAX

COMMANDS	RESULTS	INDICATION	TIME
3	Thrust OK Pressure Switch No. 1 Engine 1	KA9-1 OFF	KA7-1 ON +.250 MAX
	Thrust OK Pressure Switch No. 2 Engine 1	KA9-1A OFF	KA7-1 ON +.250 MAX
	Thrust OK Pressure Switch No. 3 Engine 1	KA9-1B OFF	KA7-1 ON +.250 MAX
	Thrust OK Pressure Switch No. 1 Engine 2	KA9-2 OFF	KA7-2 ON +.250 MAX
	Thrust OK Pressure Switch No. 2 Engine 2	KA9-2A OFF	KA7-2 ON +.250 MAX
	Thrust OK Pressure Switch No. 3 Engine 2	KA9-2B OFF	KA7-2 ON +.250 MAX
	Thrust OK Pressure Switch No. 1 Engine 3	KA9-3 OFF	KA7-3 ON +.250 MAX
	Thrust OK Pressure Switch No. 2 Engine 3	KA9-3A OFF	KA7-3 ON +.250 MAX
	Thrust OK Pressure Switch No. 3 Engine 3	KA9-3B OFF	KA7-3 ON +.250 MAX
	Thrust OK Pressure Switch No. 1 Engine 4	KA9-4 OFF	KA7-4 ON +.250 MAX
	Thrust OK Pressure Switch No. 2 Engine 4	KA9-4A OFF	KA7-4 ON +.250 MAX
	Thrust OK Pressure Switch No. 3 Engine 4	KA9-4B OFF	KA7-4 ON +.250 MAX
	Engine No. 1 Thrust Not OK No. 1	KDI441 ON	KA7-1 ON +.250 MAX
	Engine No. 1 Thrust Not OK No. 2	KDI442 ON	KA7-1 ON +.250 MAX
	Engine No. 1 Thrust Not OK No. 3	KDI443 ON	KA7-1 ON +.250 MAX
	Engine No. 2 Thrust Not OK No. 1	KDI444 ON	KA7-2 ON +.250 MAX
	Engine No. 2 Thrust Not OK No. 2	KDI445 ON	KA7-2 ON +.250 MAX
	Engine No. 2 Thrust Not OK No. 3	KDI446 ON	KA7-2 ON +.250 MAX
	Engine No. 3 Thrust Not OK No. 1	KDI447 ON	KA7-3 ON +.250 MAX
	Engine No. 3 Thrust Not OK No. 2	KDI448 ON	KA7-3 ON +.250 MAX
	Engine No. 3 Thrust Not OK No. 3	KDI449 ON	KA7-3 ON +.250 MAX
	Engine No. 4 Thrust Not OK No. 1	KDI450 ON	KA7-4 ON +.250 MAX
	Engine No. 4 Thrust Not OK No. 2	KDI451 ON	KA7-4 ON +.250 MAX
	Engine No. 4 Thrust Not OK No. 3	KDI452 ON	KA7-4 ON +.250 MAX
3 2	Engine 1 GG Valve Open	KDI264 OFF	KA7-1 ON +.050 NOM.
	Engine 2 GG Valve Open	KDI284 OFF	KA7-2 ON +.050 NOM.
	Engine 3 GG Valve Open	KDI304 OFF	KA7-3 ON +.050 NOM.
	Engine 4 GG Valve Open	KDI324 OFF	KA7-4 ON +.050 NOM.
2			

REVISIONS

SYM	DESCRIPTION	DATE	APPROVAL

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL

FIGURE -12
(Sheet 10 of 14)

COMMANDS	RESULTS	INDICATION	TIME
	Engine 1 GG Valve Closed	KDI272 ON	KDI264 OFF +.085 ±.015
	Engine 2 GG Valve Closed	KDI292 ON	KDI284 OFF +.085 ±.015
	Engine 3 GG Valve Closed	KDI312 ON	KDI304 OFF +.085 ±.015
	Engine 4 GG Valve Closed	KDI332 ON	KDI324 OFF +.085 ±.015
	No. 1 Main LOX Valve Open Engine 1	KA36-1 OFF	KA7-1 ON +.185 NOM.
	No. 1 Main LOX Valve Open Engine 2	KA36-2 OFF	KA7-2 ON +.185 NOM.
	No. 1 Main LOX Valve Open Engine 3	KA36-3 OFF	KA7-3 ON +.185 NOM.
	No. 1 Main LOX Valve Open Engine 4	KA36-4 OFF	KA7-4 ON +.185 NOM.
	No. 1 Main LOX Valve Closed Engine 1	KA37-1 ON	KA36-1 OFF +.295 NOM.
	No. 1 Main LOX Valve Closed Engine 2	KA37-2 ON	KA36-2 OFF +.295 NOM.
	No. 1 Main LOX Valve Closed Engine 3	KA37-3 ON	KA36-3 OFF +.295 NOM.
	No. 1 Main LOX Valve Closed Engine 4	KA37-4 ON	KA36-4 OFF +.295 NOM.
	No. 2 Main LOX Valve Open Engine 1	KA38-1 OFF	KA7-1 ON +.185 NOM.
	No. 2 Main LOX Valve Open Engine 2	KA38-2 OFF	KA7-2 ON +.185 NOM.
	No. 2 Main LOX Valve Open Engine 3	KA38-3 OFF	KA7-3 ON +.185 NOM.
	No. 2 Main LOX Valve Open Engine 4	KA38-4 OFF	KA7-4 ON +.185 NOM.
	No. 2 Main LOX Valve Closed Engine 1	KA39-1 ON	KA38-1 OFF .295 NOM.
	No. 2 Main LOX Valve Closed Engine 2	KA39-2 ON	KA38-2 OFF .295 NOM.
	No. 2 Main LOX Valve Closed Engine 3	KA39-3 ON	KA38-3 OFF .295 NOM.
	No. 2 Main LOX Valve Closed Engine 4	KA39-4 ON	KA38-4 OFF .295 NOM.
	No. 1 Main Fuel Valve Open Engine 1	KA40-1 OFF	KA7-1 ON +.125 NOM.
	No. 1 Main Fuel Valve Open Engine 2	KA40-2 OFF	KA7-2 ON +.125 NOM.
	No. 1 Main Fuel Valve Open Engine 3	KA40-3 OFF	KA7-3 ON +.125 NOM.
	No. 1 Main Fuel Valve Open Engine 4	KA40-4 OFF	KA7-4 ON +.125 NOM.
	No. 1 Main Fuel Valve Closed Engine 1	KA41-1 ON	KA40-1 OFF +.975 NOM.
	No. 1 Main Fuel Valve Clo-ed Engine 2	KA41-2 ON	KA40-2 OFF +.975 NOM.
	No. 1 Main Fuel Valve Closed Engine 3	KA41-3 ON	KA40-3 OFF +.975 NOM.
	No. 1 Main Fuel Valve Closed Engine 4	KA41-4 ON	KA40-4 OFF +.975 NOM.

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SYM	DESCRIPTION	DATE	APPROVAL

FIGURE ?-12
(Sheet 11 of 14)

COMMANDS		RESULTS	INDICATION	TIME
	2	No. 2 Main Fuel Valve Open Engine 1	KA42-1 OFF	KA7-1 ON +.125 NOM.
		No. 2 Main Fuel Valve Open Engine 2	KA42-2 OFF	KA7-2 ON +.125 NOM.
		No. 2 Main Fuel Valve Open Engine 3	KA42-3 OFF	KA7-3 ON +.125 NOM.
		No. 2 Main Fuel Valve Open Engine 4	KA42-4 OFF	KA7-4 ON +.125 NOM.
		No. 2 Main Fuel Valve Closed Engine 1	KA43-1 ON	KA42-1 OFF +.975 NOM.
		No. 2 Main Fuel Valve Closed Engine 2	KA43-2 ON	KA42-2 OFF +.975 NOM.
		No. 2 Main Fuel Valve Closed Engine 3	KA43-3 ON	KA4 -3 OFF +.975 NOM.
	2	No. 2 Main Fuel Valve Closed Engine 4	KA43-4 ON	KA4 -4 OFF +.975 NOM.
		Engine 1 Hydraulic Checkout Valve Eng. Pos.	KDI260 OFF	KDI432 ON +1.500 MAX.
		Engine 2 Hydraulic Checkout Valve Eng. Pos.	KDI280 OFF	KDI432 ON +1.500 MAX
		Engine 3 Hydraulic Checkout Valve Eng. Pos.	KDI300 OFF	KDI432 ON +1.500 MAX
		Engine 4 Hydraulic Checkout Valve Eng. Pos.	KDI320 OFF	KDI432 ON +1.500 MAX
		Engine 1 Hydraulic Checkout Valve Grd. Pos.	KDI277 ON	KDI260 OFF+.5 to 3.5
		Engine 2 Hydraulic Checkout Valve Grd. Pos.	KDI297 ON	KDI280 OFF+.5 to 3.5
		Engine 3 Hydraulic Checkout Valve Grd. Pos.	KDI317 ON	KDI300 OFF+.5 to 3.5
		Engine 4 Hydraulic Checkout Valve Grd. Pos.	KDI337 ON	KDI320 OFF+.5 to 3.5
	*	Engine No. 1 LOX Prevalve Open	KDI121 OFF	KDI706 ON +.700 MAX
		Engine No. 2 LOX Prevalve Open	KDI127 OFF	KDI708 ON +.700 MAX
		Engine No. 3 LOX Prevalve Open	KDI133 OFF	KDI710 ON +.700 MAX
		Engine No. 4 LOX Prevalve Open	KDI141 OFF	KDI712 ON +.700 MAX
		Engine No. 1 LOX Prevalve Closed	KDI120 ON	KDI706 ON +.825 tol.350
		Engine No. 2 LOX Prevalve Closed	KDI126 ON	KDI708 ON +.825 tol.350
		Engine No. 3 LOX Prevalve Closed	KDI132 ON	KDI710 ON +.825 tol.350
		Engine No. 4 LOX Prevalve Closed	KDI140 ON	KDI712 ON +.825 tol.350
		Engine No. 1 Fuel Prevalve No. 1 Open	KDI123 OFF	KDI270 OFF +.800 MAX
		Engine No. 2 Fuel Prevalve No. 1 Open	KDI129 OFF	KDI290 OFF +.800 MAX
		Engine No. 3 Fuel Prevalve No. 1 Open	KDI135 OFF	KDI310 OFF +.800 MAX
	*	Engine No. 4 Fuel Prevalve No. 1 Open	KDI143 OFF	KDI330 OFF +.800 MAX

COMMANDS	RESULTS	INDICATION	TIME
*	Engine No. 1 Fuel Prevalve No. 1 Closed	KDI122 ON	KDI270 OFF+1.500 to 3.000
	Engine No. 2 Fuel Prevalve No. 1 Closed	KDI128 ON	KDI290 OFF+1.500 to 3.000
	Engine No. 3 Fuel Prevalve No. 1 Closed	KDI134 ON	KDI310 OFF+1.500 to 3.000
	Engine No. 4 Fuel Prevalve No. 1 Closed	KDI142 ON	KDI330 OFF+1.500 to 3.000
	Engine No. 1 Fuel Prevalve No. 2 Open	KDI125 OFF	KDI270 OFF +.800 MAX
	Engine No. 2 Fuel Prevalve No. 2 Open	KDI131 OFF	KDI290 OFF +.800 MAX
	Engine No. 3 Fuel Prevalve No. 2 Open	KDI137 OFF	KDI310 OFF +.800 MAX
	Engine No. 4 Fuel Prevalve No. 2 Open	KDI145 OFF	KDI330 OFF +.800 MAX
	Engine No. 1 Fuel Prevalve No. 2 Closed	KDI124 ON	KDI270 OFF+1.500 to 3.000
	Engine No. 2 Fuel Prevalve No. 2 Closed	KDI130 ON	KDI290 OFF+1.500 to 3.000
	Engine No. 3 Fuel Prevalve No. 2 Closed	KDI136 ON	KDI310 OFF+1.500 to 3.000
	Engine No. 4 Fuel Prevalve No. 2 Closed	KDI144 ON	KDI330 OFF+1.500 to 3.000
*			
	Engine Stop Solenoid Backup Open Command	KDI440 ON	KA55 ON +.200 ±.020
	Engine 1 4-way Solenoid Backup Valve Closed	KDI366 OFF	KDI440 ON +.050 MAX
	Engine 2 4-way Solenoid Backup Valve Closed	KDI375 OFF	KDI440 ON +.050 MAX
	Engine 3 4-way Solenoid Backup Valve Closed	KDI386 OFF	KDI440 ON +.050 MAX
	Engine 4 4-way Solenoid Backup Valve Closed	KDI395 OFF	KDI440 ON +.050 MAX
	Hydraulic Override Engine 1	KA13-1 ON	KDI440 ON +.100 MAX
	Hydraulic Override Engine 2	KA13-2 ON	KDI440 ON +.100 MAX
	Hydraulic Override Engine 3	KA13-3 ON	KDI440 ON +.100 MAX
	Hydraulic Override Engine 4	KA13-4 ON	KDI440 ON +.100 MAX
	Fuel Tank Flight Vent & Relief Valve Closed	KDI221 OFF	KDI432 ON +.100 MAX
	Fuel Tank Flight Vent & Relief Valve Open	KDI222 ON	KDI432 ON +.200 MAX
	Aux Fuel Tank Vents Open Command	KDI223 ON	KDI432 ON +.050 MAX
	Aux Fuel Tank Vent No. 1 Closed	KDI224 OFF	KDI223 ON +.150 MAX
	Aux Fuel Tank Vent No. 1 Open	KDI225 ON	KDI223 ON +.300 MAX
	Aux Fuel Tank Vent No. 2 Closed	KDI226 OFF	KDI223 ON +.150 MAX
	Aux Fuel Tank Vent No. 2 Open	KDI227 ON	KDI223 ON +.300 MAX
	LOX Tank Vent & Relief Valve Closed	KDI246 OFF	KDI432 ON +.150 MAX
	LOX Tank Vent & Relief Valve Open	KDI247 ON	KDI432 ON +.300 MAX
	Aux LOX Vent Open Command	KDI257 ON	KDI432 ON +.050 MAX
	LOX Tank Aux Vent Valve Closed	KDI248 OFF	KDI257 ON +.150 MAX
	LOX Tank Aux Vent Valve Open	KDI249 ON	KDI257 ON +.300 MAX

REVISIONS

SYM	DESCRIPTION	DATE	APPROVAL

MSFC FORM 422-C (VERTICAL) (NOVEMBER 1962)
C D5-17009-2

FIGURE 5-12
(Sheet 13 of 14)

COMMANDS	RESULTS	INDICATION	TIME
	△4 Helium Flow Control Valve No. 1 Open	KDI629 OFF	KDI434 ON +.100 MAX
	Helium Flow Control Valve No. 1 Closed	KDI460 ON	KDI434 ON +.200 MAX
	Helium Flow Control Valve No. 5 Open	KDI637 OFF	KDI432 ON +.100 MAX
	△4 Helium Flow Control Valve No. 5 Closed	KDI636 ON	KDI432 ON +.200 MAX
	GSE LOX Bubbling Valve Open	KDI240 ON	KDI432 ON +.200 MAX
	* LOX Bubbling 4 lines	KDI242 ON	KDI240 ON +10.000 MAX
	High Engine Area Purge Engine No. 1 Open	KDI152 ON	KA55 ON +.100 MAX
	High Engine Area Purge Engine No. 2 Open	KDI153 ON	KA55 ON +.100 MAX
	High Engine Area Purge Engine No. 3 Open	KDI154 ON	KA55 ON +.100 MAX
	High Engine Area Purge Engine No. 4 Open	KDI155 ON	KA55 ON +.100 MAX
	Engine 1-3 Cutoff Enable	KDI666 ON	KA55 ON +.300 +.200
Switch Selector T+125.4	Engine 1-3 Cutoff Enable	KDI666 ON	T+125.4 + .200 △5
Switch Selector T+125.6	Engine 1-3 Cutoff Backup Enable	KDI666 ON	T+125.6 ∓ .200 △5
Switch Selector T+125.8	S-IC/S-IV Separation No. 1	KDI666 ON	T+125.8 ∓ .200 △5
Switch Selector T+126.0	S-IC/S-IV Separation No. 2	KDI666 ON	T+126.0 ∓ .200 △5
Cutoff Reset	Cutoff Reset	KDI430 ON	
	Sequence and Control Distributor Reset	KDI175 ON	KDI430 ON +0.050 MAX
	△4 Helium Flow Control Valve No. 2 Open	KDI631 OFF	KDI430 ON +.100 MAX
	Helium Flow Control Valve No. 2 Closed	KDI630 ON	KDI430 ON +.200 MAX
	Helium Flow Control Valve No. 3 Open	KDI633 OFF	KDI430 ON +.100 MAX
	Helium Flow Control Valve No. 3 Closed	KDI632 ON	KDI430 ON +.200 MAX
	Helium Flow Control Valve No. 4 Open	KDI635 OFF	KDI430 ON +.100 MAX
	△4 Helium Flow Control Valve No. 4 Closed	KDI634 ON	KDI430 ON +.200 MAX
	LOX Interconnect Valve No. 1 Closed	KDI201 OFF	KDI430 ON +4.000 MAX
	LOX Interconnect Valve No. 1 Open	KDI200 ON	KDI430 ON +5.000 MAX
	LOX Interconnect Valve No. 3 Closed	KDI207 OFF	KDI430 ON +4.000 MAX
	LOX Interconnect Valve No. 3 Open	KDI206 ON	KDI430 ON +5.000 MAX
	LOX Interconnect Valve No. 4 Closed	KDI209 OFF	KDI430 ON +4.000 MAX
	LOX Interconnect Valve No. 4 Open	KDI208 ON	KDI430 ON +5.000 MAX
	* Engine No. 1 LOX Prevalve Closed	KDI120 OFF	KDI430 ON +5.000 MAX
	Engine No. 2 LOX Prevalve Closed	KDI126 OFF	KDI430 ON +5.000 MAX
	Engine No. 3 LOX Prevalve Closed	KDI132 OFF	KDI430 ON +5.000 MAX
	* Engine No. 4 LOX Prevalve Closed	KDI140 OFF	KDI430 ON +5.000 MAX

REVISIONS

SYM	DESCRIPTION	DATE	APPROVAL

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL

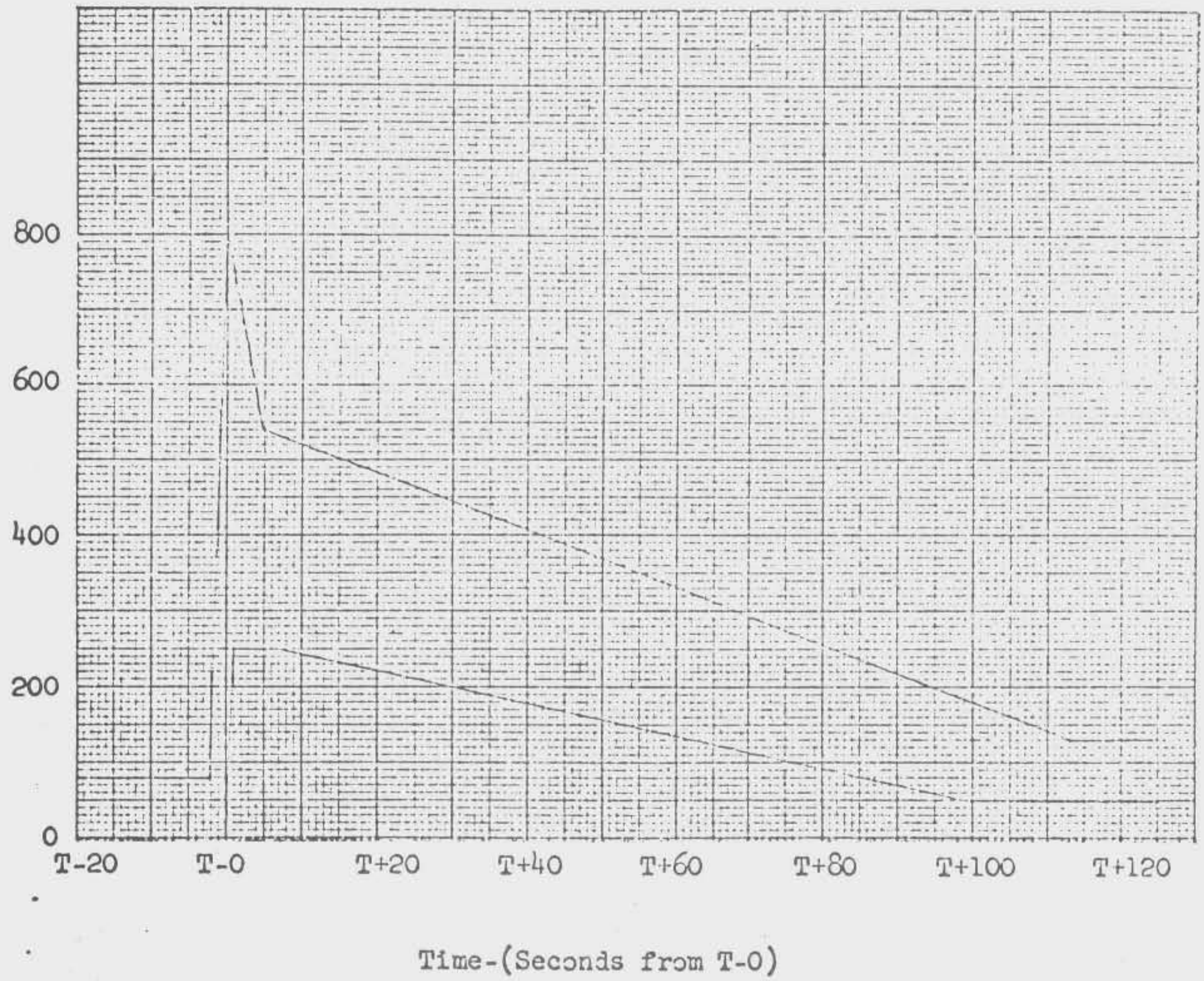
FIGURE 12
(Sheet 14 of 14)

COMMANDS	RESULTS	INDICATION	TIME
*	Engine No. 1 LOX Prevalve Open	KDI121 ON	KDI430 ON +6.000 MAX
	Engine No. 2 LOX Prevalve Open	KDI127 ON	KDI430 ON +6.000 MAX
	Engine No. 3 LOX Prevalve Open	KDI133 ON	KDI430 ON +6.000 MAX
	Engine No. 4 LOX Prevalve Open	KDI141 ON	KDI430 ON +6.000 MAX
	Engine No. 1 Fuel Prevalve No. 1 Closed	KDI122 OFF	KDI430 ON +5.000 MAX
	Engine No. 2 Fuel Prevalve No. 1 Closed	KDI128 OFF	KDI430 ON +5.000 MAX
	Engine No. 3 Fuel Prevalve No. 1 Closed	KDI134 OFF	KDI430 ON +5.000 MAX
	Engine No. 4 Fuel Prevalve No. 1 Closed	KDI142 OFF	KDI430 ON +5.000 MAX
	Engine No. 1 Fuel Prevalve No. 1 Open	KDI123 ON	KDI430 ON +10.000 MAX
	Engine No. 2 Fuel Prevalve No. 1 Open	KDI129 ON	KDI430 ON +10.000 MAX
	Engine No. 3 Fuel Prevalve No. 1 Open	KDI135 ON	KDI430 ON +10.000 MAX
	Engine No. 4 Fuel Prevalve No. 1 Open	KDI143 ON	KDI430 ON +10.000 MAX
	Engine No. 1 Fuel Prevalve No. 2 Closed	KDI124 OFF	KDI430 ON +5.000 MAX
	Engine No. 2 Fuel Prevalve No. 2 Closed	KDI130 OFF	KDI430 ON +5.000 MAX
	Engine No. 3 Fuel Prevalve No. 2 Closed	KDI136 OFF	KDI430 ON +5.000 MAX
	Engine No. 4 Fuel Prevalve No. 2 Closed	KDI144 OFF	KDI430 ON +5.000 MAX
	Engine No. 1 Fuel Prevalve No. 2 Open	KDI125 ON	KDI430 ON+10.000 MAX
	Engine No. 2 Fuel Prevalve No. 2 Open	KDI131 ON	KDI430 ON+10.000 MAX
	Engine No. 3 Fuel Prevalve No. 2 Open	KDI137 ON	KDI430 ON+10.000 MAX
	Engine No. 4 Fuel Prevalve No. 2 Open	KDI145 ON	KDI430 ON+10.000 MAX
*			
	Stage LOX Bubbling Valve Close Command	KDI244 ON	KDI430 ON +6.000 MAX
*	LOX Bubbling 4 lines	KDI242 OFF	KDI244 ON +.050 MAX
*	LOX Bubbling 2 lines	KDI243 ON	KDI244 ON +.050 MAX
	Power Changeover Internal	KDI193 OFF	KDI430 ON +.200 MAX
	Power Changeover External	KDI194 ON	KDI430 ON +.400 MAX
	Turbopump Heaters Enable	KDI210 ON	KDI430 ON +.050 MAX
	Terminal Countdown Sequencer Reset	KDI169 ON	KDI430 OFF+2.000 MAX

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL
G	See Sheet 1		

FIGURE 5-13

LOX Prevalve Helium Injection Pressure Requirements
(Measurement D182-115)



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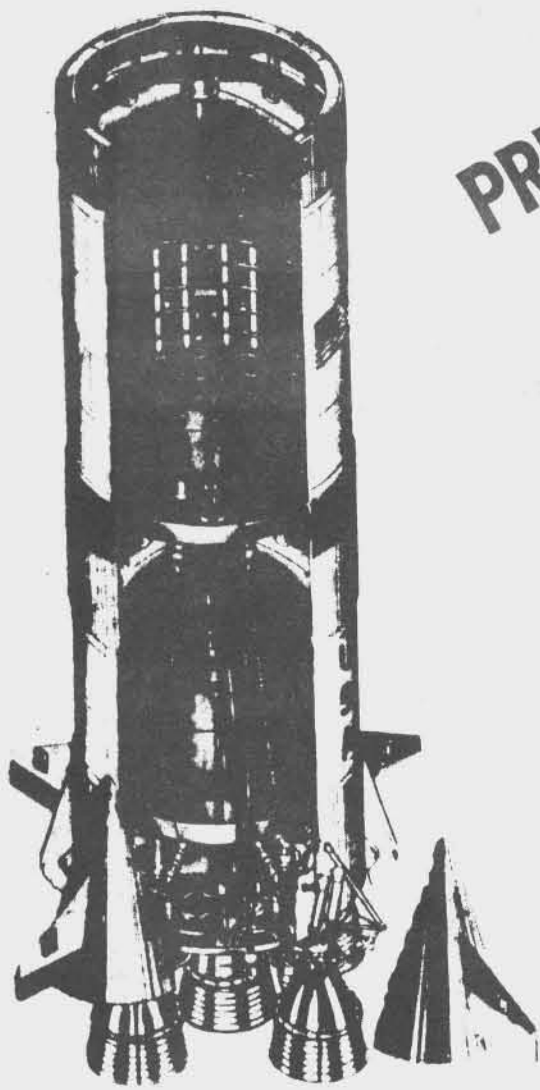


PRELIMINARY

INT-20

S-IC [redacted] STAGE
ELECTRICAL SCHEMATICS AND CID'S

PREPARED BY

ELECTRICAL AND ORDNANCE SYSTEMS

S-IC STAGE DESIGN

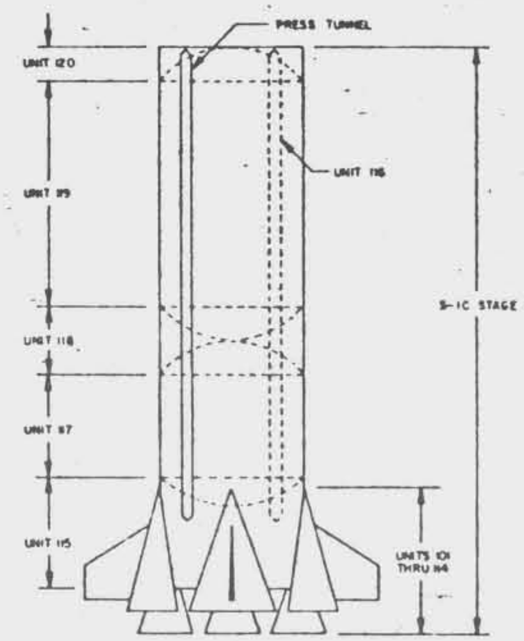
THE BOEING COMPANY

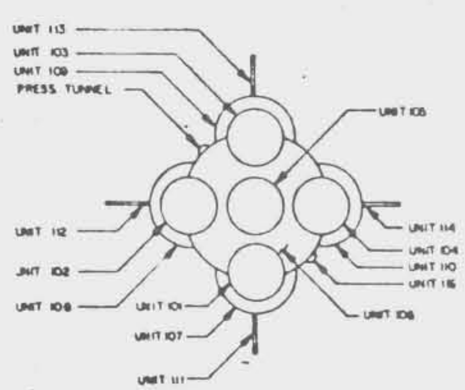
PRELIMINARY

60B55400 & 60B55401 COVER

H	REVISION DESCRIPTION A THRU G REMOVED. EDPO1556 1. ADDED STRAIN MEASUREMENTS TO UNIT 104 WIND LOADS ON SH 40. PRO 2500 2. PROCEDURALLY UPDATED SH 20, 6F AND 6G.	

S-IC





VIEW LOOKING FORWARD

REVISION INDEX										
SH	EFFECTIVITY									
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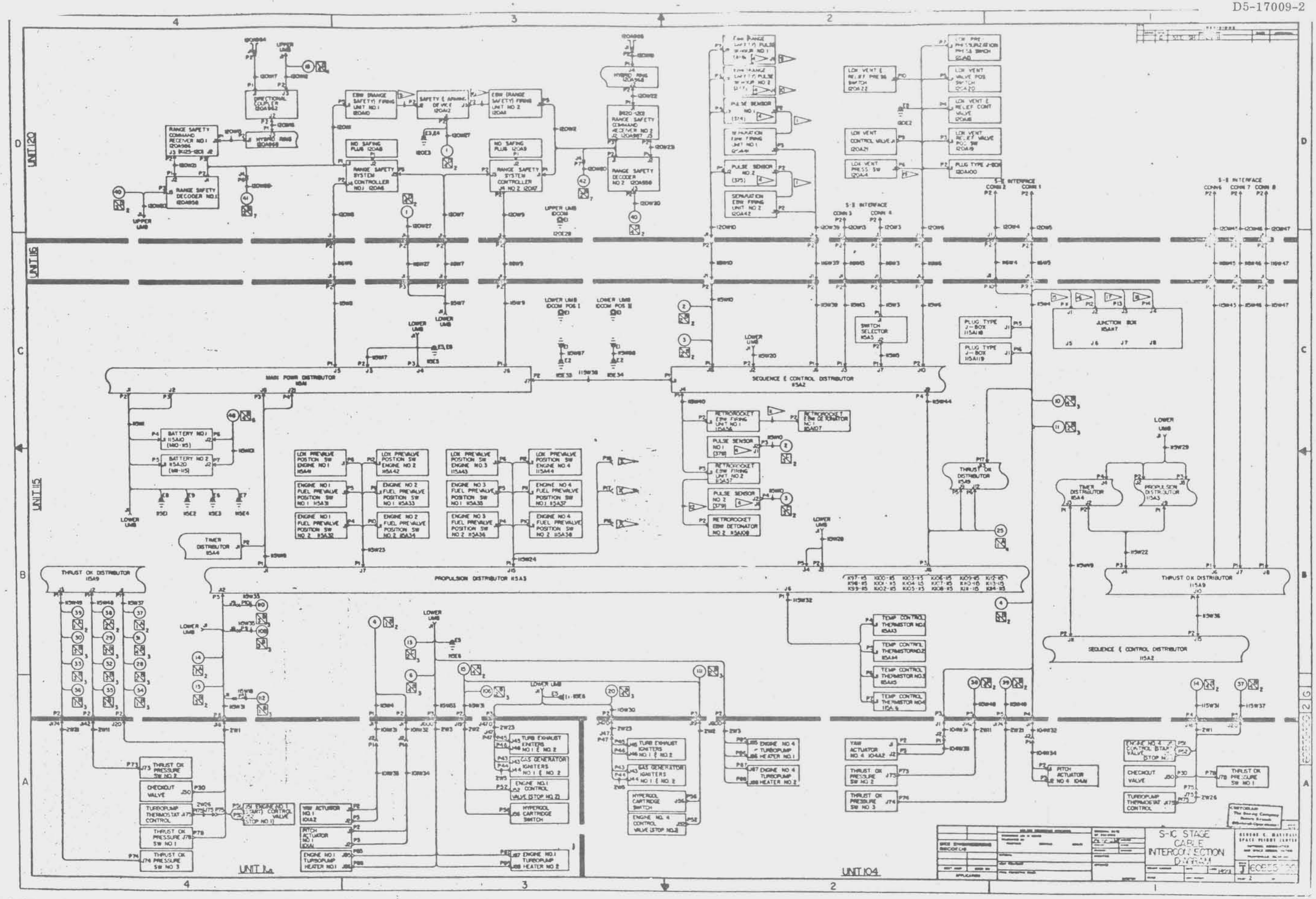
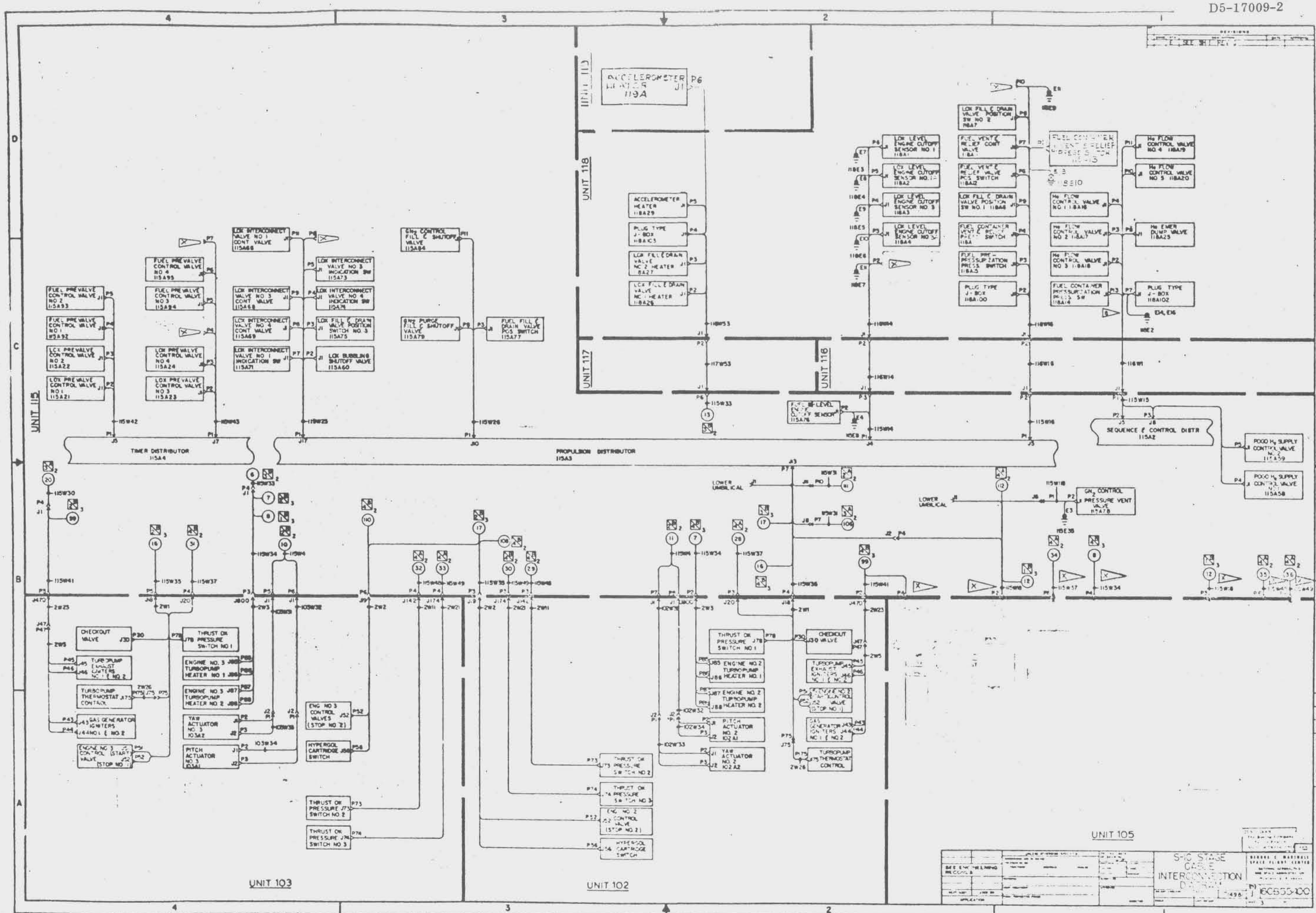
2	F	F	F	F	F	G	G	G	G	G
3	D	D	D	D	D	E	E	E	E	E
4	G	G	G	G	G	G	G	G	G	G
5	C	C	B	B	B	A	A	A	A	A
6	F	D	G	G	G	P	B	B	B	B
7	E	E	E	E	E	E	E	E	E	E

GENERAL NOTES
UNLESS OTHERWISE SPECIFIED.

1. SEPARATION EBW FIRING UNITS & PULSE SENSORS WILL BE LOCATED IN S-II STAGE AT VEHICLE MATING.
2. EQUIPMENT SHOWN FOR REFERENCE ONLY.
3. WHERE CABLE AND COMPONENT REFERENCE DESIGNATOR NUMBERS ARE LISTED FOR UNITS 101 THRU 105, THEY ARE TO BE ASSIGNED BY THE ROCKETDYNE CO.
4. EQUIPMENT FURNISHED & INSTALLED BY GSD AND SHOWN FOR REFERENCE.
5. REFERENCE DESIGNATIONS ARE ABBREVIATED WHERE PRACTICABLE. PREFIX THE PART DESIGNATION WITH THE SUBASSEMBLY DESIGNATION. FOR EXAMPLE: TERMINAL E346 OF MEASURING DISTRIBUTOR 115A7 IS COMPLETELY DESIGNATED AS 115A7E346.
6. MEASUREMENTS AND TRANSDUCERS ARE DESIGNATED WITH A CODE NUMBER AS ENUMERATED IN THE MEASURING PROGRAM, REFERENCE 60B57008) INDICATING THE TYPE OF MEASUREMENT, THE VEHICLE UNIT, AND THE MEASUREMENT NUMBER WITHIN THE UNIT. [illegible] INDICATES A PRESSURE MEASUREMENT (D), THE TWENTY FIRST MEASUREMENT [illegible] IN UNIT 102. THE TYPES OF MEASUREMENTS ARE AS FOLLOWS: A ACCELERATION; C TEMPERATURE; D PRESSURE; F FLOW RATE; G POSITION; K SIGNALS; L LIQUID LEVEL; M VOLTAGE [illegible] CURRENT; R VELOCITY; S STRAIN; T RPM; V LAUNCH CONTROL DDAS; X PRECEDES THE SYSTEM LETTER IN A BLOCKHOUSE MEASUREMENT NUMBER.
7. THE EFFECTIVITY INDEX (SHEET 1) SHOWS STAGE EFFECTIVITY FOR SHEETS OF THIS DRAWING AS FOLLOWS:
   (a) A LETTER IN THE EFFECTIVITY BLOCK INDICATES THE EFFECTIVITY OF THAT SHEET AND REVISION.
   (b) THE ORIGINAL RELEASE (NO REVISION) OF A SHEET IS INDICATED BY A DASH IN THE EFFECTIVITY BLOCK.
   (c) A SHADED EFFECTIVITY BLOCK DENOTES A SHEET NOT APPLICABLE TO THAT EFFECTIVITY.
8. CONNECTOR 116W1P13 WILL NOT BE MATED WITH 118A14J1 FOR STATIC FIRING.
9. MATE P2 TO 376J1 FOR TEST.
10. MATE P2 TO 377J1 FOR TEST.
11. MATE P2 TO 378J1 FOR TEST.
12. MATE P2 TO 379J1 FOR TEST.
13. BOND ALL ELECTRICAL COMPONENTS IN ACCORDANCE WITH BAC5117.
14. ( ) DENOTES REFERENCE INFORMATION ONLY.
15. WHEN 60B84500-1 (MOOG) SERVOACTUATORS ARE INSTALLED ON ENGINE 101, MATE 115W4P11 WITH 115A17J1. WHEN 60B84500-3 (HR) SERVOACTUATORS ARE INSTALLED ON ENGINE 101, MATE 115W4P11 WITH 115A17J5.
16. WHEN 60B84500-1 (MOOG) SERVOACTUATORS ARE INSTALLED ON ENGINE 102, MATE 115W4P12 WITH 115A17J2. WHEN 60B84500-3 (HR) SERVOACTUATORS ARE INSTALLED ON ENGINE 102, MATE 115W4P12 WITH 115A17J6.
17. WHEN 60B84500-1 (MOOG) SERVOACTUATORS ARE INSTALLED ON ENGINE 103, MATE 115W4P13 WITH 115A17J3. WHEN 60B84500-3 (HR) SERVOACTUATORS ARE INSTALLED ON ENGINE 103, MATE 115W4P13 WITH 115A17J7.
18. WHEN 60B84500-1 (MOOG) SERVOACTUATORS ARE INSTALLED ON ENGINE 104, MATE 115W4P14 WITH 115A17J4. WHEN 60B84500-3 (HR) SERVOACTUATORS ARE INSTALLED ON ENGINE 104, MATE 115W4P14 WITH 115A17J8.
19. THE CONNECTOR BRANCH 120W8P6 WILL BE REMOVED AFTER STATIC FIRING.
20. COIL AND STOW

S-IC STAGE CABLE INTERCONNECTION DIAGRAM


S-IC STAGE
CABLE
INTERCONNECTION
DIAGRAM
MAIN POWER DISTRIBUTOR 115A1
SEQUENCE & CONTROL DISTRIBUTOR 115A2
PROPULSION DISTRIBUTOR 115A3
THRUST OK DISTRIBUTOR 115A9
SEQUENCE & CONTROL DISTRIBUTOR 115A2
TIMER DISTRIBUTOR 115A4
JUNCTION BOX 115A117
UNIT 120
UNIT 116
UNIT 115
UNIT 104
S-II INTERFACE
THRUST OK PRESSURE SW NO 1
CHECKOUT VALVE
TURBOPUMP THERMOSTAT CONTROL
The Boeing Company
SHEET 2


UNIT 115
UNIT 118
UNIT 117
UNIT 116
UNIT 119
ACCELEROMETER HEATER 119A
TIMER DISTRIBUTOR 115A4
PROPULSION DISTRIBUTOR 115A3
SEQUENCE & CONTROL DISTR 115A2
FUEL PREVALVE CONTROL VALVE NO 2 115A93
FUEL PREVALVE CONTROL VALVE NO 1 115A92
LOX PREVALVE CONTROL VALVE NO 2 115A22
LOX PREVALVE CONTROL VALVE NO 1 115A21
FUEL PREVALVE CONTROL VALVE NO 4 115A95
FUEL PREVALVE CONTROL VALVE NO 3 115A94
LOX PREVALVE CONTROL VALVE NO 4 115A24
LOX PREVALVE CONTROL VALVE NO 3 115A23
LOX INTERCONNECT VALVE NO 1 CONT VALVE 115A66
LOX INTERCONNECT VALVE NO 3 INDICATION SW 115A73
LOX INTERCONNECT VALVE NO 3 CONT VALVE 115A68
LOX INTERCONNECT VALVE NO 4 INDICATION SW 115A74
LOX INTERCONNECT VALVE NO 4 CONT VALVE 115A69
LOX FILL & DRAIN VALVE POSITION SWITCH NO. 3 115A75
LOX INTERCONNECT VALVE NO 1 INDICATION SW 115A71
LOX BUBBLING SHUTOFF VALVE 115A60
GN2 CONTROL FILL & SHUTOFF VALVE 115A84
GN2 PURGE FILL & SHUTOFF VALVE 115A79
FUEL FILL & DRAIN VALVE POS SWITCH 115A77
ACCELEROMETER HEATER 118A29
PLUG TYPE J-BOX 118A1C3
LOX FILL & DRAIN VALVE NO 2 HEATER
LOX FILL & DRAIN VALVE NO 1 HEATER 118A28
LOX LEVEL ENGINE CUTOFF SENSOR NO 1 118A1
LOX LEVEL ENGINE CUTOFF SENSOR NO 2 118A2
LOX LEVEL ENGINE CUTOFF SENSOR NO 3 118A3
LOX LEVEL ENGINE CUTOFF SENSOR NO 5 118A4
LOX FILL & DRAIN VALVE POSITION SW NO 2
FUEL VENT & RELIEF CONT VALVE
FUEL VENT & RELIEF VALVE POS SWITCH
LOX FILL & DRAIN VALVE POSITION SW NO 1 118A6
FUEL CONTAINER VENT & RELIEF PRESS SWITCH
FUEL PRE-PRESSURIZATION PRESS SWITCH 118A5
PLUG TYPE J-BOX 118A100
FUEL CONTAINER VENT & RELIEF PRESS SWITCH 118A15
He FLOW CONTROL VALVE NO 4 118A19
He FLOW CONTROL VALVE NO 5 118A20
He FLOW CONTROL VALVE NO 1 118A16
He FLOW CONTROL VALVE NO 2 118A17
He EMER DUMP VALVE 118A23
He FLOW CONTROL VALVE NO 3 118A18
FUEL CONTAINER PRESSURIZATION PRESS SW 118A14
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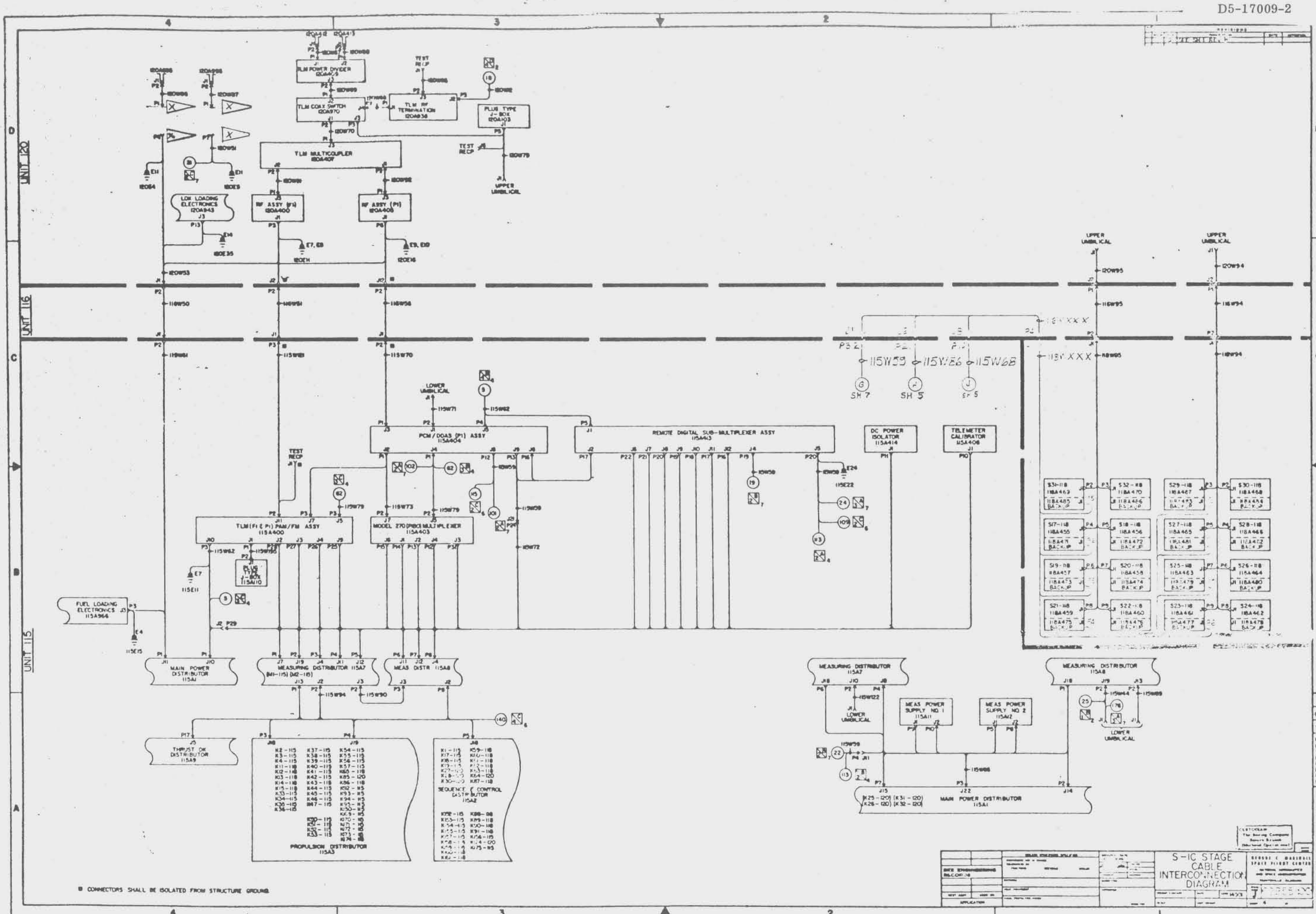
FUEL LEVEL ENGINE CUTOFF SENSOR 115A76
POGO He SUPPLY CONTROL VALVE 115A59
POGO He SUPPLY CONTROL VALVE NO 1 115A58
LOWER UMBILICAL
GN2 CONTROL PRESSURE VENT VALVE 115A78
CHECKOUT VALVE
THRUST OK PRESSURE SWITCH NO 1
TURBOPUMP EXHAUST HEATERS NO 1 & NO 2
ENGINE NO. 3 TURBOPUMP HEATER NO 1
ENGINE NO. 3 TURBOPUMP HEATER NO 2
TURBOPUMP THERMOSTAT CONTROL
GAS GENERATOR IGNITERS NO 1 & NO 2
ENGINE NO 3 CONTROL (START) VALVE (STOP NO 1)
YAW ACTUATOR NO. 3 103A2
PITCH ACTUATOR NO. 3 103A1
ENG NO 3 CONTROL VALVES (STOP NO 2)
HYPERGOL CARTRIDGE SWITCH
THRUST OK PRESSURE SWITCH NO 2
THRUST OK PRESSURE SWITCH NO 3
THRUST OK PRESSURE SWITCH NO 2
THRUST OK PRESSURE SWITCH NO 3
ENG NO 2 CONTROL VALVE (STOP NO 2)
HYPERGOL CARTRIDGE SWITCH
THRUST OK PRESSURE SWITCH NO 1
ENGINE NO. 2 TURBOPUMP HEATER NO. 1
ENGINE NO. 2 TURBOPUMP HEATER NO. 2
PITCH ACTUATOR NO. 2 102A1
YAW ACTUATOR NO. 2 102A2
CHECKOUT VALVE
TURBOPUMP EXHAUST IGNITERS NO 1 & NO 2
ENGINE NO 2 CONTROL VALVE (STOP NO 1)
GAS GENERATOR IGNITERS NO 1 & NO 2
TURBOPUMP THERMOSTAT CONTROL
UNIT 103
UNIT 102
UNIT 105
S-IC STAGE CABLE INTERCONNECTION DIAGRAM
60B55300
SEE SHT 1
GEORGE C. MARSHALL SPACE FLIGHT CENTER


UNIT 120
UNIT 116
UNIT 115
TLM POWER DIVIDER
TLM COAX SWITCH 120A970
TLM RF TERMINATION 120A838
PLUG TYPE J-BOX 120A103
TLM MULTICOUPLER 120A407
LOX LOADING ELECTRONICS 120A943
RF ASSY (P1) 120A400
RF ASSY (P1) 120A408
UPPER UMBILICAL
TEST RECP
LOWER UMBILICAL
PCM/DDAS (P1) ASSY 115A404
REMOTE DIGITAL SUB-MULTIPLEXER ASSY 115A413
DC POWER ISOLATOR 115A414
TELEMETER CALIBRATOR 115A406
TLM (F1 & P1) PAM/FM ASSY 115A400
MODEL 270 (P1B0) MULTIPLEXER 115A403
PLUG TYPE J-BOX 115A110
FUEL LOADING ELECTRONICS 115A966
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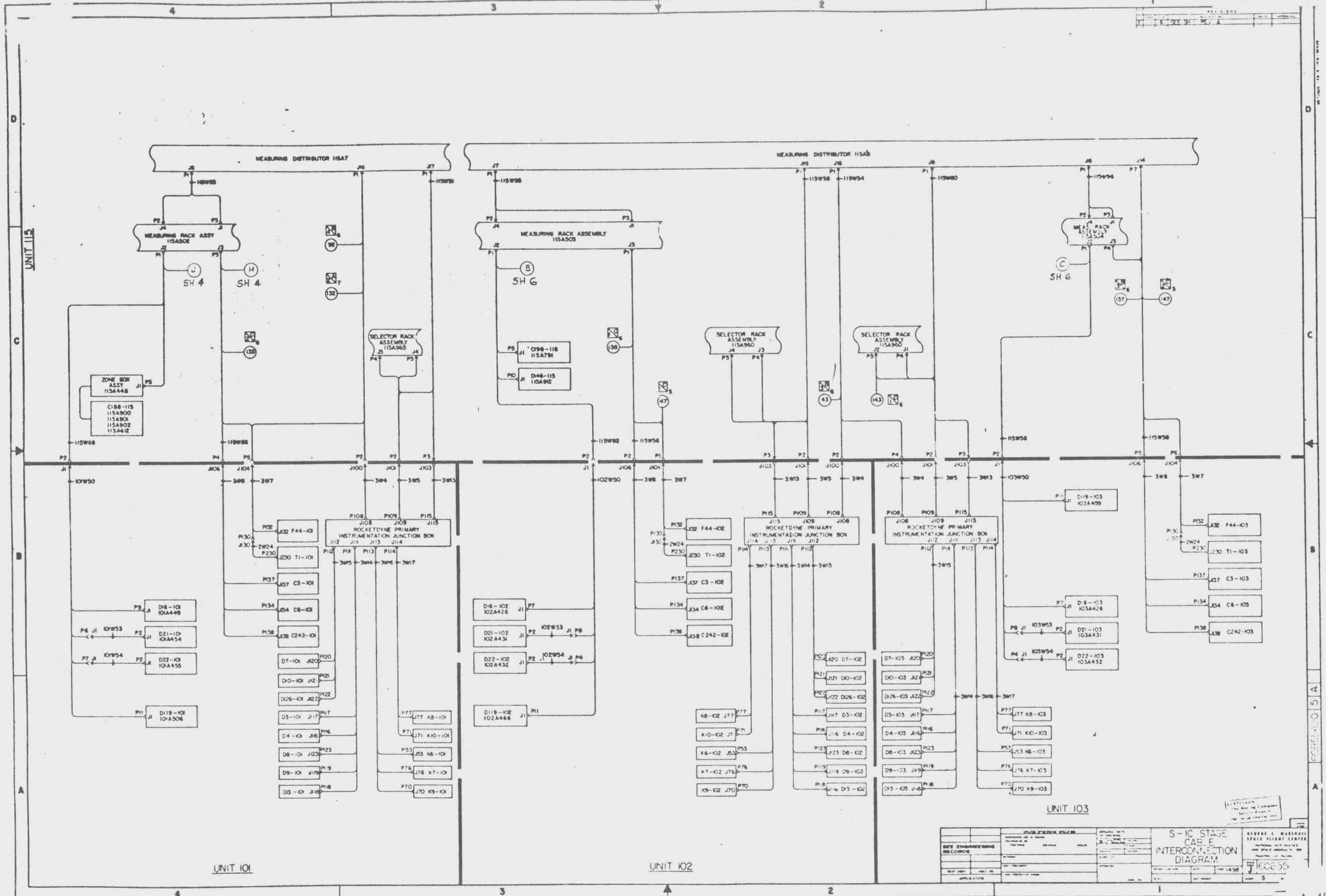
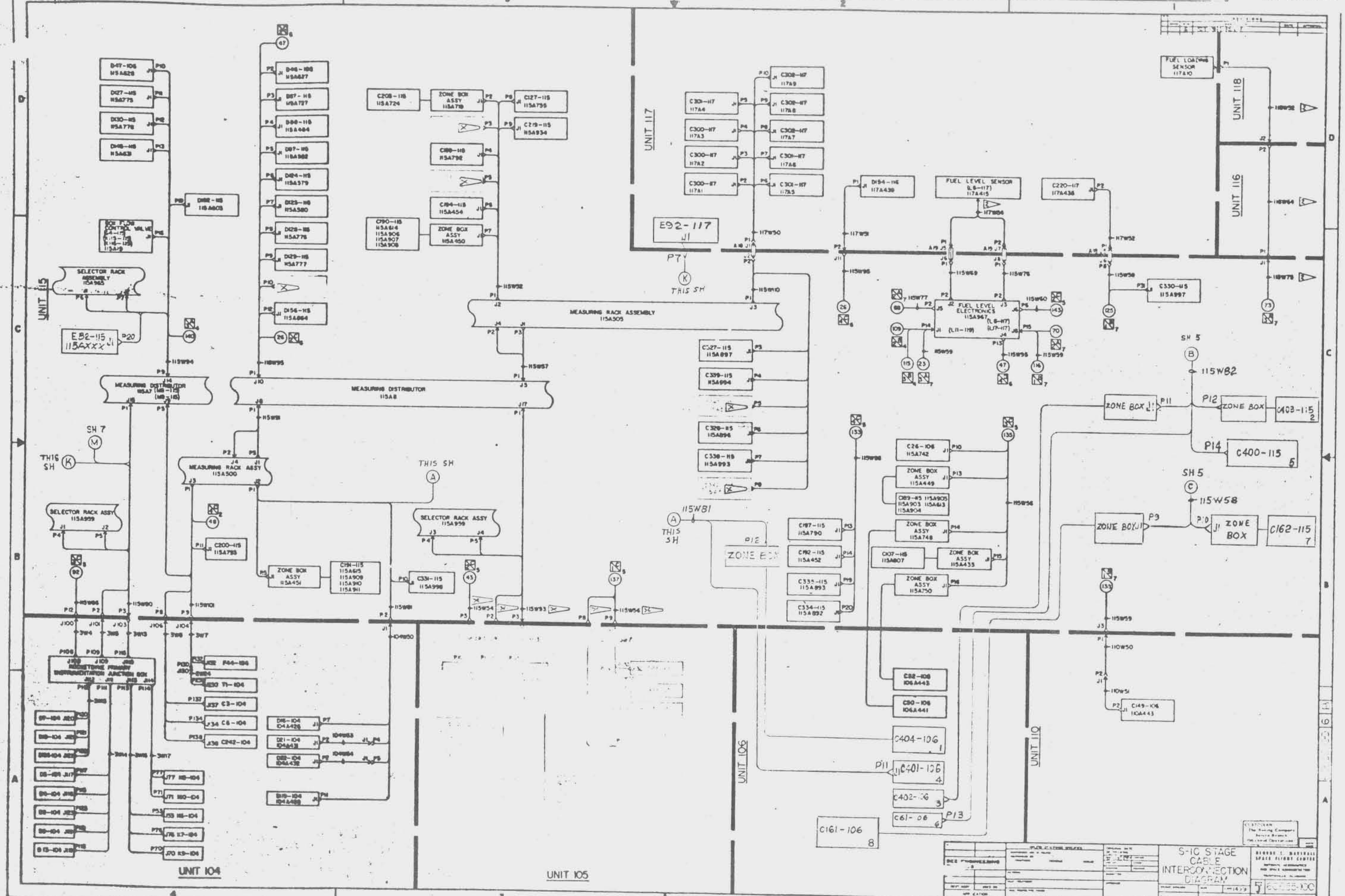
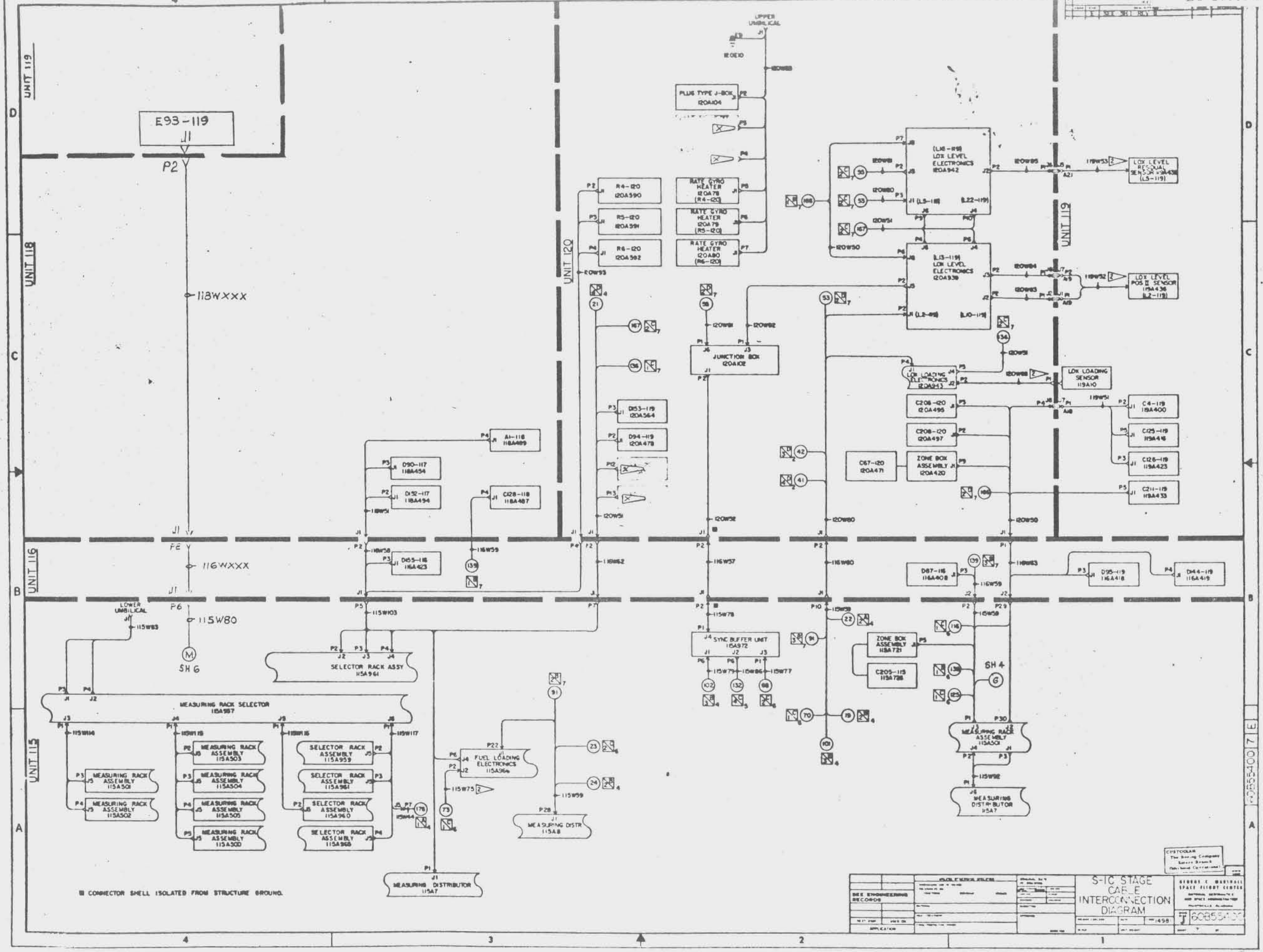
MEASURING DISTRIBUTOR 115A7
MEAS DISTR 115A8
THRUST OK DISTRIBUTOR 115A9
PROPULSION DISTRIBUTOR 115A3
SEQUENCE & CONTROL DISTRIBUTOR 115A2
MEASURING DISTRIBUTOR 115A7
MEASURING DISTRIBUTOR 115A8
MEAS POWER SUPPLY NO. 1 115A11
MEAS POWER SUPPLY NO. 2 115A12
MAIN POWER DISTRIBUTOR 115A1
115W59
115W66
115W68
SH 7
SH 5
SH 5
■ CONNECTORS SHALL BE ISOLATED FROM STRUCTURE GROUND
S-IC STAGE CABLE INTERCONNECTION DIAGRAM



S-IC STAGE CABLE INTERCONNECTION DIAGRAM
UNIT 115
UNIT 101
UNIT 102
UNIT 103
MEASURING DISTRIBUTOR 115A7
MEASURING DISTRIBUTOR 115A8
MEASURING RACK ASSY 115A502
MEASURING RACK ASSEMBLY 115A503
MEAS. RACK ASSEMBLY 115A504
SELECTOR RACK ASSEMBLY 115A965
SELECTOR RACK ASSEMBLY 115A960
ZONE BOX ASSY 115A448
ROCKETDYNE PRIMARY INSTRUMENTATION JUNCTION BOX
SH 4
SH 6



UNIT 115
UNIT 117
UNIT 118
UNIT 116
UNIT 104
UNIT 105
UNIT 106
UNIT 110
MEASURING DISTRIBUTOR 115A7
MEASURING DISTRIBUTOR 115A8
MEASURING RACK ASSEMBLY 115A505
MEASURING RACK ASSY 115A500
SELECTOR RACK ASSEMBLY 115A965
SELECTOR RACK ASSY 115A959
FUEL LEVEL SENSOR
FUEL LEVEL ELECTRONICS 115A967
FUEL LOADING SENSOR
E92-117 J1
E82-115 115AXXX
THIS SH
SH 7
SH 5
115W82
115W58
115W81
ZONE BOX
C403-115
C400-115
C162-115
C404-106
C401-106
C402-106
C61-06
C161-106
P13
P14
P12
P11
P9
P10
S-IC STAGE CABLE INTERCONNECTION DIAGRAM


UNIT 119
UNIT 118
UNIT 116
UNIT 115
UNIT 120
E93-119
J1
P2
118WXXX
116WXXX
115W80
SH 6
SH 4
UPPER UMBILICAL
LOWER UMBILICAL
PLUS TYPE J-BOX 120A104
RATE GYRO HEATER 120A78 (R4-120)
RATE GYRO HEATER 120A79 (R5-120)
RATE GYRO HEATER 120A80 (R6-120)
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R5-120 120A591
R6-120 120A592
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LOX LEVEL ELECTRONICS 120A938
LOX LEVEL RESIDUAL SENSOR
LOX LEVEL POS II SENSOR 119A436
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LOX LOADING ELECTRONICS 120A943
LOX LOADING SENSOR 119A10
C206-120 120A495
C208-120 120A497
ZONE BOX ASSEMBLY 120A420
C67-120 120A471
C4-119 119A400
C125-119 119A416
C126-119 119A423
C211-119 119A433
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D94-119 120A478
A1-118 118A489
D90-117 118A454
D152-117 118A494
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D87-116 116A408
D95-119 116A418
D144-119 116A419
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MEASURING RACK SELECTOR 115A957
MEASURING RACK ASSEMBLY 115A501
MEASURING RACK ASSEMBLY 115A502
MEASURING RACK ASSEMBLY 115A503
MEASURING RACK ASSEMBLY 115A504
MEASURING RACK ASSEMBLY 115A505
MEASURING RACK ASSEMBLY 115A500
SELECTOR RACK ASSEMBLY 115A959
SELECTOR RACK ASSEMBLY 115A961
SELECTOR RACK ASSEMBLY 115A960
SELECTOR RACK ASSEMBLY 115A968
FUEL LOADING ELECTRONICS 115A964
MEASURING DISTR 115A8
MEASURING DISTRIBUTOR 115A7
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ZONE BOX ASSEMBLY 115A721
C205-115 115A726
MEASURING RACK ASSEMBLY 115A501
MEASURING DISTRIBUTOR 115A7
■ CONNECTOR SHELL ISOLATED FROM STRUCTURE GROUND.
S-IC STAGE CABLE INTERCONNECTION DIAGRAM
60B55400
7
E

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL
H	REVISION DESCRIPTION A THRU G REMOVED. ECP0480 1. INITIATED CENTER ENGINE CUTOFF BY IU COMMAND ON SH 5G,5H,6F,6G,7E,7F,29D,41D, 41E,42D,46C AND 47D. ECP0456 2. ADDED STRAIN MEAS TO MONITOR WIND LOADS ON SH 101C. ECP0520 3. REVISED TELEMETRY CHANNEL FOR RANGE SAFETY MEAS ON SH 79B,104E AND 104F. PRR1265 4. PROVIDED NEW DIODES IN THE S-IC STAGE DISTR AND IN COMPONENT BD ASSEMBLIES ON SH 5H,6G, 7F AND 10C. PRR9500 5. PROCEDURALLY UPDATED SH 11D,11E,13B,20C,27C,33E, 33F,50B,67E,67F,74B,77B,81B, 95B,97C,98B AND 102C.	12-5-68	DRAWN CHECKED APPROVED APPROVED 12-16-8

INDEX

SH NO.	EFFECTIVITY 6	7	8	9	10	11	12	13	14	15
1	H	H	H	H	H	H	H	H	H	H
2	A	A	A	A	A	A	A	A	A	A
3	C	C	C	C	C	C	C	C	C	C
4	D	D	D	D	C	C	C	C	C	C
5	G	G	H	H	H	H	H	H	H	H
6	F	F	G	G	G	G	G	G	G	G
7	E	E	F	F	F	F	F	F	F	F
8	C	C	C	C	C	C	C	C	C	C
9	D	D	D	D	D	D	D	D	D	D
10	B	B	C	C	C	C	C	C	C	C
11	D	E	A	A	A	A	A	A	A	A
12	E	E	E	E	E	E	E	E	E	E
13	B	B	B	B	B	B	B	B	B	B
14	C	C	C	C	C	C	C	C	C	C
15	C	C	C	C	B	B	B	B	B	B
16	–	–	–	–	–	–	–	–	–	–
17	B	B	B	B	B	B	B	B	B	B
18	A	A	A	A	A	A	A	A	A	A
19	A	A	A	A	A	A	A	A	A	A
20	C	C	C	C	C	C	C	C	C	C
21	C	C	C	C	C	C	C	C	C	C
22	C	C	C	C	C	C	C	C	C	C
23	A	A	A	A	A	A	A	A	A	A
24	A	A	A	A	A	–	–	–	–	–
25	B	B	B	B	B	A	A	A	A	A
26	B	B	B	B	B	A	A	A	A	A
27	B	B	B	B	B	C	C	C	C	C
28	B	B	B	B	B	A	A	A	A	A
29	D	D	D	D	D	D	D	D	D	D
30	E	E	E	E	E	E	E	E	E	E

SH NO.	EFFECTIVITY 6	7	8	9	10	11	12	13	14	15
31	B	B	B	B	B	B	B	B	B	B
32	C	C	C	C	C	B	B	B	B	B
33	E	E	E	E	E	F	F	F	F	F
34	C	C	C	C	C	B	B	B	B	B
35	C	C	C	C	C	B	B	B	B	B
36	B	B	B	B	B	A	A	A	A	A
37	C	C	C	C	C	B	B	B	B	B
38	B	B	B	B	B	A	A	A	A	A
39	B	B	B	B	B	A	A	A	A	A
40	C	C	C	C	C	B	B	B	B	B
41	D	D	D	D	D	E	E	E	E	E
42	D	D	D	D	D	D	D	D	D	D
43	A	A	A	A	A	A	A	A	A	A
44	–	–	–	–	–	–	–	–	–	–
45	–	–	–	–	–	–	–	–	–	–
46	C	C	C	C	C	C	C	C	C	C
47	D	D	D	D	D	D	D	D	D	D
48	B	B	B	B	B	B	B	B	B	B
49	B	B	B	B	B	B	B	B	B	B
50	B	B	B	B	B	B	B	B	B	B
51	C	C	C	C	C	C	C	C	C	C
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53	B	B	B	B	B	A	A	A	A	A
54	–	–	–	–	–	–	–	–	–	–
55	–	–	–	–	–	–	–	–	–	–
56	–	A	A	A	A	–	–	–	–	–
57	A	A	A	A	A	–	–	–	–	–
58	A	A	A	A	A	A	A	A	A	A
59	A	A	A	A	A	A	A	A	A	A
60	–	–	–	–	–	–	–	–	–	–

SH NO.	EFFECTIVITY 6	7	8	9	10	11	12	13	14	15
61	A	A	A	A	A	A	A	A	A	A
62	B	B	A	A	A	A	A	A	A	A
63	B	B	B	B	B	A	A	A	A	A
64	A	A	A	A	A	A	A	A	A	A
65	C	B	B	B	B	B	B	B	B	B
66	A	A	–	–	–	–	–	–	–	–
67	E	F	F	F	F	B	B	B	B	B
68	B	B	A	A	A	A	A	A	A	A
69	B	B	B	B	B	A	A	A	A	A
70	A	A	–	–	–	–	–	–	–	–
71	B	B	B	B	B	A	A	A	A	A
72	–	–	–	–	–	–	–	–	–	–
73	C	B	B	B	B	B	B	B	B	B
74	B	B	B	B	B	–	–	–	–	–
75	B	B	B	B	B	A	A	A	A	A
76	A	A	A	A	A	–	–	–	–	–
77	A	A	A	A	A	B	B	B	B	B
78	B	B	B	B	B	B	B	B	B	B
79	B	B	B	B	B	B	B	B	B	B
80	B	B	B	B	B	B	B	B	B	B
81	B	B	B	B	B	–	–	–	–	–
82	A	A	A	A	A	–	–	–	–	–
83	B	B	B	B	B	A	A	A	A	A
84	B	B	B	B	B	A	A	A	A	A
85	A	A	A	A	A	–	–	–	–	–
86	A	A	A	A	A	–	–	–	–	–
87	B	B	B	B	B	B	B	B	B	B
88	–	–	–	–	–	–	–	–	–	–
89	A	A	A	A	A	A	A	A	A	A
90	–	–	–	–	–	–	–	–	–	–

SH NO.	EFFECTIVITY 6	7	8	9	10	11	12	13	14	15
91	B	B	B	B	B	B	B	B	B	B
92	A	A	A	A	A	A	A	A	A	A
93	–	–	–	–	–	–	–	–	–	–
94	A	A	A	A	A	A	A	A	A	A
95	B	B	B	B	B	B	B	B	B	B
96	B	B	B	B	B	B	B	B	B	B
97	C	C	C	C	C	C	C	C	C	C
98	B	B	B	B	B	B	B	B	B	B
99	A	A	A	A	A	A	A	A	A	A
100	A	A	A	A	A	A	A	A	A	A
101	C	C	C	C	C	C	C	C	C	C
102	C	C	C	C	C	C	C	C	C	C
103	B	B	B	B	B	B	B	B	B	B
104	E	E	F	F	F	F	F	F	F	F
105	A	A	A	A	A	A	A	A	A	A
106	–	–	–	–	–	–	–	–	–	–

CUSTODIAN:
The Boeing Company
Saturn Branch
(Michoud Operations)

SEE ENGINEERING RECORDS

60B57008	SATURN S-IC
NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED

ORIGINAL DATE OF DRAWING APRIL 5, 1967

H. PARIDISE

S-IC STAGE
ELECTRICAL SCHEMATICS
EFFECTIVITY
INDEX

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

CODE 14981 SIZE D 60B55401

SCALE NONE SHEET 1

60B55401 1 H

REVISIONS				
ZONE	SYM	DESCRIPTION	DATE	APPROVAL
	A	SEE SH I REV D		

13 EQUIPMENT FURNISHED AND INSTALLED BY GSD AND SHOWN FOR REFERENCE.

14 CONNECTOR 116W1P13 WILL NOT BE MATED WITH 118A14J1 FOR STATIC FIRING.

15 MATE P2 WITH 376J1 TO TEST.

16 MATE P2 WITH 377J1 TO TEST.

17 MATE P2 WITH 378J1 TO TEST.

18 MATE P2 WITH 379J1 TO TEST.

19 CABLE ASSEMBLY 116W1 IS ROUTED INTO UNIT 118 WITH 116W1 MATING TO THE APPLICABLE ASSEMBLY OF UNIT 118.

20 WHEN 60B84500-1 (MOOG) SERVOACTUATORS ARE INSTALLED ON ENGINE 101, MATE 115W4P11 WITH 115A117J1. WHEN 60B84500-3 (HR) SERVOACTUATORS ARE INSTALLED ON ENGINE 101, MATE 115W4P11 WITH 115A117J5.

21 WHEN 60B84500-1(MOOG) SERVOACTUATORS ARE INSTALLED ON ENGINE 102, MATE 115W4P12 WITH 115A117J2. WHEN 60B84500-3(HR) SERVOACTUATORS ARE INSTALLED ON ENGINE 102, MATE 115W4P12 WITH 115A117J6.

22 WHEN 60B84500-1(MOOG) SERVOACTUATORS ARE INSTALLED ON ENGINE 103, MATE 115W4P13 WITH 115A117J3. WHEN 60B84500-3(HR) SERVOACTUATORS ARE INSTALLED ON ENGINE 103, MATE 115W4P13 WITH 115A117J7.

23 WHEN 60B84500-1(MOOG) SERVOACTUATORS ARE INSTALLED ON ENGINE 104, MATE 115W4P14 WITH 115A117J4. WHEN 60B84500-3(HR) SERVOACTUATORS ARE INSTALLED ON ENGINE 104, MATE 115W4P14 WITH 115A117J8.

24 THE CONNECTOR BRANCH 120W6P6 WILL BE REMOVED AFTER STATIC FIRING.

X COIL & STOW.

Y. ALL TELEMETRY CHANNEL GROUNDING IS NOT SHOWN FOR CLARITY.

Z. ADDITIONAL MEASUREMENTS FOR THE FIRST TWO VEHICLES ARE NOT SHOWN IN SCHEMATICS.

GENERAL NOTES:
UNLESS OTHERWISE SPECIFIED.

1. REFERENCE DESIGNATOR NUMBER TO BE ASSIGNED BY THE ROCKETDYNE CO WHERE NOT SHOWN FOR UNITS 101 THRU 105.
2. REFERENCE DESIGNATIONS ARE ABBREVIATED WHERE PRACTICABLE. PREFIX THE PART DESIGNATION WITH THE SUBASSEMBLY DESIGNATION. FOR EXAMPLE: TERMINAL E346 OF MEASURING DISTRIBUTOR 115A7 IS COMPLETELY DESIGNATED AS 115A7E346.
3. MEASUREMENTS AND TRANSDUCERS ARE DESIGNATED WITH A CODE NUMBER AS ENUMERATED IN THE MEASURING PROGRAM,(REF 60B57008) INDICATING THE TYPE OF MEASUREMENT, THE VEHICLE UNIT, AND THE MEASUREMENT NUMBER WITHIN THE UNIT. EXAMPLE: D21-102 INDICATES A PRESSURE MEASUREMENT (D), THE TWENTY FIRST MEASUREMENT (21), TAKEN IN UNIT 102. THE TYPES OF MEASUREMENTS ARE AS FOLLOWS: A. ACCELERATION; C. TEMPERATURE; D. PRESSURE; F. FLOW RATE; G. POSITION; K. SIGNALS; L. LIQUID LEVEL; M. VOLTAGE, CURRENT; R. VELOCITY; T. RPM; V. LAUNCH CONTROL DDAS; X. PRECEDES THE SYSTEM LETTER IN A BLOCKHOUSE MEASUREMENT NUMBER.
4. THE UNIT NUMBERING METHOD FOR ELECTRICAL REFERENCE DESIGNATION PER MSFC STD 349 IS USED FOR WIRING APPLICATIONS. THE VEHICLE IS DIVIDED INTO BASIC UNITS (SEE FIGURE ON SHEET 3), AND ELECTRICAL COMPONENTS INSTALLED THEREIN ARE DESIGNATED AS SUBASSEMBLIES. EXAMPLE 115A7A5K1 DESIGNATES FIRST (1) RELAY (K) OF FIFTH (5) SUBASSEMBLY (A) OF SEVENTH (7) ASSEMBLY (A) IN UNIT (115).
5. ( ) DENOTES REFERENCE INFORMATION ONLY.
6. EQUIPMENT SHOWN FOR REFERENCE ONLY.
7. THE CONDITION (NO. OR NC) OF VALVES PERTAIN TO THE PNEUMATIC MAIN VALVE. SOLENOID CONTROL VALVES ARE NC.
8. THE POSITION SWITCH OF HELIUM FLOW VALVE NO. 1 IS SHOWN WITH NO HELIUM PRESSURE APPLIED TO THE VALVE.
9. TERMINATE OUTER SHIELD.
10. TERMINATE INNER SHIELD.
11. ALL NOTES THAT APPEAR ON SHEETS OTHER THAN SHEET TWO APPLY TO THAT SHEET ONLY.
12. THE EFFECTIVITY INDEX (SHEET 1) SHOWS STAGE EFFECTIVITY FOR SHEETS OF THIS DRAWING AS FOLLOWS.
    (a) A LETTER IN THE EFFECTIVITY BLOCK INDICATES THE EFFECTIVITY OF THAT SHEET AND REVISION.
    (b) THE ORIGINAL RELEASE (NO REVISION) OF A SHEET IS INDICATED BY A DASH IN THE EFFECTIVITY BLOCK.
    (c) A SHADED EFFECTIVITY BLOCK DENOTES A SHEET NOT APPLICABLE TO THAT EFFECTIVITY.

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APPLICATION

S-IC STAGE
ELECTRICAL SCHEMATICS
ELECTRICAL DESIGNATION
&
NOTES

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HUNTSVILLE, ALABAMA

D 14981 60B55401
SHEET 2

60B55401 2 A

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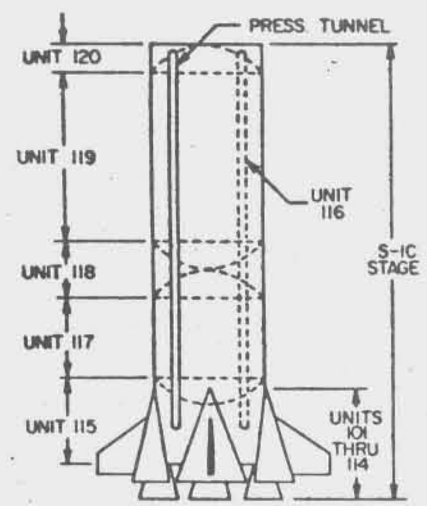
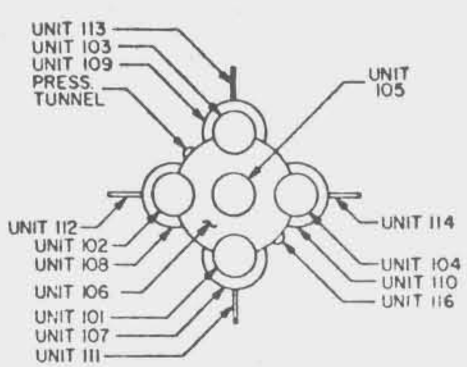
S-IC STAGE ELECTRICAL SCHEMATICS





VIEW LOOKING FORWARD

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S-IC STAGE ELECTRICAL SCHEMATICS INDEX

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CODE 14981 D 60B55401 SHEET 3

REVISIONS				
ZONE	SYM	DESCRIPTION	DATE	APPROVAL
	C	SEE SH 1 REV E		

MAIN POWER DISTRIBUTOR 115A1

RELAY NO. REF DES	SYSTEM COORD NO	RELAY FUNCTION	TYPE	CONTACTS A1-A2	A3-A4	1-2	1-3	4-5	4-6	COIL X1-X2	19-20
K1	K201	POWER ON EXTERNAL	10A,2PDT				13				13
K2	K202	POWER ON INTERNAL					13				13
K3		NOT USED									13
K4		NOT USED									13
K5		NOT USED									13
K6	K241	PAM/FM DIGITAL SYSTEM ON					17				17
K7	K221	F1 RF ASSEMBLY ON					17				17
K8		NOT USED									17
K9		NOT USED									17
K10	K240	P1 RF ASSEMBLY ON					17				17
K11		NOT USED	10A,2PDT								17
K14	K210	MEASURING SUPPLIES ON	10A,2PDT				15				15
K15		NOT USED									15
K16	K213	NOT USED					17				15
K17		NOT USED									15
K18	K220	COMMAND TM CALIBRATOR ON					17				15
K19	K205	FUEL AND LOX LOADING ON					17		17		15
K20		NOT USED	10A,2PDT								13
K21	K211	OPERATIONAL MEASURING RACK ON	25A,2PDT	15						15	

MAIN POWER DISTRIBUTOR 115A1

SWITCH CONTACTS	SH NO	POWER TRANSFER SWITCH (S1) FUNCTION
A	13	TRANSFER SWITCH MOTOR GROUND
B	13	POWER ON INTERNAL
C	13	POWER ON EXTERNAL
DE	13	POWER ON INTERNAL INDICATION
DF	13	POWER ON EXTERNAL INDICATION
1-2-3		NOT USED
4-5-6		NOT USED
7-8-9	15	MEASURING SUPPLIES (+1D29)
10-11-12		NOT USED
13-14-15		NOT USED
16-17-18	13	28 VOLT HOLD IN BUS (+1D12)
19-20-21	13	28 VOLT HOLD IN BUS (+1D22)
22-23-24		NOT USED
25-26-27		NOT USED
28-29-30	17	F1 RF ASSEMBLY
31-32-33		NOT USED
34-35-36		NOT USED
37-38-39	17	P1 RF ASSEMBLY
40-41-42	17	PAM/FM DIGITAL SYSTEM
43-44-45	15	OPERATIONAL MEASURING RACK (+1D23)
46-47-48		NOT USED
49-50-51	17	NOT USED
52-53-54		NOT USED
55-56-57	17	DC POWER ISOLATOR ON
58-59-60		NOT USED
61-62-63		NOT USED
64-65-66		NOT USED
67-68-69		NOT USED
70-71-72	13	28 VOLT FOR GENERAL USAGE (INST SYSTEM) (+1D21)
76-77-78	13	28VOLT FOR GENERAL USAGE (CONTROL SYSTEM) (+1D11)

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S-IC STAGE
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COMPONENT INDEX,
MAIN POWER DISTRIBUTOR
115A1

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REVISIONS				
ZONE	SYM	DESCRIPTION	DATE	APPROVED
	H	SEE SH 1 REV H		

SEQUENCE AND CONTROL DISTRIBUTOR 115A2																		
RELAY NO		P/C CARD NO	RELAY FUNCTION	TYPE	CONTACTS AND COIL LOCATIONS BY SHEETS													
					CONTACTS												COIL	
REF DES	SYSTEM COORD NO				1-2	1-3	4-5	4-6	7-8	7-9	10-11	10-12	13-14	13-15	16-17	16-18	19-20	19-21
K1	K30	A1	FIRE RETROROCKET EBW FIRING UNIT NO 1	2A,2PDT		50	50	50									50	
K2	K80		FIRE RETROROCKET EBW FIRING UNIT NO 2				50	50									50	
K3			NOT USED															
K4	K118		He FLOW CONTROL VALVE NO 5 INHIBIT		21												21	
K5			NOT USED															
K6	K50	A1	SIMULATE SEPARATION	2A,2PDT	29		29										50	
K1	K117	A2	ENABLE TWO ADJACENT ENGINES OUT	2A,2PDT		33	46										47	47
K2	K36-1		ENG 2 & 4 CUTOFF BACKUP			29	46										47	47
K3	K36-2		ENG 2 & 4 CUTOFF BACKUP			29	46										47	47
K4	K26-2		ENG 2 & 4 CUTOFF			29	46										47	47
K5		A2	ENG 1 & 3 CUTOFF	2A,2PDT		29	46										47	47
K1	K149	A3	ENG 1 & 3 CUTOFF BACKUP	2A,2PDT		29	46										47	47
K2	K119		ENG 1 & 3 CUTOFF BACKUP			29	46										47	47
K3	K107		OUTBOARD ENGINE CUTOFF BACKUP ENABLE			30	46										47	47
K4	K20		FIRE EBW FIRING UNIT (SEPARATION NO 1)		50	50	46										47	47
K5	K70	A3	FIRE EBW FIRING UNIT (SEPARATION NO 2)	2A,2PDT	50	50	46										47	47
K1	K104	A4	He FLOW CONTROL VALVE NO 4	2A,2PDT		20	46										47	47
K2	K26-1		ENG 2 & 4 CUTOFF			29	46										47	47
K3	K27		ENABLE OUTBOARD ENGINE CUTOFF			30	46										47	47
K4	K10		ARM EBW FIRING UNIT (RETRO & SEP NO 1)			50	46										47	47
K5	K90	A4	ARM EBW FIRING UNIT (RETRO & SEP NO 2)	2A,2PDT		50	46										47	47
K1	K109	A5	TELEMETRY CALIBRATION	2A,2PDT		46	46										47	47
K2	K47		ENABLE ENGINE OUT			29	46										47	47
K3	K139		ENG 1 & 3 CUTOFF			[illegible]	46										47	47
K4	K102		He FLOW CONTROL VALVE NO 2			20	46										47	47
K5	K103	A5	He FLOW CONTROL VALVE NO 3	2A,2PDT		20	46										47	47
K3	K111		He FLOW CONTROL VALVE NO 1	10A,4PDT			20										20	
K4	K120		LIFTOFF	2A,6PDT		47			50		50						46	
K21	K40		ARM EBW FIRING UNIT (RETRO & SEP NO 1)	2A,6PDT		50		50		50		50					50	
K22	K112		He FLOW VALVE NO 2	10A,4PDT		20											20	
K23	K113		He FLOW VALVE NO 3			20											20	
K24	K114		He FLOW VALVE NO 4			20											20	
K25	K115		He FLOW VALVE NO 5			20											21	
K28	K126		LOX VENT & RELIEF VALVE FLT DISABLE		22												22	
K29	K60		ARM EBW FIRING UNIT (RETRO & SEP NO 2)			50		50		50		50					50	
K30	K130		LIFTOFF (BACKUP)		50		50			50							50	
K2	K127		TWO ADJACENT OUTBD ENG OUT CUTOFF	10A,4PDT		33											33	
K1		A9	FUEL [illegible] RELIEF PRESS SW ENABLE	[illegible]			[illegible]										47	47
K2			NOT USED															
K3			NOT USED															
K4			NOT USED															
K5		A9	NOT USED	[illegible]														

SEQUENCE AND CONTROL DISTRIBUTOR 115A2					
DIODE NO	P/C CARD NO	PURPOSE	SH NO	MILLIAMP RATING	TYPE OR DWG NO.
CR1	A6	BLOCKING	47		MBSIC-1
CR2		NOT USED			
CR3		BLOCKING	47		
CR4		NOT USED			
CR5		NOT USED			
CR6		NOT USED			
CR7		BLOCKING	50		
CR8		BLOCKING	50		
CR9		NOT USED			
CR10		NOT USED			
CR11		NOT USED			
CR12		NOT USED			
CR13		SUPPRESSION	21		
CR14		SUPPRESSION	21		
CR15		SUPPRESSION	21		
CR16		SUPPRESSION	21		
CR17		NOT USED			
CR18					
CR19					
CR20					
CR21					
CR22	A6	NOT USED			
CR1	A8	SUPPRESSION	20		
CR2			20		
CR3			20		
CR4			20		
CR5		SUPPRESSION	20		
CR6		NOT USED			
CR7		SUPPRESSION	20		
CR8			20		
CR9			20		
CR10			20		
CR11			20		
CR12			21		
CR13			22		
CR14		SUPPRESSION	22		
CR15		NOT USED			
CR16		NOT USED			
CR17		NOT USED			
CR18		SUPPRESSION	21		
CR19		SUPPRESSION	22		
CR20		SUPPRESSION	22		
CR21		NOT USED			
CR22	A8	NOT USED			MBSIC-1

SEQUENCE AND CONTROL DISTRIBUTOR 115A2					
DIODE NO	P/C CARD NO	PURPOSE	SH NO	MILLIAMP RATING	TYPE OR DWG NO.
CR	A7	BLOCKING	46		MBSIC-1
CR2		BLOCKING	30		
CR3		BLOCKING	29		
CR4		NOT USED			
CR5		NOT USED			
CR6		BLOCKING	46		
CR7		BLOCKING	30		
CR8		BLOCKING	29		
CR9		NOT USED			
CR10		NOT USED			
CR11		BLOCKING	46		
CR12		BLOCKING	30		
CR13		BLOCKING	29		
CR14		NOT USED			
CR15		NOT USED			
CR16		BLOCKING	46		
CR17		BLOCKING	30		
CR18		BLOCKING	29		
CR19		NOT USED			
CR20	A7	NOT USED			MBSIC-1

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ELECTRICAL SCHEMATICS
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SEQUENCE & CONTROL
DISTRIBUTOR
115A2

CODE 14981

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PROPULSION DISTRIBUTOR 115A3

RELAY NO. REF DES	SYS DCDRD NO	P/C CARD NO.	RELAY FUNCTION	TYPE	CONTACTS 1-2	1-3	4-5	4-6	7-8	7-9	10-11	10-12	13-14	13-15	16-17	16-18	COIL 19-20
K4	K110		LIFTOFF	2A,6PDT	18	18											18
K5	K37		ENABLE ENGINE OUT	2A,6PDT	33	33	35	35	37	37	39	39	41	41			29
K21	K1-1		ENGINE NO. 1 CUTOFF	10A,4PDT		33				29		33					33
K22	K2-1		ENGINE NO. 2 CUTOFF			35				29		33					35
K23	K3-1		ENGINE NO. 3 CUTOFF			37				29		33					37
K24	K4-1		ENGINE NO. 4 CUTOFF			39				29		33					39
K25	K5-1		~~ENGINE NO. 5 CUTOFF~~			41				29							41
K26	K1-2		ENGINE NO. 1 CUTOFF			33											33
K27	K2-2		ENGINE NO. 2 CUTOFF			35											35
K28	K3-2		ENGINE NO. 3 CUTOFF			37											37
K29	K4-2		ENGINE NO. 4 CUTOFF			39											39
K30	K5-2		~~ENGINE NO. 5 CUTOFF~~			41											41
K31	K7-1		OUTBOARD ENGINES CUTOFF			30											30
K32	K121		LOX INTERCONNECT VALVE NO. 1	10A,4PDT		23		23									23
K33	K106		LOX INTERCONNECT OVERRIDE	2A,6PDT	23		23		23								23
K34	K123		LOX INTERCONNECT VALVE NO. 3	10A,4PDT		23		23									23
K35	K124		LOX INTERCONNECT VALVE NO. 4	10A,4PDT		23		23									23
K36	K98		LOX LEVEL LOGIC RELAYS RESET	2A,6PDT		31		31		31		31		29	31	31	31
K37	K7-2		OUTBOARD ENGINES CUTOFF	10A,4PDT		30											30
K1	K91	A2	THRUST NOT OK CUTOFF ENG NO. 1	2A,2PDT		42		42									33
K2	K92		THRUST NOT OK CUTOFF ENG NO. 2			42		42									35
K3	K93		THRUST NOT OK CUTOFF ENG NO. 3			42		42									37
K4	K94		THRUST NOT OK CUTOFF ENG NO. 4			42		42									39
K5	K68		LOX LEVEL CUTOFF LOGIC			29		29									29
K6	K78	A2	LOX LEVEL CUTOFF LOGIC	2A,2PDT		31	31	31									31
K1	K95	A3	~~THRUST NOT OK CUTOFF ENG NO 5~~	2A,2PDT		42		42									41
K2	K58		OUTBD ENG CUTOFF BACKUP ENABLE			31		31									30
K3			NOT USED														
K4	K17		OUTBOARD ENGINES CUTOFF ENABLE		30	30											30
K5			NOT USED														
K6	K16-2	A3	ENABLE INBOARD ENGINE CUTOFF	2A,2PDT	31	31											31
K1	K18	A7	LOX LEVEL CUTOFF LOGIC	2A,2PDT		31		31									31
K2	K28		LOX LEVEL CUTOFF LOGIC			31	31	31									31
K3	K38		LOX LEVEL CUTOFF LOGIC			31	31	31									31
K4	K16-1		ENABLE INBOARD ENGINE CUTOFF				29	29									29
K5			NOT USED														
K6		A7	NOT USED	2A,2PDT													

PROPULSION DISTRIBUTOR 115A3

DIODE NO.	P/C CARD NO	PURPOSE	SH NO.	MILLI AMP RATING	TYPE OR DWG NO.
CR1	A1	BLOCKING	31		MBSIC-1
CR2			31		
CR3			31		
CR4			31		
CR5			29		
CR6			31		
CR7			31		
CR8			31		
CR9			31		
CR10			30		
CR11			42		
CR12			42		
CR13			42		
CR14			42		
CR15			41		
CR16			41		
CR17		BLOCKING	30		
CR18		NOT USED			
CR19		BLOCKING	30		
CR20		BLOCKING	41		
CR21		BLOCKING	41		
CR22	A1	BLOCKING	30		MBSIC-1
CR1	A4	NOT USED			MBSIC-1
CR2		BLOCKING	23		SIN649
CR3		BLOCKING	23		
CR4		BLOCKING	23		
CR5		BLOCKING	29		
CR6		NOT USED			
CR7					
CR8					
CR9					
CR10					
CR11					
CR12					
CR13					
CR14		NOT USED			
CR15		BLOCKING	41		
CR16		BLOCKING	41		
CR18		NOT USED			
CR19					SIN649
CR20					MBSIC-1
CR21					
CR22					
CR23					
CR24					
CR25					
CR26					
CR41	A4	NOT USED			MBSIC-1

PROPULSION DISTRIBUTOR 115A3

DIODE NO	P/C CARD NO	PURPOSE	SH NO.	MILLI AMP RATING	TYPE OR DWG NO.
CR42	A4	NOT USED			MBSIC-1
CR43	A4	BLOCKING	41		MBSIC-1
CR44	A4	NOT USED			MBSIC-1
CR1	A5	SUPPRESSION	33		MBSIC-1
CR2			35		
CR3			37		
CR4			39		
CR5		SUPPRESSION	41		
CR6		[illegible]	[illegible]		
CR7		SUPPRESSION	33		
CR8			35		
CR9			37		
CR10			39		
CR11			41		
CR12			33		
CR13			35		
CR14			37		
CR15		SUPPRESSION	39		
CR16		[illegible]	[illegible]		
CR17		SUPPRESSION	41		
CR18		SUPPRESSION	33		
CR19			35		
CR20			37		
CR21			39		
CR22	A5	SUPPRESSION	41		MBSIC-1
CR1	A9	SUPPRESSION	18		MBSIC-1
CR2		SUPPRESSION	18		
CR3		BLOCKING	31		
CR4		SUPPRESSION	19		
CR5		SUPPRESSION	23		
CR6		NOT USED			
CR7		SUPPRESSION	18		
CR8		SUPPRESSION	18		
CR9		BLOCKING	31		
CR10		SUPPRESSION	19		
CR11			23		
CR12			23		
CR13			23		
CR14		SUPPRESSION	23		
CR15		NOT USED			
CR16		NOT USED			
CR17		NOT USED			
CR18		SUPPRESSION	23		
CR19		SUPPRESSION	23		
CR20		SUPPRESSION	23		
CR21		BLOCKING	31		
CR22	A9	BLOCKING	31		MBSIC-1

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S-IC STAGE
ELECTRICAL SCHEMATICS
COMPONENT INDEX,
PROPULSION DISTRIBUTOR
115A3

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

CODE 14981 | SIZE D | 60B35401 | SHEET 6

60B35401 6 G

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVAL
F	SEE SH1 REV H		

TIMER DISTRIBUTOR 115A4

TIMER NO.	P/C CARD NO.	FUNCTION	SH NO.	NOMINAL TIME DELAY IN SEC	PART NO.
1	A1	LOX OUTBD CUTOFF BACKUP	30	1.200	60B62101-43
2	A2	FUEL OUTBD CUTOFF BACKUP	30	2.100	60B62101-39
2	A1	LOX INBD CUTOFF BACKUP	29	1.300	60B62101-43
2	A3	FUEL OUTBD CUTOFF	30	2.100	60B62101-39
1	A4	LOX OUTBD CUTOFF	30	1.200	60B62101-43
2	A4	LOX INBD CUTOFF	29	1.300	60B62101-43

TIMER DISTRIBUTOR 115A4

DIODE NO.	P/C CARD NO.	PURPOSE	SH NO.	MILLIAMP RATING	TYPE OR DWG NO.
CR1	A6	BLOCKING	42		MBSIC-1
CR2			42		
CR3			42		
CR4			42		
CR5			42		
CR6			42		
CR7			42		
CR8			42		
CR9			42		
CR10			42		
CR11			42		
CR12		BLOCKING	42		
CR13		NOT USED			
CR14					
CR15					
CR16					
CR17					
CR18					
CR19					
CR20		NOT USED			
CR21		BLOCKING	42		
CR22	A6	BLOCKING	42		
CR1	A7	SUPPRESSION	43		
CR2			43		
CR3			43		
CR4			43		
CR5		SUPPRESSION	43		
CR6		NOT USED			
CR7		SUPPRESSION	43		
CR8			43		
CR9			43		
CR10			43		
CR11			43		
CR12			43		
CR13			43		
CR14			43		
CR15		SUPPRESSION	43		
CR16		NOT USED			
CR17		SUPPRESSION	43		
CR18			43		
CR19			43		
CR20			43		
CR21			43		
CR22	A7	SUPPRESSION	43		MBSIC-1

TIMER DISTRIBUTOR 115A4

RELAY NO. REF DES	RELAY NO. SYSTEM COORD NO.	P/C CARD NO.	RELAY FUNCTION	TYPE	CONTACTS 1-2	1-3	4-5	4-6	7-8	7-9	10-11	10-12	13-14	13-15	16-17	16-18	COIL 19-20
K1	K61		THRUST NOT OK CUTOFF ENGINE NO 1	10A, 4PDT		43		43		42		42					42
K2	K62		NO 2			43		43		42		42					42
K3	K63		NO 3			43		43		42		42					42
K4	K64		NO 4			43		43		42		42					42
K5	K65		~~THRUST NOT OK CUTOFF ENGINE NO 5~~			43		43		42		42					42
K6	K77-2		OUTBD ENG CUTOFF BACKUP			30											30
K7	K71-2		ENGINE NO. 1 CUTOFF BACKUP			43		43		33							42
K8	K72-2		2			43		43		35							42
K9	K73-2		3			43		43		37							42
K10	K74-2		4			43		43		39							42
K11	K75-2		ENGINE ~~NO 5~~ CUTOFF BACKUP	10A, 4PDT		43		43		41							42
K1	K46	A8	INBD ENG CUTOFF BACKUP ENABLE	2A, 2PDT		29	29	29									29
K2	K68		LOX LEVEL CUTOFF LOGIC			29		29									29
K3	K67		OUTBD ENG CUTOFF BACKUP ENABLE		30	30											30
K4			NOT USED														
K5			NOT USED														
K6		A8	NOT USED	2A, 2PDT													
K12	K71-1		ENGINE NO. 1 CUTOFF BACKUP	10A, 4PDT		33				29							42
K13	K72-1		2			35				29							42
K14	K73-1		3			37				29							42
K15	K74-1		4			39				29							42
K16	K75-1		~~ENGINE NO 5 CUTOFF BACKUP~~			41											42
K17	K77-1		OUTBD ENGINES CUTOFF BACKUP	10A, 4PDT		30											30

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ORIGINAL DATE OF DRAWING

S-IC STAGE
ELECTRICAL SCHEMATICS
COMPONENT INDEX
TIMER DISTRIBUTOR
115A4

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

14981 | D | 60B55401

SHEET 7

REVISIONS			
C	SEE SH 1 REV G		

MEASURING DISTRIBUTOR 115A7 — P/C BOARD A1

RESISTOR DES	PURPOSE	SH NO.	RATING W	RATING Ω	TYPE OR DWG NO.
R1	NOT USED		1/8	50	
R2	NOT USED			50	
R3	NOT USED			50	
R4	NOT USED			50	
R5	CURRENT LIMITER	87		50	
R6	NOT USED			50	
R7	NOT USED			50	
R8	NOT USED			50	
R9	NOT USED			50	
R10	CURRENT LIMITER	98		50	
R11		98		50	
R12		98		50	
R13		98		50	
R14	CURRENT LIMITER	97		50	
R15	NOT USED			50	
R16				50	
R17				50	
R18				50	
R19				50	
R20				50	
R21				50	
R22				50	
R23				50	
R24				50	
R25	NOT USED			100K	
R26	MEAS LOADING	67		100K	
R27	MEAS LOADING	65		100K	
R28	MEAS LOADING	95		100K	
R29	MEAS LOADING	95		100K	
R30	CURRENT LIMITER	98	1/8	50	

MEASURING DISTRIBUTOR 115A7 — P/C BOARD A3

RESISTOR DES	PURPOSE	SH NO.	RATING W	RATING Ω	TYPE OR DWG NO.
R1	VOLTAGE DIVIDER	96	1/8	5K	
R2		96		40K	
R3		96		80K	
R4		85		5K	
R5				40K	
R6				80K	
R7				5K	
R8				40K	
R9		85		80K	
R10		93		24K	
R11	VOLTAGE DIVIDER	93		12K	
R12	NOT USED			24K	
R13	NOT USED			12K	
R14	NOT USED			50	
R15	CURRENT LIMITER	97		50	
R16	VOLTAGE DIVIDER	85		5K	
R17	VOLTAGE DIVIDER	85		40K	
R18	VOLTAGE DIVIDER	85		80K	
R19	NOT USED			5K	
R20				40K	
R21				80K	
R22				5K	
R23				40K	
R24				80K	
R25				5K	
R26				40K	
R27				80K	
R28	NOT USED			50	
R29	CURRENT LIMITER	87		50	
R30	MEAS LOADING	67	1/8	100K	

MEASURING DISTRIBUTOR 115A7 — P/C BOARD A2

RESISTOR DES	PURPOSE	SH NO.	RATING W	RATING Ω	TYPE OR DWG NO.
R1	VOLTAGE DIVIDER	80	1/8	12K	
R2	VOLTAGE DIVIDER	80		2.4K	
R3	NOT USED			2.4K	
R4	NOT USED			12K	
R5	VOLTAGE DIVIDER	96		12K	
R6				2.4K	
R7				2.4K	
R8				12K	
R9				12K	
R10				2.4K	
R11				2.4K	
R12				12K	
R13				12K	
R14				2.4K	
R15				2.4K	
R16				12K	
R17				12K	
R18				2.4K	
R19				2.4K	
R20				12K	
R21				12K	
R22				2.4K	
R23				2.4K	
R24				12K	
R25				12K	
R26				2.4K	
R27				2.4K	
R28		96		12K	
R29		95		12K	
R30		95		2.4K	
R31		95		2.4K	
R32	VOLTAGE DIVIDER	95	1/8	12K	

MEASURING DISTRIBUTOR 115A7 — P/C BOARD A6

RESISTOR DES	PURPOSE	SH NO.	RATING W	RATING Ω	TYPE OR DWG NO.
R1	NOT USED		1/8	12K	
R2	NOT USED			2.4K	
R3	NOT USED			2.4K	
R4	NOT USED			12K	
R5	VOLTAGE DIVIDER	95		12K	
R6		95		2.4K	
R7		95		2.4K	
R8		95		12K	
R9		92		12K	
R10				2.4K	
R11				2.4K	
R12				12K	
R13				12K	
R14				2.4K	
R15				2.4K	
R16				12K	
R17				12K	
R18		92		2.4K	
R19		95		2.4K	
R20	VOLTAGE DIVIDER	95		12K	
R21	NOT USED			12K	
R22				2.4K	
R23				2.4K	
R24				12K	
R25				12K	
R26				2.4K	
R27				2.4K	
R28	NOT USED			12K	
R29	VOLTAGE DIVIDER	95		12K	
R30	VOLTAGE DIVIDER	95		2.4K	
R31	VOLTAGE DIVIDER	95		2.4K	
R32	VOLTAGE DIVIDER	95	1/8	12K	

MEASURING DISTRIBUTOR 115A7 — P/C BOARD A8

RESISTOR DES	PURPOSE	SH NO.	RATING W	RATING Ω	TYPE OR DWG NO.
R1	VOLTAGE DIVIDER	80	1/8	12K	
R2		80		2.4K	
R3		80		2.4K	
R4		80		12K	
R5		93		12K	
R6				2.4K	
R7				2.4K	
R8				12K	
R9				12K	
R10				2.4K	
R11				2.4K	
R12		93		12K	
R13		80		12K	
R14		80		2.4K	
R15		80		2.4K	
R16		80		12K	
R17		95		12K	
R18		95		2.4K	
R19		95		2.4K	
R20		95		12K	
R21		80		12K	
R22	VOLTAGE DIVIDER	80		2.4K	
R23	NOT USED			2.4K	
R24	NOT USED			12K	
R25	VOLTAGE DIVIDER	93		12K	
R26				2.4K	
R27				2.4K	
R28				12K	
R29				12K	
R30				2.4K	
R31				2.4K	
R32	VOLTAGE DIVIDER	93	1/8	12K	

MEASURING DISTRIBUTOR 115A7 — P/C BOARD A7

RESISTOR DES	PURPOSE	SH NO.	RATING W	RATING Ω	TYPE OR DWG NO.
R1	VOLTAGE DIVIDER	85	1/8	5K	
R2				40K	
R3				80K	
R4				5K	
R5				40K	
R6		85		80K	
R7		82		5K	
R8		82		40K	
R9		82		80K	
R10		80		2.4K	
R11		80		12K	
R12		80		2.4K	
R13	VOLTAGE DIVIDER	80		12K	
R14	CURRENT LIMITER	87		50	
R15	CURRENT LIMITER	87		50	
R16	VOLTAGE DIVIDER	82		5K	
R17				40K	
R18				80K	
R19				5K	
R20				40K	
R21				80K	
R22				5K	
R23				40K	
R24				80K	
R25				5K	
R26				40K	
R27	VOLTAGE DIVIDER	82		80K	
R28	CURRENT LIMITER	87		50	
R29	CURRENT LIMITER	87		50	
R30	MEAS LOADING	87	1/8	100K	

MEASURING DISTRIBUTOR 115A7 — P/C BOARD A9

RESISTOR DES	PURPOSE	SH NO.	RATING W	RATING Ω	TYPE OR DWG NO.
R1	MEAS LOADING	64	1/8	100K	
R2	MEAS LOADING	64		100K	
R3	MEAS LOADING	65		100K	
R4	NOT USED			100K	
R5				100K	
R6				100K	
R7				100K	
R8				100K	
R9	NOT USED			100K	
R10	VOLTAGE DIVIDER	93		24K	
R11	VOLTAGE DIVIDER	93		12K	
R12	VOLTAGE DIVIDER	93		2.4K	
R13	VOLTAGE DIVIDER	93		12K	
R14	MEAS LOADING	96		100K	
R15	MEAS LOADING	98		100K	
R16	MEAS LOADING	79		100K	
R17	MEAS LOADING	96		100K	
R18	NOT USED			100K	
R19	MEAS LOADING	97		100K	
R20	NOT USED			100K	
R21				100K	
R22				100K	
R23				100K	
R24				100K	
R25				100K	
R26				100K	
R27	NOT USED			100K	
R28	TELEMETRY LOADING	91		100K	
R29	TELEMETRY LOADING	91		100K	
R30	NOT USED		1/8	100K	

MEASURING DISTRIBUTOR 115A7 — P/C BOARD A4

RELAY NO REF DES	RELAY NO SYS COORD NO.	RELAY FUNCTION	CONTACTS 1-2	CONTACTS 1-3	CONTACTS 4-5	CONTACTS 4-6	COIL 19-20
K1	K403	CONSOLE CAL ON		58			54
K2	K400-14	DDAS TRANSFER	65	65	79	79	54
K3	K402-4	HARDWIRE TRANSFER	87	87	64	64	54
K4	K400-15	DDAS TRANSFER	65	65	96	96	54
K5	K400-16	DDAS TRANSFER	95	95	96	96	54
K6	K400-17	DDAS TRANSFER	64	64	64	64	54

MEASURING DISTRIBUTOR 115A7 — P/C BOARD A5

RELAY NO REF DES	RELAY NO SYS COORD NO.	RELAY FUNCTION	CONTACTS 1-2	CONTACTS 1-3	CONTACTS 4-5	CONTACTS 4-6	COIL 19-20
K1	K400-1	DDAS TRANSFER	98	98			54
K2	K400-2	DDAS TRANSFER	87	87	95	95	54
K3	K402-1	HARDWIRE TRANSFER	64	64	98	98	54
K4	K402-2	HARDWIRE TRANSFER	98	98	98	98	54
K5	K402-3	HARDWIRE TRANSFER	81	81	98	98	54
K6	K405	TLM CAL ON	58			59	54

CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)

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J.H.

S-IC STAGE ELECTRICAL SCHEMATICS COMPONENT INDEX, MEASURING DISTRIBUTOR 115A7

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

14981 D 6CB55401

6CB55401 8 C

REVISIONS

SYM	DESCRIPTION	DATE	APPROVAL
D	SEE SH 1 REV F		

MEASURING DISTRIBUTOR 115A8			P/C BOARD A2		
RESISTOR DES	PURPOSE	SH NO	RATING W	RATING Ω	TYPE OR DWG NO
R1	NOT USED		1/8	100K	
R2	NOT USED			100K	
R3	NOT USED			100K	
R4	MEAS LOADING	94		100K	
R5		94		100K	
R6		94		100K	
R7		71		100K	
R8		71		100K	
R9	MEAS LOADING	71		100K	
R10	VOLTAGE DIVIDER	97		24K	
R11	VOLTAGE DIVIDER	97		12K	
R12	VOLTAGE DIVIDER	97		24K	
R13	VOLTAGE DIVIDER	97		12K	
R14	MEAS LOADING	G2		100K	
R15		88		100K	
R16		69		100K	
R17		72		100K	
R18	MEAS LOADING	72		100K	
R19	NOT USED			100K	
R20	MEAS LOADING	69		100K	
R21		69		100K	
R22		62		100K	
R23		68		100K	
R24		68		100K	
R25		94		100K	
R26		94		100K	
R27	MEAS LOADING	94		100K	
R28	NOT USED			100K	
R29	NOT USED			100K	
R30	MEAS LOADING	88	1/8	100K	

MEASURING DISTRIBUTOR 115A8			P/C BOARD A3		
RESISTOR DES	PURPOSE	SH NO	RATING W	RATING Ω	TYPE OR DWG NO
R1	VOLTAGE DIVIDER	84	1/8	5K	
R2				40K	
R3				80K	
R4				5K	
R5				40K	
R6				80K	
R7				5K	
R8				40K	
R9	VOLTAGE DIVIDER	84		80K	
R10	CURRENT LIMITER	88		50	
R11				50	
R12				50	
R13				50	
R14				50	
R15	CURRENT LIMITER	88		50	
R16	VOLTAGE DIVIDER	84		5K	
R17				40K	
R18				80K	
R19				5K	
R20				40K	
R21	VOLTAGE DIVIDER	84		80K	
R22	NOT USED			25K	
R23				50K	
R24				90K	
R25				25K	
R26				50K	
R27				90K	
R28				3K	
R29				3K	
R30	NOT USED		1/8	100K	

MEASURING DISTRIBUTOR 115A8			P/C BOARD A7		
RESISTOR DES	PURPOSE	SH NO	RATING W	RATING Ω	TYPE OR DWG NO
R1	VOLTAGE DIVIDER	83	1/8	5K	
R2				40K	
R3				80K	
R4				5K	
R5				40K	
R6				80K	
R7				5K	
R8				40K	
R9	VOLTAGE DIVIDER	83		80K	
R10	CURRENT LIMITER	88		50	
R11	CURRENT LIMITER	88		50	
R12	CURRENT LIMITER	88		50	
R13	CURRENT LIMITER	88		50	
R14	NOT USED			50	
R15	CURRENT LIMITER	88		50	
R16	VOLTAGE DIVIDER	86		5K	
R17				40K	
R18				80K	
R19				5K	
R20				40K	
R21	VOLTAGE DIVIDER	86		80K	
R22	NOT USED			25K	
R23				50K	
R24				90K	
R25				25K	
R26				50K	
R27				90K	
R28				3K	
R29				3K	
R30	NOT USED		1/8	100K	

MEASURING DISTRIBUTOR 115A8			P/C BOARD A9		
RESISTOR DES	PURPOSE	SH NO	RATING W	RATING Ω	TYPE OR DWG NO
R1	VOLTAGE DIVIDER	94	1/8	12K	
R2		94		24K	
R3		94		24K	
R4		94		12K	
R5		93		12K	
R6		93		24K	
R7		93		24K	
R8		93		12K	
R9		94		12K	
R10				24K	
R11				24K	
R12				12K	
R13				12K	
R14				24K	
R15				24K	
R16				12K	
R17				12K	
R18				24K	
R19				24K	
R20				12K	
R21				12K	
R22				24K	
R23				24K	
R24				12K	
R25				12K	
R26				24K	
R27				24K	
R28				12K	
R29				12K	
R30				24K	
R31				24K	
R32	VOLTAGE DIVIDER	94	1/8	12K	

MEASURING DISTRIBUTOR 115A8			P/C BOARD A1		
RESISTOR DES	PURPOSE	SH NO	RATING W	RATING Ω	TYPE OR DWG NO
R1	VOLTAGE DIVIDER	94	1/8	12K	
R2				24K	
R3				24K	
R4				12K	
R5				12K	
R6				24K	
R7				24K	
R8	VOLTAGE DIVIDER	94		12K	
R9	NOT USED			12K	
R10				24K	
R11				24K	
R12				12K	
R13				12K	
R14				24K	
R15				24K	
R16				12K	
R17				12K	
R18				24K	
R19				24K	
R20				12K	
R21				12K	
R22				24K	
R23				24K	
R24				12K	
R25				12K	
R26				24K	
R27				24K	
R28				12K	
R29				12K	
R30				24K	
R31				24K	
R32	NOT USED		1/8	12K	

MEASURING DISTRIBUTOR 115A8			P/C BOARD A8		
RESISTOR DES	PURPOSE	SH NO	RATING W	RATING Ω	TYPE OR DWG NO
R1	VOLTAGE DIVIDER	83	1/8	5K	
R2				40K	
R3				80K	
R4				5K	
R5				40K	
R6		83		80K	
R7		86		5K	
R8		8C		40K	
R9	VOLTAGE DIVIDER	86		80K	
R10	NOT USED			50	
R11				50	
R12				50	
R13				50	
R14				50	
R15	NOT USED			50	
R16	VOLTAGE DIVIDER	86		5K	
R17				40K	
R18				80K	
R19				5K	
R20				40K	
R21	VOLTAGE DIVIDER	86		80K	
R22	NOT USED			25K	
R23				50K	
R24				90K	
R25				25K	
R26				50K	
R27				90K	
R28				3K	
R29	NOT USED			3K	
R30	TLM LOADING	73	1/8	100K	

MEASURING DISTRIBUTOR 115A8			P/C BOARD A6		
RESISTOR DES	PURPOSE	SH NO.	RATING W	RATING Ω	TYPE OR DWG NO
R1	MEAS LOADING	63	1/8	100K	
R2		69		100K	
R3		69		100K	
R4		94		100K	
R5	MEAS LOADING	94		100K	
R6	NOT USED			100K	
R7	MEAS LOADING	97		100K	
R8	NOT USED			100K	
R9				100K	
R10				24K	
R11				12K	
R12				24K	
R13				12K	
R14				100K	
R15				100K	
R16				100K	
R17				100K	
R18				100K	
R19				100K	
R20				100K	
R21				100K	
R22				100K	
R23				100K	
R24				100K	
R25				100K	
R26				100K	
R27				100K	
R28				100K	
R29				100K	
R30	NOT USED		1/8	100K	

MEASURING DISTRIBUTOR 115A8			P/C BOARD A5				
RELAY NO		RELAY FUNCTION	LOCATION BY SHEET				
REF DES	SYSTEM COORD NO		CONTACTS 1-2	CONTACTS 1-3	CONTACTS 4-5	CONTACTS 4-6	COIL 19-20
K1	K400-11	DDAS TRANSFER	72	72	72	72	54
K2	K400-9	DDAS TRANSFER	69	69	62	62	54
K3	K400-10	DDAS TRANSFER			68	68	54
K4	K400-12	DDAS TRANSFER	69	69	69	69	54
K5	K402-6	HARDWIRE TRANSFER	88	88	88	88	54
K6	K400-13	DDAS TRANSFER	94	94			54

MEASURING DISTRIBUTOR 115A8			P/C BOARD A4				
RELAY NO		RELAY FUNCTION	LOCATION BY SHEET				
REF DES	SYSTEM COORD NO		CONTACTS 1-2	CONTACTS 1-	CONTACTS 4-5	CONTACTS 4-6	COIL 19-20
K1	K400-3	DDAS TRANSFER	62	62	68	68	54
K2	K400-4		71	71	88	88	54
K3	K400-5		88	88	94	94	54
K4	K400-6		71	71	71	71	54
K5	K400-7		94	94	94	94	54
K6	K400-8	DDAS TRANSFER	94	94	94	94	54

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ELECTRICAL SCHEMATICS
COMPONENT INDEX,
MEASURING DISTRIBUTOR
115A8

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

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THRUST OK DISTRIBUTOR 115A9

RELAY NO. REF DES	RELAY NO. SYSTEM COORD NO	RELAY FUNCTION	TYPE	CONTACTS 1-2	1-3	4-5	4-6	7-8	7-9	10-11	10-12	13-14	13-15	16-17	16-18	COIL X1-X2	[illegible]
K1	K31	THRUST OK LOGIC ENG NO 1	2A,6PDT	32		32			32	38						32	
K2	K32	THRUST OK LOGIC ENG NO 2		34		34			34	38						34	
K3	K33	THRUST OK LOGIC ENG NO 3		36		36			36	38						36	
K4	K34	THRUST OK LOGIC ENG NO 4		38		38			38	38						38	
K5	K35	THRUST OK LOGIC ENG NO 5		40		40			40	38						40	
K6	K21	THRUST OK LOGIC ENG NO 1		32		32			32	36						32	
K7	K22	THRUST OK LOGIC ENG NO 2		34		34			34	36						34	
K8	K23	THRUST OK LOGIC ENG NO 3		36		36			36	36						36	
K9	K24	THRUST OK LOGIC ENG NO 4		38		38			38	36						38	
K10	K25	THRUST OK LOGIC ENG NO 5	2A,6PDT	40		40			40	36						40	
K11	K39	EDS/RS NO.2 ENGINES CUTOFF	10A,4PDT		42	42	42				32					32	
K12	K69	RS NO.3 ENG CUTOFF INHIBIT	10A,4PDT	32				42								32	
K13	K11	THRUST OK LOGIC ENG NO 1	2A,6PDT	32			32			34						32	
K14	K12	THRUST OK LOGIC ENG NO 2	2A,6PDT	34			34			34						34	
K15	K13	THRUST OK LOGIC ENG NO 3	2A,6PDT	36			36			34						36	
K16	K29	EDS/RS NO.1 ENGINES CUTOFF	10A,4PDT		32	32	32				42					32	
K17	K15	~~THRUST OK LOGIC ENG NO 5~~	2A,6PDT	40			40			34						40	
K18	K14	THRUST OK LOGIC ENG NO 4	2A,6PDT	38			38			34						38	
K19	K79	EDS NO.3 ENGINES CUTOFF	10A,4PDT		32		42									32	

THRUST OK DISTRIBUTOR 115A9

RESISTOR NO.	DIODE NO.	P/C CARD NO.	FUNCTION	SH NO.	RATING W	RATING Ω	TYPE OR DWG NO.
	CR1	A6	BLOCKING	32			MBSIC-1
	CR2			34			
	CR3			36			
	CR4			38			
	CR5			40			
	CR6			32			
	CR7			34			
	CR8			36			
	CR9			38			
	CR10		BLOCKING	40			MBSIC-1
R1			CURRENT LIMITER	32		10	
R2				34		10	
R3				36		10	
R4				38		10	
R5				40		10	
R6				32		10	
R7				34		10	
R8				36		10	
R9				38		10	
R10		A6	CURRENT LIMITER	40		10	

THRUST OK DISTRIBUTOR 115A9

RESISTOR NO.	DIODE NO.	P/C CARD NO.	FUNCTION	SH NO.	RATING W	RATING Ω	TYPE OR DWG NO.
	CR1	A9	BLOCKING	32			MBSIC-1
	CR2			34			
	CR3			36			
	CR4			38			
	CR5			40			
	CR6			32			
	CR7			34			
	CR8			36			
	CR9			38			
	CR10		BLOCKING	40			MBSIC-1
R1			CURRENT LIMITER	32		10	
R2				34		10	
R3				36		10	
R4				38		10	
R5				40		10	
R6				32		10	
R7				34		10	
R8				36		10	
R9				38		10	
R10		A9	CURRENT LIMITER	40		10	

THRUST OK DISTRIBUTOR 115A9

RESISTOR NO.	P/C CARD NO.			PURPOSE	SH NO.	RATING W	RATING Ω	TYPE OR DWG NO.
R1	A1	A2	A3	NOT USED		1/8	5K	
R2				VOLTAGE DIVIDER	32		40K	
R3				VOLTAGE DIVIDER	32		80K	
R4				NOT USED			5K	
R5				VOLTAGE DIVIDER	34		40K	
R6				VOLTAGE DIVIDER	34		80K	
R7				NOT USED			5K	
R8				VOLTAGE DIVIDER	36		40K	
R9				VOLTAGE DIVIDER	36		80K	
R10				NOT USED			24K	
R11							12K	
R12							24K	
R13							12K	
R14							50	
R15							50	
R16				NOT USED			5K	
R17				VOLTAGE DIVIDER	38		40K	
R18				VOLTAGE DIVIDER	38		80K	
R19				NOT USED			5K	
R20				VOLTAGE DIVIDER	40		40K	
R21				VOLTAGE DIVIDER	40		80K	
R22				NOT USED			5K	
R23							40K	
R24							80K	
R25							5K	
R26							40K	
R27							80K	
R28							50	
R29							50	
R30	A1	A2	A3	NOT USED		1/8	100K	

THRUST OK TIMER 115A9

TIMER NO.	P/C CARD NO.	FUNCTION	SH NO	NOMINAL TIME DELAY IN SEC	PART NO.
1	A4	ENGINE NO 1 THRUST NOT OK	32	044	60B62101-37
2	A4	ENGINE NO 2 THRUST NOT OK	34	044	60B62101-37
1	A5	ENGINE NO 3 THRUST NOT OK	36	044	60B62101-37
2	A5	ENGINE NO 4 THRUST NOT OK	38	044	60B62101-37
1	A7	~~ENGINE NO 5 THRUST NOT OK~~	40	044	60B62101-37
2	A7	NOT USED			

JUNCTION BOX 115A117

RESISTOR NO.	CAPACITOR NO.	FUNCTION	SH NO.	RATING KΩ	RATING μFd	TYPE OR DWG NO.
	C1	COMPENSATING	51		8	MBC18312 -2
	C2	COMPENSATING			8	-2
	C3	COMPENSATING			8	-2
	C4	COMPENSATING			8	-2
	C5	FILTERING			2	-1
	C6	FILTERING			2	-1
	C7	FILTERING			2	-1
	C8	FILTERING	51		2	-1
	C9	COMPENSATING	52		8	-2
	C10	COMPENSATING			8	-2
	C11	COMPENSATING			8	-2
	C12	COMPENSATING			8	-2
	C13	FILTERING			2	-1
	C14	FILTERING			2	-1
	C15	FILTERING			2	-1
	C16	FILTERING	52		2	MBC18312-1
R1		COMPENSATING	51	2		MB65020000F
R2			51			
R3			51			
R4			51			
R5			52			
R6			52			
R7			52			
R8		COMPENSATING	52	2		MB65020000F

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115A9 & JUNCTION BOX 115A117

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MEASUREMENT AND SHEET NUMBER

A1-118	79			C128-118	65	C208-120	64			D10-102	77					D129-115	88	D182-115	87				
								D3-101	81	D10-103	76	D21-101	66	D94-119	98	D130-115	87						
								D3-102	77	D10-104	74	D21-102	68	D95-119	64								
						C211-119	64	D3-103	76			D21-103	70										
								D3-104	74			D21-104	62	D97-115	88								
		C26-106	69	C149-106	65							D22-101	66										
								D4-101	81			D22-102	68										
C3-101	67			C161-106	*			D4-102	77			D22-103	70										
C3-102	69			C162-106	*			D4-103	76	D13-101	81	D22-104	62										
C3-103	71							D4-104	74	D13-102	77							E82-115	*				
C3-104	63	C50-106	69	C188-115	66					D13-103	76							E92-117	*				
				C189-115	69	C219-115	72			D13-104	74							E93-119	*				
C4-119	64	C52-106	69	C190-115	72	C220-117	65																
				C191-115	62	C242-101	67					D46-106	88	D119-101	66								
C6-101	67	C61-106	*	C192-115	67	C242-102	69	D7-101	81			D47-106	87	D119-102	68								
C6-102	69					C242-103	71	D7-102	77					D119-103	70	D144-119	64						
C6-103	71			C194-115	72	C242-104	63	D7-103	76					D119-104	62	D145-115	87						
C6-104	63	C67-120	65					D7-104	74							D146-115	68						
						C300-117	73																
				C197-115	67	C301-117	73	D8-101	81	D16-101	66	D67-115	88										
C404-106	*			C198-115	68	C302-117	73	D8-102	77	D16-102	68												
C403-115	*			C199-115	72	C326-115	73	D8-103	76	D16-103	70			D124-115	88								
C402-106	*	C107-115	69	C200-115	63	C327-115	73	D8-104	74	D16-104	62			D125-115	88								
C401-106	*					C330-115	65							D126-101	81	D152-117	98						
C401-115	*					C331-115	62	D9-101	81			D87-116	65	D126-102	77	D153-119	98						
				C203-115	72	C334-115	67	D9-102	77			D88-115	88	D126-103	76	D154-116	88						
						C335-115	67	D9-103	76					D126-104	74	D155-116	98						
		C125-119	64	C205-115	65	C338-115	73	D9-104	74			D90-117	98			D156-115	88						
		C126-119	64	C206-120	64	C339-115	73							D127-115	87								
		C127-115	72					D10-101	81					D128-115	88								

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MEASUREMENT AND SHEET NUMBER

F44-101	67 82	K9-102	83	K32-120	97	K62-118	96	K92-115	92			K152-115	93			T1-101	67	S123-118	*				
F44-102	69 83	K9-103	84	K33-115	91	K63-118	96	K93-115	92			K153-115	93			T1-102	69	S125-118	*				
F44-103	71 84	K9-104	85	K34-115	91	K64-120	96	K94-115	92	K124-120	96	K154-115	93			T1-103	71	S127-118	*				
F44-104	63 85			K35-115	91	K65-118	95	K95-115	92	K125-120	97	K155-115	93			T1-104	63	S129-118	*				
		K10-101	82	K36-115	91							K156-115	93	L22-119	103	[illegible]	71	S131-118	*				
		K10-102	83	K37-115	91			K97-115	94			K157-115	93										
		K10-103	84	K38-115	91			K98-115	94			K158-118	95										
G4-115	87	K10-104	85	K39-115	91			K99-115	94			K159-118	95										
				K40-115	91			K100-115	94			K160-118	95										
		K11-118	80	K41-115	92			K101-115	94			K161-118	95	M1-115	97								
K1-115	96	K12-118	80	K42-115	92			K102-115	94			K169-115	93	M2-115	97	S17-118	101						
K2-115	95	K13-118	80	K43-115	92			K103-115	94			K170-115	93			S18-118	101						
K3-115	95	K14-118	80	K44-115	92			K104-115	94			K171-115	93			S19-118	101						
				K45-115	92			[illegible]	[illegible]			K172-115	93			S20-118	101						
K6-101	82			K46-115	92			[illegible]	94			K173-115	93			S21-118	101						
K6-102	83	K17-115	96	K47-115	[illegible]			K107-115	94			K174-118	80			S22-118	101						
K6-103	84	K18-115	96					K108-115	94			K175-115	97	M8-115	63	S23-118	101						
K6-104	85	K19-115	96					K109-115	94					M9-115	63	S24-118	101						
				K50-115	80			K110-115	94					M10-115	63	S25-118	101						
K7-101	82			K51-115	80			K111-115	[illegible]					M11-115	63	S26-118	101						
K7-102	83			K52-115	93			K112-115	94			L2-119	78 102			S27-118	101						
K7-103	84			K53-115	93			K113-115	94			L5-119	78 103			S28-118	101						
K7-104	85			K54-115	93			K114-115	94			L6-117	76 99			S29-118	101						
		K25-120	97	K55-115	93	K85-120	96	K115-115	87			L10-119	102			S30-118	101						
K8-101	82	K26-120	97			K86-118	95	K116-115	87			L11-119	99	R4-120	79 105	S31-118	101						
K8-102	83	K27-120	96	K57-115	93	K87-118	96	K117-120	103			L13-119	64 102	R5-120	79 105	S32-118	101						
K8-103	84	K28-120	96			K88-118	96	K118-120	103					R6-120	79 105								
K8-104	85			K59-118	96	K89-118	96	K119-120	103							S117-118	*						
		K30-120	97	K60-118	96	K90-118	96	K120-120	97	K150-115	92	L16-119	64 103			S119-118	*						
K9-101	82	K31-120	97	K61-118	96	K91-118	96					L17-117	65 99			S121-118	*						

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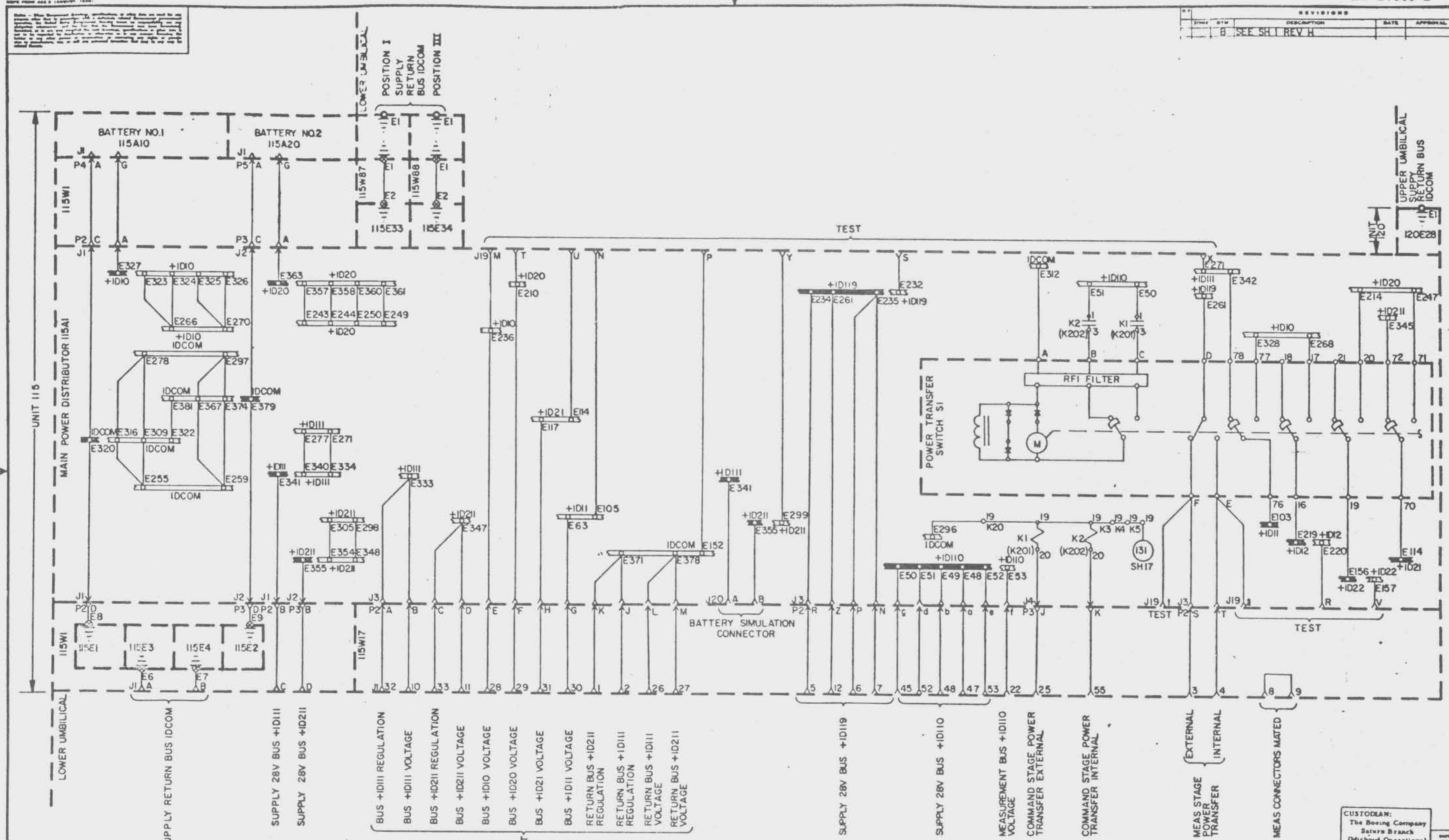

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S-IC STAGE
ELECTRICAL SCHEMATICS
BATTERIES, POWER CHANGEOVER REGULATION AND MONITORING

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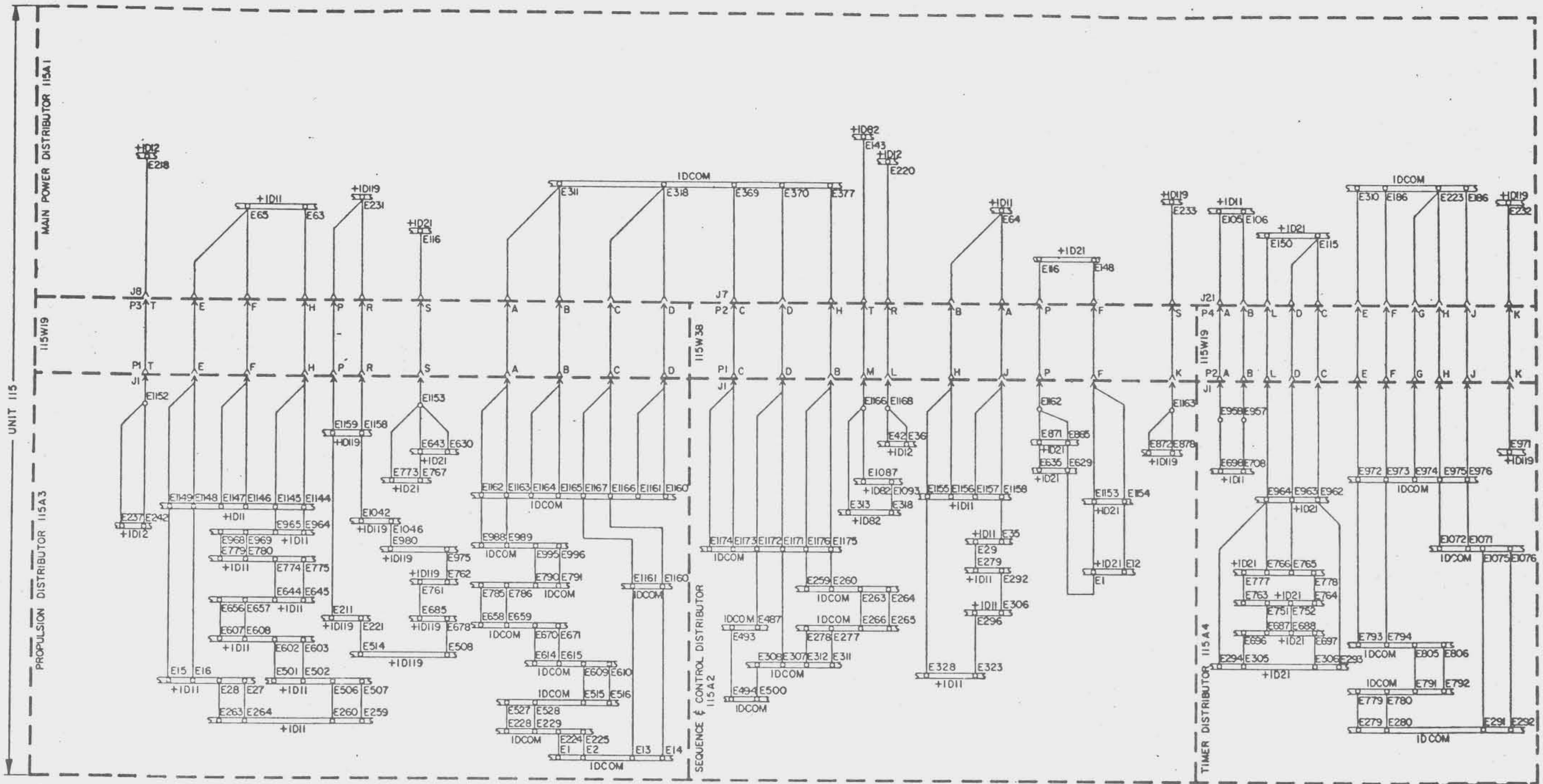

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HEAT TREATMENT
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S-IC STAGE
ELECTRICAL SCHEMATICS
28 VOLT DC
POWER DISTRIBUTION SYSTEM,
SEQ & CONT, PRPLN & TIMER
DISTRIBUTORS

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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CODE 14981
SIZE D 60B55401
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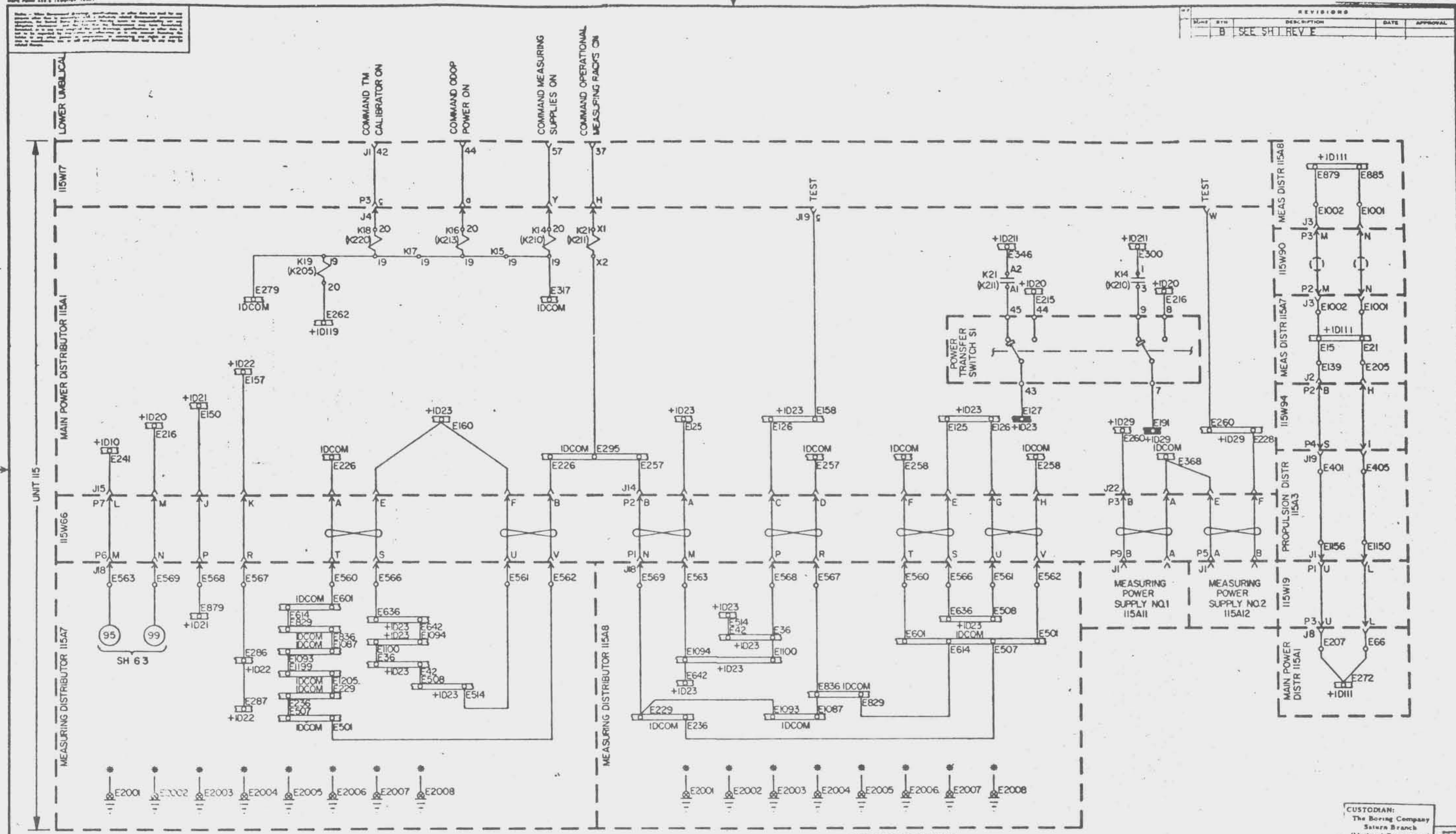

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S-IC STAGE
ELECTRICAL SCHEMATICS
28 VOLT DC POWER DISTRIBUTION, MEAS DISTR & 5 VOLT MEAS SUPPLIES

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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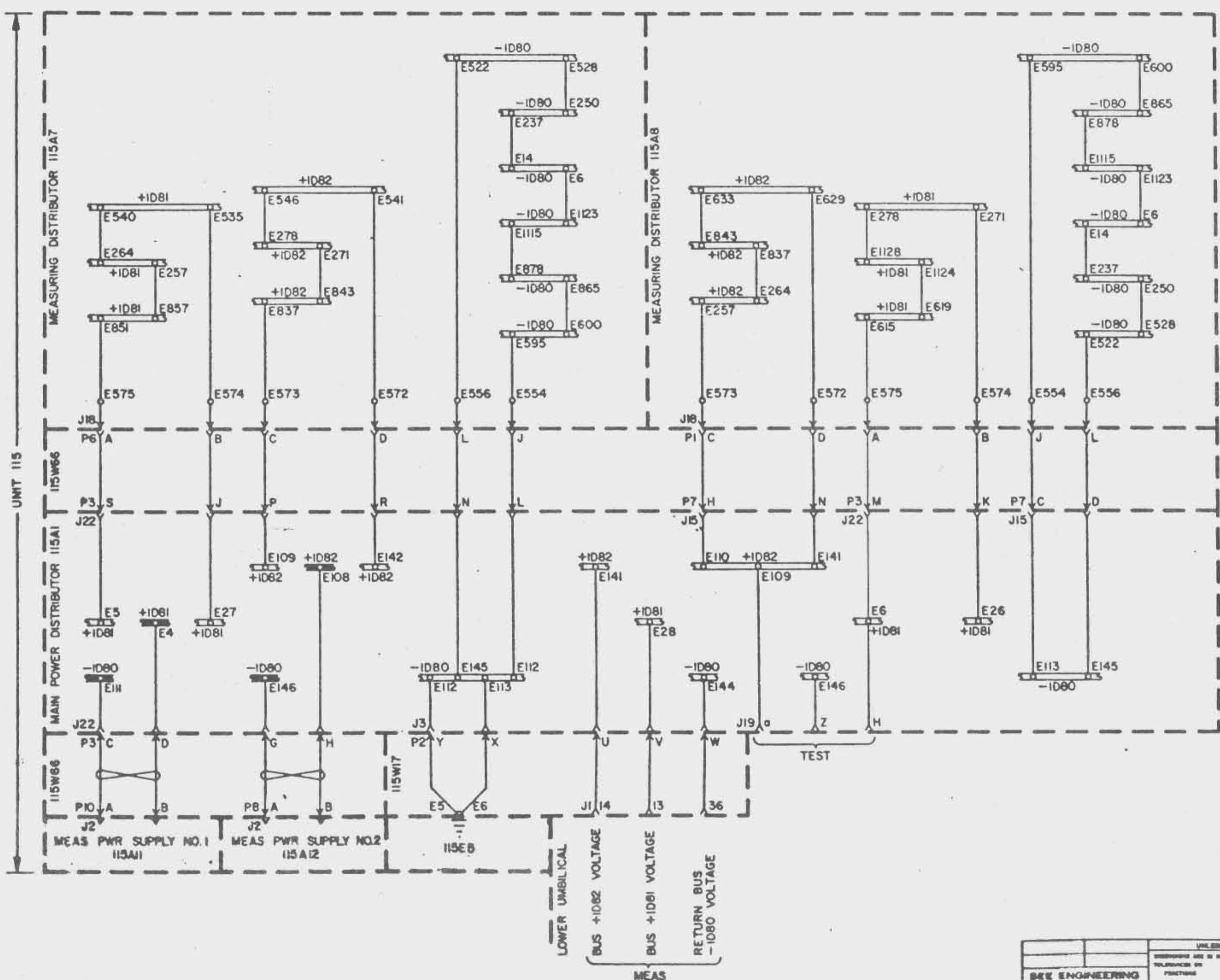


S-IC STAGE
ELECTRICAL SCHEMATICS
5 VOLT DC
DISTRIBUTION SYSTEM

D 60B55401

14981

CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)

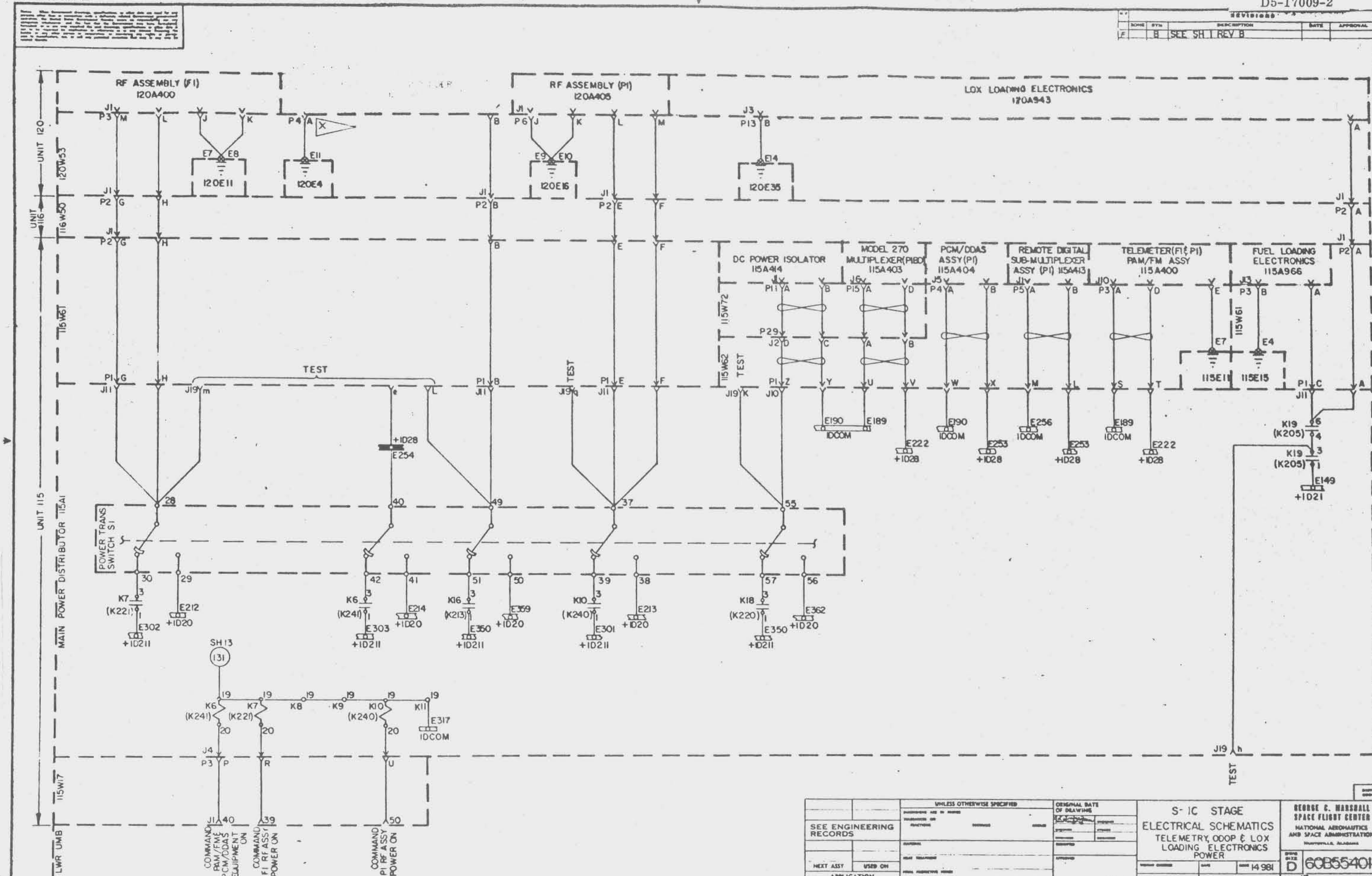
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

B&E ENGINEERING RECORDS

APPLICATION

REVISIONS

60B55401 16 -


SEE SH 1 REV B
RF ASSEMBLY (F1)
120A400
RF ASSEMBLY (P1)
120A405
LOX LOADING ELECTRONICS
120A943
120E11
120E4
120E16
120E35
UNIT 120
120W53
UNIT 116
116W50
DC POWER ISOLATOR
115A414
MODEL 270
MULTIPLEXER(P1BD)
115A403
PCM/DDAS
ASSY(P1)
115A404
REMOTE DIGITAL
SUB-MULTIPLEXER
ASSY (P1) 115A413
TELEMETER(F1 & P1)
PAM/FM ASSY
115A400
FUEL LOADING
ELECTRONICS
115A966
115W72
115W62
115W61
115E11
115E15
TEST
IDCOM
+1D28
+1D21
+1D20
+1D211
UNIT 115
MAIN POWER DISTRIBUTOR 115A1
POWER TRANS
SWITCH S1
SH 13
131
115W17
LWR UMB
COMMAND
PAM/FM&
PCM/DDAS
EQUIPMENT
ON
COMMAND
F1 RF ASSY
POWER ON
COMMAND
P1 RF ASSY
POWER ON
SEE ENGINEERING RECORDS
NEXT ASSY
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED
S-IC STAGE
ELECTRICAL SCHEMATICS
TELEMETRY, ODOP & LOX
LOADING ELECTRONICS
POWER
GEORGE C. MARSHALL
SPACE FLIGHT CENTER
NATIONAL AERONAUTICS
AND SPACE ADMINISTRATION
14981
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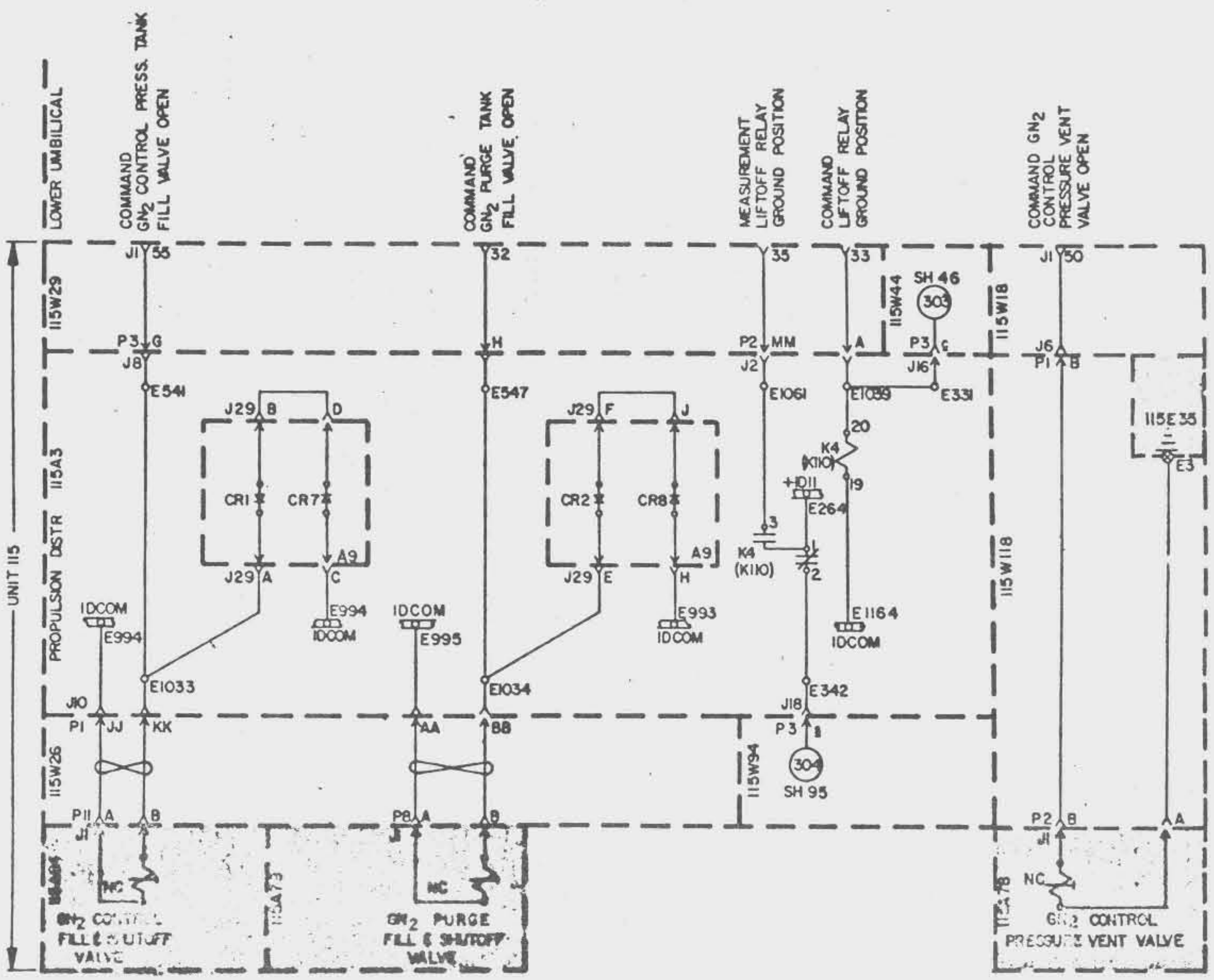
60B55401 17 B

ZONE	SYM	DESCRIPTION	DATE	APPROVAL
	A	SEE SH 1 REV A		



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SEE ENGINEERING RECORDS

NEXT ASSY | USED ON
APPLICATION

S-IC STAGE
ELECTRICAL SCHEMATICS
GN_2 CONTROL & PURGE SYSTEM

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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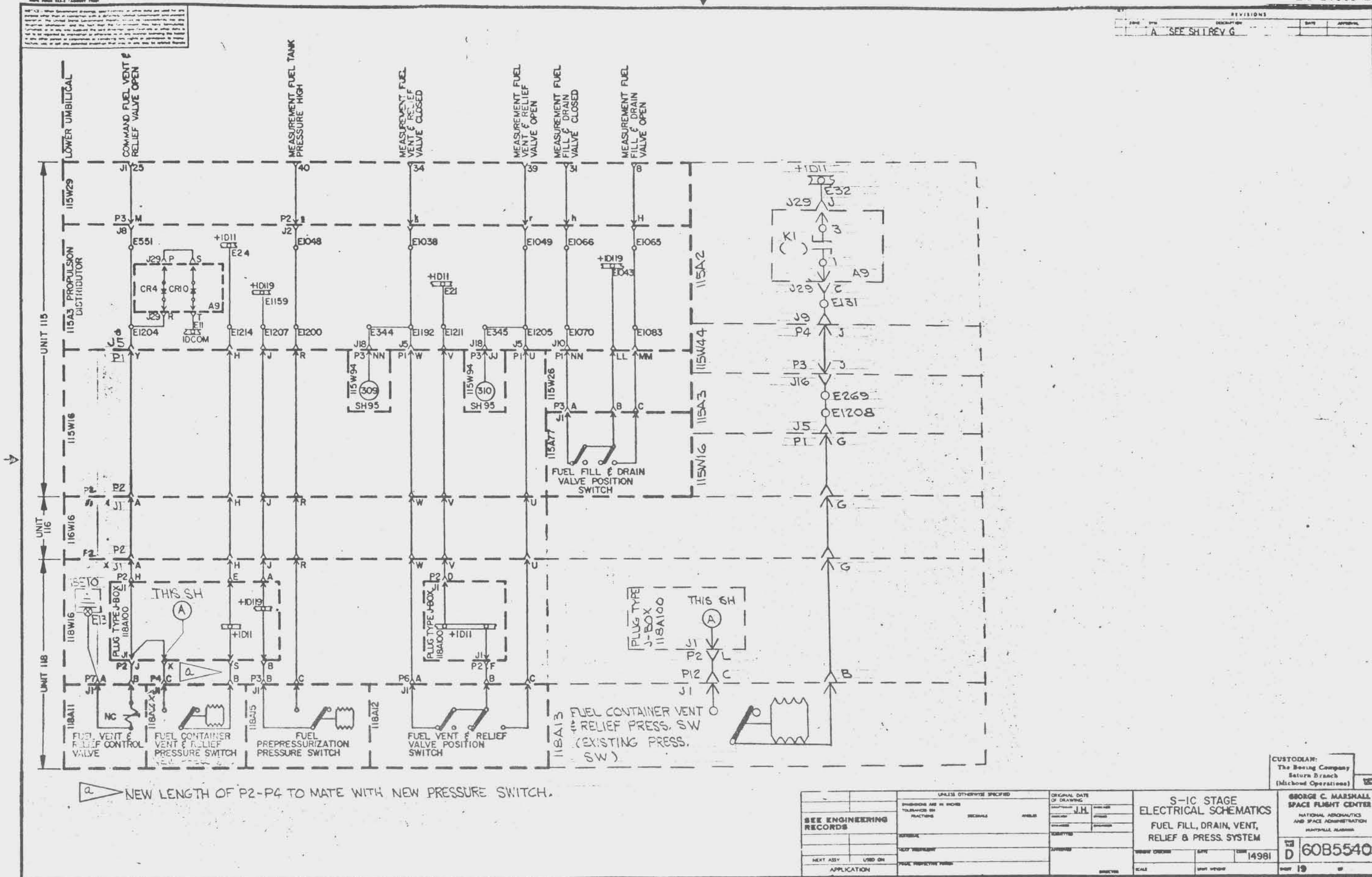
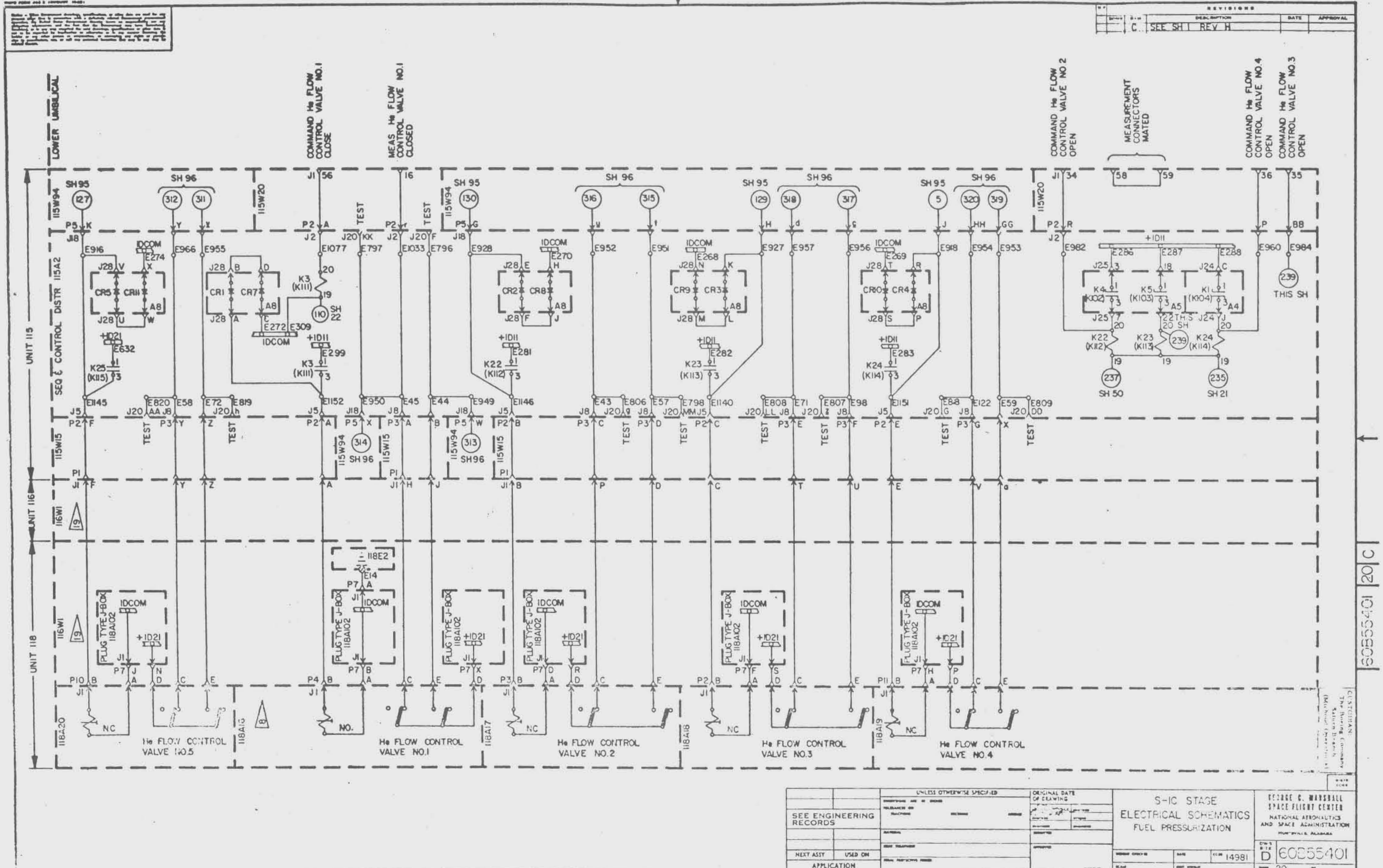


A SEE SH 1 REV G
LOWER UMBILICAL
COMMAND FUEL VENT & RELIEF VALVE OPEN
MEASUREMENT FUEL TANK PRESSURE HIGH
MEASUREMENT FUEL VENT & RELIEF VALVE CLOSED
MEASUREMENT FUEL VENT & RELIEF VALVE OPEN
MEASUREMENT FUEL FILL & DRAIN VALVE CLOSED
MEASUREMENT FUEL FILL & DRAIN VALVE OPEN
UNIT 115
115W29
115A3 PROPULSION DISTRIBUTOR
115W16
UNIT 116
116W16
UNIT 118
118W16
115A2
115W44
115A3
115W16
115W26
115A17
115W94
SH95
FUEL FILL & DRAIN VALVE POSITION SWITCH
THIS SH
PLUG TYPE J-BOX 118A100
118A11
118A14
118A15
118A12
118A13
FUEL VENT & RELIEF CONTROL VALVE
FUEL CONTAINER VENT & RELIEF PRESSURE SWITCH
FUEL PREPRESSURIZATION PRESSURE SWITCH
FUEL VENT & RELIEF VALVE POSITION SWITCH
FUEL CONTAINER VENT & RELIEF PRESS. SW (EXISTING PRESS. SW)
NEW LENGTH OF P2-P4 TO MATE WITH NEW PRESSURE SWITCH.
CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)
SEE ENGINEERING RECORDS
APPLICATION
S-IC STAGE ELECTRICAL SCHEMATICS
FUEL FILL, DRAIN, VENT, RELIEF & PRESS. SYSTEM
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA
14981
D 60B55401
60B55401 19 A


SEE SH 1 REV H
LOWER UMBILICAL
COMMAND He FLOW CONTROL VALVE NO.1 CLOSE
MEAS He FLOW CONTROL VALVE NO.1 CLOSED
COMMAND He FLOW CONTROL VALVE NO.2 OPEN
MEASUREMENT CONNECTORS MATED
COMMAND He FLOW CONTROL VALVE NO.4 OPEN
COMMAND He FLOW CONTROL VALVE NO.3 OPEN
UNIT 115
UNIT 116
UNIT 118
SEQ & CONTROL DISTR 115A2
SH 95
SH 96
THIS SH
SH 50
SH 21
TEST
PLUG TYPE J-BOX 118A102
IDCOM
He FLOW CONTROL VALVE NO.5
He FLOW CONTROL VALVE NO.1
He FLOW CONTROL VALVE NO.2
He FLOW CONTROL VALVE NO.3
He FLOW CONTROL VALVE NO.4
SEE ENGINEERING RECORDS
NEXT ASSY
USED ON
APPLICATION
S-IC STAGE
ELECTRICAL SCHEMATICS
FUEL PRESSURIZATION
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA
14981
D 60B55401
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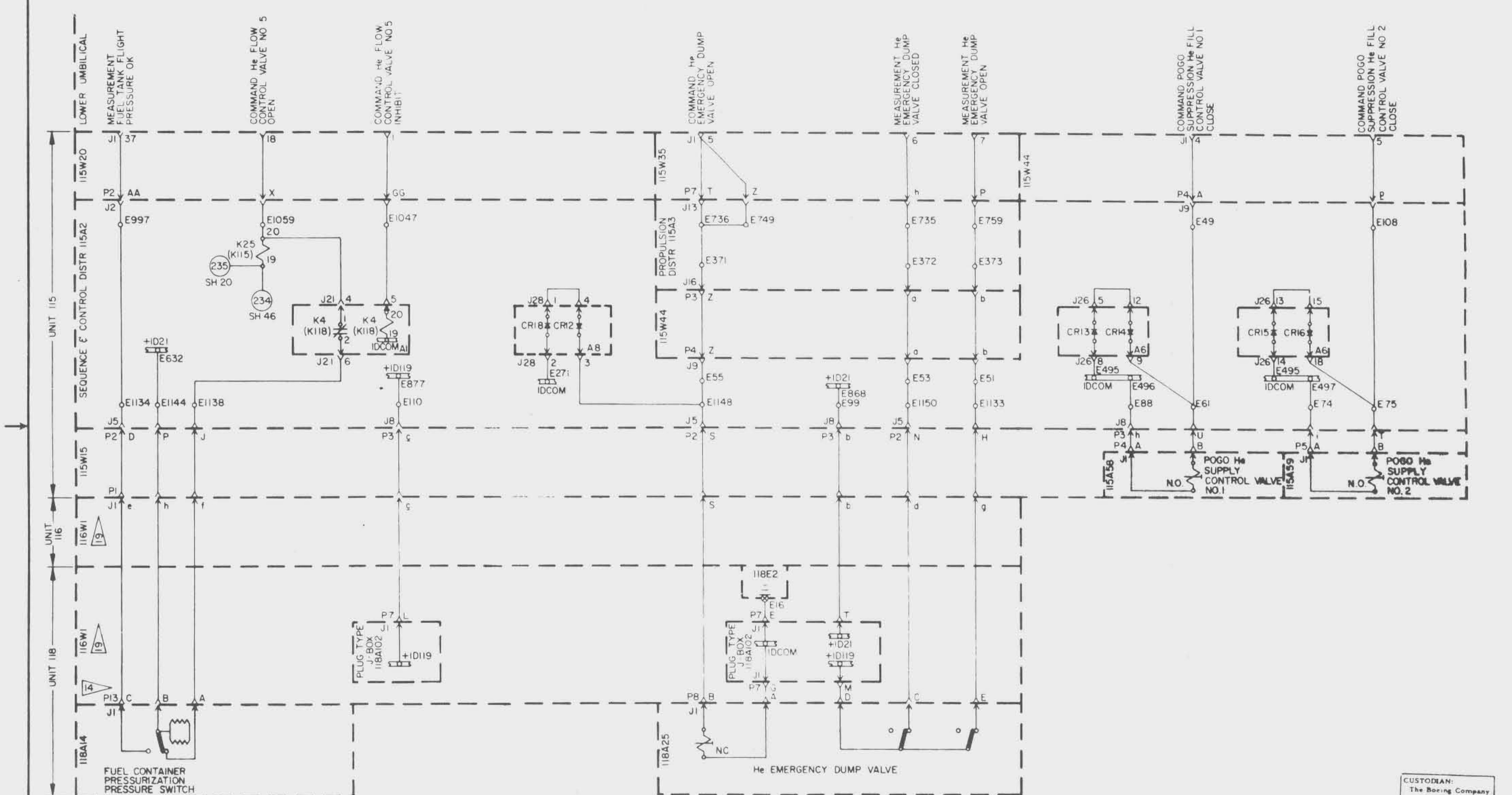
60B55401 20 C



REVISIONS: C — SEE SH 1 REV F

CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)

SEE ENGINEERING RECORDS

NEXT ASSY | USED ON — APPLICATION

UNLESS OTHERWISE SPECIFIED

S-IC STAGE ELECTRICAL SCHEMATICS

FUEL PRESSURIZATION

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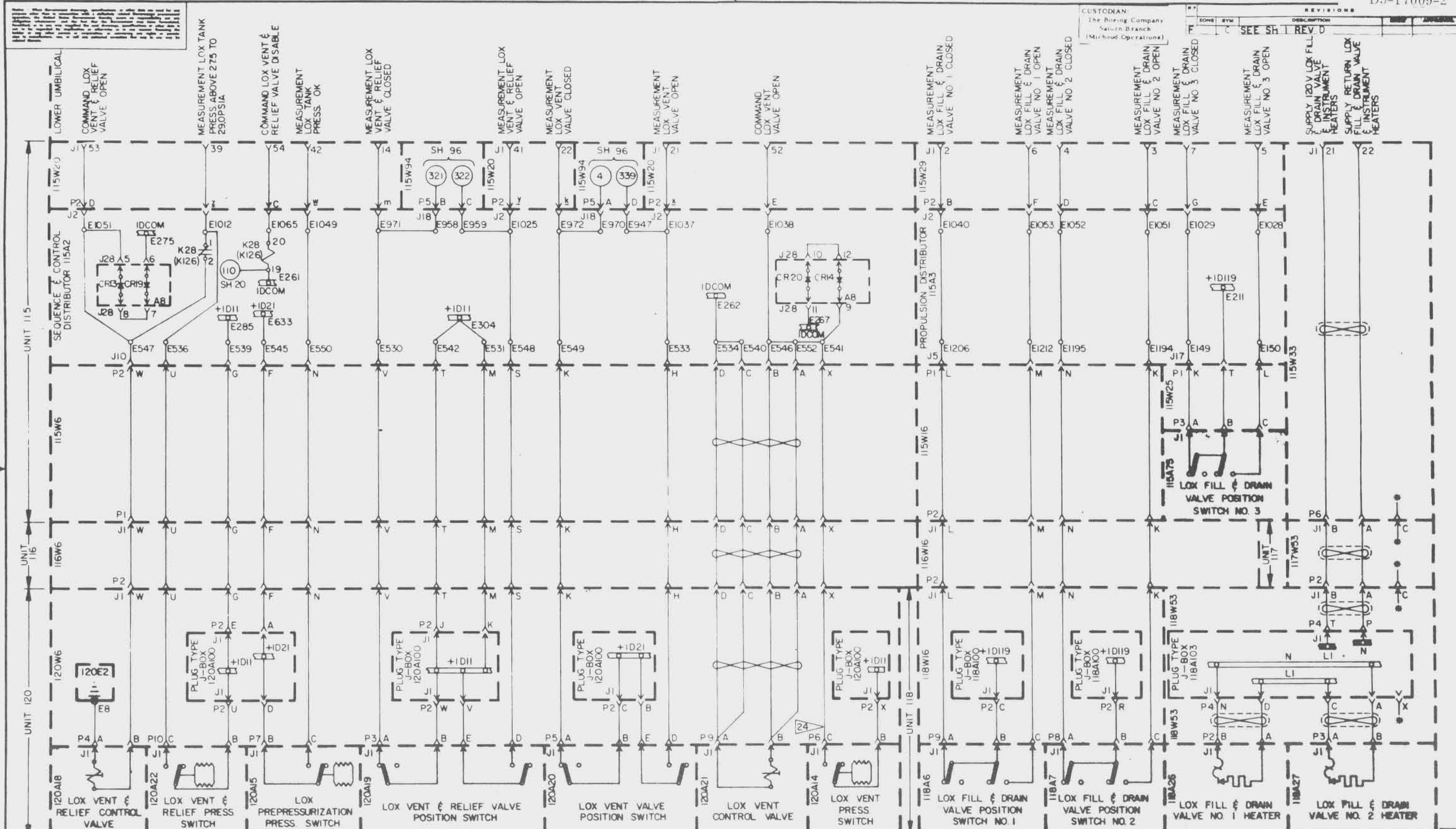
HUNTSVILLE, ALABAMA

14981 D 60B55401

SHEET 21

60B55401 21 C



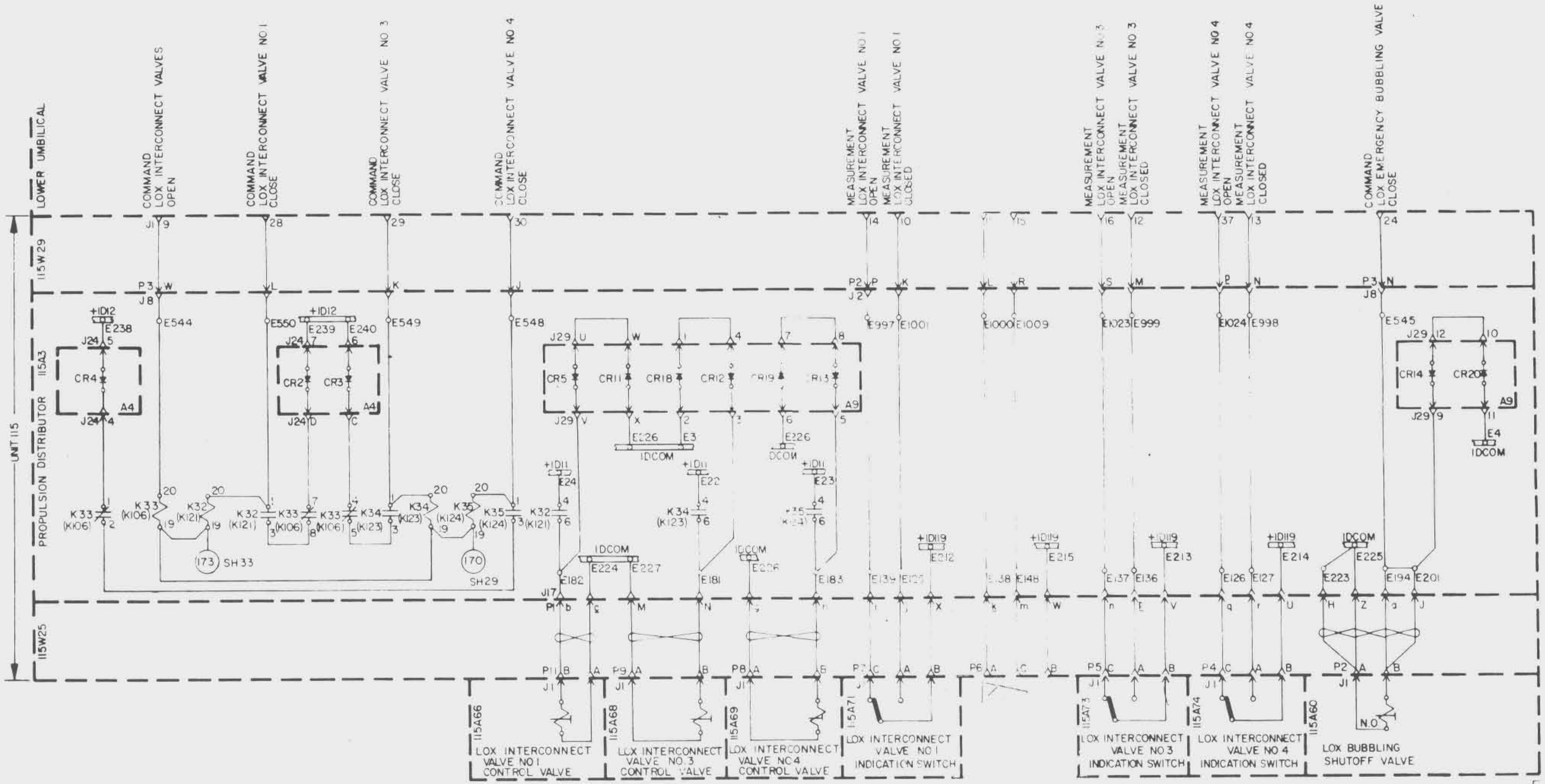
✱ TERMINATE SHIELDS

SEE ENGINEERING RECORDS	UNLESS OTHERWISE SPECIFIED	ORIGINAL DATE OF DRAWING	S-IC STAGE ELECTRICAL SCHEMATICS LOX FILL, DRAIN, VENT, RELIEF & PRESS. SYSTEM
NEXT ASSY / USED ON			14981
APPLICATION			D 60B55401

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

22

A SEE SH 1 REV E



CUSTODIAN
The Boeing Company
Saturn Branch
(Michoud Operations)

SEE ENGINEERING RECORDS

S-IC STAGE
ELECTRICAL SCHEMATICS
LOX INTERCONNECT & BUBBLING SYSTEM

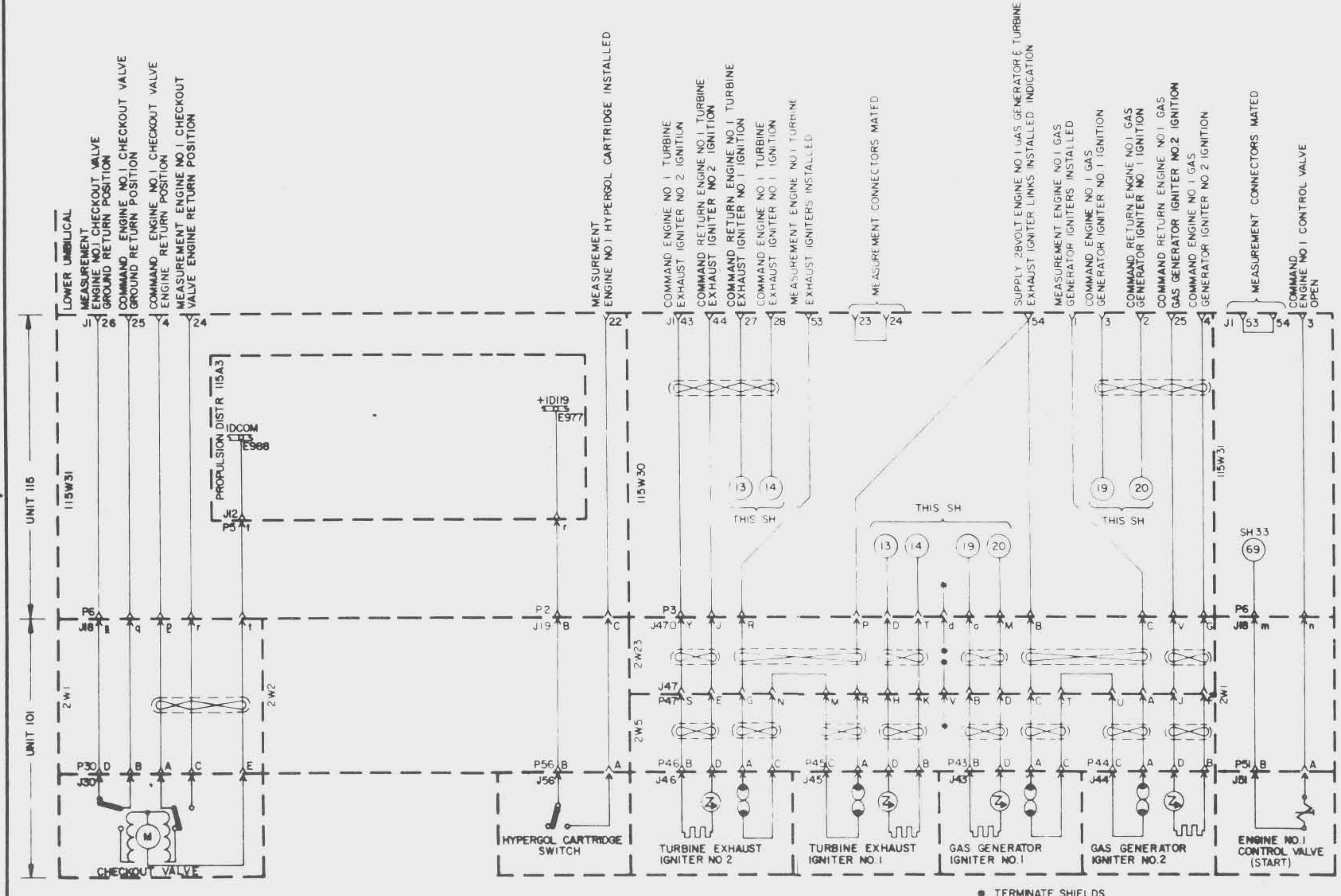
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

CODE 14981

D 60B55401

SHEET 23

60B55401 23 A



CUSTODIAN:
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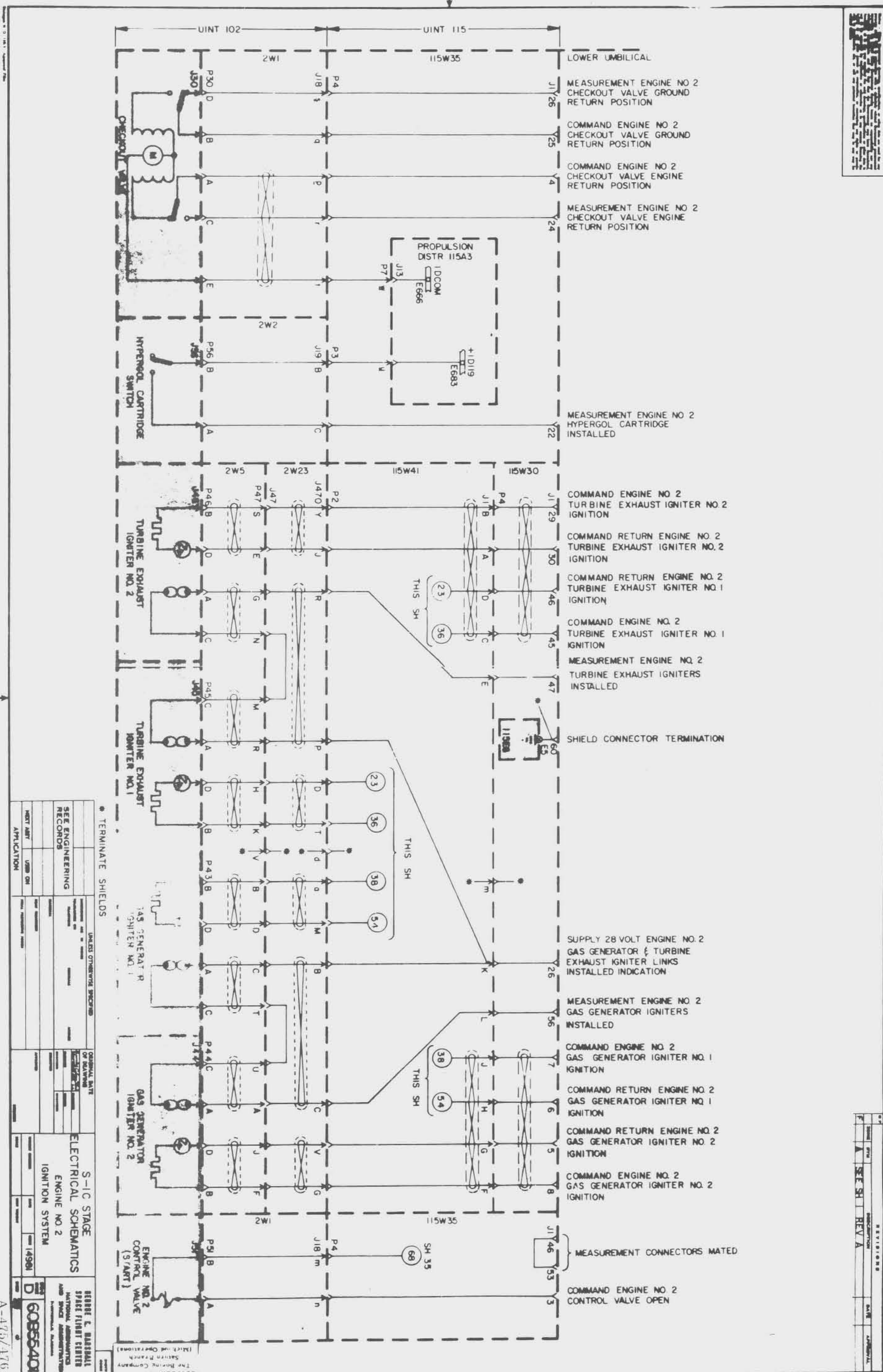
Saturn Branch
(Michoud Operations)

SEE ENGINEERING RECORDS	UNLESS OTHERWISE SPECIFIED	ORIGINAL DATE OF DRAWING	S-IC STAGE ELECTRICAL SCHEMATICS ENGINE NO.1 IGNITION SYSTEM	GEORGE C. MARSHALL SPACE FLIGHT CENTER NATIONAL AERONAUTICS AND SPACE ADMINISTRATION HUNTSVILLE, ALABAMA
NEXT ASSY / USED ON / APPLICATION		DRAFTSMAN J.H.	14981	D 60B55401 SHEET 24



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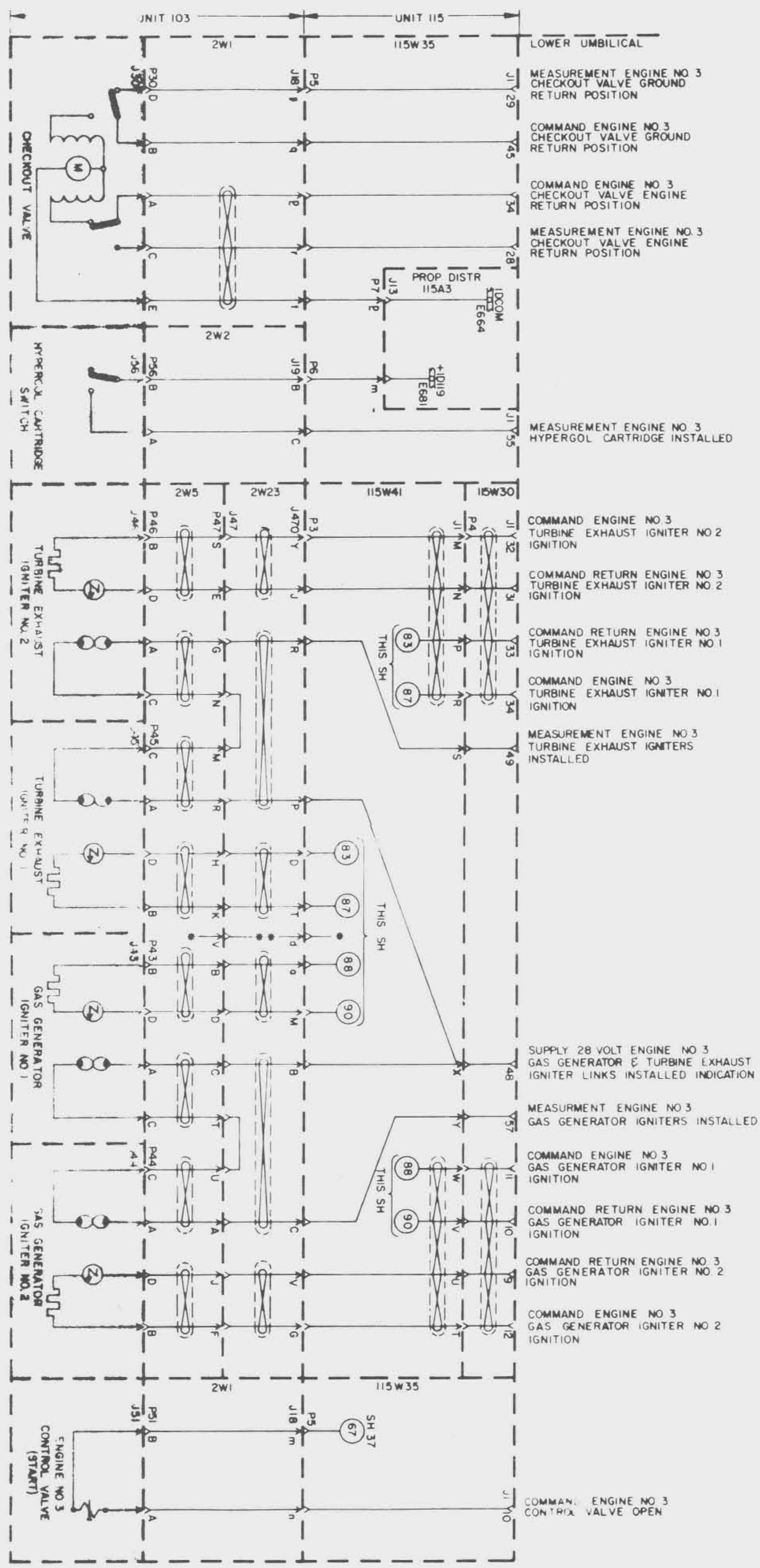
D5-170092

A-475/476



• TERMINATE SHIELDS

SEE ENGINEERING RECORDS

CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

S-IC STAGE
ELECTRICAL SCHEMATICS
ENGINE NO. 3
IGNITION SYSTEM

14981 D 60B55401

REVISIONS: A SEE SH 1 REV A

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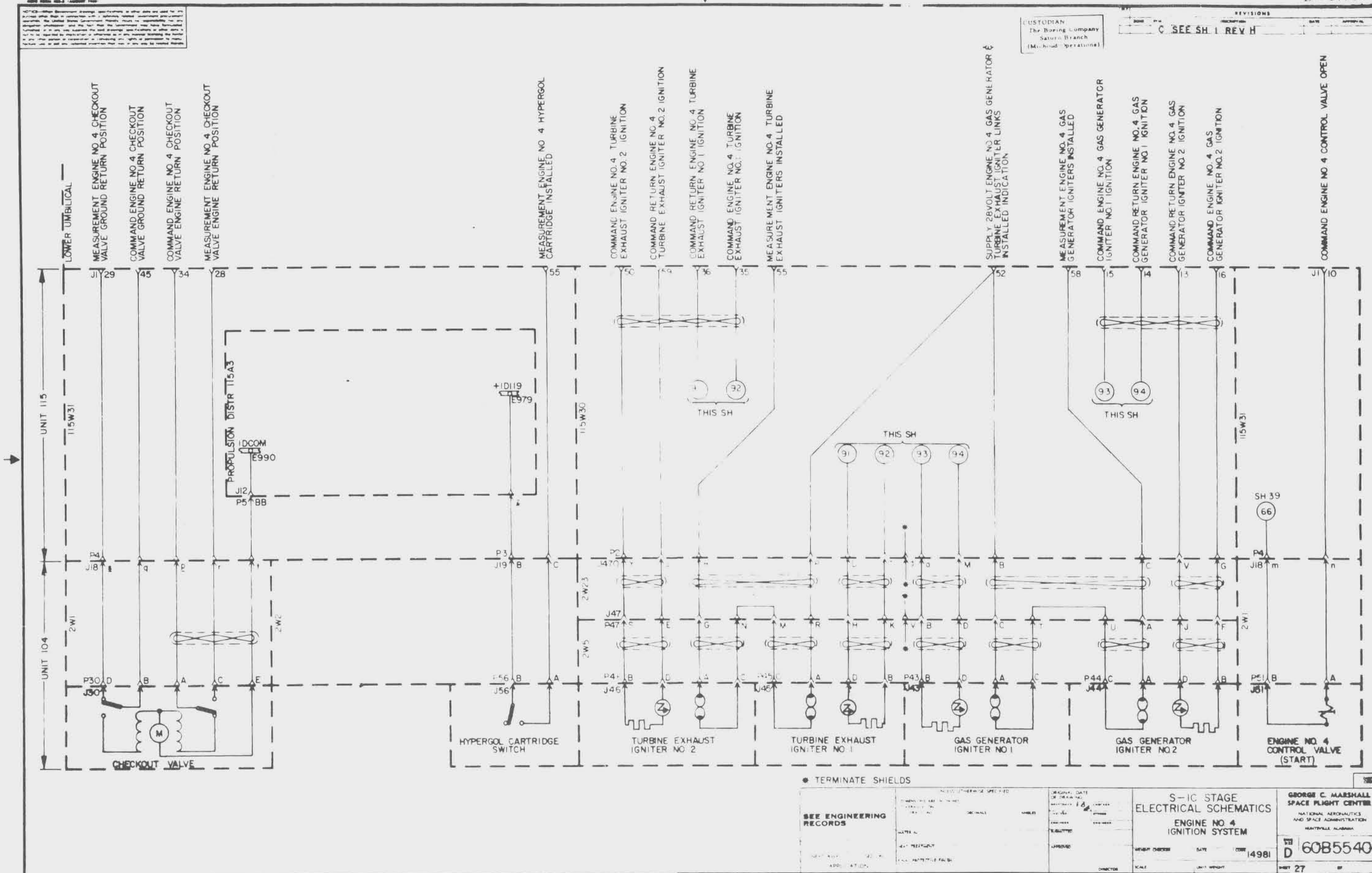
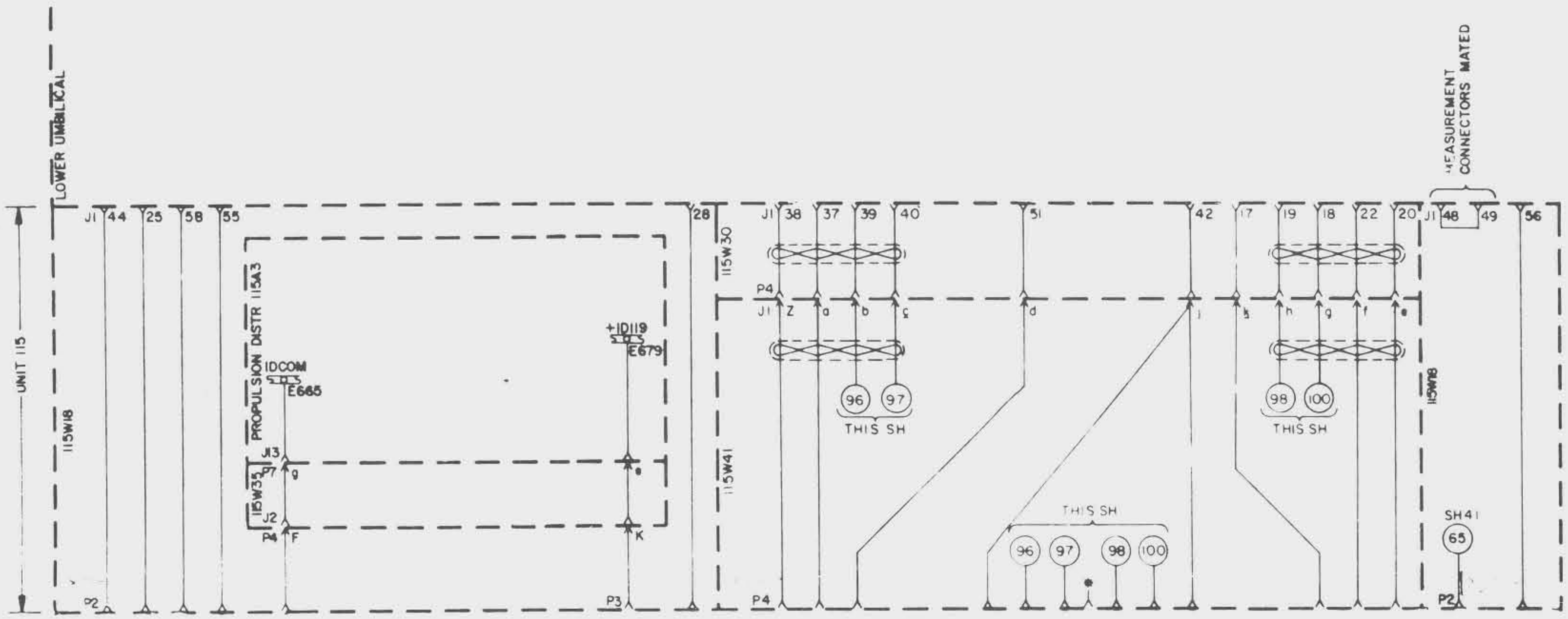
D5-17009-2

A-477/478


C SEE SH 1 REV H
CUSTODIAN The Boeing Company Saturn Branch (Michoud Operations)
LOWER UMBILICAL
MEASUREMENT ENGINE NO 4 CHECKOUT VALVE GROUND RETURN POSITION
COMMAND ENGINE NO 4 CHECKOUT VALVE GROUND RETURN POSITION
COMMAND ENGINE NO 4 CHECKOUT VALVE ENGINE RETURN POSITION
MEASUREMENT ENGINE NO 4 CHECKOUT VALVE ENGINE RETURN POSITION
MEASUREMENT ENGINE NO 4 HYPERGOL CARTRIDGE INSTALLED
COMMAND ENGINE NO 4 TURBINE EXHAUST IGNITER NO 2 IGNITION
COMMAND RETURN ENGINE NO 4 TURBINE EXHAUST IGNITER NO 2 IGNITION
COMMAND RETURN ENGINE NO 4 TURBINE EXHAUST IGNITER NO 1 IGNITION
COMMAND ENGINE NO 4 TURBINE EXHAUST IGNITER NO 1 IGNITION
MEASUREMENT ENGINE NO 4 TURBINE EXHAUST IGNITERS INSTALLED
SUPPLY 28VOLT ENGINE NO 4 GAS GENERATOR & TURBINE EXHAUST IGNITER LINKS INSTALLED INDICATION
MEASUREMENT ENGINE NO 4 GAS GENERATOR IGNITERS INSTALLED
COMMAND ENGINE NO 4 GAS GENERATOR IGNITER NO 1 IGNITION
COMMAND RETURN ENGINE NO 4 GAS GENERATOR IGNITER NO 1 IGNITION
COMMAND RETURN ENGINE NO 4 GAS GENERATOR IGNITER NO 2 IGNITION
COMMAND ENGINE NO 4 GAS GENERATOR IGNITER NO 2 IGNITION
COMMAND ENGINE NO 4 CONTROL VALVE OPEN
UNIT 115
115W31
UNIT 104
2W1
2W2
115W30
2W23
2W5
PROPULSION DISTR 115A3
+1D1119
E979
1DCOM
E990
THIS SH
SH 39
CHECKOUT VALVE
HYPERGOL CARTRIDGE SWITCH
TURBINE EXHAUST IGNITER NO 2
TURBINE EXHAUST IGNITER NO 1
GAS GENERATOR IGNITER NO 1
GAS GENERATOR IGNITER NO 2
ENGINE NO 4 CONTROL VALVE (START)
● TERMINATE SHIELDS
SEE ENGINEERING RECORDS
S-IC STAGE ELECTRICAL SCHEMATICS
ENGINE NO 4 IGNITION SYSTEM
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA
14981
D 60B55401
SHEET 27
60B55401 27



● TERMINATE SHIELDS

SEE ENGINEERING RECORDS	UNLESS OTHERWISE SPECIFIED	S-IC STAGE ELECTRICAL SCHEMATICS ENGINE NO. 5 IGNITION SYSTEM	GEORGE C. MARSHALL SPACE FLIGHT CENTER NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
NEXT ASSY / USED ON / APPLICATION		14981	D 60B55401 SHEET 28

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60B55401 28 A

REVISIONS				
ZONE	SYM	DESCRIPTION	DATE	APPROVAL
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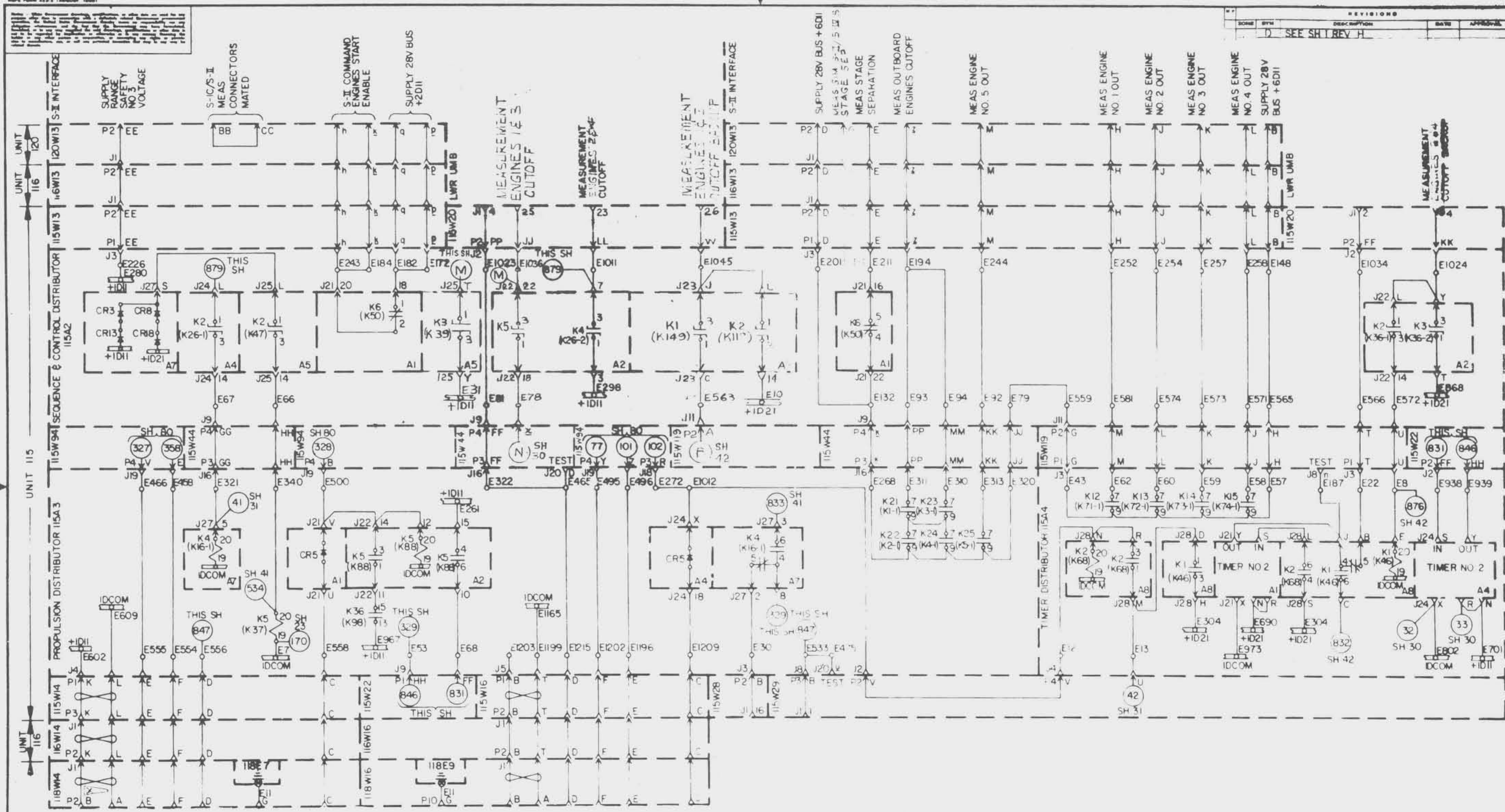

CUSTODIAN:
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Saturn Branch
(Michoud Operations)

SEE ENGINEERING RECORDS

NEXT ASSY | USED ON
APPLICATION

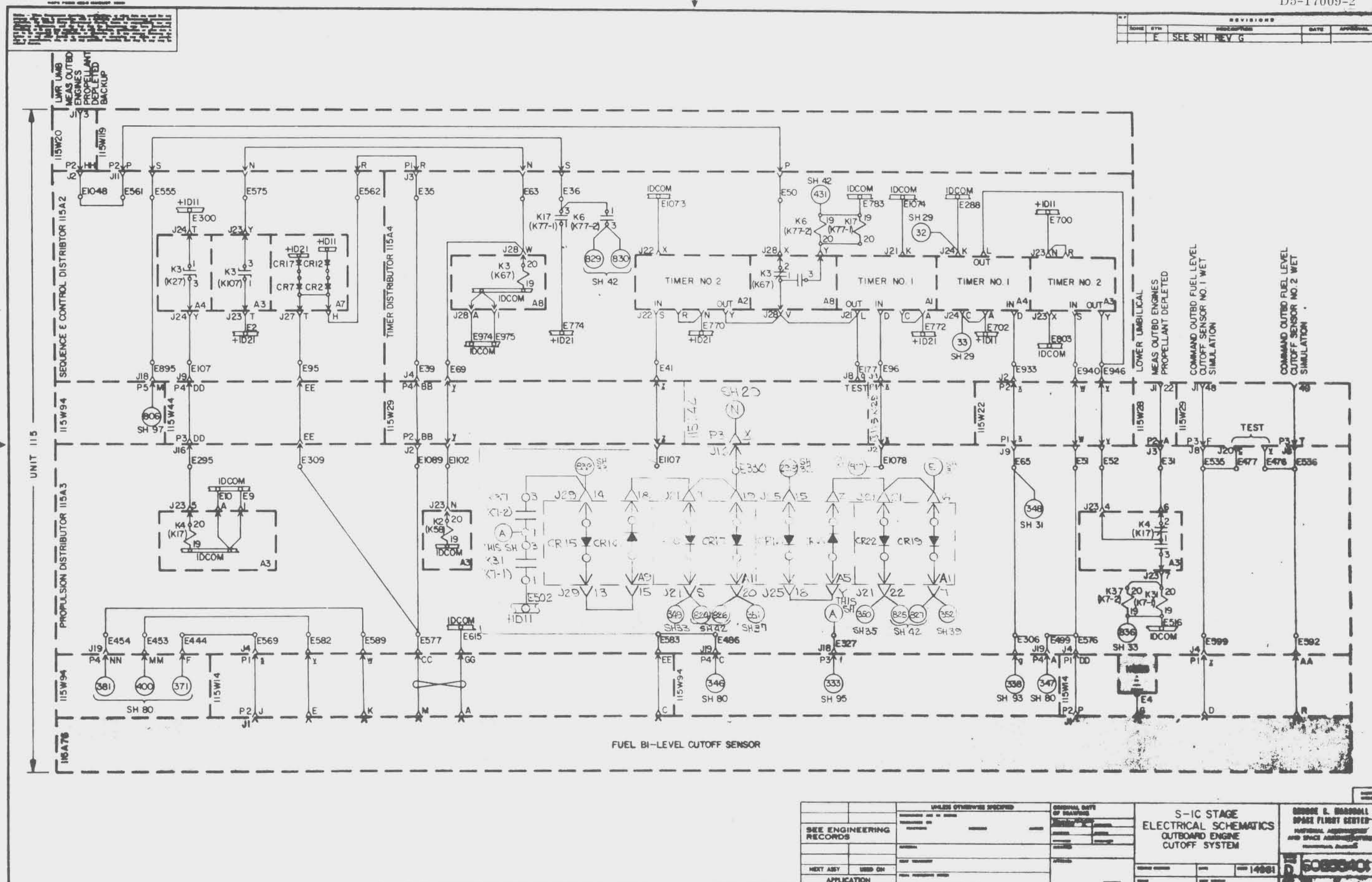
UNLESS OTHERWISE SPECIFIED

ORIGINAL DATE OF DRAWING

S-IC STAGE
ELECTRICAL SCHEMATICS
INBOARD ENGINE CUTOFF SYSTEM

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

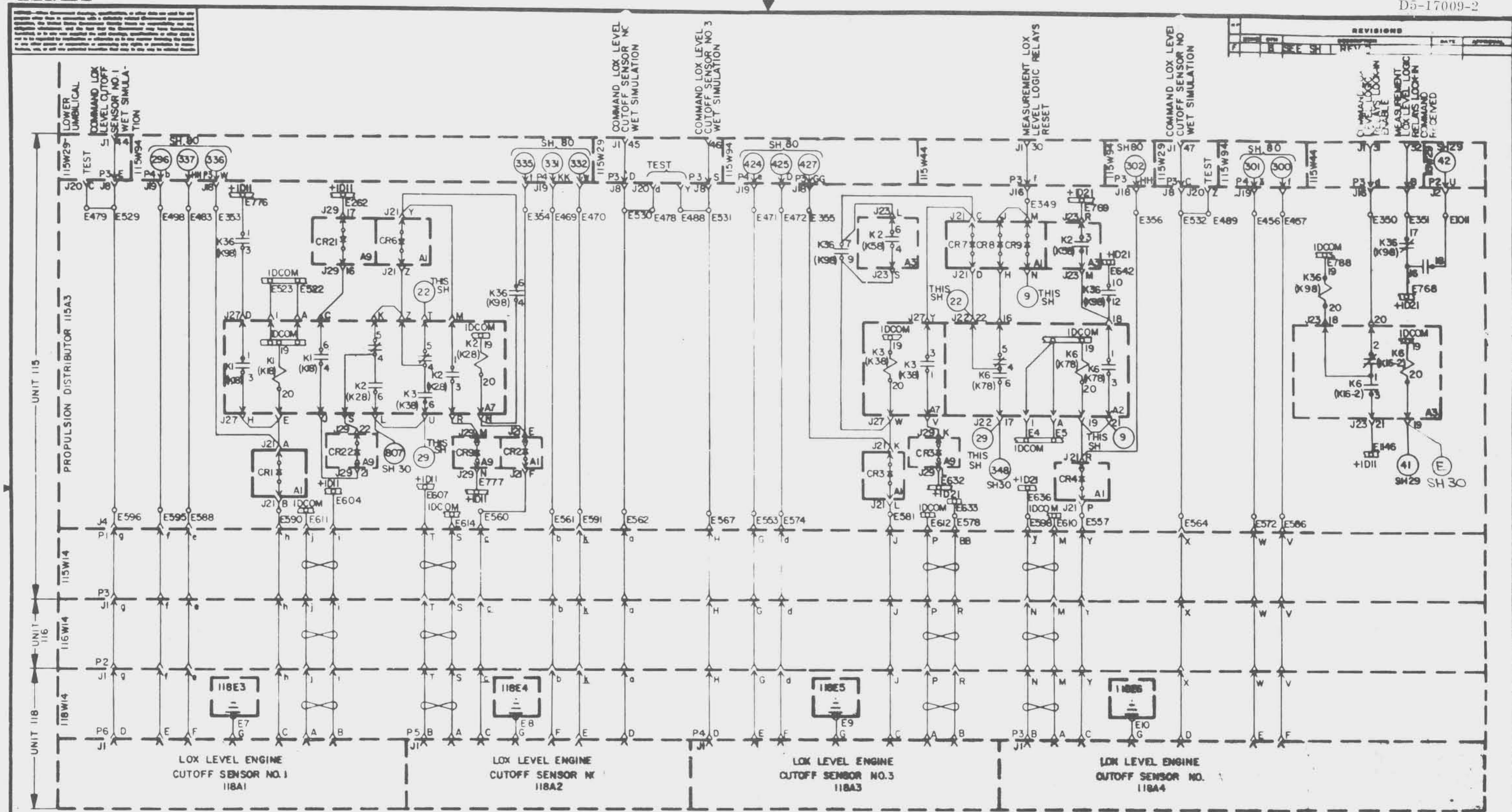
CODE 14981
SIZE D
DWG NO 60B55401
SHEET 29



SEE ENGINEERING RECORDS

S-IC STAGE ELECTRICAL SCHEMATICS OUTBOARD ENGINE CUTOFF SYSTEM

60B58401 30 E



CUSTODIAN:
The Boeing Company
Saturn Branch
(Michoud Operations)

SEE ENGINEERING RECORDS

NEXT ASSY | USED ON

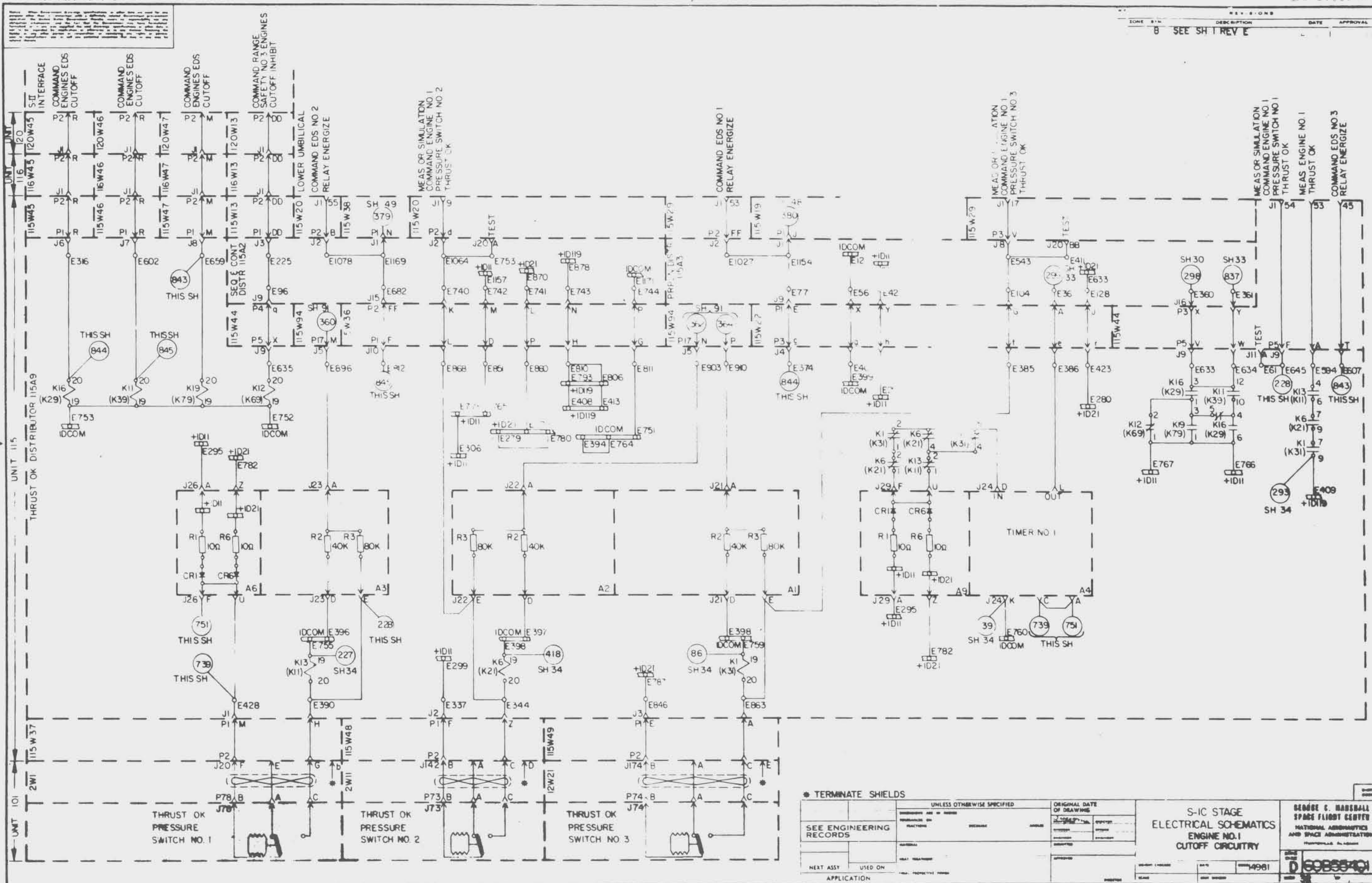
APPLICATION

S-IC STAGE
ELECTRICAL SCHEMATICS
OUTBOARD ENGINE
CUTOFF SYSTEM

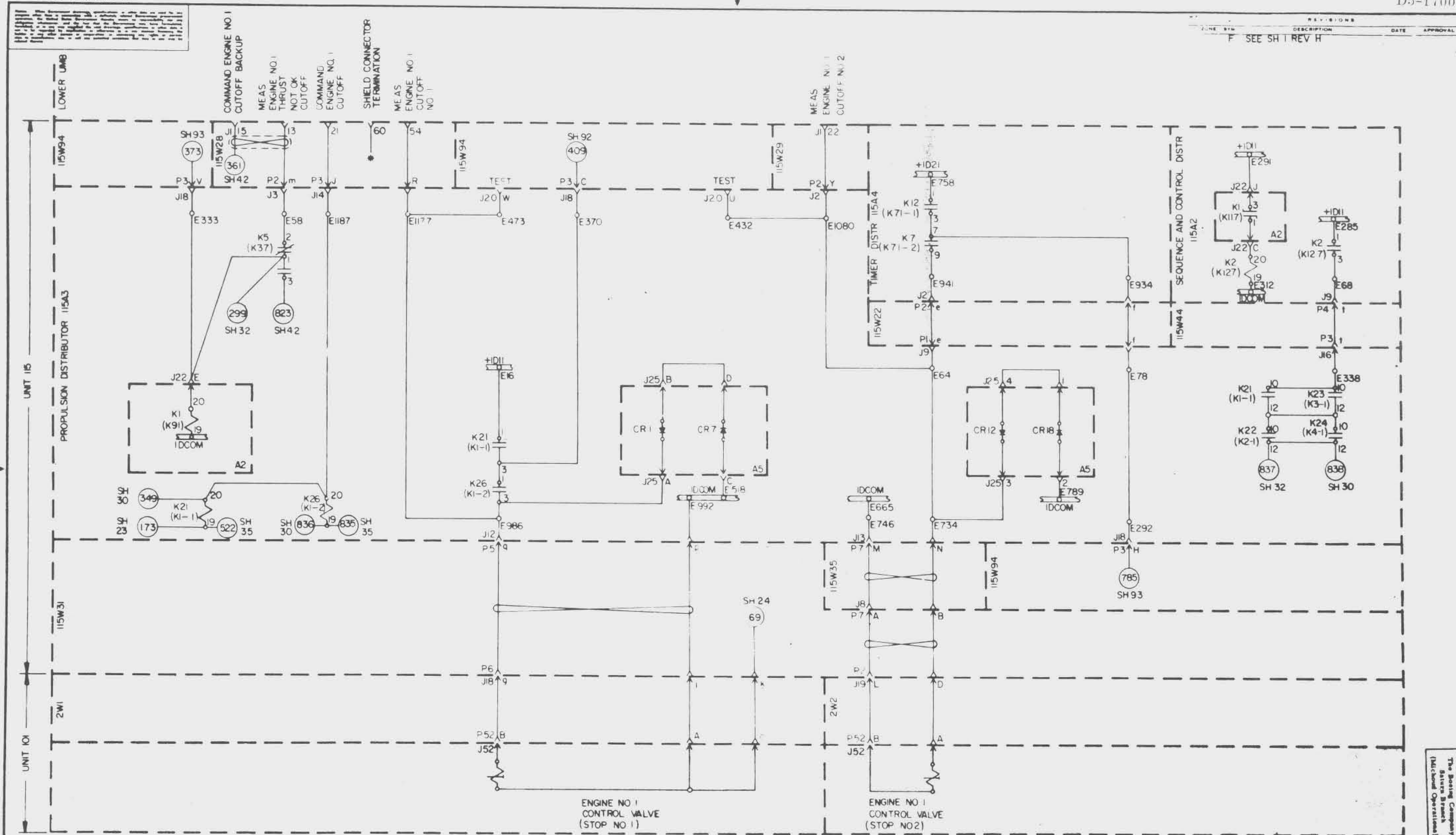
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

14981 D 60B55401

SHEET 31



B SEE SH I REV E
COMMAND ENGINES EDS CUTOFF
COMMAND RANGE SAFETY NO 3 ENGINES CUTOFF INHIBIT
LOWER UMBILICAL
COMMAND EDS NO 2 RELAY ENERGIZE
MEAS OR SIMULATION COMMAND ENGINE NO 1 PRESSURE SWITCH NO 2 THRUST OK
COMMAND EDS NO 1 RELAY ENERGIZE
MEAS OR SIMULATION COMMAND ENGINE NO 1 PRESSURE SWITCH NO 3 THRUST OK
MEAS OR SIMULATION COMMAND ENGINE NO 1 PRESSURE SWITCH NO 1 THRUST OK
MEAS ENGINE NO 1 THRUST OK
COMMAND EDS NO 3 RELAY ENERGIZE
UNIT 115 THRUST OK DISTRIBUTOR 115A9
TIMER NO 1
THRUST OK PRESSURE SWITCH NO. 1
THRUST OK PRESSURE SWITCH NO. 2
THRUST OK PRESSURE SWITCH NO. 3
* TERMINATE SHIELDS
SEE ENGINEERING RECORDS
S-IC STAGE
ELECTRICAL SCHEMATICS
ENGINE NO. 1
CUTOFF CIRCUITRY
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
D 60B55401
60B55401 32 B



* TERMINATE SHIELDS

SEE ENGINEERING RECORDS	UNLESS OTHERWISE SPECIFIED	ORIGINAL DATE OF DRAWING
NEXT ASSY / USED ON	APPLICATION	

S-IC STAGE
ELECTRICAL SCHEMATICS
ENGINE NO. I
CUTOFF CIRCUITRY

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

CODE 14981 — SIZE D — 60B55401 — SHEET 33

CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)

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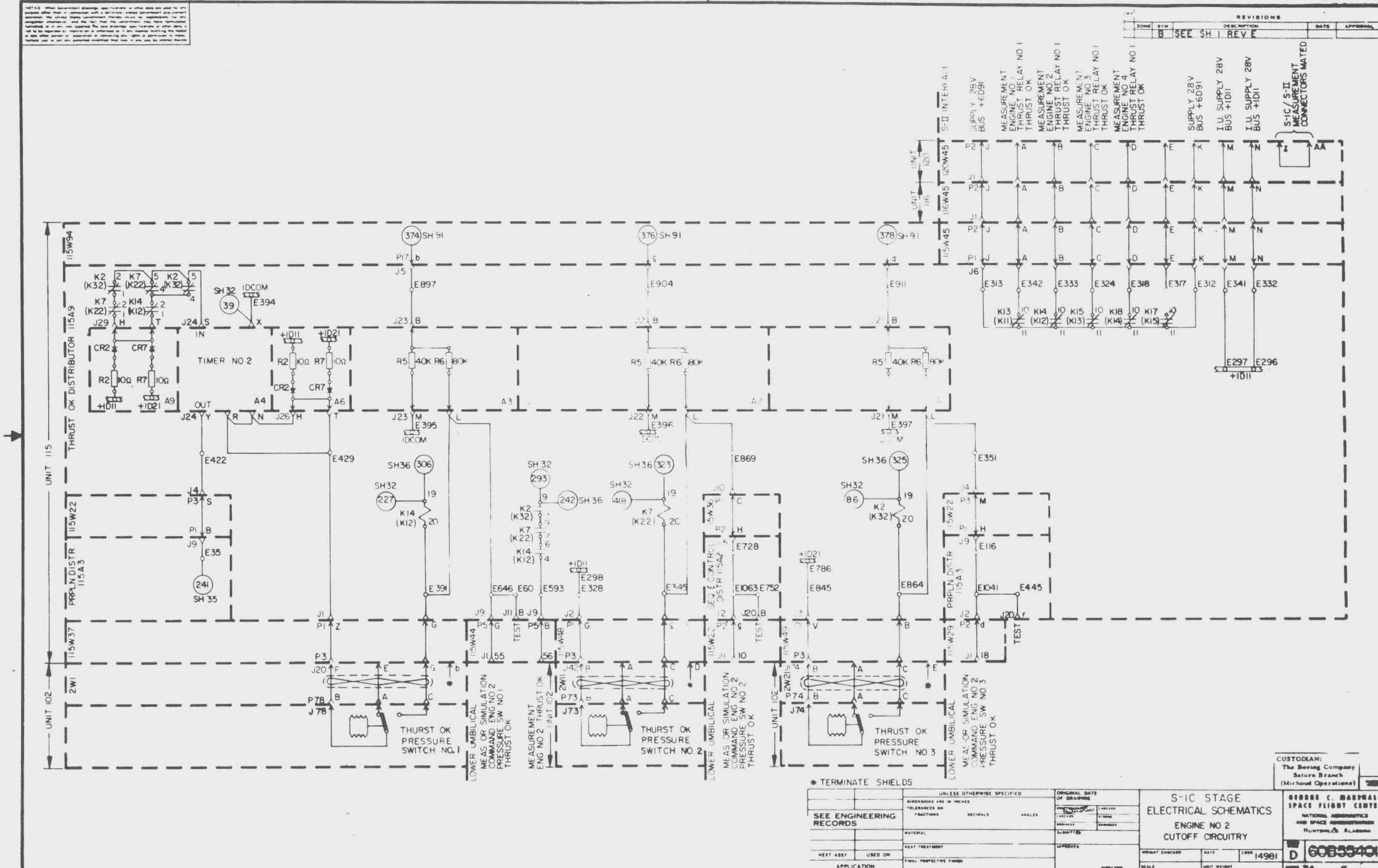

CUSTODIAN:
The Boeing Company
Saturn Branch
(Michoud Operations)

SEE ENGINEERING RECORDS

S-IC STAGE
ELECTRICAL SCHEMATICS
ENGINE NO 2
CUTOFF CIRCUITRY

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

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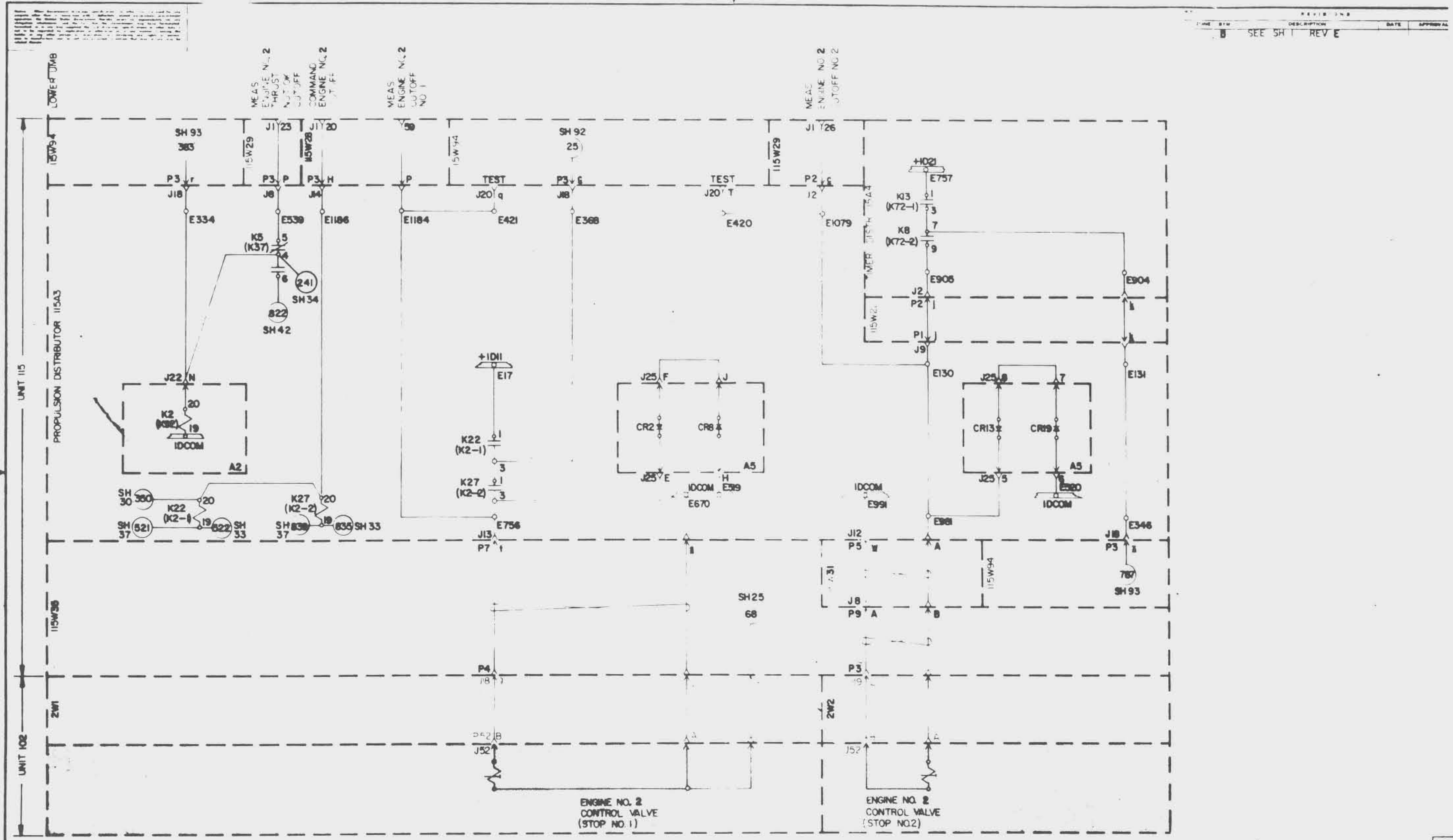
SHEET 34

60B55401 34 B

B SEE SH 1 REV E



SEE ENGINEERING RECORDS

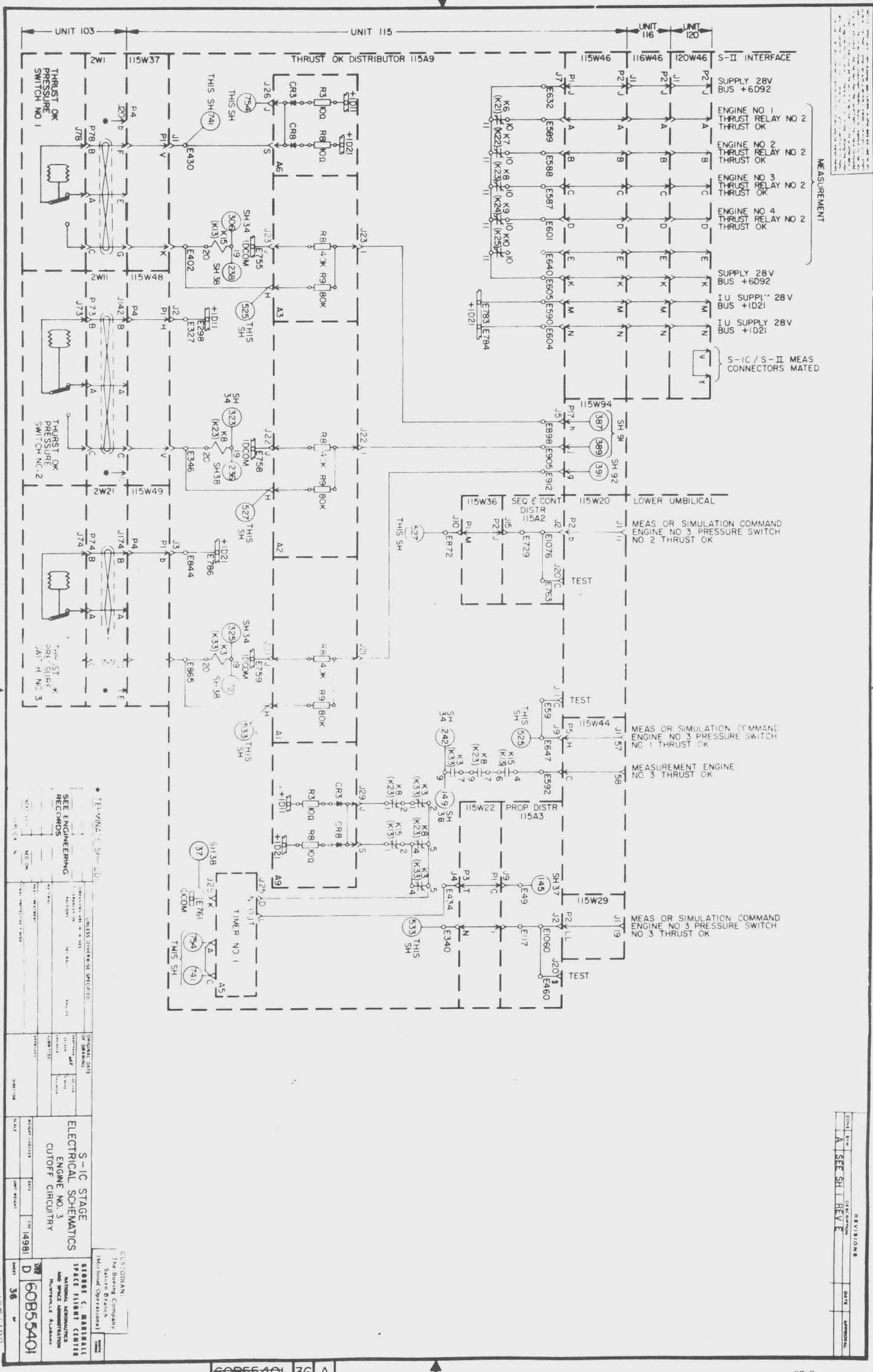
UNLESS OTHERWISE SPECIFIED

NEXT ASSY | USED ON
APPLICATION

S-IC STAGE
ELECTRICAL SCHEMATICS
ENGINE NO. 2
CUTOFF CIRCUITRY

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

14981 D 60B35401



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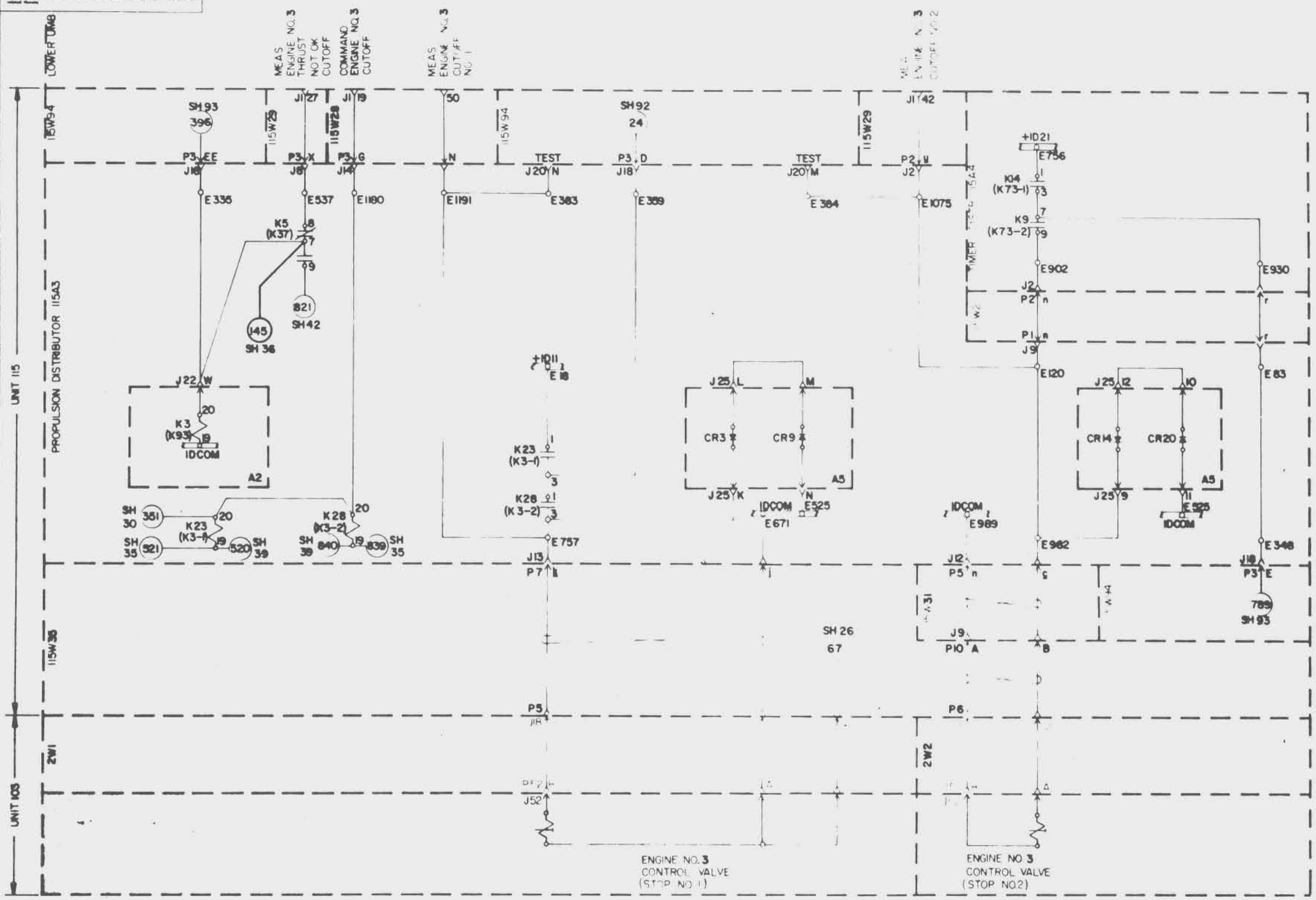
A-197/198

D5-17009-2



B SEE SH 1 REV E

SEE ENGINEERING RECORDS

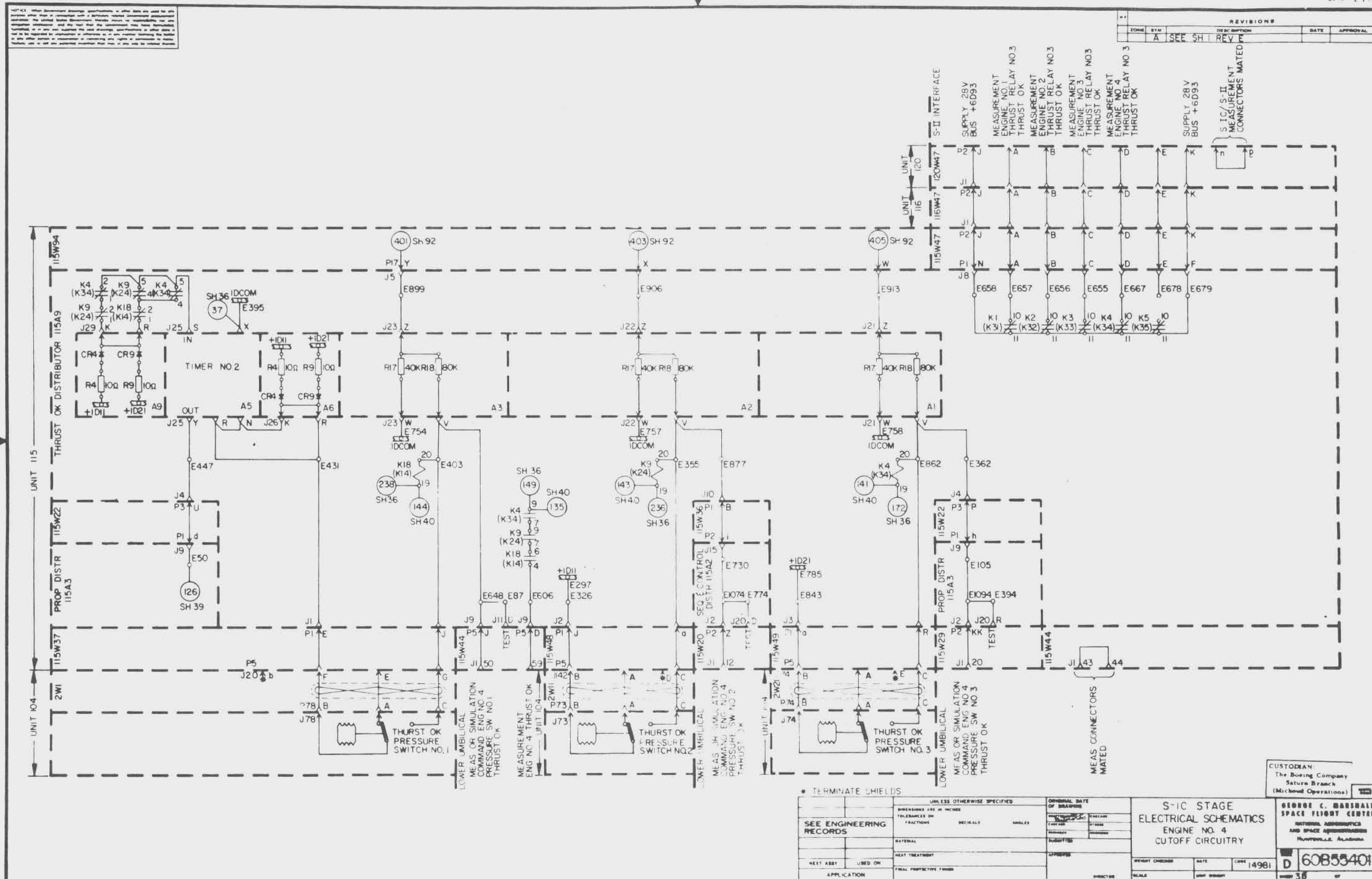
NEXT ASSY | USED ON
APPLICATION

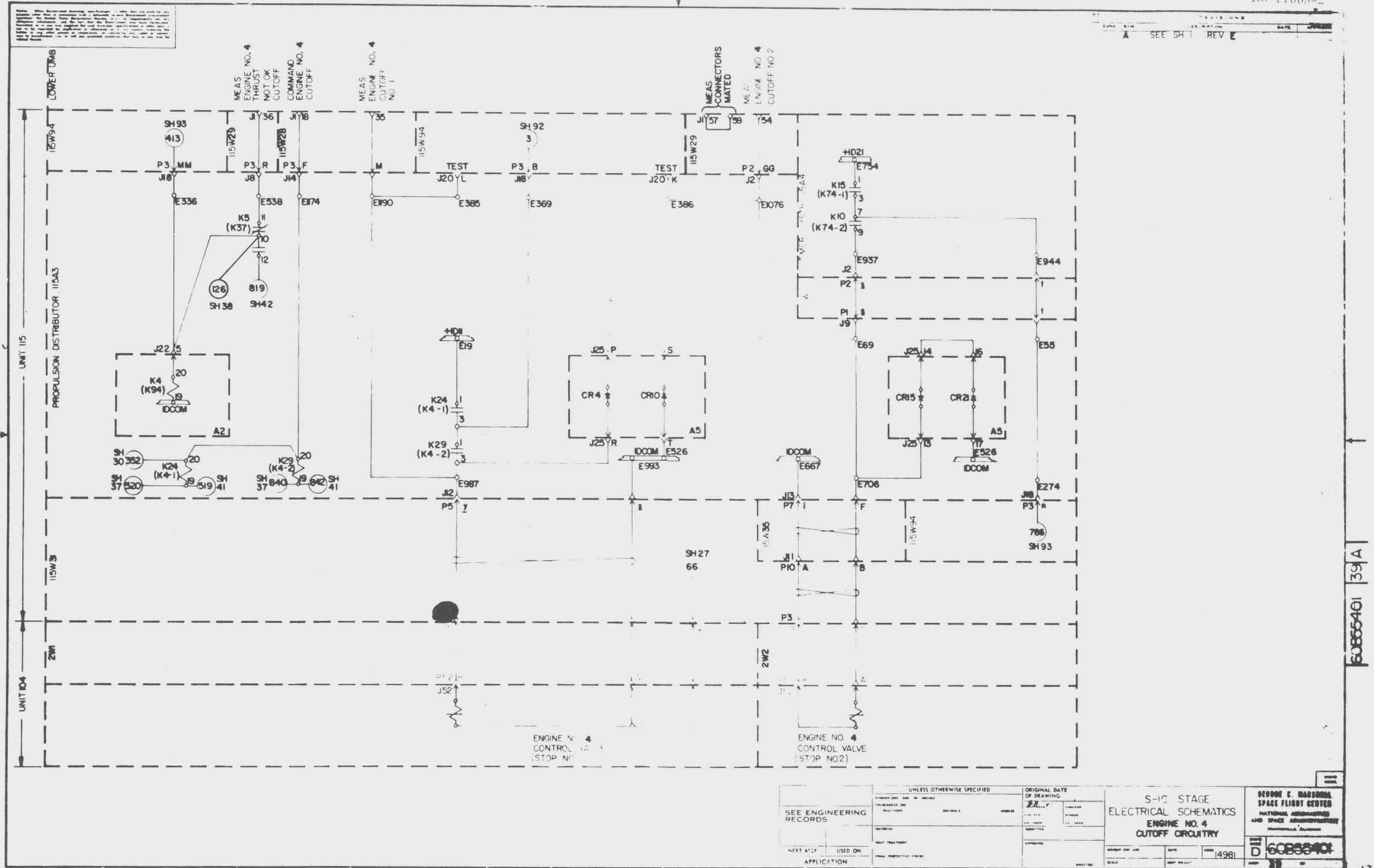
UNLESS OTHERWISE SPECIFIED

S-IC STAGE
ELECTRICAL SCHEMATICS
ENGINE NO.3
CUTOFF CIRCUITRY

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

D 14981 60B55401
37


REVISIONS
A SEE SH I REV E
S-II INTERFACE
SUPPLY 28V BUS +6D93
MEASUREMENT ENGINE NO 1 THRUST RELAY NO3 THRUST OK
MEASUREMENT ENGINE NO 2 THRUST RELAY NO3 THRUST OK
MEASUREMENT ENGINE NO3 THRUST RELAY NO3 THRUST OK
MEASUREMENT ENGINE NO 4 THRUST RELAY NO 3 THRUST OK
SUPPLY 28V BUS +6D93
S IC/S-II MEASUREMENT CONNECTORS MATED
UNIT 120
120W47
UNIT 116
116W47
115W47
115W94
THRUST OK DISTRIBUTOR 115A9
UNIT 115
TIMER NO 2
401 SH 92
403 SH 92
405 SH 92
A1
A2
A3
A5
A6
A9
115W22
PROP DISTR 115A3
115W37
2W1
UNIT 104
115W44
115W48
2W11
SEQ E CONTROL DISTR 115A2
115W36
115W20
115W49
2W20
115W29
THRUST OK PRESSURE SWITCH NO.1
THRUST OK PRESSURE SWITCH NO.2
THRUST OK PRESSURE SWITCH NO.3
LOWER UMBILICAL
MEAS OR SIMULATION COMMAND ENG NO 4 PRESSURE SW NO 1 THRUST OK
MEASUREMENT ENG NO 4 THRUST OK
MEAS OR SIMULATION COMMAND ENG NO 4 PRESSURE SW NO 2 THRUST OK
MEAS OR SIMULATION COMMAND ENG NO 4 PRESSURE SW NO 3 THRUST OK
MEAS CONNECTORS MATED
TEST
● TERMINATE SHIELDS
SEE ENGINEERING RECORDS
NEXT ASSY
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED
CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)
S-IC STAGE
ELECTRICAL SCHEMATICS
ENGINE NO. 4
CUTOFF CIRCUITRY
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA
14981
D 60B55401
SHEET 38
38 A


SEE SH 1 REV E
LOWER UMB
115W94
UNIT 115
PROPULSION DISTRIBUTOR 115A3
MEAS ENGINE NO. 4 THRUST NOT OK CUTOFF
COMMAND ENGINE NO. 4 CUTOFF
MEAS ENGINE NO. 4 CUTOFF NO. 1
MEAS CONNECTORS MATED
MEAS ENGINE NO. 4 CUTOFF NO. 2
115W29
115W28
TEST
SH 93
SH 92
SH 38
SH 42
+HD21
E754
K15 (K74-1)
K10 (K74-2)
E937
E944
K5 (K37)
+HD11
K24 (K4-1)
K29 (K4-2)
K4 (K94)
IDCOM
A2
A5
CR4
CR10
CR15
CR21
E993
E526
E667
E706
E987
E274
SH 93
115W31
115A35
SH 27
66
2W1
2W2
UNIT 104
ENGINE NO. 4 CONTROL VALVE (STOP NO. 1)
ENGINE NO. 4 CONTROL VALVE (STOP NO2)
SEE ENGINEERING RECORDS
NEXT ASSY
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED
ORIGINAL DATE OF DRAWING
S-IC STAGE
ELECTRICAL SCHEMATICS
ENGINE NO. 4
CUTOFF CIRCUITRY
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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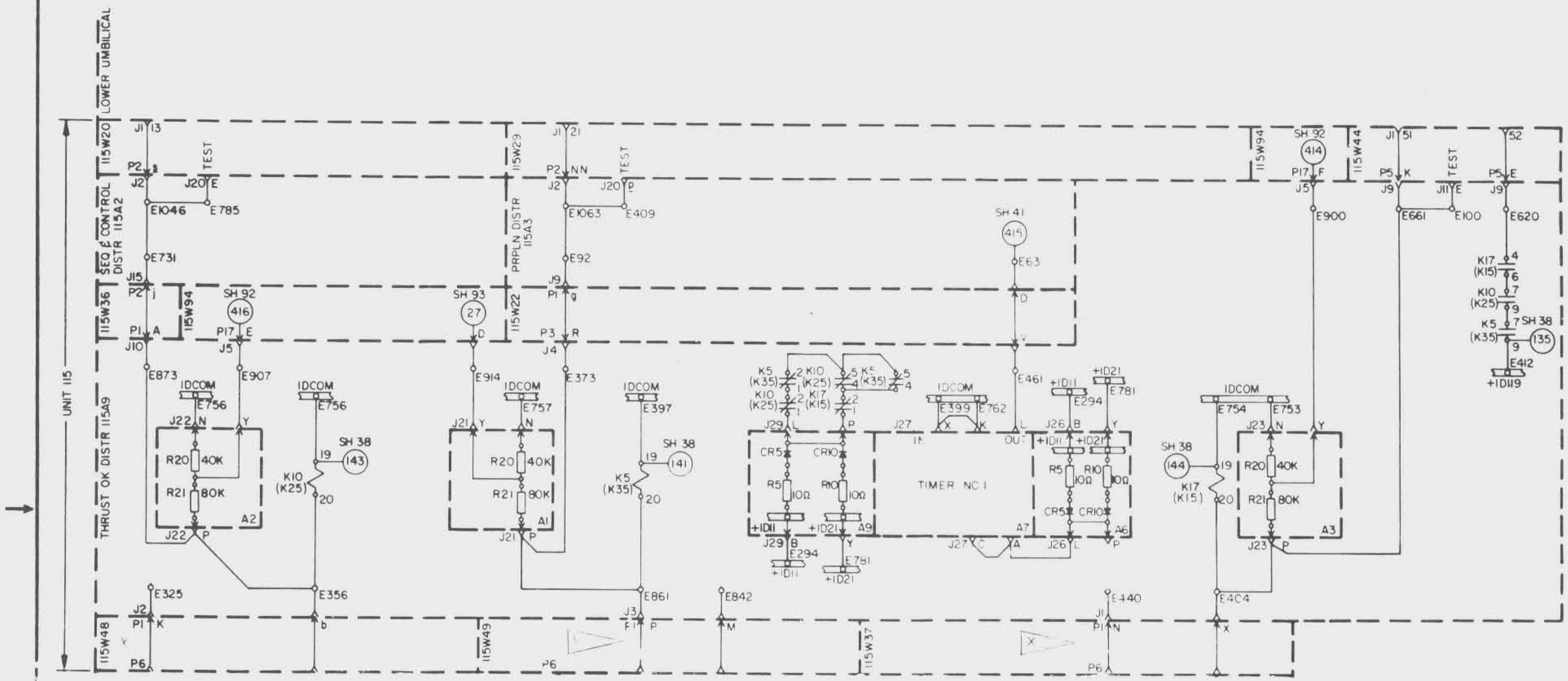
ZONE	SYM	DESCRIPTION	DATE	APPROVAL
	B	SEE SH I REV E		



* TERMINATE SHIELDS

SEE ENGINEERING RECORDS

NEXT ASSY | USED ON

APPLICATION

UNLESS OTHERWISE SPECIFIED

ORIGINAL DATE OF DRAWING

S-IC STAGE
ELECTRICAL SCHEMATICS
ENGINE NO 5
CUTOFF CIRCUITRY

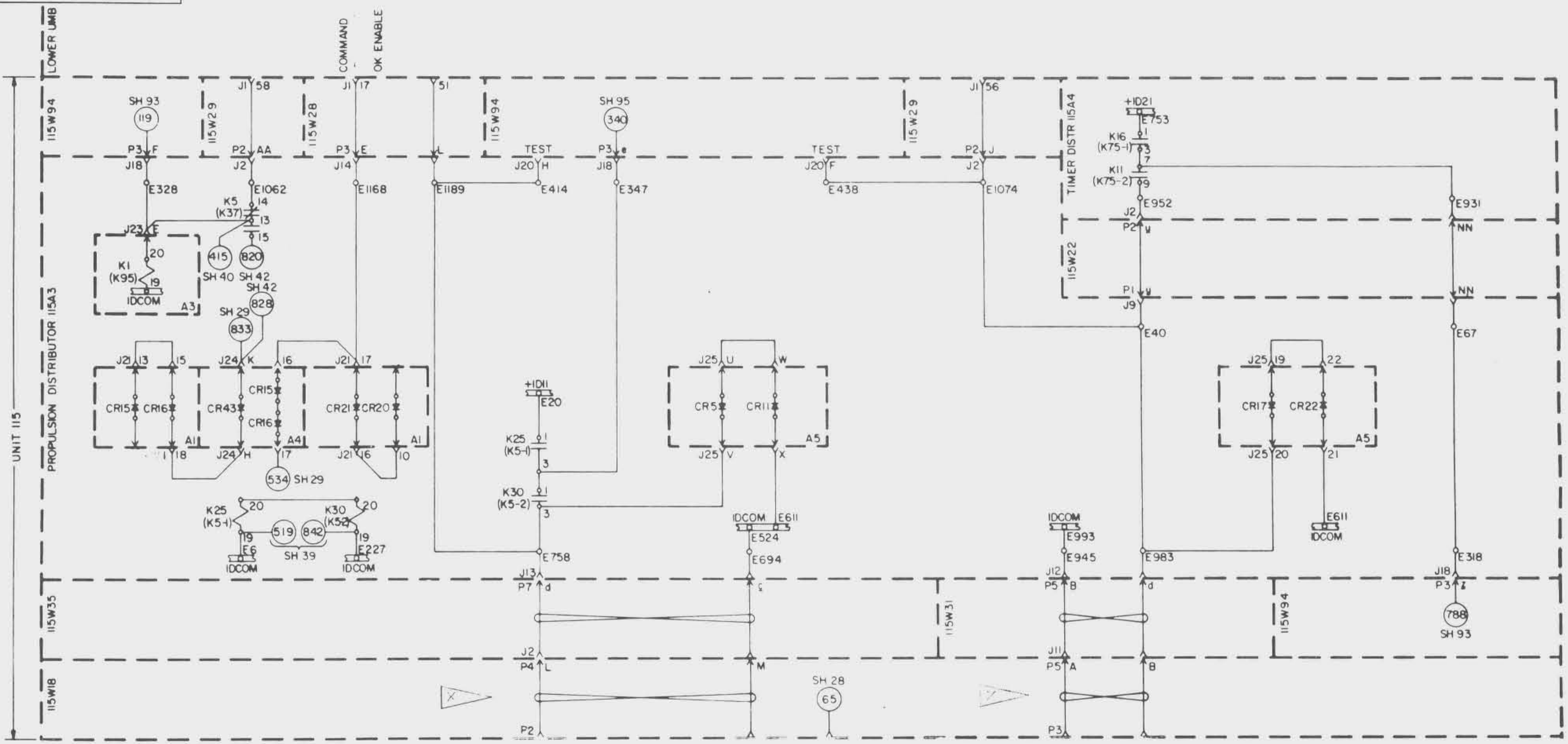
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

14981 D 60B55401

SHEET 40

60B55401 40 B

REVISIONS				
ZONE	SYM	DESCRIPTION	DATE	APPROVAL
	E	SEE SH I REV H		



UNLESS OTHERWISE SPECIFIED

SEE ENGINEERING RECORDS

NEXT ASSY | USED ON

APPLICATION

ORIGINAL DATE OF DRAWING

S-IC STAGE
ELECTRICAL SCHEMATICS
ENGINE NO 5
CUTOFF CIRCUITRY

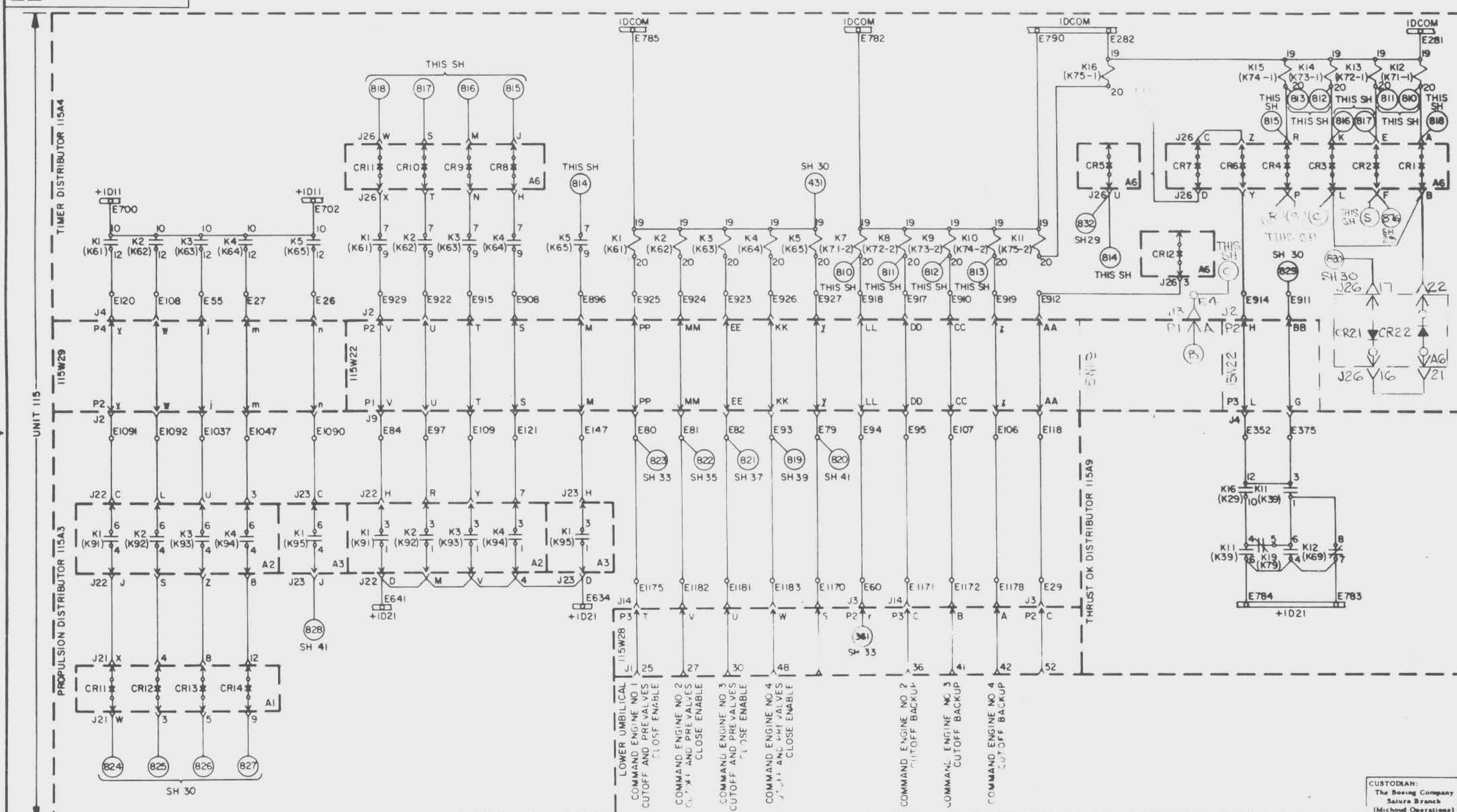
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

14981

D 60B55401

SHEET 41

REVISIONS				
ZONE	SYM	DESCRIPTION	DATE	APPROVAL
	D	SEE SH 1 REV H		



CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)

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ORIGINAL DATE OF DRAWING

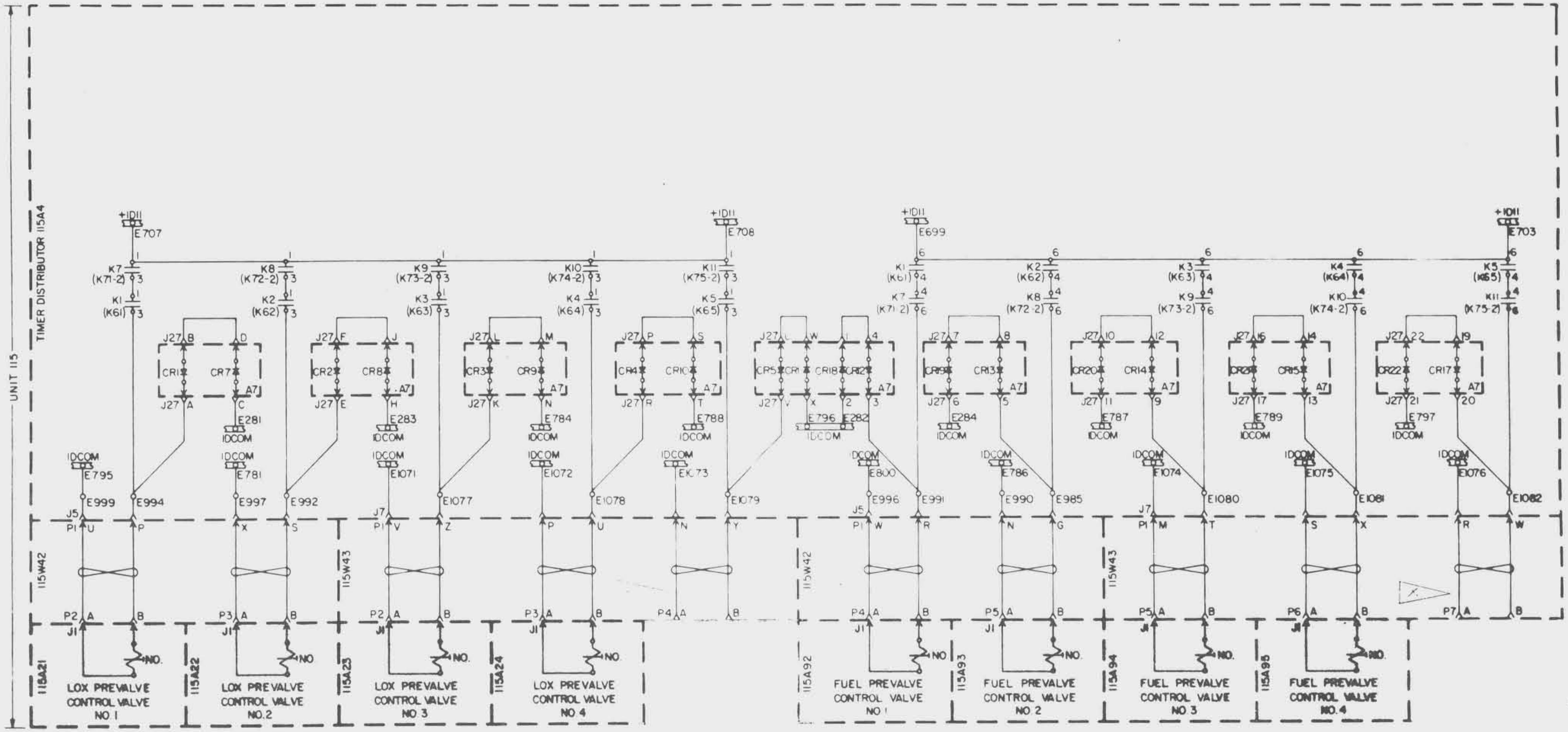
S-IC STAGE
ELECTRICAL SCHEMATICS
CUTOFF BACKUP CIRCUITRY

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

14981 | D | 60B55401

SHEET 42

ZONE	SYM	DESCRIPTION	DATE	APPROVAL
	A	SEE SH I REV E		



SEE ENGINEERING RECORDS	UNLESS OTHERWISE SPECIFIED
NEXT ASSY / USED ON	APPLICATION

S-IC STAGE
ELECTRICAL SCHEMATICS
LOX AND FUEL
PREVALVES

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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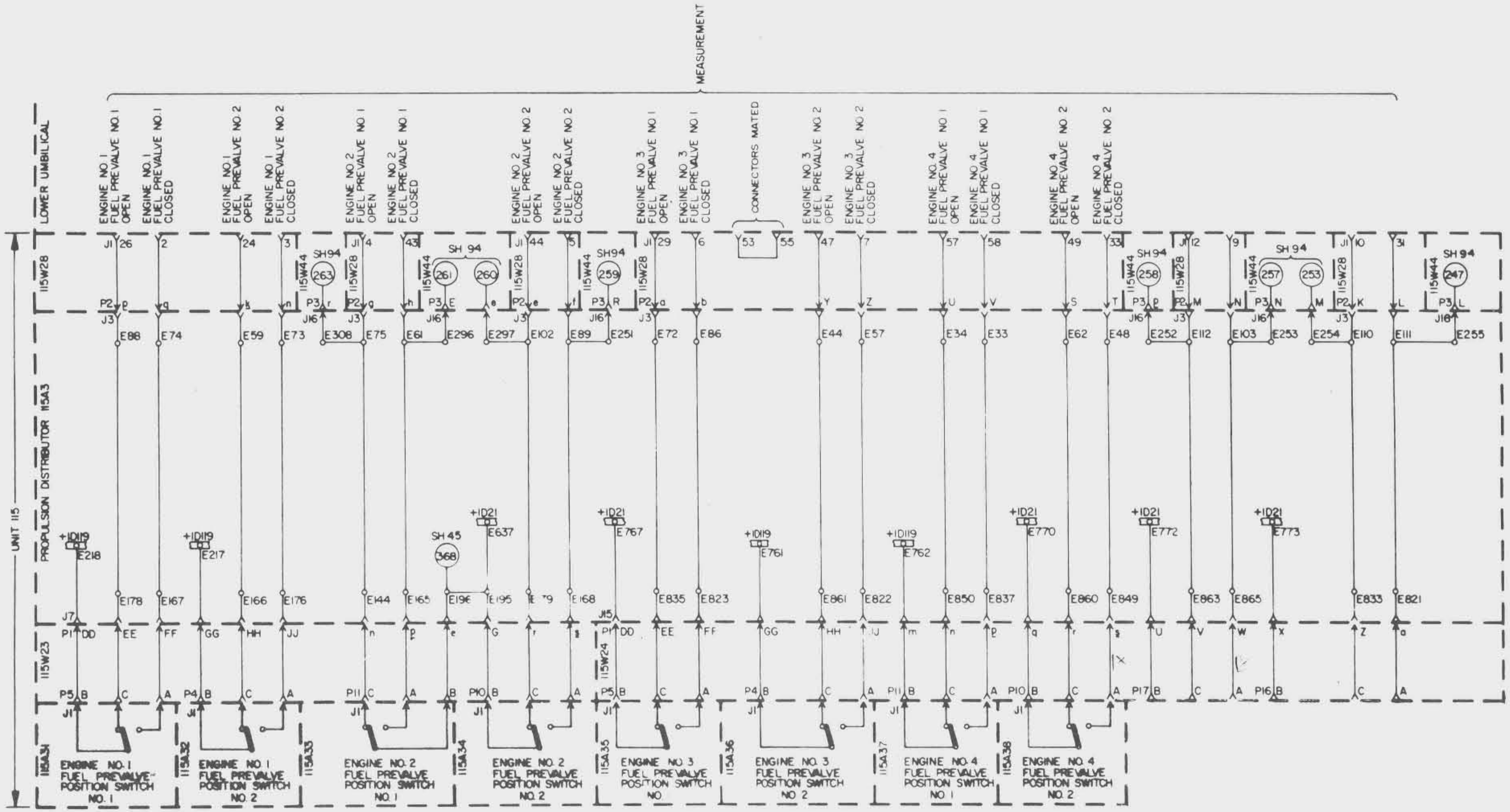
REVISIONS

ZONE	SYM	DESCRIPTION	DATE	APPROVAL



CUSTODIAN:
The Boeing Company
Saturn Branch
(Michoud Operations)

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APPLICATION

UNLESS OTHERWISE SPECIFIED

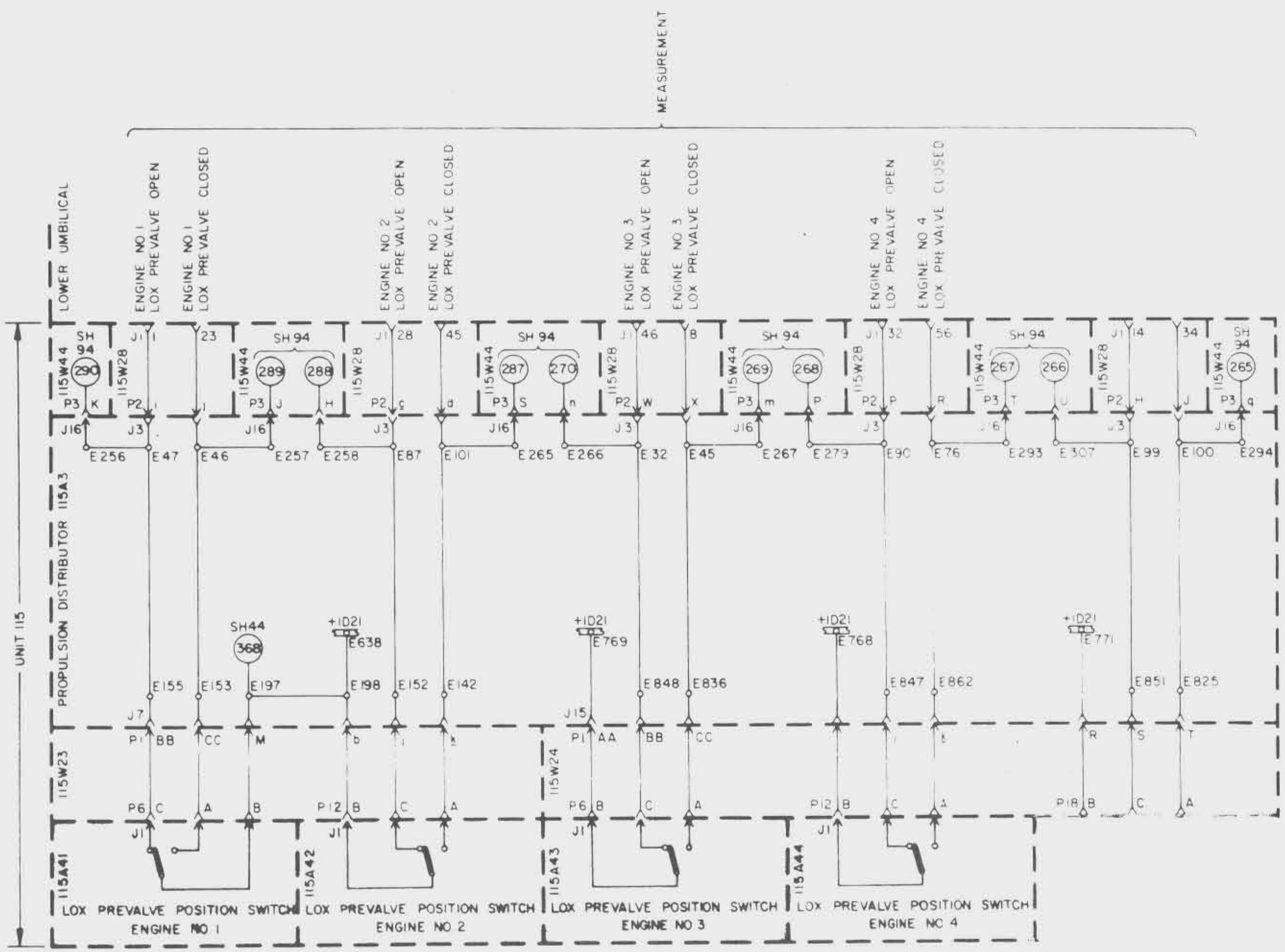
S-IC STAGE
ELECTRICAL SCHEMATICS
FUEL PREVALVE
POSITION INDICATION

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

D 14981 60B55401

44

60B55401 44



CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)

SEE ENGINEERING RECORDS

APPLICATION

UNLESS OTHERWISE SPECIFIED

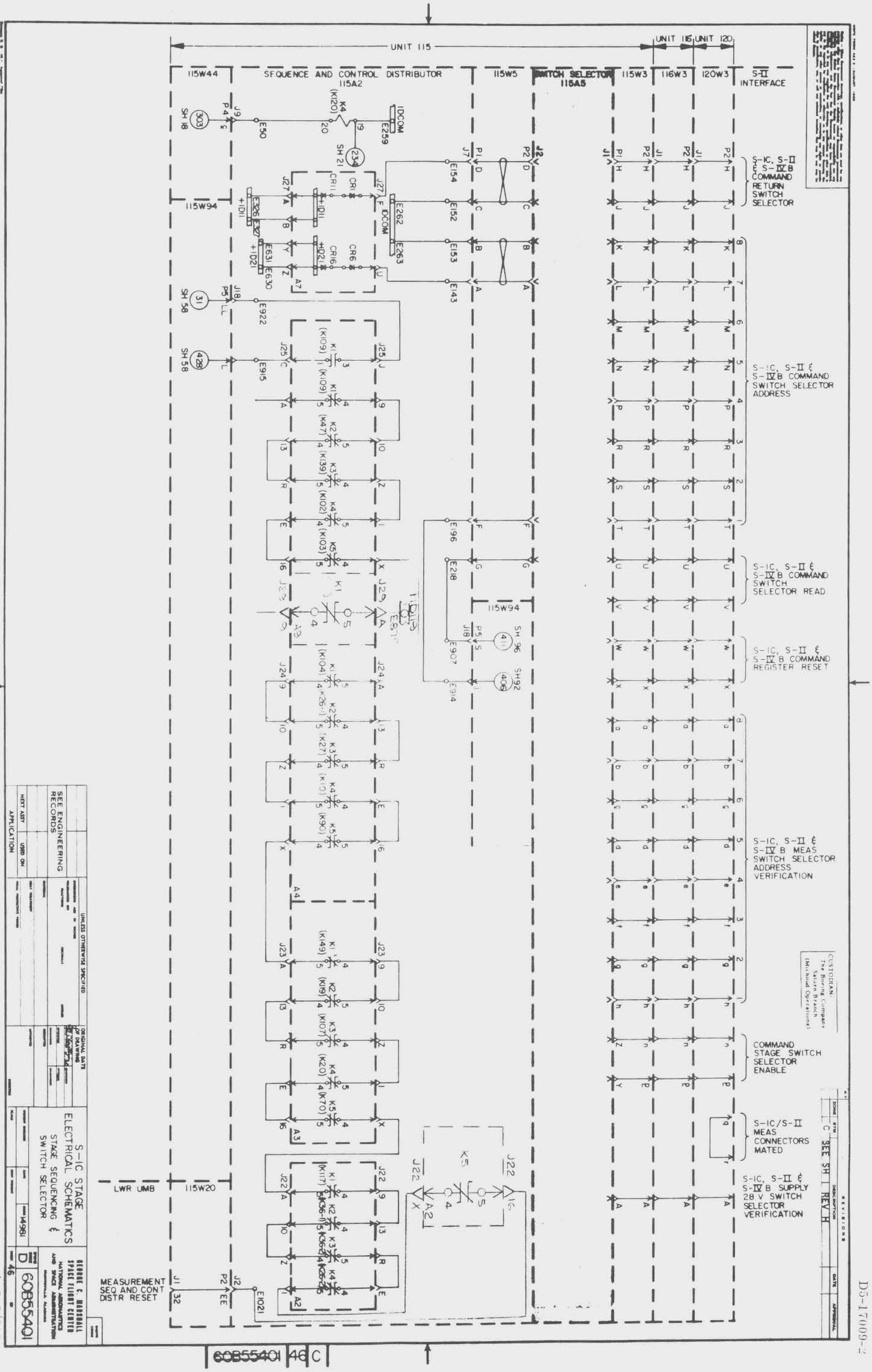
J.H.

S-IC STAGE
ELECTRICAL SCHEMATICS
LOX PREVALVE
POSITION INDICATION

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

14981 D 60B55401

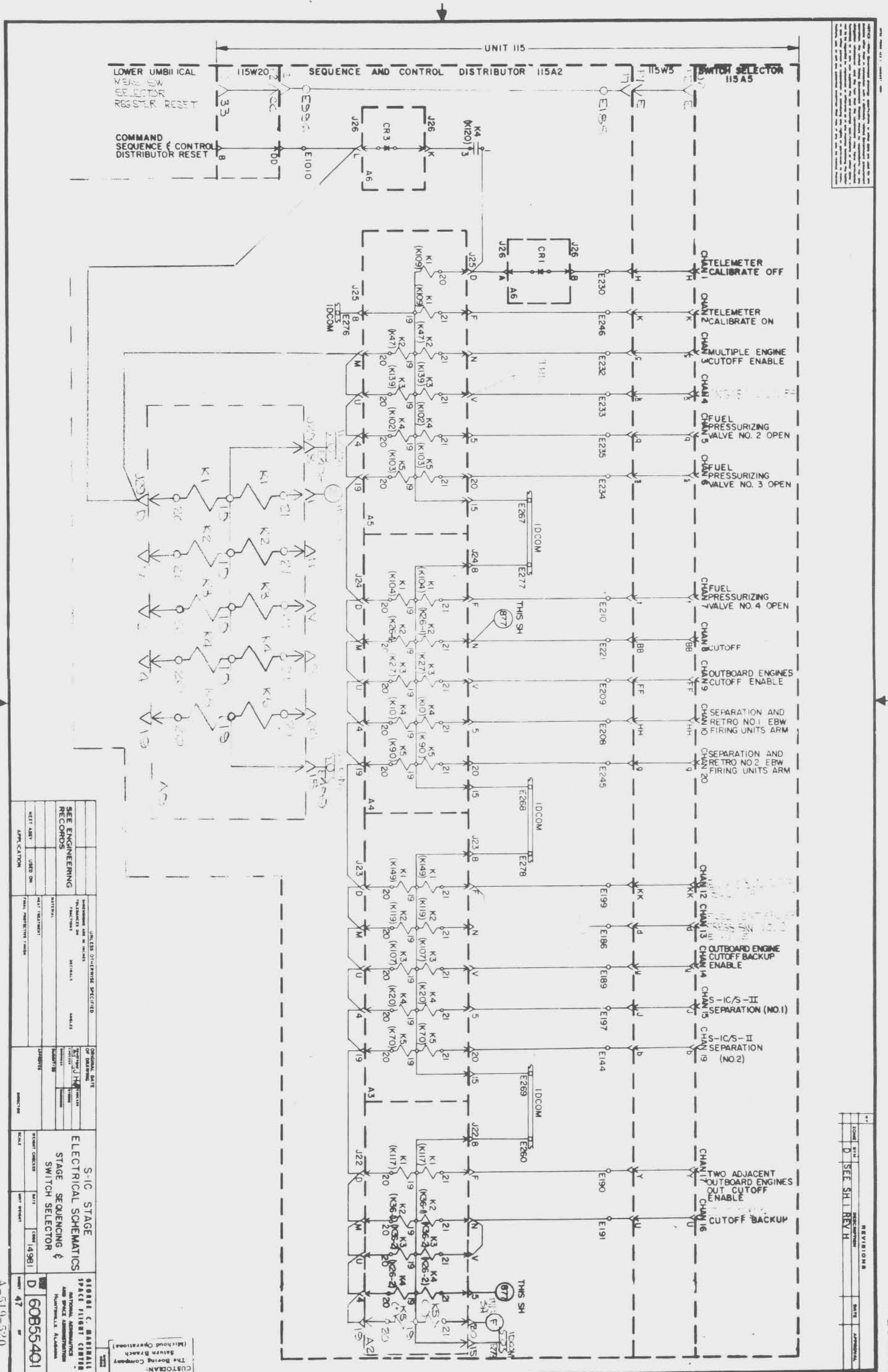
SHEET 45



60B55401 46 C

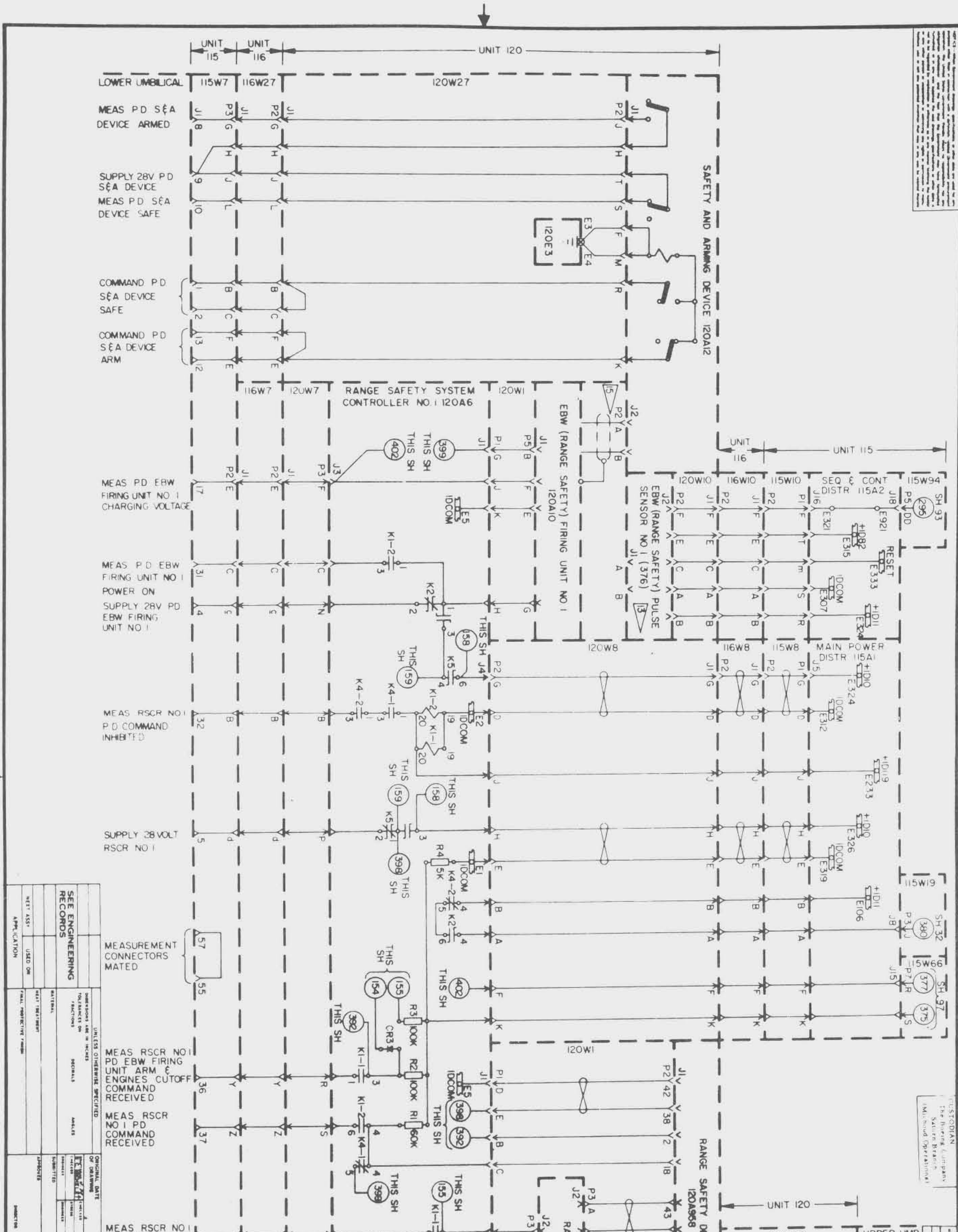
A-517/518

D5-17009-2



A-519-520

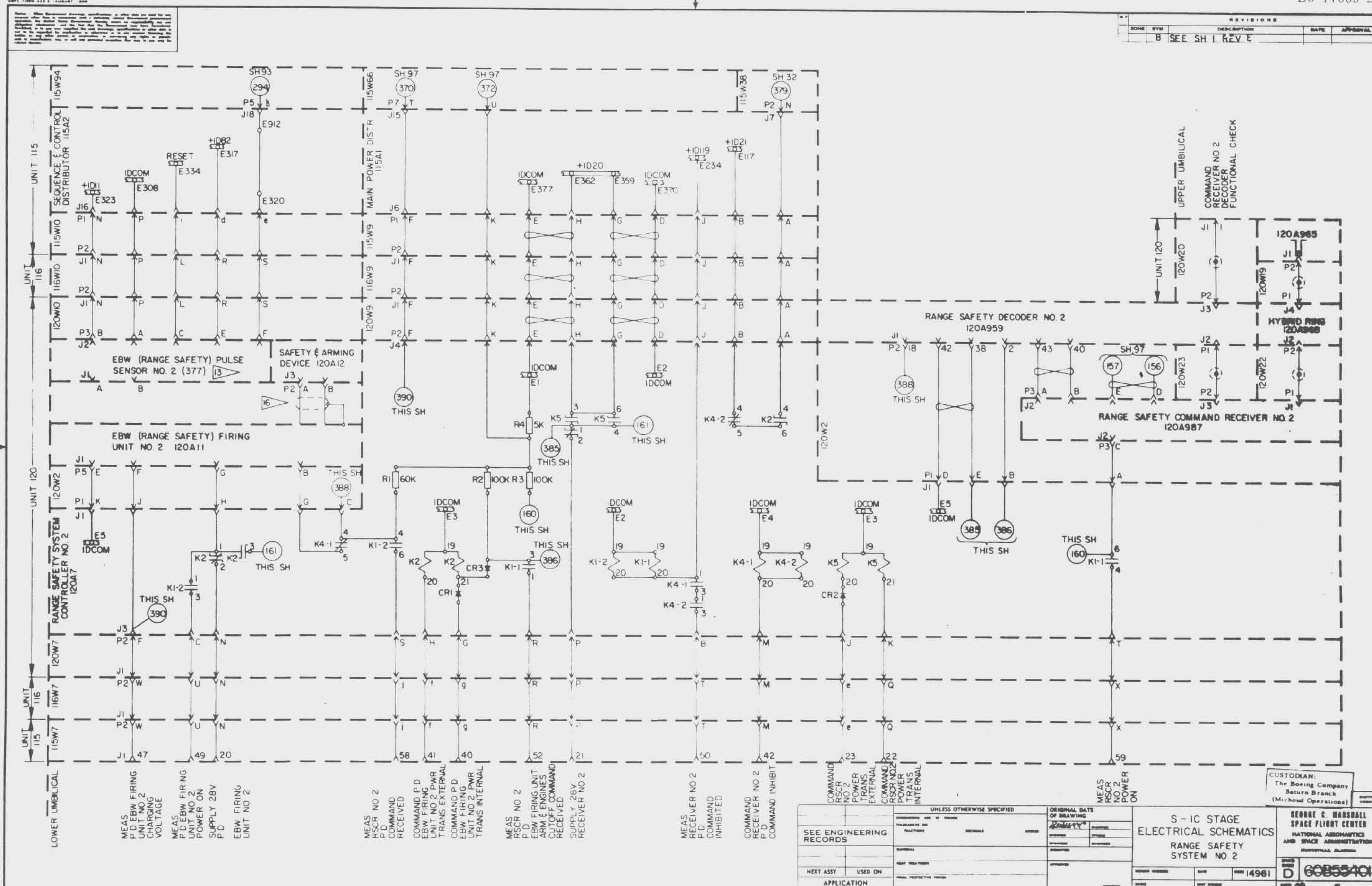
D5-17009-2



60B55401 48 B

A-521/522

D5-17009-2



CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)

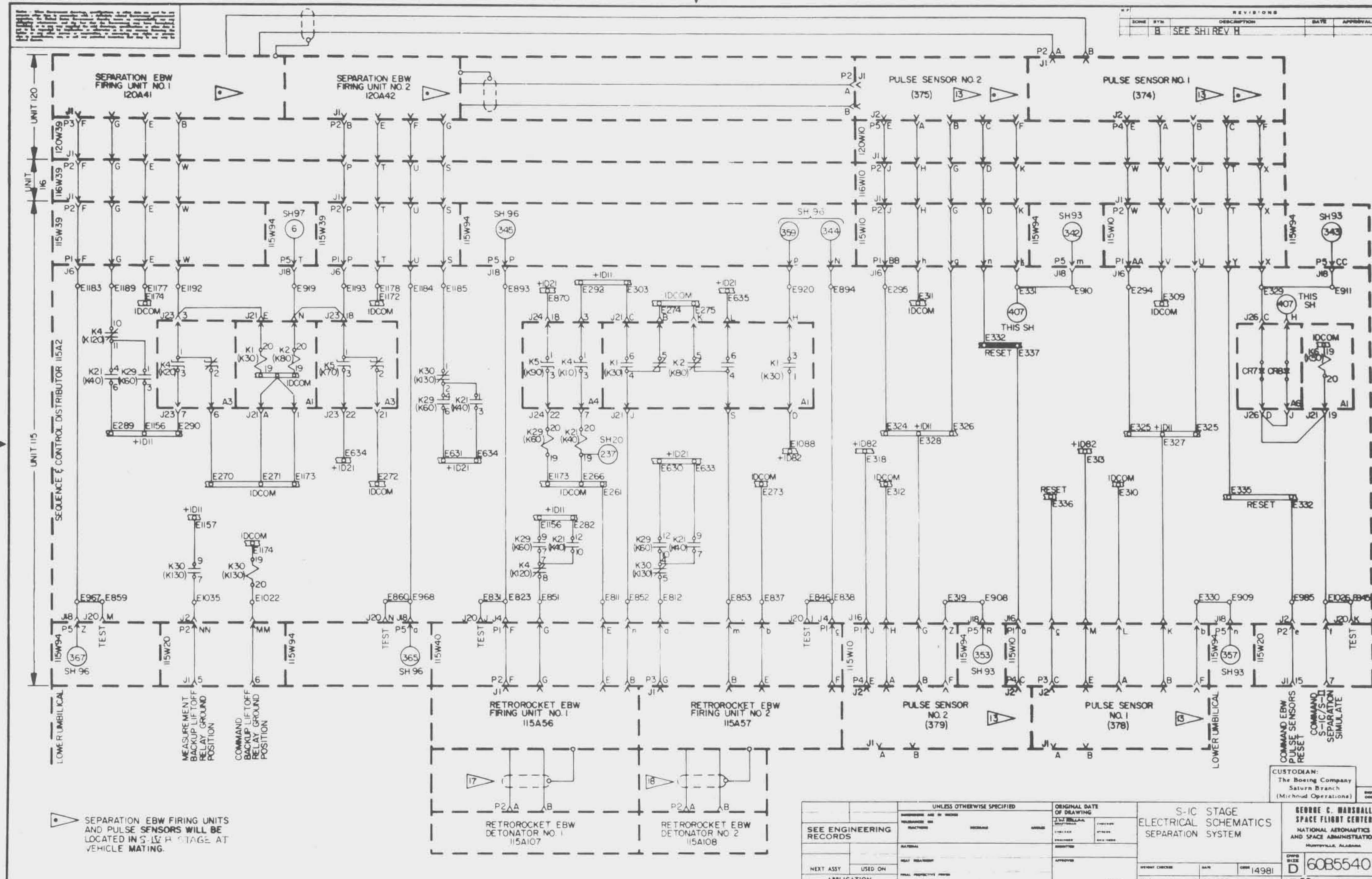
SEE ENGINEERING RECORDS

S-IC STAGE ELECTRICAL SCHEMATICS

RANGE SAFETY SYSTEM NO. 2

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

14981 D 60B55401


SEE SH1 REV H
SEPARATION EBW FIRING UNIT NO. 1 120A41
SEPARATION EBW FIRING UNIT NO. 2 120A42
PULSE SENSOR NO. 2 (375)
PULSE SENSOR NO. 1 (374)
UNIT 120
UNIT 116
UNIT 115
SEQUENCE & CONTROL DISTRIBUTOR 115A2
THIS SH
RESET
IDCOM
TEST
LOWER UMBILICAL
MEASUREMENT BACKUP LIFTOFF RELAY GROUND POSITION
COMMAND BACKUP LIFTOFF RELAY GROUND POSITION
RETROROCKET EBW FIRING UNIT NO. 1 115A56
RETROROCKET EBW FIRING UNIT NO. 2 115A57
PULSE SENSOR NO. 2 (379)
PULSE SENSOR NO. 1 (378)
COMMAND EBW PULSE SENSORS RESET
COMMAND S-IC/S-II SEPARATION SIMULATE
RETROROCKET EBW DETONATOR NO. 1 115A107
RETROROCKET EBW DETONATOR NO. 2 115A108
SEPARATION EBW FIRING UNITS AND PULSE SENSORS WILL BE LOCATED IN S-IV B STAGE AT VEHICLE MATING.
CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)
SEE ENGINEERING RECORDS
NEXT ASSY
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED
S-IC STAGE ELECTRICAL SCHEMATICS SEPARATION SYSTEM
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA
D 14981 60B55401
SHEET 50
60B55401 50 B

ZONE	SYM	DESCRIPTION	DATE	APPROVAL
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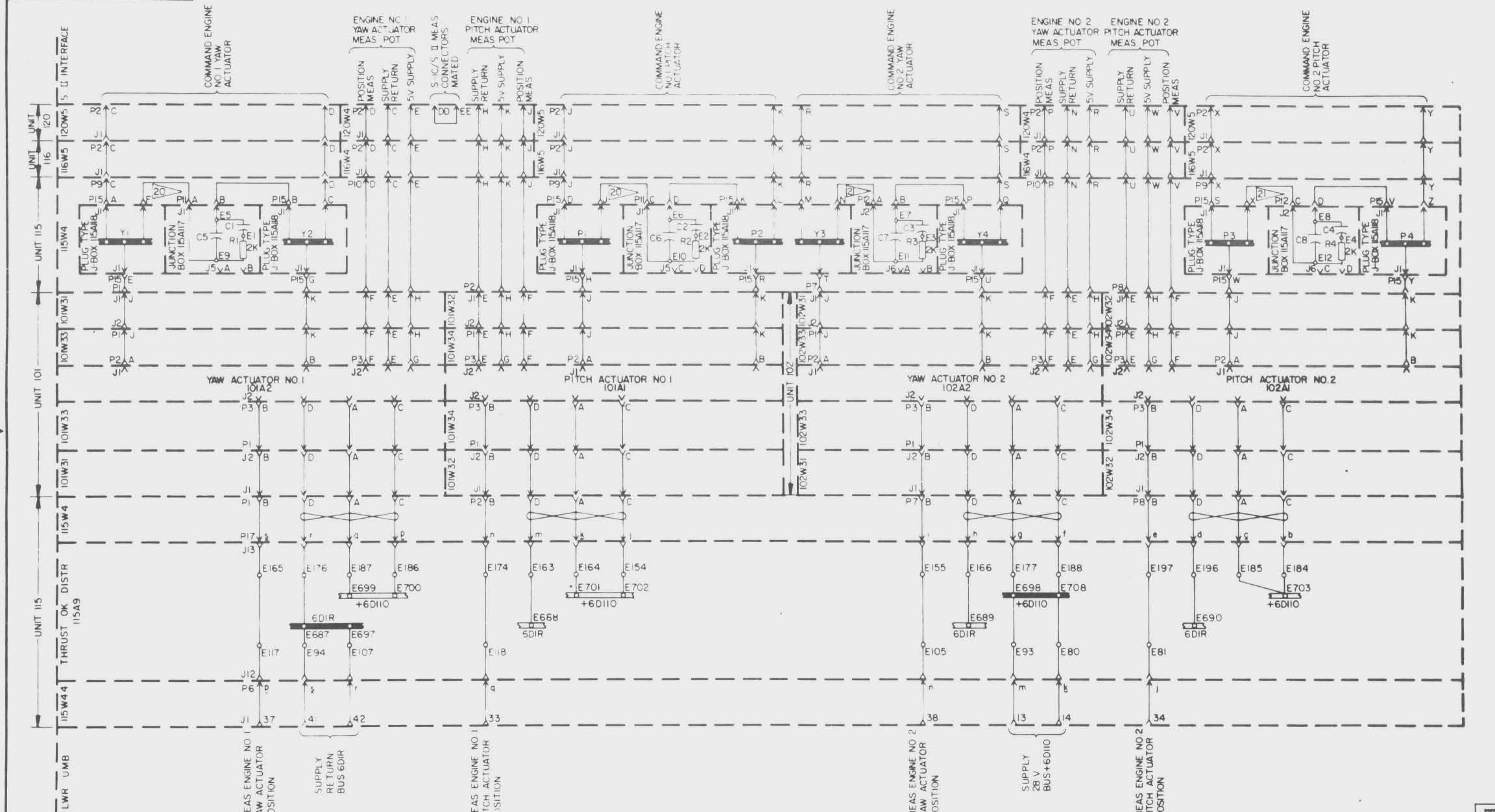

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APPLICATION

UNLESS OTHERWISE SPECIFIED

S-IC STAGE
ELECTRICAL SCHEMATICS
ENGINE ACTUATORS

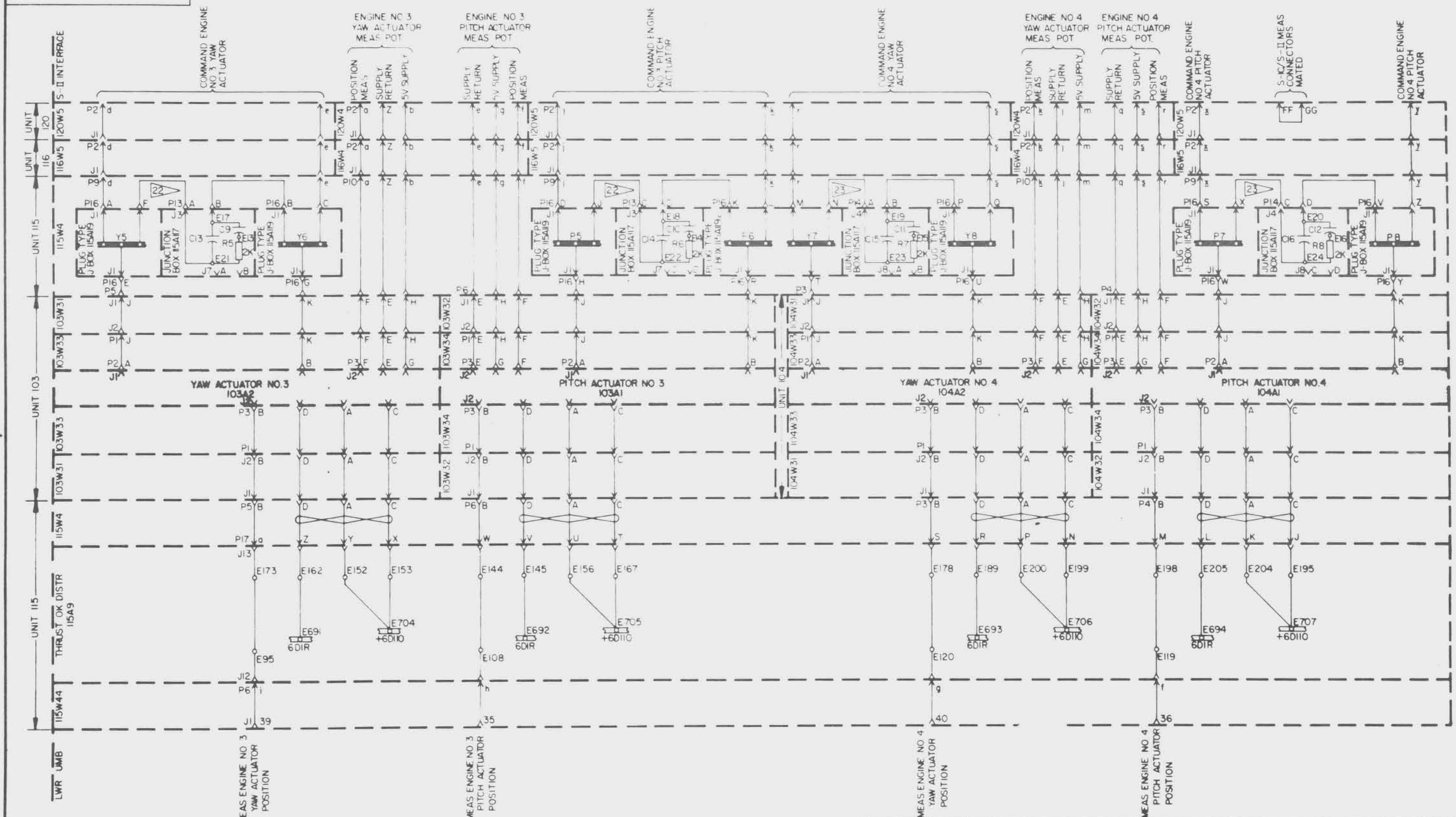
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

CODE 14981 | SIZE D | 60B55401 | SHEET 51

60B55401 | 51 | C

D5-17009-2

ZONE	SYM	DESCRIPTION	DATE	APPROVAL
F	A	SEE SH 1 REV C		



SEE ENGINEERING RECORDS	UNLESS OTHERWISE SPECIFIED	ORIGINAL DATE OF DRAWING
NEXT ASSY / USED ON		
APPLICATION		

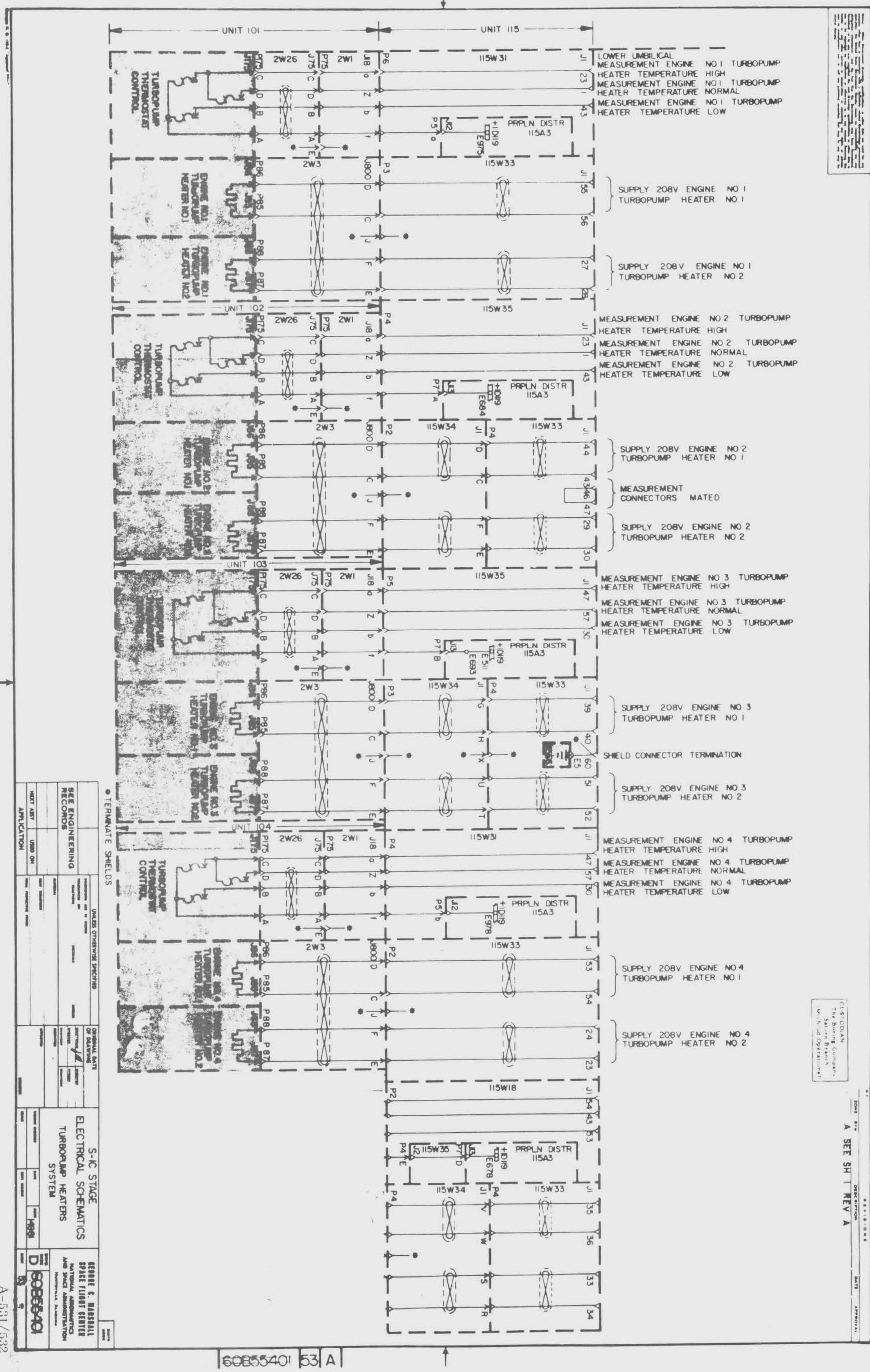
S-IC STAGE
ELECTRICAL SCHEMATICS
ENGINE ACTUATORS

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

14981 D 60B55401
SHEET 52

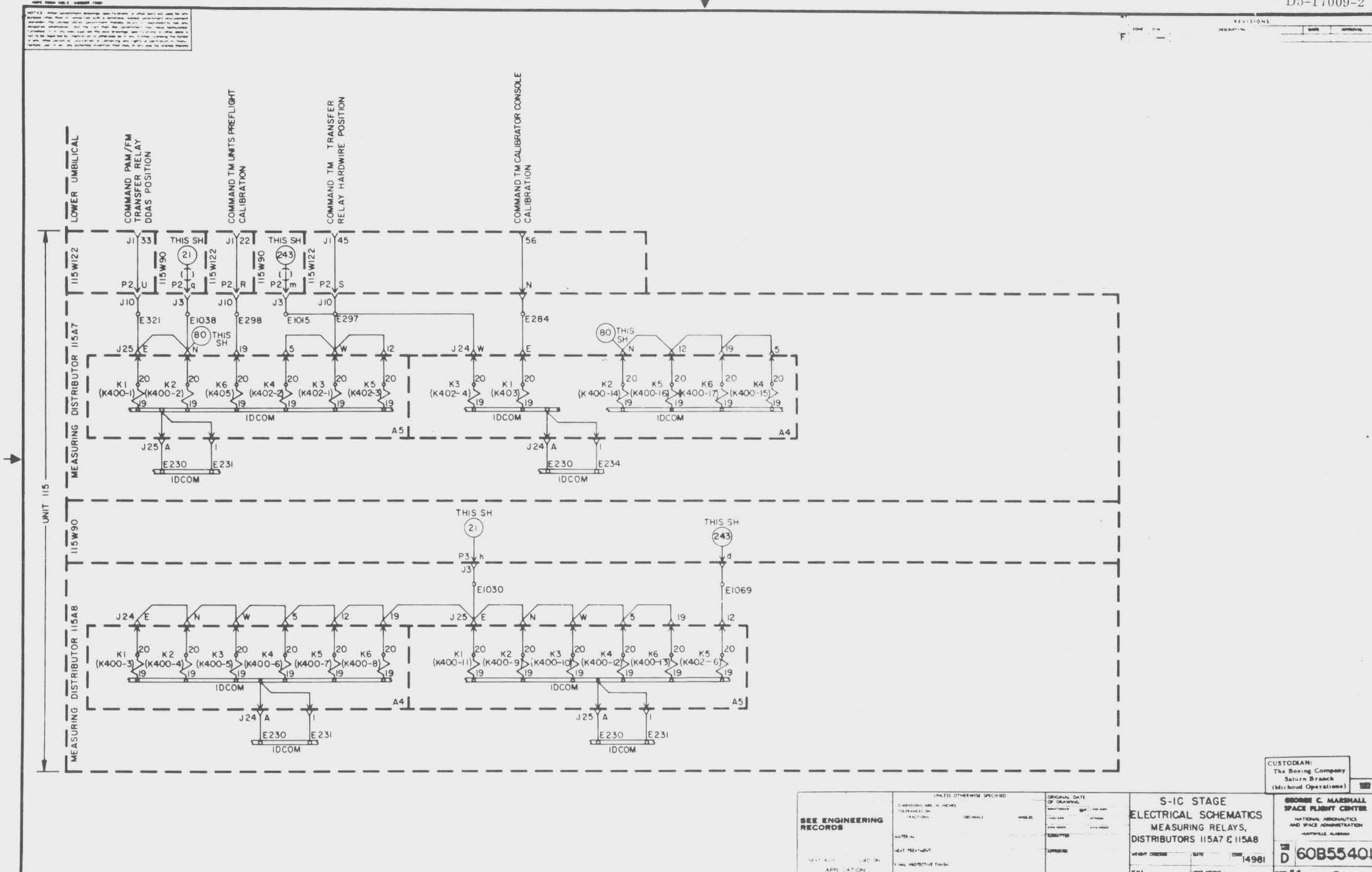
60B55401 52A

A-529/530



A-531/532

D5-17009-2


LOWER UMBILICAL
COMMAND PAM/FM TRANSFER RELAY DDAS POSITION
COMMAND TM UNITS PREFLIGHT CALIBRATION
COMMAND TM TRANSFER RELAY HARDWIRE POSITION
COMMAND TM CALIBRATOR CONSOLE CALIBRATION
115W122
115W90
MEASURING DISTRIBUTOR 115A7
MEASURING DISTRIBUTOR 115A8
UNIT 115
THIS SH
IDCOM
A4
A5
CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)
SEE ENGINEERING RECORDS
S-IC STAGE
ELECTRICAL SCHEMATICS
MEASURING RELAYS, DISTRIBUTORS 115A7 & 115A8
14981
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA
D 60B55401
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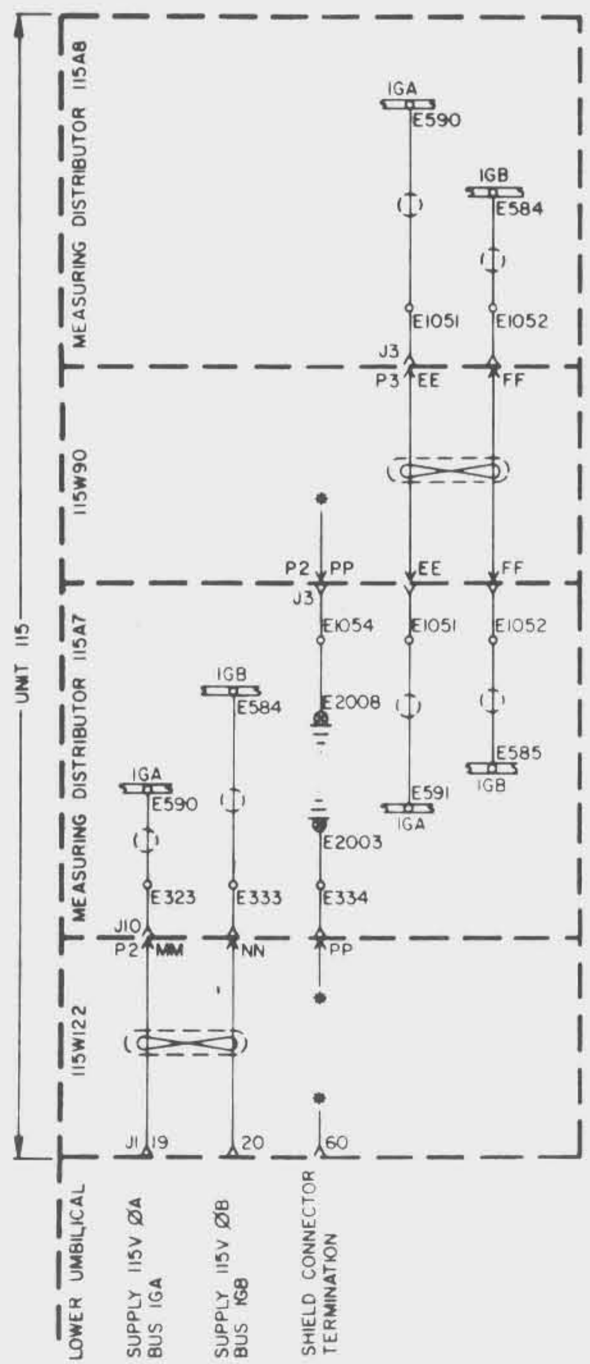
60B55401 54

REVISIONS				
ZONE	SYM	DESCRIPTION	DATE	APPROVAL



● TERMINATE SHIELDS

SEE ENGINEERING RECORDS

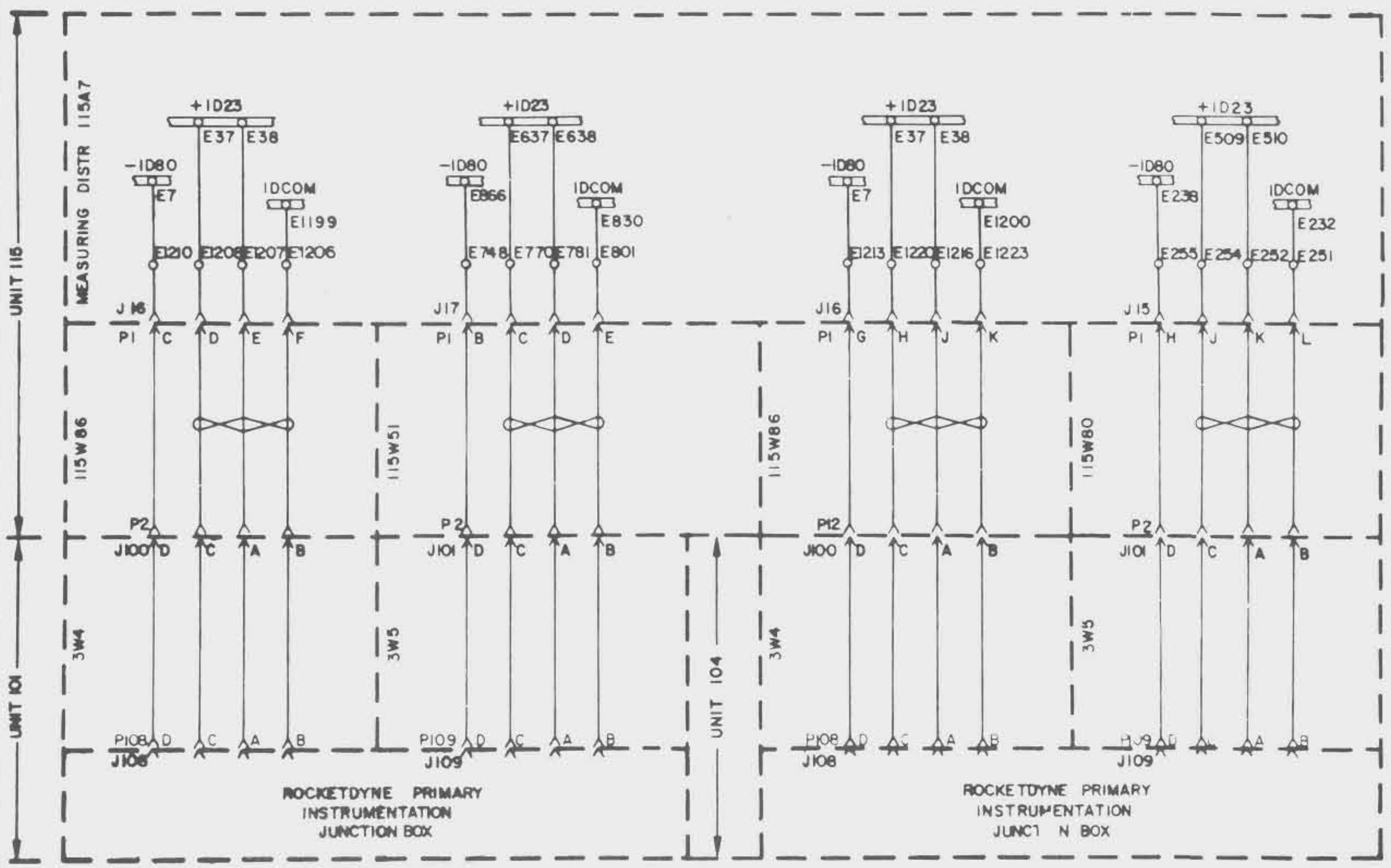
CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)

S-IC STAGE
ELECTRICAL SCHEMATICS
400 CYCLES
POWER DISTRIBUTION

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

CODE 14981 | D | 60B55401 | SHEET 55

60B55401 | 55 | 1



CUSTODIAN:
The Boeing Company
Saturn Branch
(Michoud Operations)

SEE ENGINEERING RECORDS

APPLICATION

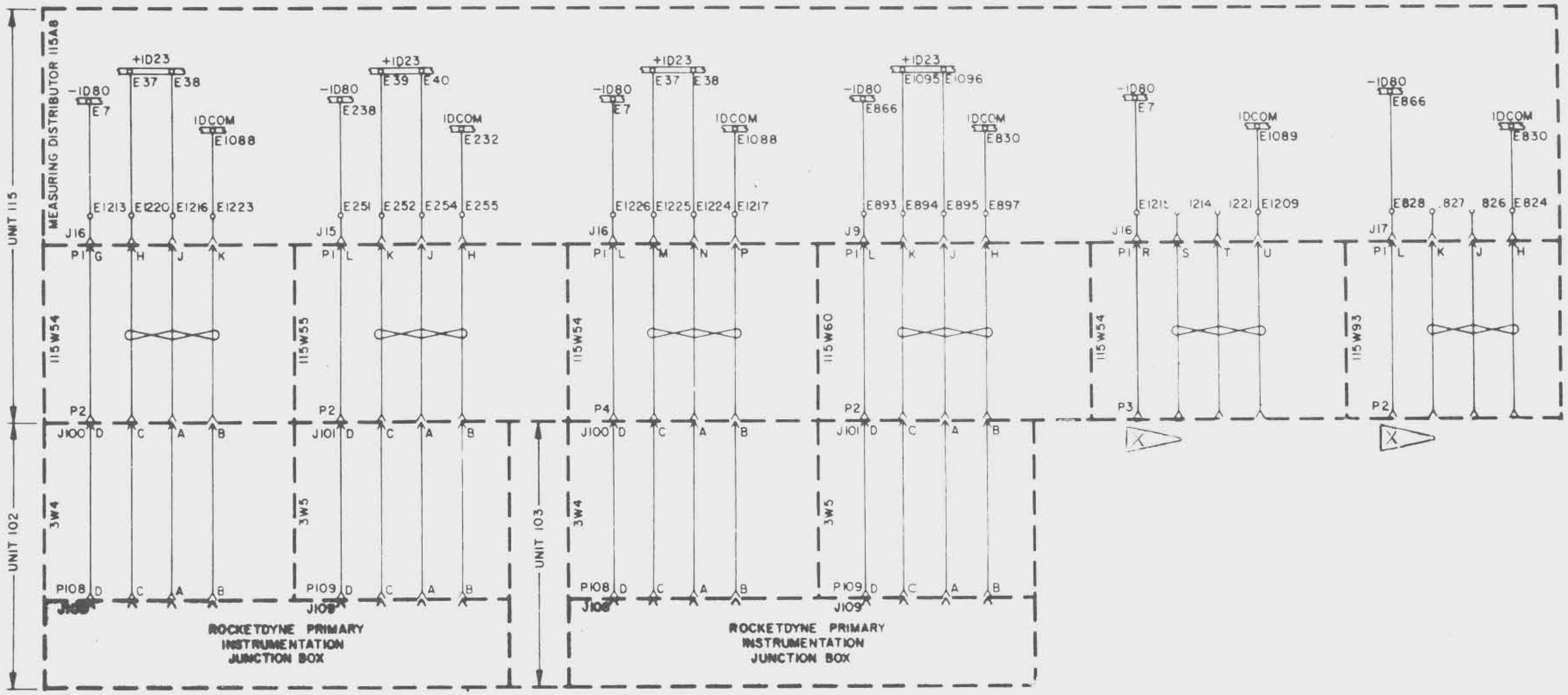
S-IC STAGE
ELECTRICAL SCHEMATICS
POWER DISTRIBUTION
ENGINE INSTRUMENTATION
JUNCTION BOX

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

14981 D 60B55401

SHEET 56

60B55401 56



REVISIONS

CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)

SEE ENGINEERING RECORDS

APPLICATION

UNLESS OTHERWISE SPECIFIED

S-IC STAGE ELECTRICAL SCHEMATICS

POWER DISTRIBUTION ENGINE INSTRUMENTATION JUNCTION BOX

GEORGE C. MARSHALL SPACE FLIGHT CENTER

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

HUNTSVILLE, ALABAMA

14981 D 60B55401

SHEET 57

60B55401 57 —

ZONE	SYM	REVISIONS DESCRIPTION	DATE	APPROVAL
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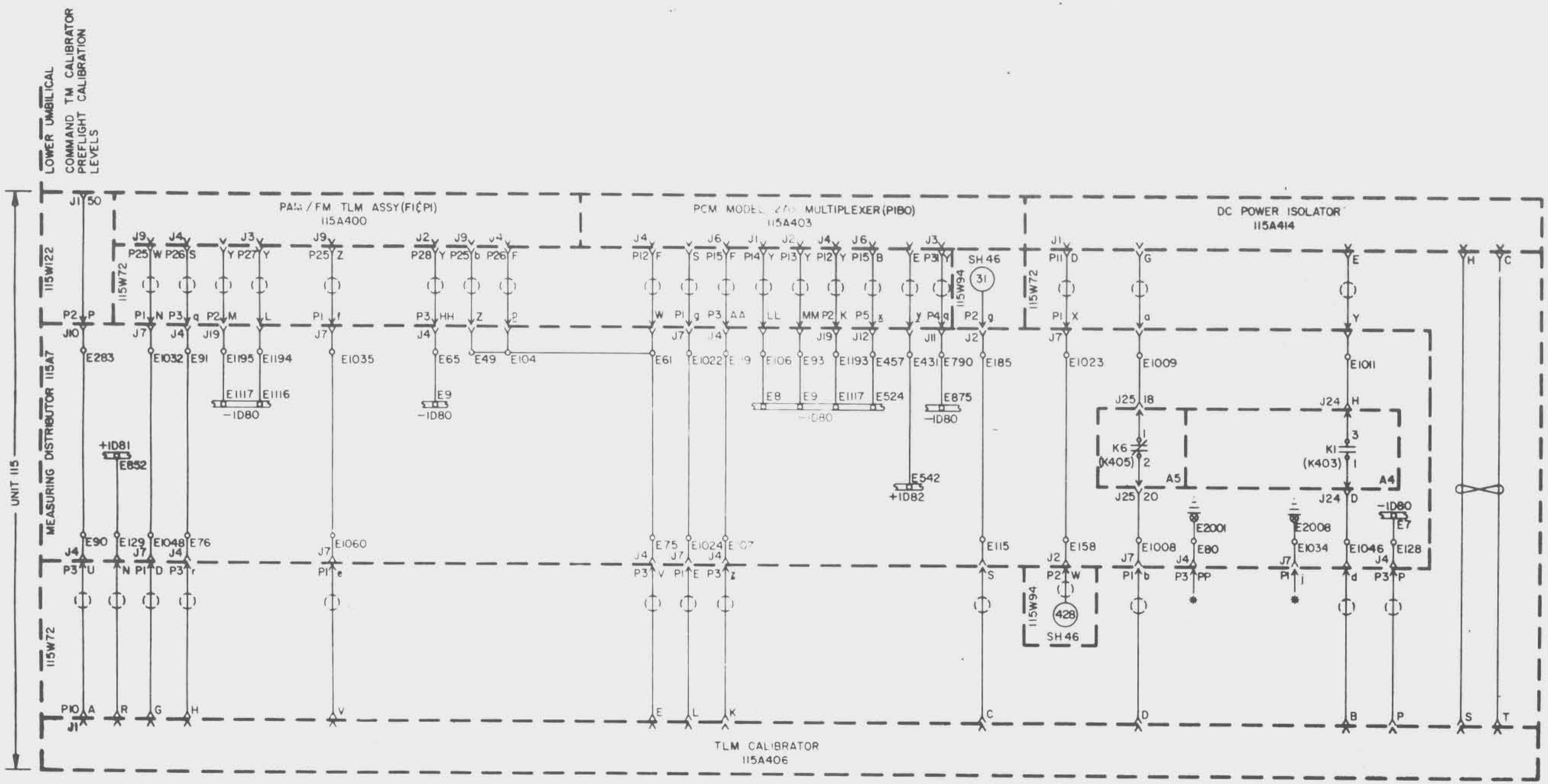


✱TERMINATE SHIELDS

SEE ENGINEERING RECORDS	UNLESS OTHERWISE SPECIFIED
NEXT ASSY / USED ON	APPLICATION

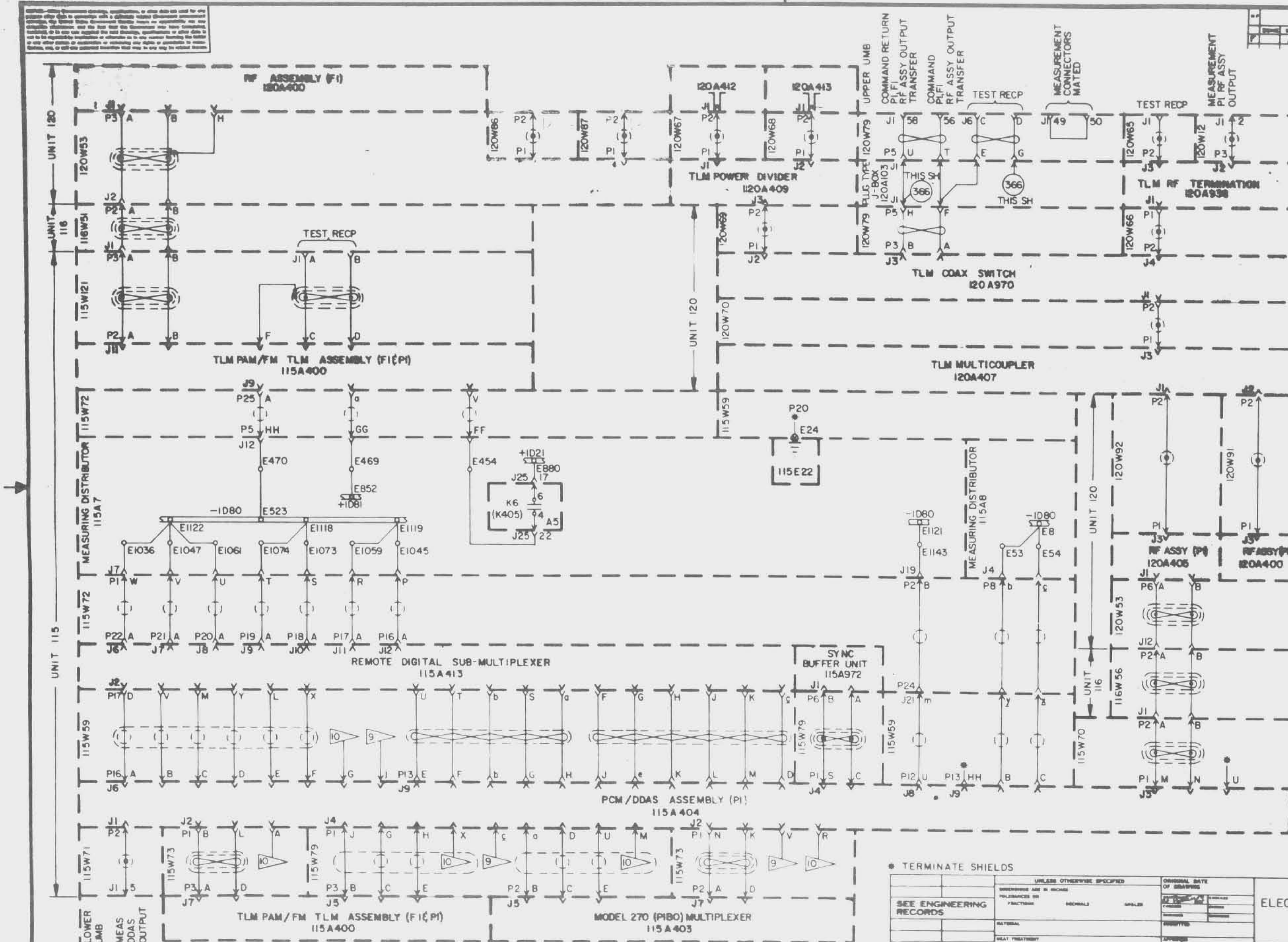
S-IC STAGE
ELECTRICAL SCHEMATICS
TLM CALIBRATOR

CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

CODE 14981 D 60B55401 SHEET 58

60B55401 58 A



● TERMINATE SHIELDS

SEE ENGINEERING RECORDS	UNLESS OTHERWISE SPECIFIED
NEXT ASSY / USED ON	APPLICATION

REVISIONS: A — SEE SH — REV D

CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)

S-IC STAGE ELECTRICAL SCHEMATICS

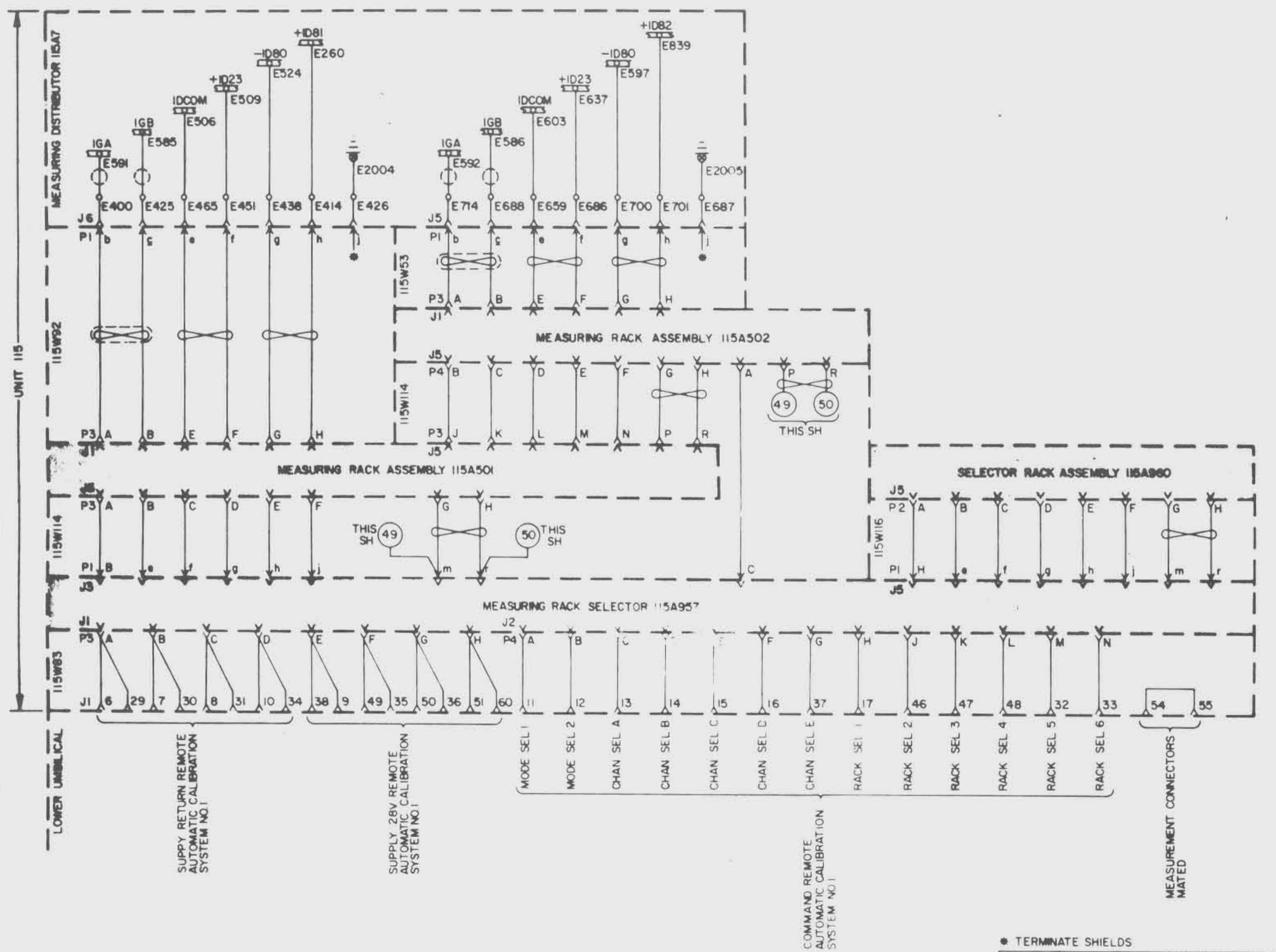
TELEMETERS F1, P1

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

D 14981 60B55401

SHEET 59

60B55401 59 A



● TERMINATE SHIELDS

SEE ENGINEERING RECORDS

NEXT ASSY | USED ON

APPLICATION

CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)

S-IC STAGE
ELECTRICAL SCHEMATICS
MEASURING RACK ASSEMBLIES, POWER & CALIBRATE DISTR
115A7

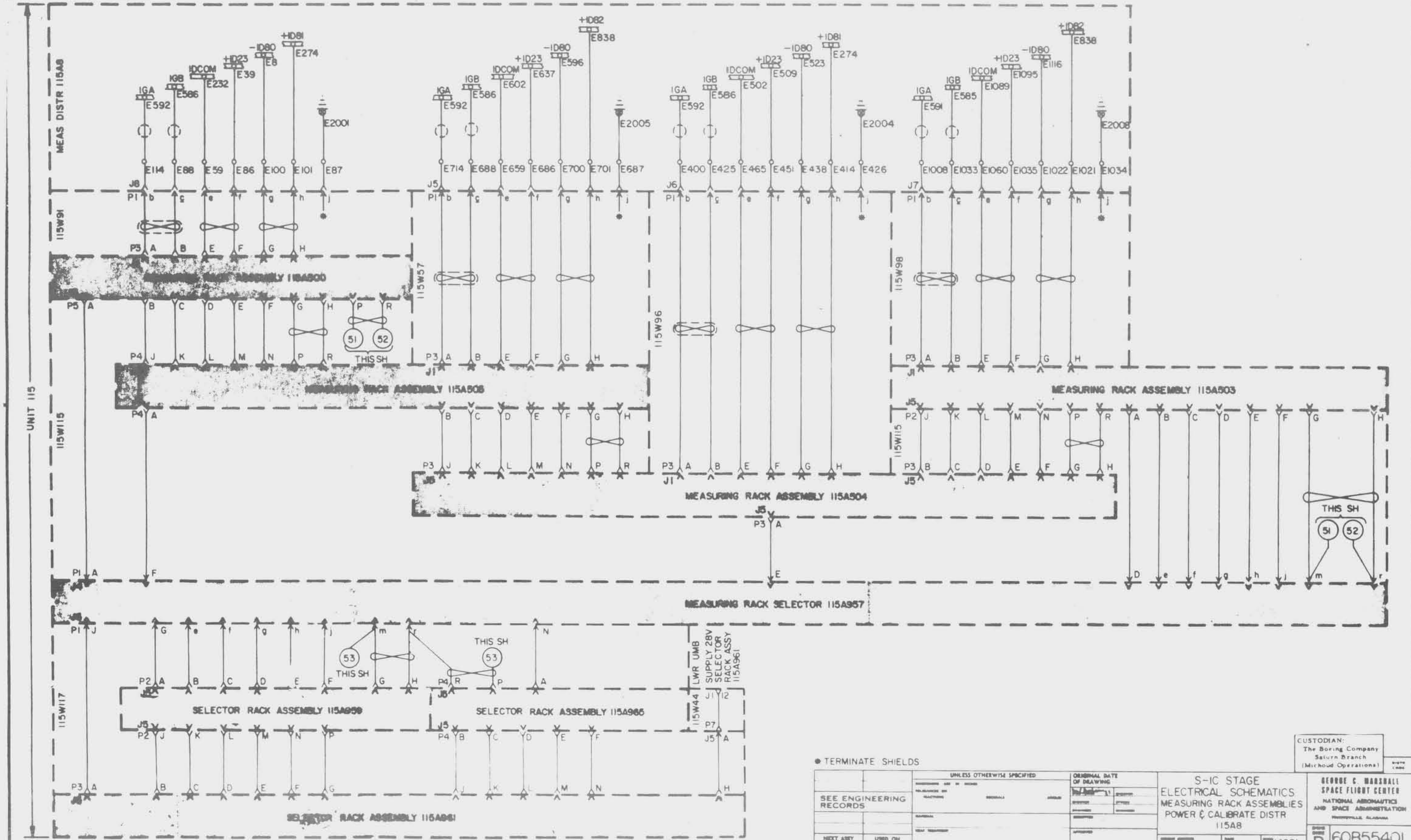
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

14981 D 60B55401

60B55401 60

D5-17009-2

ZONE	SYM	REVISIONS DESCRIPTION	DATE	APPROVAL
F	A	SEE SH I REV D		



SEE ENGINEERING RECORDS	UNLESS OTHERWISE SPECIFIED
NEXT ASSY / USED ON	APPLICATION

CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)

S-IC STAGE
ELECTRICAL SCHEMATICS
MEASURING RACK ASSEMBLIES
POWER & CALIBRATE DISTR
115A8

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

14981 D 60B55401
SHEET 61

60B55401 61 A

V-547 548

REVISIONS				
ZONE	SYM	DESCRIPTION	DATE	APPROVAL
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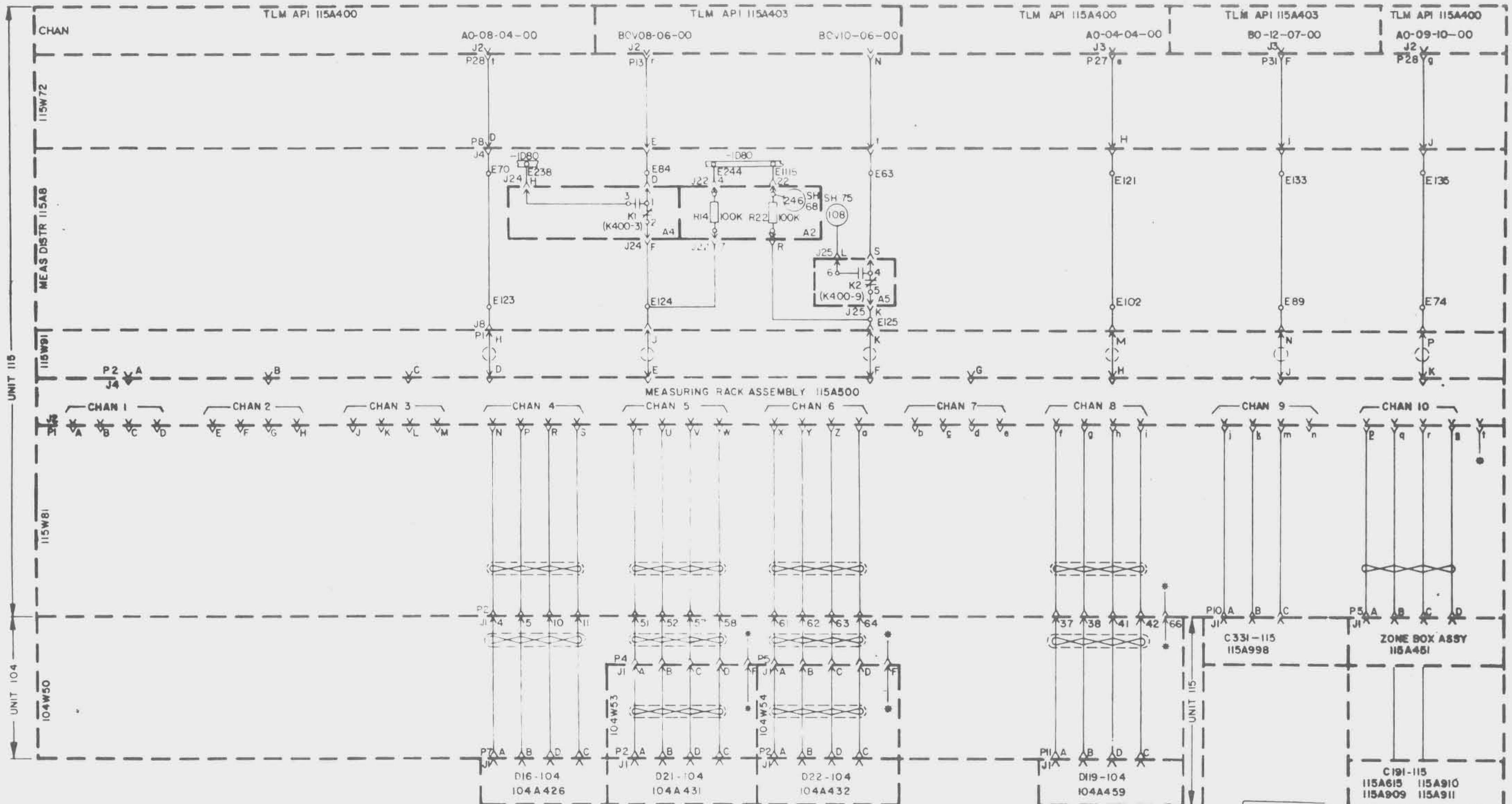


CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)

● TERMINATE SHIELDS

SEE ENGINEERING RECORDS

S-IC STAGE
ELECTRICAL SCHEMATICS
MEASURING RACK ASSEMBLY
115A500
CHANNELS 1-10

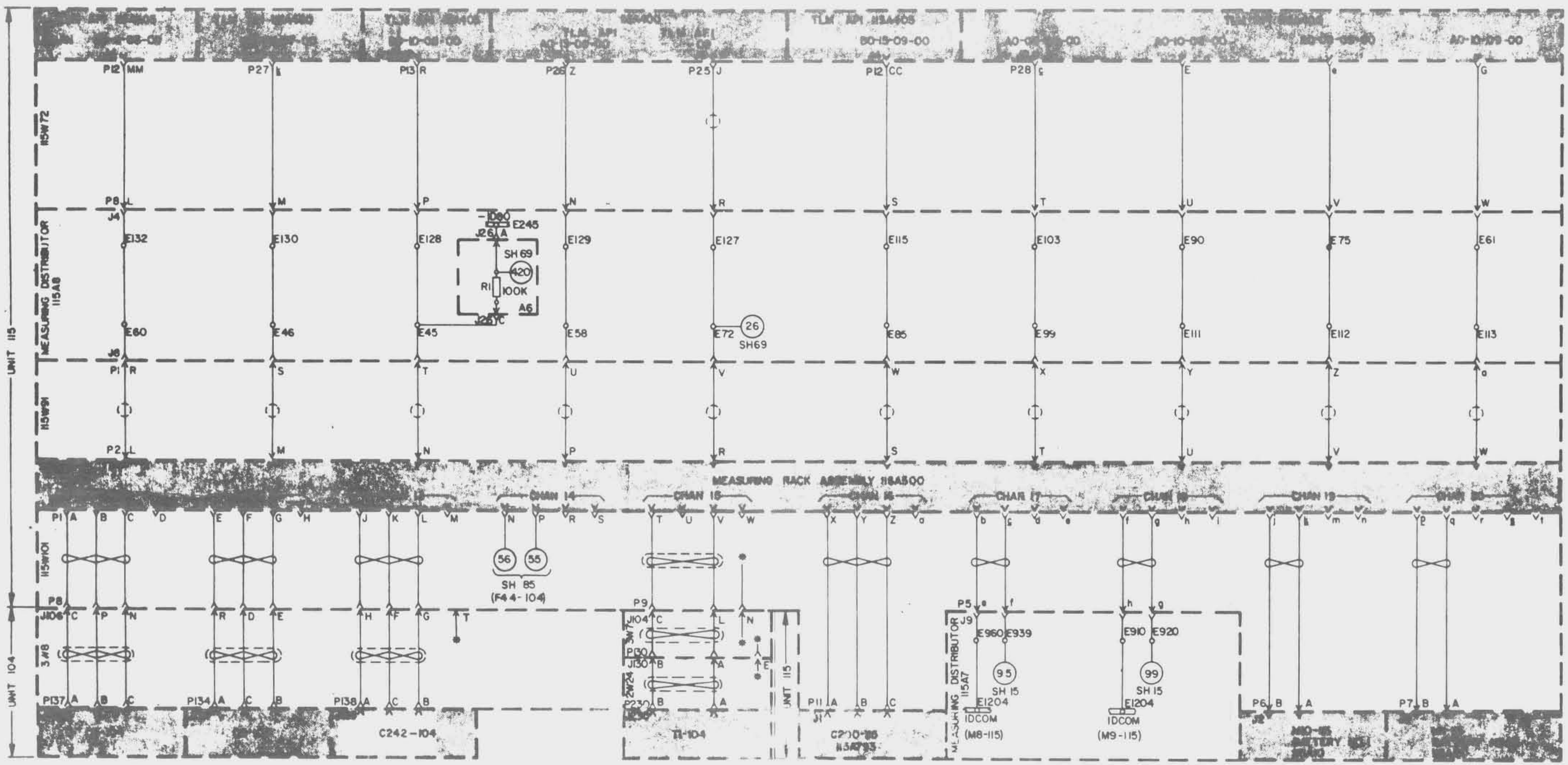
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

D 14981 60B55401

SHEET 62

60B55401 62 A

REVISIONS				
A	SEE SH	REV A		



● TERMINATE SHIELDS

CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)

SEE ENGINEERING RECORDS

APPLICATION

S-IC STAGE
ELECTRICAL SCHEMATICS
MEASURING RACK ASSEMBLY
115A500
CHANNELS 11-20

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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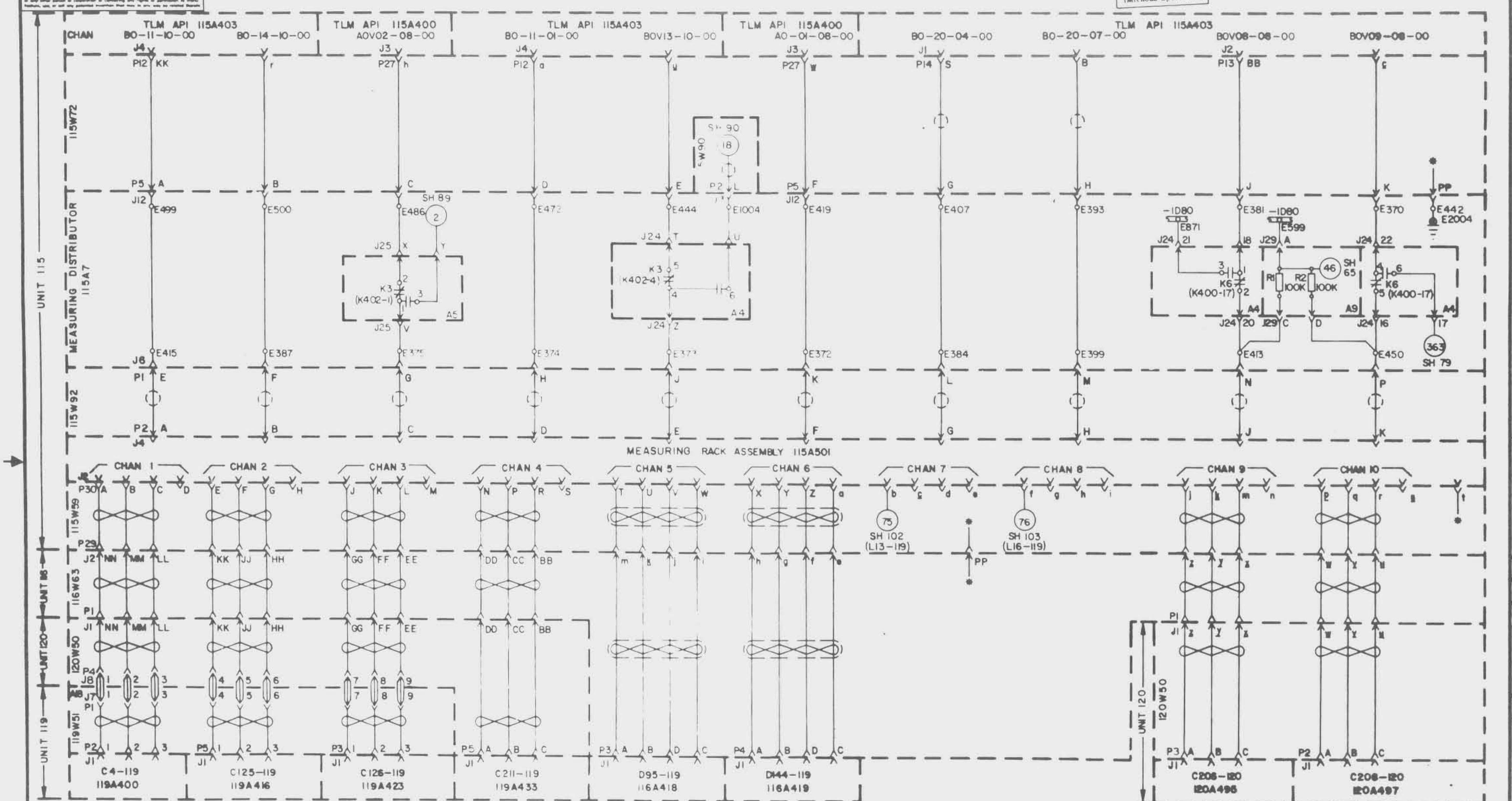
14981 | D | 60B55401

SHEET 63

60B55401 63 A

CUSTODIAN:
The Boeing Company
Saturn Branch
(Michoud Operations)

REVISIONS			
A	SEE SH 1 REV E		



● TERMINATE SHIELDS

SEE ENGINEERING RECORDS

UNLESS OTHERWISE SPECIFIED

S-IC STAGE
ELECTRICAL SCHEMATICS
MEASURING RACK ASSY
115A501
CHANNELS 1-10

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

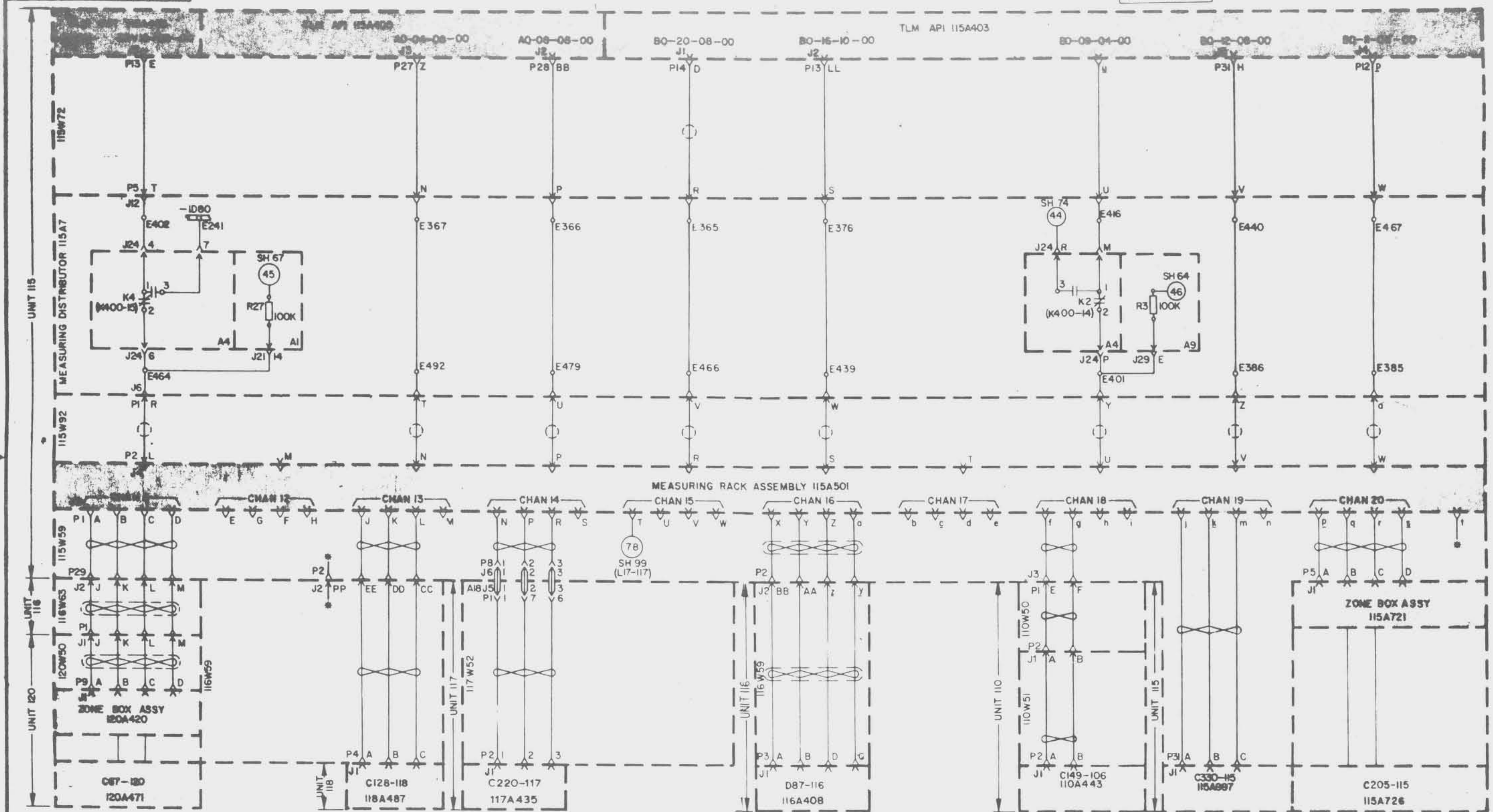
14981

D 60B55401

SHEET 64

CUSTODIAN
The Boeing Company
Saturn Branch
(Michoud Operations)

REVISIONS
B SEE SH 1 REV F



* TERMINATE SHIELDS

SEE ENGINEERING RECORDS

APPLICATION

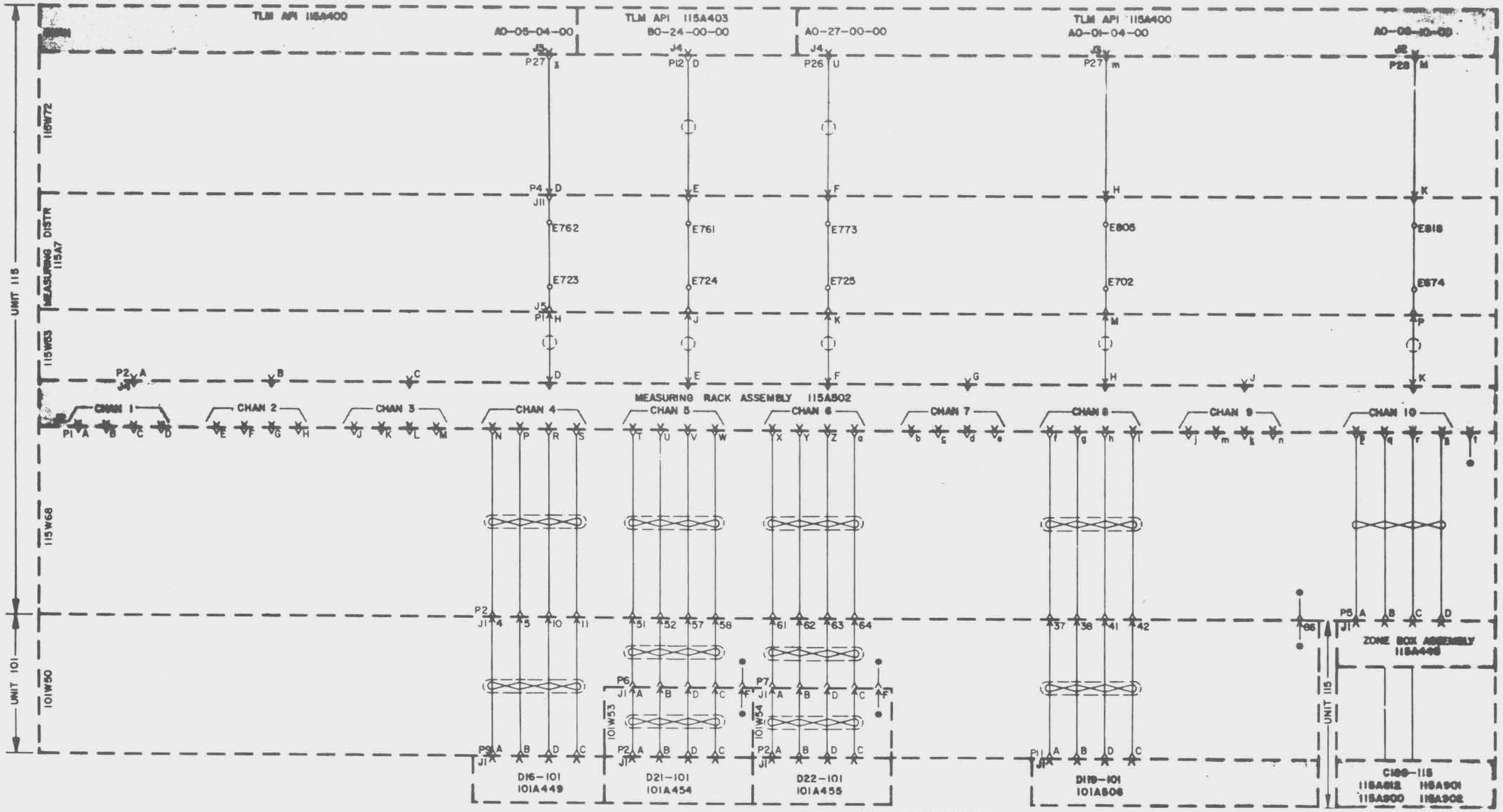
S-IC STAGE
ELECTRICAL SCHEMATICS
MEASURING RACK ASSEMBLY
115A501
CHANNELS 11-20

GEORGE C. MARSHALL SPACE FLIGHT CENTER

14981 D 60B55401

65

60B55401 65 B



● TERMINATE SHIELDS

SEE ENGINEERING RECORDS

APPLICATION

S-IC STAGE
ELECTRICAL SCHEMATICS
MEASURING RACK ASSEMBLY
115A502
CHANNELS 1-10

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

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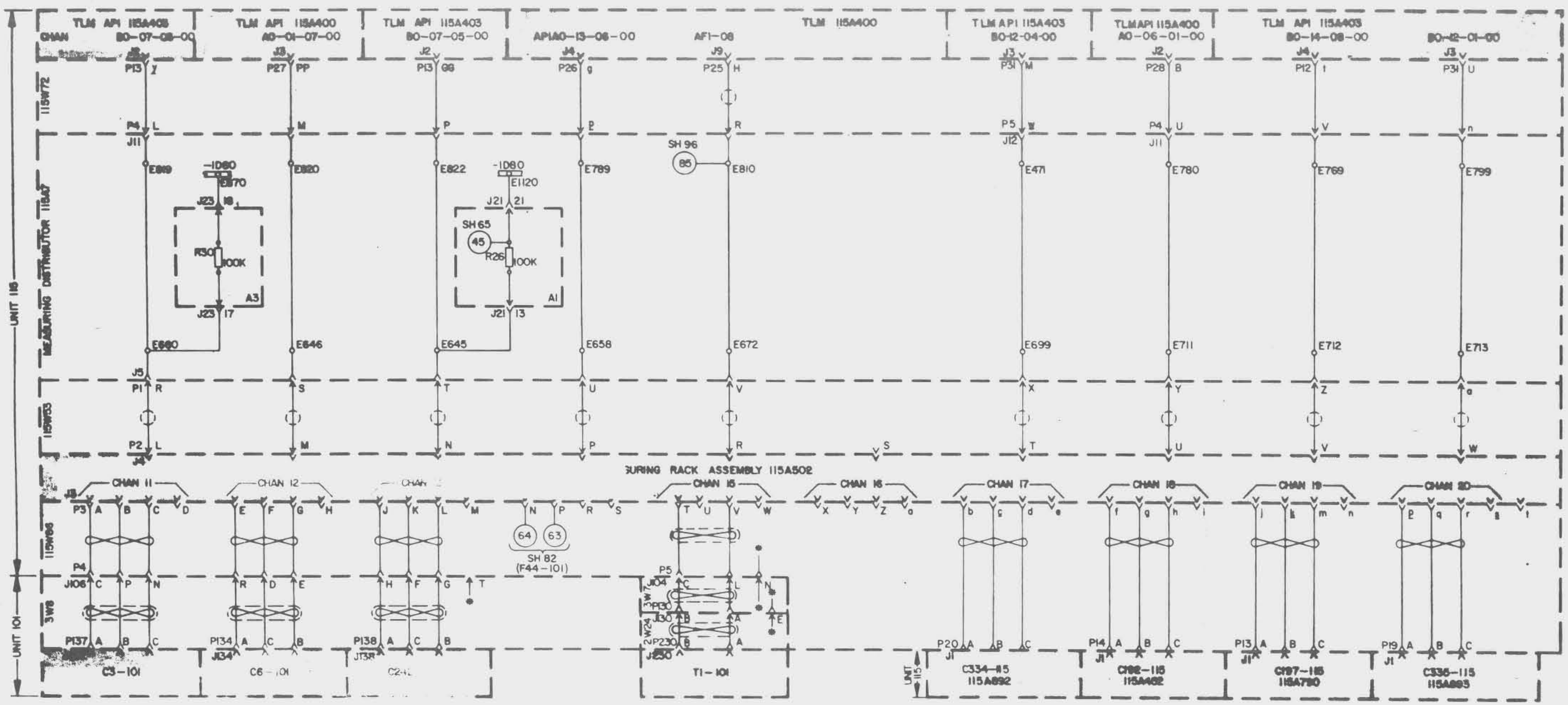
14981

CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)



CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)

SEE ENGINEERING RECORDS

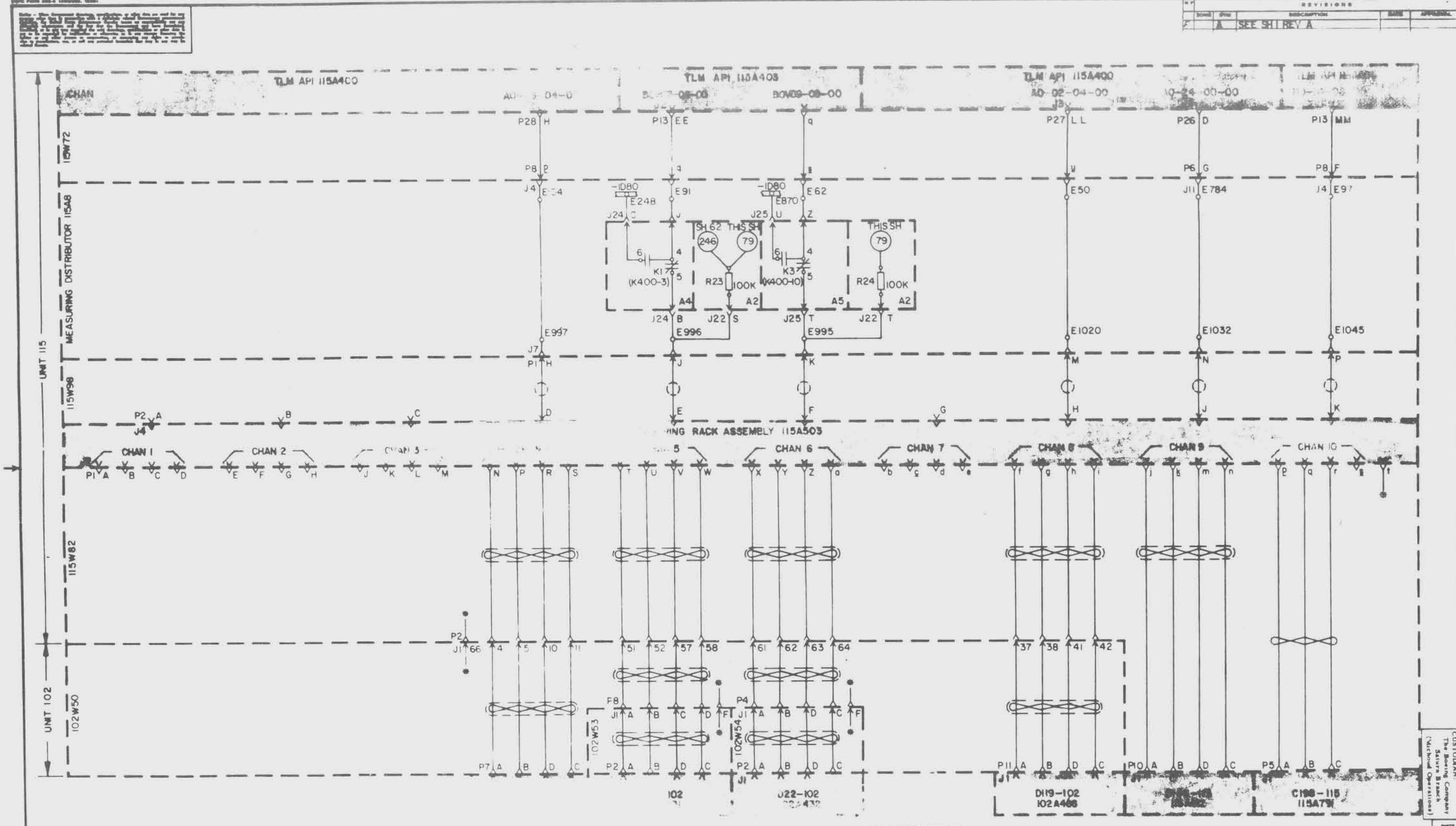
S-IC STAGE ELECTRICAL SCHEMATICS

MEASURING RACK ASSEMBLY 115A502 CHANNELS 11-20

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

14981 D 60B55401

SHEET 67



SEE ENGINEERING RECORDS

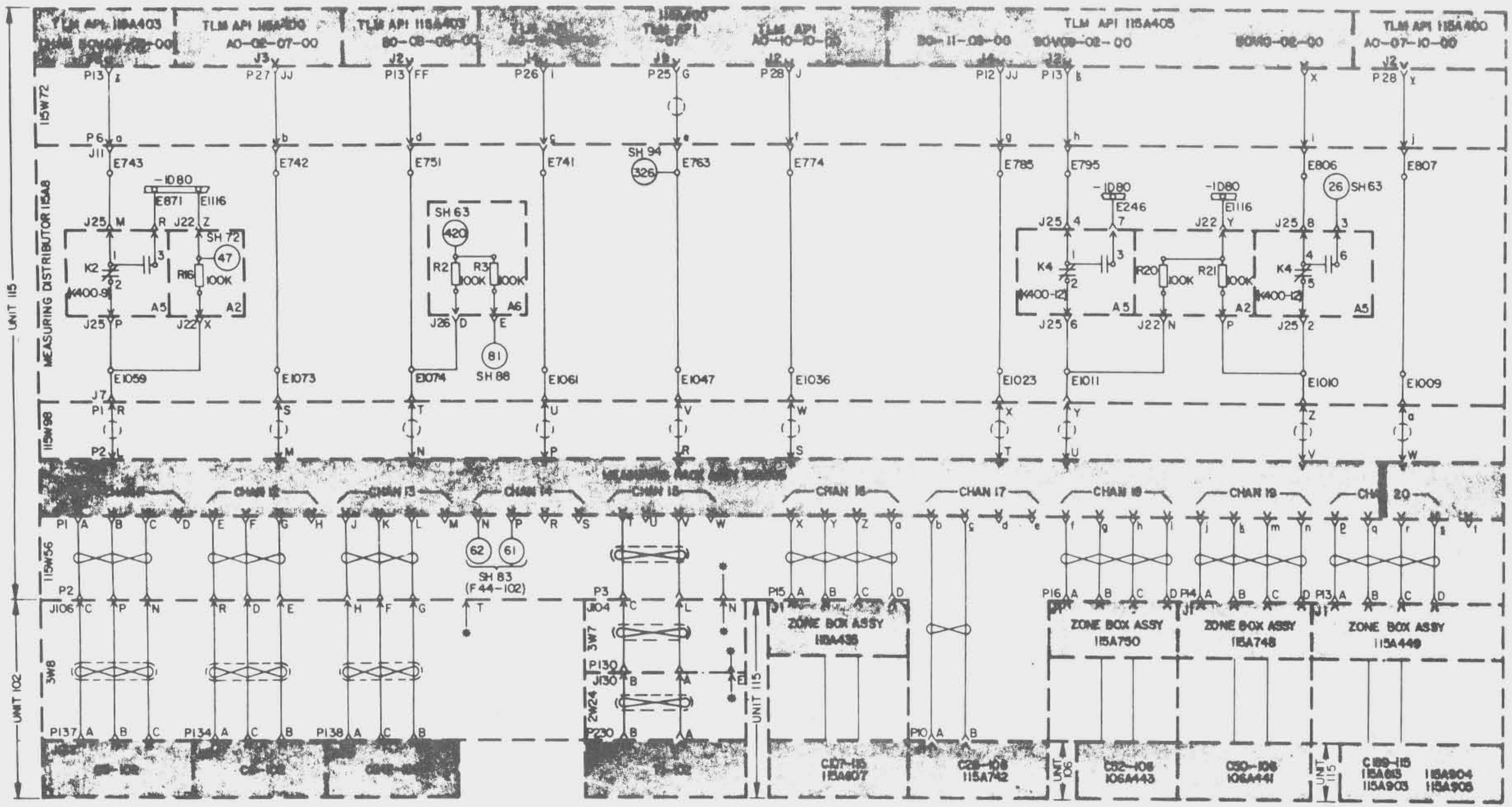
S-IC STAGE
ELECTRICAL SCHEMATICS
MEASURING RACK ASSEMBLY
115A503
CHANNELS 1-10

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

D 60B55401

CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)

60B55401 68 A



SEE ENGINEERING RECORDS

S-IC STAGE
ELECTRICAL SCHEMATICS
MEASURING RACK ASSEMBLY
115A503
CHANNELS 11-20

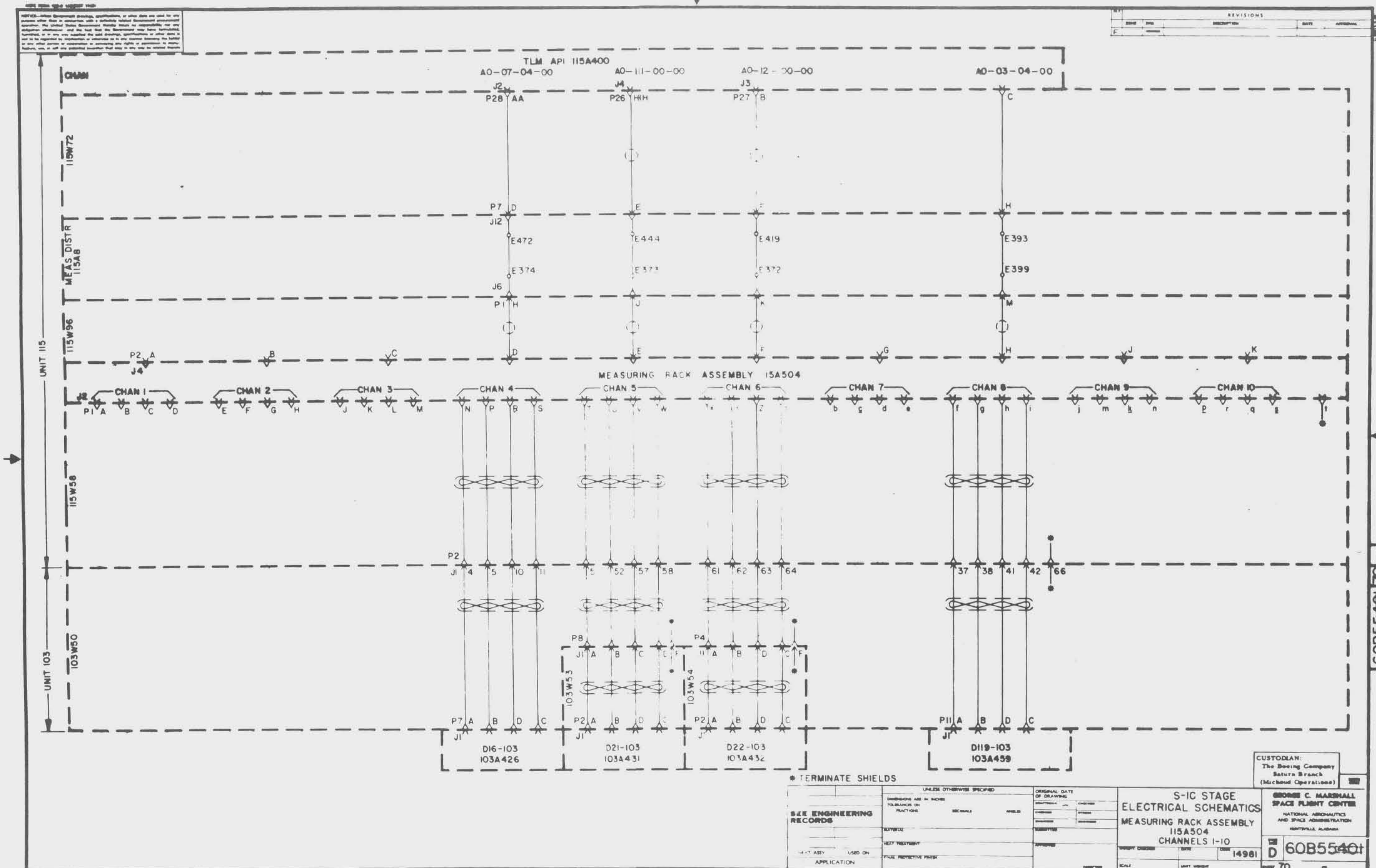
CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

D 14981 60B55401

SHEET 69

60B55401 69 A



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A0-111-00-00
A0-12-00-00
A0-03-04-00
CHAN
115W72
MEAS DISTR 115A8
115W96
UNIT 115
MEASURING RACK ASSEMBLY 15A504
CHAN 1
CHAN 2
CHAN 3
CHAN 4
CHAN 5
CHAN 6
CHAN 7
CHAN 8
CHAN 9
CHAN 10
115W58
UNIT 103
103W50
103W53
103W54
D16-103
103A426
D21-103
103A431
D22-103
103A432
D119-103
103A459
* TERMINATE SHIELDS
CUSTODIAN:
The Boeing Company
Saturn Branch
(Michoud Operations)
S&E ENGINEERING RECORDS
APPLICATION
S-IC STAGE
ELECTRICAL SCHEMATICS
MEASURING RACK ASSEMBLY
115A504
CHANNELS 1-10
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA
14981
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60B55401
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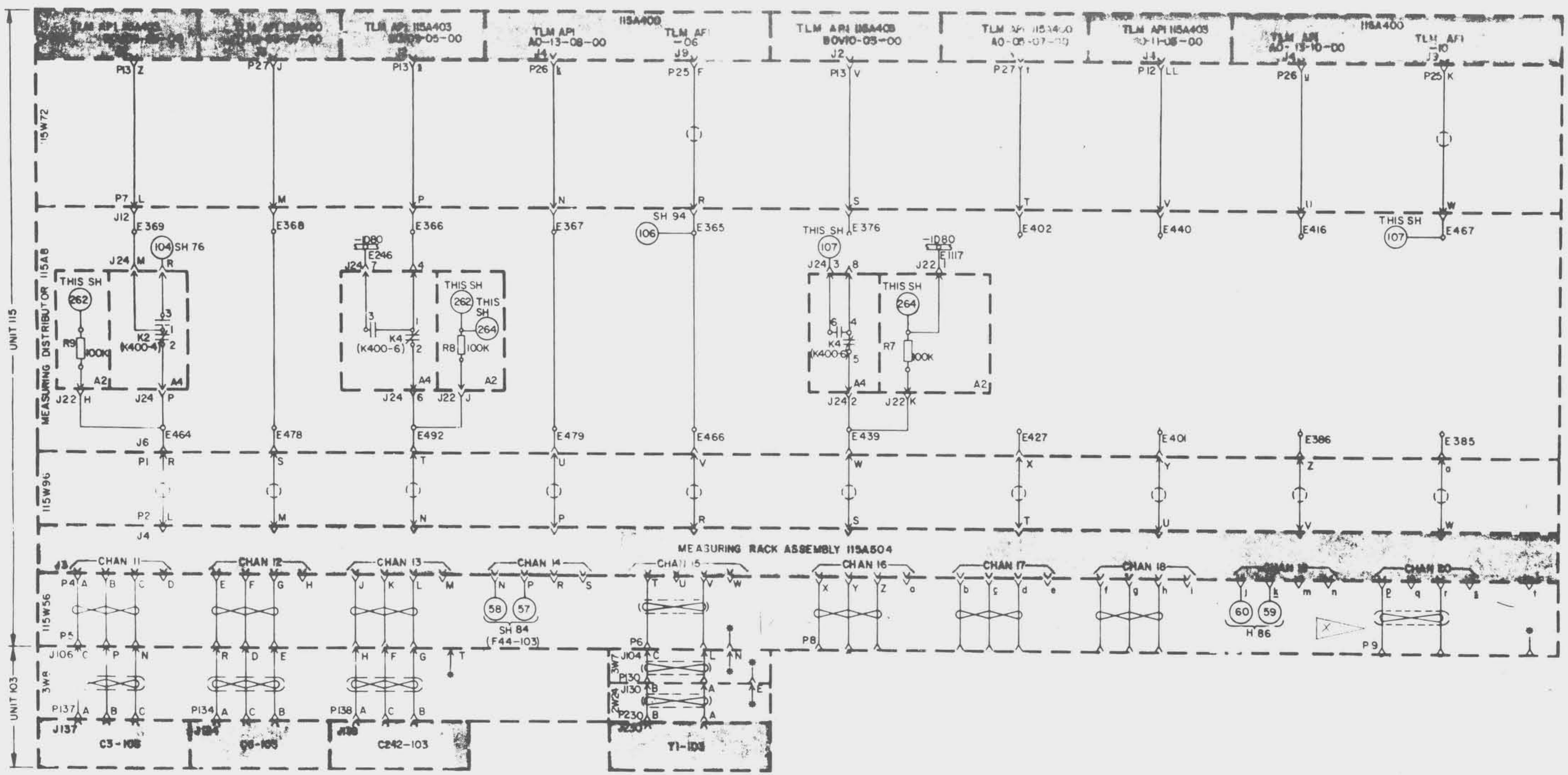
ZONE	SYM	DESCRIPTION	DATE	APPROVAL
	A	SEE SH 1 REV A		



✱ TERMINATE SHIELDS

SEE ENGINEERING RECORDS

UNLESS OTHERWISE SPECIFIED

NEXT ASSY | USED ON

APPLICATION

S-IC STAGE
ELECTRICAL SCHEMATICS
MEASURING RACK ASSEMBLY
115A504
CHANNELS 11-20

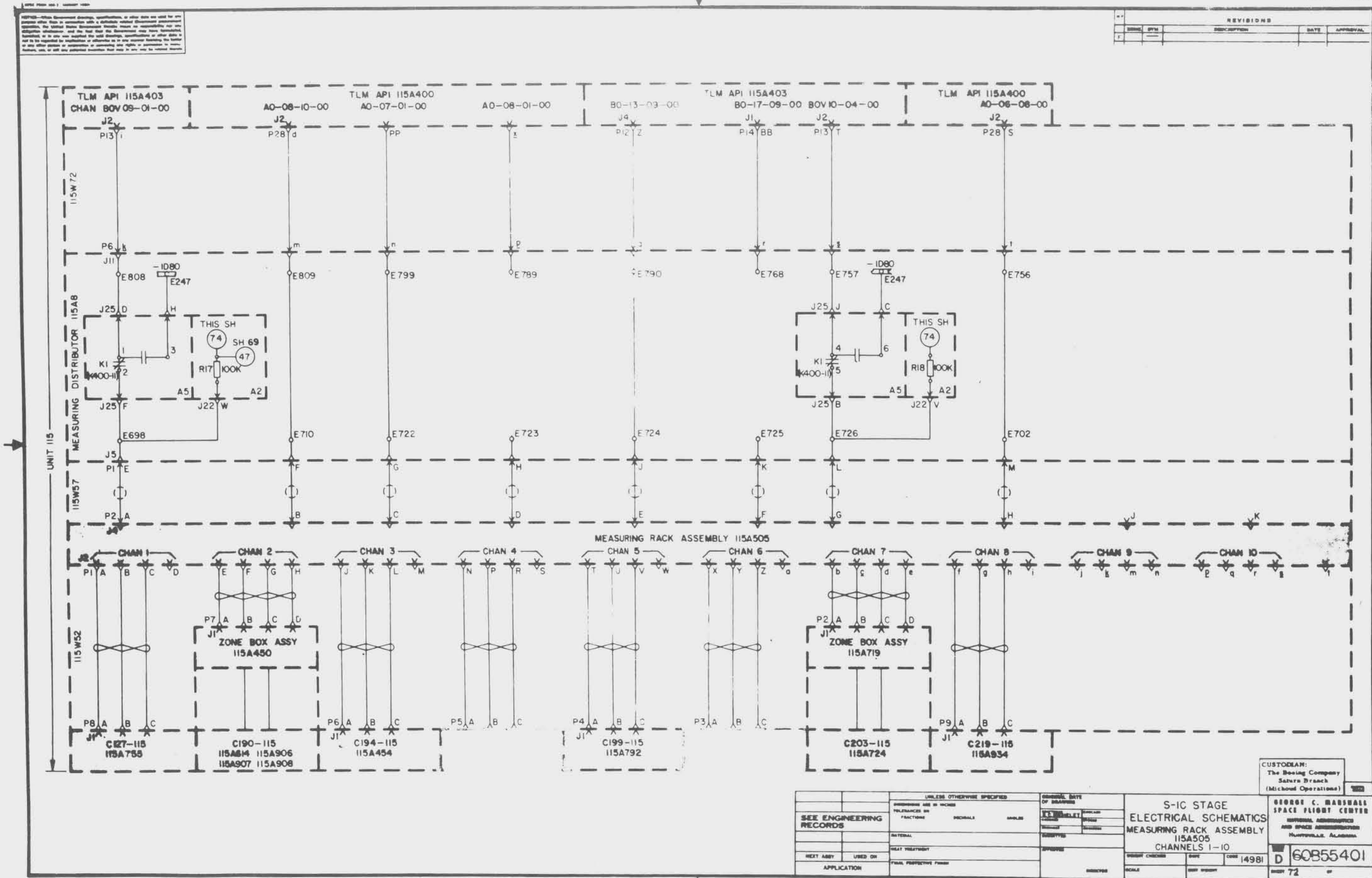
14981

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

D 60B55401

SHEET 71

60B55401 71 A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B0-13-03-00
B0-17-09-00 BOV 10-04-00
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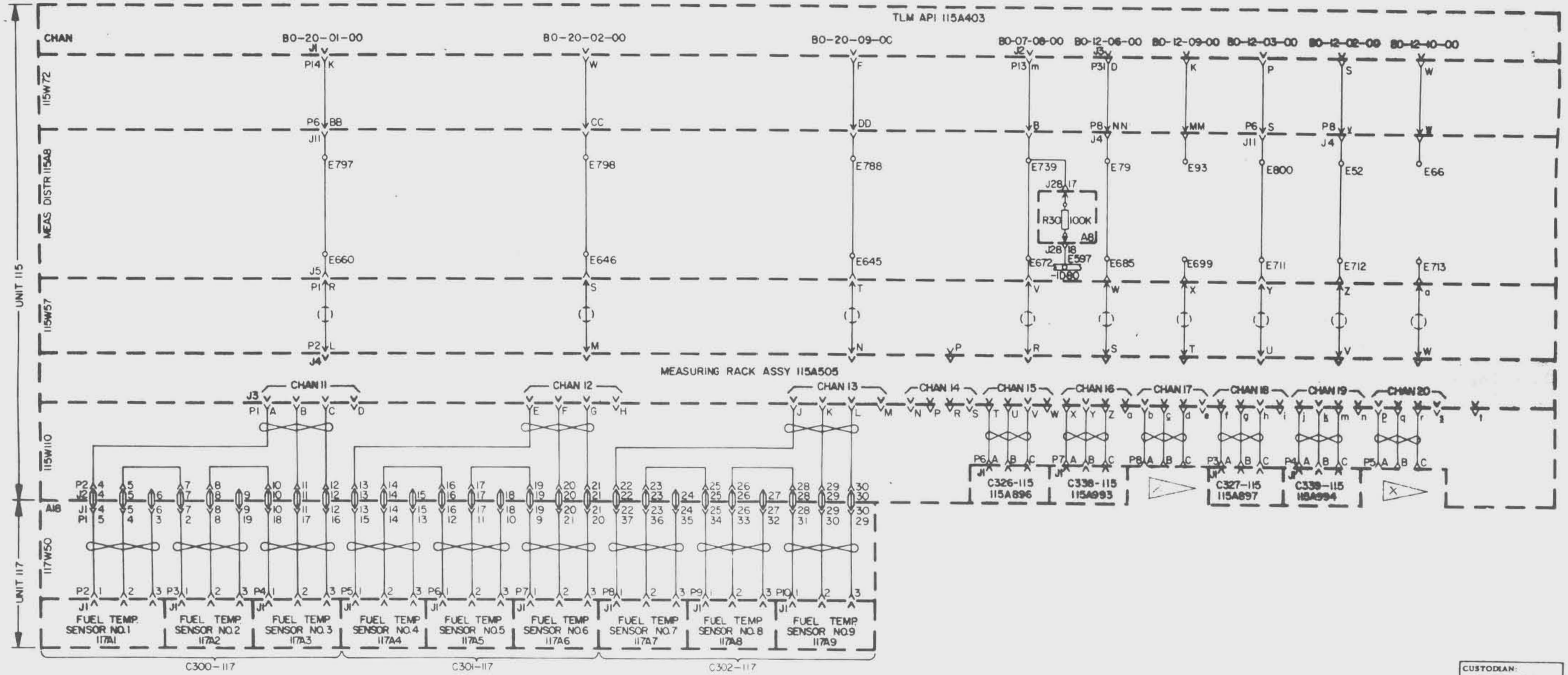
A0-06-08-00
UNIT 115
115W72
MEASURING DISTRIBUTOR 115A8
115W57
115W52
THIS SH
SH 69
R17 100K
R18 100K
K1 K400-11
E808
E809
E799
E789
E790
E768
E757
E756
E247
E698
E710
E722
E723
E724
E725
E726
E702
MEASURING RACK ASSEMBLY 115A505
CHAN 1
CHAN 2
CHAN 3
CHAN 4
CHAN 5
CHAN 6
CHAN 7
CHAN 8
CHAN 9
CHAN 10
ZONE BOX ASSY 115A450
ZONE BOX ASSY 115A719
C127-115 115A758
C190-115 115A614 115A906 115A907 115A908
C194-115 115A454
C199-115 115A792
C203-115 115A724
C219-115 115A934
CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)
SEE ENGINEERING RECORDS
APPLICATION
S-IC STAGE
ELECTRICAL SCHEMATICS
MEASURING RACK ASSEMBLY 115A505
CHANNELS 1-10
GEORGE C. MARSHALL SPACE FLIGHT CENTER
14981
D 60B55401
72
60B55401 72

ZONE	SYM	DESCRIPTION	DATE	APPROVAL
	B	SEE SH 1 REV F		



CUSTODIAN:
The Boeing Company
Saturn Branch
(Michoud Operations)

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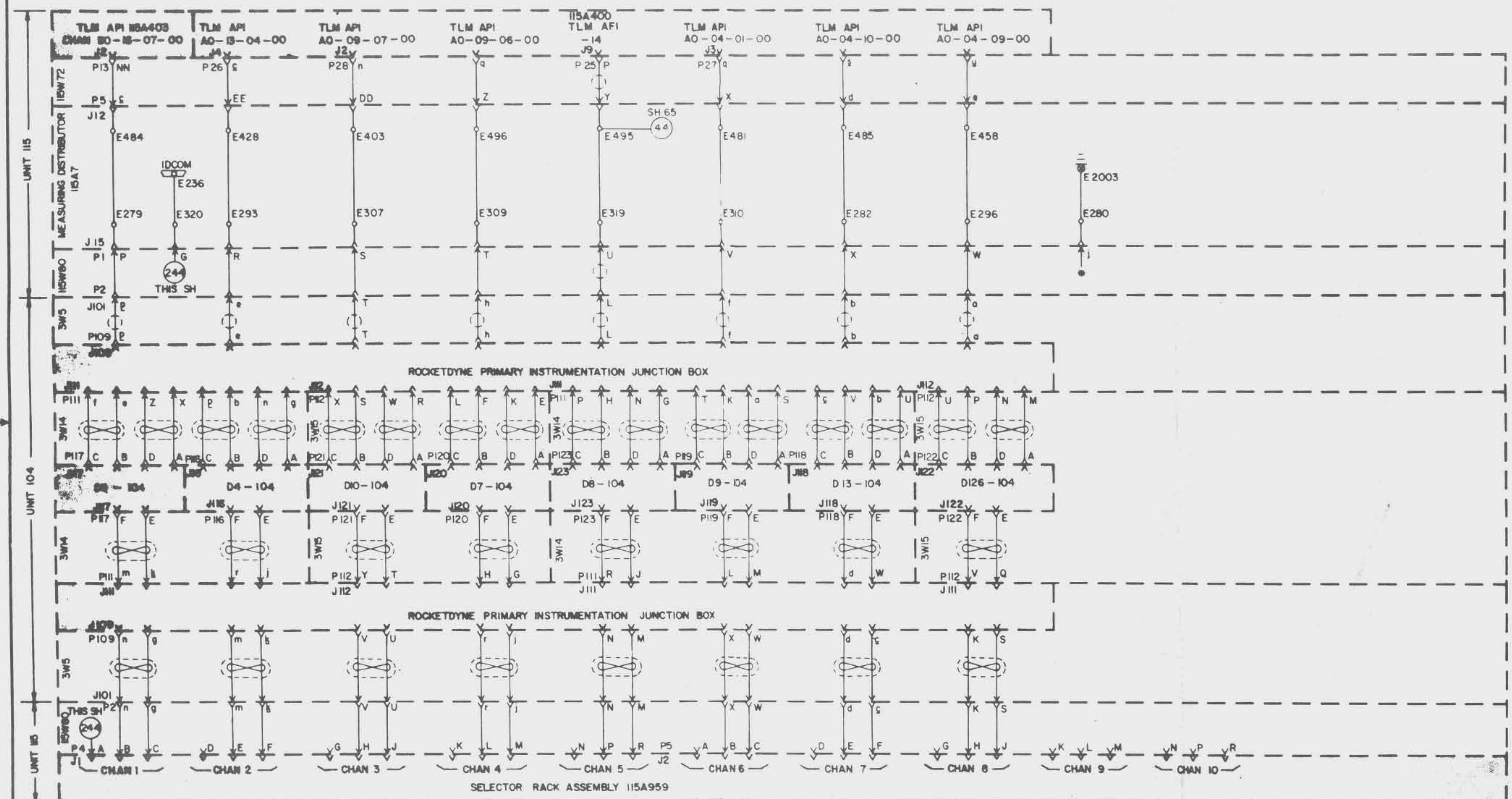
APPLICATION

S-IC STAGE
ELECTRICAL SCHEMATICS
MEASURING RACK ASSEMBLY
115A505
CHANNELS 11-20

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

14981 D 60B55401

73



* TERMINATE SHIELDS

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APPLICATION

S-IC STAGE ELECTRICAL SCHEMATICS
SELECTOR RACK ASSEMBLY 115A959
CHANNELS 1-10

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)

14981 D 60B55401 74

REV	ZONE	SYM	DESCRIPTION	DATE	APPROVAL
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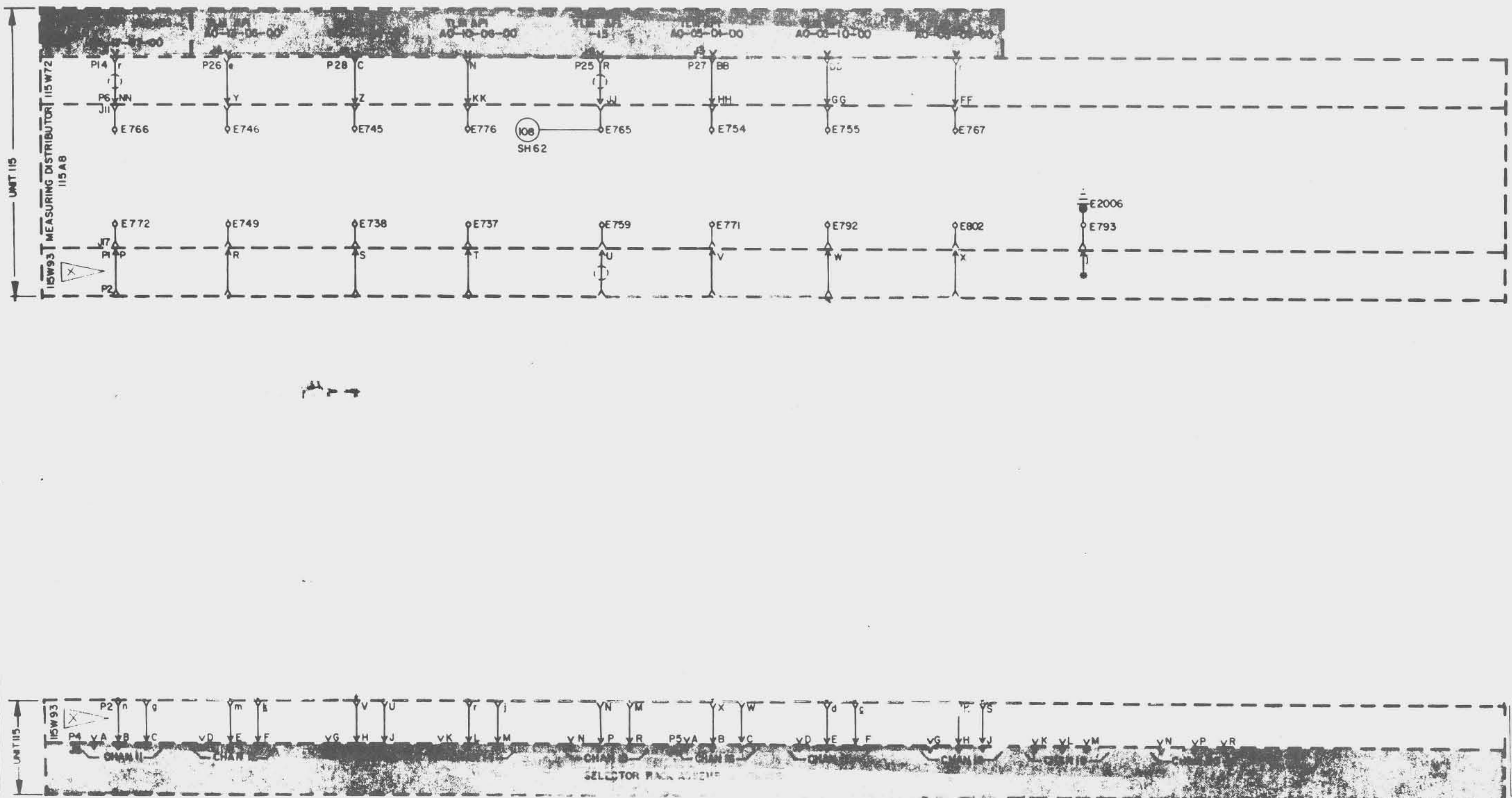

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APPLICATION

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ORIGINAL DATE OF DRAWING

S-IC STAGE
ELECTRICAL SCHEMATICS
SELECTOR RACK ASSEMBLY
115A959
CHANNELS 11-20

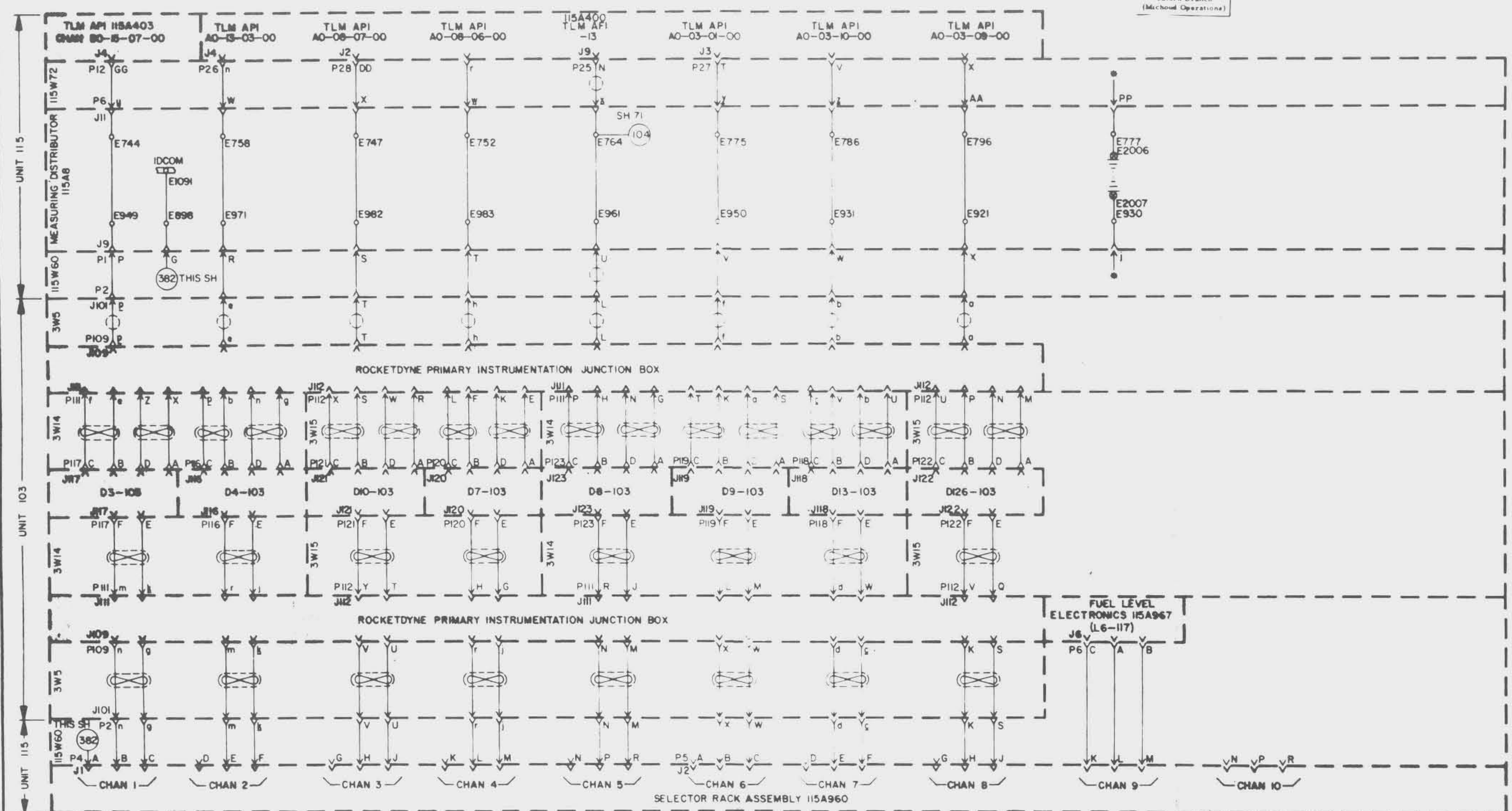
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

D 60B55401

SHEET 75

60B55401 75 A

CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)



SEE ENGINEERING RECORDS

S-IC STAGE ELECTRICAL SCHEMATICS

SELECTOR RACK ASSEMBLY 115A960 CHANNELS 1-10

GEORGE C. MARSHALL SPACE FLIGHT CENTER
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76

REVISIONS				
ZONE	SYM	DESCRIPTION	DATE	APPROVAL
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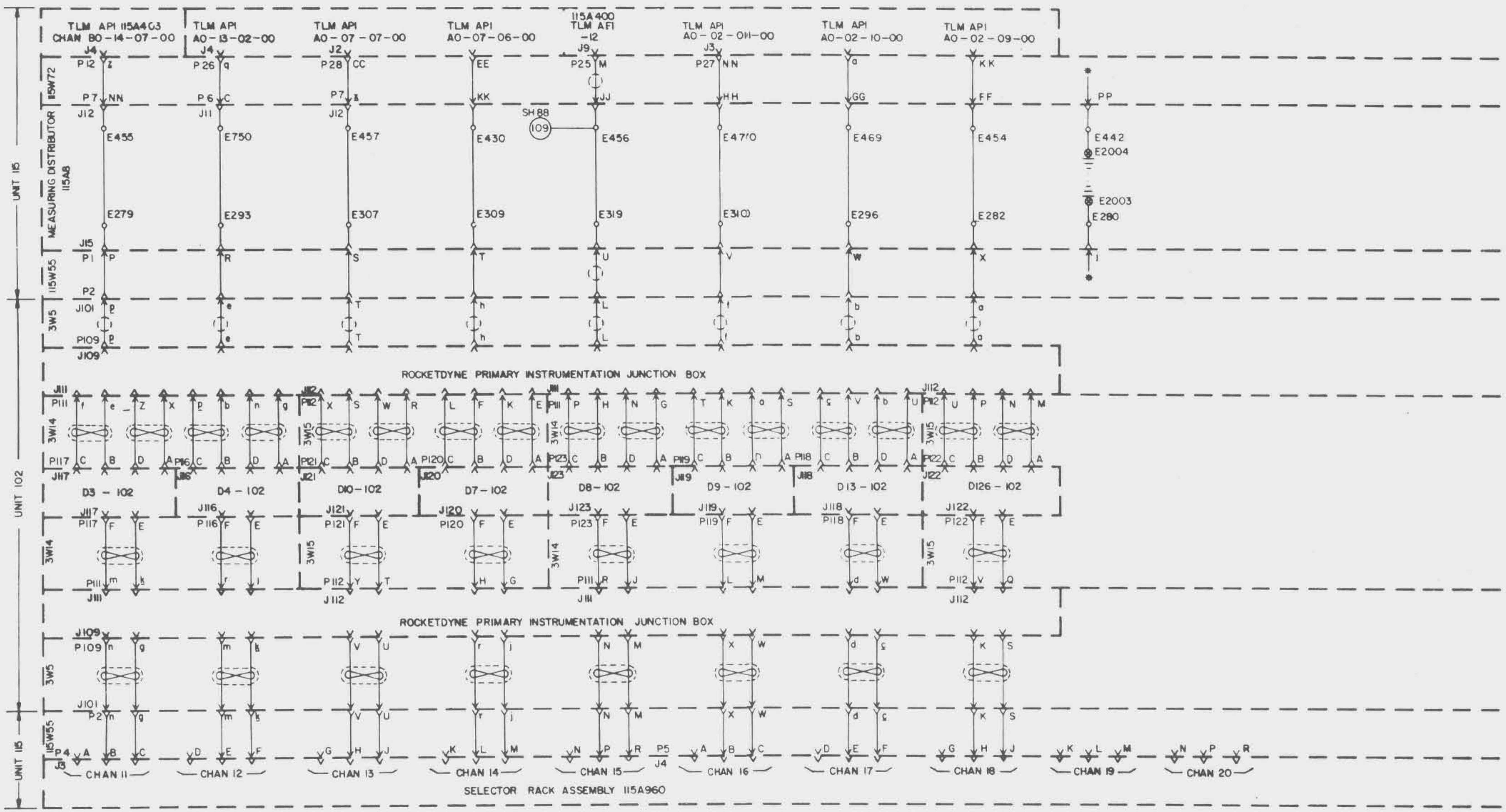

* TERMINATE SHIELDS

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APPLICATION

UNLESS OTHERWISE SPECIFIED

ORIGINAL DATE OF DRAWING

S-IC STAGE
ELECTRICAL SCHEMATICS
SELECTOR RACK ASSEMBLY
115A960
CHANNELS 11-20

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

14981

D 60B55401

77

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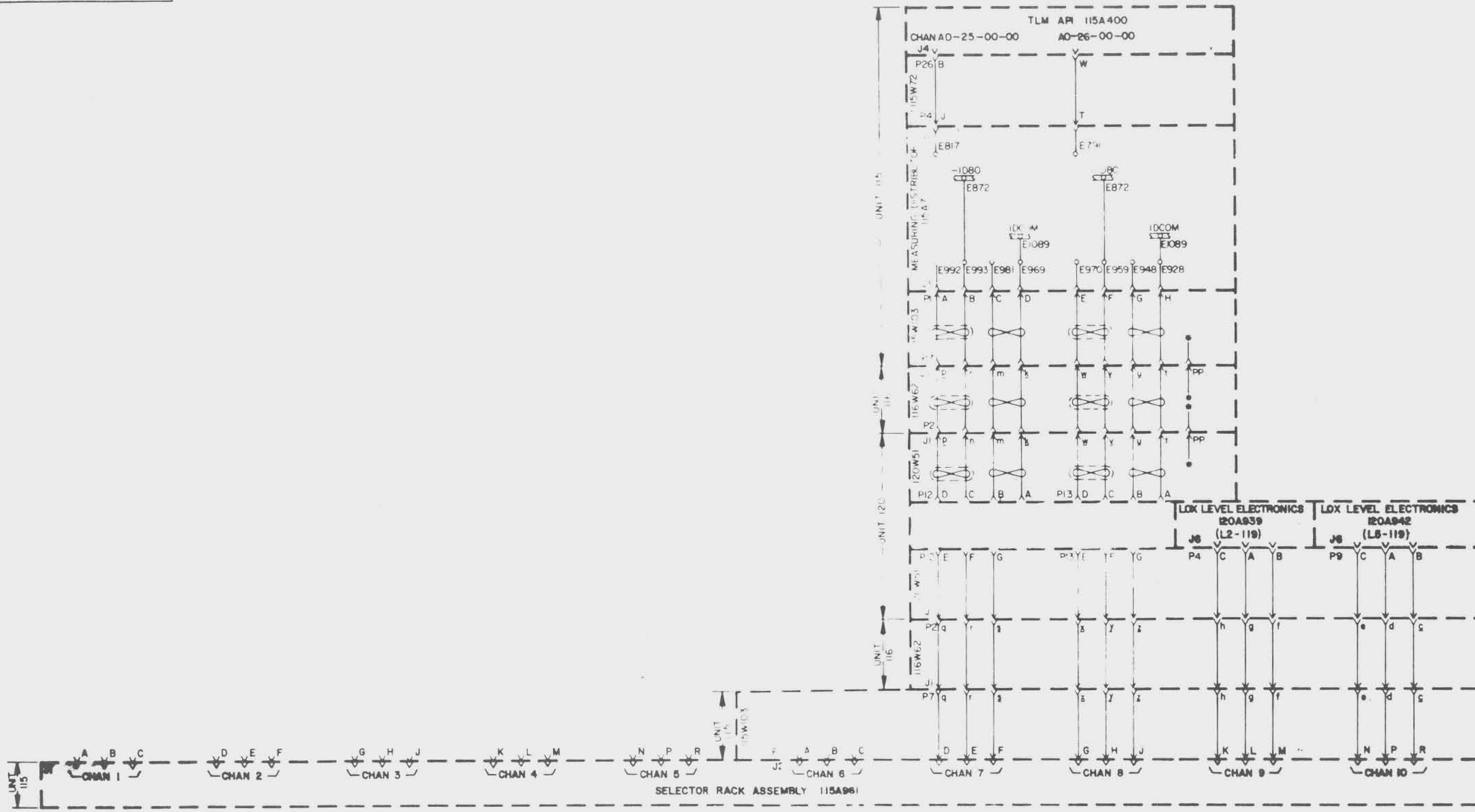
CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)

B SEE SH 1 REV G



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S-IC STAGE
ELECTRICAL SCHEMATICS
SELECTOR RACK ASSEMBLY
115A961
CHANNELS 1-10

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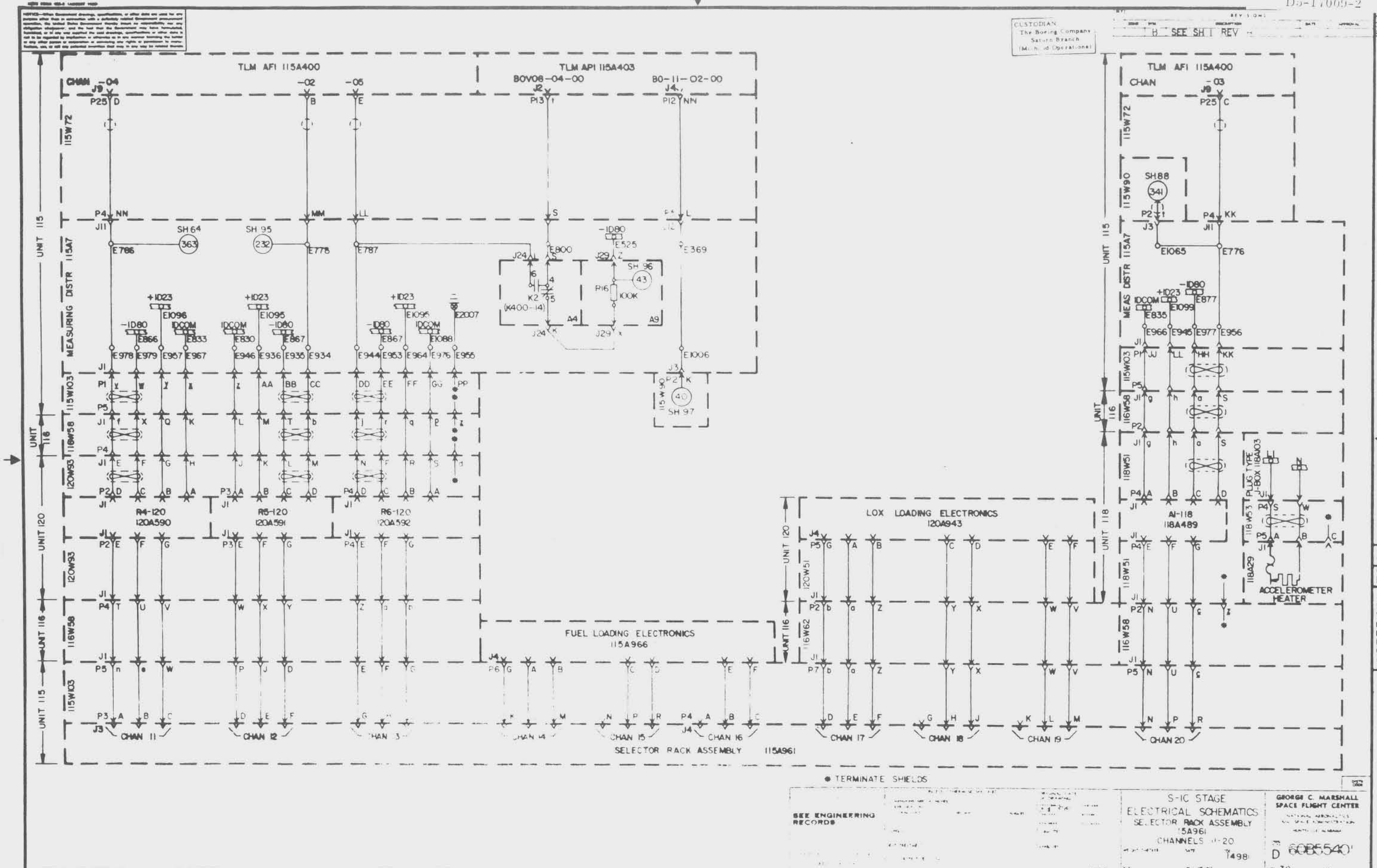
SHEET 78

CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)

60B55401 78 B

D5-17009-2



A-583 584

REVISIONS				
ZONE	SYM	DESCRIPTION	DATE	APPROVAL
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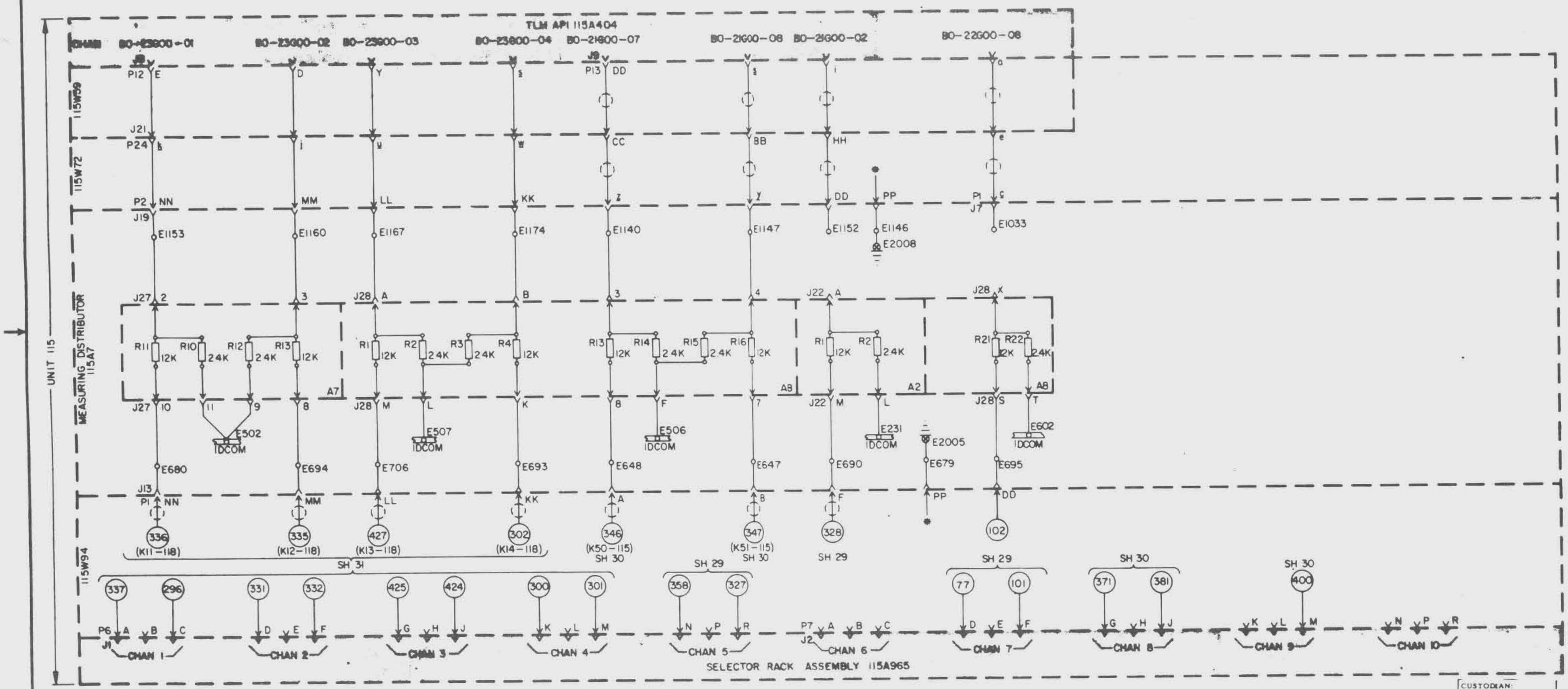

* TERMINATE SHIELDS

CUSTODIAN: The Boeing Company, Saturn Branch (Michoud Operations)

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NEXT ASSY | USED ON

APPLICATION

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ORIGINAL DATE OF DRAWING

S-IC STAGE ELECTRICAL SCHEMATICS

SELECTOR RACK ASSEMBLY 115A965 CHANNELS 1-10

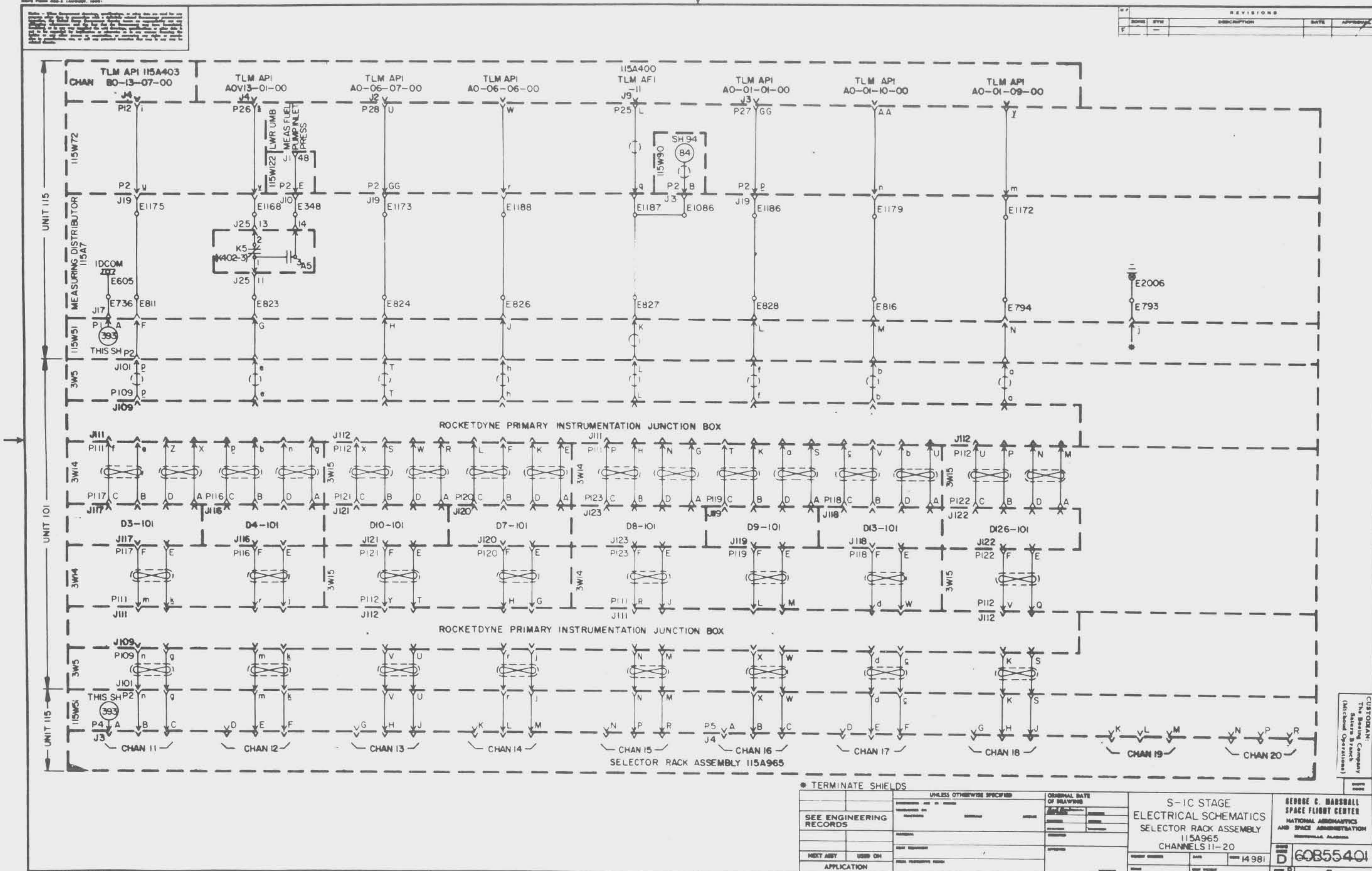
GEORGE C. MARSHALL SPACE FLIGHT CENTER

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

HUNTSVILLE, ALABAMA

D 14981 60B55401

SHEET 80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115A400 TLM AFI -11
TLM API A0-01-01-00
TLM API A0-01-10-00
TLM API A0-01-09-00
115W72
MEASURING DISTRIBUTOR 115A7
115W51
3W5
UNIT 115
UNIT 101
LWR UMB
MEAS FUEL PUMP INLET PRESS
115W122
115W90
SH 94
IDCOM
THIS SH
ROCKETDYNE PRIMARY INSTRUMENTATION JUNCTION BOX
3W14
3W15
D3-101
D4-101
D10-101
D7-101
D8-101
D9-101
D13-101
D126-101
CHAN 11
CHAN 12
CHAN 13
CHAN 14
CHAN 15
CHAN 16
CHAN 17
CHAN 18
CHAN 19
CHAN 20
SELECTOR RACK ASSEMBLY 115A965
* TERMINATE SHIELDS
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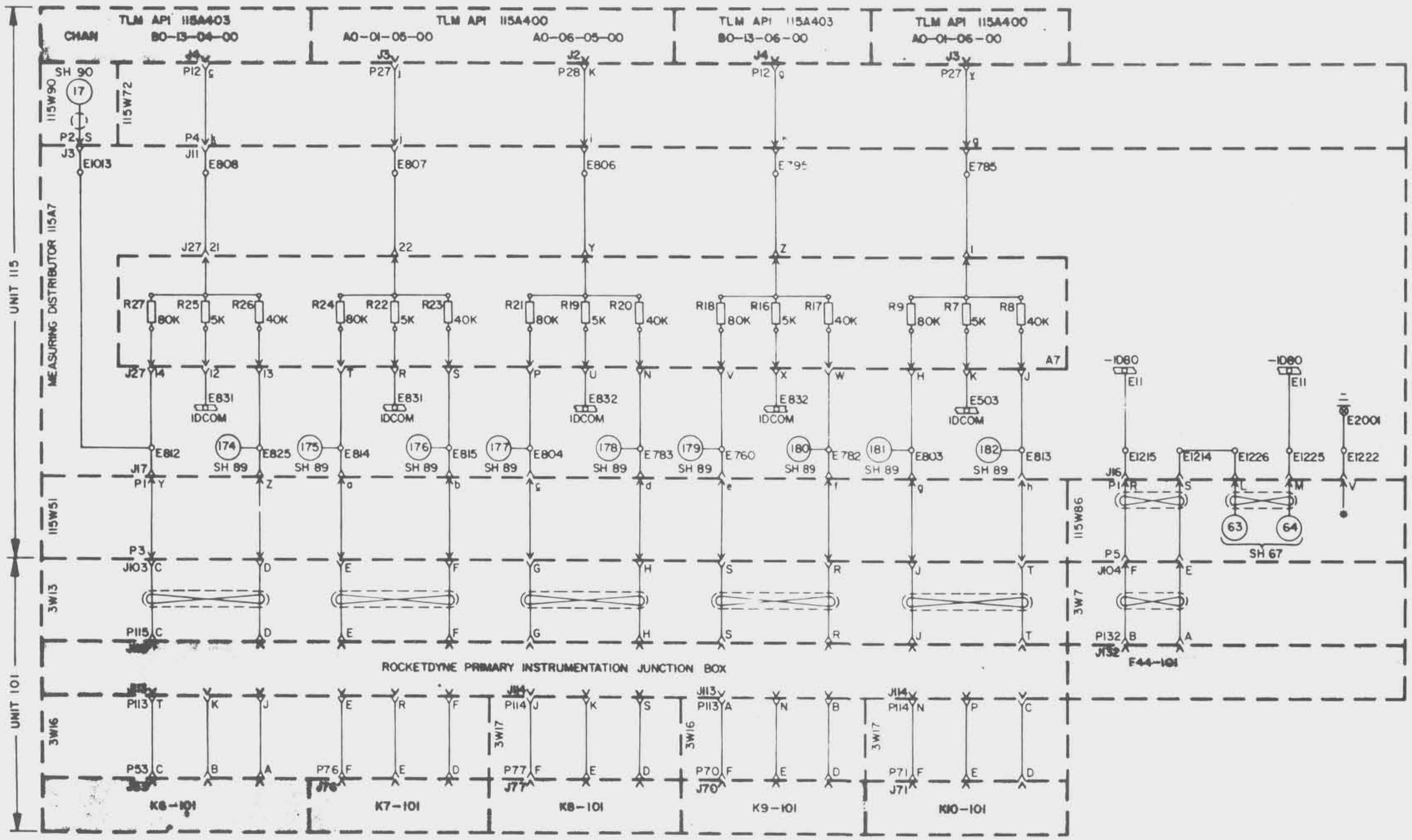
NEXT ASSY
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED
S-IC STAGE
ELECTRICAL SCHEMATICS
SELECTOR RACK ASSEMBLY
115A965
CHANNELS 11-20
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
14981
D
60B55401
81
CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)
60B55401 81
REVISIONS



● TERMINATE SHIELDS

CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)

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APPLICATION

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S-IC STAGE
ELECTRICAL SCHEMATICS
MEASURING UNIT 101

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

14981 D 60B55401
82

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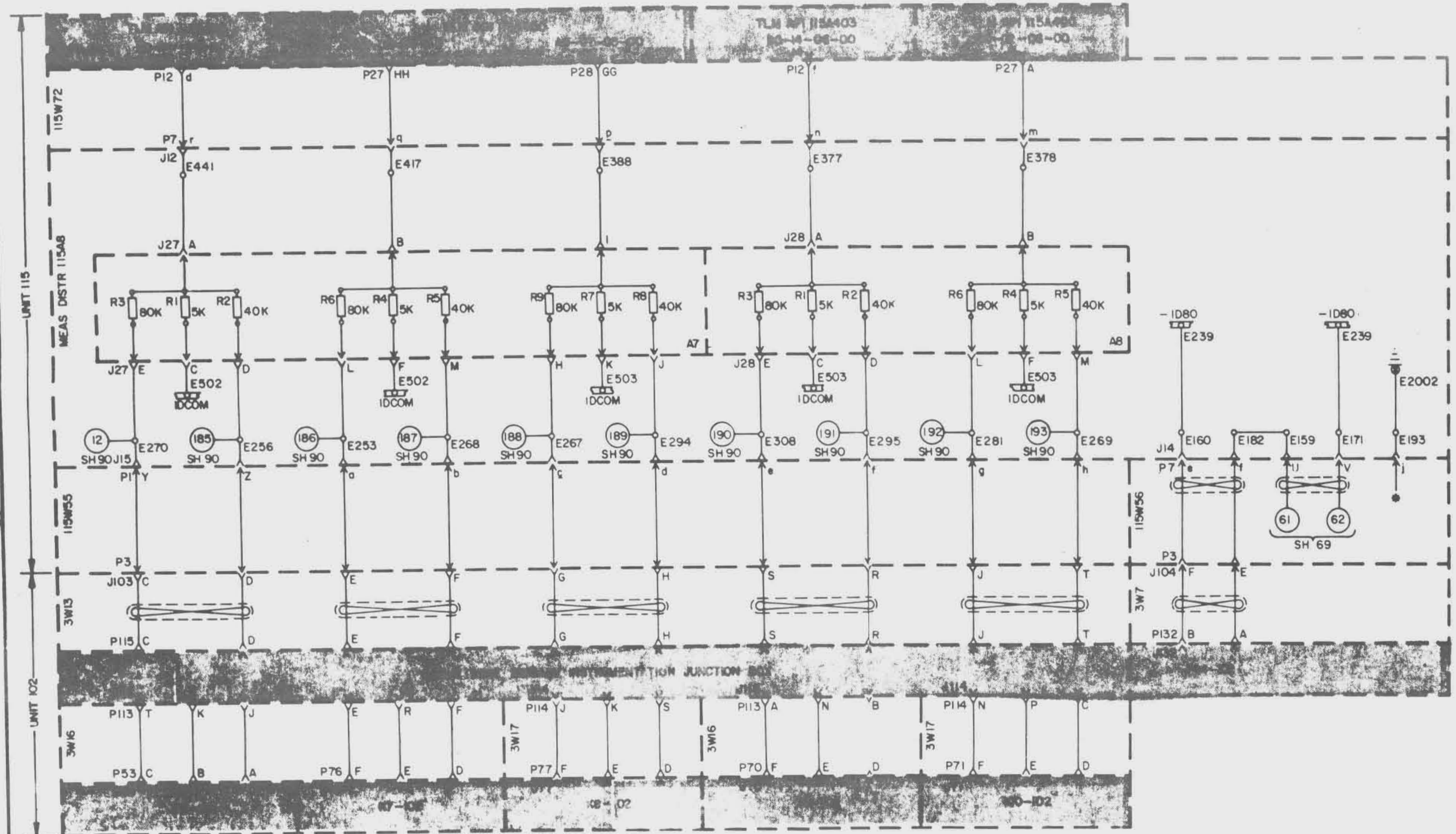
REVISIONS				
F	A	SEE SH 1 REV A		



● TERMINATE SHIELDS

CUSTODIAN:
The Boeing Company
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(Michoud Operations)

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APPLICATION

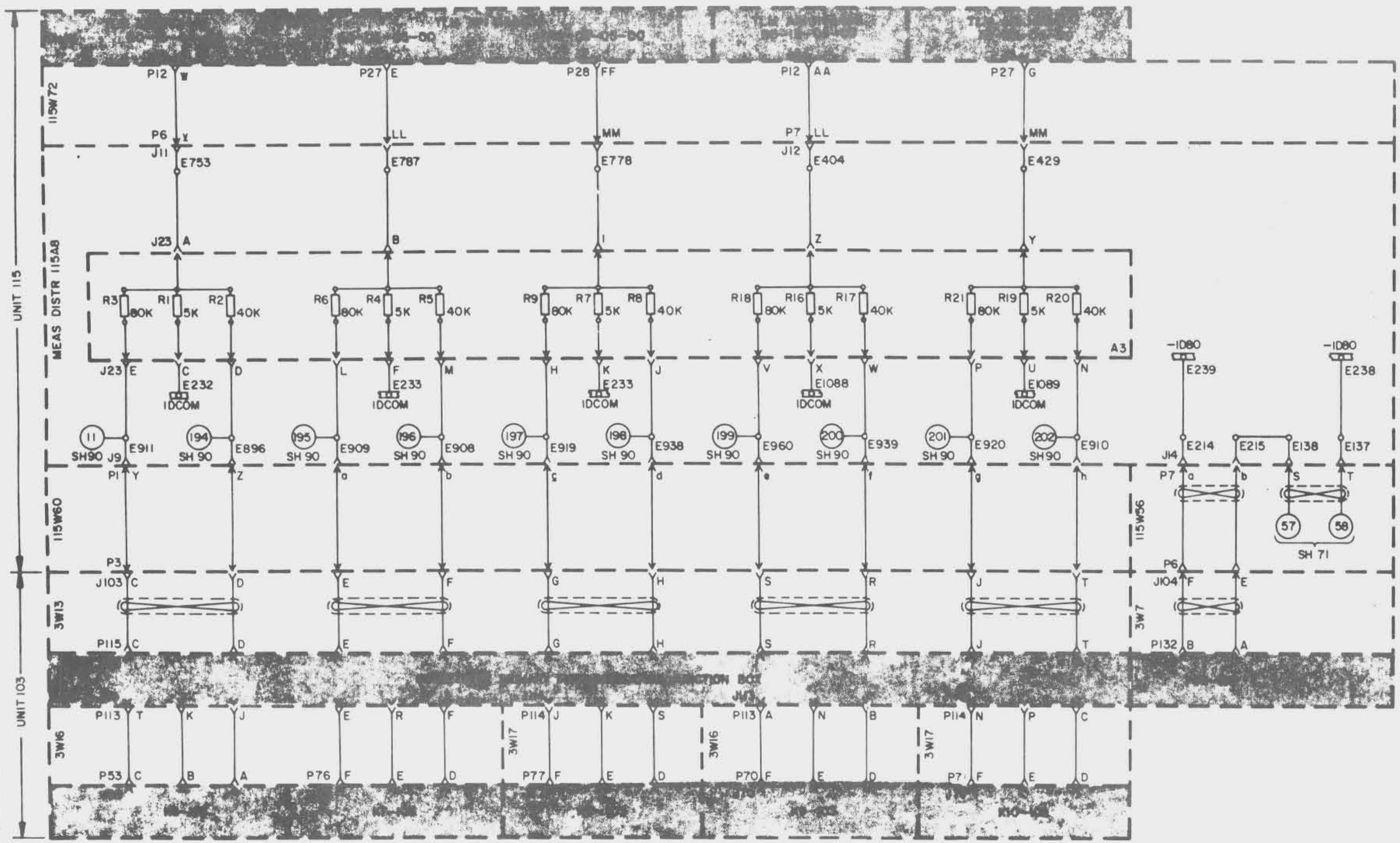
S-IC STAGE
ELECTRICAL SCHEMATICS
MEASURING UNIT 102

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

14981 D 60B55401

60B55401 83 A

ZONE	SYM	DESCRIPTION	DATE	APPROVAL
	A	SEE SH 1 REV A		

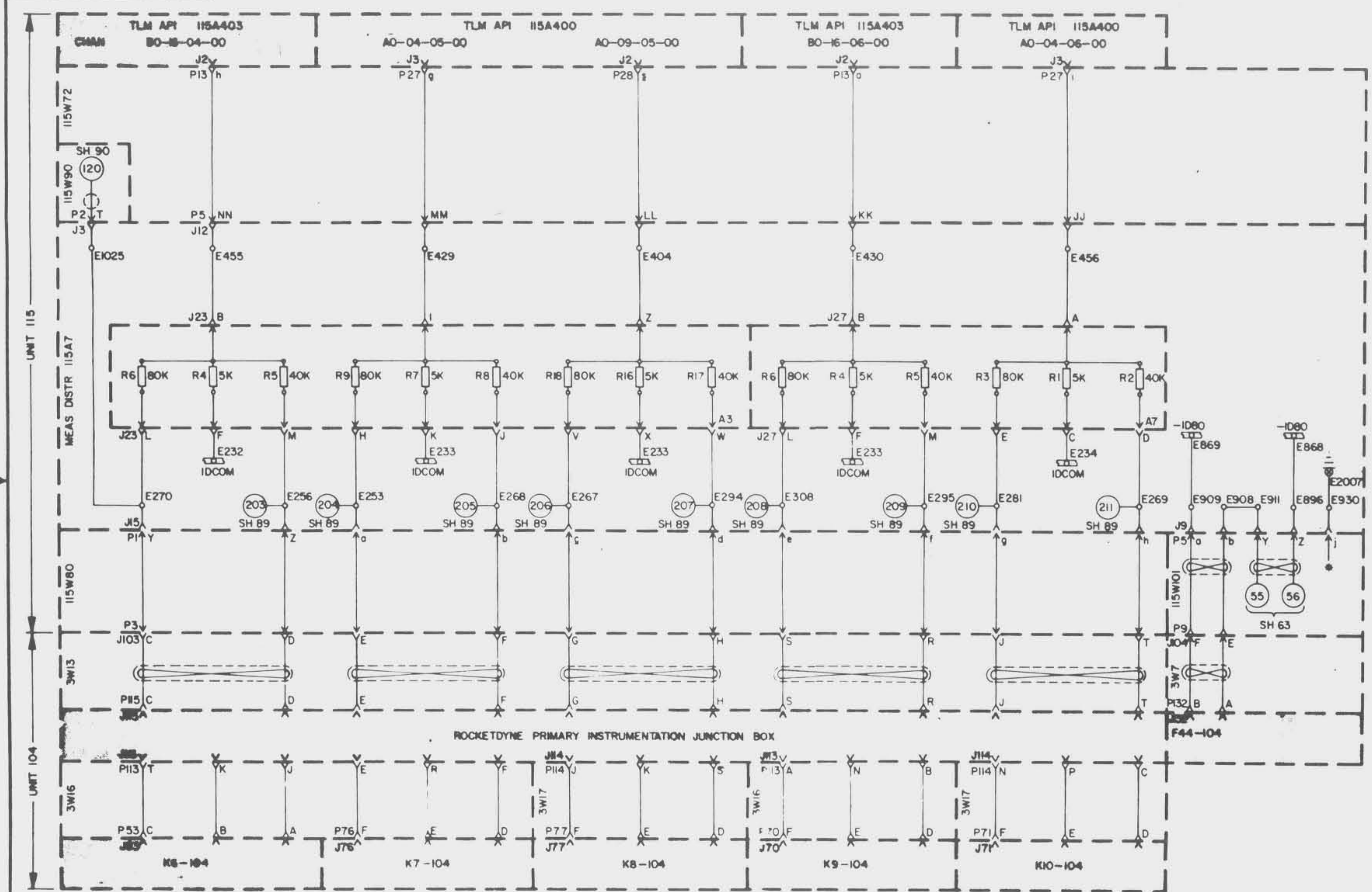


SEE ENGINEERING RECORDS	S-IC STAGE ELECTRICAL SCHEMATICS MEASURING UNIT 103	GEORGE C. MARSHALL SPACE FLIGHT CENTER NATIONAL AERONAUTICS AND SPACE ADMINISTRATION HUNTSVILLE, ALABAMA
APPLICATION	14981	D 60B55401

CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)

SH 84

60B55401 84 A



● TEMINATE SHIELDS

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APPLICATION

CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)

S-IC STAGE ELECTRICAL SCHEMATICS MEASURING UNIT 104

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

14981 D 60B55401

85

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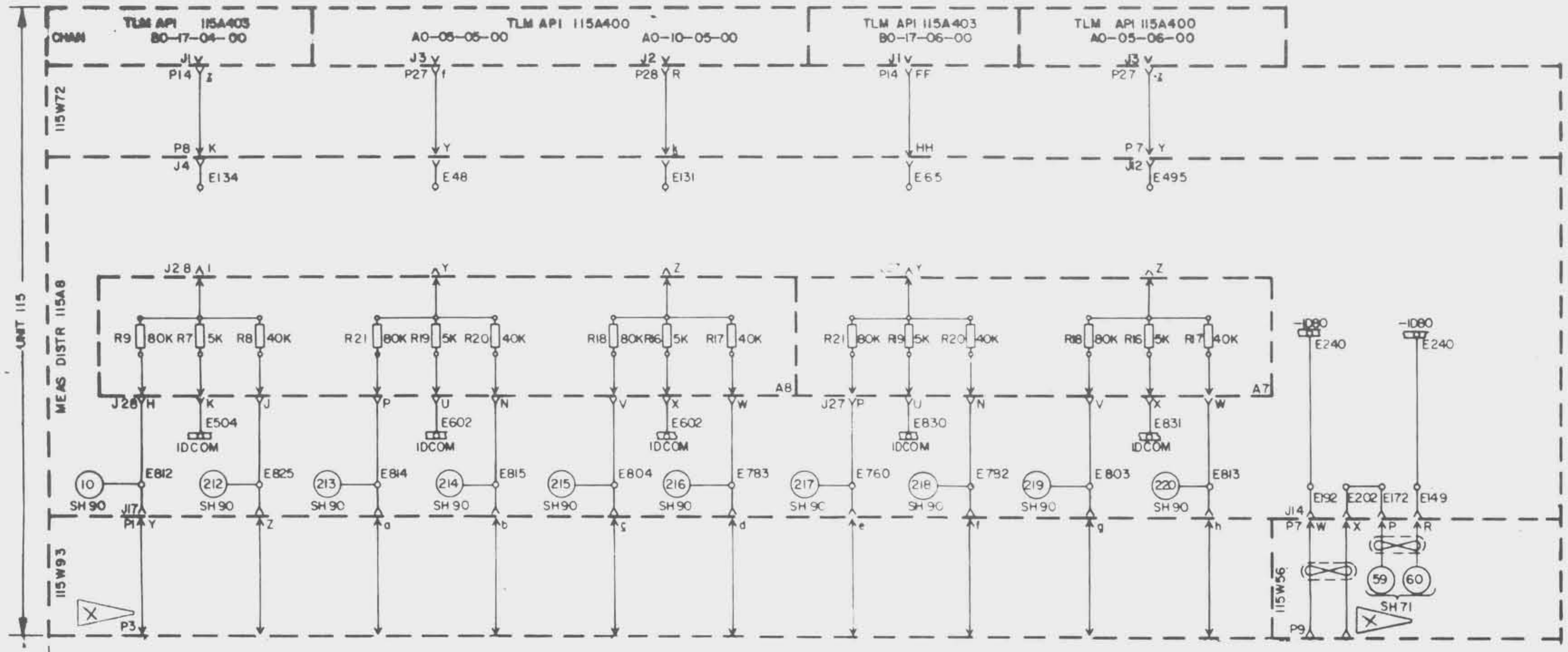

CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)

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APPLICATION

UNLESS OTHERWISE SPECIFIED

S-IC STAGE
ELECTRICAL SCHEMATICS
MEASURING UNIT 105

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

D 14981 60B55401

SHEET 86

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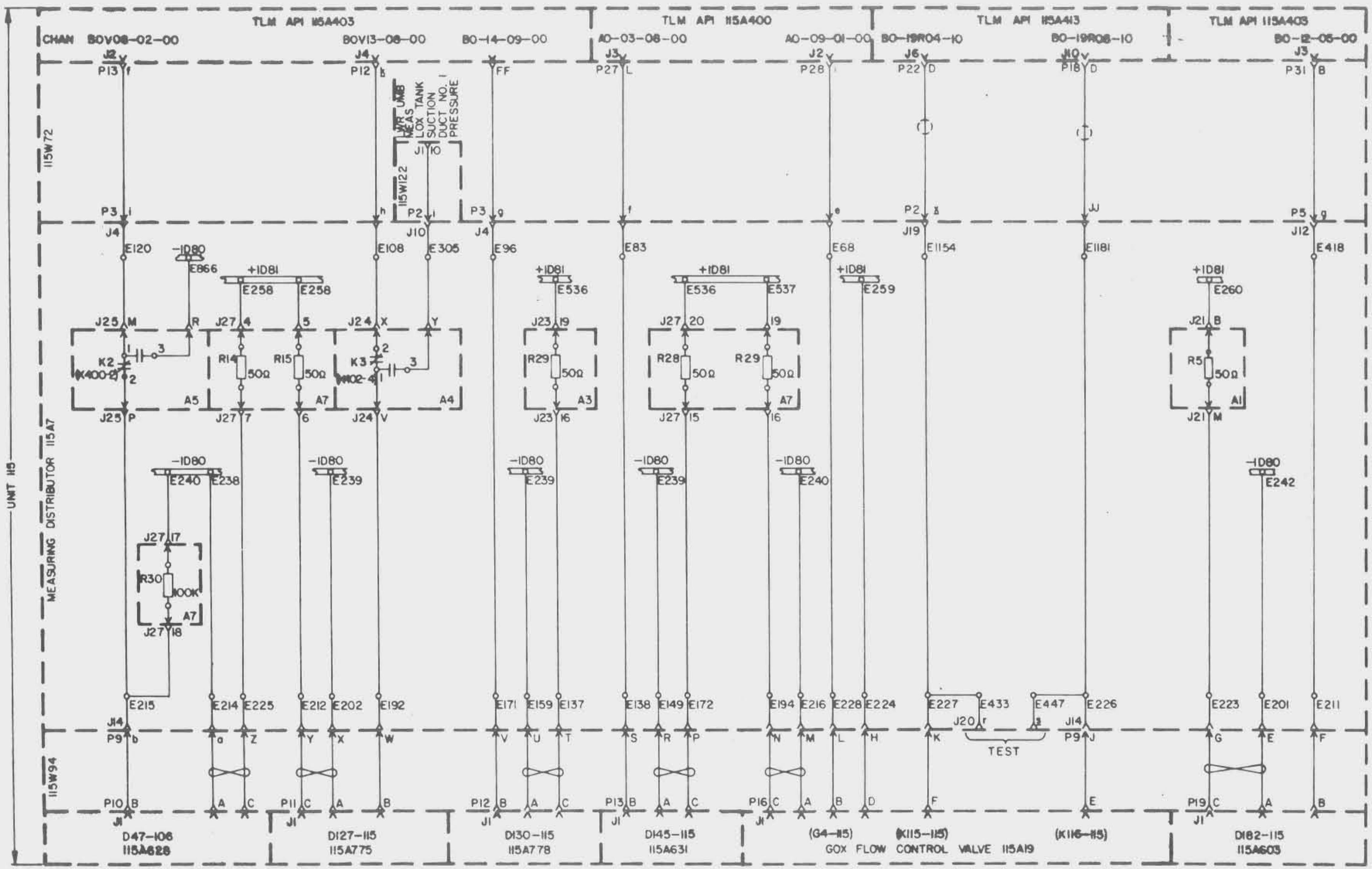
REVISIONS				
	B	SEE SH 1 REV F		



CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)

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APPLICATION

UNLESS OTHERWISE SPECIFIED

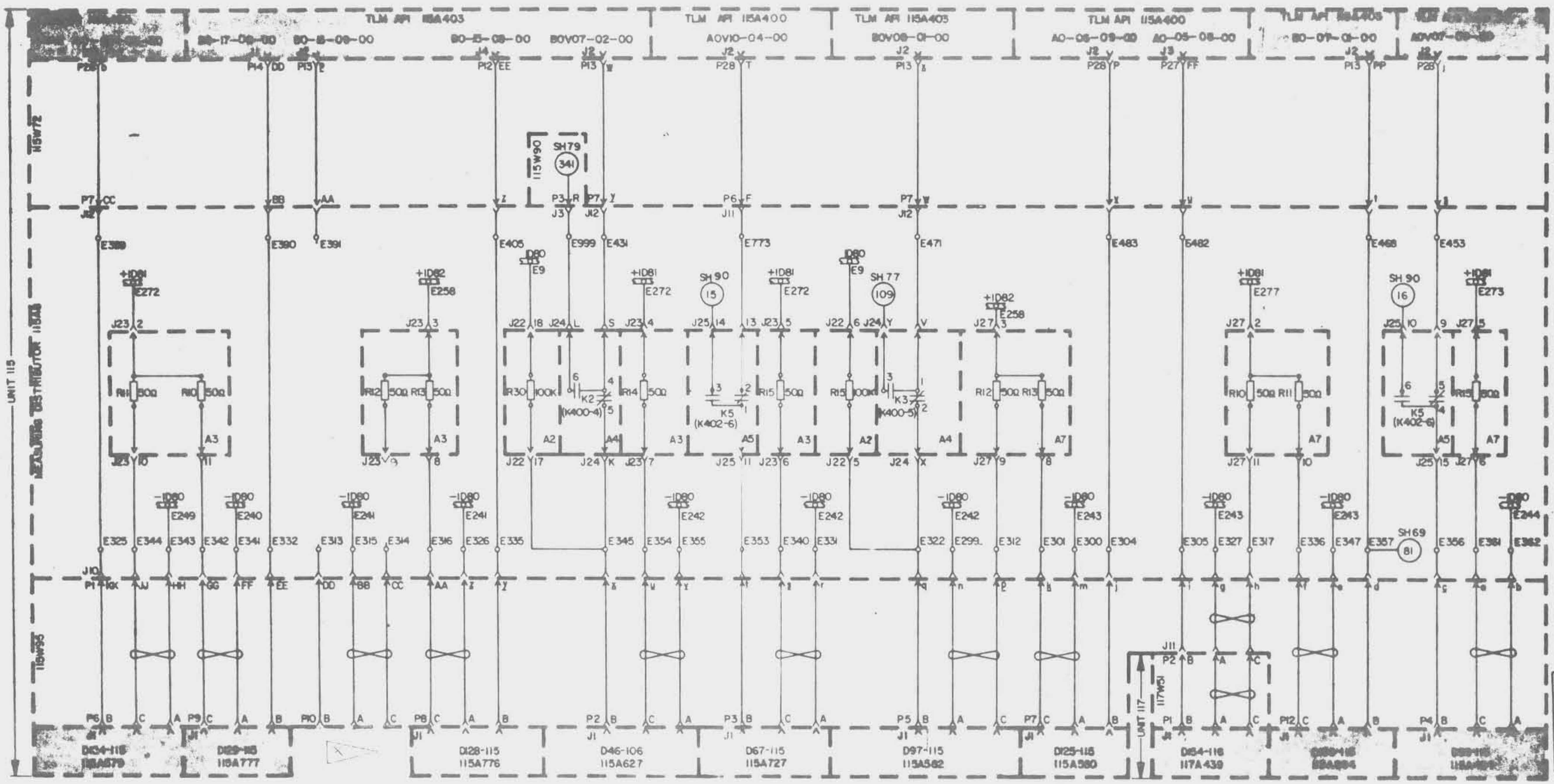
S-IC STAGE
ELECTRICAL SCHEMATICS
MEASURING UNITS
106 & 115

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

CODE 14981 | D | 60B55401

SHEET 87

60B55401 | 87 | B



CUSTODIAN
The Boeing Company
Saturn Branch
(Michoud Operations)

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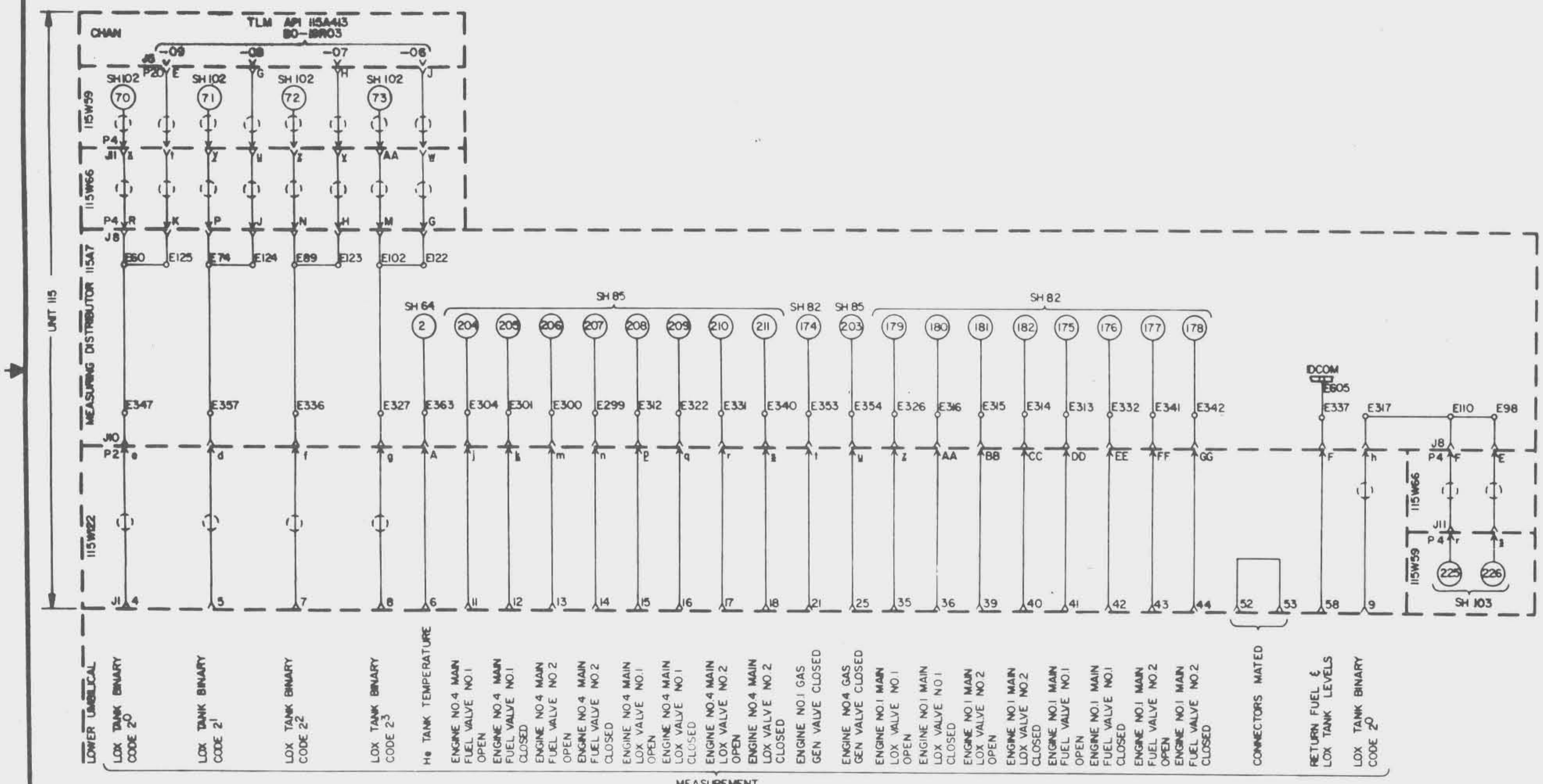
NEXT ASSY	USED ON
APPLICATION	

S-IC STAGE
ELECTRICAL SCHEMATICS
MEASURING UNITS
106, 115 & 116

GEORGE C. MARSHALL
SPACE FLIGHT CENTER
NATIONAL AERONAUTICS
AND SPACE ADMINISTRATION

14981

D 60B55401



CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)

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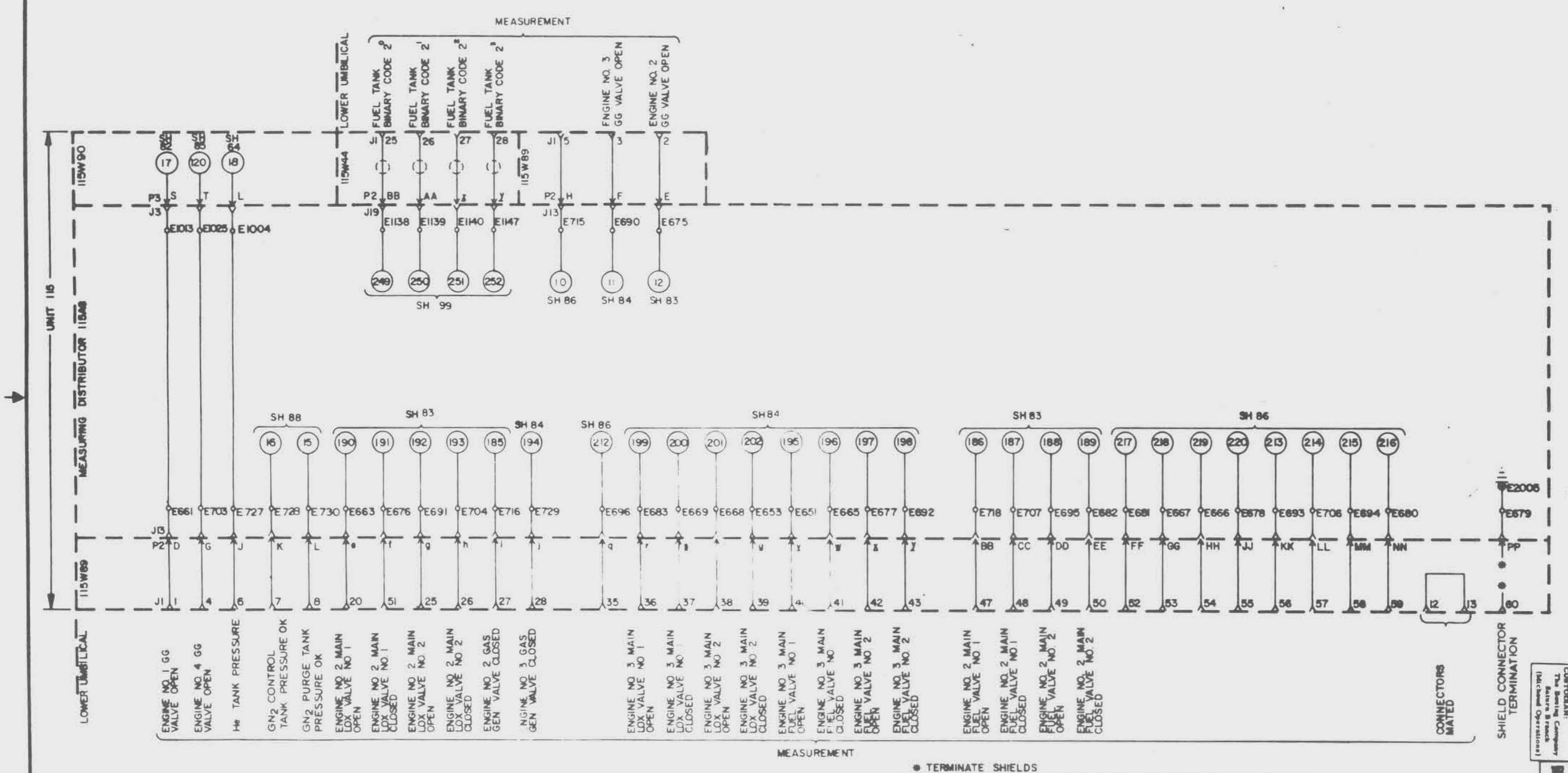
S-IC STAGE ELECTRICAL SCHEMATICS MEASURING UNIT 115

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

14981 D 60B55401 SHEET 89



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S-IC STAGE ELECTRICAL SCHEMATICS
MEASURING UNIT 115

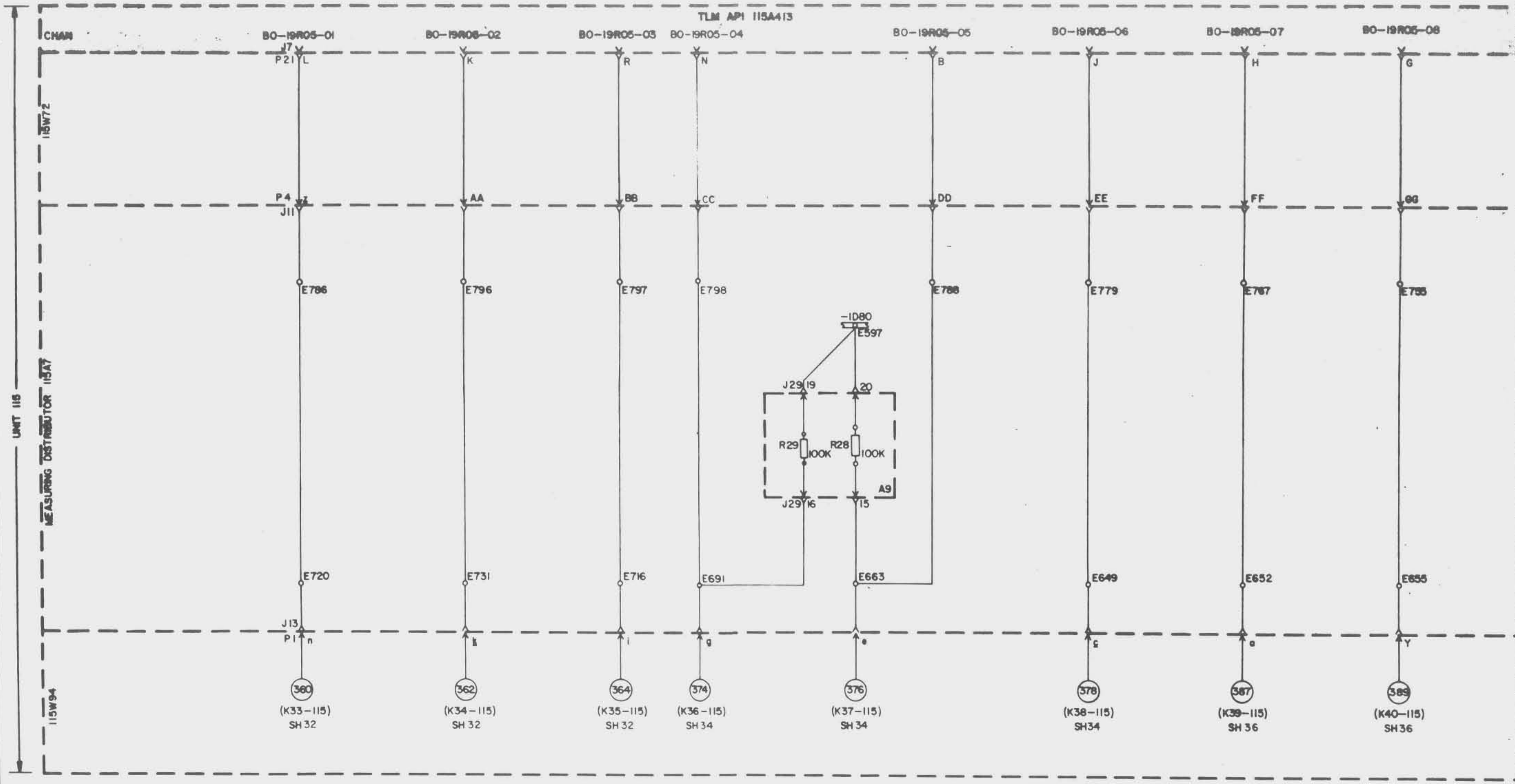
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

14981 D 60B55401
SHEET 90

CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)

CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)

REVISIONS: B SEE SH 1 REV G



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APPLICATION

S-IC STAGE
ELECTRICAL SCHEMATICS
MEASURING UNIT 115

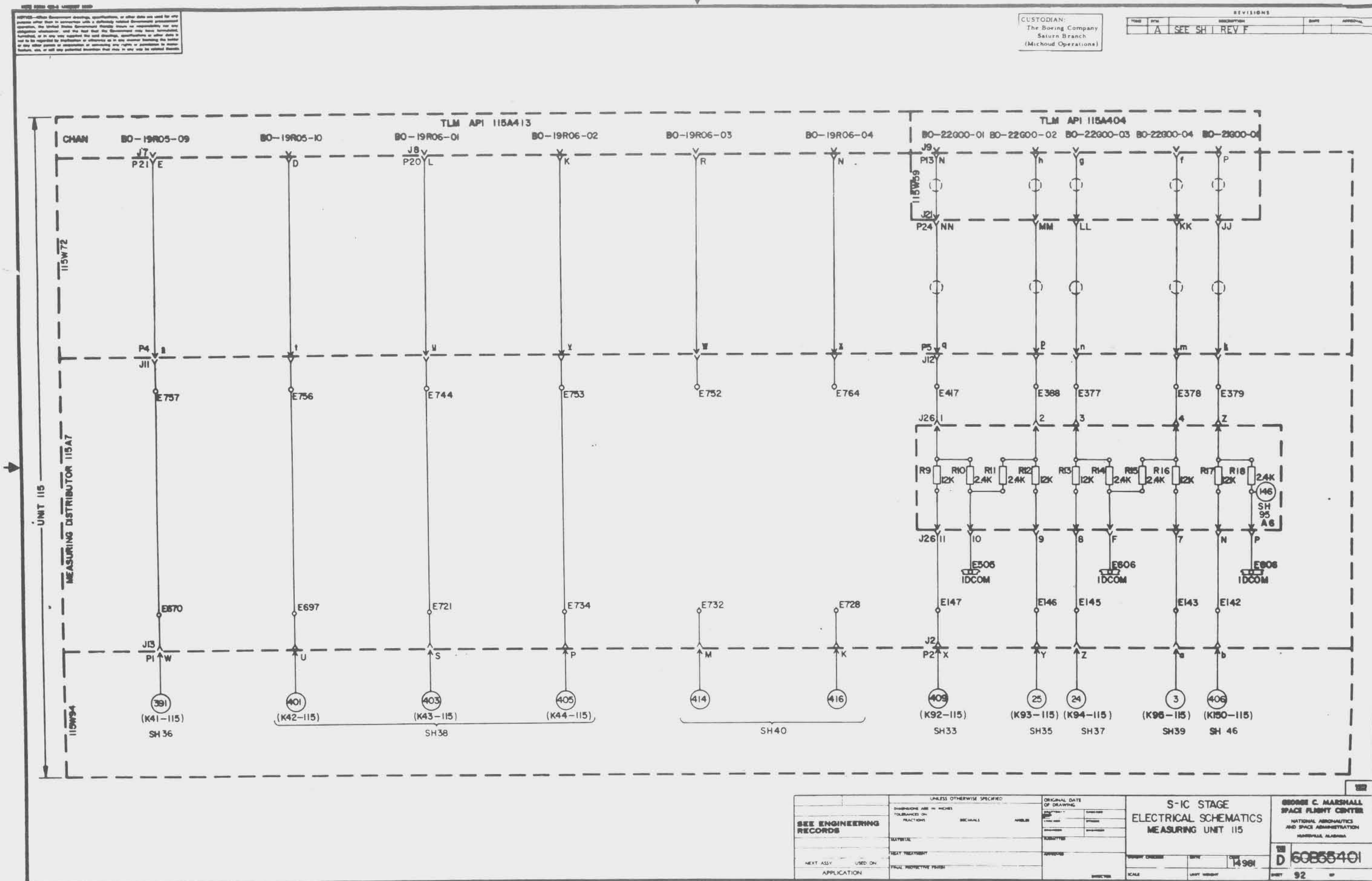
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

14981

D 60B55401

SHEET 91

60B55401 | 91 | B



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APPLICATION

S-IC STAGE ELECTRICAL SCHEMATICS MEASURING UNIT 115

GEORGE C. MARSHALL SPACE FLIGHT CENTER

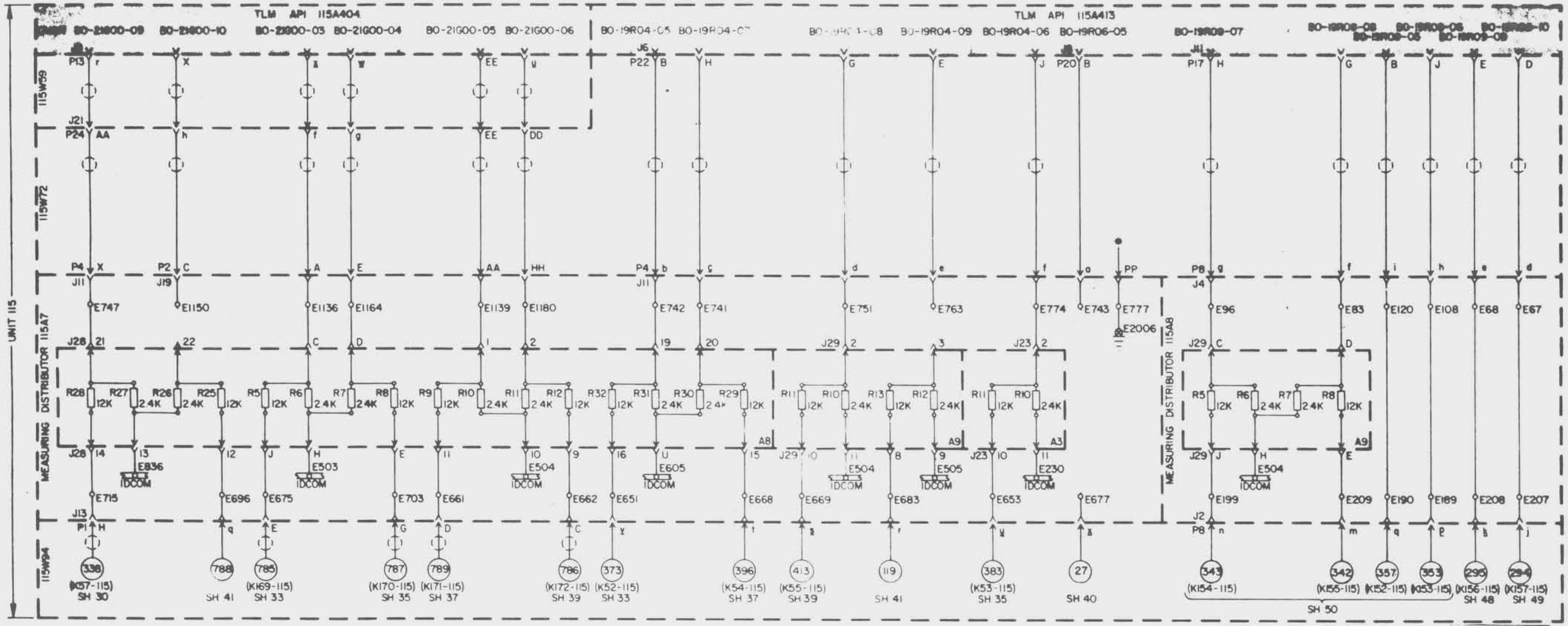
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

HUNTSVILLE, ALABAMA

D 60B55401

14981

SHEET 92



S-IC STAGE ELECTRICAL SCHEMATICS

MEASURING UNIT 115

SEE ENGINEERING RECORDS

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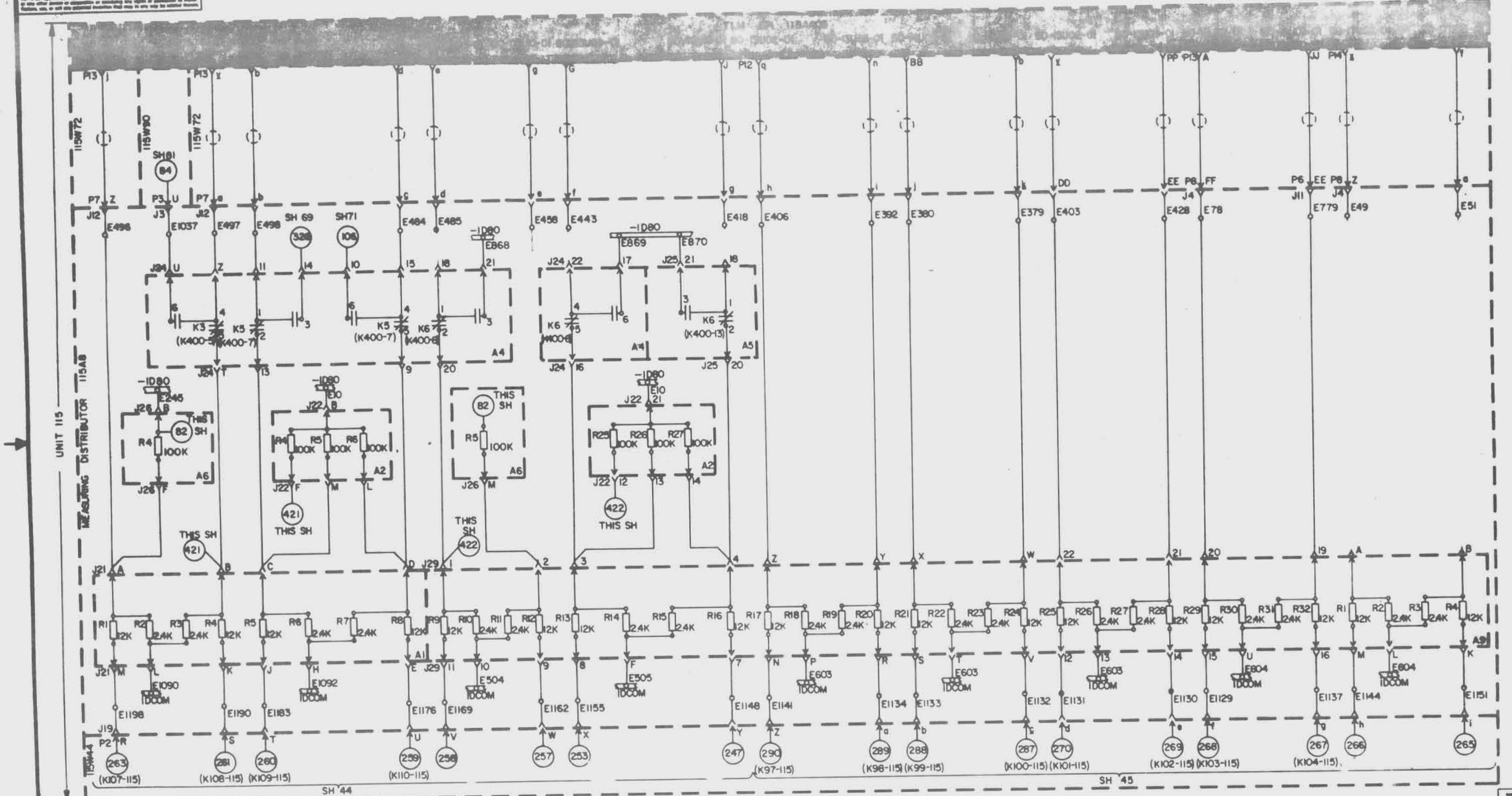
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

D 14981 60B55401

93

The Boeing Company
Saturn Branch
(Michoud Operations)

REVISIONS			
F	A	SEE SH1	REV A



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B	B0V07-10-00	(D8-101)	E	B0V08U10-01	(K110-115)
C	B0V08U09-01	(K109-115)	F	B0V08-10-00	(T1-103)

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NEXT ASSY | USED ON
APPLICATION

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S-IC STAGE
ELECTRICAL SCHEMATICS
MEASURING UNIT 115

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

CODE 14981 | D | 60B55401
SHEET 94

REVISIONS

ZONE	SYM	DESCRIPTION	DATE	APPROVAL
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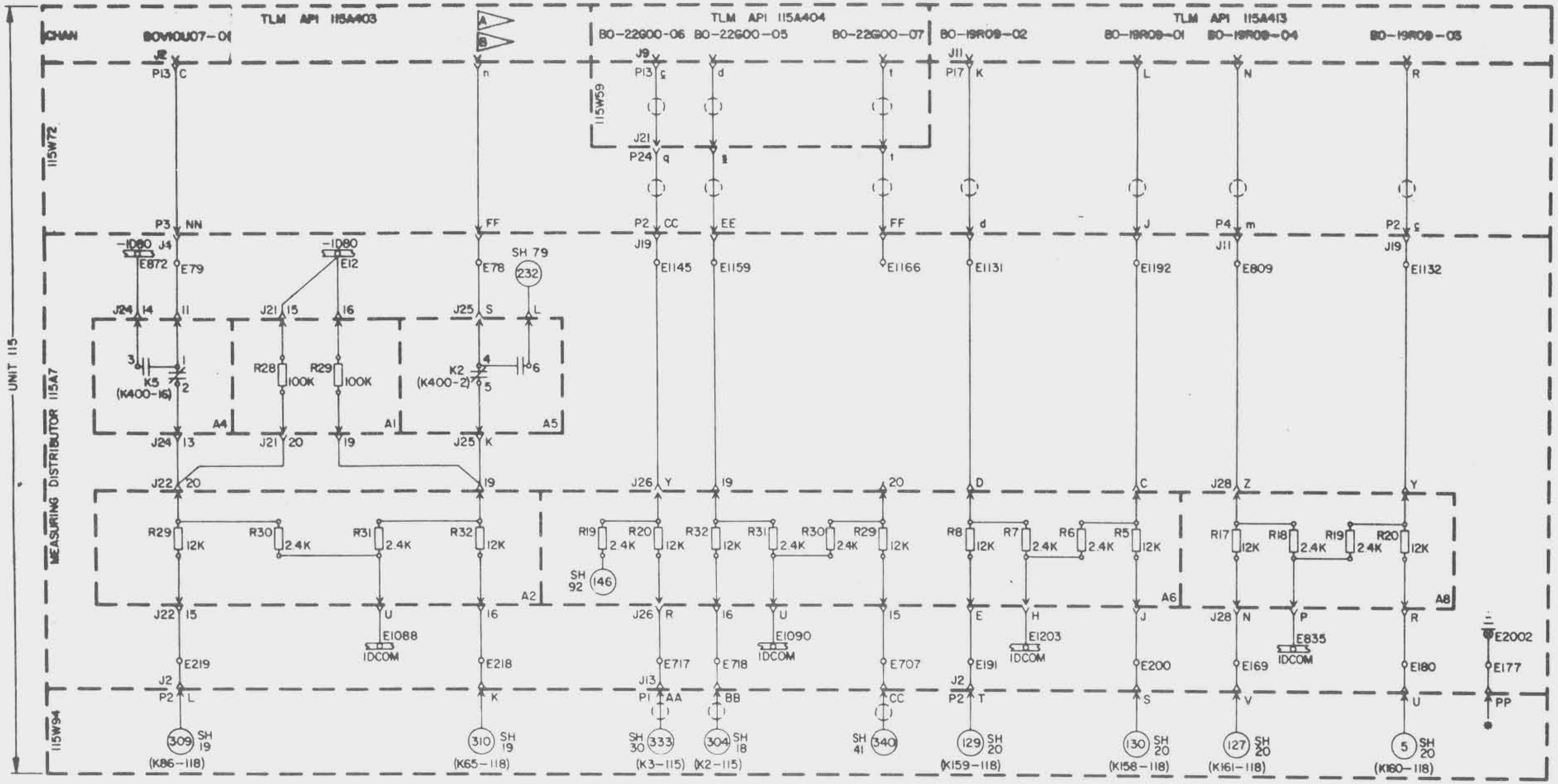

NOTE	CHAN	MEAS
A	B0V09U07-01	(K65-118)
B	B0V09-07-00	(R5-120)

* TERMINATE SHIELDS

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APPLICATION

CUSTODIAN: The Boeing Company Saturn Branch (Michoud Operations)

S-IC STAGE ELECTRICAL SCHEMATICS

MEASURING UNITS 115 & 118

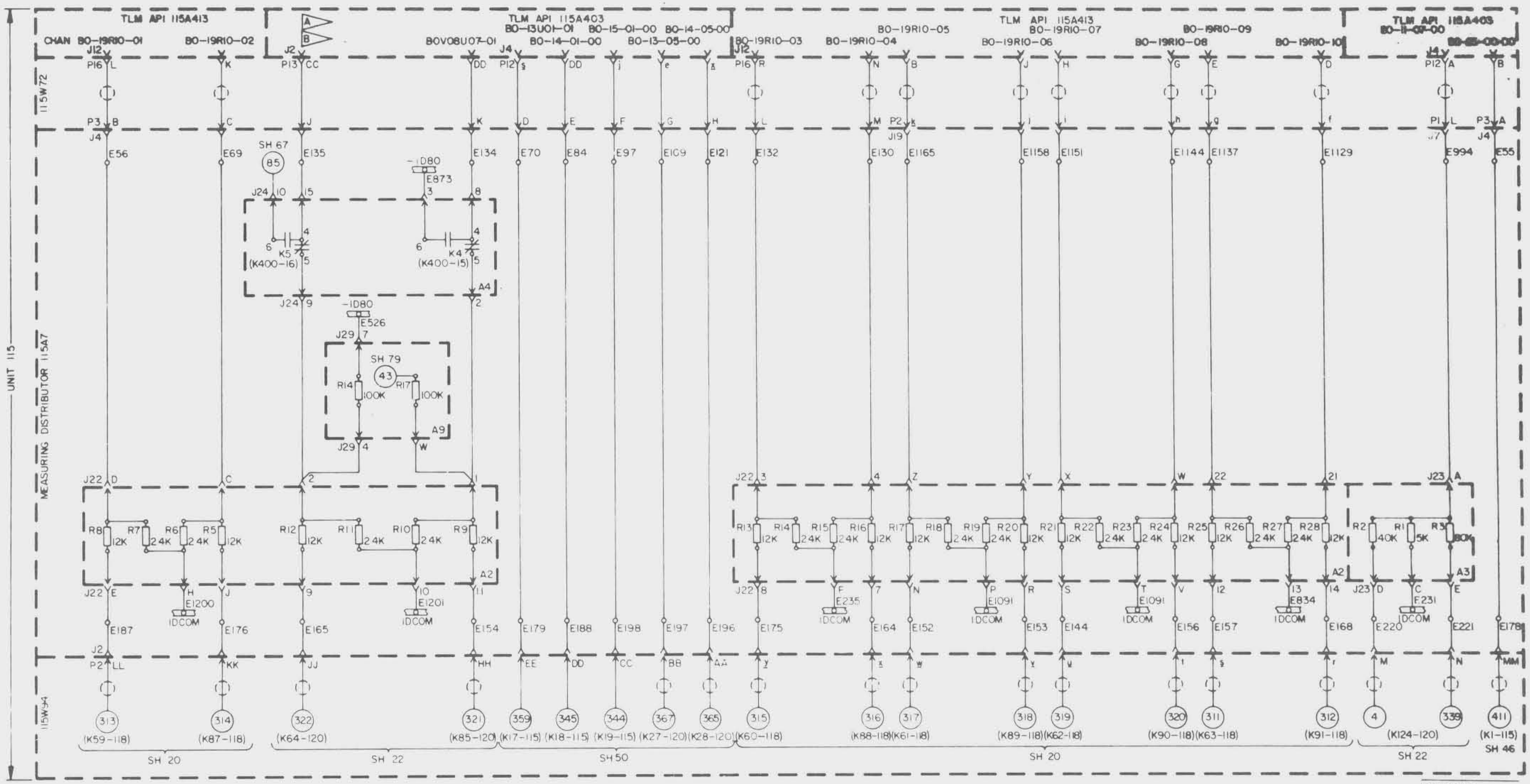
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

CODE 14981 | D | 60B55401

SHEET 95

60B55401 | 95 | B

REVISIONS				
ZONE	SYM	DESCRIPTION	DATE	APPROVAL
	D	SEE SH 1 REV F		



NOTE	CHAN	MEAS
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B	B0V07-07-00	(T1-101)

CUSTODIAN:
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S-IC STAGE
ELECTRICAL SCHEMATICS

MEASURING UNITS
115, 118 & 120

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

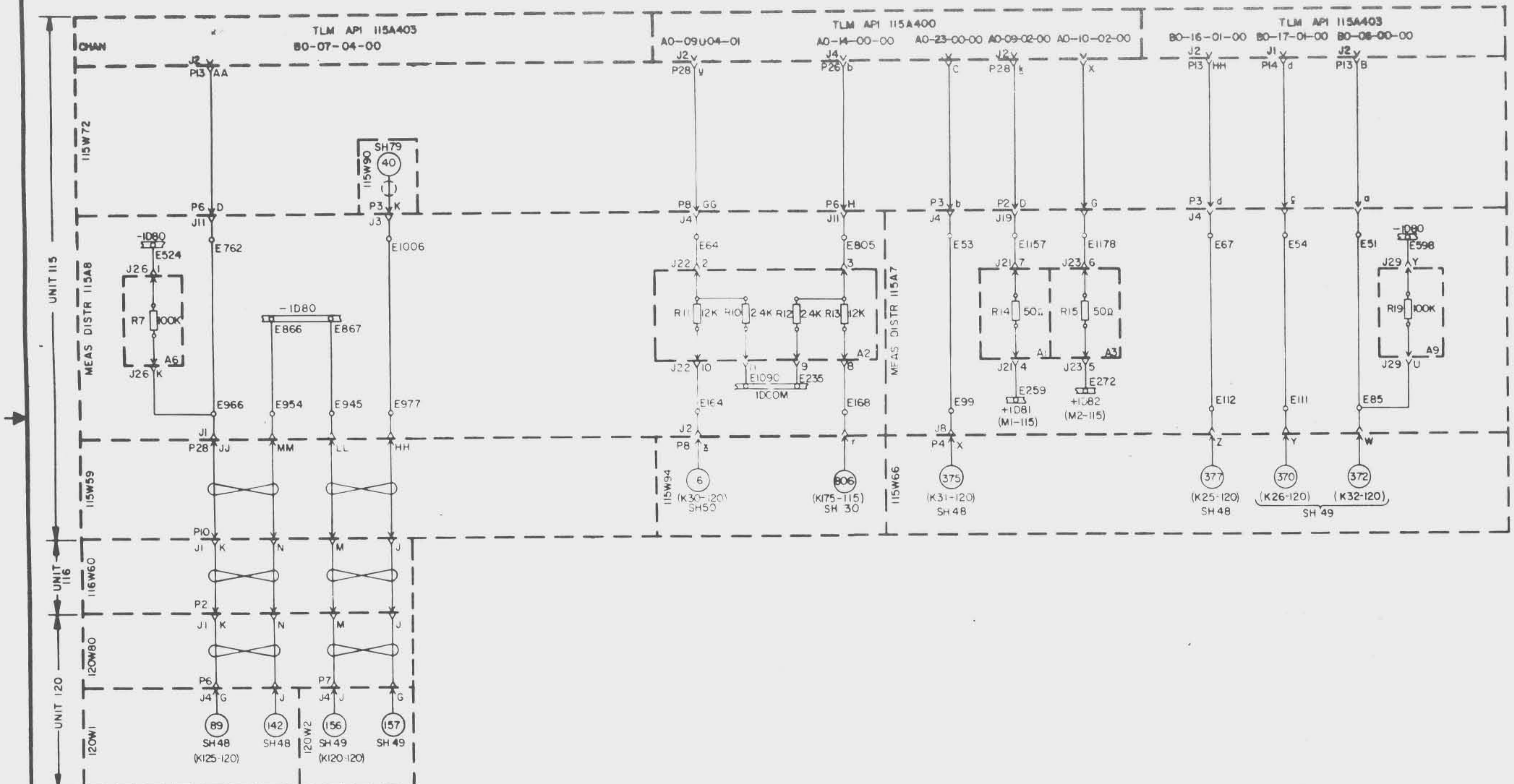
14981

D 60B55401

SHEET 96

60B55401 96 B

ZONE	SYM	DESCRIPTION	DATE	APPROVAL
	C	SEE SH1 REV H		



CUSTODIAN
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Saturn Branch
(Michoud Operations)

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NEXT ASSY / USED ON	
APPLICATION	

S-IC STAGE
ELECTRICAL SCHEMATICS
MEASURING UNITS
115 & 120

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

14981 D 60B55401

SHEET 97

REV	ZONE	SYM	DESCRIPTION	DATE	APPROVAL
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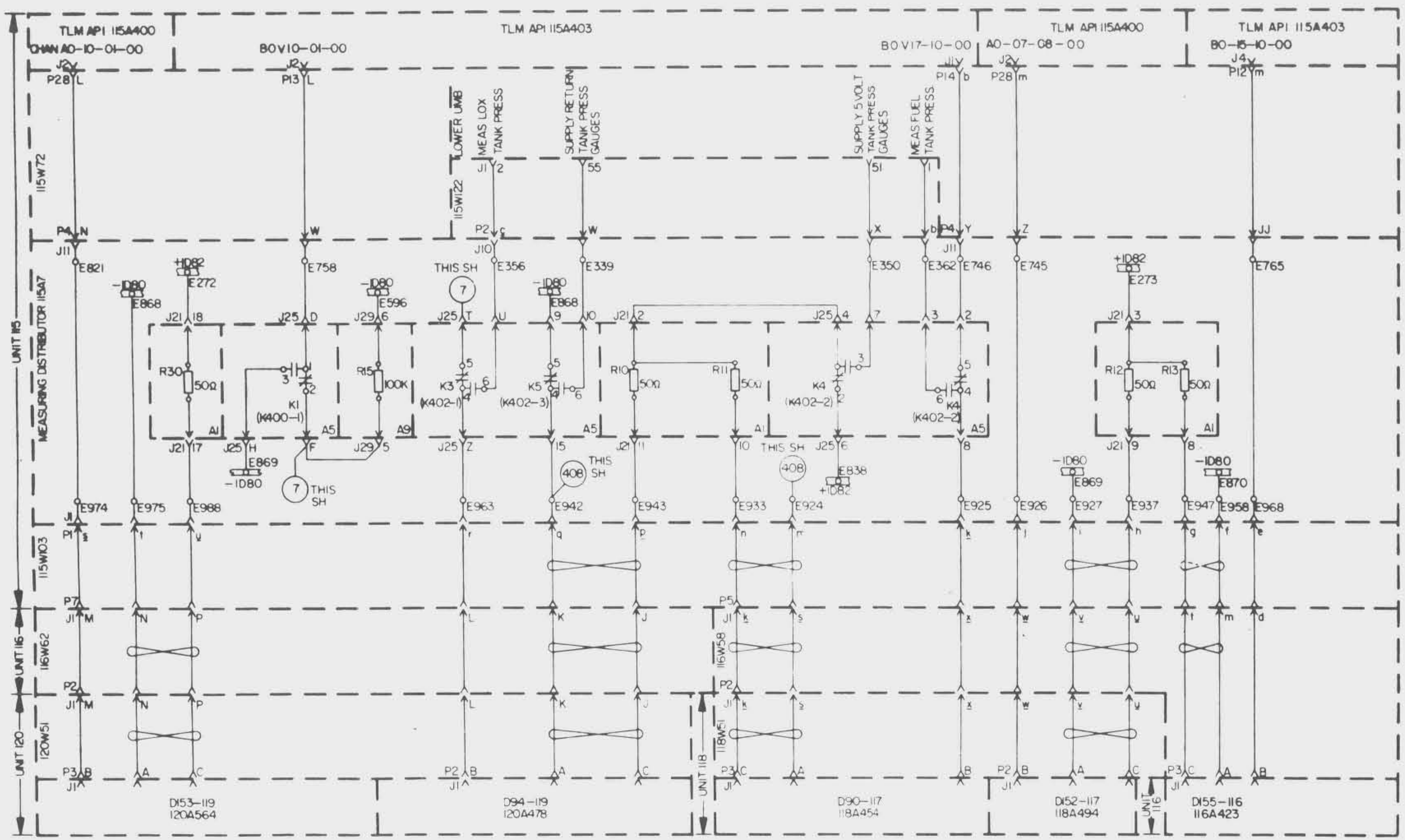

CUSTODIAN
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Saturn Branch
(Michoud Operations)

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APPLICATION	

S-IC STAGE
ELECTRICAL SCHEMATICS
MEASURING UNITS
116,117 & 119

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

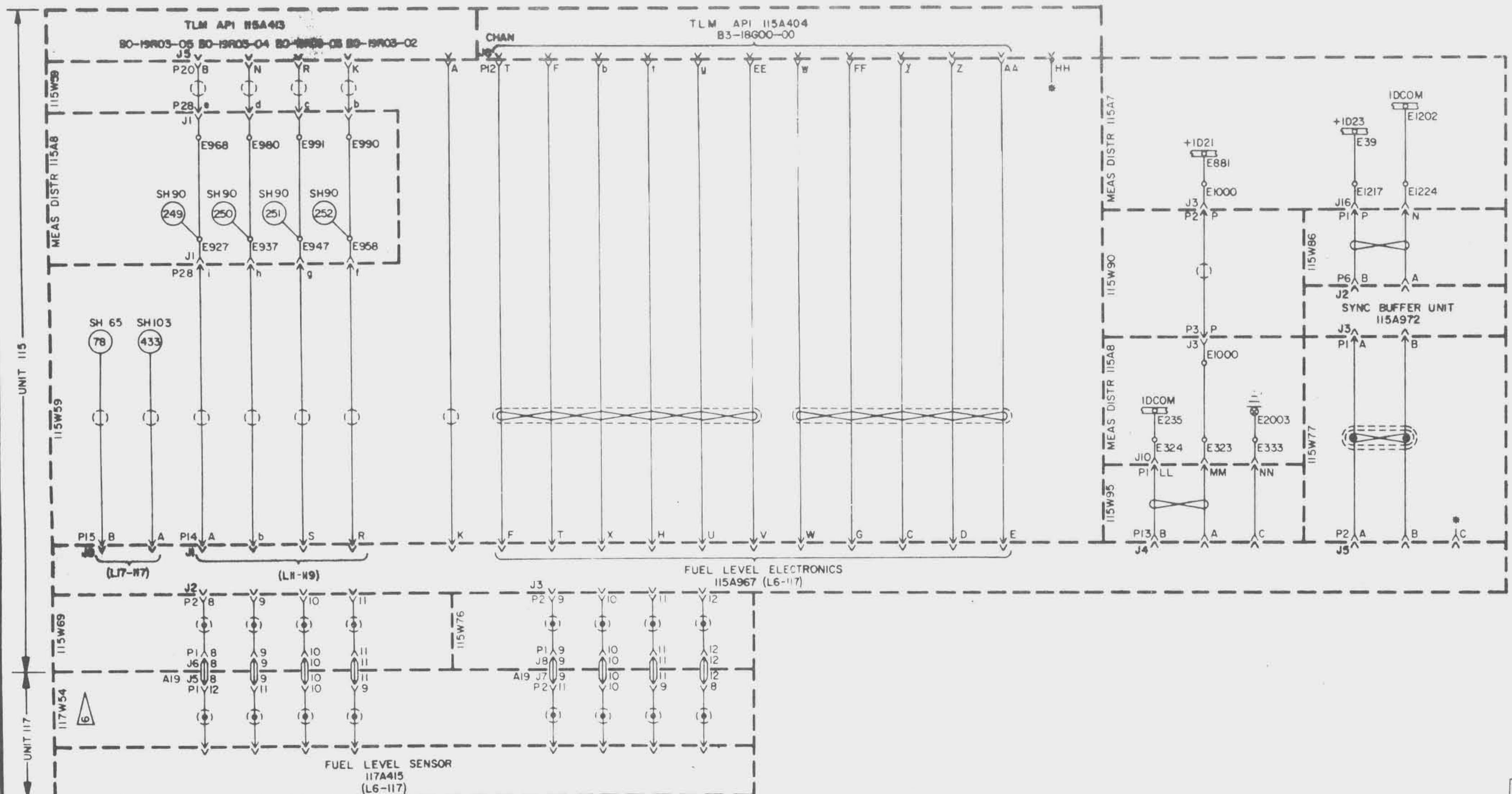
CODE 14981

D 60B55401

SHEET 98

60B55401 98 B

REVISIONS				
ZONE	SYM	DESCRIPTION	DATE	APPROVAL
	A	SEE SH 1 REV E		



* TERMINATE SHIELDS

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S-IC STAGE
ELECTRICAL SCHEMATICS
MEASURING UNITS
117 & 119

GEORGE C. MARSHALL SPACE FLIGHT CENTER
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SHEET 99

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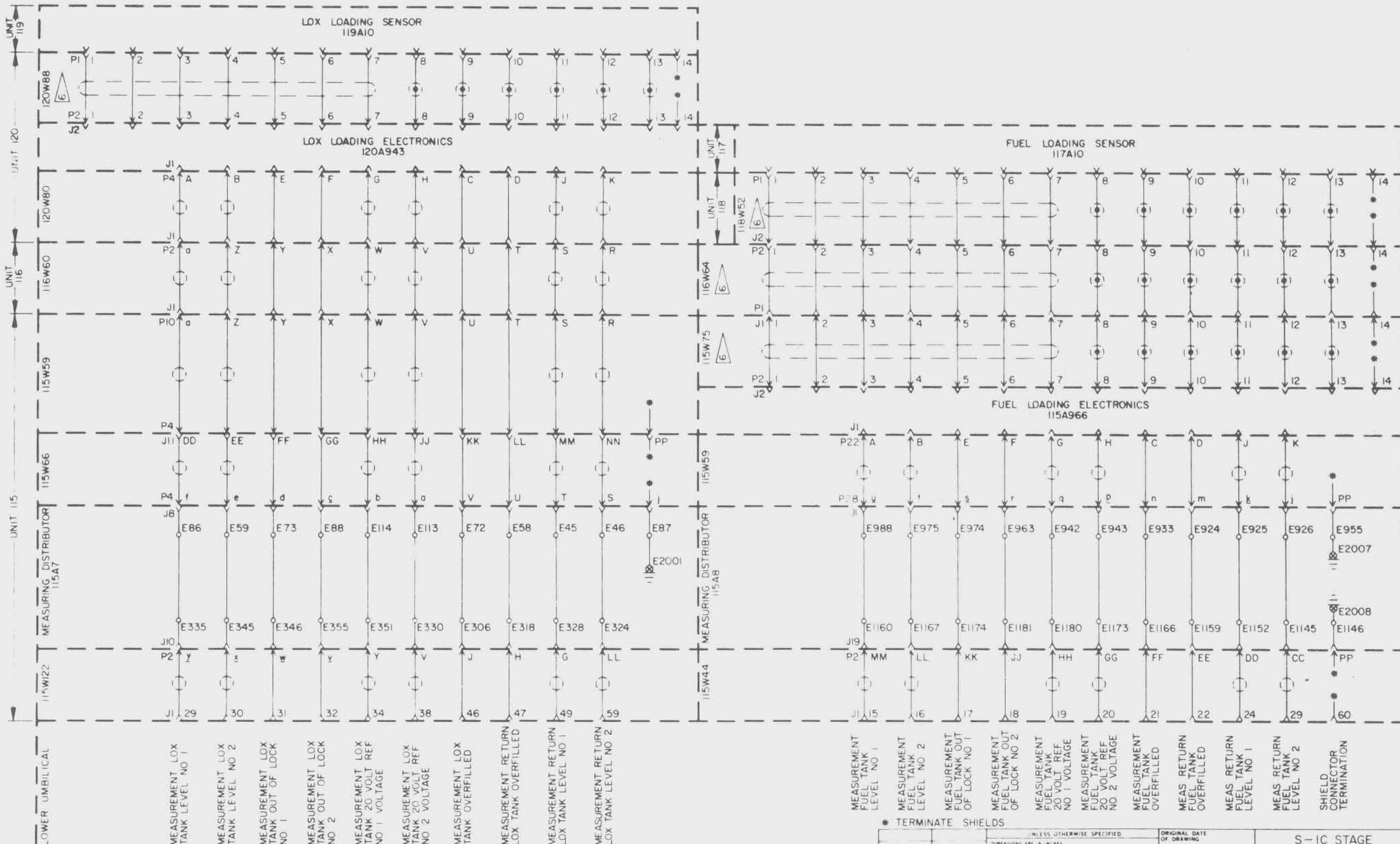

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CUSTODIAN:
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APPLICATION

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S-IC STAGE ELECTRICAL SCHEMATICS

MEASURING UNITS 117 & 119

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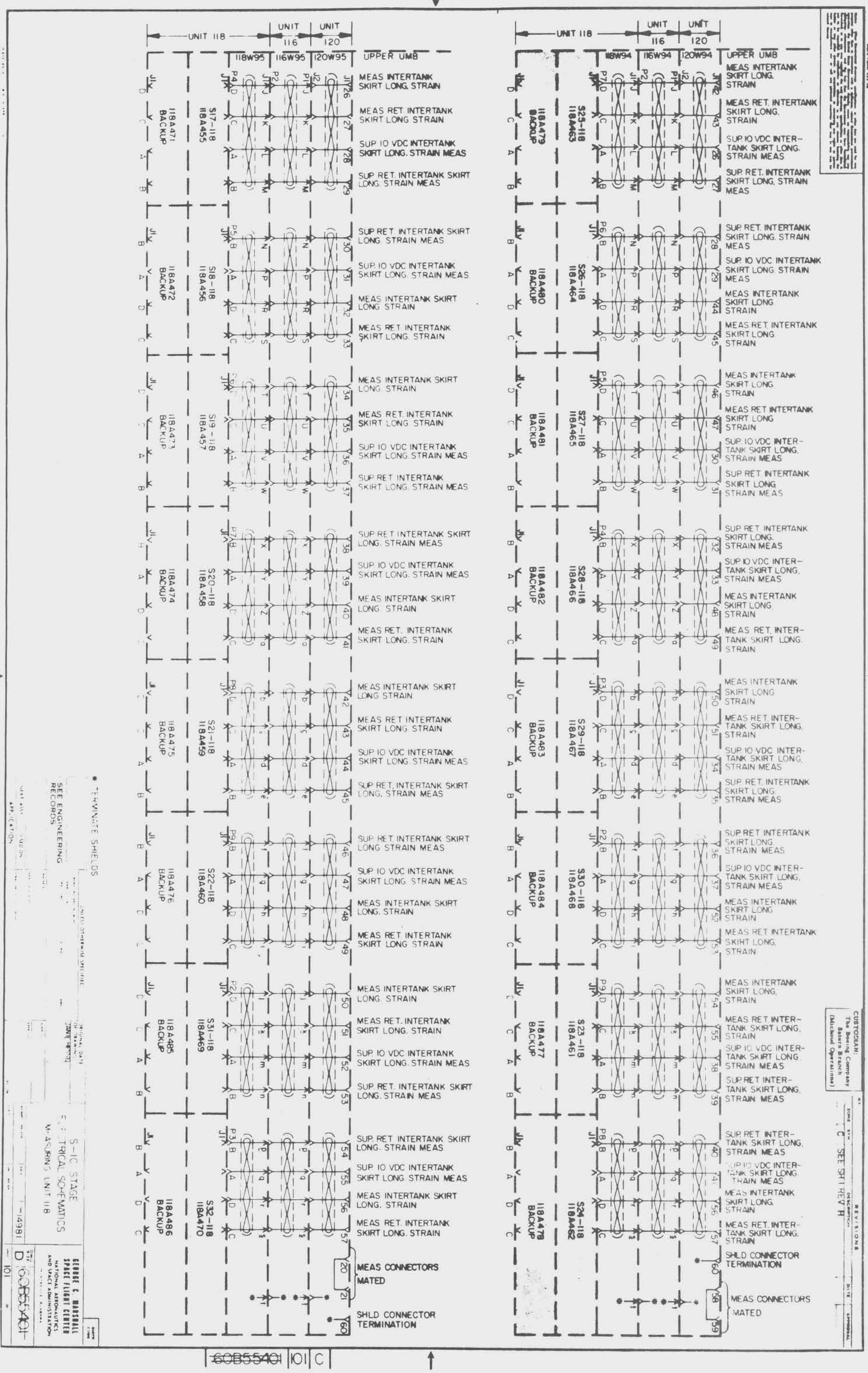

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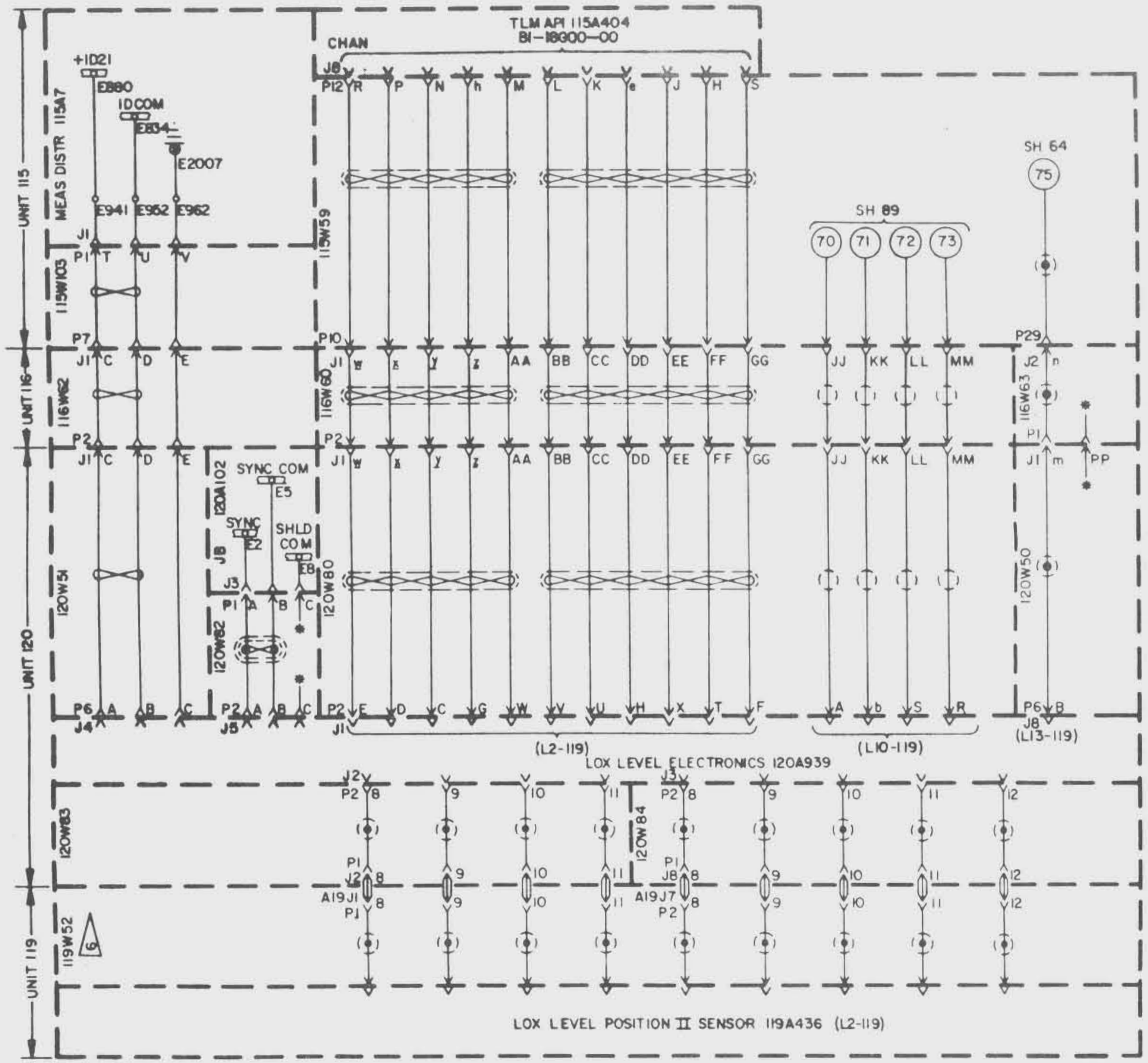

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S-IC STAGE
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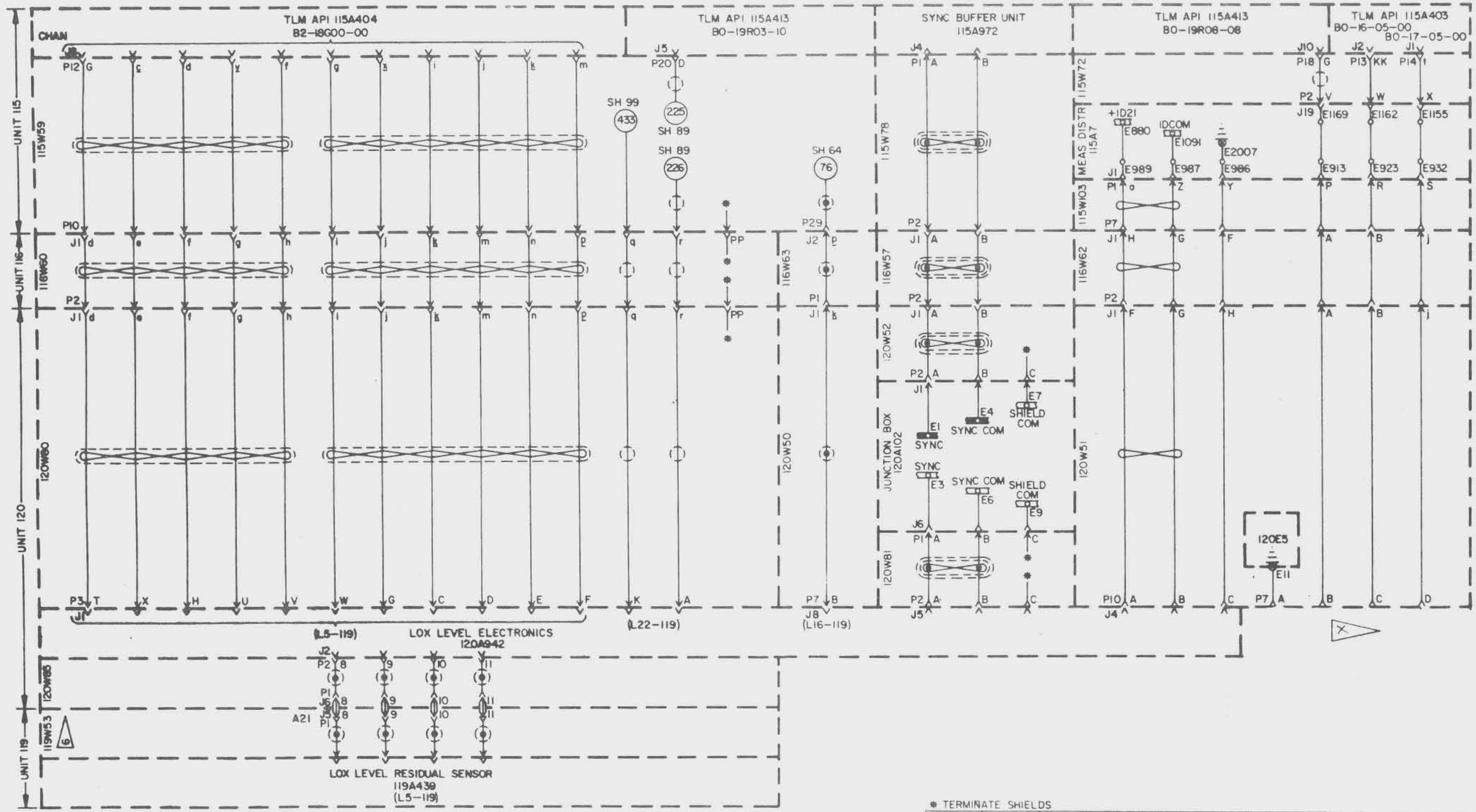

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S-IC STAGE
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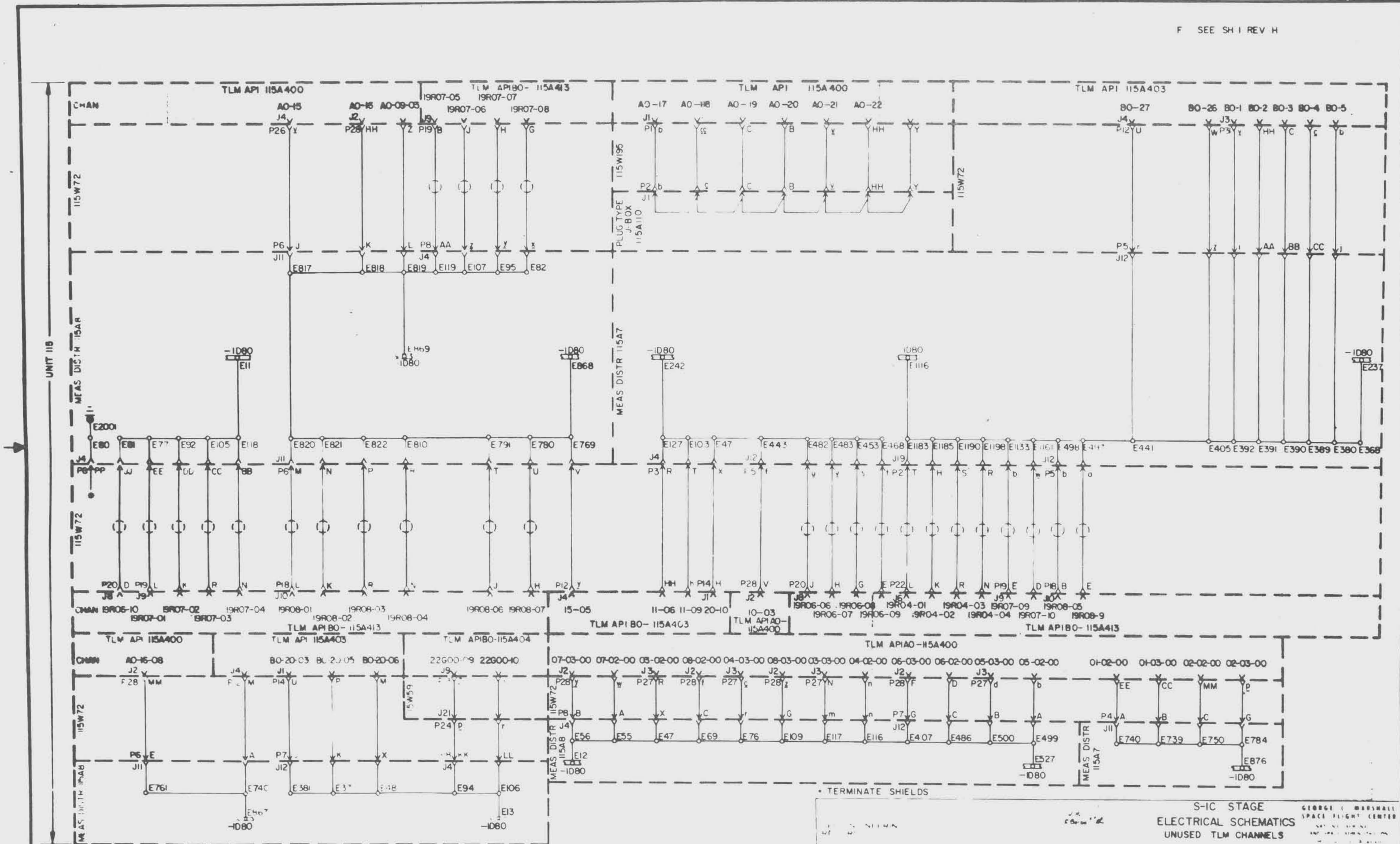

S-IC STAGE
ELECTRICAL SCHEMATICS
UNUSED TLM CHANNELS

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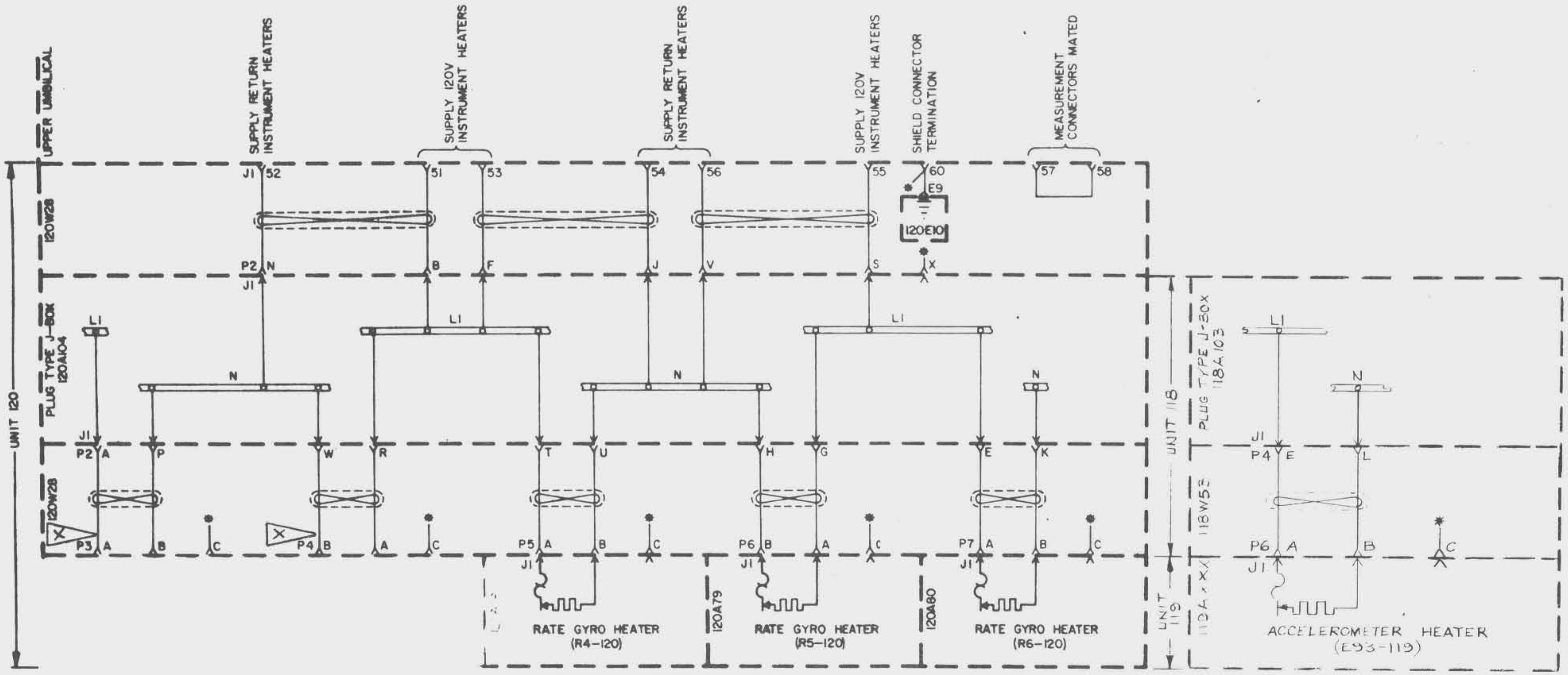

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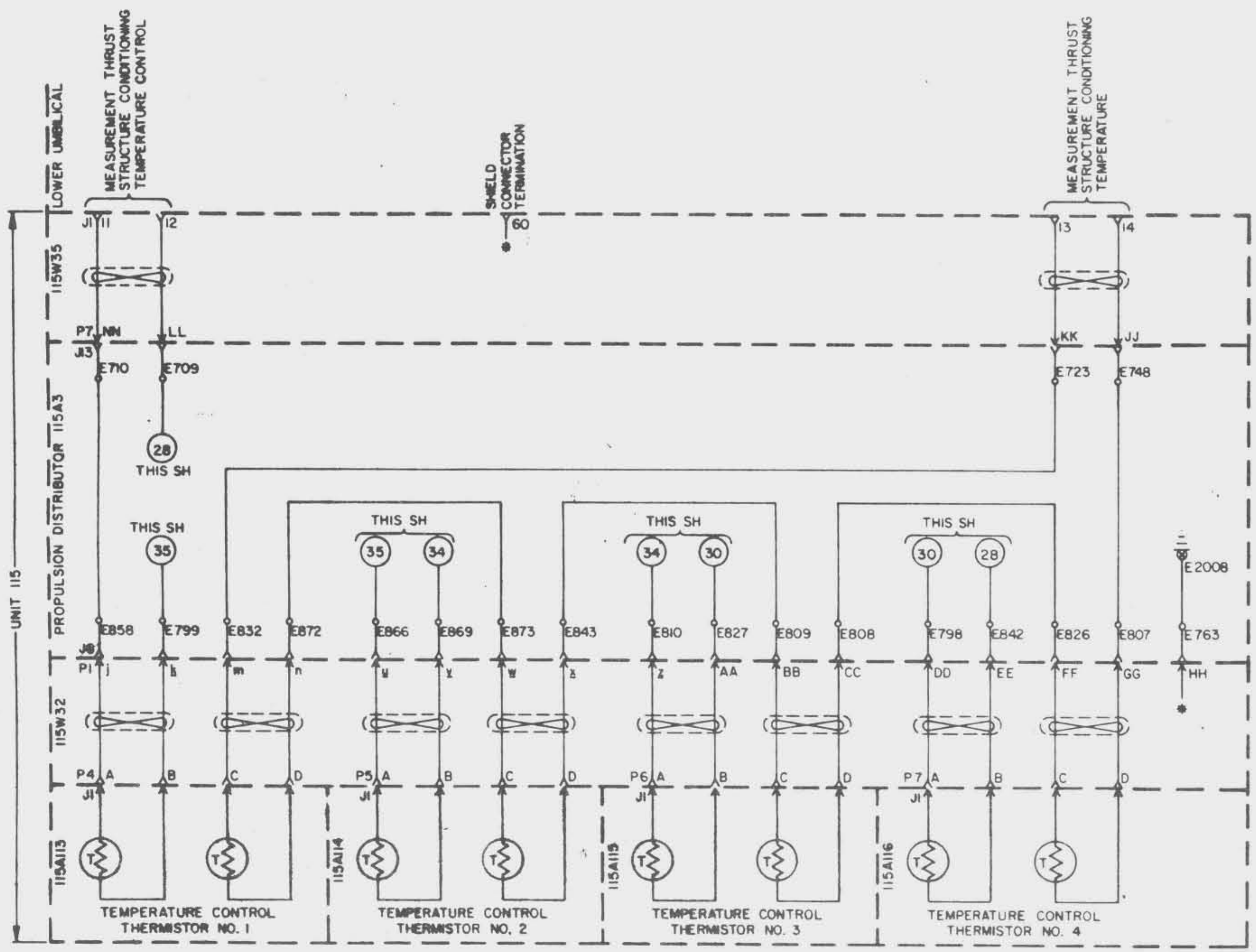

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APPLICATION

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S—IC STAGE
ELECTRICAL SCHEMATICS
THRUST STRUCTURE
CONDITIONING TEMPERATURE
CONTROL

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ACCEPTANCE TEST PLAN

NEW BUSINESS PROPOSAL

INT-20 STAGE

PRELIMINARY

TABLE OF CONTENTS

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1.0 INTRODUCTION

This test plan is a general presentation of the overall Int-20 acceptance test program. The activity described is basically an extension of S-IC testing activities as applicable to the Int-20 stage. The information presented is based on the requirements of Cost plus Incentive - Fee (CPIF) contract NAS8-5608 as appplicable to S-IC-11.

1.1 PURPOSE

The purpose of this document is to:

a. Define in general terms the total Int-20 acceptance test program.

b. Provide for assessment of the adequacy of the overall Int-20 acceptance test program to avoid duplication.

c. Provide a baseline for analyzing the impact of proposed changes in the Int-20 test program.

d. Provide the basic test policies to be used to conduct the test program.

e. Establish the basis for development of detailed test plans.

1.2 SCOPE

This plan defines the acceptance testing and other activity to be performed by S-IC Systems Test during the Int-20 program. The complete sequence of testing of the stage

1.2 (Continued)

is shown. For planning purposes five separate yearly production rates are considered. Three of these five yearly production rates show S-IC and Int-20 production being accomplished together. A sixth alternative (2 S-IC's per year) is also presented in this plan as a baseline. Annual production rates considered in this plan are:

I. 2 S-IC's

II. 2 S-IC's + 2 Int-20's

III. 2 S-IC's + 4 Int-20's

IV. 3 S-IC's + 3 Int-20's

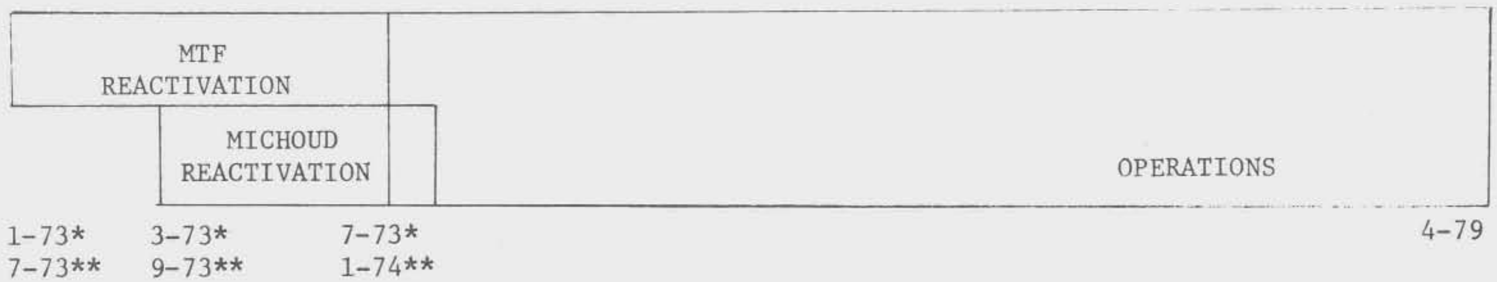
V. 2 Int-20's

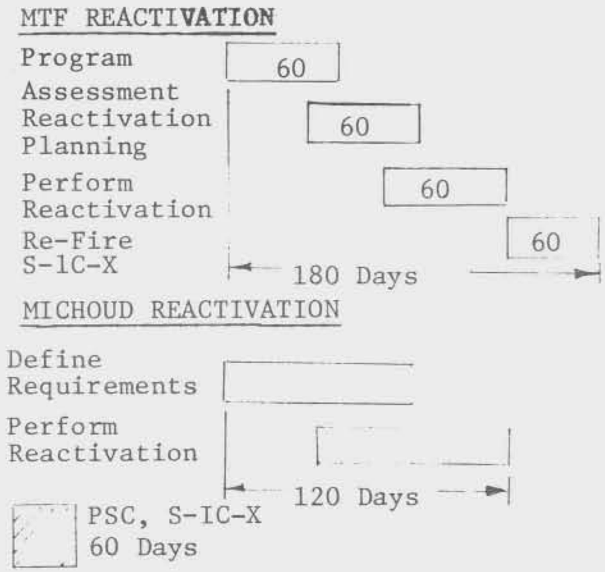
VI. 4 Int-20's

The acceptance testing activities encompassed by this plan are grossly depicted in Figure 1-1. This plan includes only the acceptance testing activities normally conducted by S-IC Systems Test on S-IC stages. Qualification, reliability and development testing of new or modified hardware are not a part of this plan.

It is assumed that all stages will be static fired as part of the acceptance testing. Should static firing testing be deleted all acceptance tests will be conducted in the test period presently defined as PSC. Figure 1-2 grossly depicts the acceptance testing sequence and shows an alternate sequence if static firing is deleted.

INT-20 STAGE PROCESSING PROPOSAL





OPERATIONS

OPTIONS	S-IC's/yr	INT-20's/yr	TOTAL/yr	PMC/SF START	PSC START	END DATE	TEST CREW
I	2	0	2	7-73	10-73	7-78	1 [1]
II	2	2	4	7-73	10-73	10-78	2 [2]
III	2	4	6	7-73	10-73	2-79	2 [2]
IV	3	3	6	7-73	10-73	11-78	2 [2]
V	0	2	2	1-74	4-74	1-79	1 [1]
VI	0	4	4	1-74	4-74	4-79	2 [2]

* Options I thru IV

** Options V thru VI

[1] Options I and V will utilize the optimized test crew concept with sustaining effort between stages

[2] PMC/SF test crew at MTF, PSC test crew at Michoud

FIGURE 1-1

SEQUENCE OF TESTS FOR INTERMEDIATE 20
S-IC STAGES

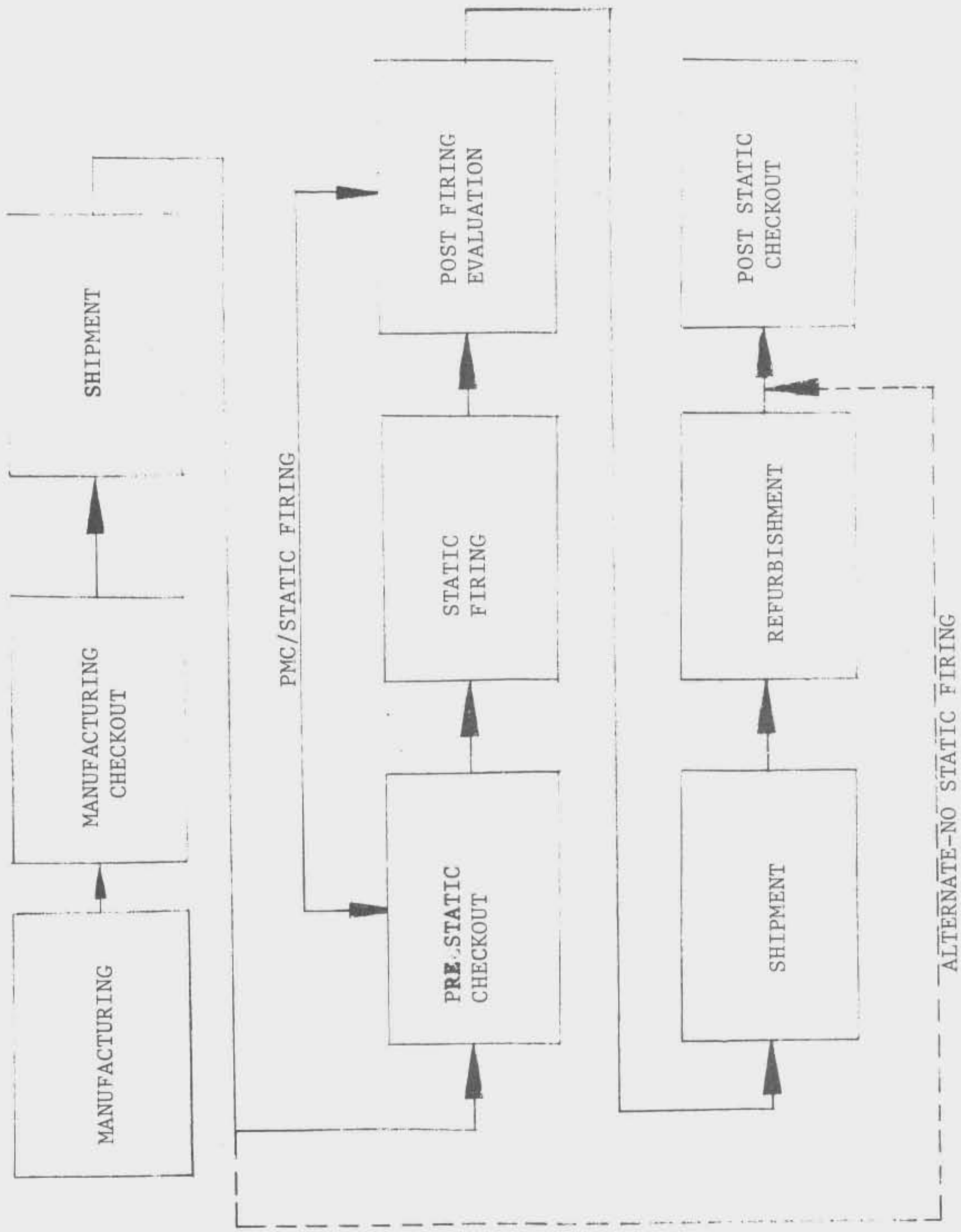


FIGURE 1-2

2.0 INT-20 CONFIGURATION

The Int-20 configuration is grossly described in "Int-20 Study Configuration Definition For Baseline S-IC," dated April 28, 1969, plus supplement. The configuration described is the S-IC-11 stage plus design changes which delete the center engine and its supporting systems. The basic design philosophy used to establish the configuration was to minimize the changes and to maintain the capability of reverting from an S-IC to an Int-20 or vice versa.

2.1 STRUCTURES SUBSYSTEMS

2.1.1 Forward Skirt (60B14009)

Two interface methods are being evaluated. Method 1 consists of adding an adapter ring compatible with the existing interface bolt patterns of both the S-IC and S-IVB. Method 2 consists of modifying the existing interface bolt patterns to attain a pattern compatible with both the S-IC and S-IVB. McDonald Douglas Aircraft Company (MDAC) has responsibility for selecting the interface configuration.

2.1.2 Oxidizer Tank (60B03101)

Oxidizer tank design changes are in the area of the inboard LOX suction duct and result from deletion of the inboard suction duct. A flat plate closure cover with a floating flange, which uses the existing LOX suction duct seal, will be added to close the oxidizer tank at the

2.1.2 (Continued)

inboard LOX suction fitting. The configuration of the cover and floating flange will be the same as presently used for hydrostatic test. The inboard LOX standpipe will be deleted. A support ring will be added to the inside of the inboard LOX suction fitting to replace the support provided to the cruciform baffle by the standpipe flange. Existing standpipe and suction duct attachment provisions in the inboard LOX suction fitting will be used for the attachment of the added ring and cover.

2.1.3 Intertank (60B29800)

No structural changes are required in the intertank area.

2.1.4 Fuel Tank (60B25001)

Flat plate closure covers will be added to the inboard fuel suction elbows to close the fuel tank. These covers will utilize existing fuel suction duct attachment provisions and seals. A non-structural and non-sealing cover will be added at the forward end of the inboard LOX tunnel. Existing tunnel handling holes will be used for attachment of the cover. The eight lower fuel tank bulkhead base gore segments will be revised to increase the thickness in the area near the Y-ring, providing increased hoop compression capability.

2.1.5 Thrust Structure (60B18054)

Thrust structure changes consist of deleting the center engine and inboard fuel suction duct support provisions. The center engine support struts, strut insulation, strut fittings, the associated strut attach hardware and the center engine adapter fitting will be deleted. The strut fitting and adapter fitting attach hardware will be retained as they provide common attachment for adjacent structure.

2.1.6 Heat Shield

The base heat shield will be revised to delete penetrations provided for the center engine and its associated systems. The array of small heat shield panels in the center engine area will be replaced with standard square panels. For flight, 6 standard flight panels will be used. For static firing, 6 standard static firing honeycomb panels and 6 standard static firing steel back-up panels will be used. The center engine flame curtain will also be deleted.

The center area heat shield support structure will be revised to a square beam grid compatible with the 6 square heat shield panels. A new bracket will be added to support the panels at the deleted center engine adapter location.

2.2 PROPULSION AND MECHANICAL SUBSYSTEMS

Changes to Propulsion and Mechanical subsystems result primarily from removal of the center engine. System deletion will be from the center engine interface to a joint

2.2 (Continued)

upstream which will result in minimum design change and minimum possible leak points.

2.2.1 Oxidizer Fill and Drain (60B41012)

No changes are required to this system.

2.2.2 Oxidizer Feed System (60B41014)

The inboard LOX suction duct, LOX prevalve and PVC duct will be deleted. A support adapter which attaches to the inboard propellant duct support structure will be added to support the LOX interconnect spool. Closure plates which use existing seals will be provided to seal the upper and lower ends of the interconnect spool. LOX cutoff sensors for engines 2, 4 and 5 will be deleted and bosses plugged. An additional sensor will be installed in an existing boss at the forward end of engines 1 and 3 LOX suction ducts.

2.2.3 Oxidizer Conditioning System (60B41014 and 60B41221)

The interconnect valve at engine position 2 will be replaced with a spool. A temperature transducer will be installed in an existing boss in the center LOX spool. The center engine bubbling system will be deleted from the branch tee to the center LOX spool. The tee will be capped and the LOX spool boss plugged.

2.2.4 Oxidizer Pressurization (60B51400)

The GOX return duct between the center engine interface and the GOX manifold will be deleted. The GOX manifold will be capped at the center engine port.

2.2.5 Fuel Fill and Drain (60B43014)

To satisfy loading criteria the fuel loading probe will be lengthened 14 inches. The minimum anticipated fuel loading will be station 640, and maximum use will be station 644.

2.2.6 Fuel Feed System (60B43014)

All inboard fuel feed system hardware aft of the fuel suction elbows at the bottom tank bulkhead will be deleted.

2.2.7 Fuel Pressurization System (60B49600)

The helium supply and return ducts between the inboard engine interface and the respective helium manifolds will be deleted. The inboard engine branches from the supply and return manifolds will be capped. A redundant fuel vent and relief pressure switch will be added and the existing pressure switch inhibited until T+50 seconds.

2.3 AUXILIARY MECHANICAL SUBSYSTEMS

2.3.1 Control Pressure System (60B52500)

The control pressure system associated with the inboard engine prevalves will be deleted.

2.3.2 Environmental Control System

No changes will be made to the environmental control system.

2.3.3 <u>Turbopump Oxidizer Seal Purge (60B37601)</u>

The turbopump oxidizer seal purge to the center engine will be deleted in its entirity on the operational configuration. On the first flight vehicles this system will be used to purge a calorimeter located on the base heat shield. The center engine turbopump oxidizer seal purge line will be deleted from the engine interface fitting to the first upstream union. An orifice will be installed at this union and a new line segment will be added from the union to the above calorimeter.

2.3.4 <u>LOX Dome and GG LOX Injector Purge (60B37600)</u>

The entire center branch line will be deleted and the manifold duct assembly plugged.

2.3.5 <u>Engine Cocoon Thermal Conditioning Purge (60B37602)</u>

The manifold tee, supplying the center engine, will be plugged and all downstream tubing deleted.

2.3.6 <u>Thrust OK Checkout System (60B37600)</u>

The center engine branch tee will be capped and all tube assemblies downstream deleted.

2.3.7 <u>Thrust Chamber Prefill System (60B37550)</u>

All hardware downstream of the center engine tee will be deleted and the tee will be plugged.

2.3.8 <u>POGO Suppression System (60B41840)</u>

Changes to the POGO suppression system are based on the ECP-446 R3 and ECP-512 R2 configuration. The tee supplying the center engine will be plugged and all downstream tubing deleted.

2.4 FLIGHT CONTROL SUBSYSTEM

2.4.1 Fluid Power System (60B82000)

The center engine ground hydraulic supply and return ducts will be deleted. The center engine branches on the supply and return duct manifolds will be capped.

2.4.2 Thrust Vector Control System (60B84000)

Early cutoff of engines 2 and 4 (at 146 seconds) will result in loss of hydraulic pressure to the servo-actuators. Except for the inherent damping of the fluid left in the actuators, engines 2 and 4 will be unrestrained. The design change resulting from this condition, if any, is yet to be determined.

2.5 ENGINE AND RELATED COMPONENTS

The center engine will be deleted. Associated static firing GN_2 purge, all center engine attachment and support hardware and thermal insulation will be deleted.

2.6 ELECTRICAL AND ORDNANCE SYSTEMS

All cables not used will be tied and stowed. Engine 5 circuitry will be deactivated with minimum changes and left installed in the distributors. Two new LOX level sensors will be installed in LOX lines 1 and 3 along with the present sensors. LOX level sensors in lines 2 and 4 will not be used. The electrical circuit for engine cutoff will be revised such that the Instrument Unit (IU) will have the capability to reverse cutoff sequence in the

2.6 (Continued)

event engine 1 or 3 is cutoff prior to engines 2 and 4 cutoff. Engine cutoff in flight normally will be a timed or "G" limit cutoff instead of a propellant depletion cutoff. Engines 2 and 4 will be cut off early, either by "G" limit or at 146 seconds. Engines 1 and 3 will normally be cut off by "G" limit or at 211 seconds.

2.7 FLIGHT MEASURING SYSTEM

A total of 18 new flight measurements will be added consisting of:

Temperature	- 7
Vibration	- 3
Strain	- 8

Five flight measurements will be deleted.

2.8 HARDWIRE MEASURING SYSTEM (SYSTEM A - STATIC FIRING ONLY)

A total of 77 System A measurements are deleted consisting of:

Temperature (CA)	- 14
Pressure (DA)	- 32
Vibration (EA)	- 3
Flow (FA)	- 1
Position (GA)	- 7
Signals (KA)	- 18
RPM (TA)	- 2

3.0 <u>TEST FACILITIES</u>

Existing S-IC test facilities at MTF and MAF will be utilized for acceptance testing of Int-20 stages.

3.0 (Continued)

Modifications to these facilities, if any, will be identified in a facilities plan.

3.1 MTF TEST FACILITIES

The MTF test facilities consist of a dual position Static Test Stand (STS) (only one position is operable), a Test Control Center (TCC), a Booster Storage Building (BSB), test support systems, technical systems and support equipment. In addition the MTF provides facilities and support required for static firing which are operated by others. These include the Data Acquisition Facility (DAF), Data Handling Center (DHC) and other support such as high pressure industrial water (HPIW), propellants (LOX and RP-1), transportation (land and water), high pressure gases and electrical power. Detailed descriptions of these facilities may be obtained from the Stage Sequence/Operations Plan for S-IC-T/4, D5-11789-000.

3.2 MAF TEST FACILITIES

The MAF acceptance test facilities are contained within the Stage Test Building and consist of four test cells. Only two of the four test cells contain support equipment and test support systems to make them fully operable.

4.0 REACTIVATION OF FACILITIES/EQUIPMENT

It is assumed that the acceptance test facilities at MAF and MTF will be in a condition of storage, having been deactivated for an unknown period of time prior to the beginning of acceptance testing outlined in this plan. A period of reactivation will therefore be necessary prior to acceptance testing of S-IC or Int-20 stages specified in this plan. It is also assumed that a significient number of the test personnel who conduct acceptance testing will be inexperienced in S-IC testing and that a training and certification program will be required.

4.1 MTF REACTIVATION TASKS

The major tasks necessary to reactivate the MTF are:

1. Define reactivation requirements and prepare a reactivation plan.
2. Reinstall equipment and perform functional tests, checkouts, calibrations and sub-system tests.
3. Perform integrated systems tests including pre-static firing tests, countdown and static firing and post static firing tests of S-IC-X (a previously static fired S-IC).
4. Personnel training and certification.

A more detailed breakdown of the MTF reactivation tasks is presented in Figure 4-1.

REACTIVATION TASK DESCRIPTION

MTF

TASK NO.	TASK DESCRIPTION
1	Prepare an MTF reactivation plan which; (1) defines reactivation requirements, (2) lists reactivation documentation, (3) presents a schedule and sequence for reactivation, (4) identifies equipment modifications necessary to support testing of both S-IC and Int-20 stages, (5) defines measurement and data requirements, (6) identifies special test equipment, and (7) specifies reactivation reporting requirements.
2	Prepare or revise procedures necessary for reactivation and operations including; (1) functional test procedures, (2) equipment checkout procedures, (3) calibration procedures, (4) sub-system test procedures, (5) integrated test procedures for S-IC-X checkout and static firing, and (6) Int-20 and S-IC test and checkout procedures.
3	Establish Technical Files.
4	Prepare and maintain pert and program schedules.
5	Prepare SRS planning paper for reactivation.
6	Determine requirements and establish parts control system to support Int-20 operations at MTF.
7	Define support requirements for reactivation and issue event plans requesting support from the support contractor.
8	Remove equipment from storage and reinstall.
9	Depreserve equipment and facilities.
10	Perform functional tests.

REACTIVATION TASK DESCRIPTION

MTF
(Continued)

TASK NO.	TASK DESCRIPTION
11	Perform equipment and system calibrations
12	Update PERT and schedules as required
13	Reestablish work control system and maintain
14	Accomplish equipment modifications to support Int-20 testing
15	Perform reactivation testing including S-IC-X static firing
16	Accomplish data reduction, analysis and report preparation for reactivation tests. Support S-IC-X static firing report preparation.
17	Refurbish MTF static firing facilities after S-IC-X static firing.
18	Establish training requirements and prepare a training plan.
19	Schedule training and certification classes and conduct training as required.

FIGURE 4-1

A-657

4.2 MAF REACTIVATION TASKS

The major tasks necessary to reactivate the MAF test facilities are:

1. Define reactivation requirements and prepare a a reactivation plan.
2. Reinstall equipment and perform functional tests, checkouts, calibrations and sub-system tests.
3. Perform integrated systems testing including refurbishment and PSC of S-IC-X.
4. Stage transportation.
5. Personnel training and certification.

A more detailed breakdown of the MAF reactivation tasks is presented in Figure 4-2.

5.0 INT-20/S-IC STAGE PROCESSING

5.1 SUMMARY

For this study five options for stage production and processing are considered. A sixth option (2 S-IC's per year) is also presented as a baseline. These options consider production rate and stage mix (Int-20's and S-IC's).

Stage processing by S-IC Systems Test begins with the acceptance of the completed stage from operations in the factory final assembly area after completion of quality shakedown. S-IC Systems Test will direct the transportation and installation of the stage in the STS at MTF for combined PMC/Static Firing tests. S-IC Systems Test will accomplish

REACTIVATION TASK DESCRIPTION

MAF

TASK NO.	TASK DESCRIPTION
1	Prepare a reactivation plan which: (1) defines reactivation requirements, (2) lists reactivation documentation, (3) presents a schedule and sequence for reactivation, (4) identifies equipment modifications necessary to support testing of both S-IC and Int-20 stages, (5) defines measurement and data requirements, (6) identifies special test equipment, and (7) specifies reactivation reporting requirements.
2	Prepare or revise procedures necessary for reactivation and operation including; (1) functional test procedures, (2) equipment checkout procedures, (3) calibration procedures, (4) Sub-system test procedures, (5) integrated test procedures for S-IC-X refurbishment and PSC, and (6) Int-20 and S-IC test and checkout procedures.
3	Establish technical files.
4	Prepare and maintain PERT and program schedules
5	Prepare SRS planning paper for reactivation.
6	Prepare a transportation plan.
7	Provide transportation for S-IC-X and monitor critical measurements during all moves.
8	Remove equipment from storage and reinstall
9	Depreserve equipment and facilities.
10	Perform functional tests.
11	Perform equipment and system calibrations.

REACTIVATION TASK DESCRIPTION

MAF
(Continued)

TASK NO.	TASK DESCRIPTION
12	Update PERT and schedules as required
13	Accomplish equipment modifications to support Int-20 testing
14	Perform refurbishment of S-IC-X
15	Perform PSC of S-IC-X
16	Accomplish data reduction, analysis and report preparation for reactivation tests including PSC of S-IC-X
17	Establish training requirements and prepare a training plan
18	Schedule training and certification classes and conduct training as required

FIGURE 4-2

5.1 (Continued)

PMC/Static Firing activities at MTF, direct the transportation of the stage to MAF, install stage is test cell, conduct refurbishment and PSC of the stage, prepare the stage for shipment and assist in delivery of the stage.

5.2 The plan for direction and control of S-IC Systems Test activities is contained in D5-12300, S-IC Systems Test Management Plan. A document tree is presented in D5-12300-1, S-IC Systems Test Document Control and Index. With necessary revisions these documents will provide the necessary top documentation for processing Int-20 stages as well as S-IC stages.

5.2.1 MTF Test Documentation

The top document for stage processing at MTF is D5-11789-0XX, Stage Sequence/Operations plan for the Saturn S-IC-XX. A sequence/operations plan is prepared for each stage. An equivalent document will provide the plan for processing each Int-20 stage.

D5-11789-100, Stage Sequence/Operations Plan for the Saturn S-IC-Procedures and Instructions for Processing Stages at MTF, delineates the stage effectivity for each acceptance test procedure and establishes the stage effectivity for each operating procedure used in processing S-IC stages at MTF. An equivalent document will be prepared and maintained for the Int-20 stages.

5.2.2 MAF Test Documentation

The top document for stage processing at MAF is D5-11786, S-IC Stage Checkout and Refurbishment Plan. Details and relationships of other MAF stage processing documentation involving transportation, procedures, refurbishment, sustaining parts requirements and reporting are presented in D5-12300-1.

5.3 TEST REQUIREMENTS

S-IC test requirements for level I acceptance tests of the assembled stage are contained in the End Item Test Plan (EITP) 66B10933. Int-20 test requirements are defined in EITP 66B10920 (unreleased). Figure 5-1 presents a listing of the acceptance test procedures necessary to fulfill the EITP requirements.

5.4 PMC/STATIC FIRING ACTIVITIES

A detailed description of PMC/Static Firing activities will be presented in D5-11789-0XX or the equivalent stage sequence/ operations plan for each Int-20 stage. A general description is presented here which basically includes the accomplishment of the procedures listed in Figure 5-1 which are applicable to PMC/Static Firing.

5.4.1 Receipt of Stage and Transportation

Each stage will be accepted by S-IC Systems Test at the completion of quality shakedown in the factory final assembly area. The stage will be transported to MTF on a barge in accordance with D5-11053, Saturn S-IC Stage Transportation Plan. The barge containing the stage will dock at the S-IC test stand and the stage will be inspected for possible damage during shipment.

FIGURE 5-1

TEST PROCEDURES

A. PMC/Static Firing Procedures

1. Stage Receival, Inspection and Installation
2. Stage Installation
3. Support Equipment Connect Electrical, Mechanical and Umbilical
4. Access Equipment Installation
5. Forward Environmental Control Unit
6. Aft Environmental Control Unit
7. Bus Resistance Checks
8. Critical Power Distribution
9. Power Application
10. Power Removal
11. Stage Electrical System, Power Transfer and Bus Voltage
12. Stage Sequence and Separation
13. Engine Cutoff System
14. Electrical Heaters Checkout
15. Strain Gage Pressure Transducer Check
16. Liquid Level Initialization
17. PCM/DDAS and PCM/FM Verification
18. Measurement Power
19. PAM/FM Verification
20. RACS Verification
21. Flight Measurement Profile
22. Range Safety and Ordnance
23. Stage Hydraulic System Checkout and Verification
24. Thrust Vector Control System
25. GN_2 Control and Purge Systems
26. Pressure Switch Checkout
27. LOX Dome and GG Injector Purge
28. Thrust Chamber Prefill
29. GOX Flow Control Valve Checkout
30. LOX Tank Prepress and GOX System
31. Fuel Tank Pressurization Systems Test
32. LOX and Fuel Tanks Confidence and Leak Test
33. Thrust Chamber Leak Test
34. Turbine Exhaust System Leak Test
35. Engine Components Test
36. Stage Components Test and Valve Timing
37. Simulated Static Firing
38. Countdown and Static Firing
39. Engine to Stage Alignment
40. Install Test Termination Modules
41. Contamination Sampling
42. Umbilical Coupling Check
43. Electro-Mechanical Checks

FIGURE 5-1

TEST PROCEDURES

(Continued)

A. (Continued)

44. Support Equipment Disconnect
45. Stage Removal

B. PSC Procedures

1. Stage Installation and Connect
2. Stage Receiving Inspection
3. Test Termination Module Installation
4. Environmental Control
5. Telemetry Antennas
6. Bus Resistance Test
7. Range Safety Antennas
8. Fuel Purge System
9. Stage Power Check
10. Electrical Power Start-Up
11. Electrical Power Shutdown
12. LOX Purge System
13. PCM/DDAS System
14. PAM/FM System
15. GN_2 Purge System
16. Command Receiver Check
17. Stage Sequence and Separation
18. GN_2 Control System
19. Flight Measurement Profile
20. DDAS Channel I.D.
21. Engine Cutoff
22. Electrical Heaters Test
23. Range Safety Test
24. Pressure Switch Calibration
25. Power Transfer Test
26. LOX Pressure System
27. RACS Verification
28. LOX Tank System Test
29. Fuel Pre-Press and Pressurization System
30. Fuel Tank System
31. Engine Control System
32. Wind Load Strain Gage Checkout
33. Thrust Vector Control
34. Engine Subsystems Test
35. Remove Power Removal Equipment
36. Simulated Flight Test
37. EMC Conducted Test
38. EMC Spurious Emission Test
39. Engine Torque Check

FIGURE 5-1

TEST PROCEDURES

(Continued)

B. (Continued)

40. Remove Test Termination Modules
41. Pressure Decay Test
42. Stage Weighing
43. Preparation to Ship
44. Remove Stage from Test Cell

5.4.2 Stage Installation and Pre-Static Firing Checkouts

The stage will be installed and secured in the static test stand. A standby pressure will be maintained in the propellant tanks. Support equipment will be connected to the stage. Hardwire instrumentation (System A) will be installed, connected and checked out. Pre firing checkouts will be conducted to determine the readiness of the stage for static firing.

5.4.3 Static Firing

A countdown and static firing will be conducted which simulates as nearly as practical the operation of the stage systems during actual flight. Data will be recorded from both the Flight Measuring System (System B) and the Hardwire System (System A) instrumentation. Static firing will verify that the stage and systems fulfill the requirements of the EITP.

5.4.4 Post Static Firing Tests and Preparation for Stage Removal

Following static firing and prior to disconnect of any equipment certain pre-firing acceptance tests are repeated in order to determine if there has been any degredation in the systems performance. Investigation of static firing anomalies is also accomplished during this period. When provisional acceptance of the stage has been obtained from NASA the System A instrumentation is removed, the support equipment disconnected and the stage prepared for removal from the test stand.

5.4.5 Static Firing Data Reduction Analysis and Reporting

A Quick-Look team from Engineering will analyze and report on the stage performance during static firing. Data will be recorded and processed by the MTF support contractor in accordance with the data requirements. Data reduction will be accomplished both at MTF and at MAF. Support will be provided to the quick-look team in the qualification, display, review and analysis of the data. Data and Stage system anomalies will be documented and investigated.

5.4.6 Stage Removal and Transportation to MAF

The stage will be removed from the static test stand, secured in its transporter and placed on a barge at the test stand. Propellant tank standby pressure will be maintained. The stage will then be transported to MAF and placed in a test cell in preparation for refurbishment and PSC testing.

5.5 REFURBISHMENT/PSC ACTIVITIES

A detailed description of refurbishment/PSC activities will be presented in D5-11786 or equivalent documentation for the Int-20 Stage. A general description is presented here.

5.5.1 Refurbishment Activities

Refurbishment of each S-1C or Int-20 stage will be accomplished at MAF after static firing testing and prior to PSC. Refurbishment consists of removing or replacing hardware that was installed on the stage for static firing only, replacing damaged or marginal parts, installing

5.5.1 (Continued)

flight hardware not installed prior to static firing, and incorporating any stage modifications required. Refurbishment requirements for S-1C stages are documented in D5-11784. Int-20 refurbishment requirements will be incorporated in this document.

5.5.2 PSC Activities

At the completion of refurbishment Post Static Checkouts will be conducted. The PSC will determine that the Stage and systems comply with the EITP acceptance test requirements, and will be the final acceptance test of the stage prior to NASA final acceptance.

Before PSC is initiated, a self check of the test and checkout complex will be accomplished using the Ground Equipment Test Set (GETS). Upon completion of the self check support equipment will be connected to the stage. Pneumatic, hydraulic and mechanical checks will be conducted. Electrical, range safety and instrumentation systems will be tested. Propulsion system checks will be conducted and will include checks of firing command preparation and execution, engine shutdown prior to launch commit, malfunction cutoff and normal propulsion sequences.

At the conclusion of PSC an all-systems test will be conducted which consists of a simulated closed loop static firing countdown followed by a simulated launch and

5.5.2 (Continued)

flight sequence (open loop with all RF systems radiating and umbilicals disconnected).

5.5.3 PSC Data Acquisition, Processing and Evaluation

Test data will be acquired by automatic test and checkout equipment, telemetry ground station equipment and manual recording. Data will be processed and reduced to provide for analysis of equipment and systems performance, for comparison with lower level test data, for determination of acceptability based on the EITP.

5.5.4 PSC Reporting

A PSC report will be prepared for each stage. The report will contain a discussion and summary of checks, a comparison of test values with requirements and copies of reduced data.

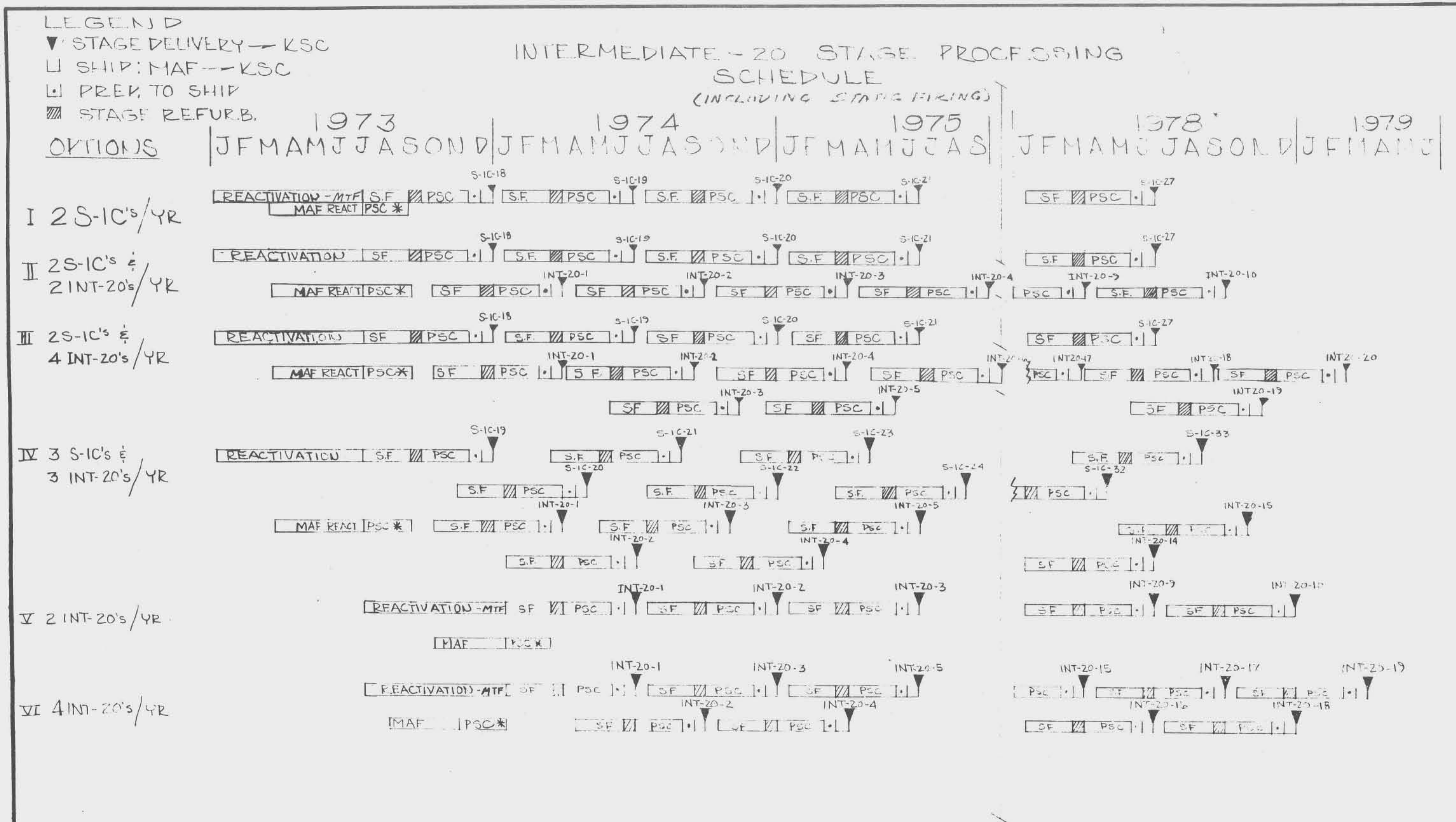
5.6 STAGE DELIVERY

The basic definition of delivery is acceptance of contract end items by the customer. Stage delivery will include the provisional acceptance of the stage by NASA at the conclusion of PMC/Static Firing testing, PSC and on the barge loaded at Michoud, completely ready for shipment to KSC. S-1C Systems Test - MAF will participate in the delivery of the stages. Details of stage delivery will be identified in a Stage Delivery Plan, D5-12886 or equivalent.

6.0 INT-20/S-IC STAGE PROCESSING SCHEDULES

The planned schedule for accomplishment of the acceptance testing described herein is presented in Figure 6-1. The schedule for all options considered in this plan is presented, including the baseline option of 2 S-1C stages per year.

Figure 6-2 presents an alternate schedule with no static firings being accomplished. Figure 6-3 presents a schedule with only the first 2 Int-20 stages being static fired.



✱ PSC OF S-IC-X FROM MTF REACTIVATION

FIGURE 6-1

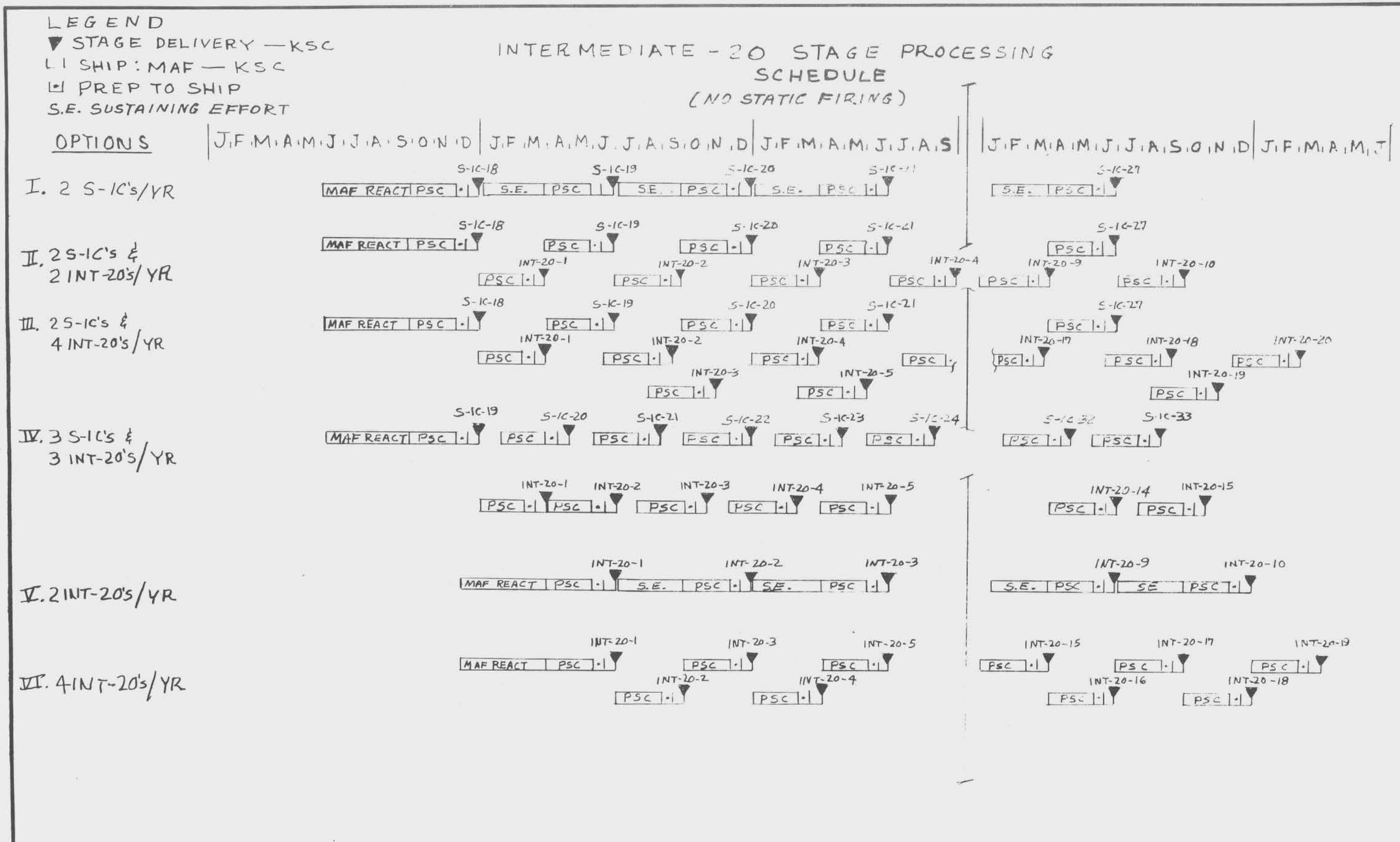

LEGEND
▼ STAGE DELIVERY — KSC
SHIP: MAF — KSC
PREP TO SHIP
S.E. SUSTAINING EFFORT
INTERMEDIATE - 20 STAGE PROCESSING SCHEDULE
(NO STATIC FIRING)
OPTIONS
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S J F M A M J J A S O N D J F M A M J
I. 2 S-IC's/YR
II. 2 S-IC's & 2 INT-20's/YR
III. 2 S-IC's & 4 INT-20's/YR
IV. 3 S-IC's & 3 INT-20's/YR
V. 2 INT-20's/YR
VI. 4 INT-20's/YR
MAF REACT
PSC
S.E.

FIGURE 6-2

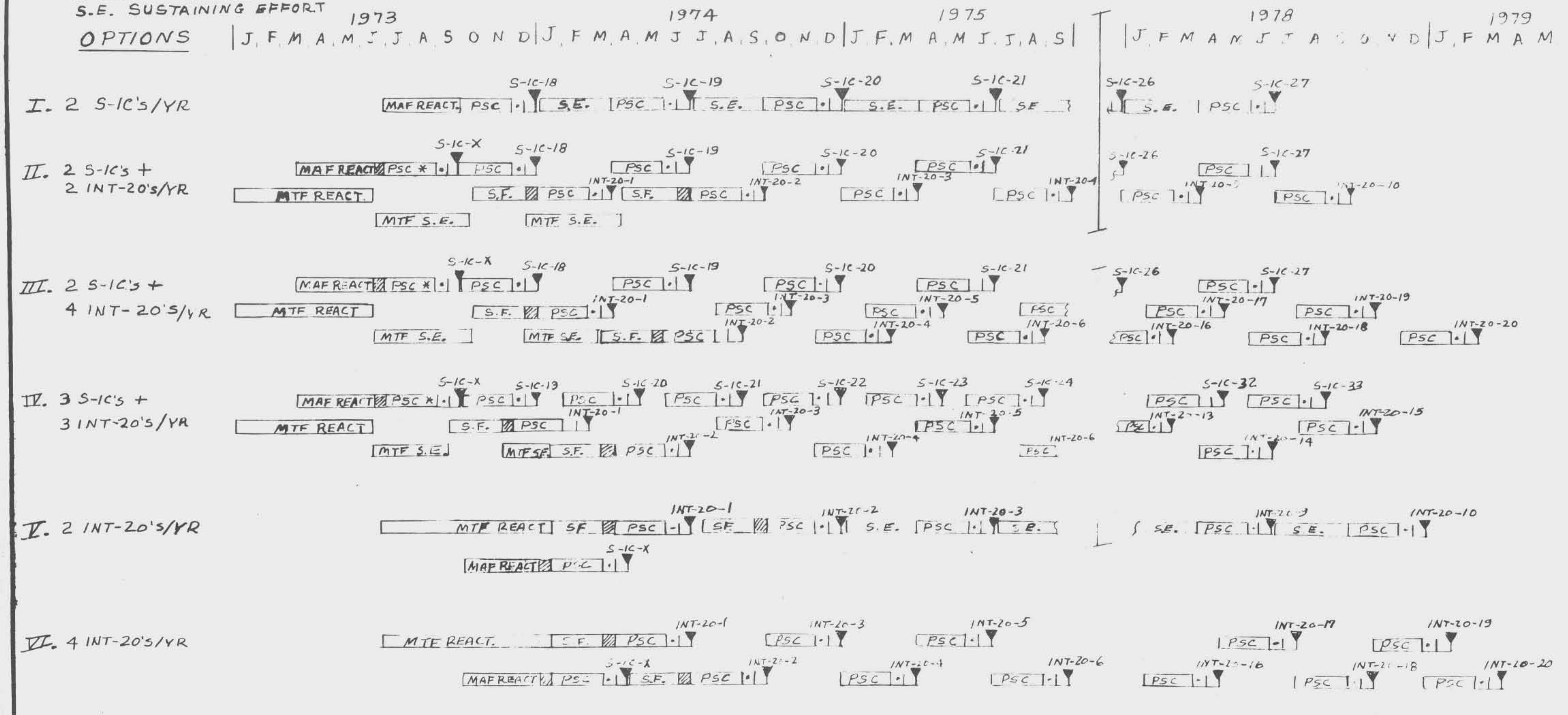
INTERMEDIATE 20 STAGE PROCESSING SCHEDULE

(STATIC FIRE INT-20-1 & -2 ONLY)

LEGEND

- ▼ STAGE DELIVERY – KSC
- ⊔· SHIP – MAF TO KSC
- [•] PREP TO SHIP
- ▨ STAGE REFURB.
- S.E. SUSTAINING EFFORT

S.F. STATIC FIRING



* PSC OF S-IC-X FROM MTF REACTIVATION

FIGURE 6-3

4.0 MISCELLANEOUS S-IC DATA

This section contains preliminary data which was generated during this study to determine the impact of the INT-20 changes defined in Section 4.2.2.1 of D5-17009-2 The items included are as follows:

60B57500	Instrumentation Program and Components List, INT-20 (Preliminary)
66B10920	Intermediate-20 S-IC Stage End Item Test Plan (Preliminary)
No Numbers Assigned	INT-20 S-IC Stage Electrical Schematics and CID's (Preliminary) 106 pages
Attachment A to memo 5-5754-P-549 dated July 7, 1969	Systems Test's INT-20 Acceptance Test Plan (Preliminary)

5.0 INT-20 RELIABILITY ASSESSMENT

A reliability assessment was performed of the baseline INT-20 launch vehicle and results compared with Saturn V values.

Reliability Assessment for INT-20 First Stage

For the first flight of INT-20, the projected INT-20 first stage reliability assessment and prediction are 0.963 [1] at 50 percent confidence and 0.981 (as minimum values) respectively. These values exceed the S-IC Stage CEI Specification reliability design objective of 0.95.

The above INT-20 first stage reliability assessment and prediction projections are based on the following assumptions:

1. The aborted static firing of stage S-IC-11 was the result of human error and not a design deficiency. Assessments are based on design integrity and human error is not used as a factor.
2. The INT-20 first stage has the same Reliability Critical Hardware (RCH). (Infact the INT-20 first stage has fewer as well as no new RCH; therefore, the reliability values above are considered low or minimum values.)
3. INT-20 first stage RCH will be stressed not greater than S-IC RCH was stressed.
4. INT-20 first stage flight time is 211 seconds.
5. The fatigue life of INT-20 first stage RCH is not exceeded during one INT-20 life cycle. (In fact the total life cycles accumulated on samples of each S-IC reliability critical Propulsion/Mechanical & Thrust Vector component type exceeds, in terms of time, the intended INT-20 first stage life cycle time, two 125 second static firings plus a 211 second flight.)

[1] This value assumes S-IC-11 thru S-IC-15 static firings and S-IC-6 thru S-IC-10 flights are successful in respect to design objectives. If S-IC static firings end with S-IC-11 and flights thru S-IC-10 are successful, the projected assessed reliability value for INT-20 first stage is 0.960 at the 50 percent confidence level.

6.0 INT-20 S-IC STAGE LOGISTICS PLAN

The effects of INT-20 implementation on spares and engineering publications requirements was ascertained. The impact is summarized in this section.

S-IC LOGISTICS PLAN

Spares

Logistics support requirements for the INT-20, S-IC Stage are not significantly impacted by the stage changes as defined under paragraph 4.2.2. The following spares items, in addition to the spares now specified for the S-IC stage, are required:

QTY	INT-20 CONFIGURATION COMPONENT
(1)	Propulsion Distributor
(1)	Sequence and Control Distributor
(1)	Timer Distributor
(2)	Measuring Distributors
(1)	Thrust OK Distributor
(3)	Fuel Loading Probes *
(3)	Cable Assemblies

* Existing S-IC electronics units are acceptable.

Engineering Publications

The following publication will require revisions to reflect the INT-20 configuration.

MANUAL NO (MSFC)	DESCRIPTION
MSFC-MAN-040	Stage System Description
MSFC-MAN-034	Stage Maintenance Information and Part Index
MSFC-MAN-035	Stage Buildup Information
MSFC-MAN-042	Stage Flight Measurements

MANUAL NO (GSE)	DESCRIPTION
MSFC-MAN-032	Stage Transportation and Handling
MSFC-MAN-048	Propellant Measuring Systems Electronics Checkout Unit
MSFC-MA-033	Stage Vertical Internal Access Equipment
MSFC-MAN-027	Forward Umbilical Carrier and Flight Plate

Engineering Publications (Continued)

MANUAL NO (GSE)	DESCRIPTION
MSFC-MAN-026	Aft Umbilical Carrier and Flight Plate
MSFC-MAN-028	Intertank Umbilical Carrier and Flight Plate
MSFC-MAN-004-1	S-IC Pneumatic Console
MSFC-MAN-004-2	S-IC Forward Umbilical Console
MSFC-MAN-004-3	S-IC Pneumatic Checkout Racks

APPENDIX B

Data intended for this Appendix has been incorporated in the main body of the final report (D5-17009-2).

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VOLUME II

APPENDIX C

INSTRUMENT UNIT

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APPENDIX C.1

ATTITUDE CONTROL ANALYSIS W-PLANE NYQUIST PLOTS (NOTE: ω FREQUENCIES INDICATED ON PLOTS ARE IN HZ)

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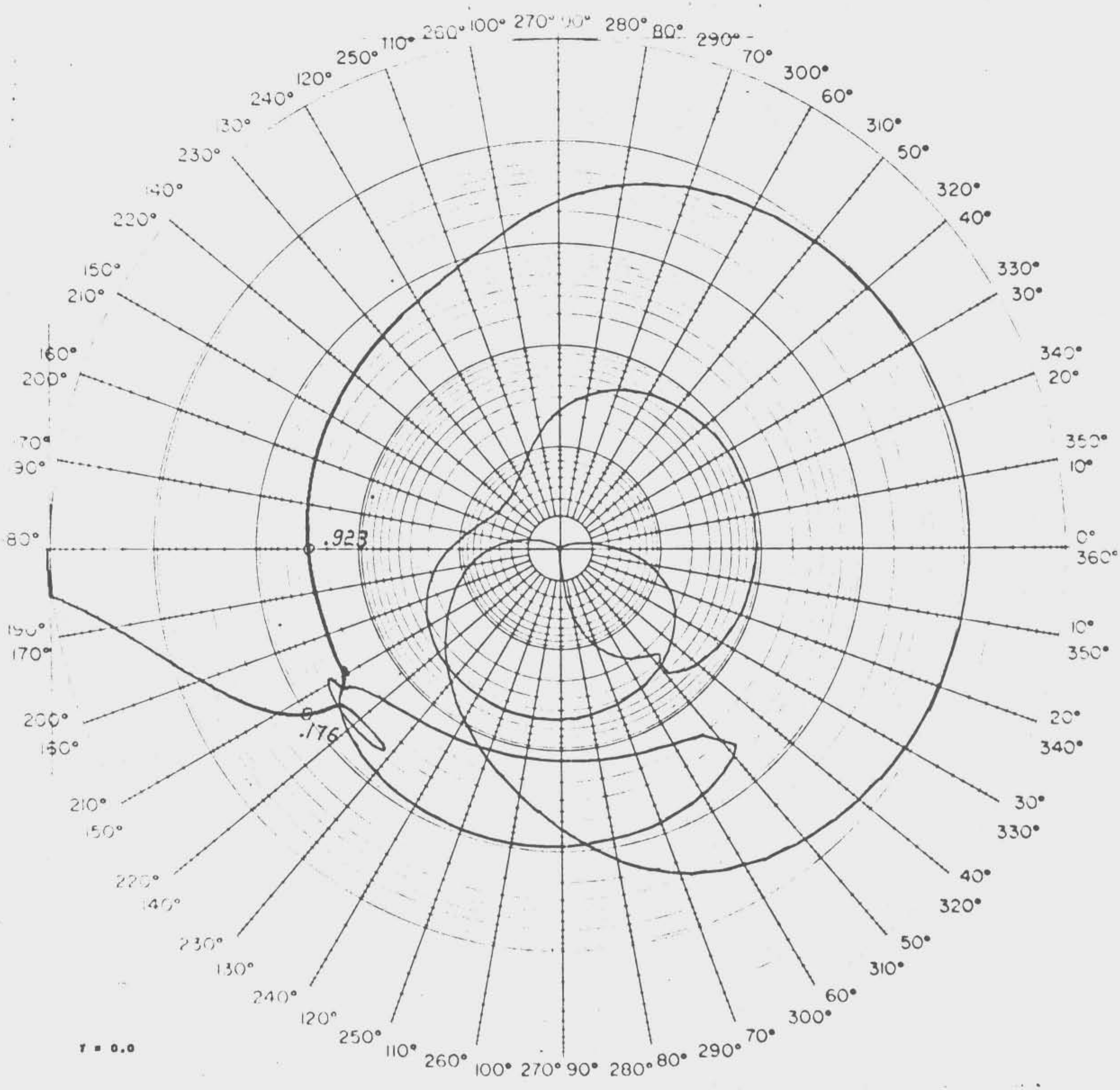

FIGURE C.1-1. W-PLANE NYQUIST PLOTS FOR S-IC STAGE, PITCH/YAW AXES (OPEN AT ACTUATOR)

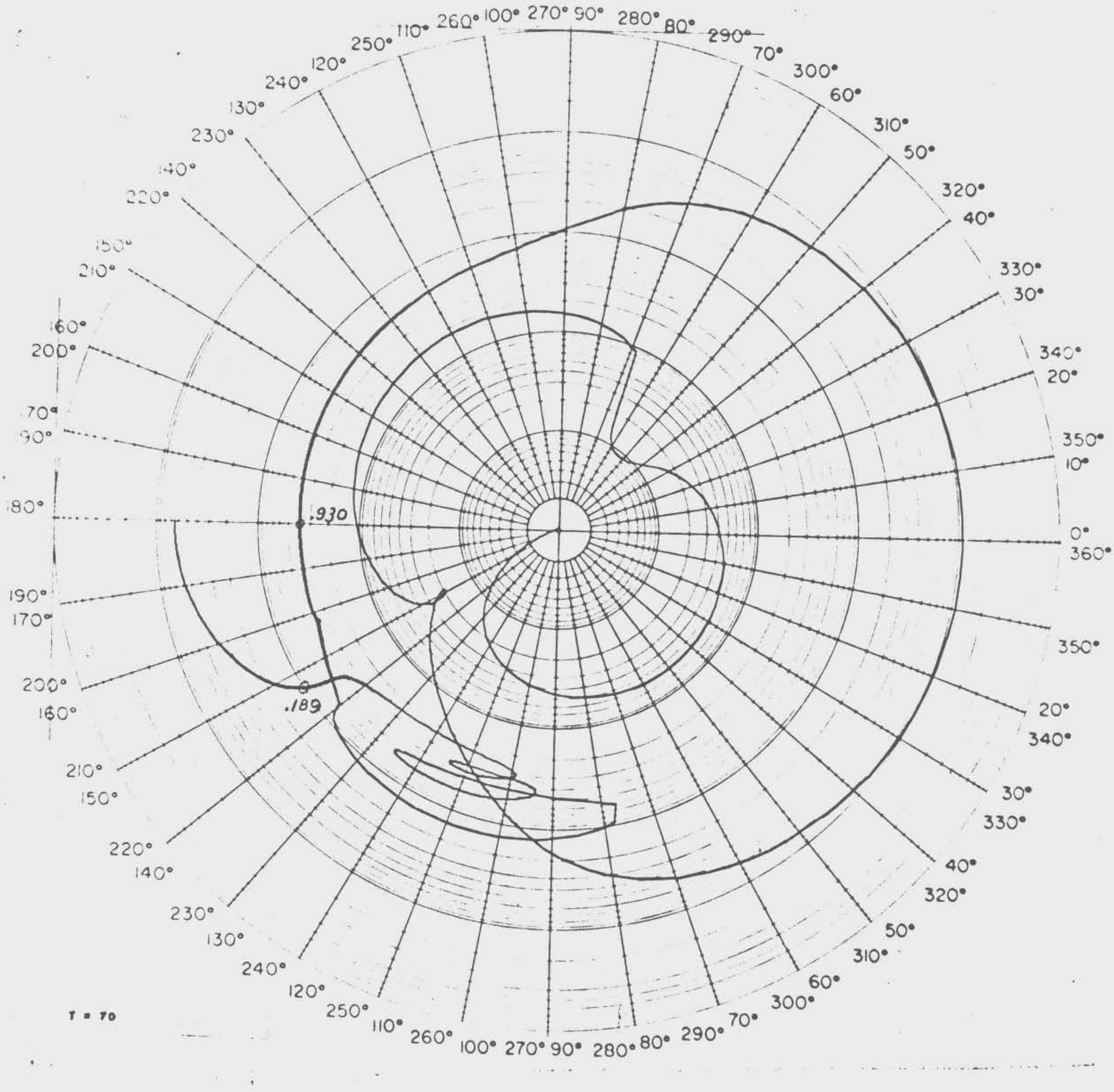

FIGURE C.1-2. W-PLANE NYQUIST PLOTS FOR S-IC STAGE, PITCH/YAW AXES (OPEN AT ACTUATOR)

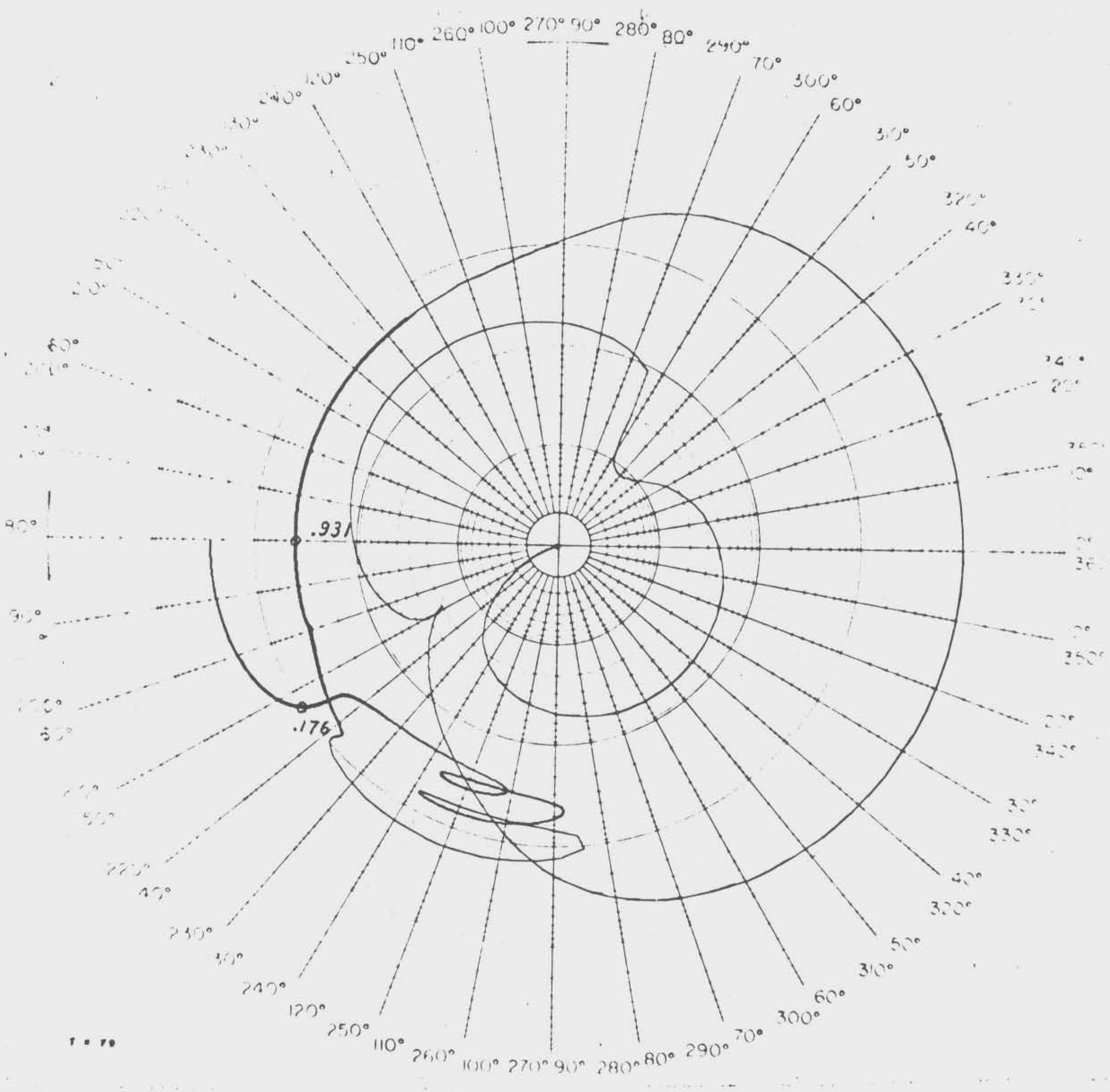

FIGURE C.1-3. W-PLANE NYQUIST PLOTS FOR S-IC STAGE, PITCH/YAW AXES (OPEN AT ACTUATOR)

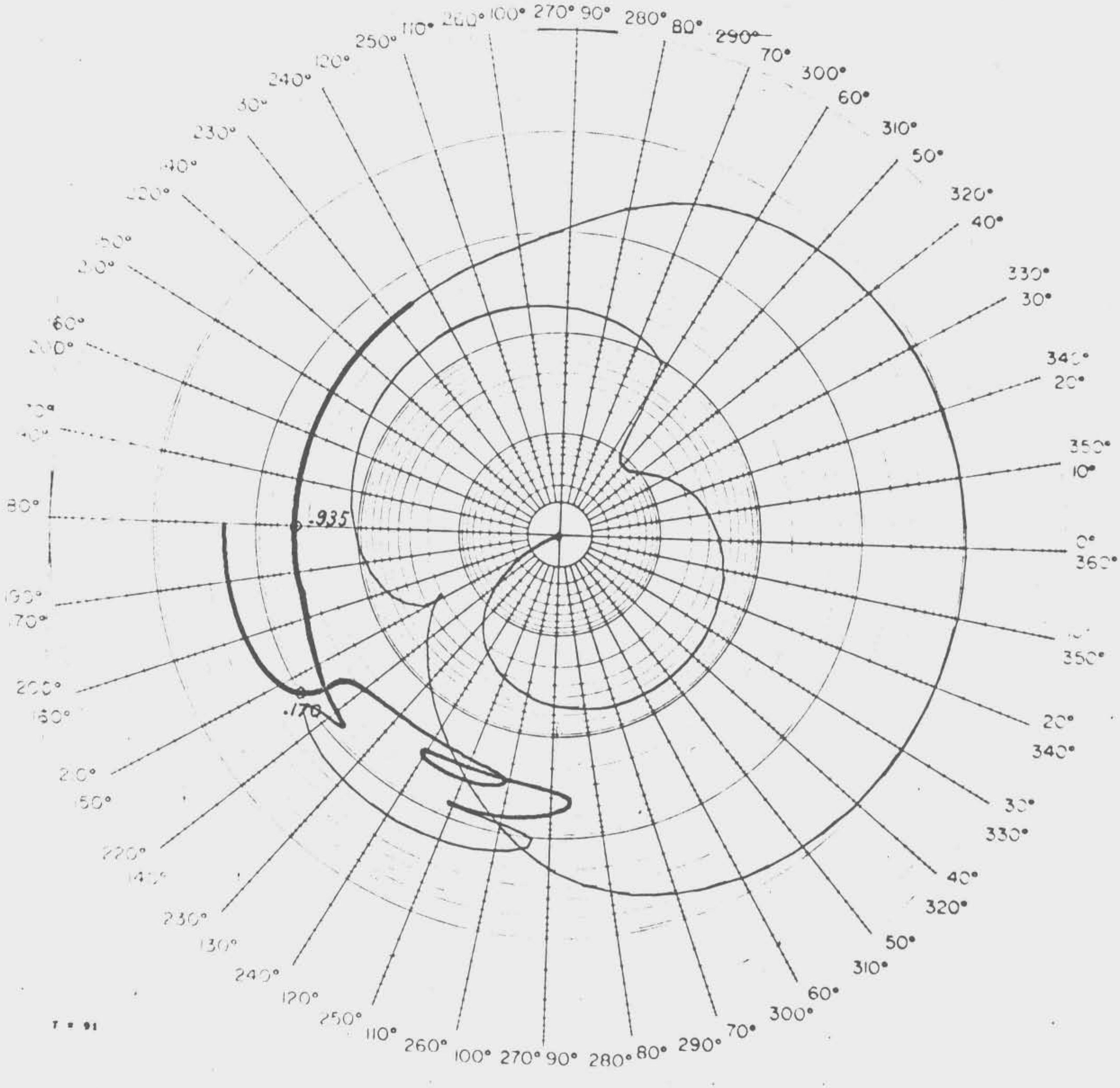

FIGURE C.1-4. W-PLANE NYQUIST PLOTS FOR S-IC STAGE, PITCH/YAW AXES (OPEN AT ACTUATOR)

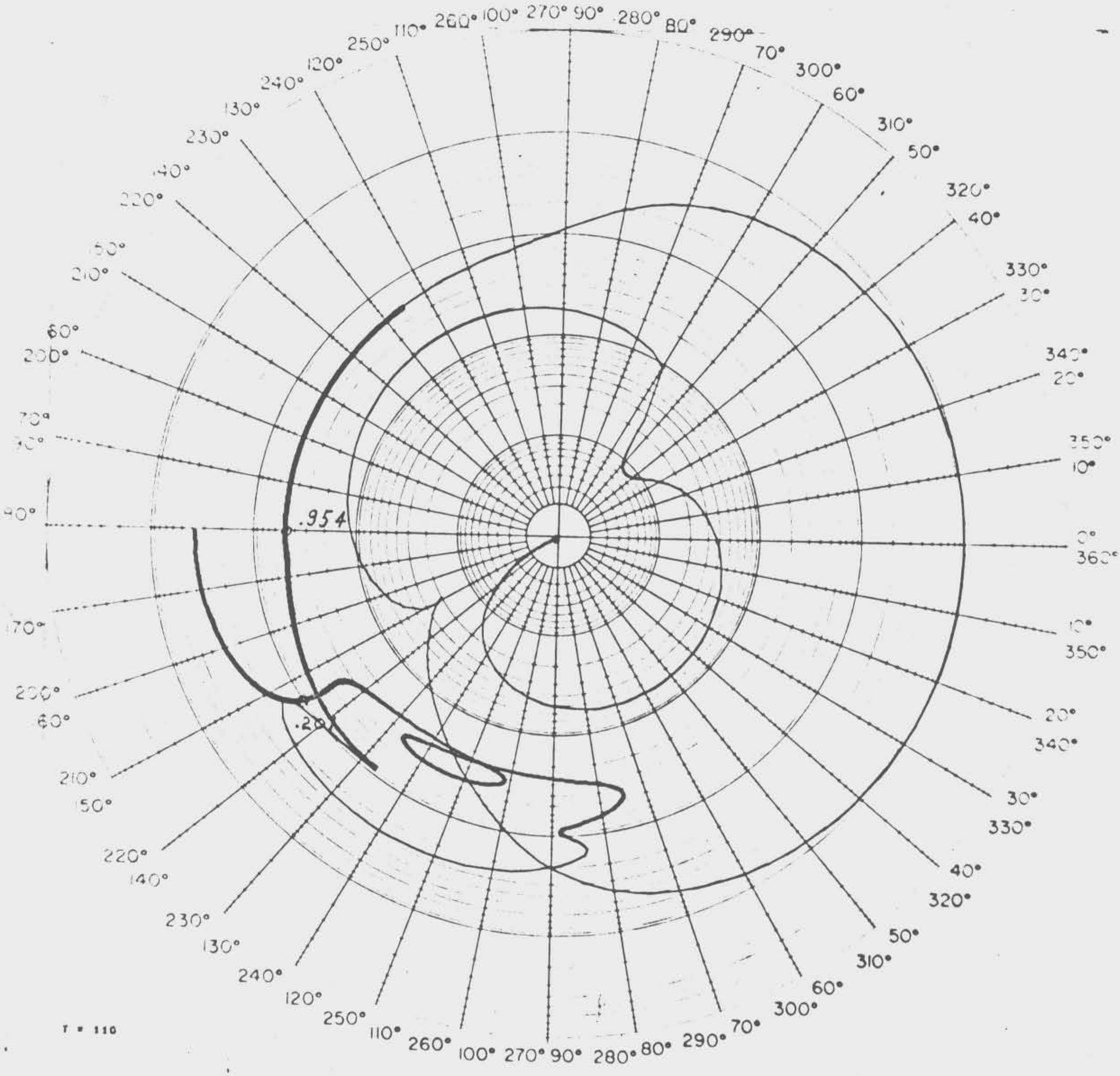

FIGURE C.1-5. W-PLANE NYQUIST PLOTS FOR S-IC STAGE, PITCH/YAW AXES (OPEN AT ACTUATOR)

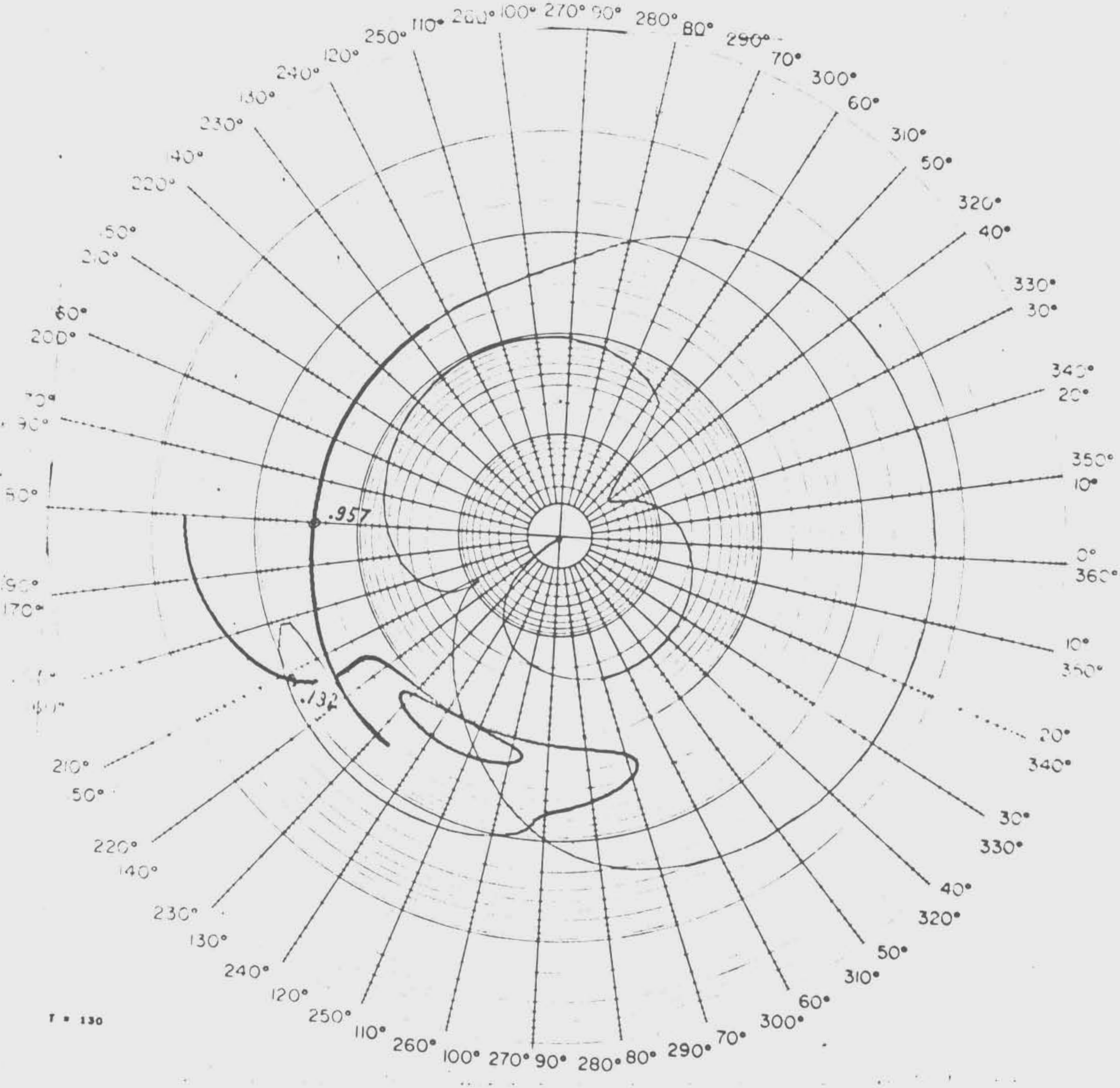

FIGURE C.1-6. W-PLANE NYQUIST PLOTS FOR S-IC STAGE, PITCH/YAW AXES (OPEN AT ACTUATOR)

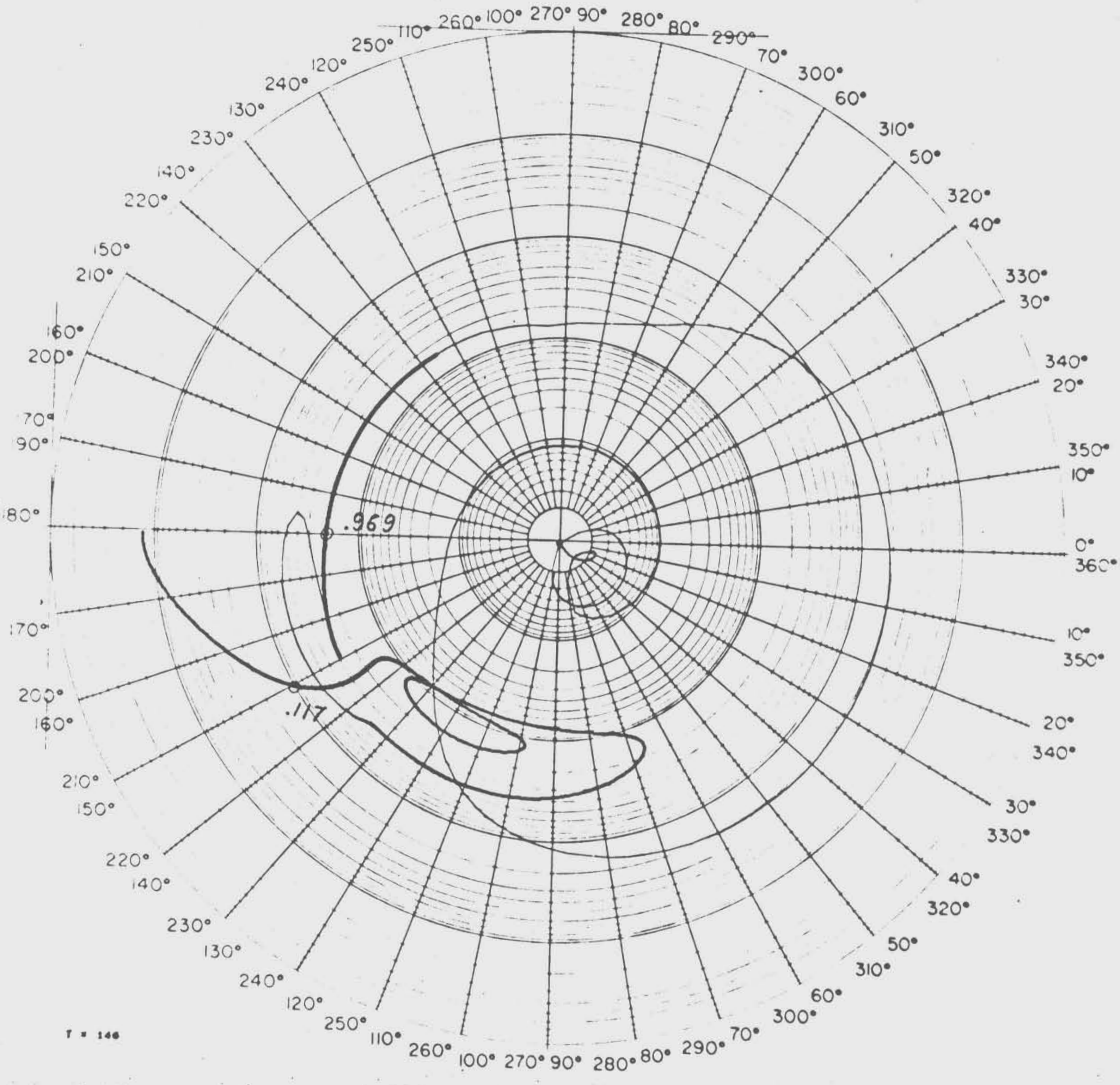

FIGURE C.1-7. W-PLANE NYQUIST PLOTS FOR S-IC STAGE, PITCH/YAW AXES (OPEN AT ACTUATOR)

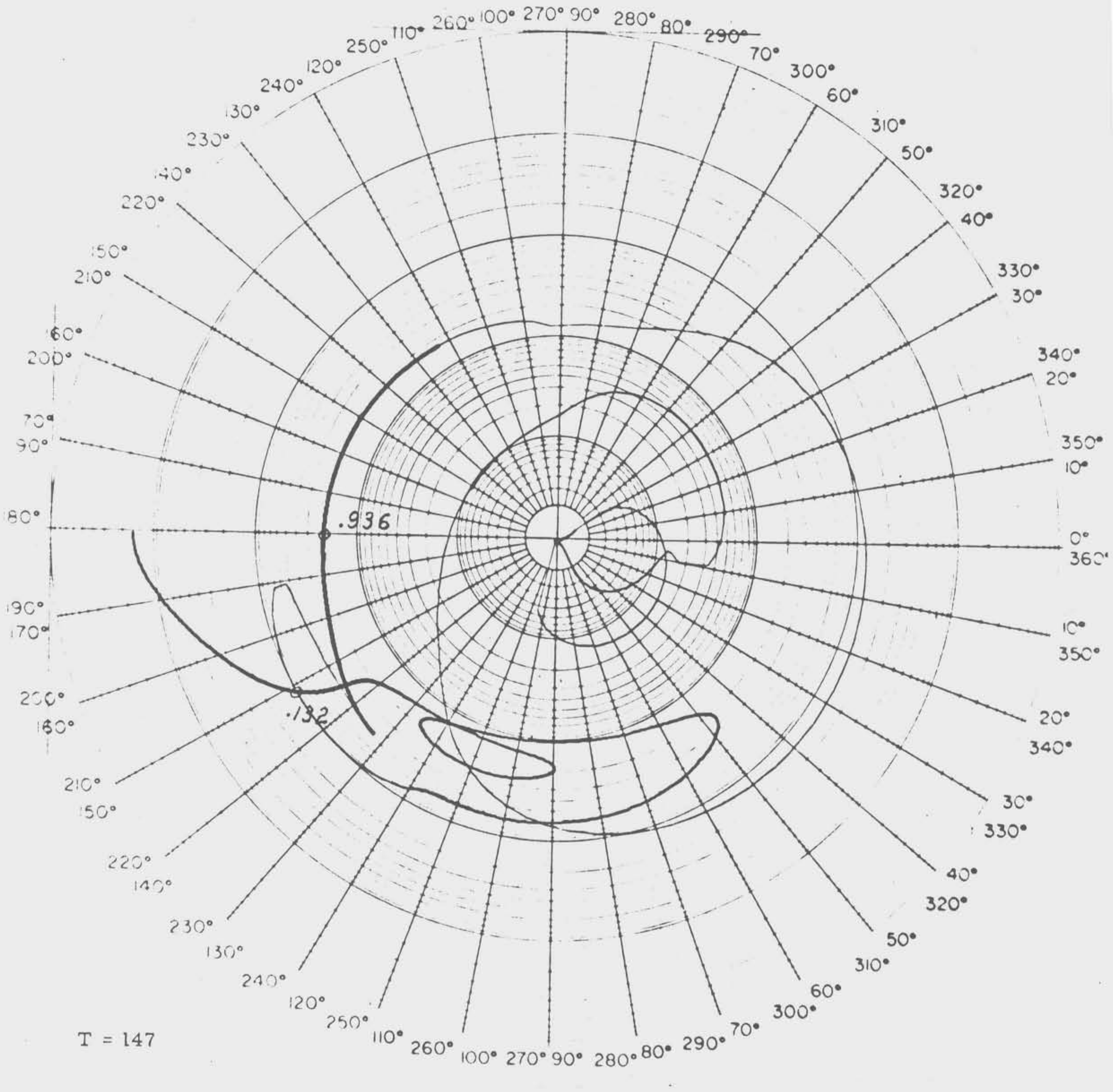

FIGURE C.1-8. W-PLANE NYQUIST PLOTS FOR S-IC STAGE, PITCH/YAW AXES (OPEN AT ACTUATOR)

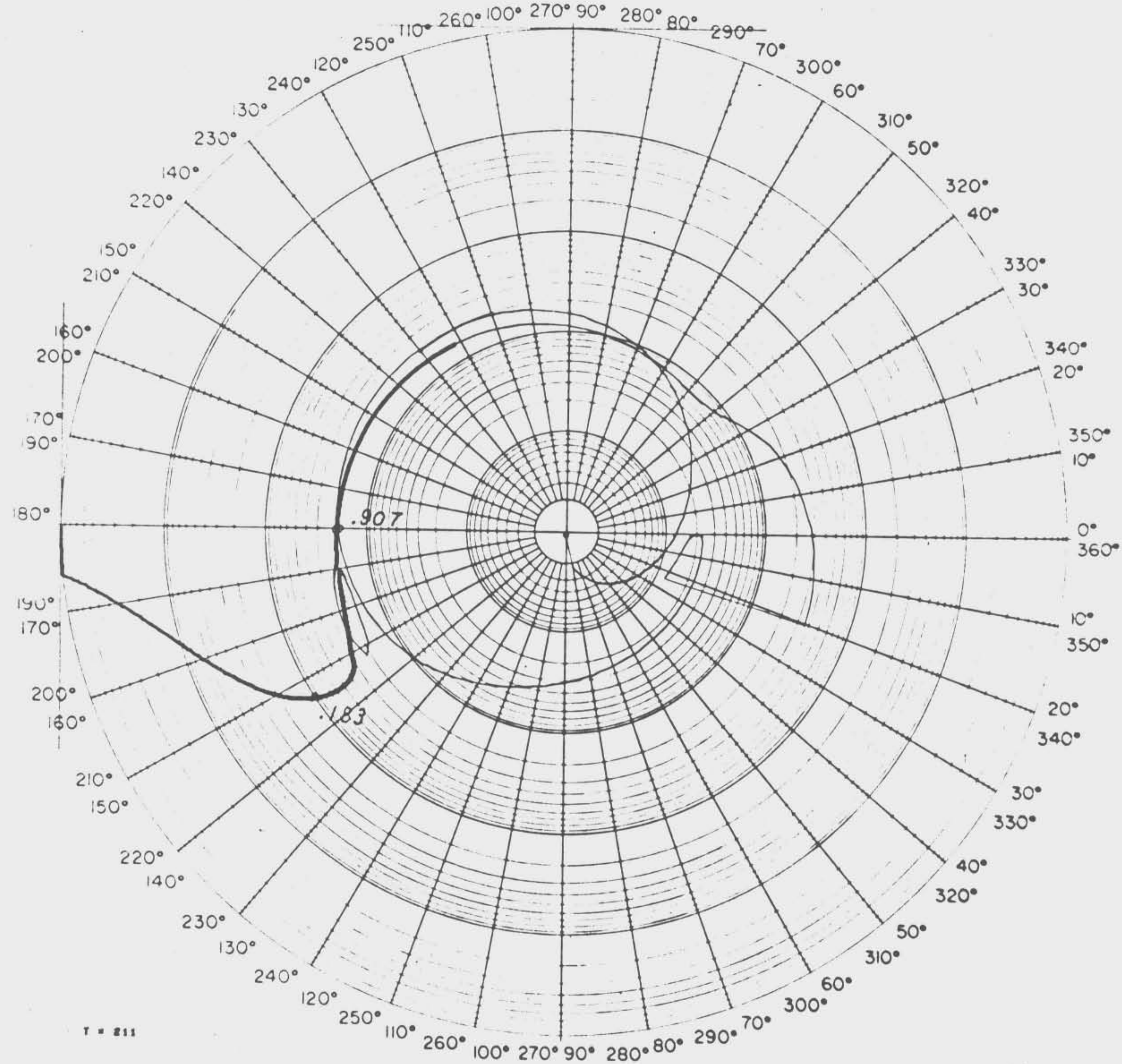

FIGURE C.1-9. W-PLANE NYQUIST PLOTS FOR S-IC STAGE, PITCH/YAW AXES (OPEN AT ACTUATOR)

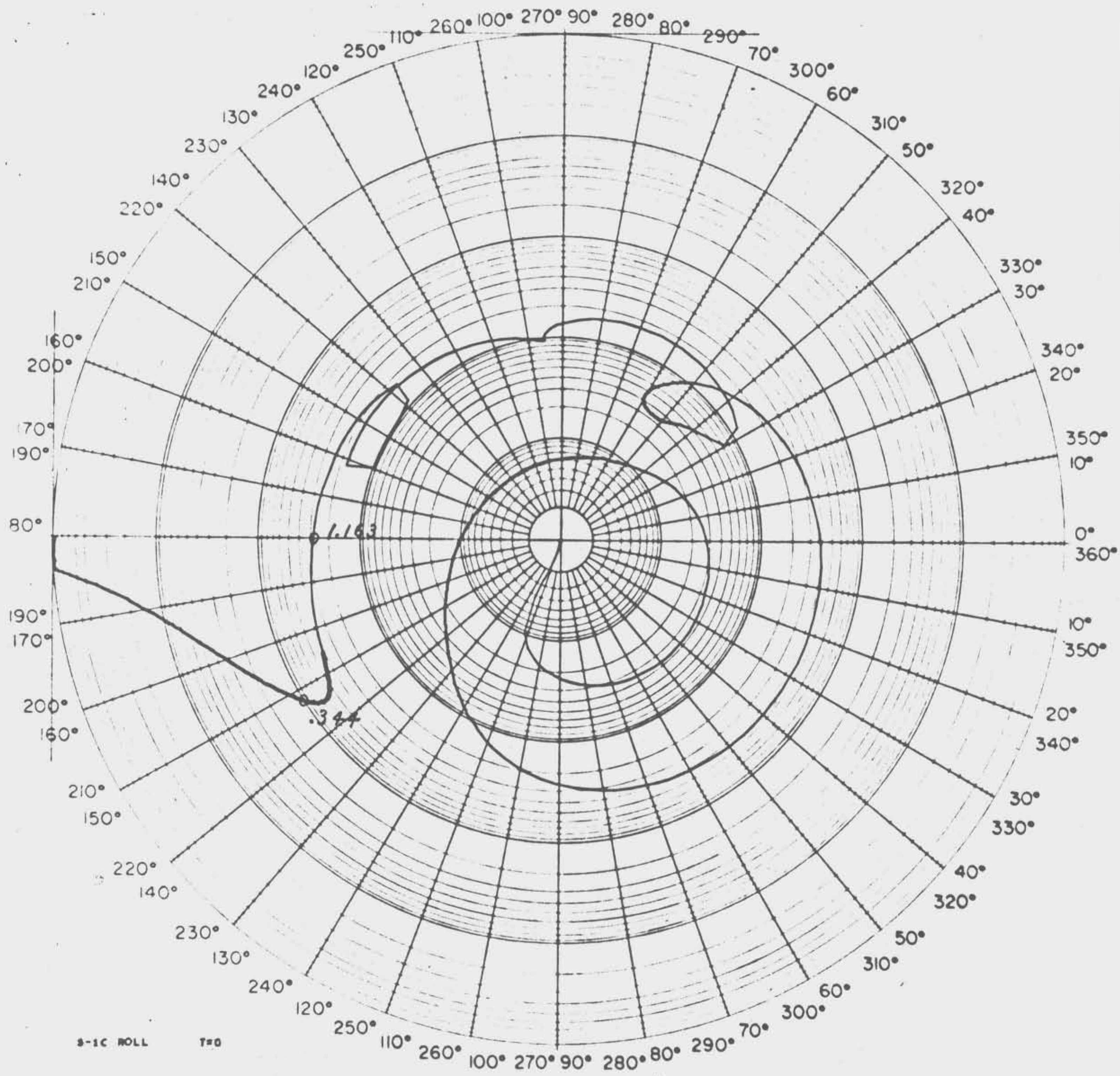

FIGURE C.1-10. W-PLANE NYQUIST PLOTS FOR S-IC STAGE, ROLL AXIS (OPEN AT ACTUATOR)

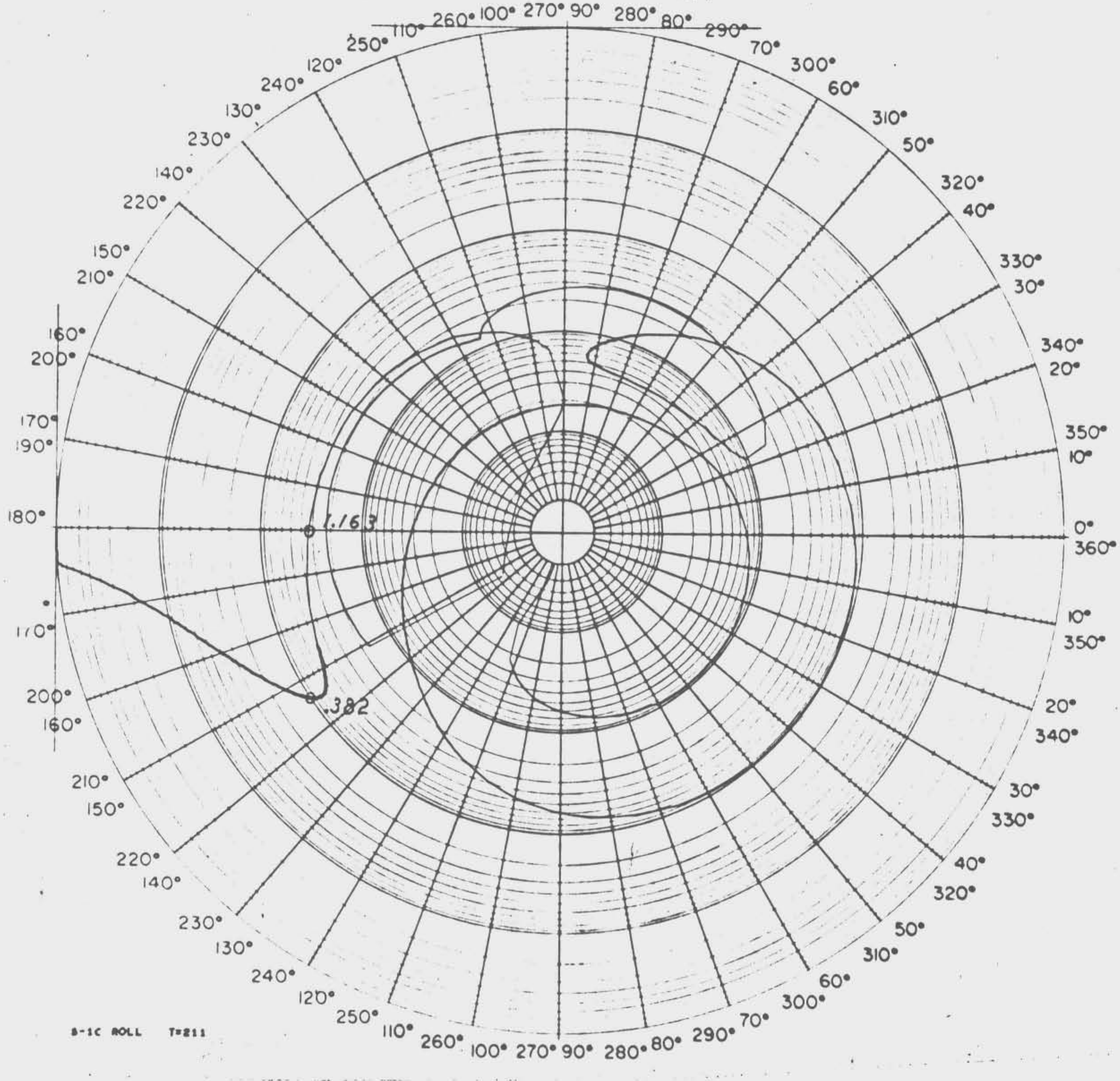

FIGURE C.1-11. W-PLANE NYQUIST PLOTS FOR S-IC STAGE, ROLL AXIS (OPEN AT ACTUATOR)

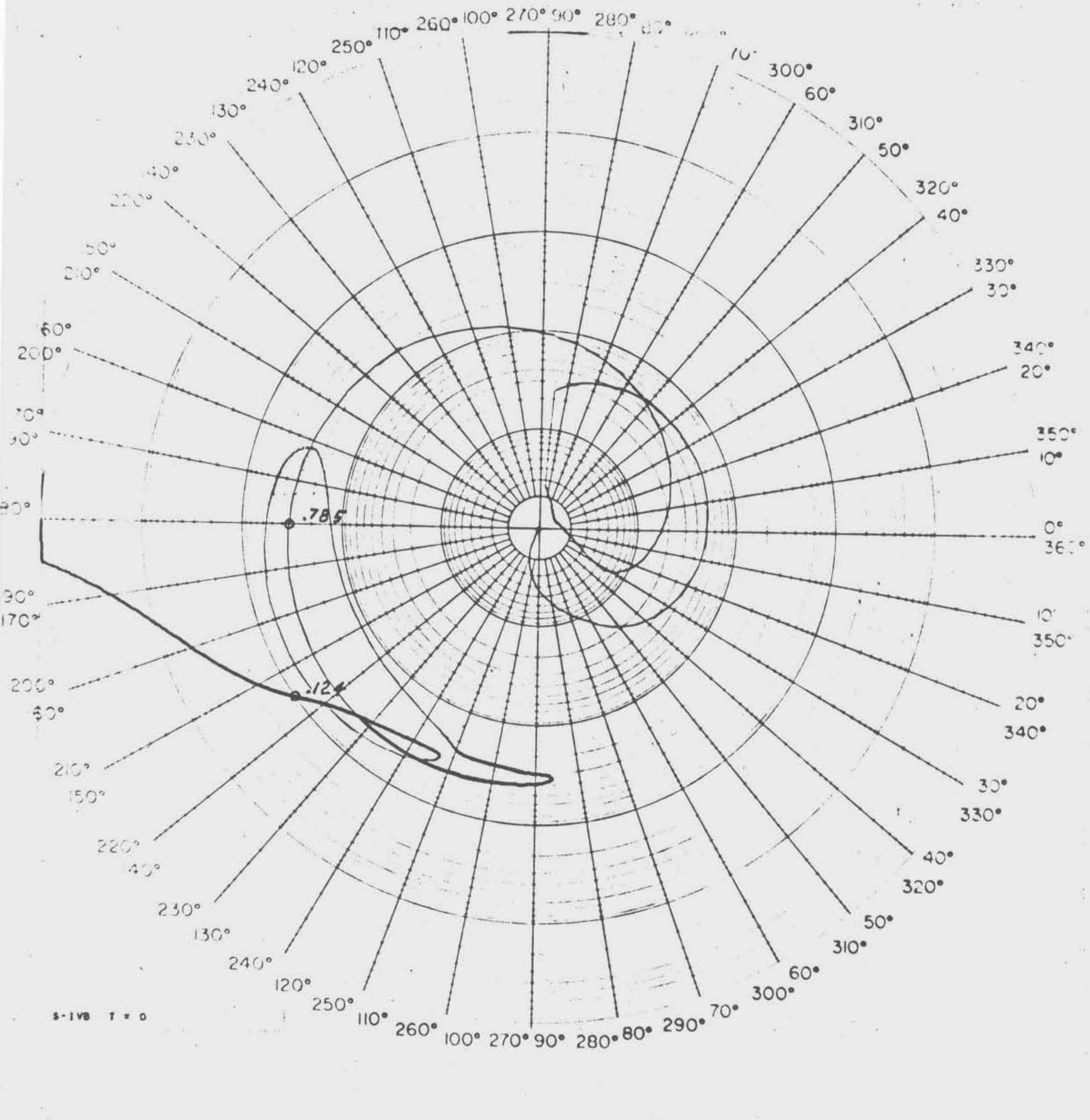

FIGURE C.1-12. W-PLANE NYQUIST PLOTS FOR S-IVB STAGE, PITCH/YAW AXES (OPEN AT ACTUATOR)

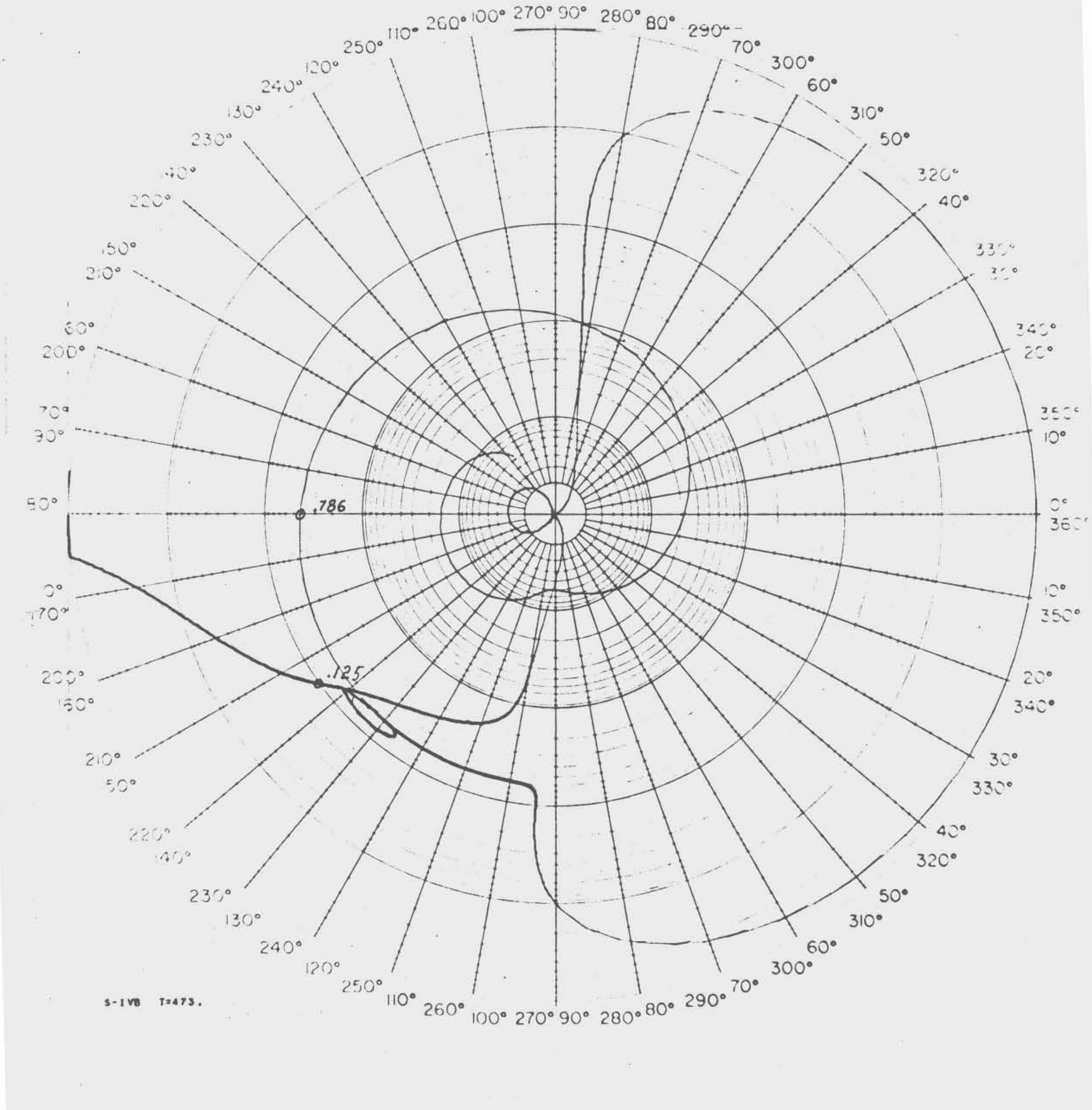

FIGURE C.1-13. W-PLANE NYQUIST PLOTS FOR S-IVB STAGE, PITCH/YAW AXES (OPEN AT ACTUATOR)

APPENDIX C.2

VEHICLE SIMULATION RESPONSES USING DIGITAL ATTITUDE CONTROL SYSTEM

APPENDIX C.2

DEFINITION OF RESPONSE PARAMETERS

PSIP	ATTITUDE ERROR IN PITCH
PSIY	ATTITUDE ERROR IN YAW
PSIR	ATTITUDE ERROR IN ROLL
PHIDP	ATTITUDE RATE IN PITCH
PHIDY	ATTITUDE RATE IN YAW
PHIDR	ATTITUDE RATE IN ROLL
ALPHAP	ANGLE OF ATTACK IN PITCH
ALPHAY	ANGLE OF ATTACK IN YAW
ENGIP	REPRESENTATIVE ENGINE DEFLECTION IN PITCH (ROLL COMPONENT ADDITIVE)
ENGIY	REPRESENTATIVE ENGINE DEFLECTION IN YAW (ROLL COMPONENT ADDITIVE)

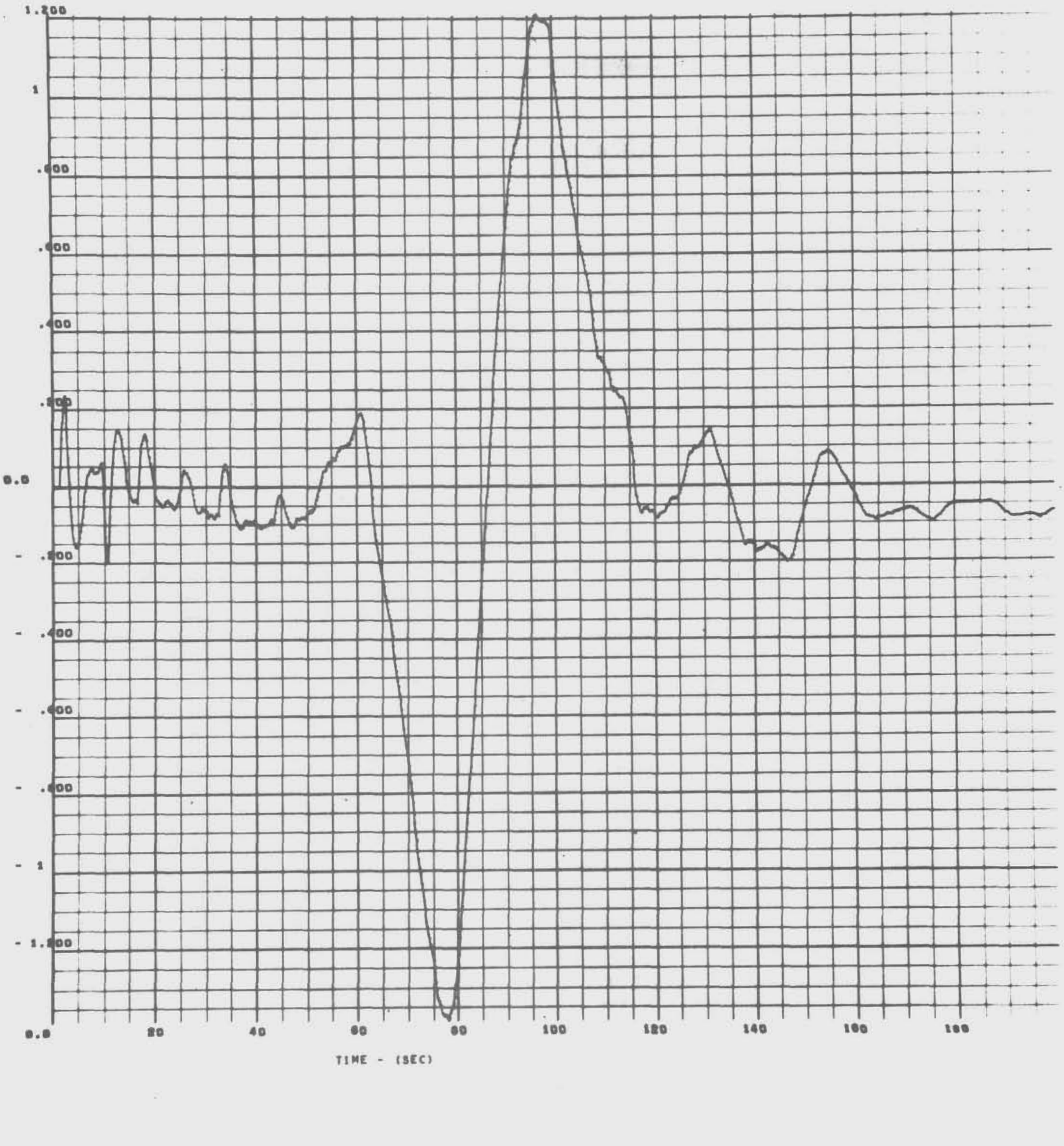

FIGURE C.2-1. SIMULATION RESPONSE TO 95% FEBRUARY DESIGN WINDS USING A LEAD FILTER WITH QUANTUM LEVELS ON βc AND θ OF $.06^{\circ}$ AND $.00279^{\circ}$ RESPECTIVELY

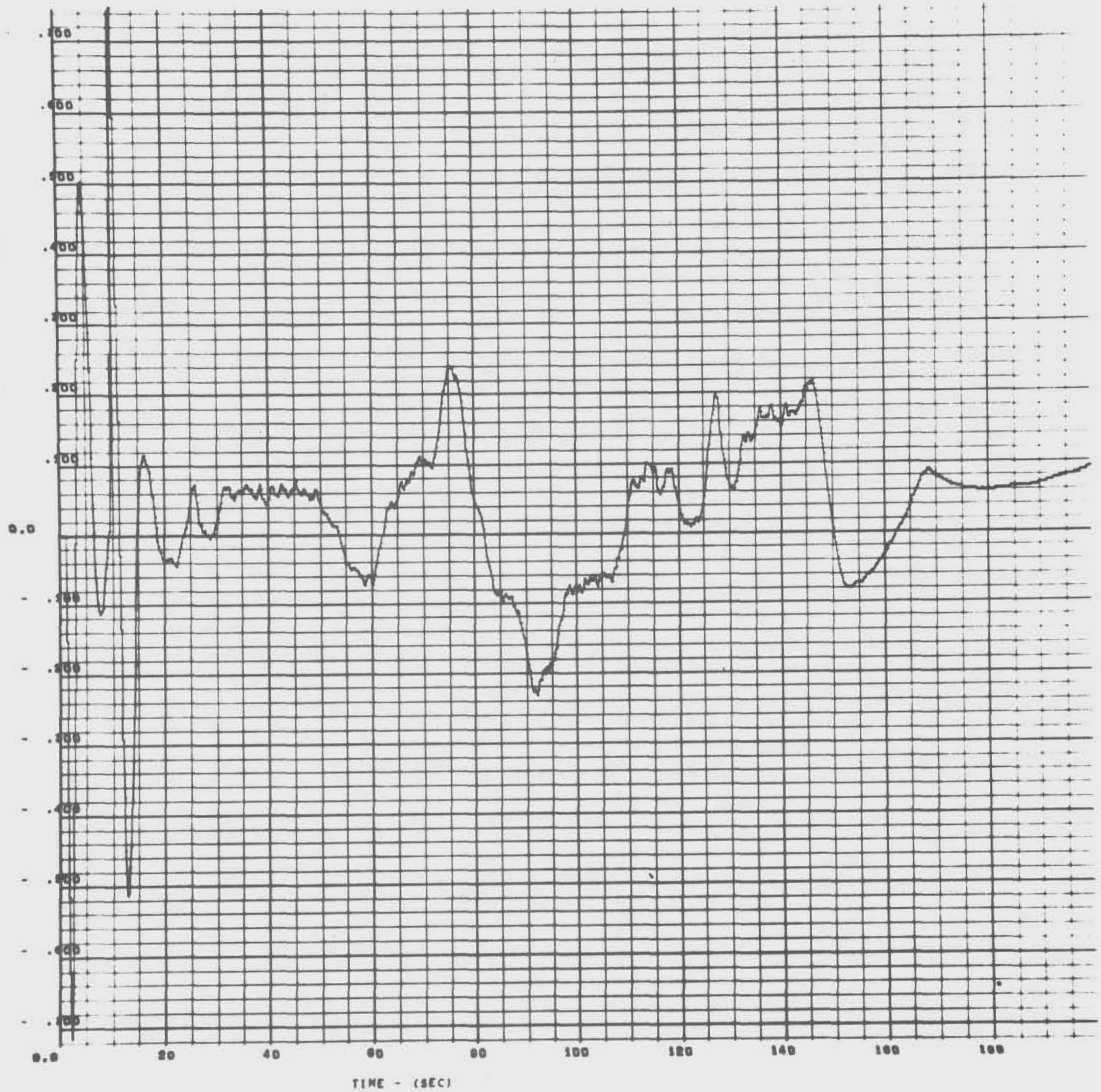

FIGURE C.2-2. SIMULATION RESPONSE TO 95% FEBRUARY DESIGN WINDS USING A LEAD FILTER WITH QUANTUM LEVELS ON βc AND θ OF $.06^{\circ}$ AND $.00279^{\circ}$ RESPECTIVELY

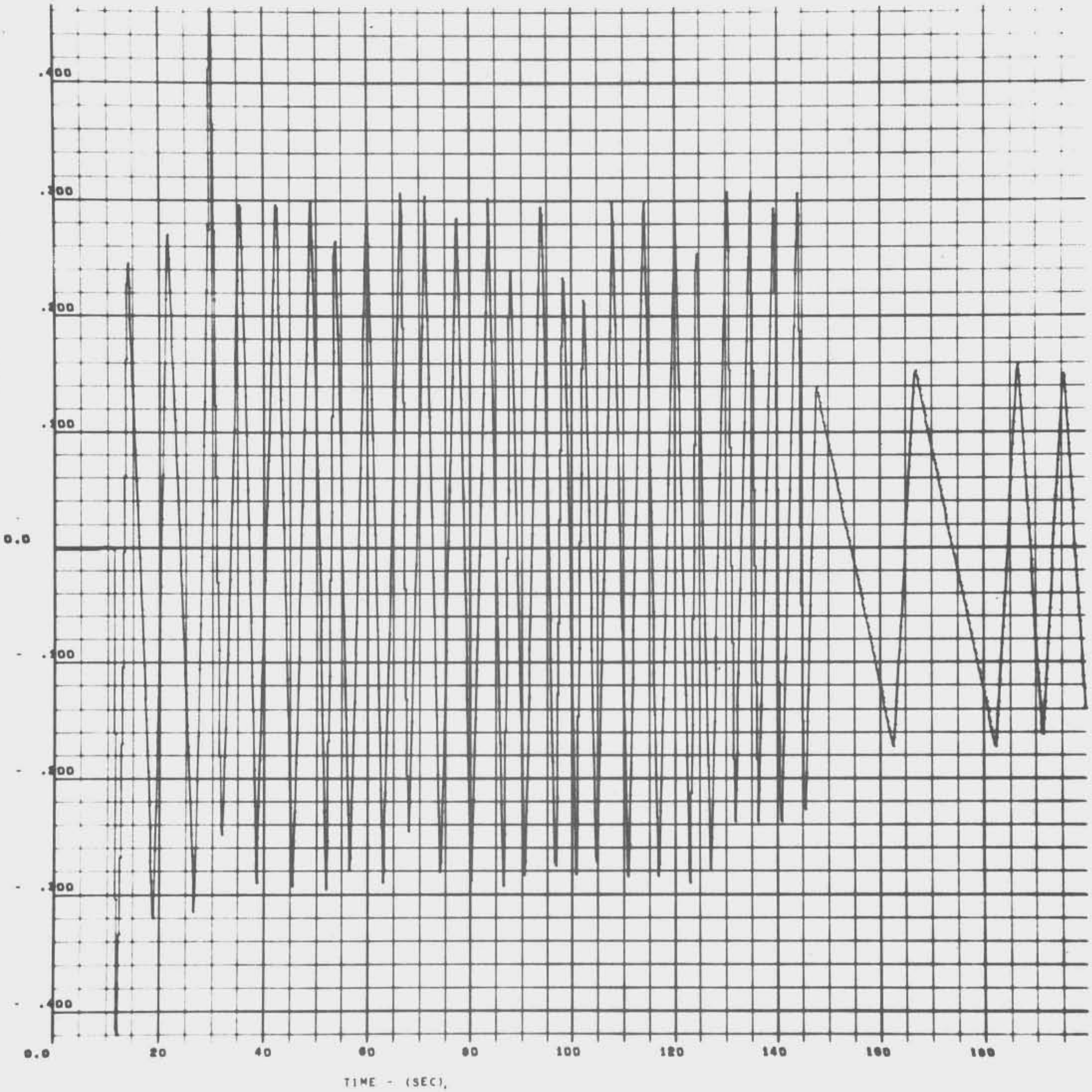

FIGURE C.2-3. SIMULATION RESPONSE TO 95% FEBRUARY DESIGN WINDS USING A LEAD FILTER WITH QUANTUM LEVELS ON βc AND θ OF $.06^{\circ}$ AND $.00279^{\circ}$ RESPECTIVELY

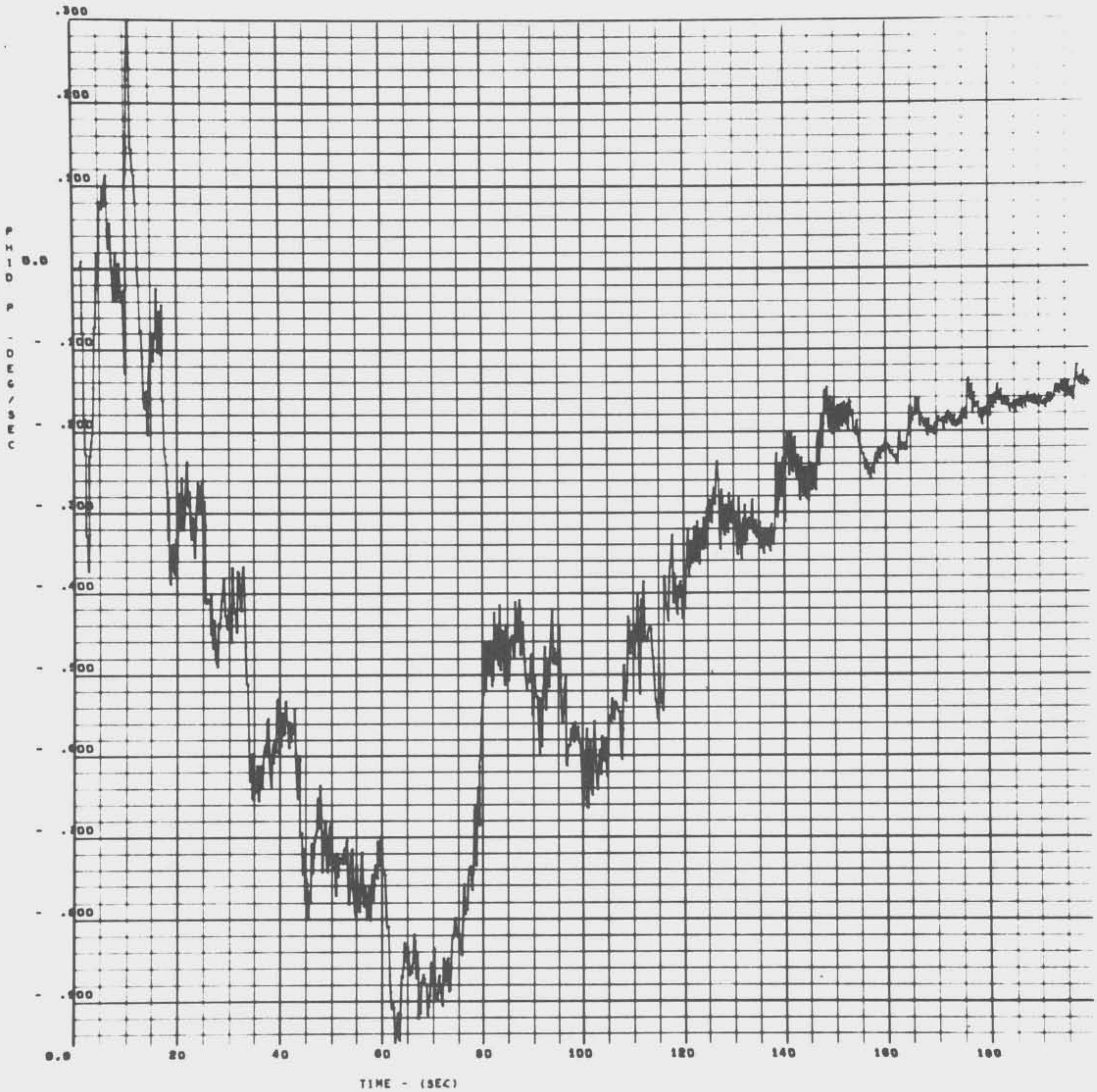

FIGURE C.2-4. SIMULATION RESPONSE TO 95% FEBRUARY DESIGN WINDS USING A LEAD FILTER WITH QUANTUM LEVELS ON βc AND θ OF $.06^{\circ}$ AND $.00279^{\circ}$ RESPECTIVELY

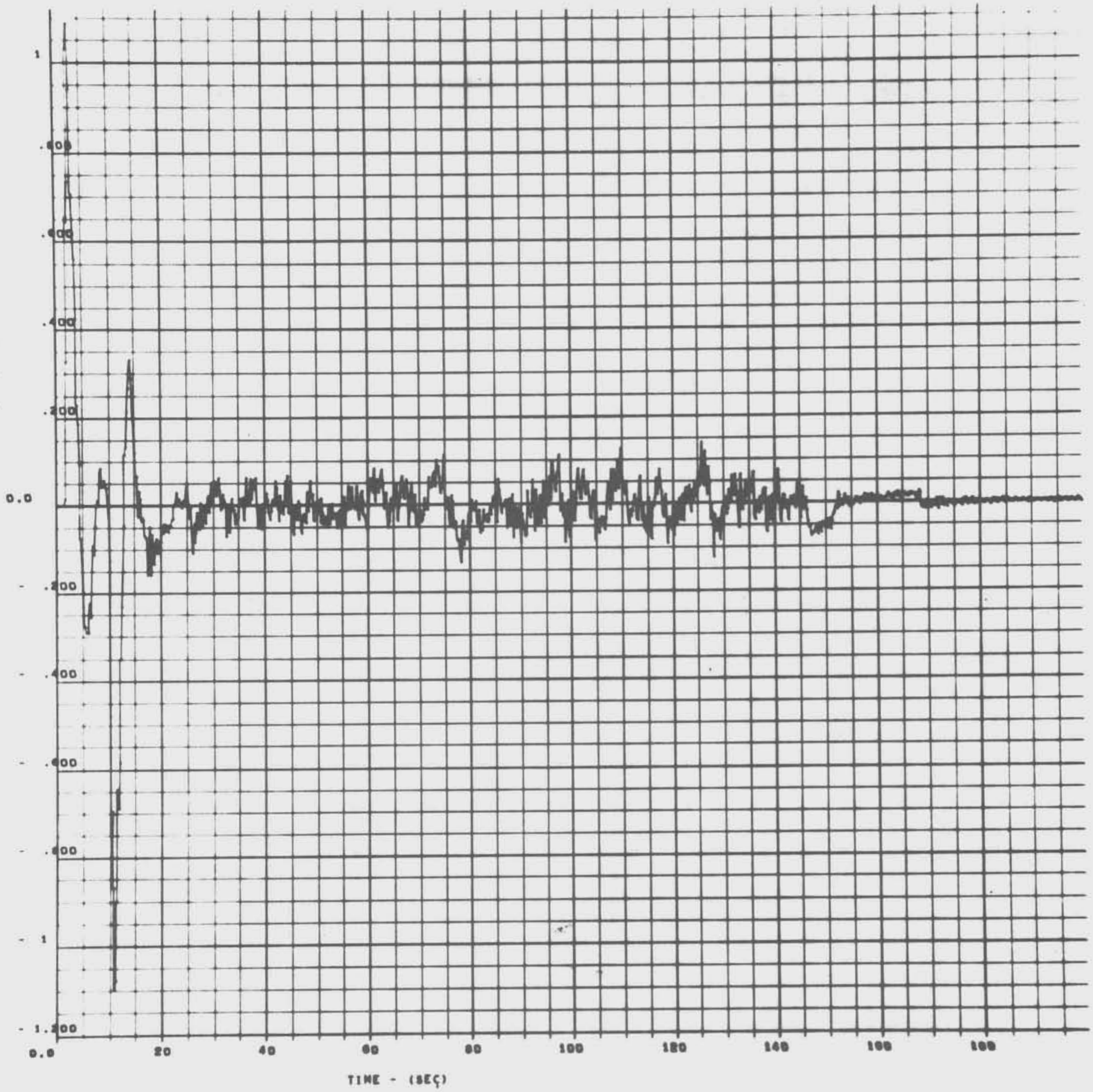

FIGURE C.2-5. SIMULATION RESPONSE TO 95% FEBRUARY DESIGN WINDS USING A LEAD FILTER WITH QUANTUM LEVELS ON βc AND θ OF $.06^{\circ}$ AND $.00279^{\circ}$ RESPECTIVELY

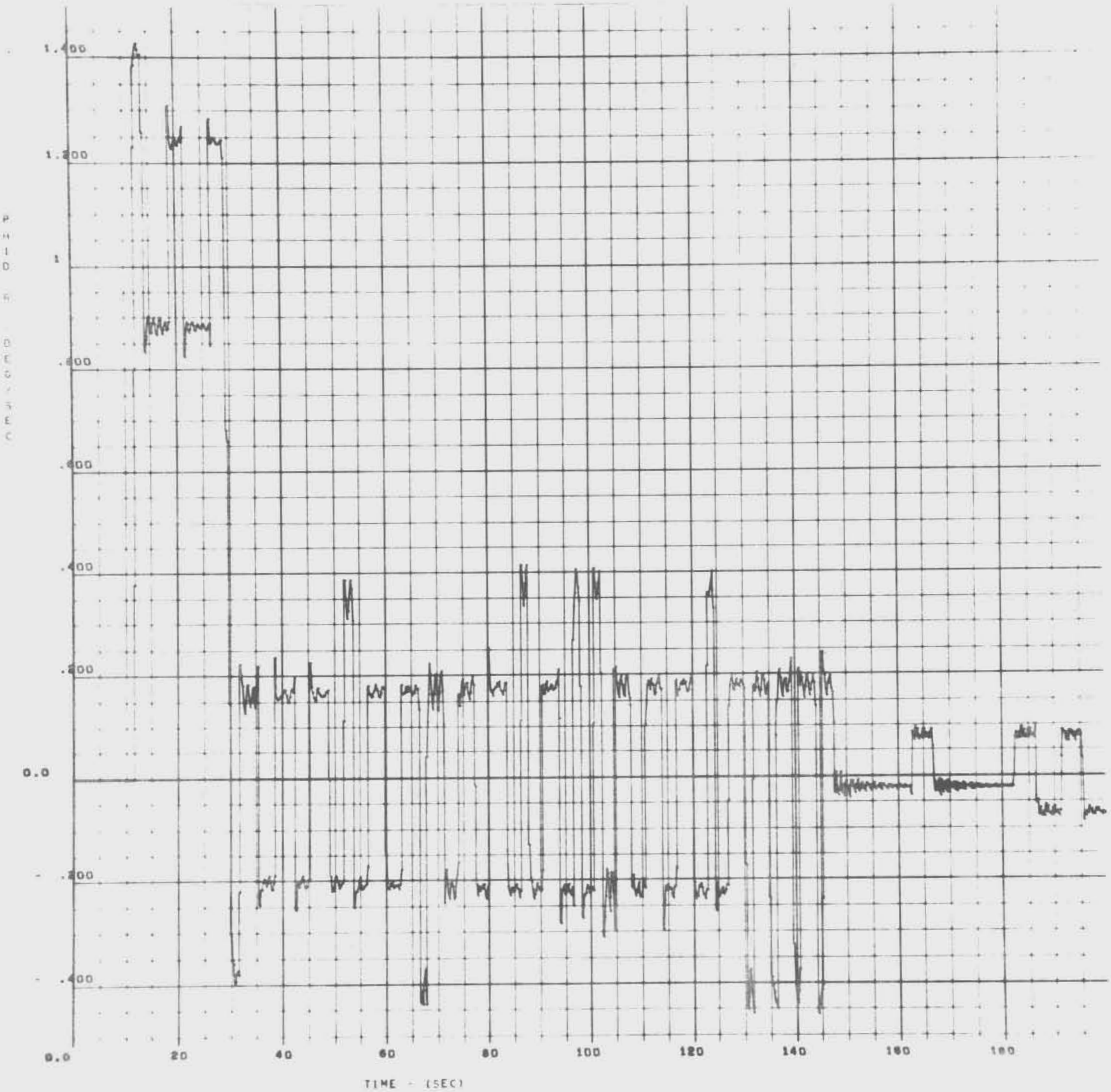

FIGURE C.2-6. SIMULATION RESPONSE TO 95% FEBRUARY DESIGN WINDS USING A LEAD FILTER WITH QUANTUM LEVELS ON βc AND θ OF $.06^{\circ}$ AND $.00279^{\circ}$ RESPECTIVELY

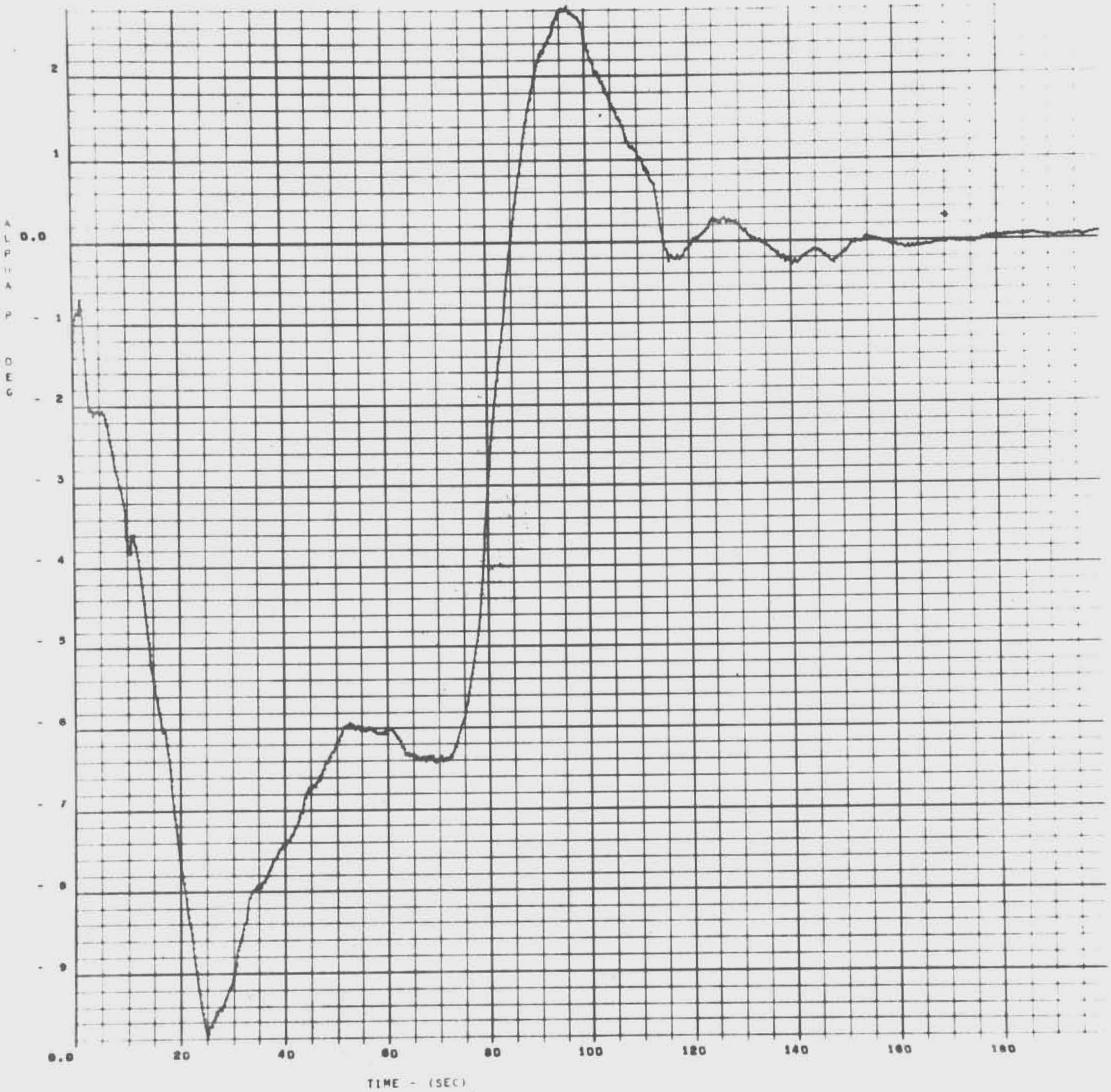

FIGURE C.2-7. SIMULATION RESPONSE TO 95% FEBRUARY DESIGN WINDS USING A LEAD FILTER WITH QUANTUM LEVELS ON β c AND θ OF .06° AND .00279° RESPECTIVELY

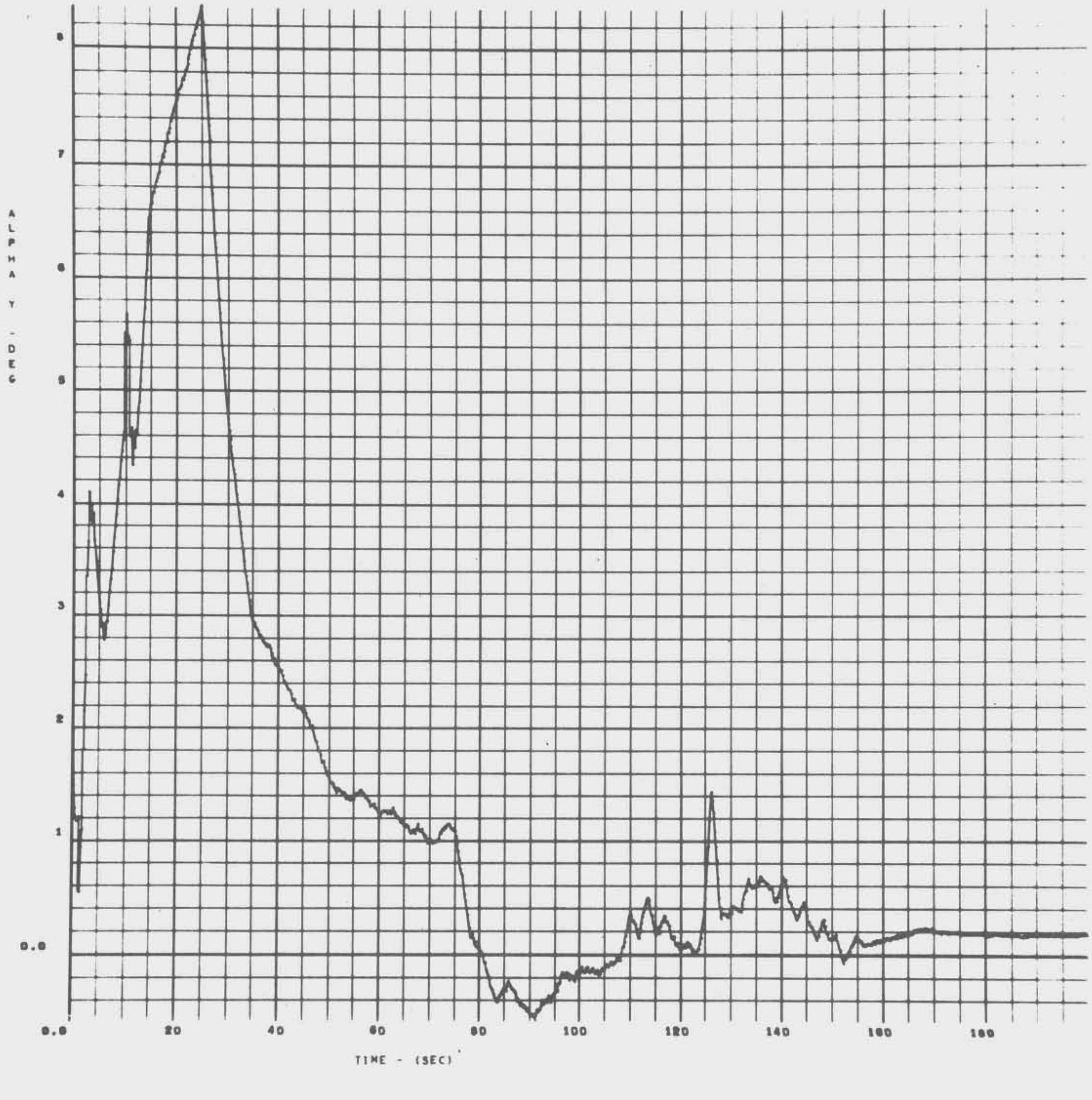

FIGURE C.2-8. SIMULATION RESPONSE TO 95% FEBRUARY DESIGN WINDS USING A LEAD FILTER WITH QUANTUM LEVELS ON βc AND θ OF $.06^{\circ}$ AND $.00279^{\circ}$ RESPECTIVELY

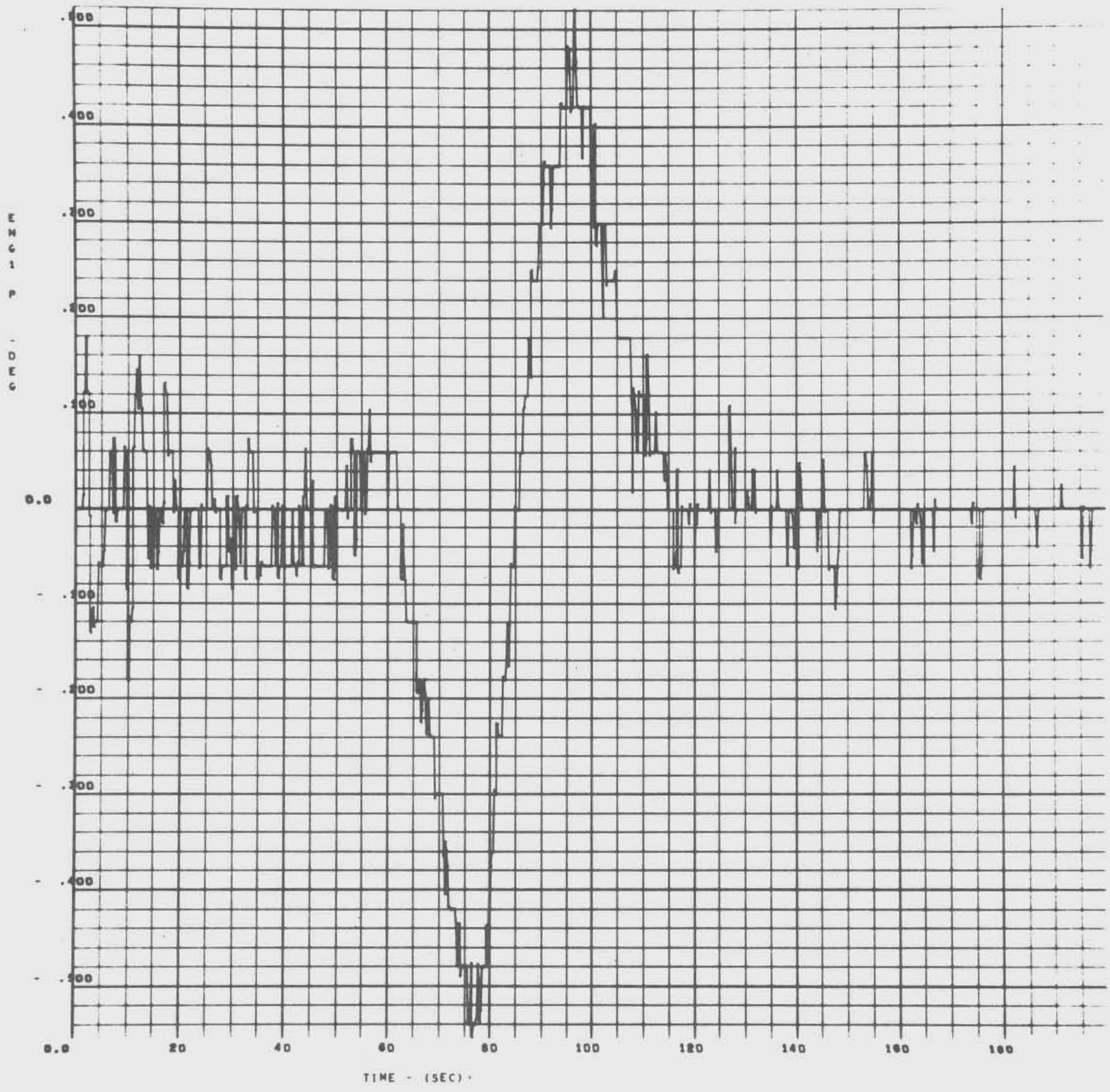

FIGURE C.2-9. SIMULATION RESPONSE TO 95% FEBRUARY DESIGN WINDS USING A LEAD FILTER WITH QUANTUM LEVELS ON βc AND θ OF $.06^{\circ}$ and $.00279^{\circ}$ RESPECTIVELY

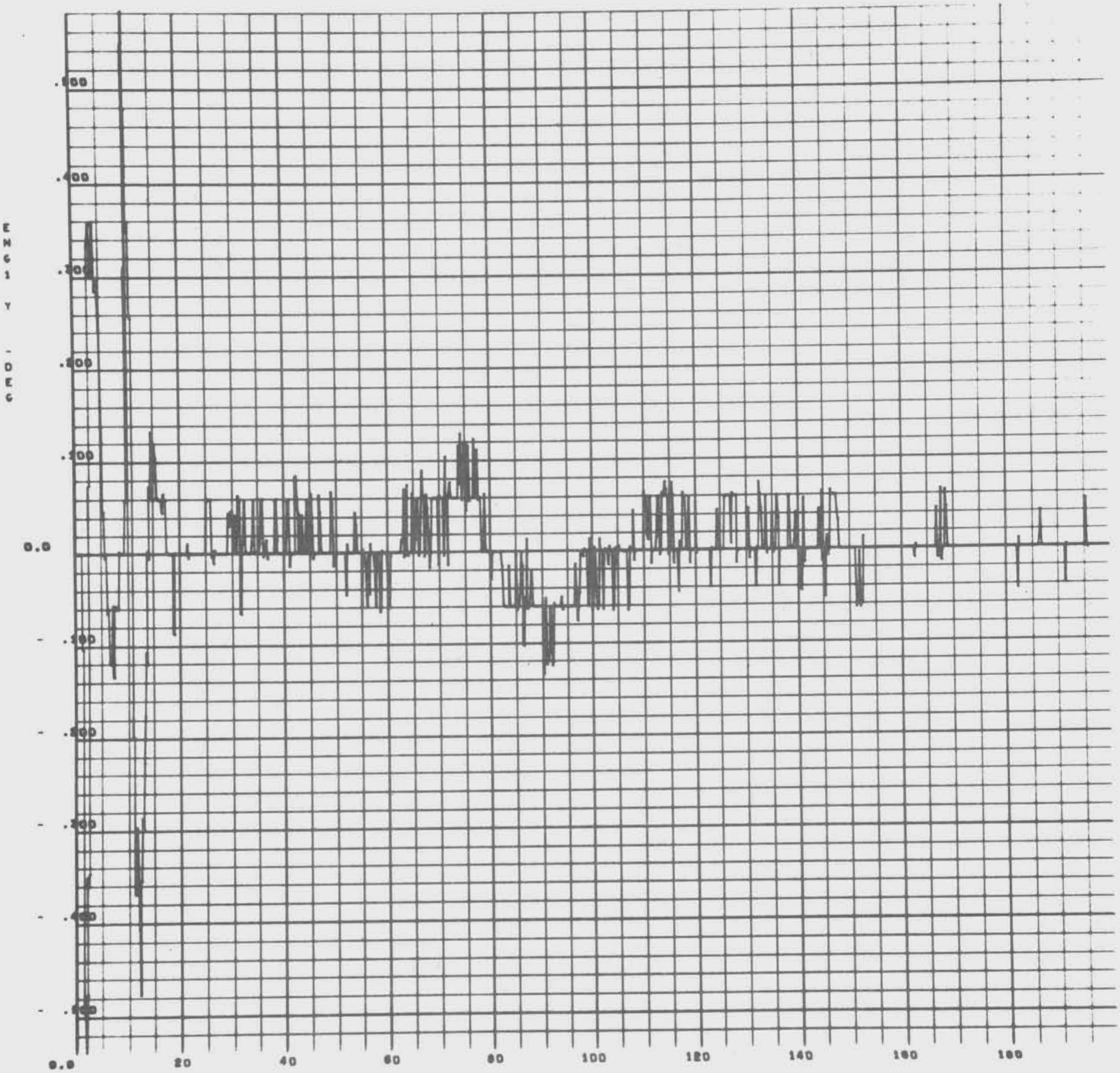

FIGURE C.2-10. SIMULATION RESPONSE TO 95% FEBRUARY DESIGN WINDS USING A LEAD FILTER WITH QUANTUM LEVELS ON βc AND θ OF $.06^{o}$ AND $.00279^{o}$ RESPECTIVELY

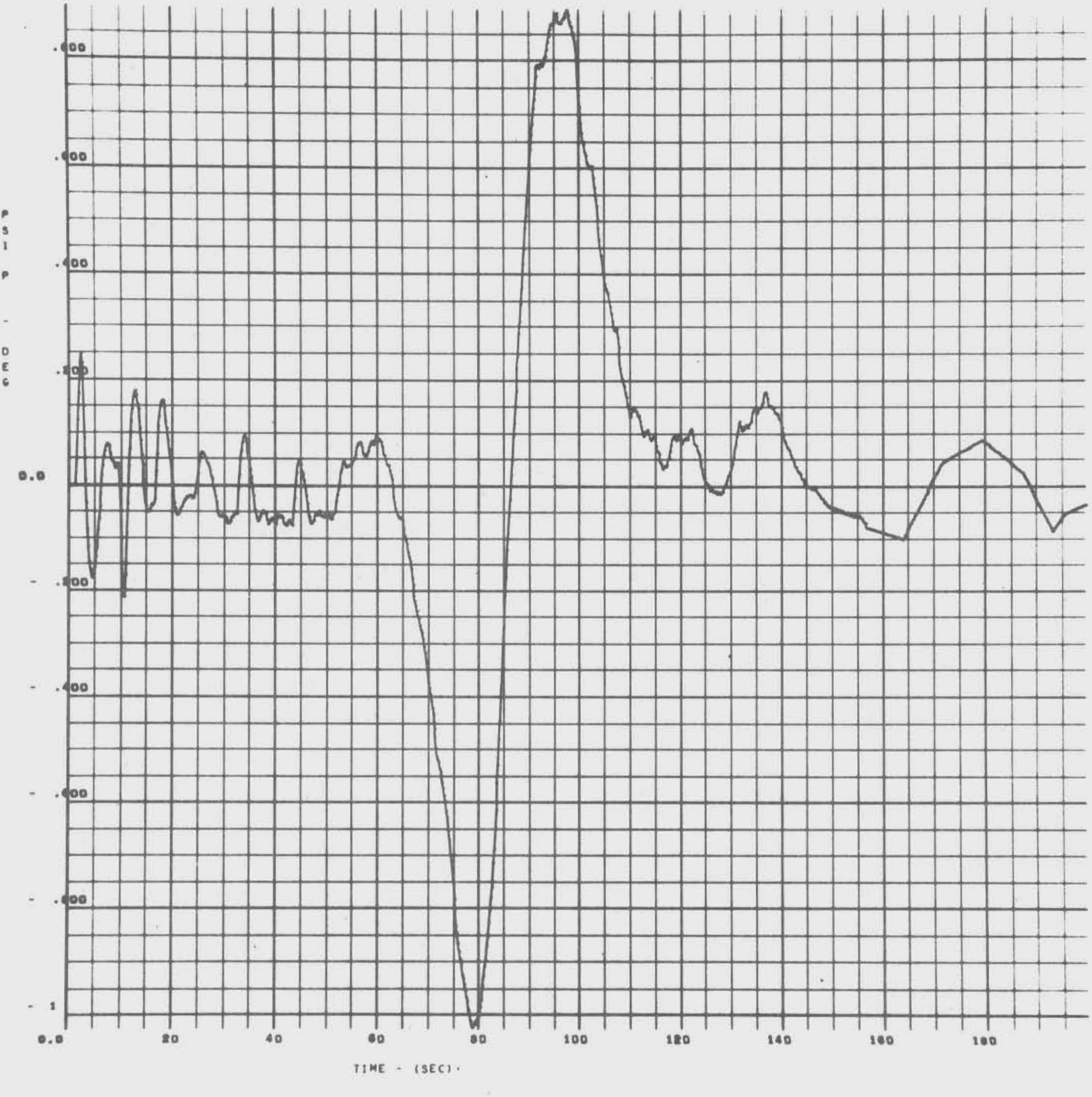

FIGURE C.2-11. SIMULATION RESPONSE TO 95% MAY DESIGN WINDS USING A LEAD FILTER WITH QUANTUM LEVELS ON βc AND θ OF $.06^{O}$ AND $.00279^{O}$ RESPECTIVELY

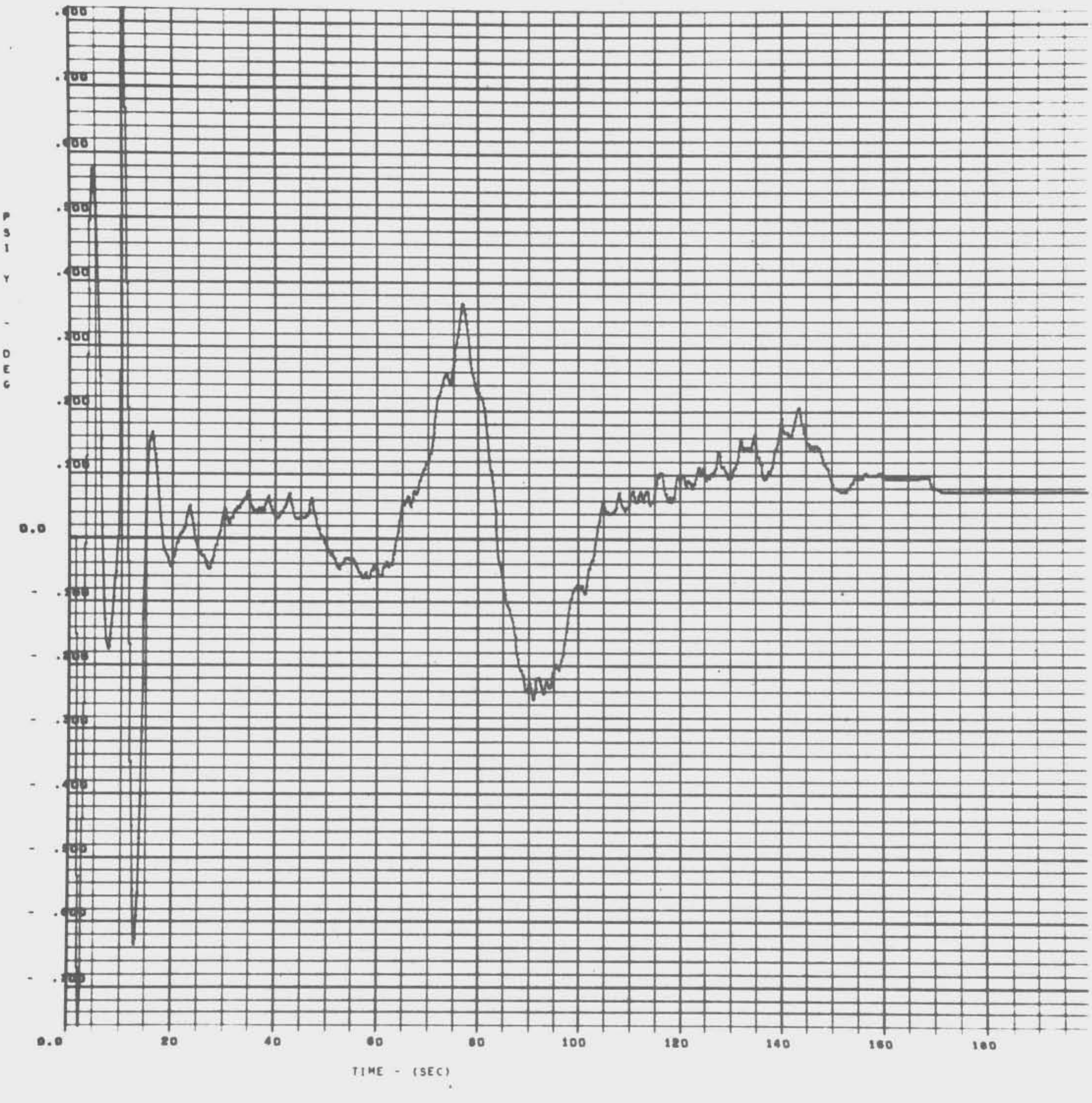

FIGURE C.2-12. SIMULATION RESPONSE TO 95% MAY DESIGN WINDS USING A LEAD FILTER WITH QUANTUM LEVELS ON βc AND θ OF .06° AND .00279° RESPECTIVELY

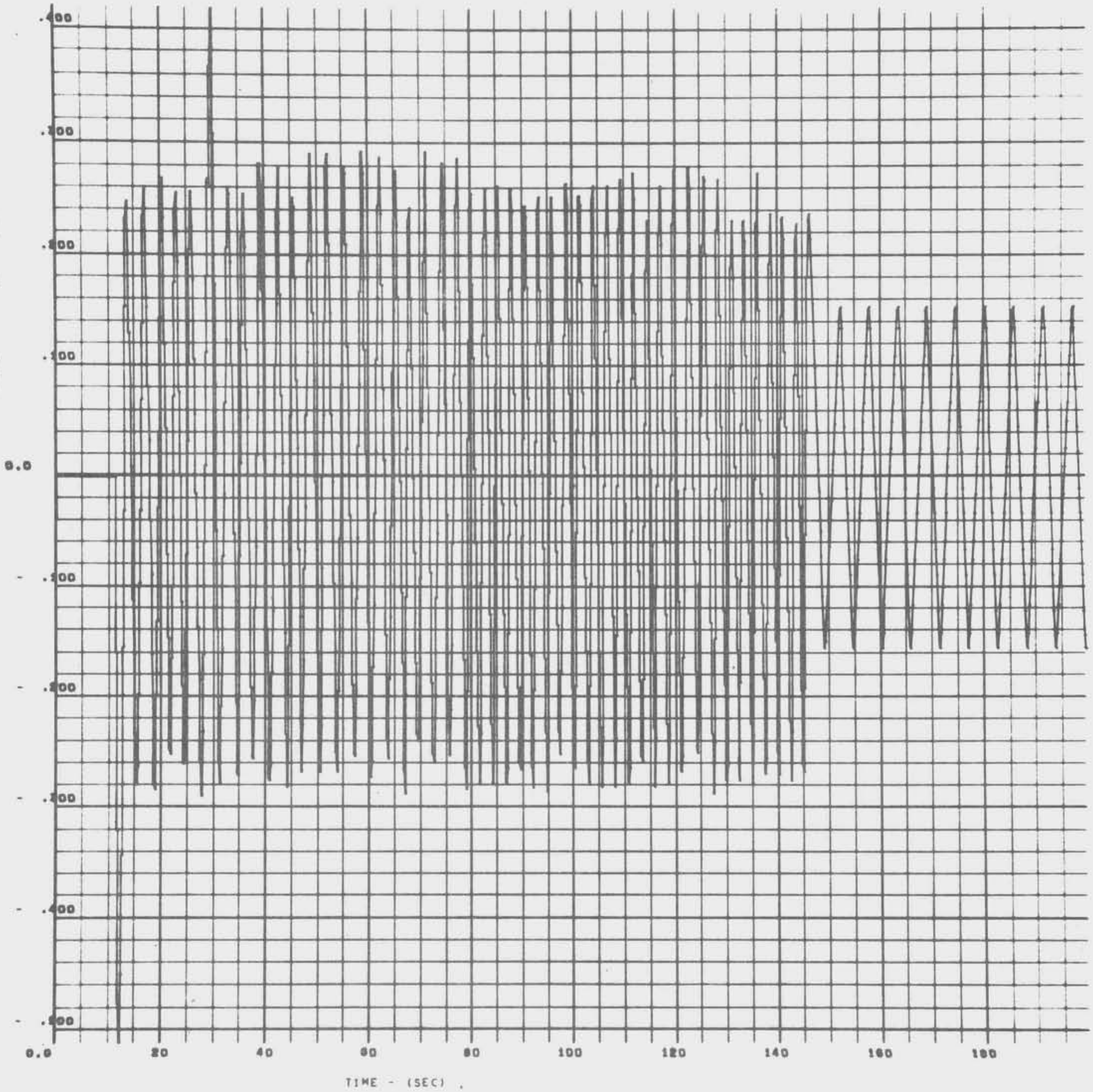

FIGURE C.2-13. SIMULATION RESPONSE TO 95% MAY DESIGN WINDS USING A LEAD FILTER WITH QUANTUM LEVELS ON βc AND θ OF $.06^{\circ}$ AND $.00279^{\circ}$ RESPECTIVELY

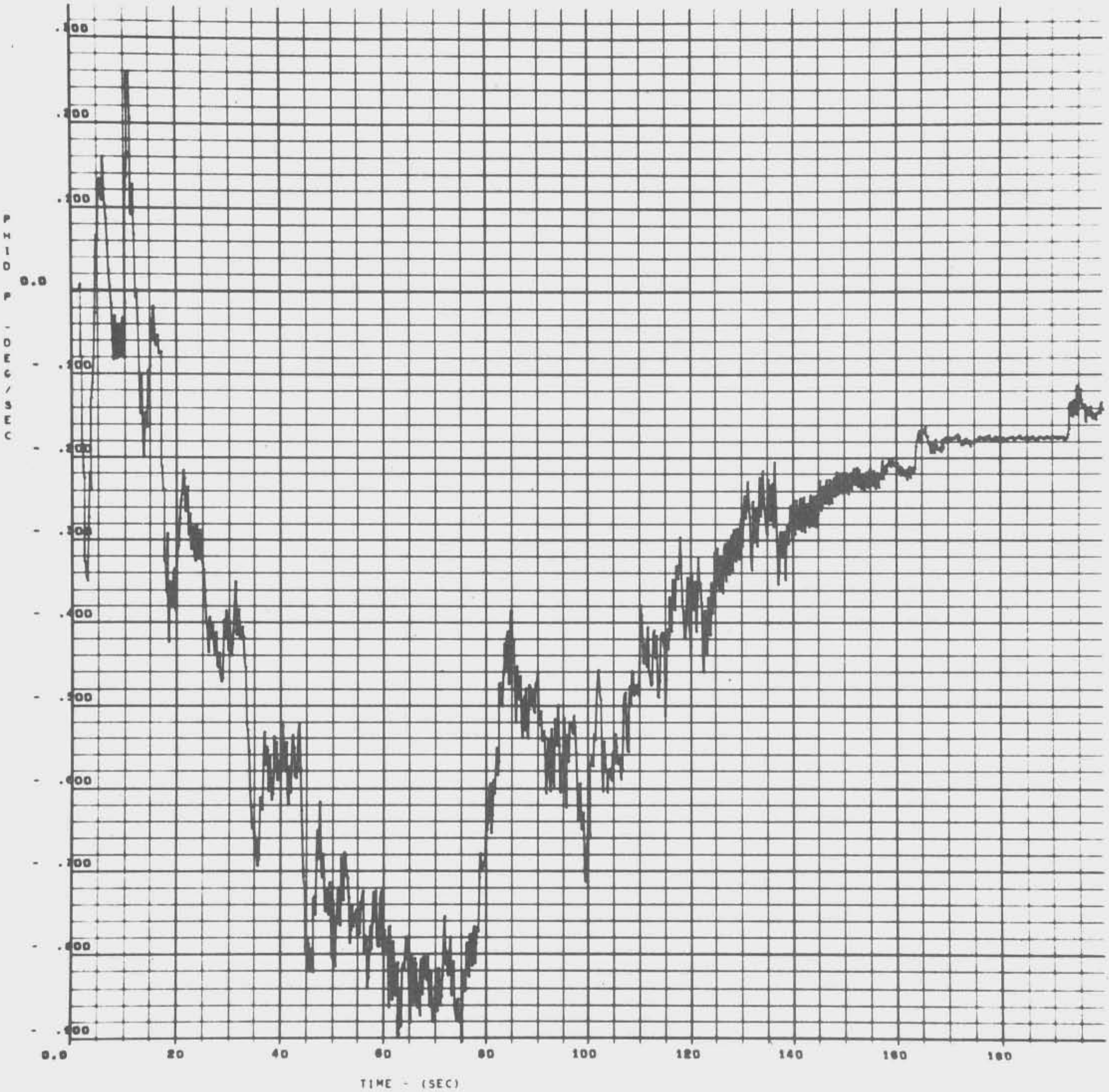

FIGURE C.2-14. SIMULATION RESPONSE TO 95% MAY DESIGN WINDS USING A LEAD FILTER WITH QUANTUM LEVELS ON βc AND θ OF $.06^{\circ}$ AND $.00279^{\circ}$ RESPECTIVELY

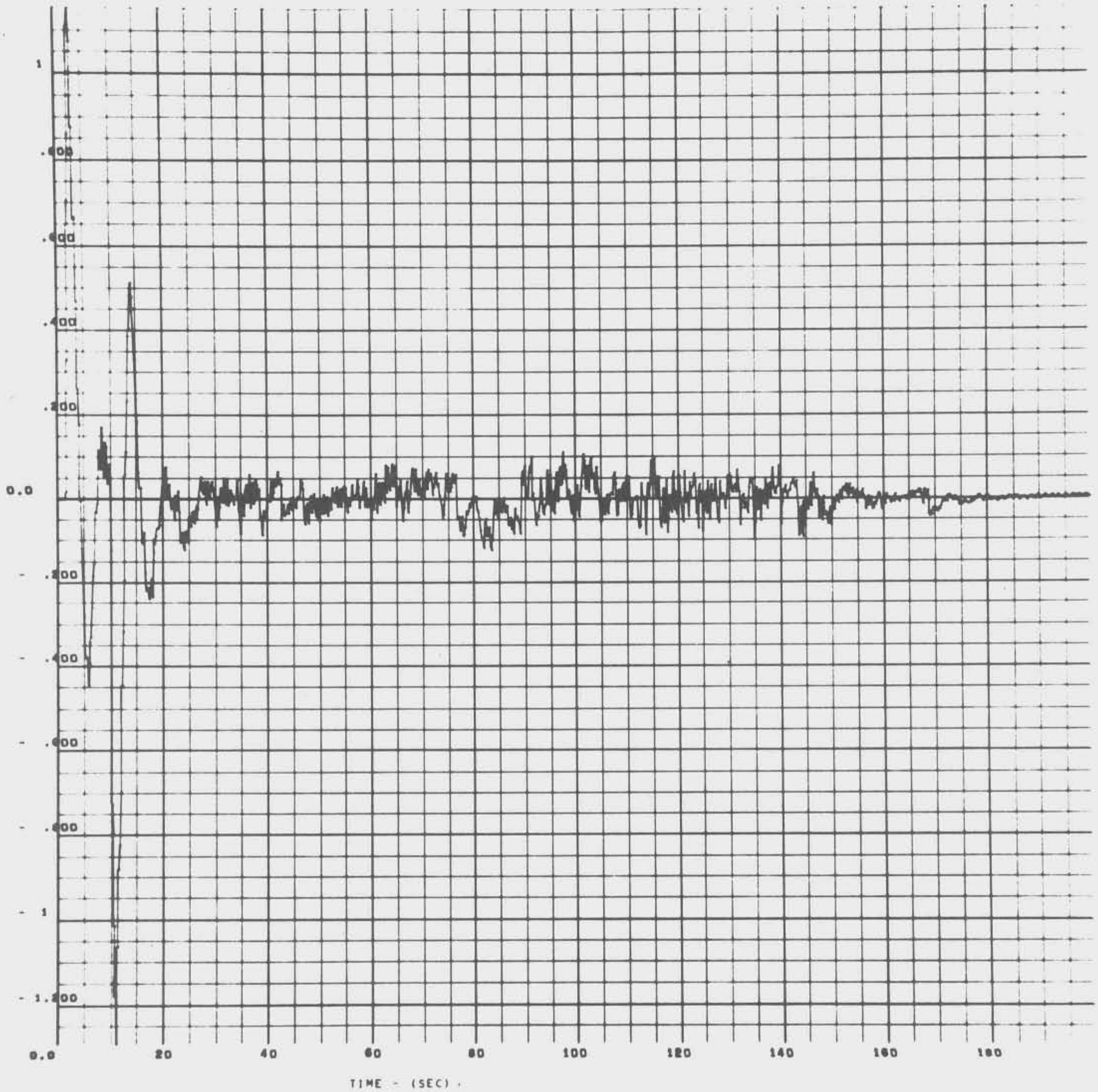

FIGURE C.2-15. SIMULATION RESPONSE TO 95% MAY DESIGN WINDS USING A LEAD FILTER WITH QUANTUM LEVELS ON βc AND θ OF .06° AND .00279° RESPECTIVELY

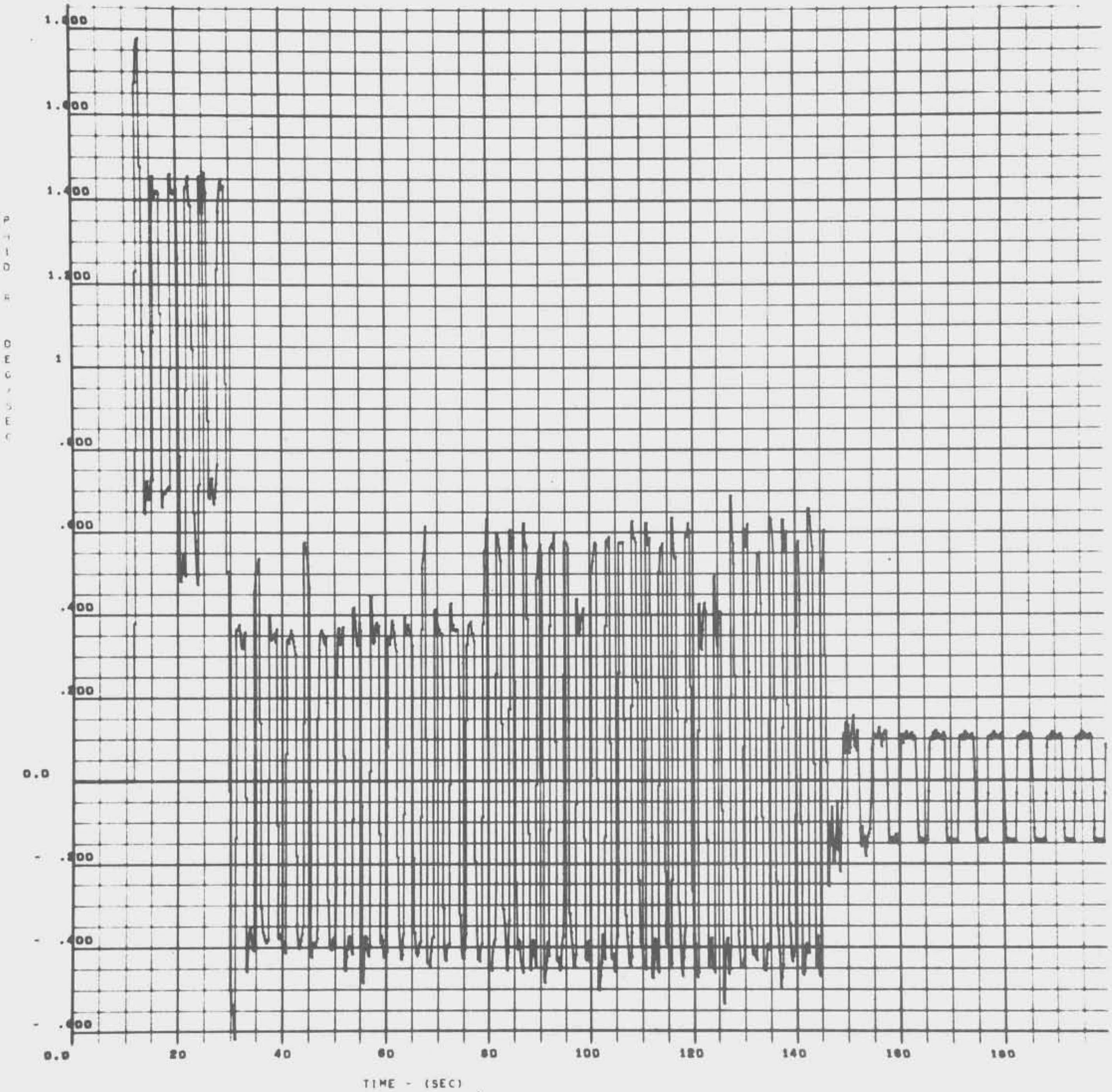

FIGURE C.2-16. SIMULATION RESPONSE TO 95% MAY DESIGN WINDS USING A LEAD FILTER WITH QUANTUM LEVELS ON βc AND θ OF $.06^{\circ}$ AND $.00279^{\circ}$ RESPECTIVELY

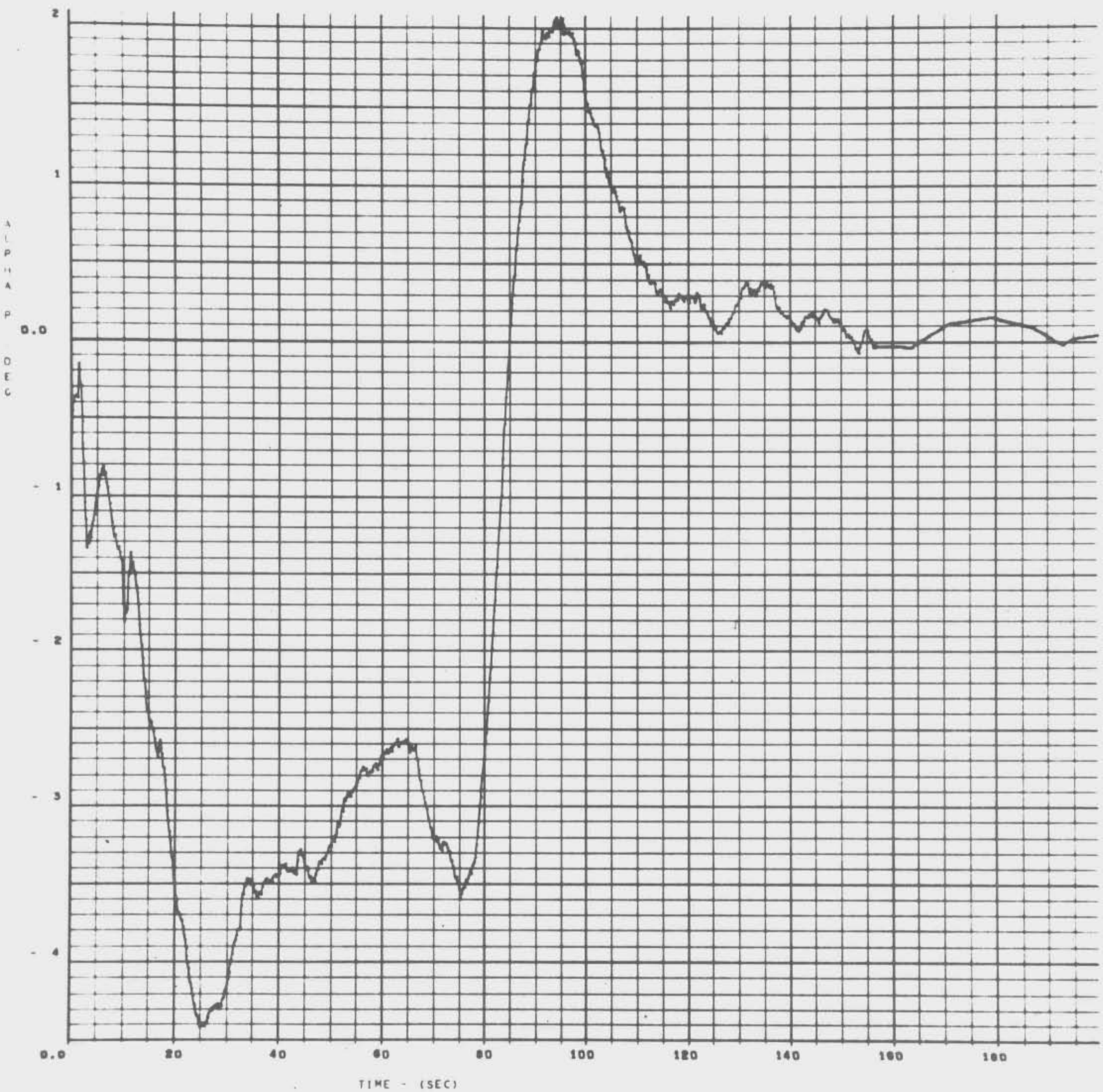

FIGURE C.2-17. SIMULATION RESPONSE TO 95% MAY DESIGN WINDS USING A LEAD FILTER WITH QUANTUM LEVELS ON βc AND θ OF $.06^{o}$ AND $.00279^{o}$ RESPECTIVELY

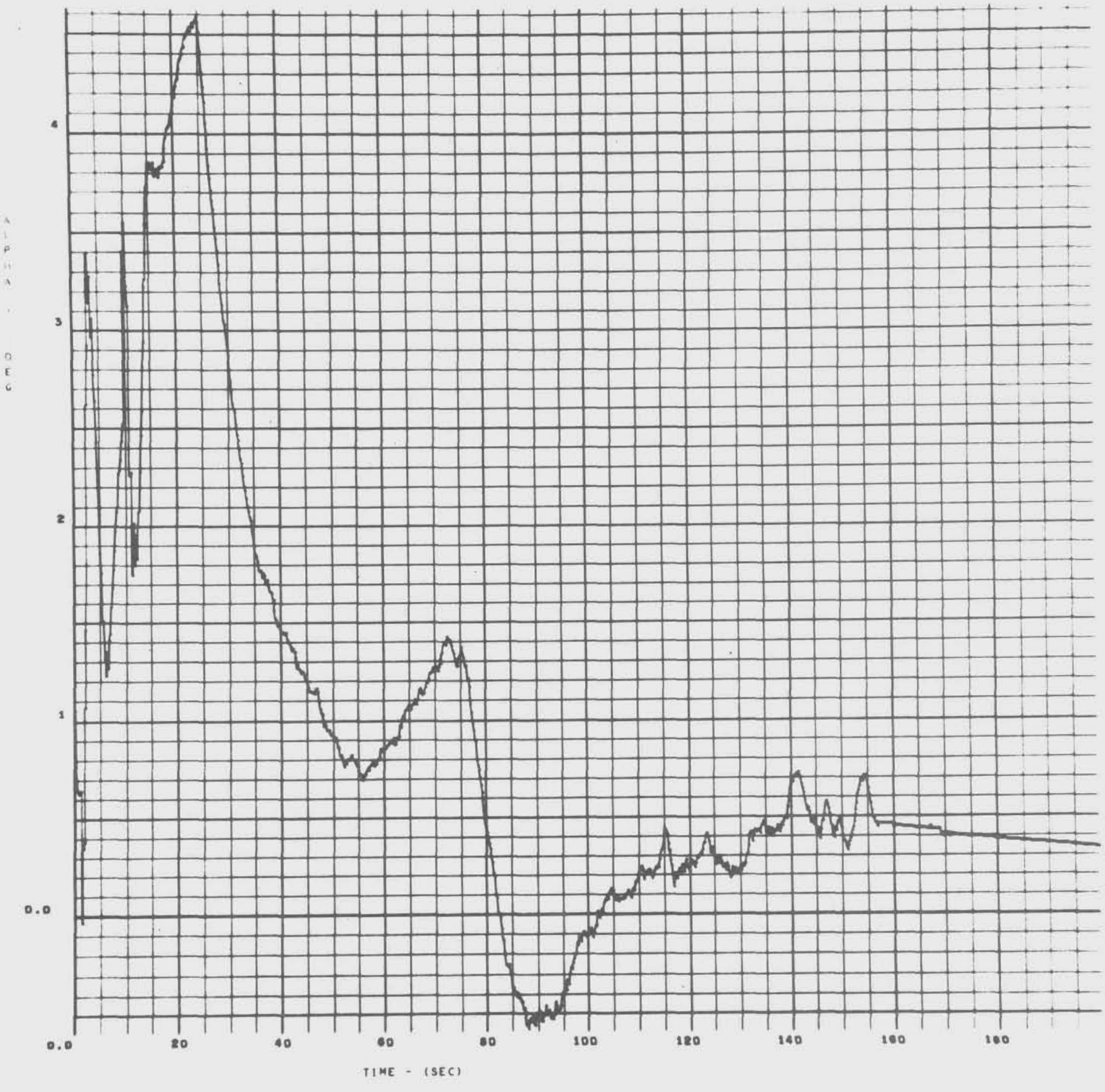

FIGURE C.2-18. SIMULATION RESPONSE TO 95% MAY DESIGN WINDS USING A LEAD FILTER WITH QUANTUM LEVELS ON βc AND θ OF .06° AND .00279° RESPECTIVELY

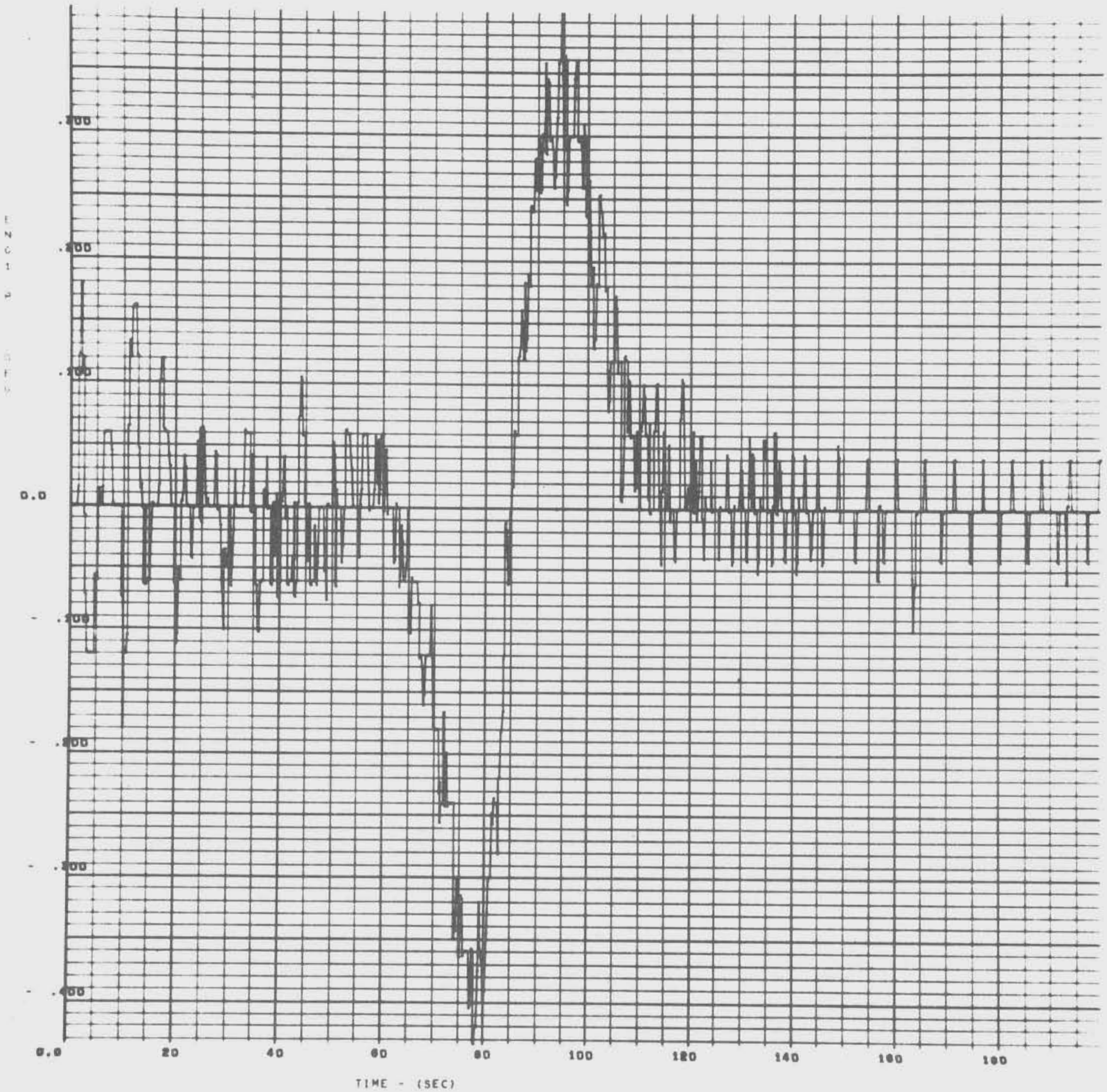

FIGURE C.2-19. SIMULATION RESPONSE TO 95% MAY DESIGN WINDS USING A LEAD FILTER WITH QUANTUM LEVELS ON βc AND θ OF $.06^{\circ}$ AND $.00279^{\circ}$ RESPECTIVELY

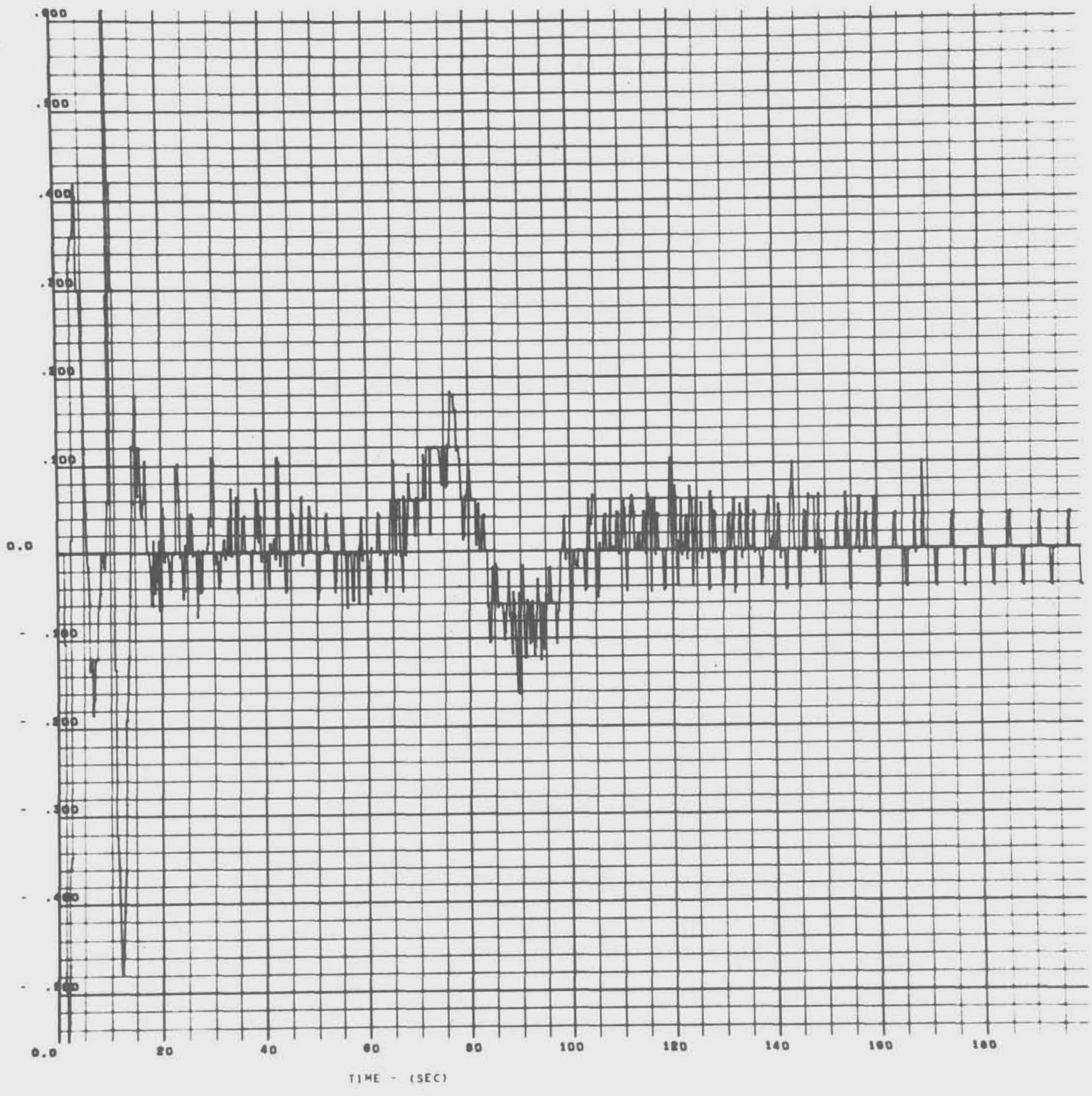

FIGURE C.2-20. SIMULATION RESPONSE TO 95% MAY DESIGN WINDS USING A LEAD FILTER WITH QUANTUM LEVELS ON βc AND θ OF $.06^{\circ}$ AND $.00279^{\circ}$ RESPECTIVELY

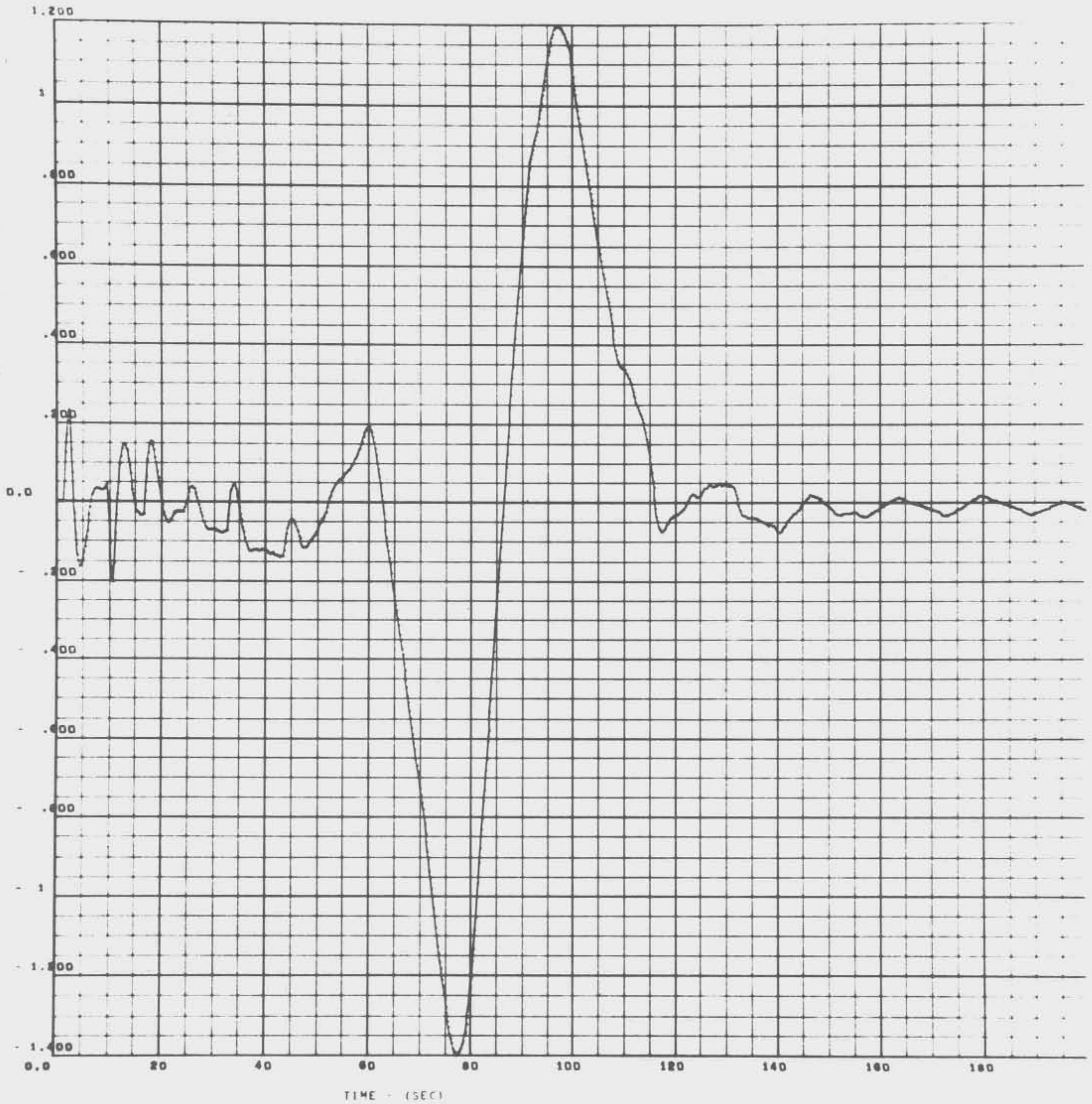

FIGURE C.2-21. SIMULATION RESPONSE TO 95% FEBRUARY DESIGN WINDS USING A LEAD FILTER WITH QUANTUM LEVELS ON β c AND θ OF .0202° AND .00279° RESPECTIVELY

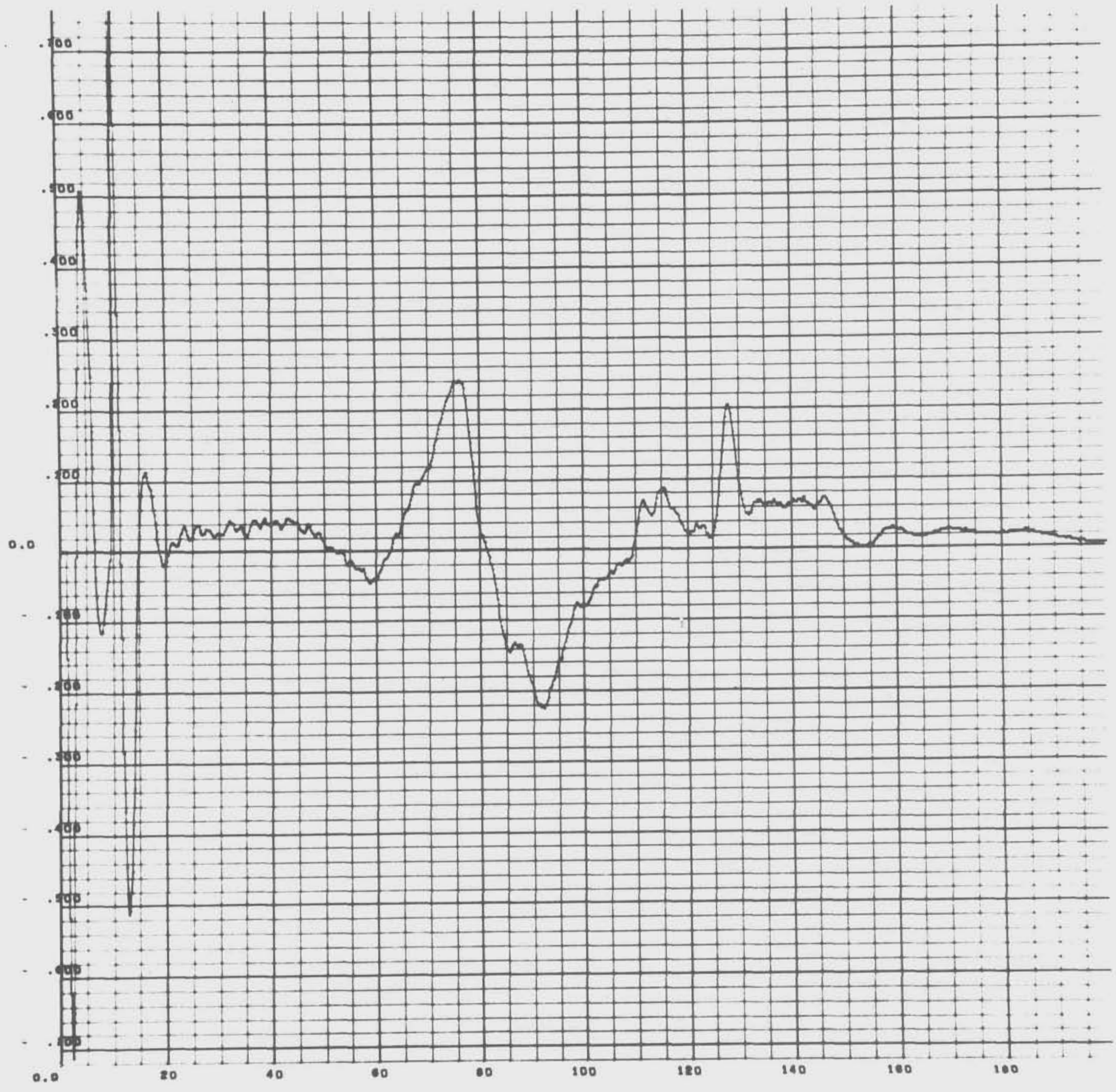

FIGURE C.2-22. SIMULATION RESPONSE TO 95% FEBRUARY DESIGN WINDS USING A LEAD FILTER WITH QUANTUM LEVELS ON βc AND θ OF $.0202^{\circ}$ AND $.00279^{\circ}$ RESPECTIVELY

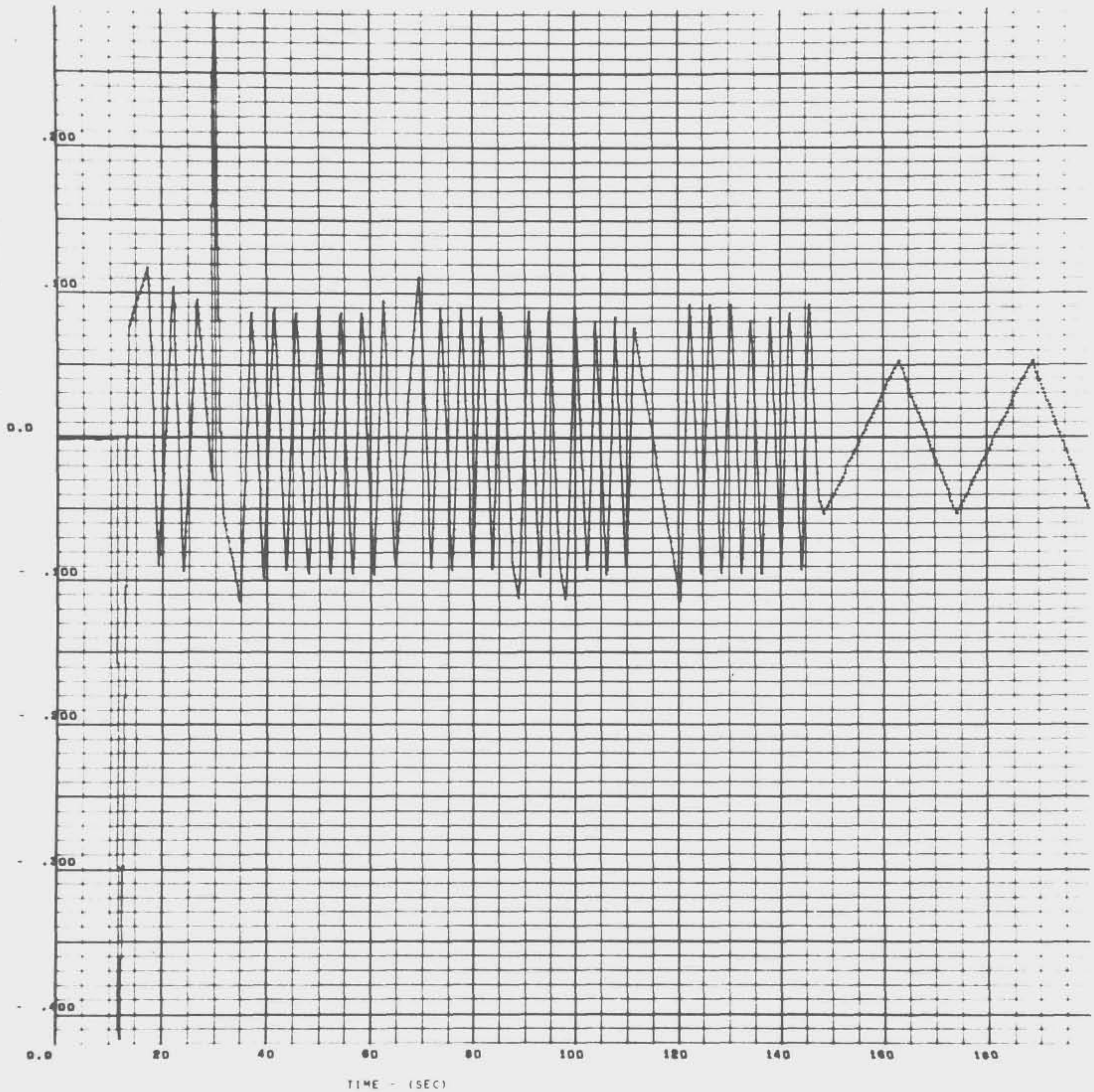

FIGURE C.2-23. SIMULATION RESPONSE TO 95% FEBRUARY DESIGN WINDS USING A LEAD FILTER WITH QUANTUM LEVELS ON βc AND θ OF $.0202^{\circ}$ AND $.00279^{\circ}$ RESPECTIVELY

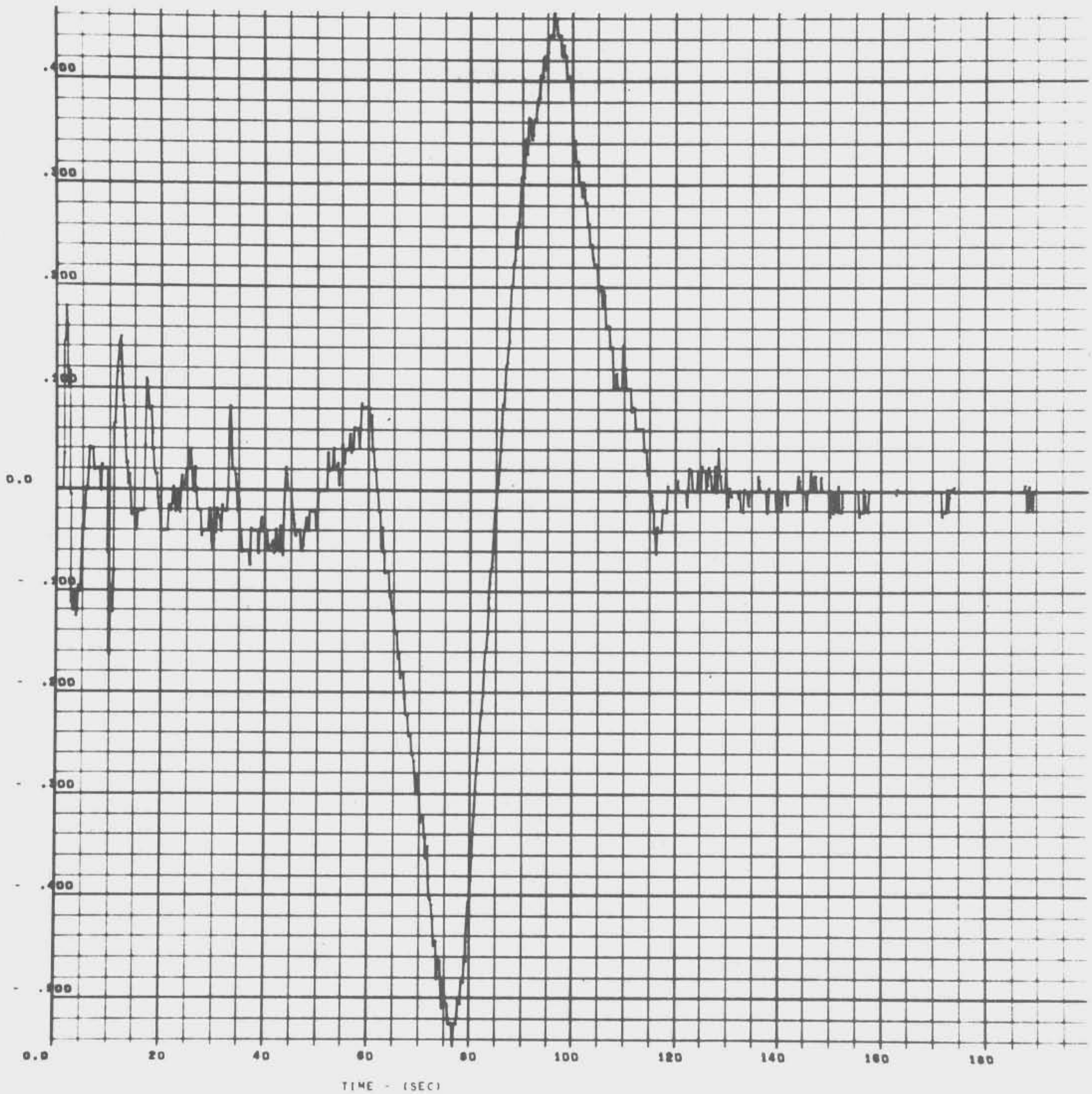

FIGURE C.2-24. SIMULATION RESPONSE TO 95% FEBRUARY DESIGN WINDS USING A LEAD FILTER WITH QUANTUM LEVELS ON βc AND θ OF $.0202^{\circ}$ AND $.00279^{\circ}$ RESPECTIVELY

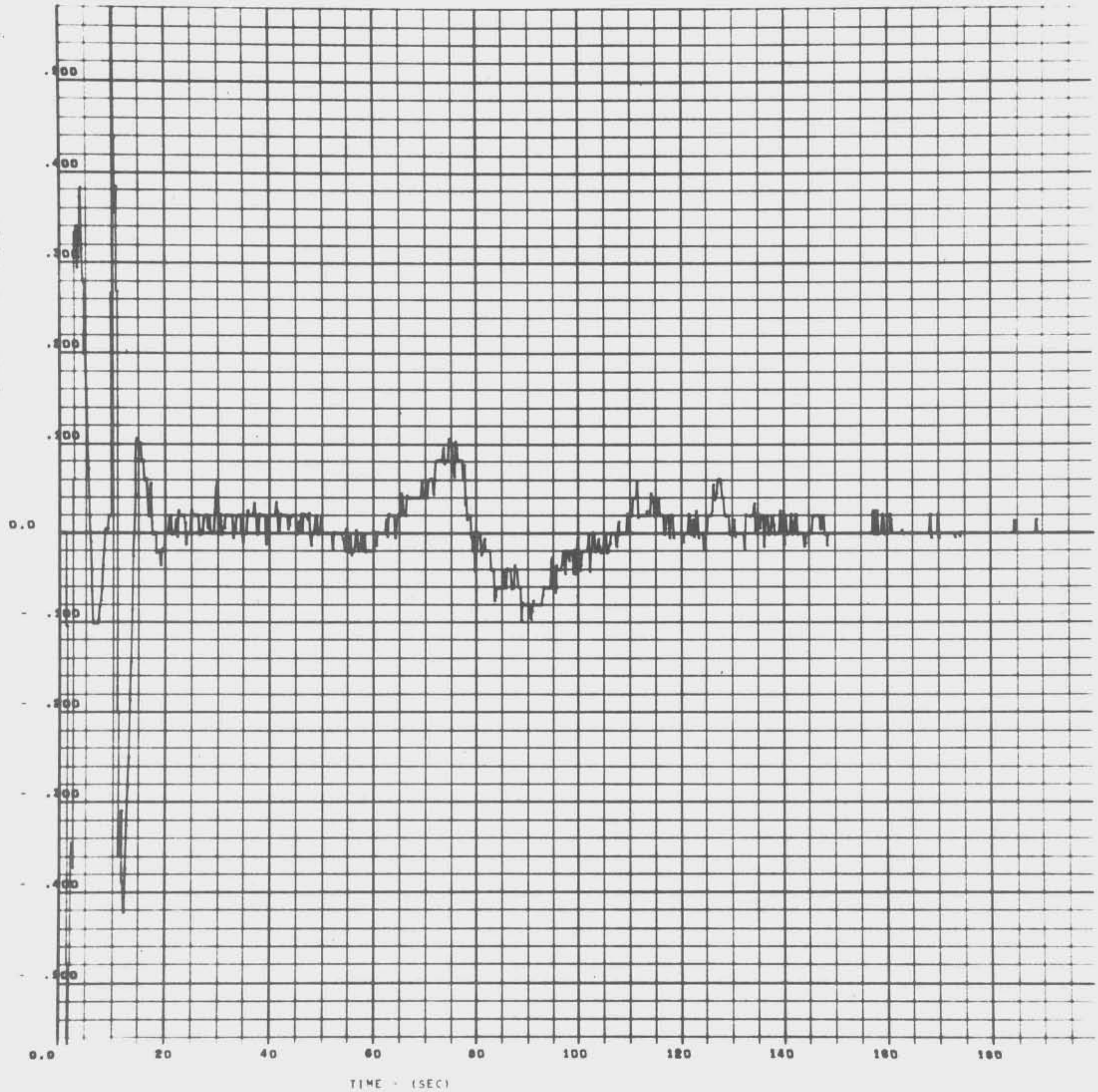

FIGURE C.2-25. SIMULATION RESPONSE TO 95% FEBRUARY DESIGN WINDS USING A LEAD FILTER WITH QUANTUM LEVELS ON βc AND θ OF .0202° AND .00279° RESPECTIVELY

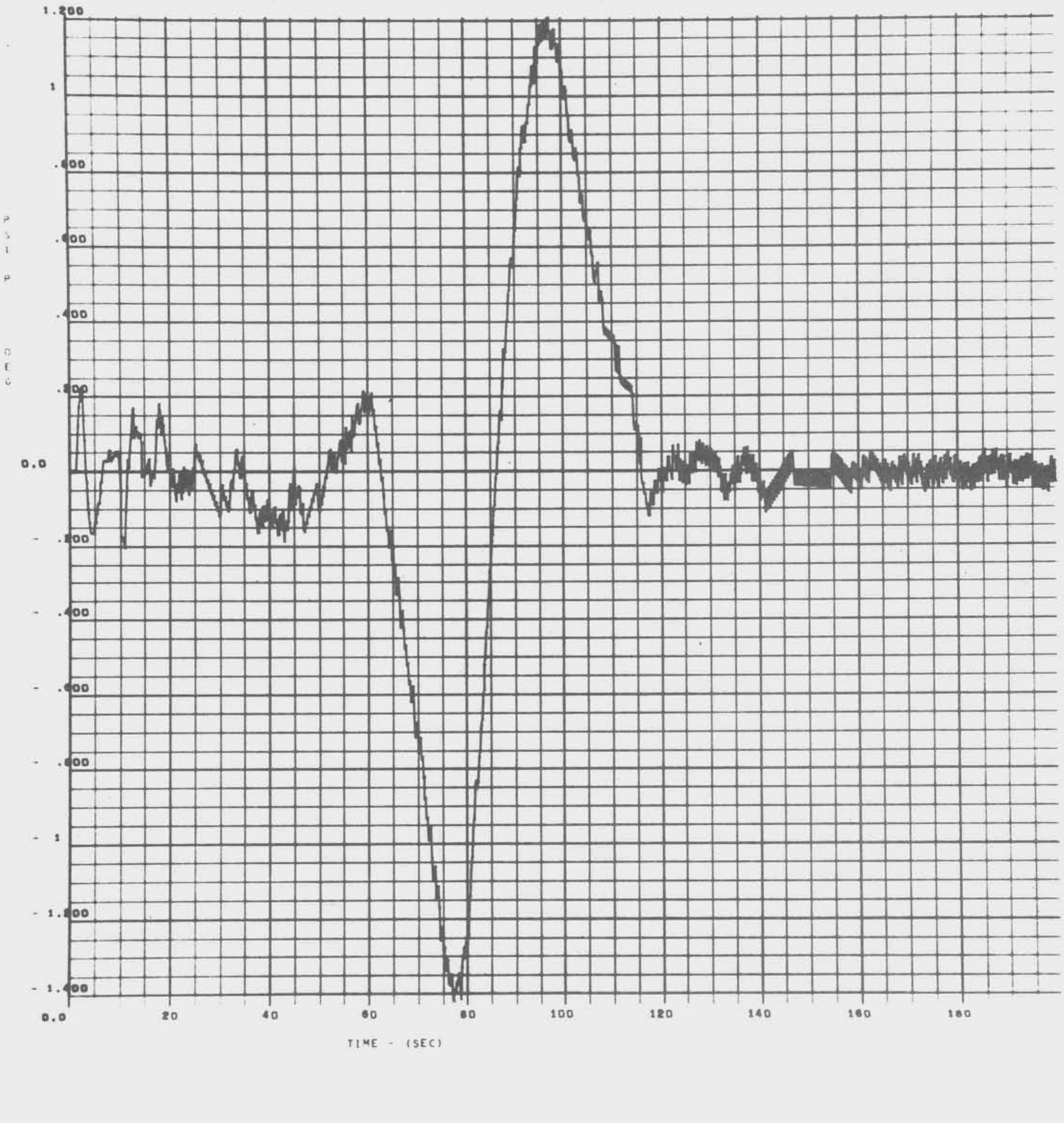

FIGURE C.2-26. SIMULATION RESPONSE TO 95% FEBRUARY DESIGN WINDS USING A LEAD FILTER WITH QUANTUM LEVELS ON βc AND θ OF .0202° AND .089° RESPECTIVELY

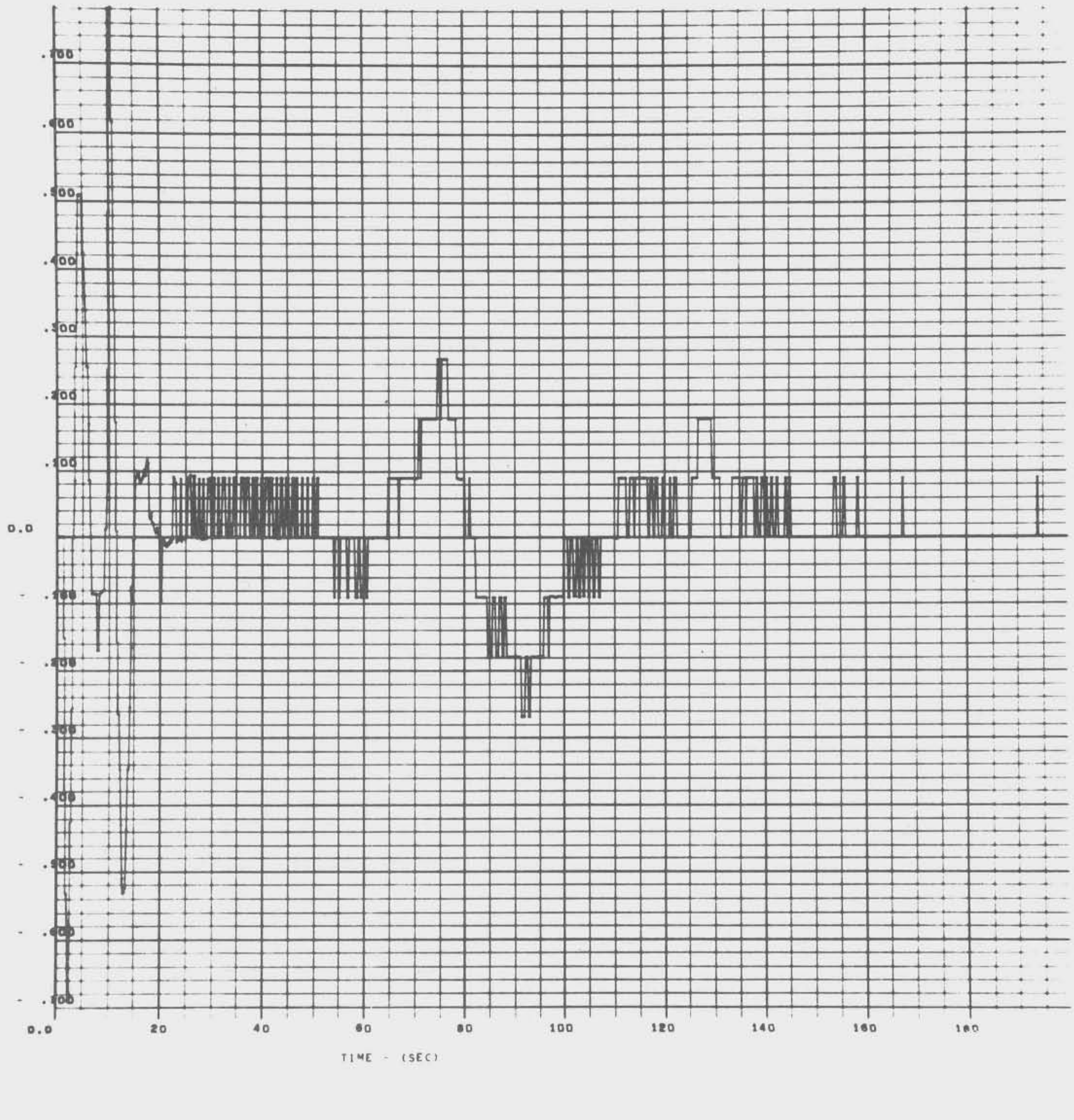

FIGURE C.2-27. SIMULATION RESPONSE TO 95% FEBRUARY DESIGN WINDS USING A LEAD FILTER WITH QUANTUM LEVELS ON βc AND θ OF .0202° AND .089° RESPECTIVELY

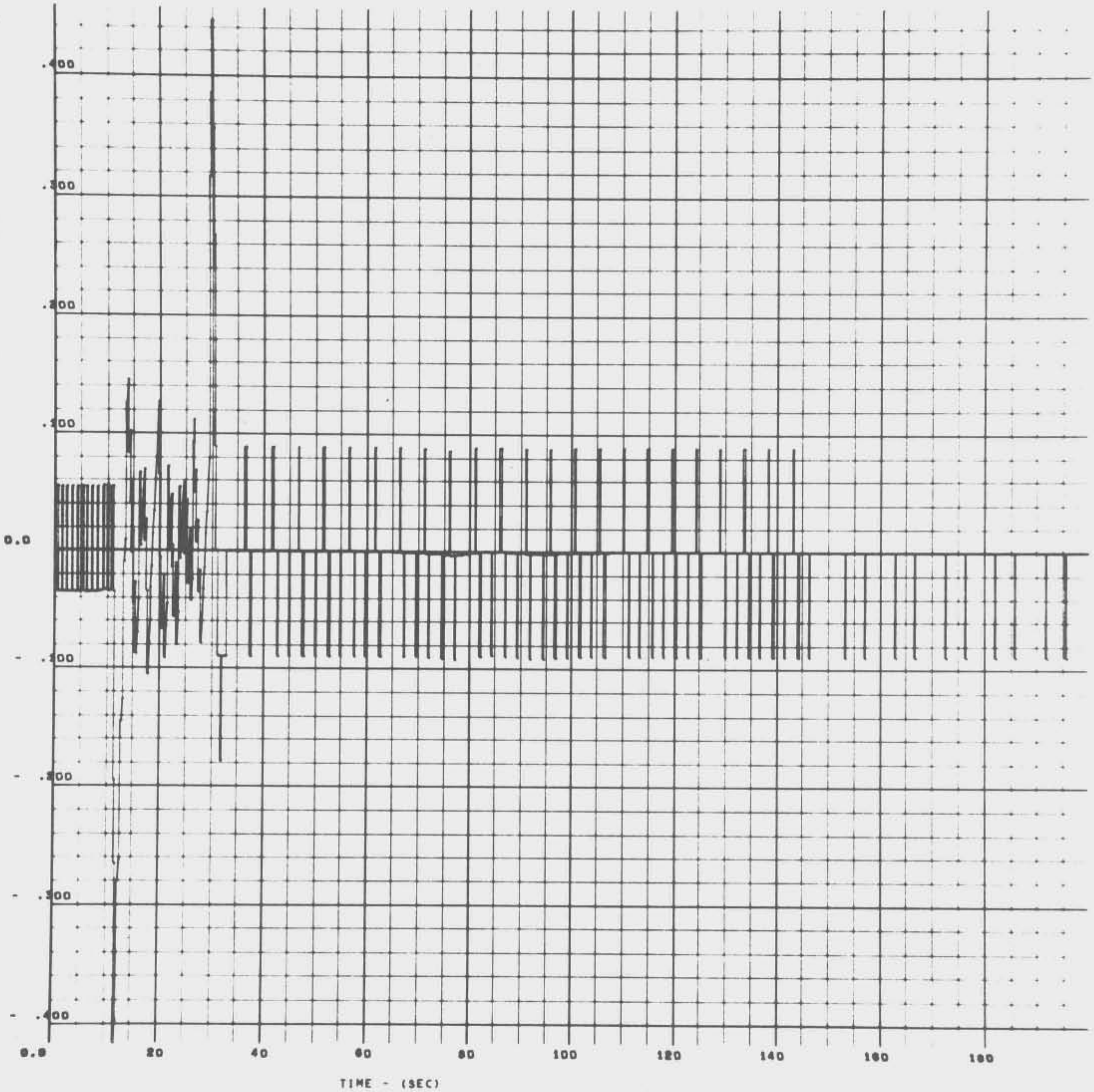

FIGURE C.2-28. SIMULATION RESPONSE TO 95% FEBRUARY DESIGN WINDS USING A LEAD FILTER WITH QUANTUM LEVELS ON βc AND θ OF .0202° AND .089° RESPECTIVELY

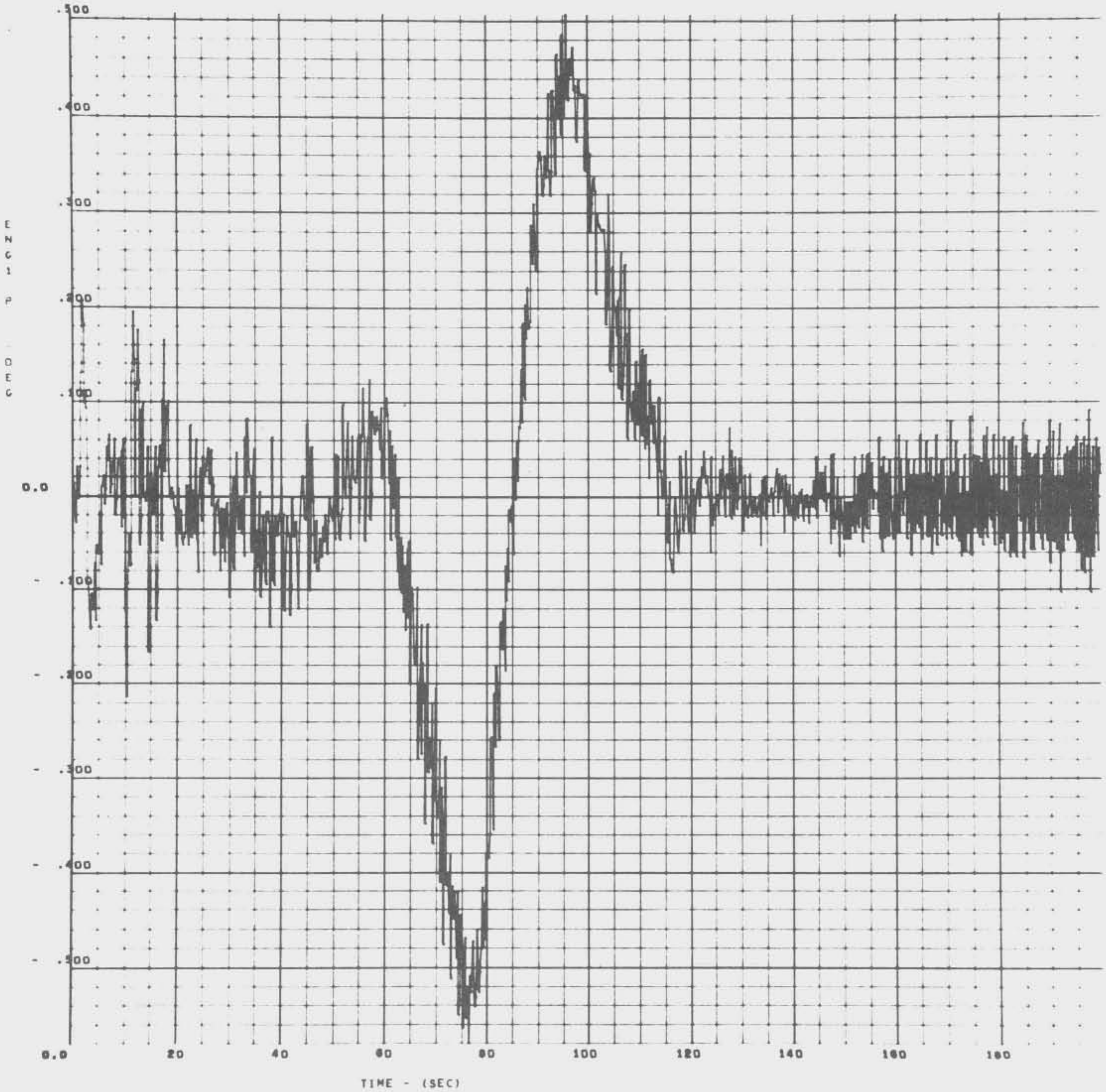

FIGURE C.2-29. SIMULATION RESPONSE TO 95% FEBRUARY DESIGN WINDS USING A LEAD FILTER WITH QUANTUM LEVELS ON β_c AND θ OF $.0202^{\circ}$ AND $.089^{\circ}$ RESPECTIVELY

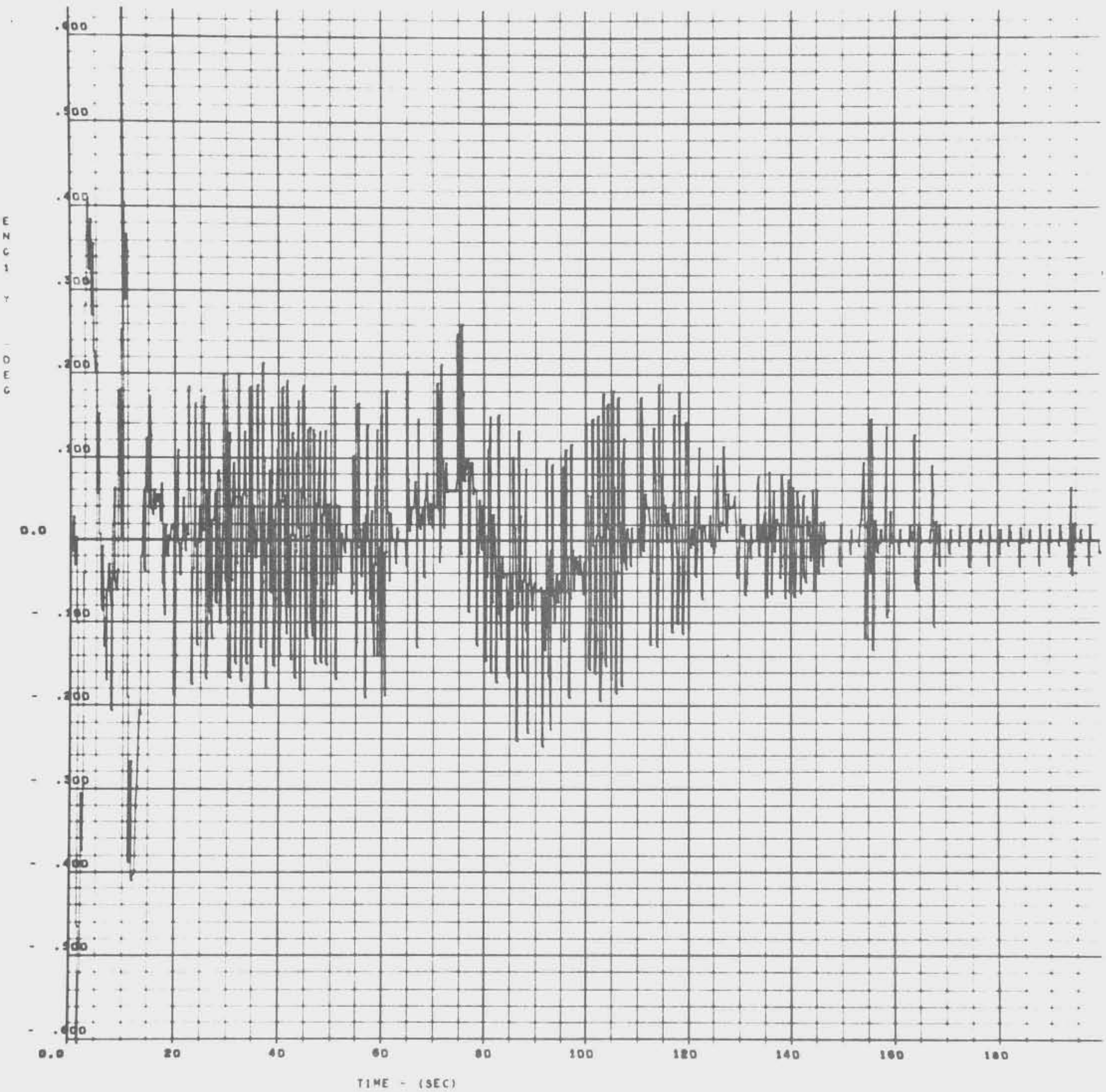

FIGURE C.2-30. SIMULATION RESPONSE TO 95% FEBRUARY DESIGN WINDS USING A LEAD FILTER WITH QUANTUM LEVELS ON βc AND θ OF $.0202^{\circ}$ AND $.089^{\circ}$ RESPECTIVELY

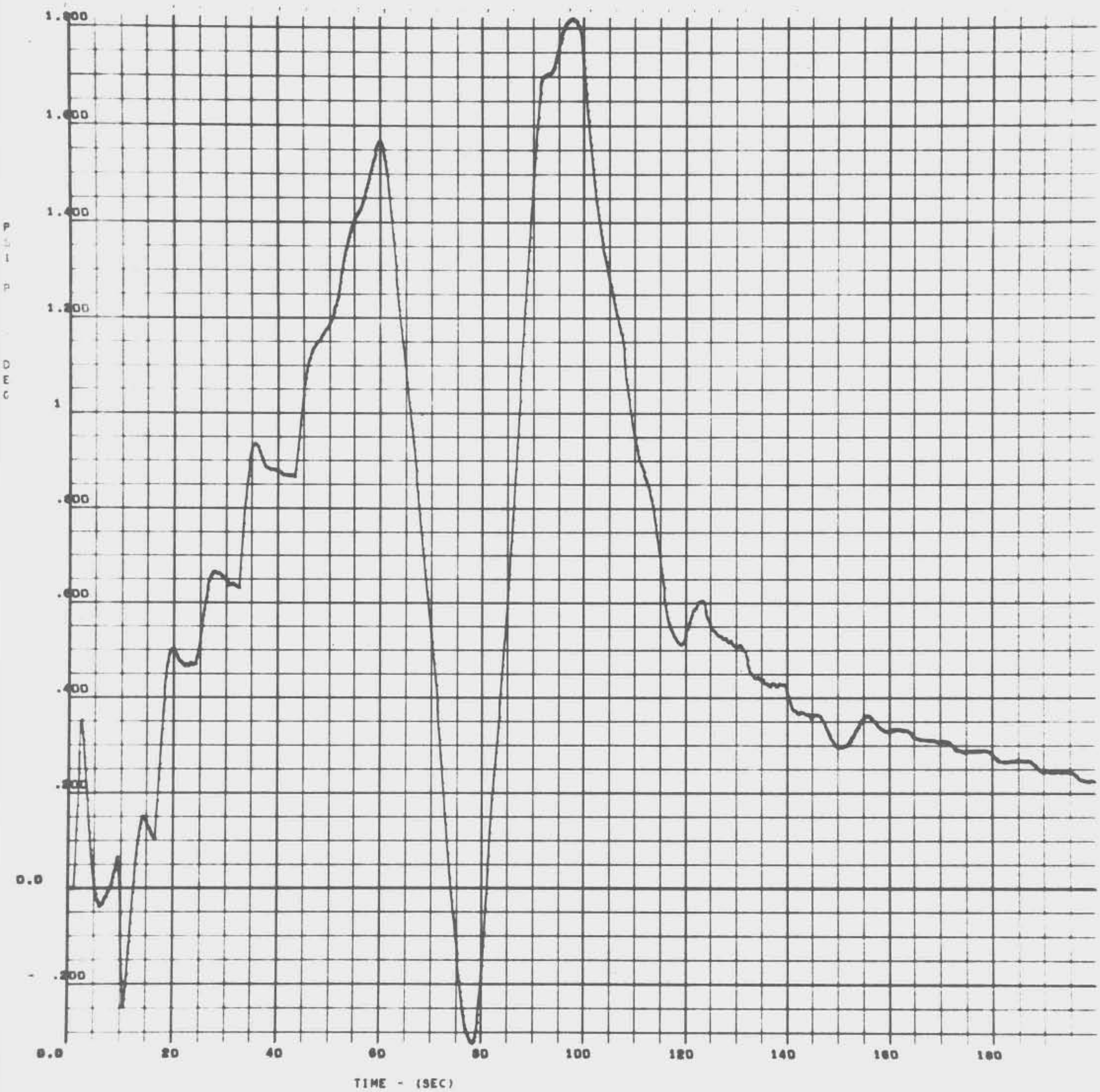

FIGURE C.2-31. SIMULATION RESPONSE TO 95% FEBRUARY DESIGN WINDS EMPLOYING "DERIVED RATE" WITH QUANTUM LEVELS ON βc AND θ OF .0202° AND .00279° RESPECTIVELY

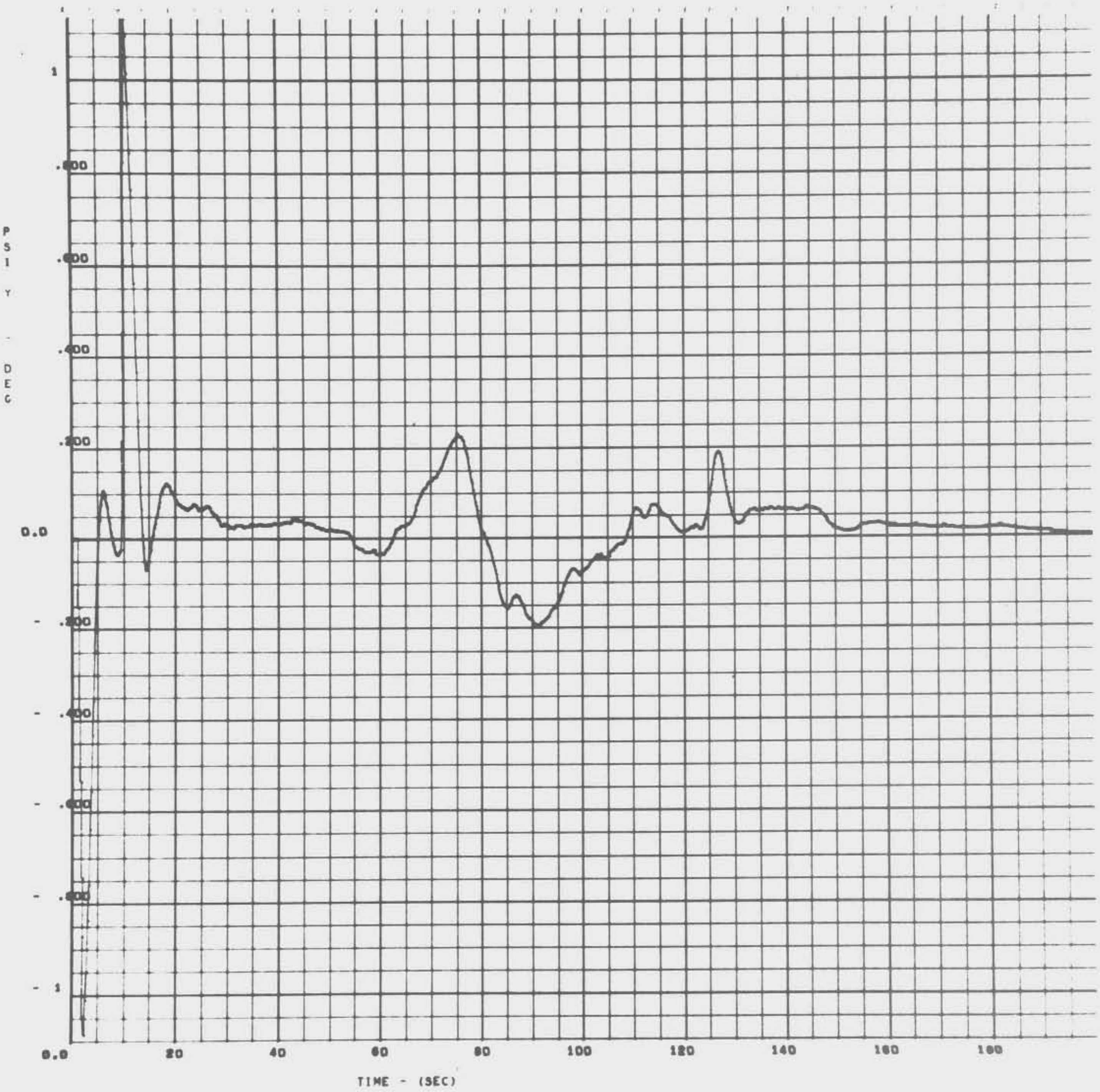

FIGURE C.2-32. SIMULATION RESPONSE TO 95% FEBRUARY DESIGN WINDS EMPLOYING "DERIVED RATE" WITH QUANTUM LEVELS ON βc AND θ OF .0202° AND .00279° RESPECTIVELY

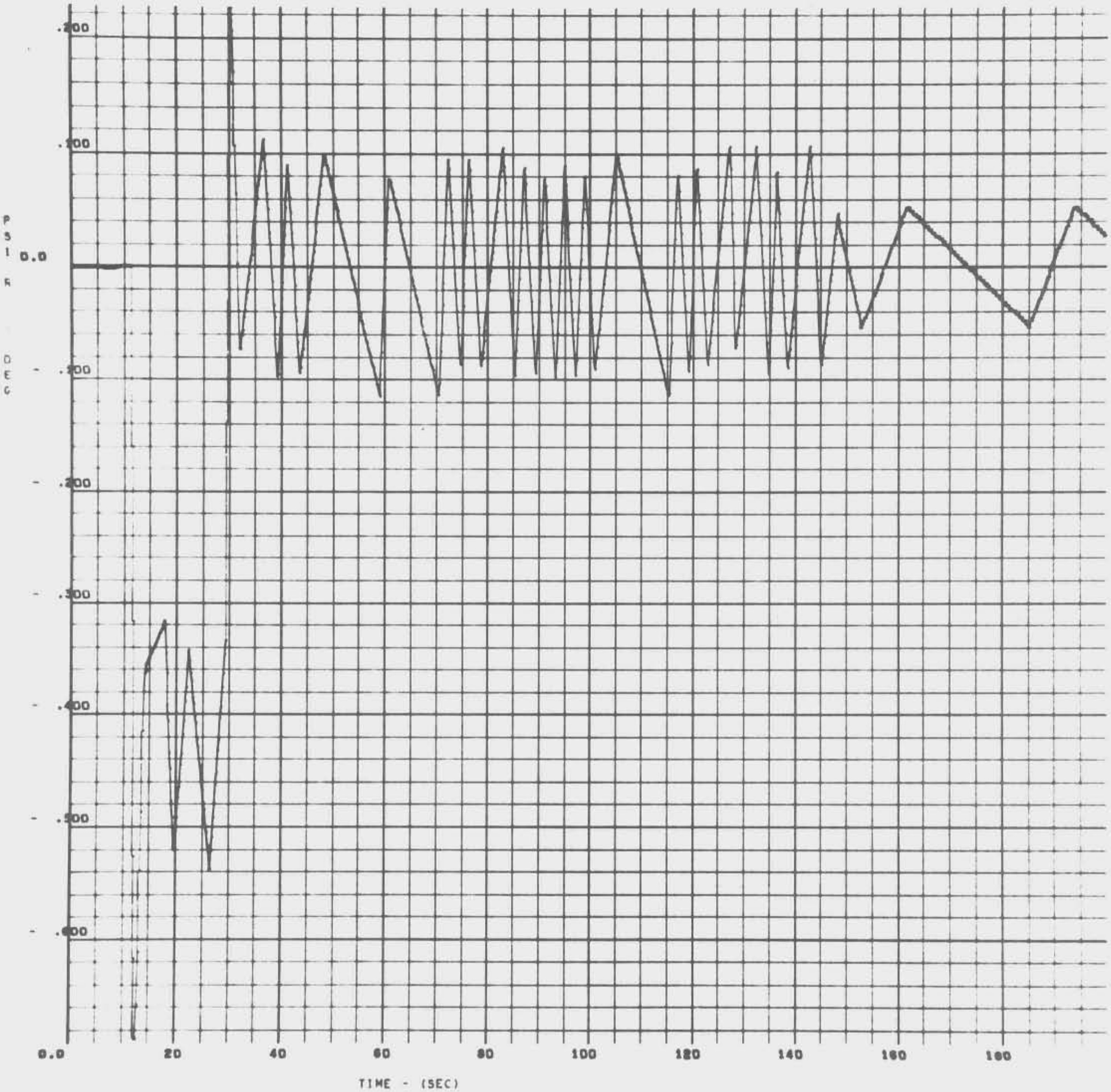

FIGURE C.2-33. SIMULATION RESPONSE TO 95% FEBRUARY DESIGN WINDS EMPLOYING "DERIVED RATE" WITH QUANTUM LEVELS ON β_c AND θ OF .0202° AND .00275° RESPECTIVELY

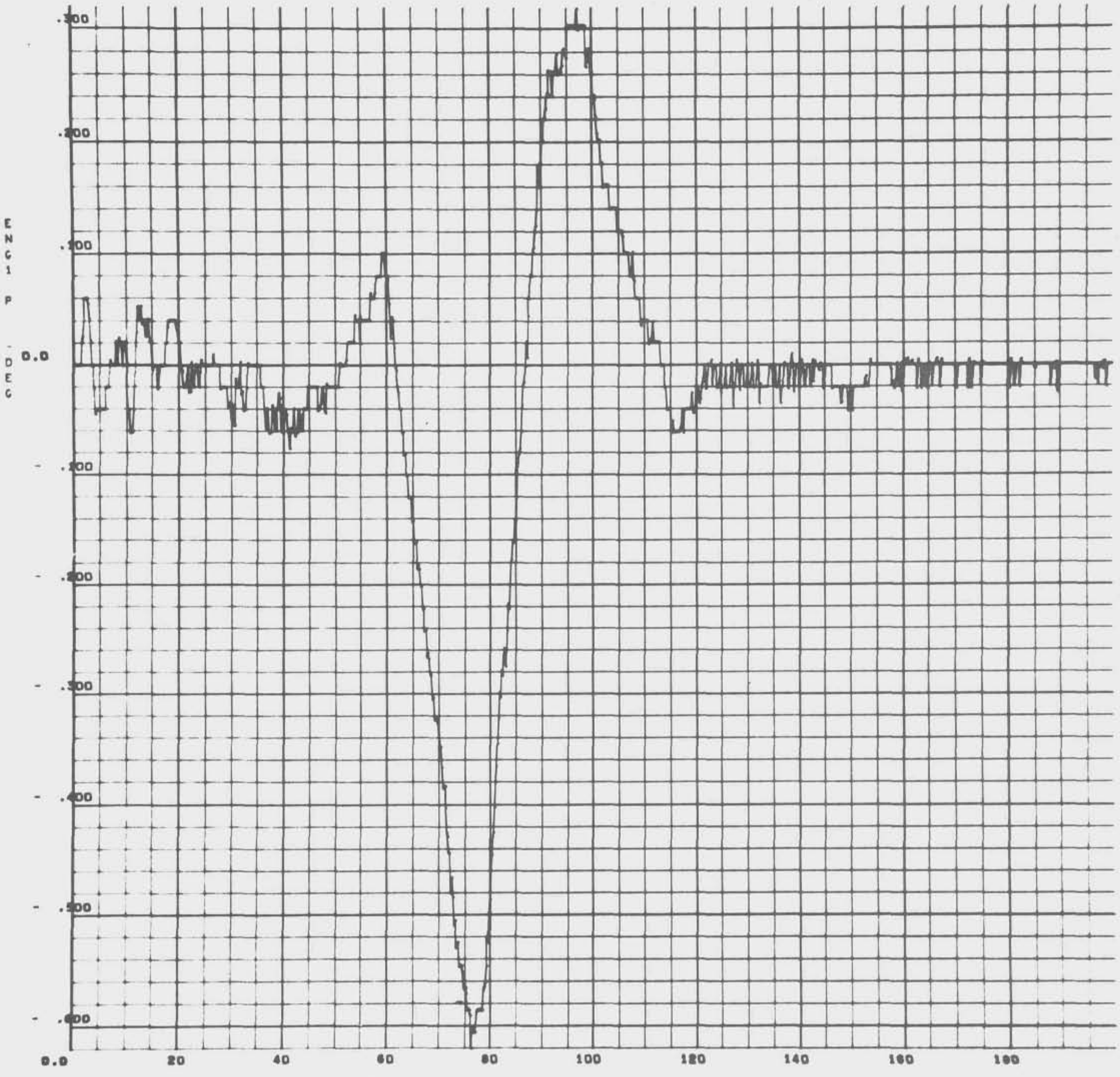

FIGURE C.2-34. SIMULATION RESPONSE TO 95% FEBRUARY DESIGN WINDS EMPLOYING "DERIVED RATE" WITH QUANTUM LEVELS ON βc AND θ OF .02029 AND .002759 RESPECTIVELY

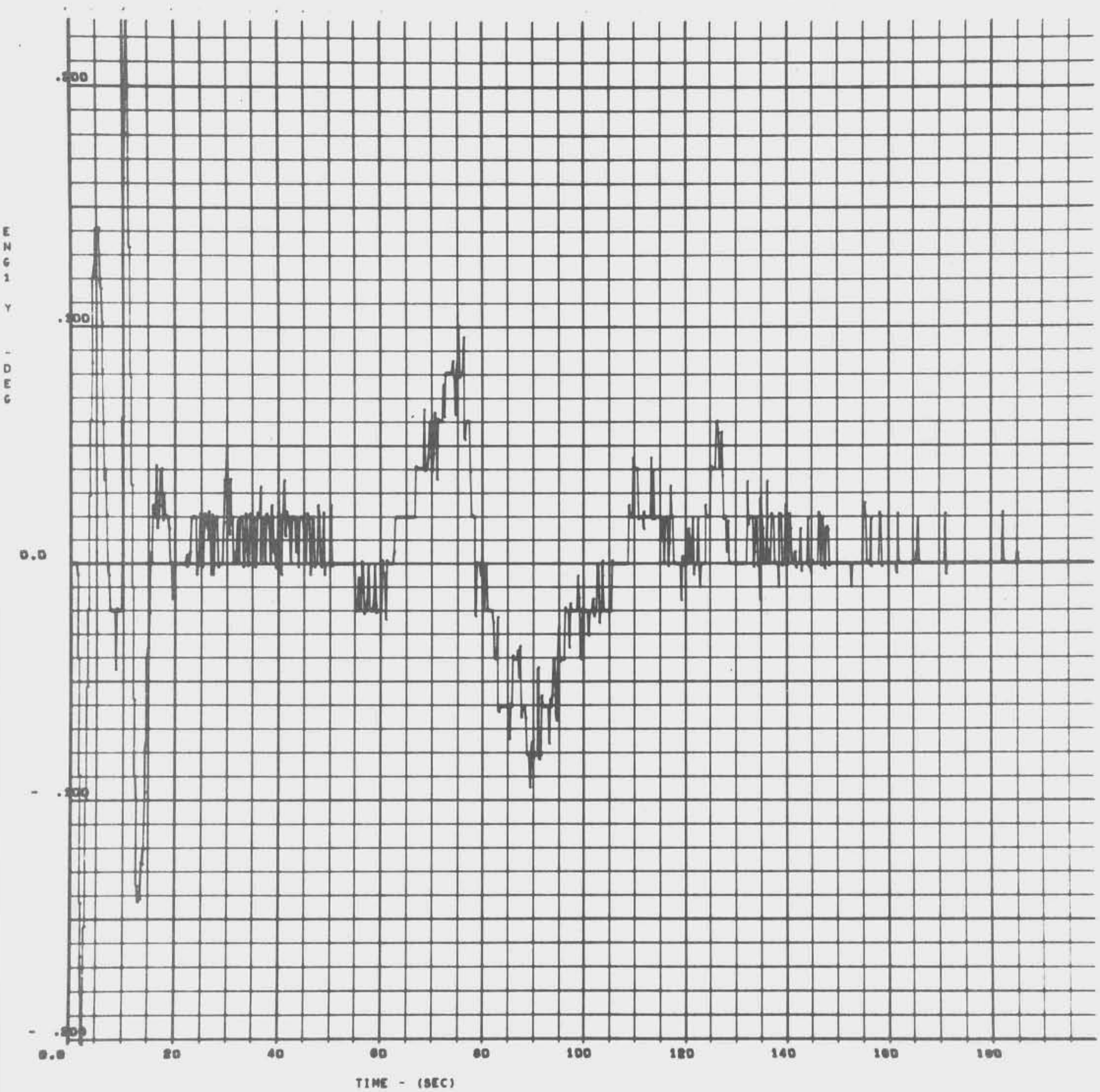

FIGURE C.2-35. SIMULATION RESPONSE TO 95% FEBRUARY DESIGN WINDS EMPLOYING "DERIVED RATE" WITH QUANTUM LEVELS ON βc AND θ OF .0202° AND .00279° RESPECTIVELY

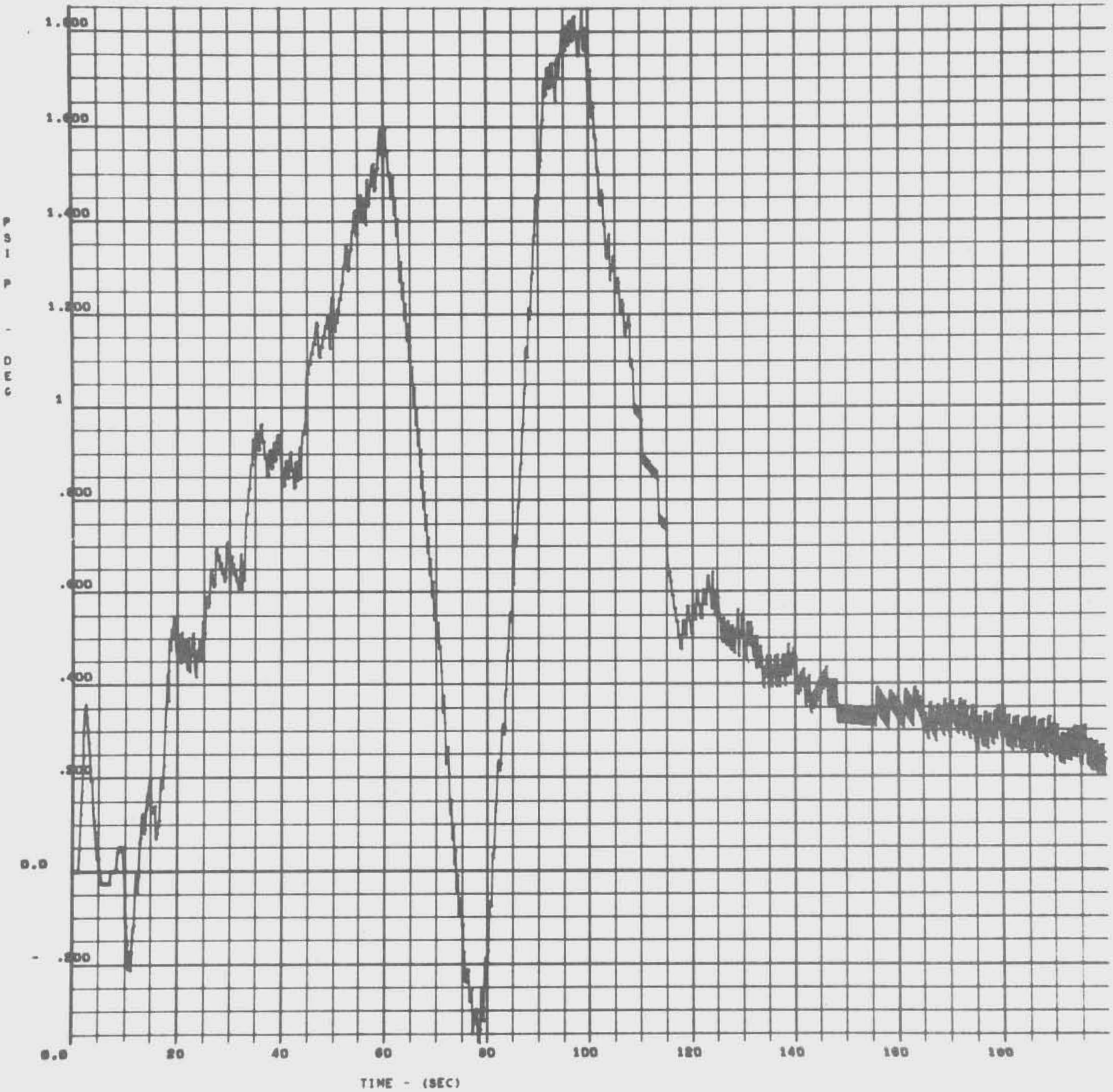

FIGURE C.2-36. SIMULATION RESPONSE TO 95% FEBRUARY DESIGN WINDS EMPLOYING "DERIVED RATE" WITH QUANTUM LEVELS ON β_c AND θ OF .0202° AND .039° RESPECTIVELY

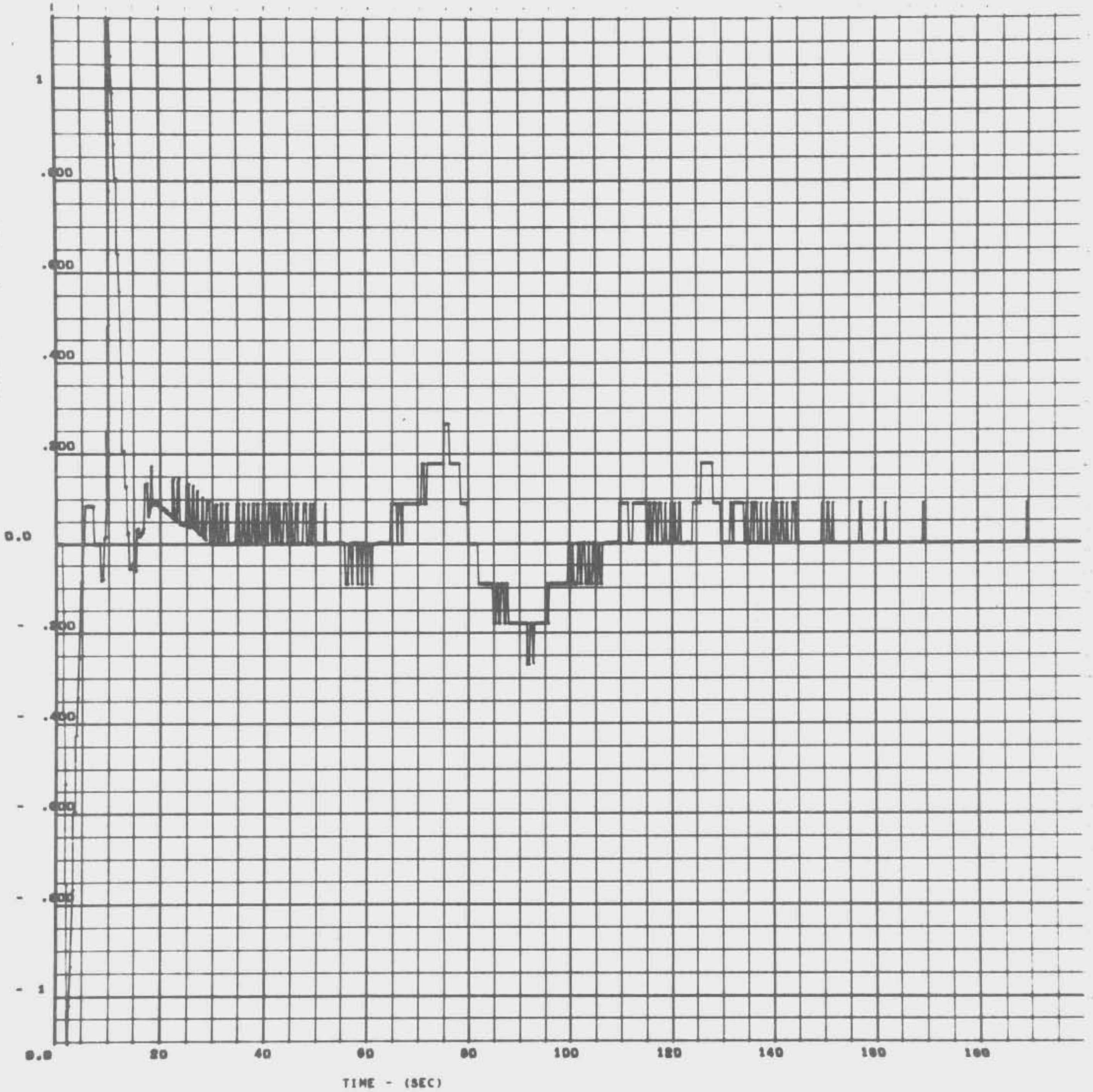

FIGURE C.2-37. SIMULATION RESPONSE TO 95% FEBRUARY DESIGN WINDS EMPLOYING "DERIVED RATE" WITH QUANTUM LEVELS ON βc AND θ OF .0202° AND .089° RESPECTIVELY

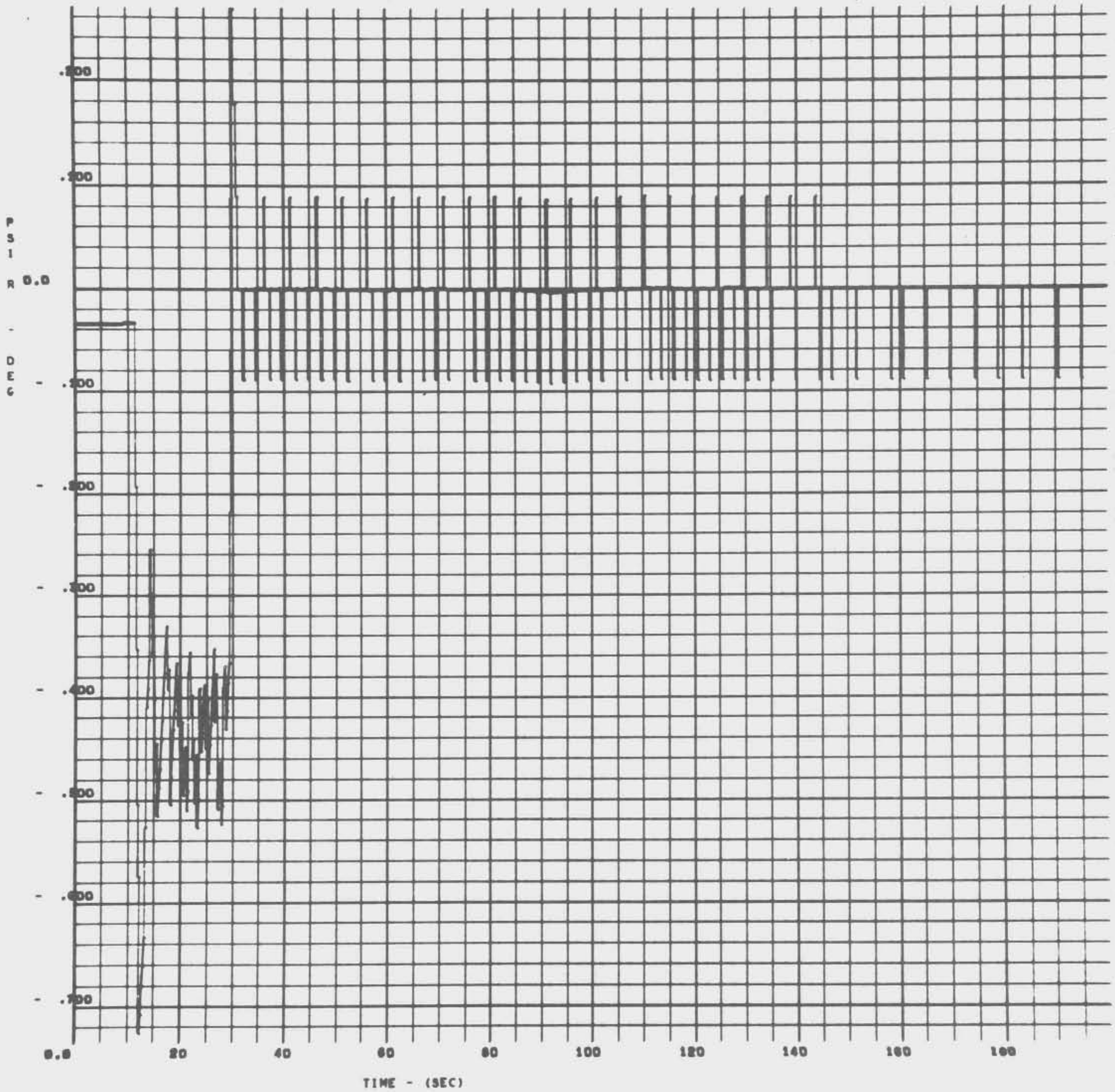

FIGURE C.2-38. SIMULATION RESPONSE TO 95% FEBRUARY DESIGN WINDS EMPLOYING "DERIVED RATE" WITH QUANTUM LEVELS ON βc AND θ OF .0202° AND .089° RESPECTIVELY

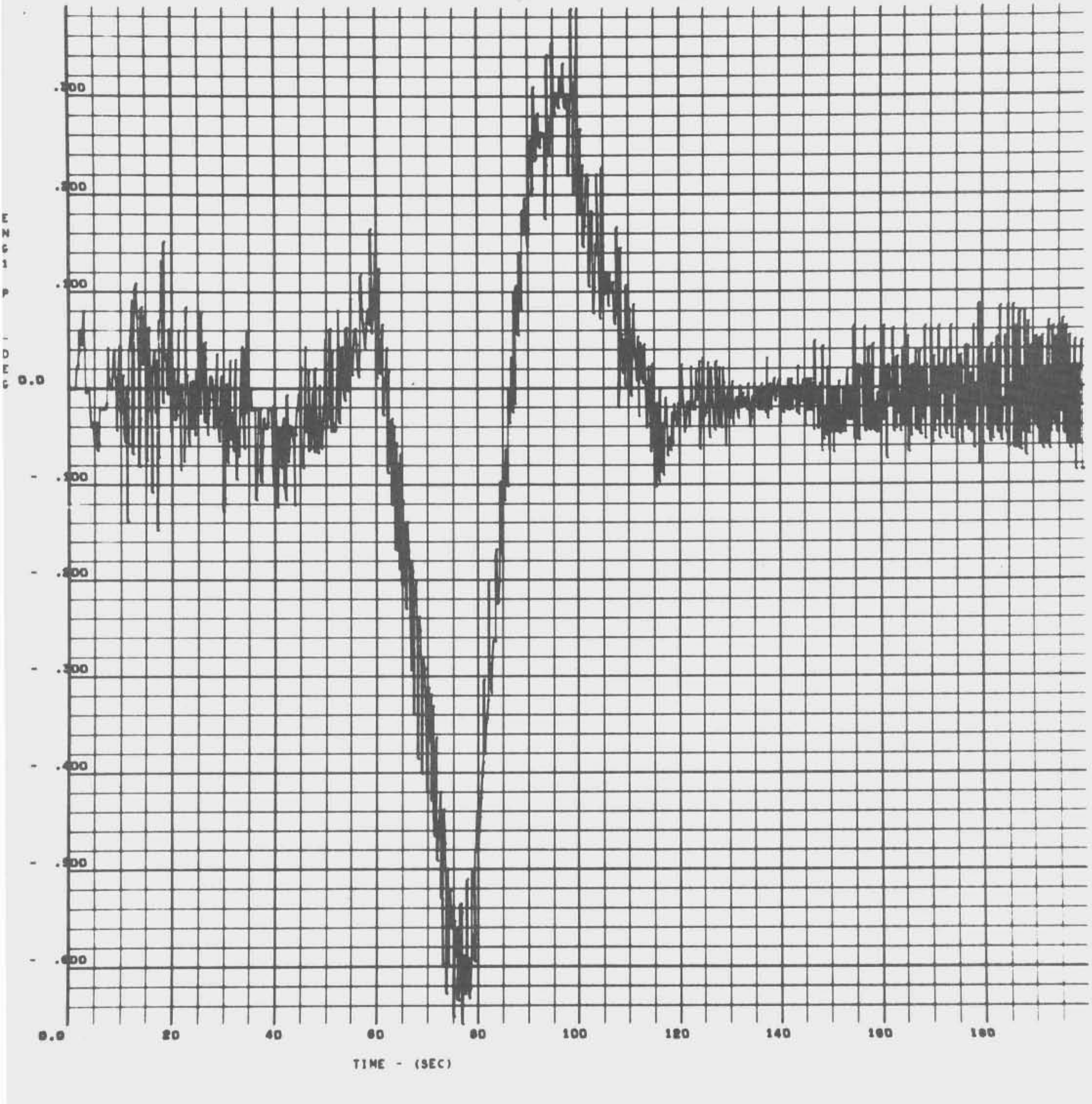

FIGURE C.2-39. SIMULATION RESPONSE TO 95% FEBRUARY DESIGN WINDS EMPLOYING "DERIVED RATE" WITH QUANTUM LEVELS OF βc AND θ OF .0202° AND .089° RESPECTIVELY

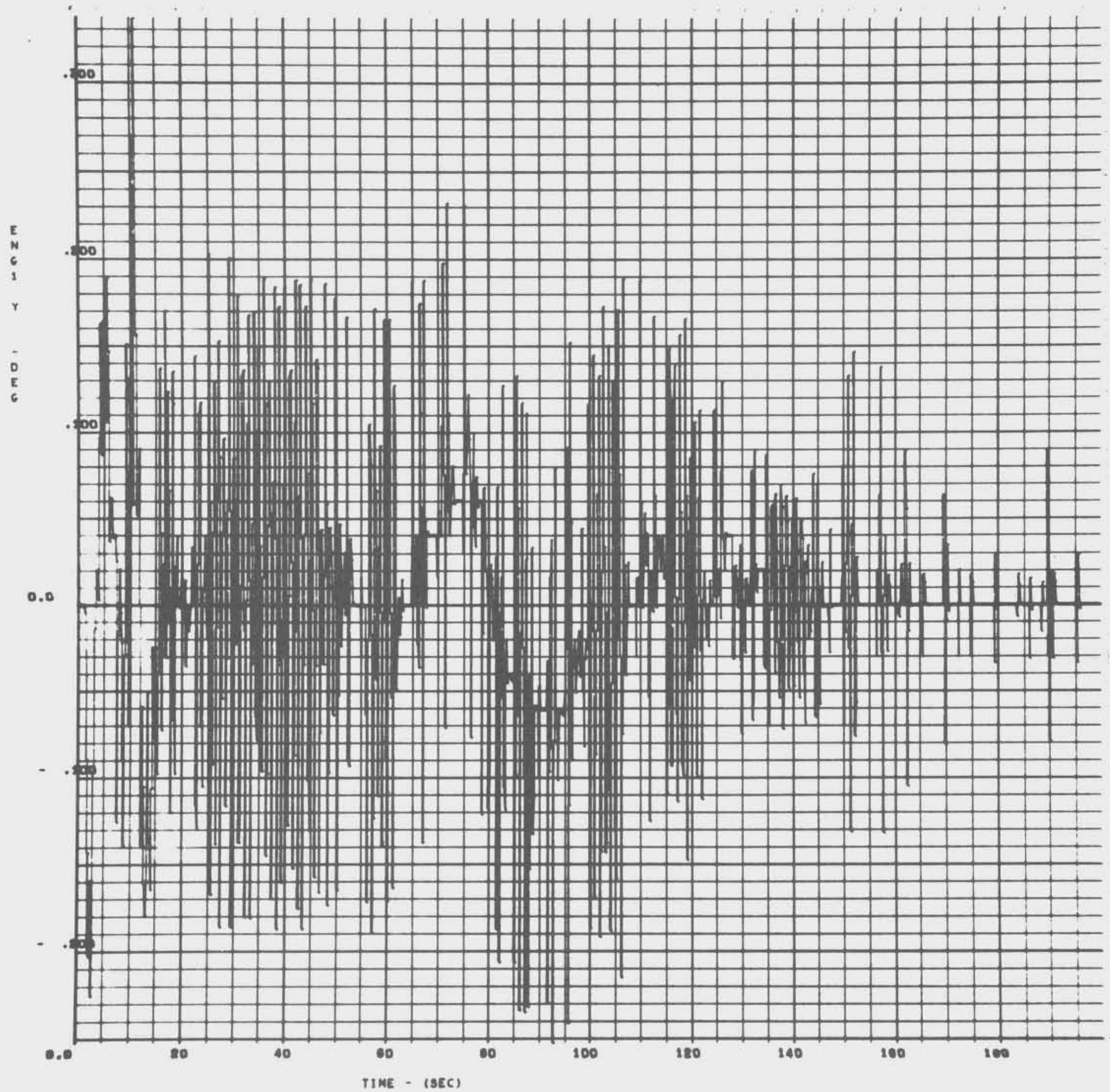

FIGURE C.2-40. SIMULATION RESPONSE TO 95% FEBRUARY DESIGN WINDS EMPLOYING "DERIVED RATE" WITH QUANTUM LEVELS ON βc AND θ OF .0202° AND .089° RESPECTIVELY

APPENDIX C.3

DICTIONARY OF CONTROL SYMBOLS

APPENDIX C. 3

Symbol	Definition	Unit
K	Gain of digital filter (pole zero form)	rad/rad
$C_1 = \frac{N' \ell_\alpha}{I_{xx}}$	Aerodynamic moment coefficient	sec^{-2}
$C_2 = \frac{R' \ell_\beta}{I_{rr}}$	Control moment coefficient	sec^{-2}
$C_{2r} \frac{R' \ell_{\beta r}}{I_{rr}}$	Roll moment coefficient	sec^{-2}
$K_3 = \frac{F - X}{m}$	Lateral acceleration coefficient per radian φ_R	sec^{-2}
$K_4 = \frac{R'}{m}$	Lateral acceleration coefficient per radian B_e	$m.sec^{-2}.rad^{-1}$
$K_5 = \frac{1}{V}$	Attach angle coefficient per m/sec lateral velocity Z_R	$sec.m^{-1}.rad$
$K_7 = \frac{N'}{m}$	Lateral acceleration coefficient per radian φ_R	$m.sec^{-2}.rad^{-1}$
$K_8 = -X_{cg} + X_a = -a$	Lateral acceleration coefficient per radian/sec^2, $\ddot{\varphi}_R$	$m.rad^{-1}$
I_{xx}	Pitch plane moment of inertia about vehicle c.g.	$kgm.m^2$
I_{rr}	Torsional moment of inertia about vehicle longitudinal center line	$kgm.m^2$
GJ_{ri}	Generalized inertia of the i^{th} torsional bending mode	$kgm.m^2$
F	Total thrust of vehicle engines	newtons
R'	Thrust of control engines	newtons
X	Drag force	newtons
$N' = \frac{q \pi d_{ref}^2 C_{Z\alpha T}}{4}$	Aerodynamic force	newtons

APPENDIX C.3

Symbol	Definition	Unit
$\ell_\alpha = (Xcg - Xcp)$	Distance from c.g. to center of pressure	m
$\ell_\beta = \ell_{cg} = (Xcg-Xb)$	Distance from c.g. to the gimbal	m
$\ell_{sj} = (Xcg-Xsj)$	Distance from c.g. to slosh mass attach point	m
ℓ_{β_r}	Radial distance from vehicle longitudinal center line to control engine gimbal	m
m	Total mass of vehicle	kgm
mi	Generalized mass of i^{th} bending mode	kgm
msj	Generalized mass of j^{th} slosh mode	kgm
q	Dynamic pressure	newton. m^{-2}
$C_{Z}\alpha T$	Normal force gradient for total vehicle	1/rad
d_{ref}	Diameter of a vehicle stage	m
dej	Radial distance from vehicle longitudinal center line to the slosh mass attach point	m
X_{cg}	Station of the c.g.	m
X_{cp}	Station of the center of pressure	m
X_{sj}	Station of the slosh mass attach point	m
X_b	Station of the gimbal	m
ω_i	Natural bending frequency of i^{th} mode	rad/sec
ω_{sj}	Natural slosh frequency of j^{th} mode	rad/sec
ω_{ri}	Natural torsional bending frequency of the i^{th} mode	rad/sec

APPENDIX C. 3

Symbol	Definition	Unit
f_i	Natural bending frequency of the i^{th} mode	H_z
f_{sj}	Natural bending frequency of the j^{th} slosh mode	H_z
f_{ri}	Natural torsional bending frequency of the i^{th} mode	H_z
ζ_i	Damping ratio of i^{th} bending mode	
ζ_{sj}	Damping ratio of j^{th} slosh mode	
ζ_{ri}	Damping ratio of the i^{th} torsional bending mode	
$Y_{i\varphi}$	Normalized deflection at the instrument unit due to the i^{th} bending mode	m/m
Y'_{ib}	Normalized slope at the gimbal station due to i^{th} bending mode	m^{-1}
$Y'_{i\varphi}$	Normalized slope at the instrument unit station due to i^{th} bending mode	m^{-1}
θ_{ib}	Normalized angular rotation at the gimbal station due to the i^{th} torsional bending mode	rad/rad
$\theta_{i\varphi}$	Normalized angular rotation at the instrument unit due to the i^{th} torsional bending mode	rad/rad
Z	Displacement of the cg in the direction normal to the reference trajectory	m
$\dot{Z}$	Velocity of the cg in the direction normal to the reference trajectory	$m. sec^{-1}$
$\ddot{Z}$	Acceleration of the cg in the direction normal to reference trajectory	$m. sec^{-2}$

APPENDIX C. 3

Symbol	Definition	Unit
ξ_{sj}	Slosh mass displacement to the j^{th} mode normal to the vehicle longitudinal axis	m
$\dot{\xi}_{sj}$	Slosh mass velocity of the j^{th} mode normal to the vehicle longitudinal axis	$m.sec^{-1}$
$\ddot{\xi}_{sj}$	Slosh mass acceleration of the j^{th} mode normal to the vehicle longitudinal axis	$m.sec^{-2}$
β_e	Total engine deflection	rad
β_c	Input signal to actuator	rad
$\ddot{\beta}$	Engine angular acceleration	$rad.sec^{-2}$
η_i	Generalized displacement of i^{th} bending mode	m
$\dot{\eta}_i$	Generalized velocity of the i^{th} bending mode	$m.sec^{-1}$
$\ddot{\eta}_i$	Generalized acceleration of i^{th} bending mode	$m.sec^{-2}$
τ_{ri}	Generalized displacement of the i^{th} torsional bending mode	rad
$\dot{\tau}_{ri}$	Generalized angular velocity of the i^{th} torsional bending mode	$rad.sec^{-1}$
$\ddot{\tau}_{ri}$	Generalized angular acceleration of the i^{th} torsional bending mode	$rad.sec^{-2}$
$\varphi(\psi)$	Vehicle attitude error angle	rad
φ_B	Attitude error angle due to bending	rad
φ_τ	Roll attitude error due to torsional bending	rad

APPENDIX C. 3

Symbol	Definition	Unit
φ_R	Rigid body attitude error angle	rad
φ_S	Attitude error angle due to sloshing	rad
$\dot{\varphi}$	Vehicle attitude angular rate	$rad. sec^{-1}$
$\dot{\varphi}_B$	Attitude angular rate due to bending	$rad. sec^{-1}$
$\dot{\varphi}_T$	Roll attitude rate due to torsional bending	$rad. sec^{-1}$
$\dot{\varphi}_R$	Rigid body attitude angular rate	$rad. sec^{-1}$
$\dot{\varphi}_S$	Attitude angular rate due to sloshing	$rad. sec^{-1}$
$\ddot{\varphi}$	Vehicle attitude angular acceleration	$rad. sec^{-2}$
$\ddot{\varphi}_R$	Rigid body attitude angular acceleration	$rad. sec^{-2}$
$\ddot{\varphi}_S$	Attitude angular acceleration due to sloshing	$rad. sec^{-2}$
$I_E = \theta_E$	Moment of inertia of control engine about the gimbal	$kgm. m^2$
$S_E - \Sigma_E$	First mass moment of control engines about the gimbal	kgm. m
W_{SS}	Engine actuator transfer function	
θ	Angle displacement of pitch, yaw, and roll control axes measured in an inertial reference frame fixed at liftoff	

APPENDIX D
VEHICLE DATA

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APPENDIX D

D.1 VEHICLE PERFORMANCE DATA

The vehicle performance data generated in support of the Phase I trades effort is contained in this section. Data are contained for 2, 3, 4, and 5 F-1 vehicles at 4 68-g and 6.0-g first peak acceleration levels. All configurations used a 3.8 second coast between S-IC shutdown and S-IVB ignition. Thrust-to-weight ratio at launch was maintained at 1.25 where possible. Ballast, in the form of unused propellant, was staged with the S-IC to maintain the specified maximum acceleration limits. A 950 lb/ft^2 maximum dynamic pressure (q) limit was also observed. Launch was due-east from KSC, unless otherwise specified.

The performance capabilities of INT-20 with both Centaur and Service Module injection stage were also determined. The Service Module used was the four-tank, shrouded version with an independent flight control system. Each injection stage was suspended within a SLA shroud, which was jettisoned at S-IC staging.

For all configurations, flight performance reserves of 3/4 percent of the vehicle total characteristic velocity are accounted for in the last stage. For missions other than two-stage direct to circular orbit, a launch window reserve (propellant) of 60 m/sec was included in the last stage.

Two discontinuities appear in the direct ascent to orbit data. Ballasting of the 6-g 2 F-1 S-IC (Figure D.1-2) is required, when the payload decreases below 51,000 lb., to limit the acceleration. A break in the curves for the 4.69-g 5 F-1 INT-20 (Figure D.1-7) occurs at an altitude of about 250 NM. This break occurs because of the requirement to limit dynamic pressure to 950 psf. At altitudes of less than about 250 NM, the initial F-1 engine shutdown occurs prior to when it would for acceleration control so that the trajectory can be shaped to limit dynamic pressure.

For the synchronous orbit missions, the following propellant boiloff and engine shutdown/ startup losses were assumed:

Stage	Losses (lb) Orbit (4-1/2 hr.)	Coast (5-1/4 hr)
S-IVB	3,725	1,602
Centaur (Insulated)	-	533
Service Module (SMIS)	-	15

D.1 (Cont'd)

The synchronous orbit mission flown by the two stage configurations is direct injection with two stages into a 100 NM parking orbit followed by a coast, reignition of the S-IVB, and boost to transfer velocity. At synchronous orbit altitude (approximately 19,320 NM), after a 5 1/4 hr coast, the S-IVB is reignited for circularization and plane change. The synchronous orbit mission flown by the three-stage configurations is direct injection with two stages into a 100 NM parking orbit followed by a coast, reignition and boost by the S-IVB, burnout and staging of the S-IVB, ignition of the third stage, and boost to transfer velocity. At synchronous orbit altitude, the third stage is reignited for circularization and plane change.

Data generated in support of the 4 F-1 INT-20 polar orbit capability study are presented in Figures A-1-13 through A-1-26. Net payloads versus S-IC rate of yaw for circular orbit altitudes of 100, 200, and 300 NM are presented in Figure 13 for a 4.68 g acceleration limit and in Figure 20 for a 6.0 g acceleration limit. Corresponding vehicle impact traces are presented in Figures D.1-14 through D.1-19 and D.1-21 through D.1-26.

The mission flown is direct injection with two stages into the circular polar orbit and assumes a launch azimuth of 145° for all cases. After the vehicle passes through maximum dynamic pressure (no boost turning is performed prior to maximum dynamic pressure), the specified rate of S-IC yaw is initiated. This constant rate of S-IC boost turning is maintained for the remainder of the first stage burn time. At S-IVB ignition, a rate of yaw is initiated which results in the configuration attaining the desired orbit inclination of 90°. In all cases, the selection of a first stage yaw rate which results in minimum land mass impact (i.e., overfly of Cuba and Panama only) does not severely penalize the payload performance of the vehicle.

Presented in Figures D.1-27 through D.1-32 are the net payload versus twice specific energy (C_3) capabilities of the 2, 3, 4 and 5 F-1 INT-20 and the 4 F-1 INT-20/Centaur or SMIS configurations. The data assume direct injection through a 100 NM circular orbit (no engine shutdown or coast time in the orbit is assumed) to the desired energy level.

TABLE I

SATURN V DERIVATIVES (NAS8-30506)

INT-20 TWO-STAGE TRADE STUDY BASELINES

	NUMBER OF F-1 ENGINES		2	3	4	5
S-IC	LIFTOFF WEIGHT	LBS	2,435,200	3,652,800	4,870,400	*
	SEA LEVEL THRUST	LBS	3,044,000	4,566,000	6,088,000	7,610,000
	SEA LEVEL I_{SP}	SEC	263.58	263.58	263.58	263.58
	PROPELLANT CONSUMED	LBS	*	*	*	4,560,000
	STAGED INERTS **	LBS	275,726	304,647	335,478	364,399
S-IVB	VACUUM THRUST	LBS	205,000	205,000	205,000	205,000
	VACUUM I_{SP}	SEC	426	426	426	426
	PROPELLANT CAPACITY	LBS	230,000	230,000	230,000	230,000
	STAGED INERTS	LBS	27,181	27,181	27,181	27,181
IU	ASTRIONICS EQUIPMENT	LBS	3,847	3,847	3,847	3,847

* VARIABLE WITH MISSION

** DOES NOT INCLUDE BALLAST FOR ACCELERATION CONTROL

TABLE II

SATURN V DERIVATIVES

INT-20 THREE-STAGE TRADE STUDY BASELINES

	THIRD STAGE		CENTAUR	SMIS
S-IC	LIFTOFF WEIGHT	LBS	4,870,400	4,870,400
	SEA LEVEL THRUST	LBS	6,088,000	6,088,000
	SEA LEVEL I_{SP}	SEC	263.58	263.58
	PROPELLANT CONSUMED	LBS	*	*
	STAGED INERTS **	LBS	335,478	335,478
	THIRD STAGE SHROUD	LBS	5,933	3,090
S-IVB	VACUUM THRUST	LBS	205,000	205,000
	VACUUM I_{SP}	SEC	426	426
	PROPELLANT CONSUMED	LBS	230,000	230,000
	STAGED INERTS	LBS	27,957	29,565
	INSULATION PANELS	LBS	1,258	0
IU	ASTRIONICS EQUIPMENT	LBS	3,847	3,847
3RD STAGE	VACUUM THRUST	LBS	30,000	20,000
	VACUUM I_{SP}	SEC	444	313
	PROPELLANT CAPACITY	LBS	30,000	40,000 ***
	STAGED INERTS	LBS	4,564	6,276

* VARIABLE WITH MISSION

** DOES NOT INCLUDE BALLAST FOR ACCELERATION CONTROL

*** REDUCED TO 37,800 FOR 6.0 g LONGITUDINAL ACCELERATION

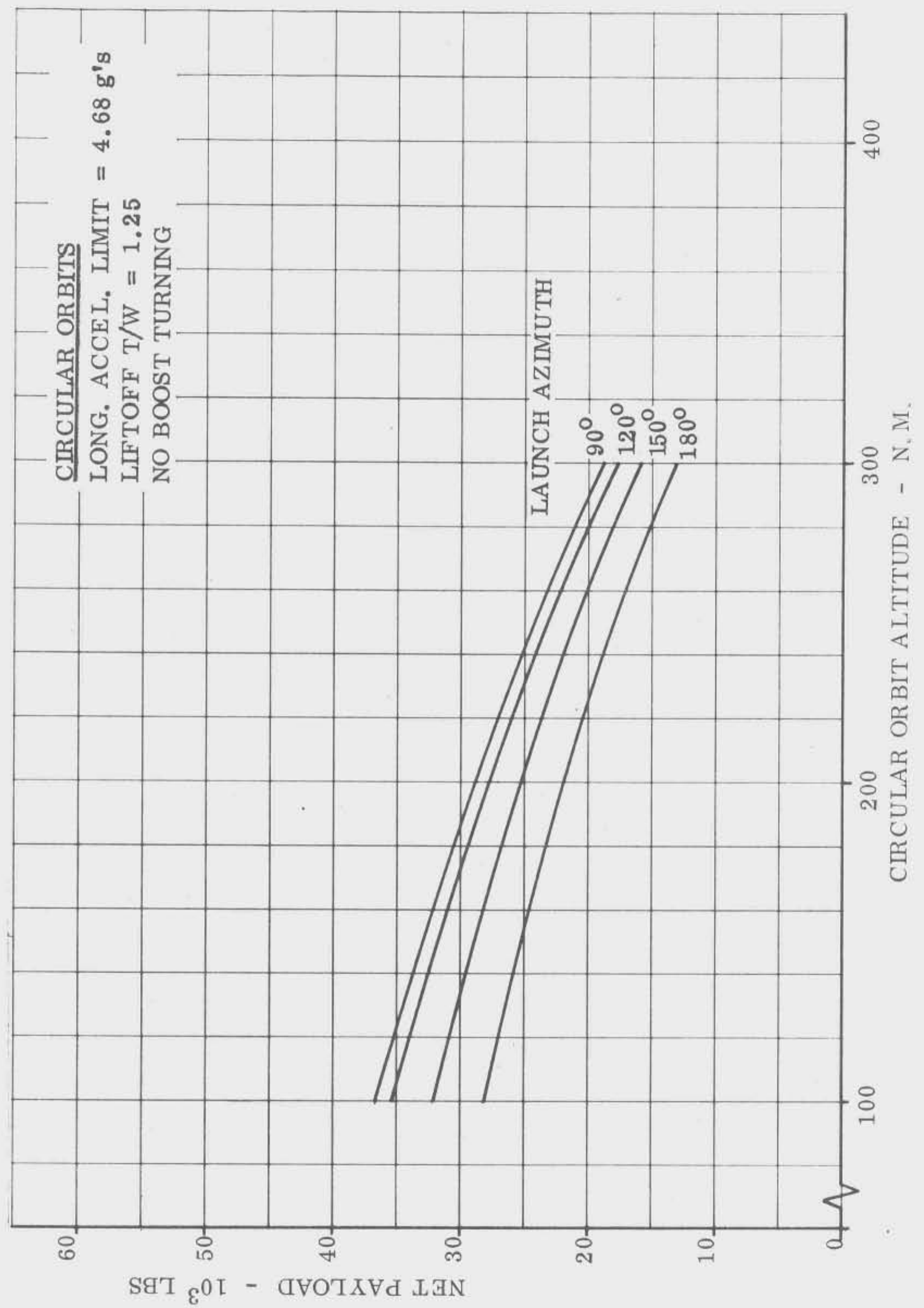

FIGURE D.1-1 4.68-g 2 F-1 INT-20 CIRCULAR ORBIT CAPABILITY

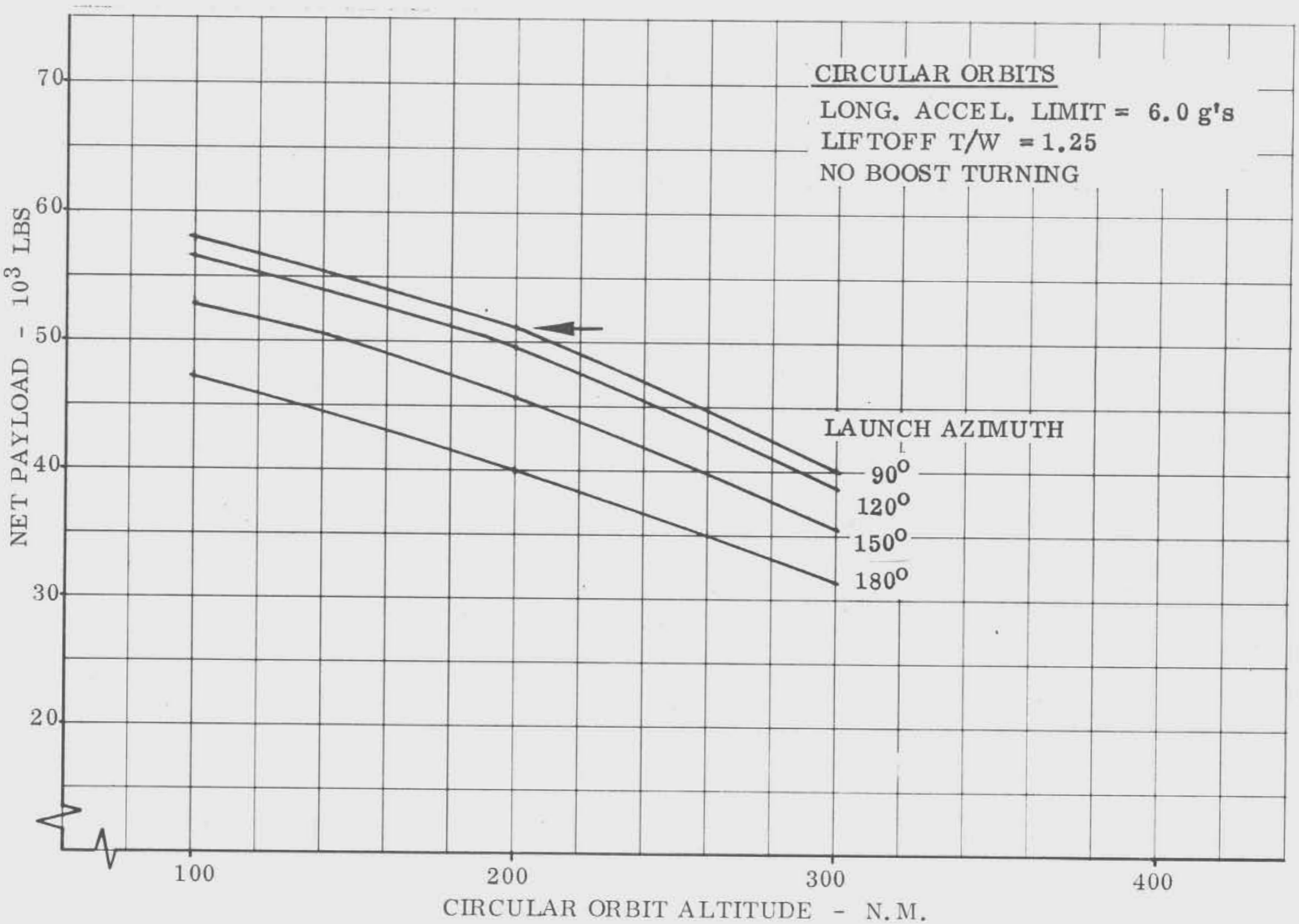

FIGURE D.1-2 6.0-g 2 F-1 INT-20 CIRCULAR ORBIT CAPABILITY

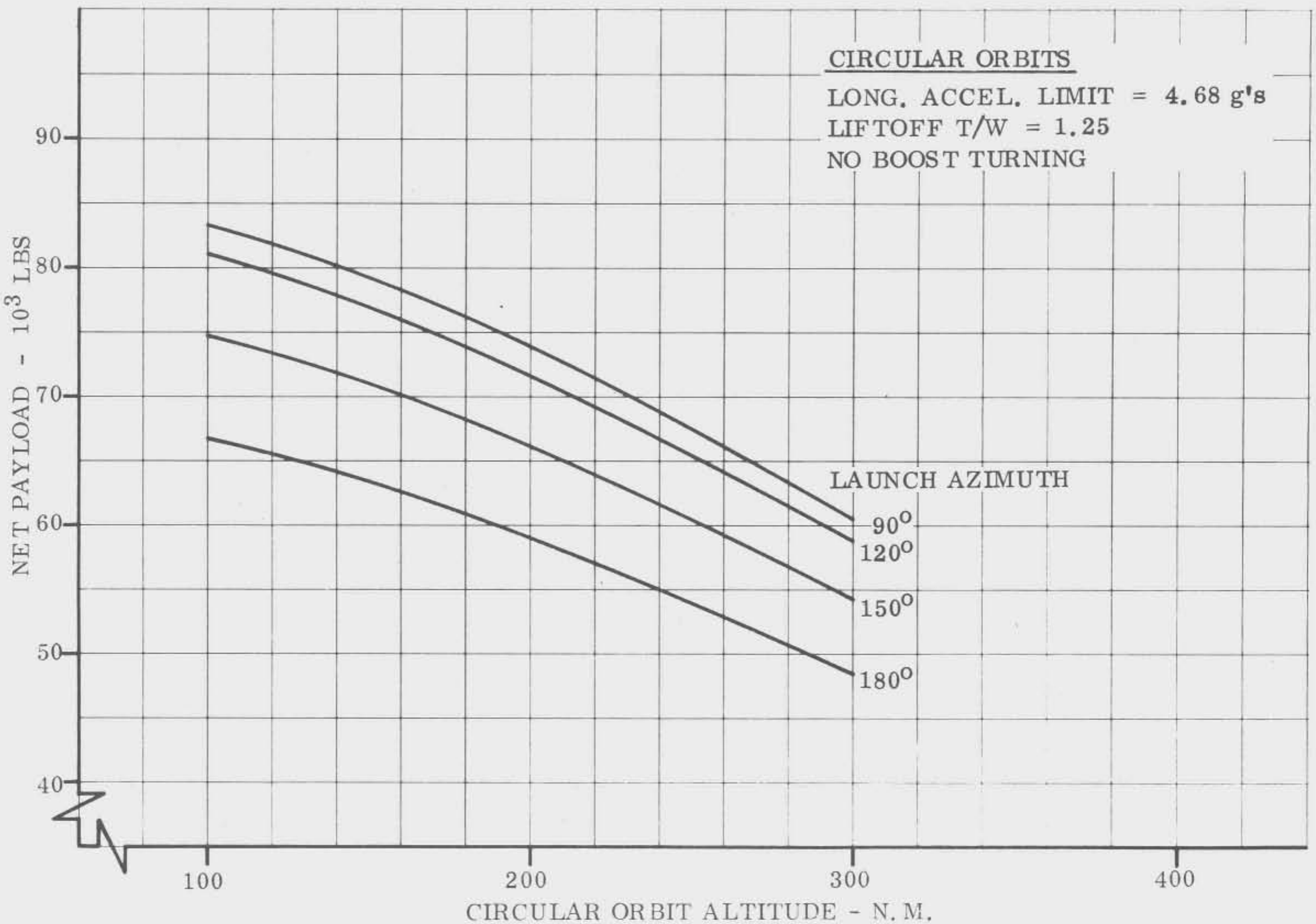

FIGURE D.1-3 4.68-g 3 F-1 INT-20 CIRCULAR ORBIT CAPABILITY

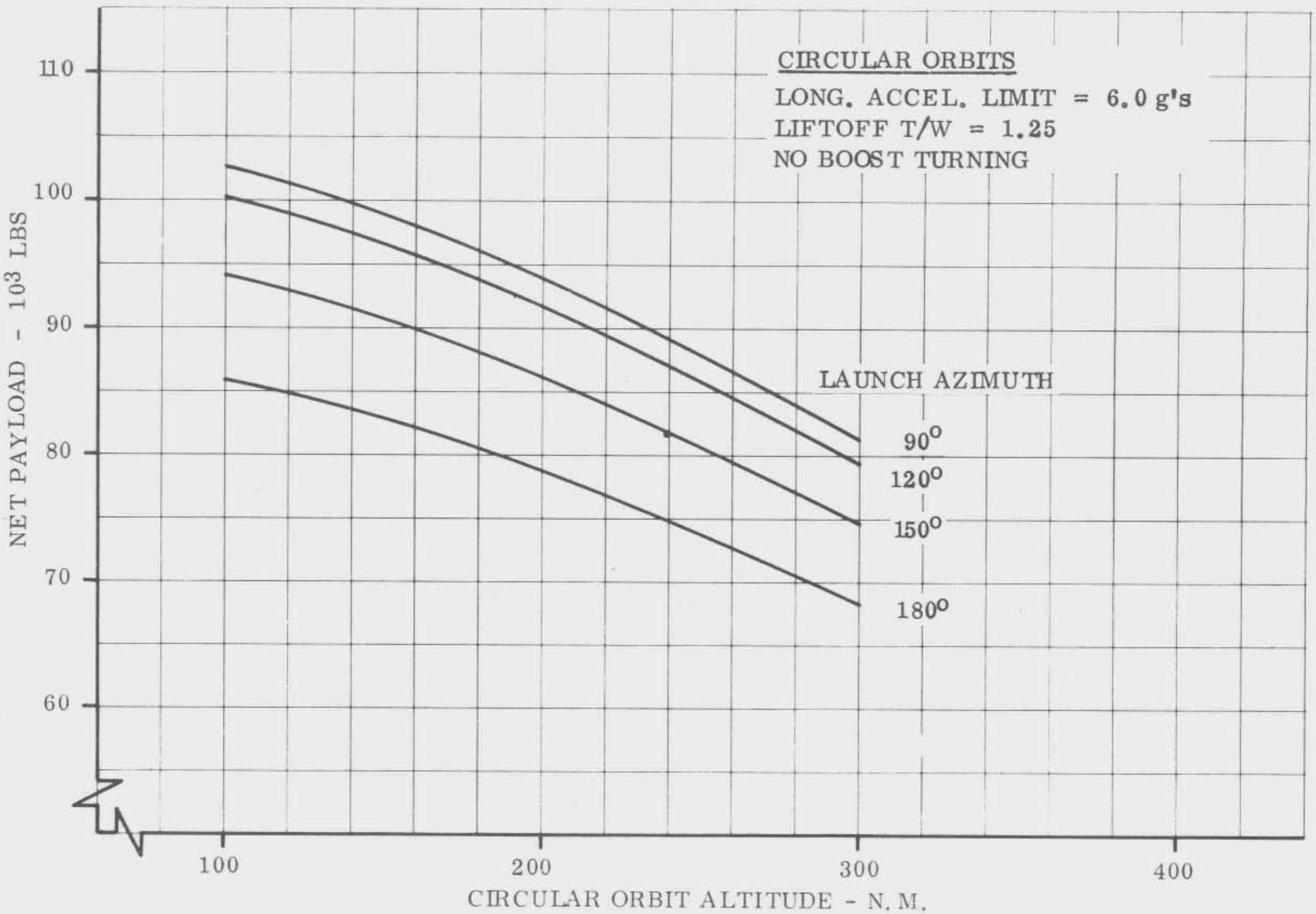

FIGURE D.1-4 6-g 3 F-1 INT-20 CIRCULAR ORBIT CAPABILITY

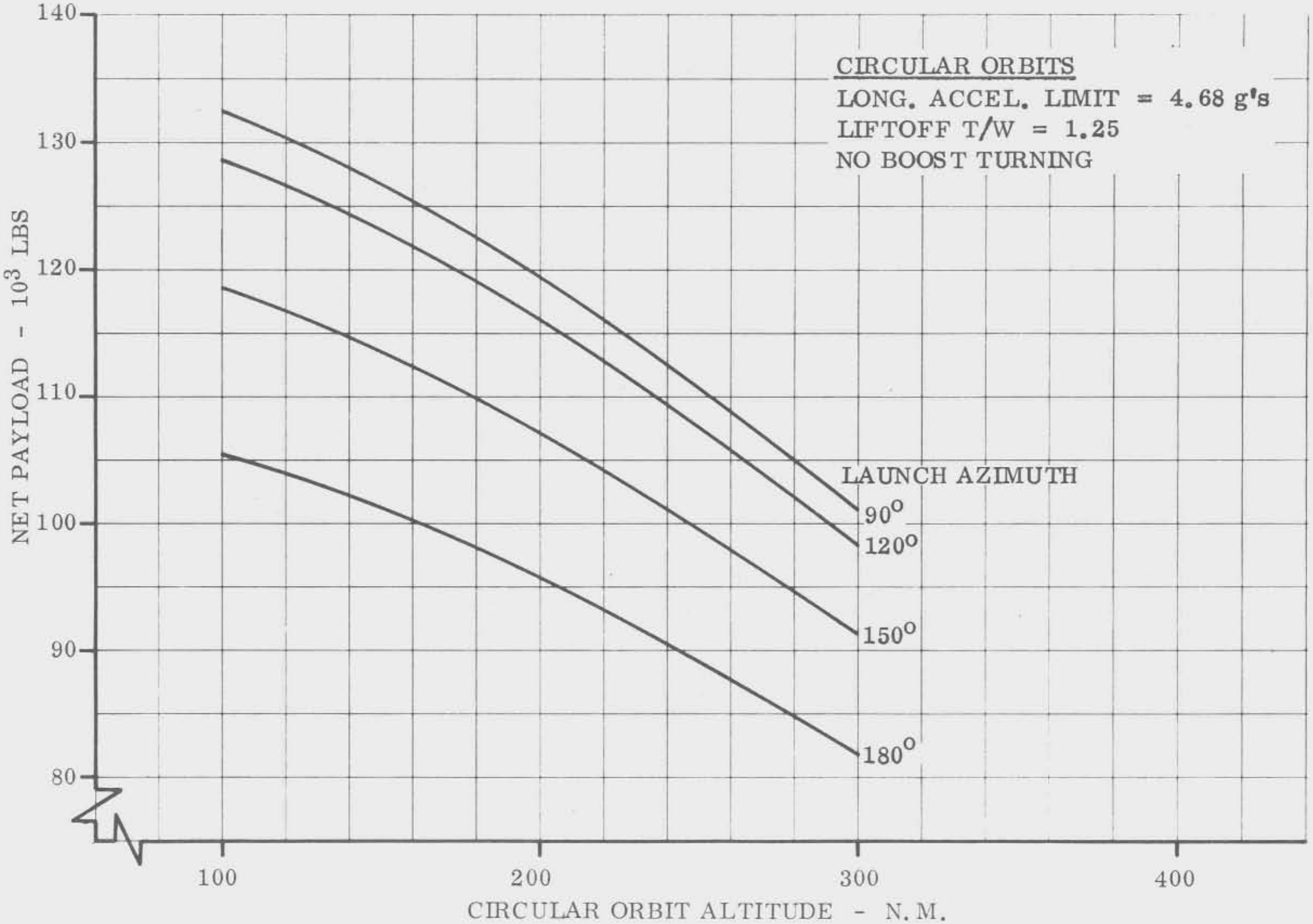

FIGURE D.1-5 4.68-g 4 F-1 INT-20 CIRCULAR ORBIT CAPABILITY

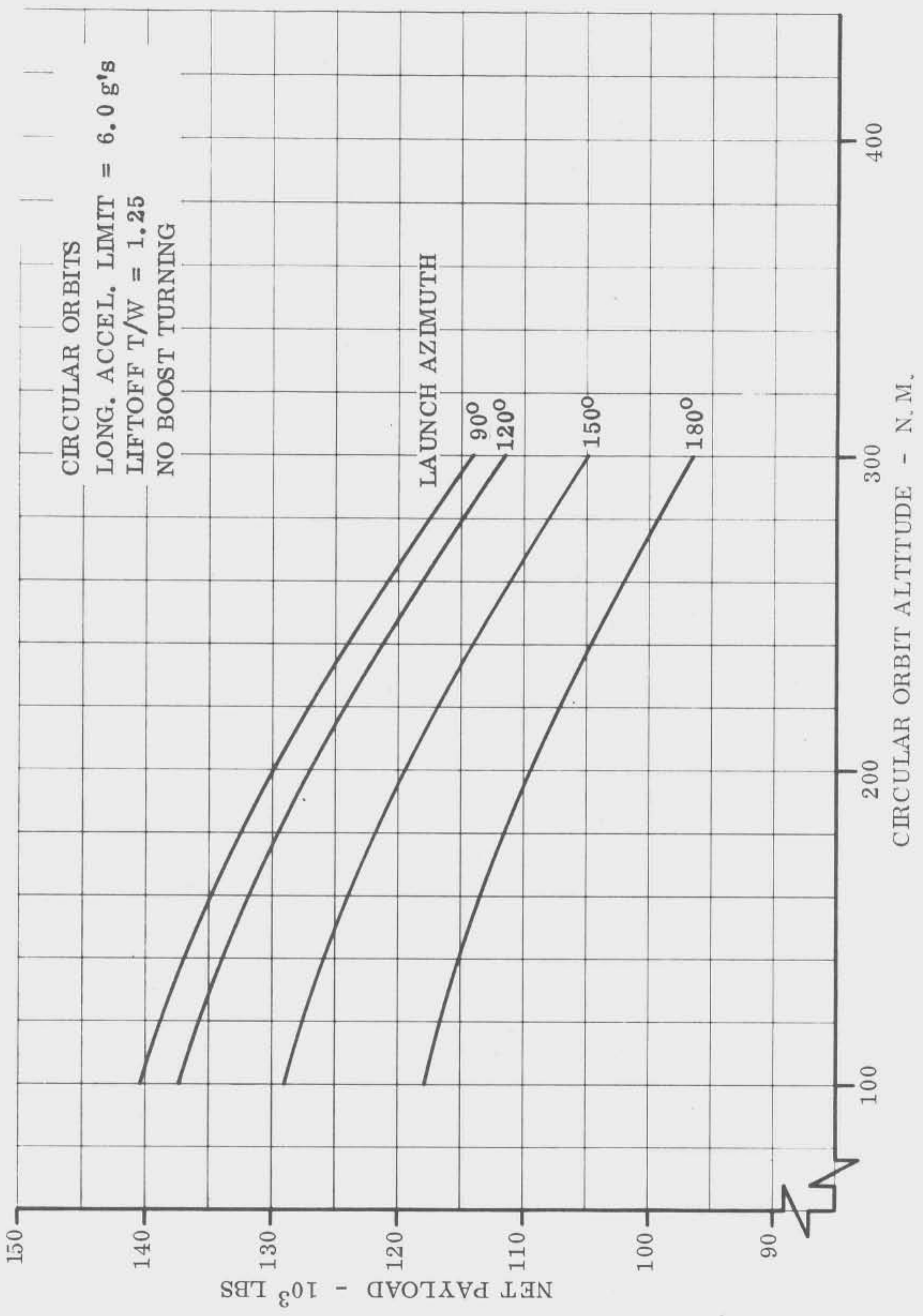

FIGURE D.1-6 6-g 4 F-1 INT-20 CIRCULAR ORBIT CAPABILITY

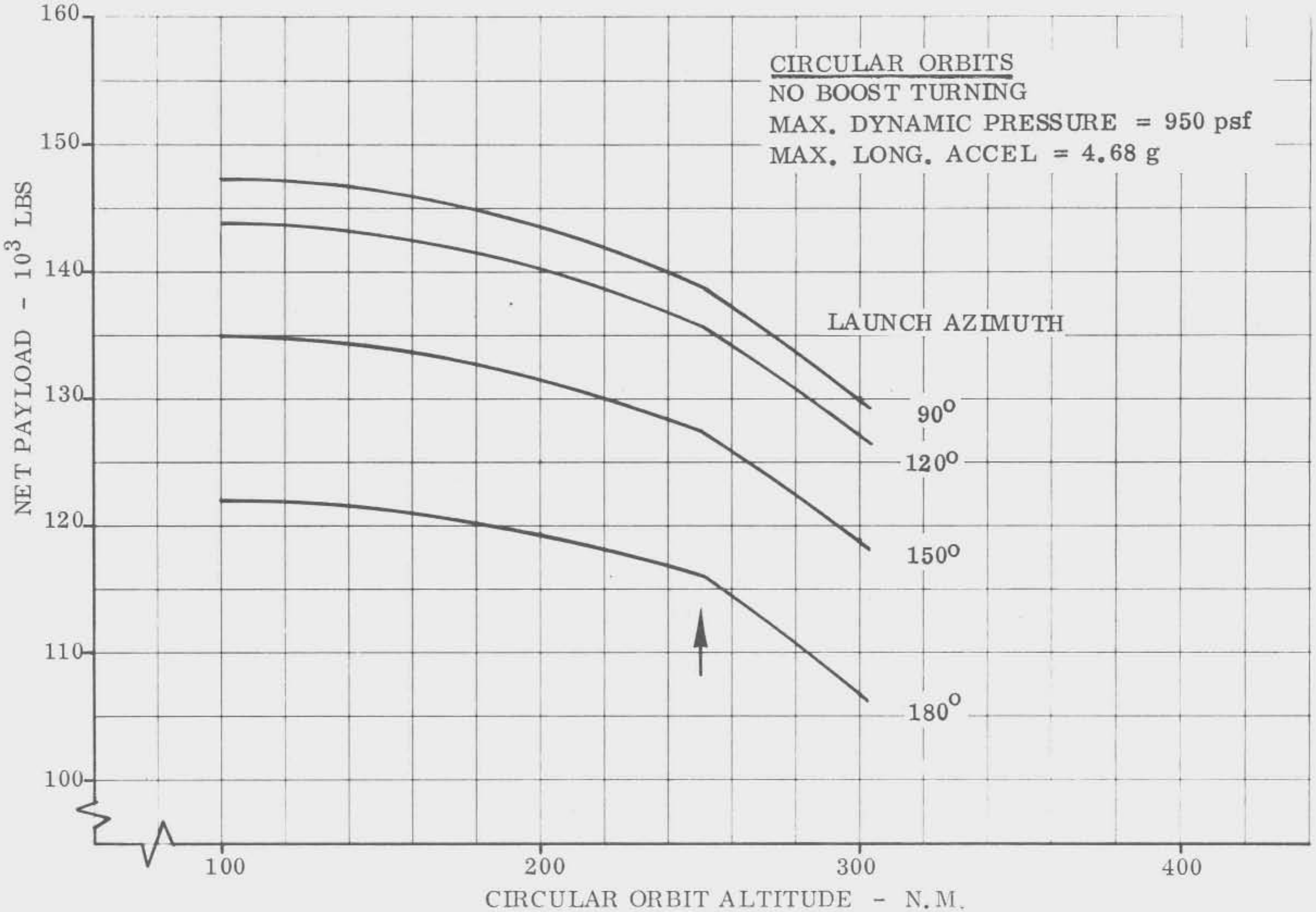

FIGURE D.1-7 4.68-g 5 F-1 INT-20 CIRCULAR ORBIT CAPABILITY

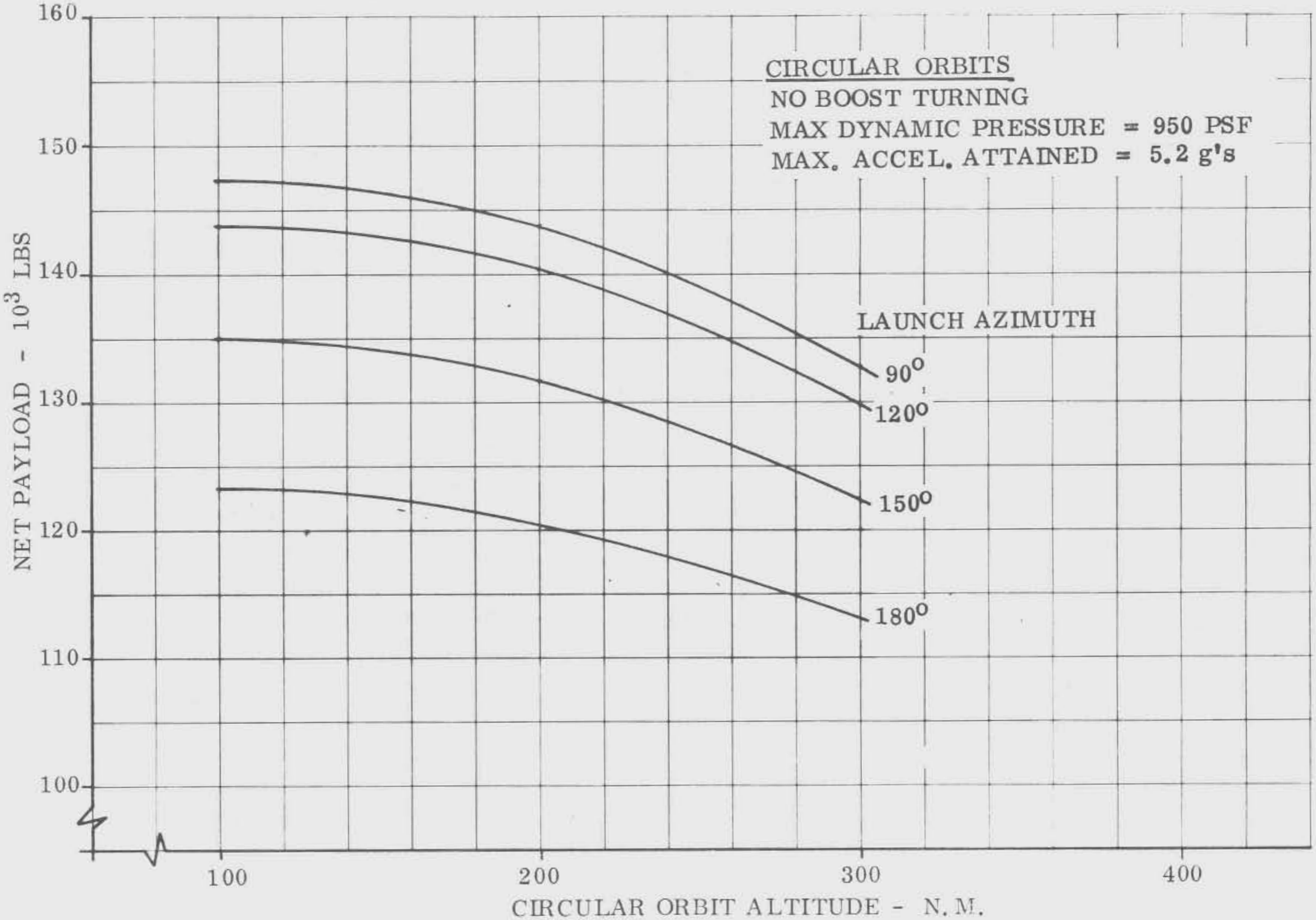

FIGURE D.1-8 6-g 5 F-1 INT-20 CIRCULAR ORBIT CAPABILITY

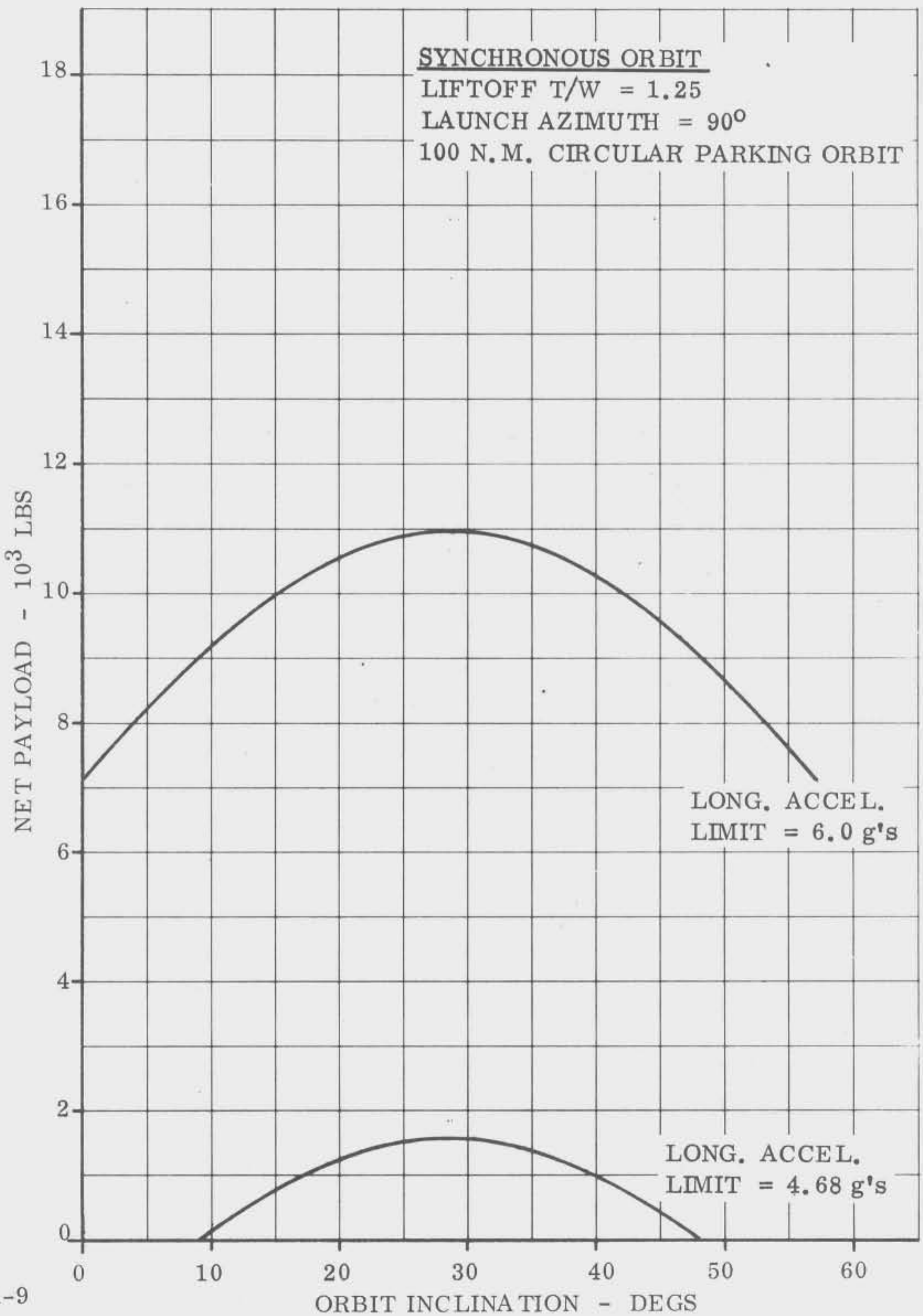

FIGURE D.1-9

3 F-1 INT-20 SYNCHRONOUS ORBIT CAPABILITY

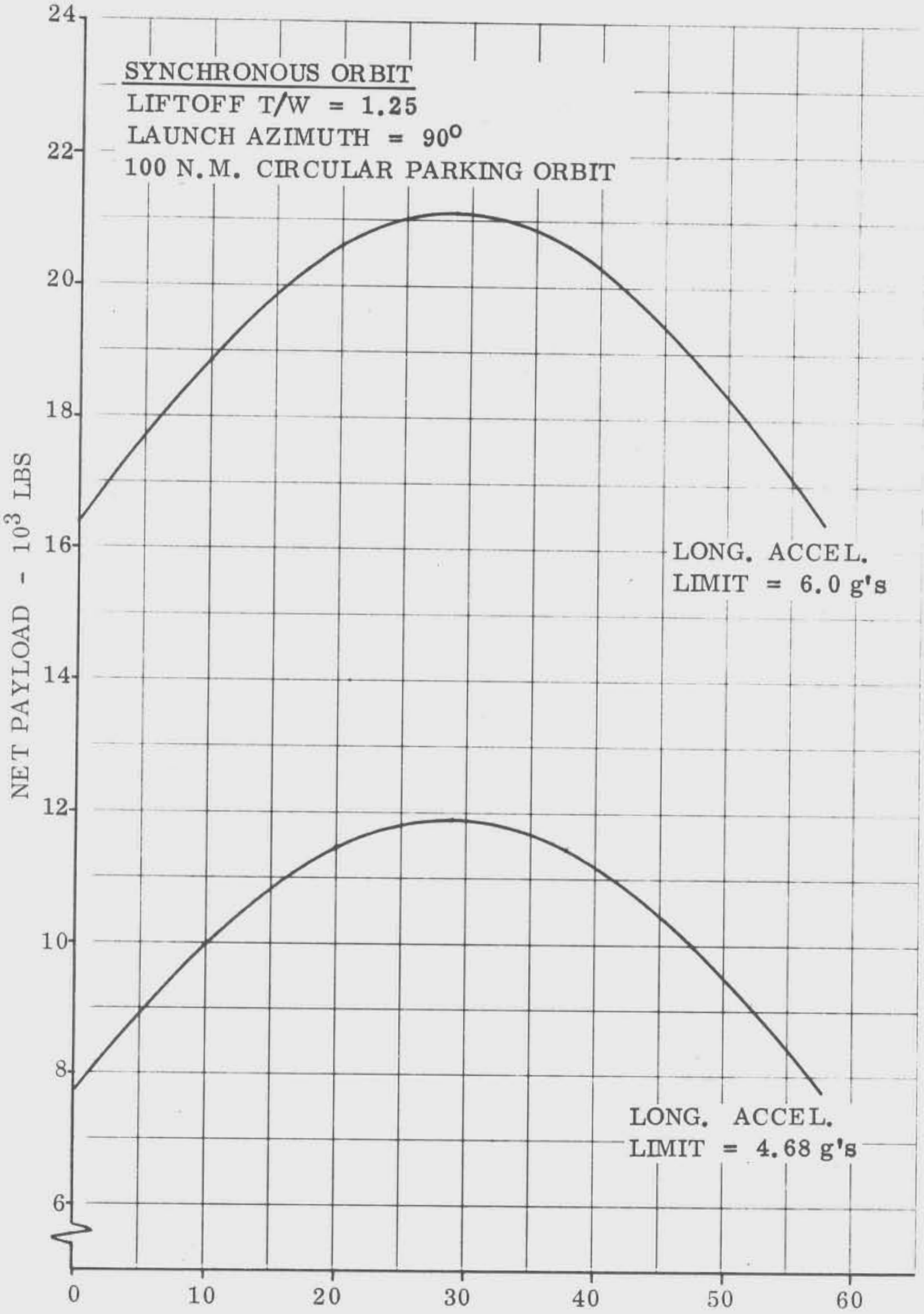

FIGURE D.1-10

4 F-1 INT-20 SYNCHRONOUS ORBIT CAPABILITY

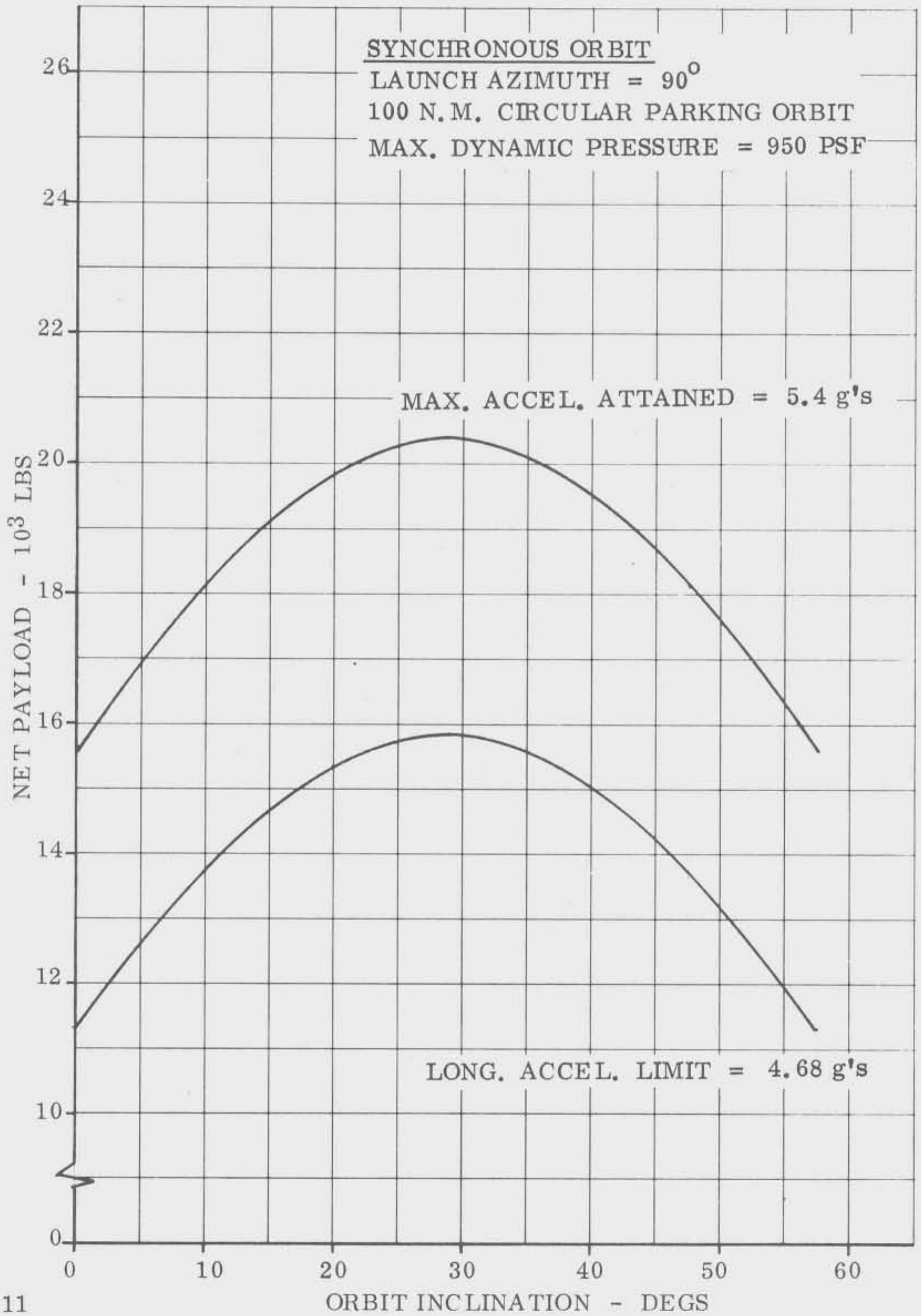

FIGURE D.1-11

5 F-1 INT-20 SYNCHRONOUS ORBIT CAPABILITY

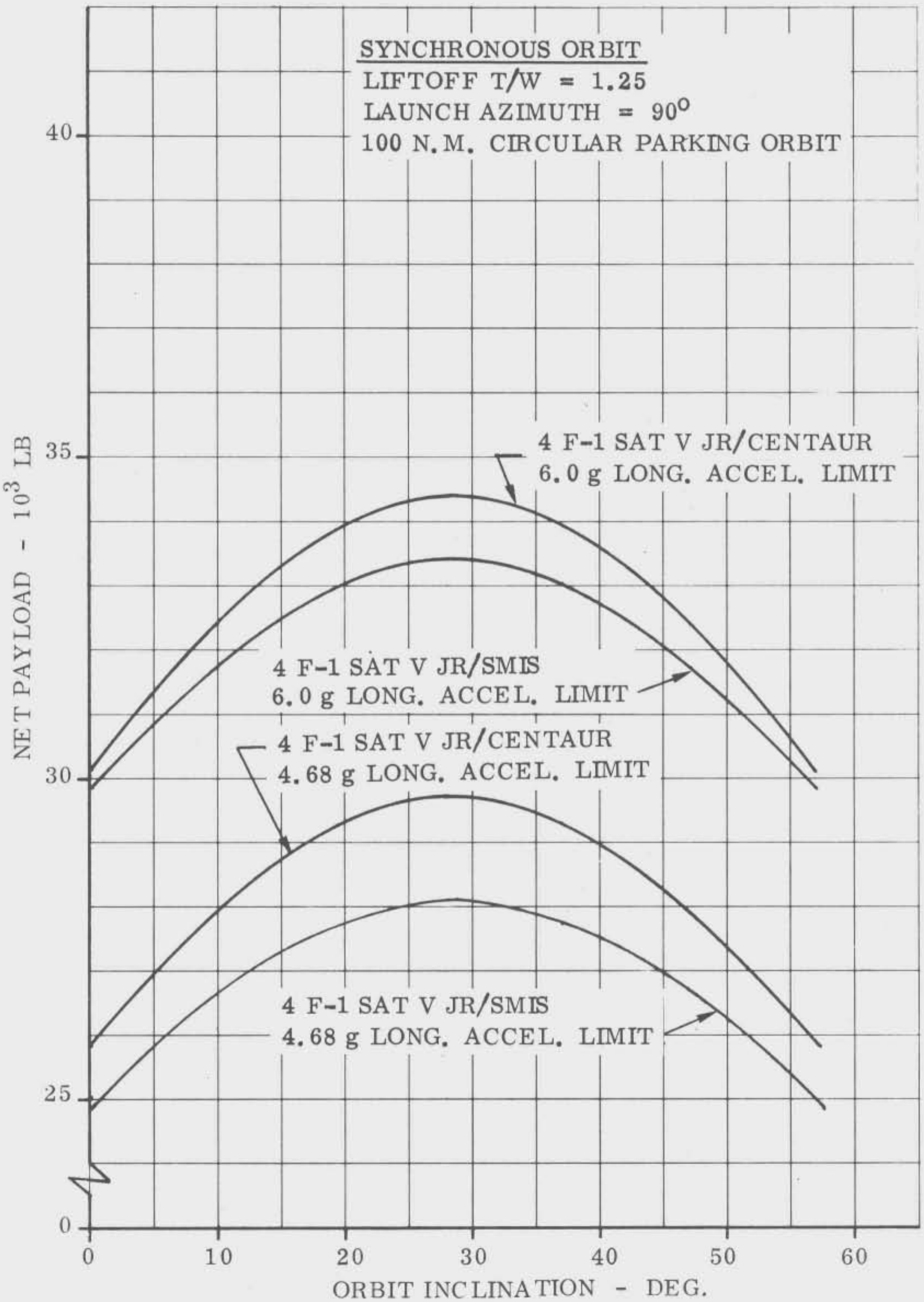

FIGURE D.1-12
INT-20/INJECTION STAGE
SYNCHRONOUS ORBIT CAPABILITY

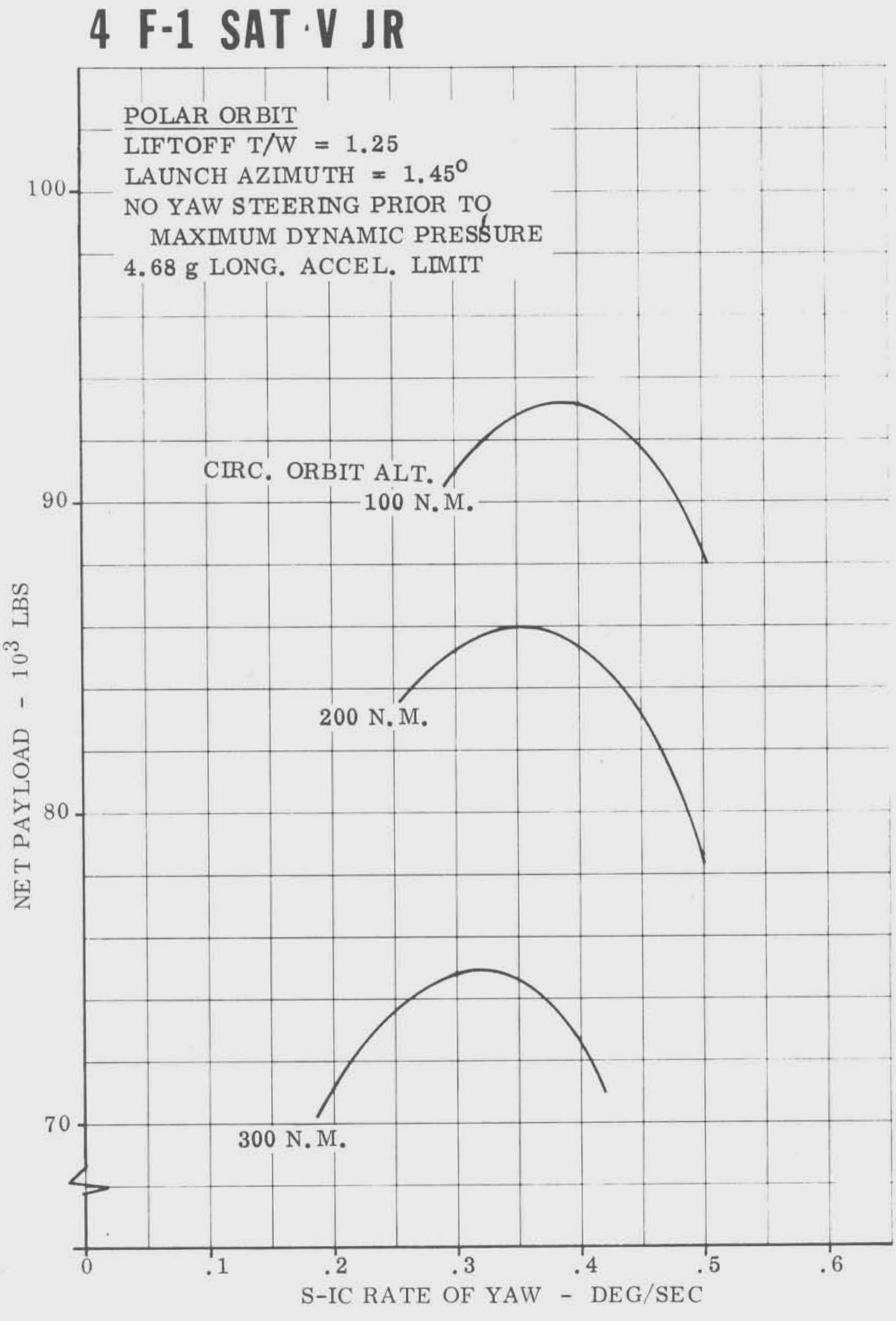

FIGURE D.1-13

4.68-g 4 F-1 POLAR ORBIT CAPABILITIES

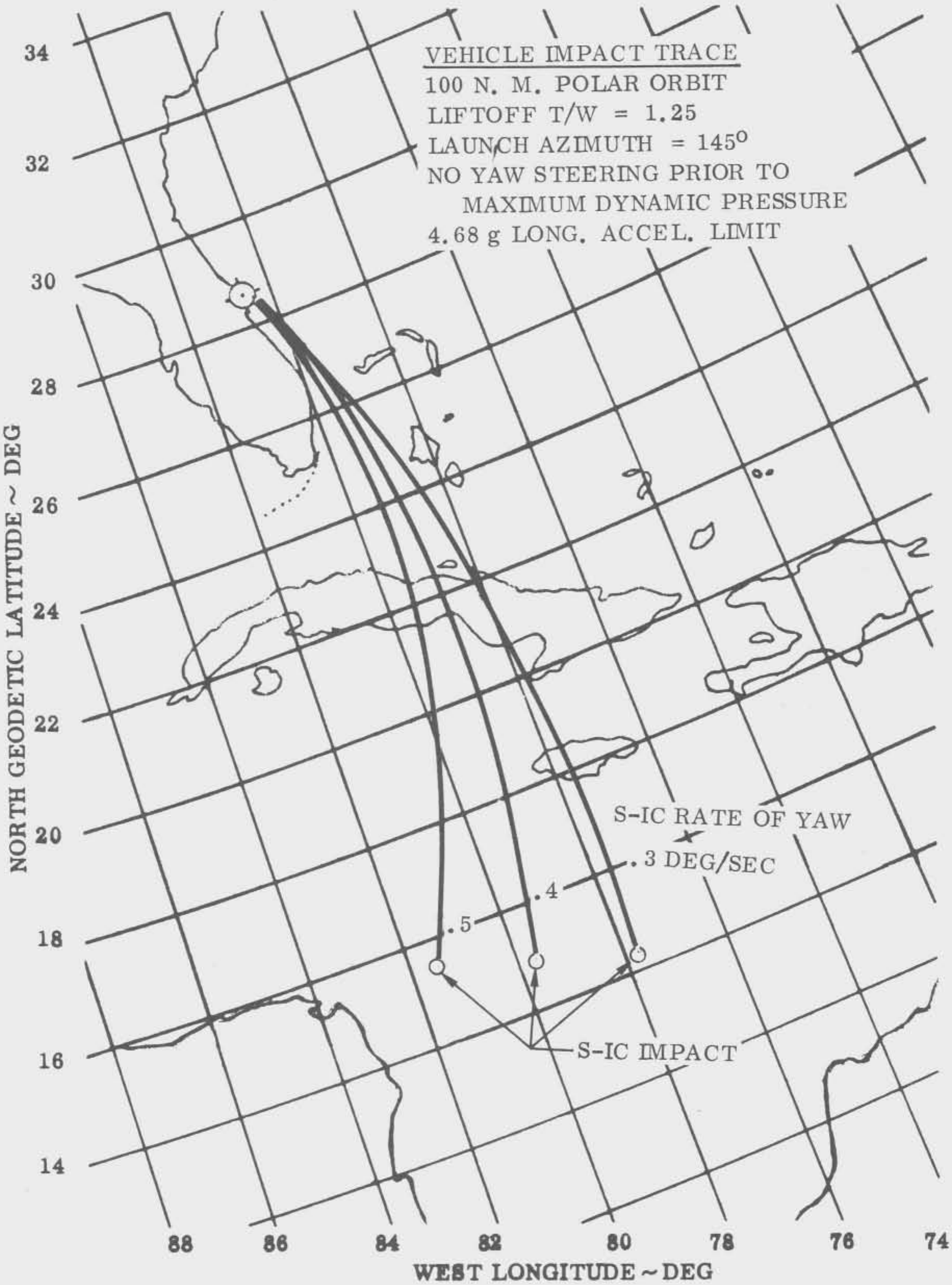

FIGURE D.1-14

4.68-g 4 F-1 S-IC IMPACT TRACES (100 NM POLAR)

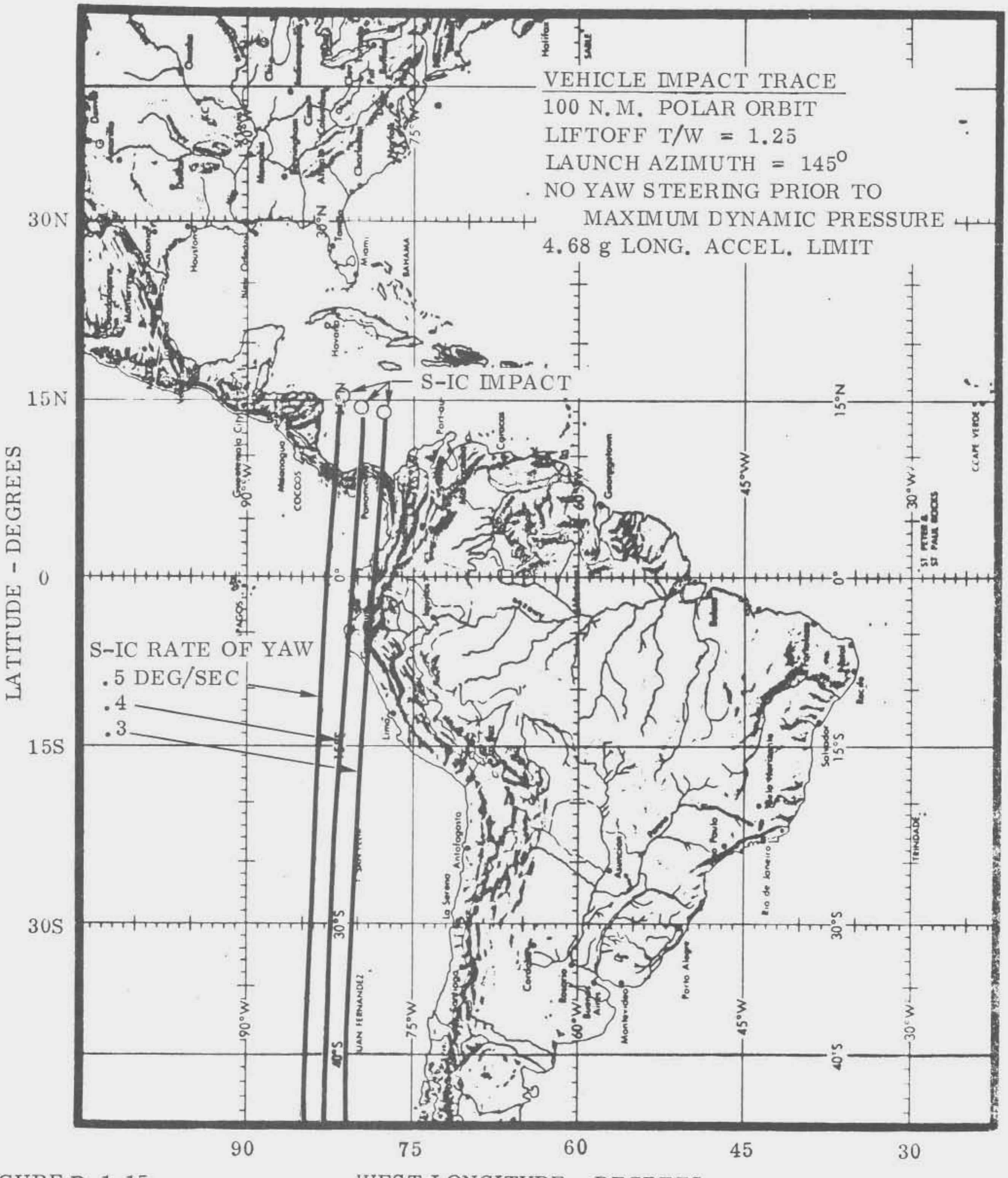

FIGURE D.1-15

4.68-g 4 F-1 INT-20 IMPACT TRACES (100 N.M. POLAR)

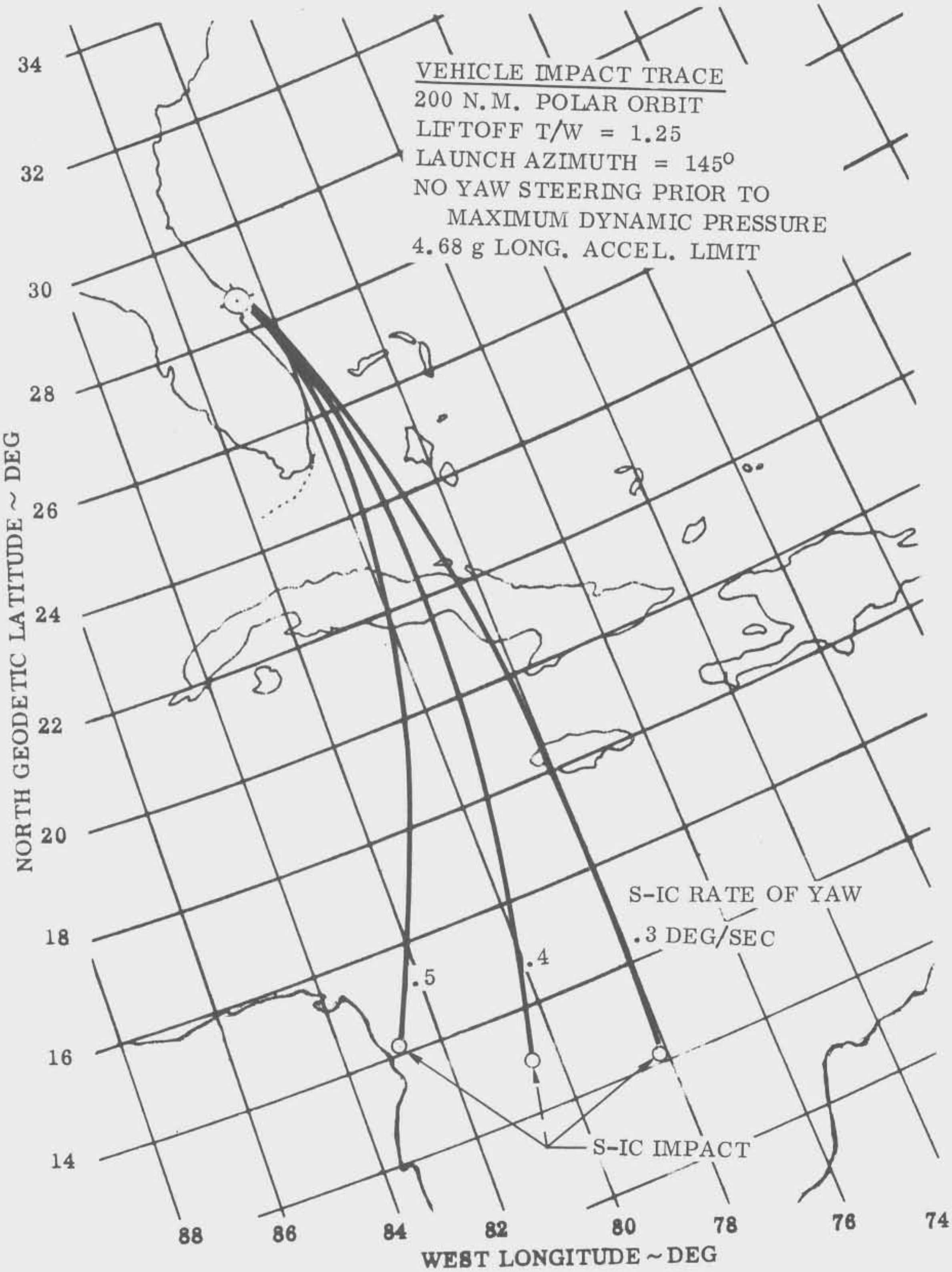

FIGURE D.1-16

4.68-g 4 F-1 S-IC IMPACT TRACES (200 NM POLAR)

FIGURE D.1-17
4.68-g 4 F-1 INT-20 IMPACT TRACES (200 NM POLAR)

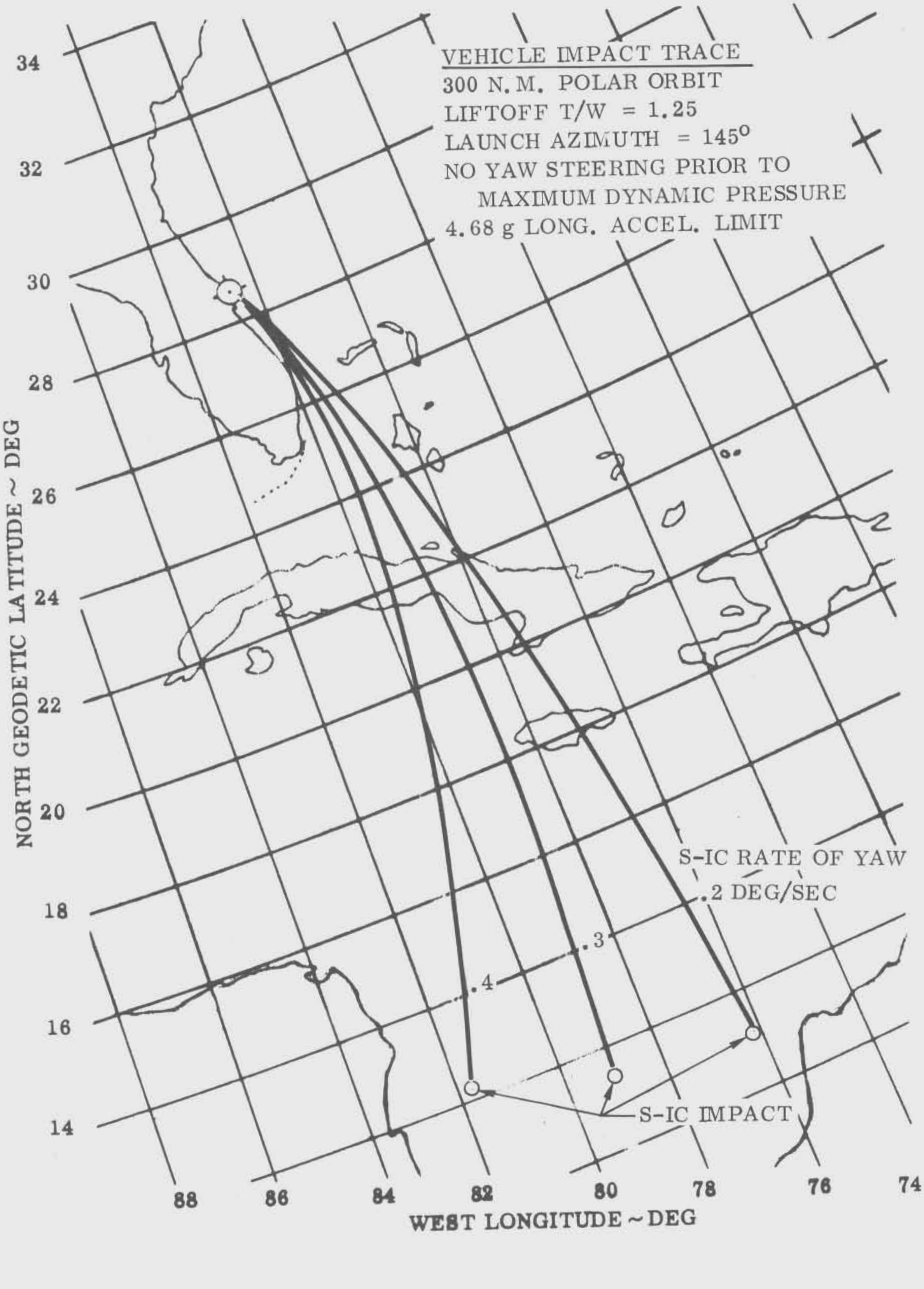

FIGURE D.1-18
4.68-g 4 F-1 S-IC IMPACT
TRACES (300 NM POLAR)

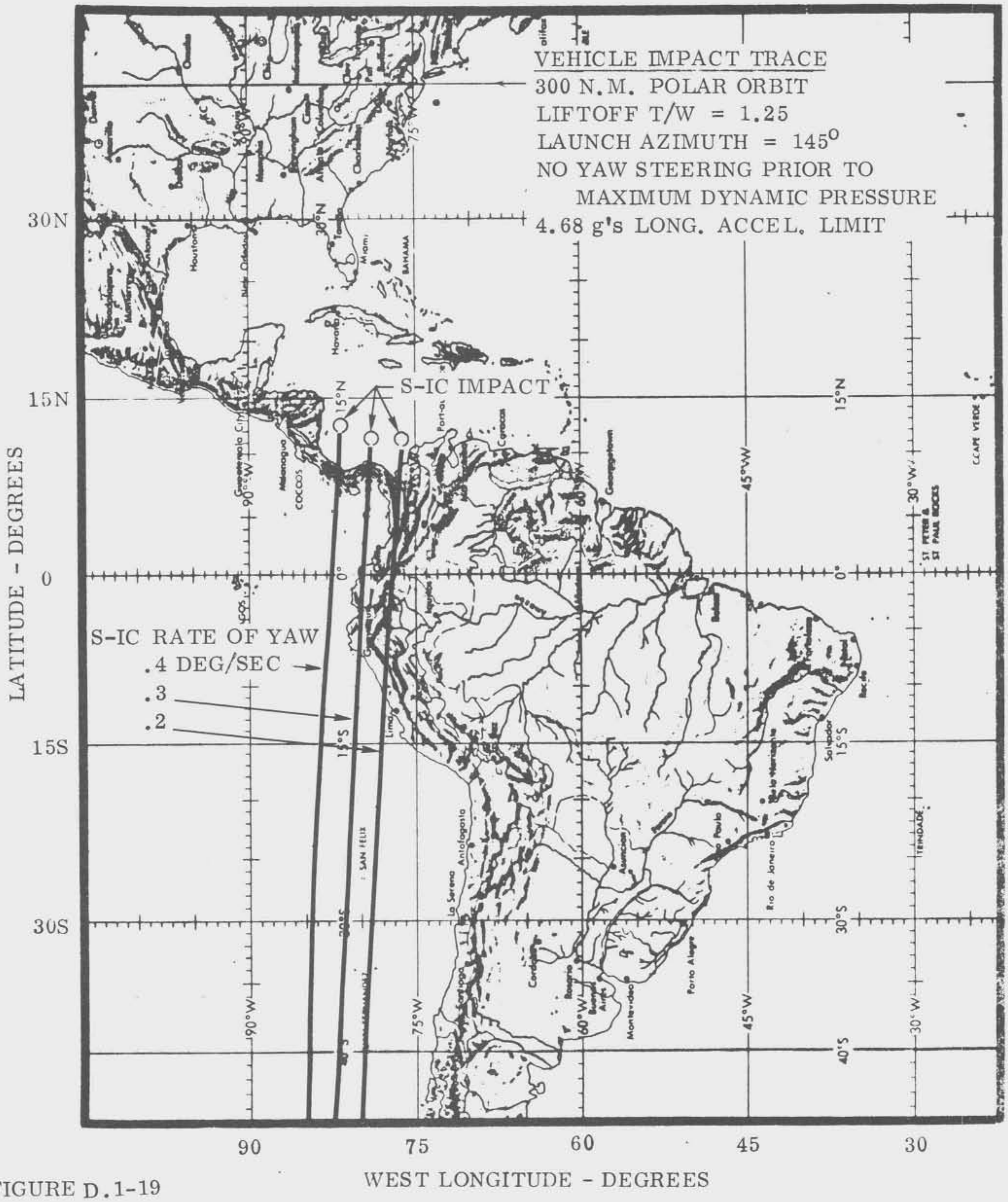

FIGURE D.1-19
4.68-g 4 F-1 INT-20 IMPACT
TRACES (300 NM POLAR)

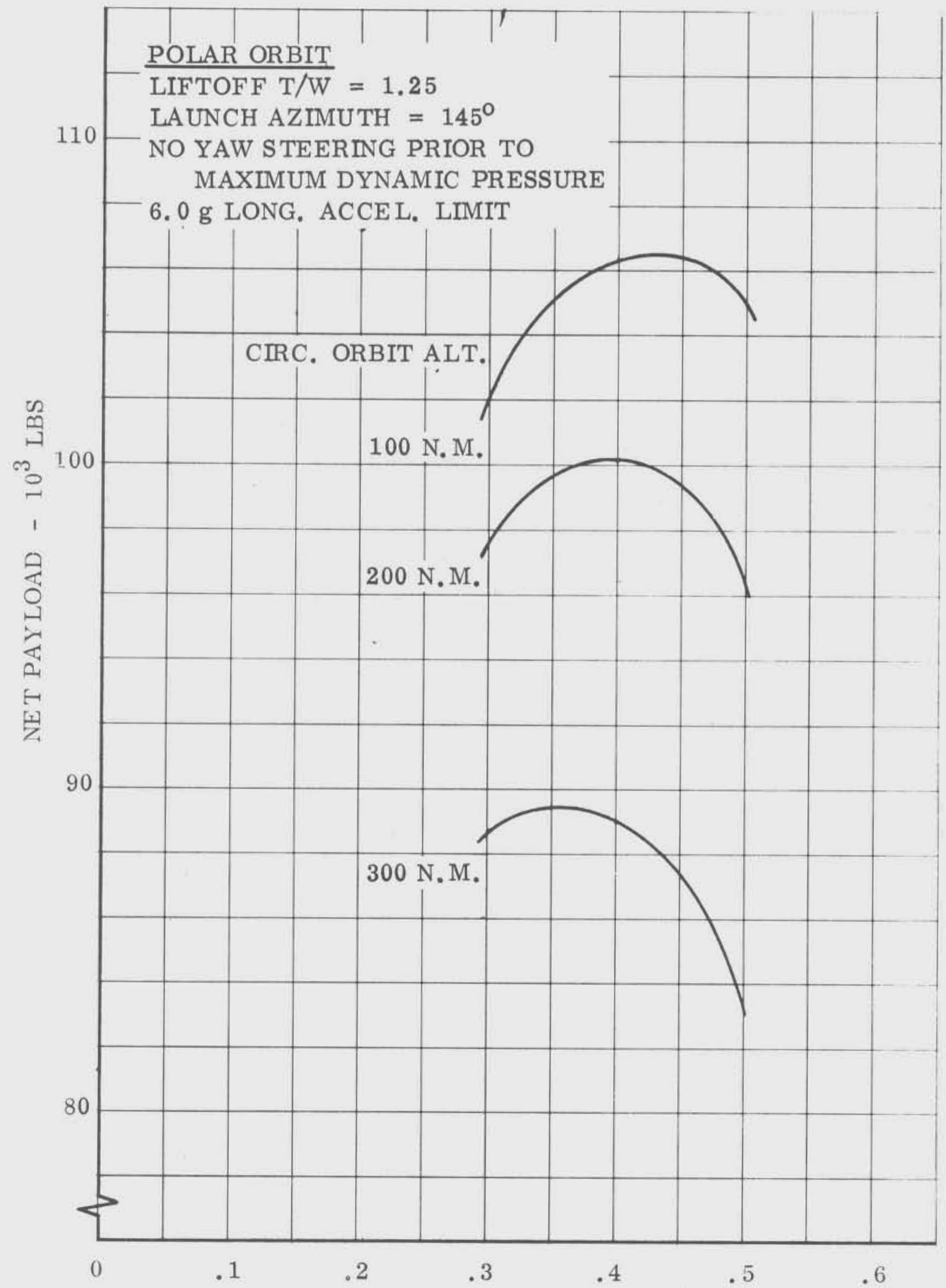

FIGURE D.1-20
6-g 4 F-1 INT-20 POLAR
ORBIT CAPABILITY

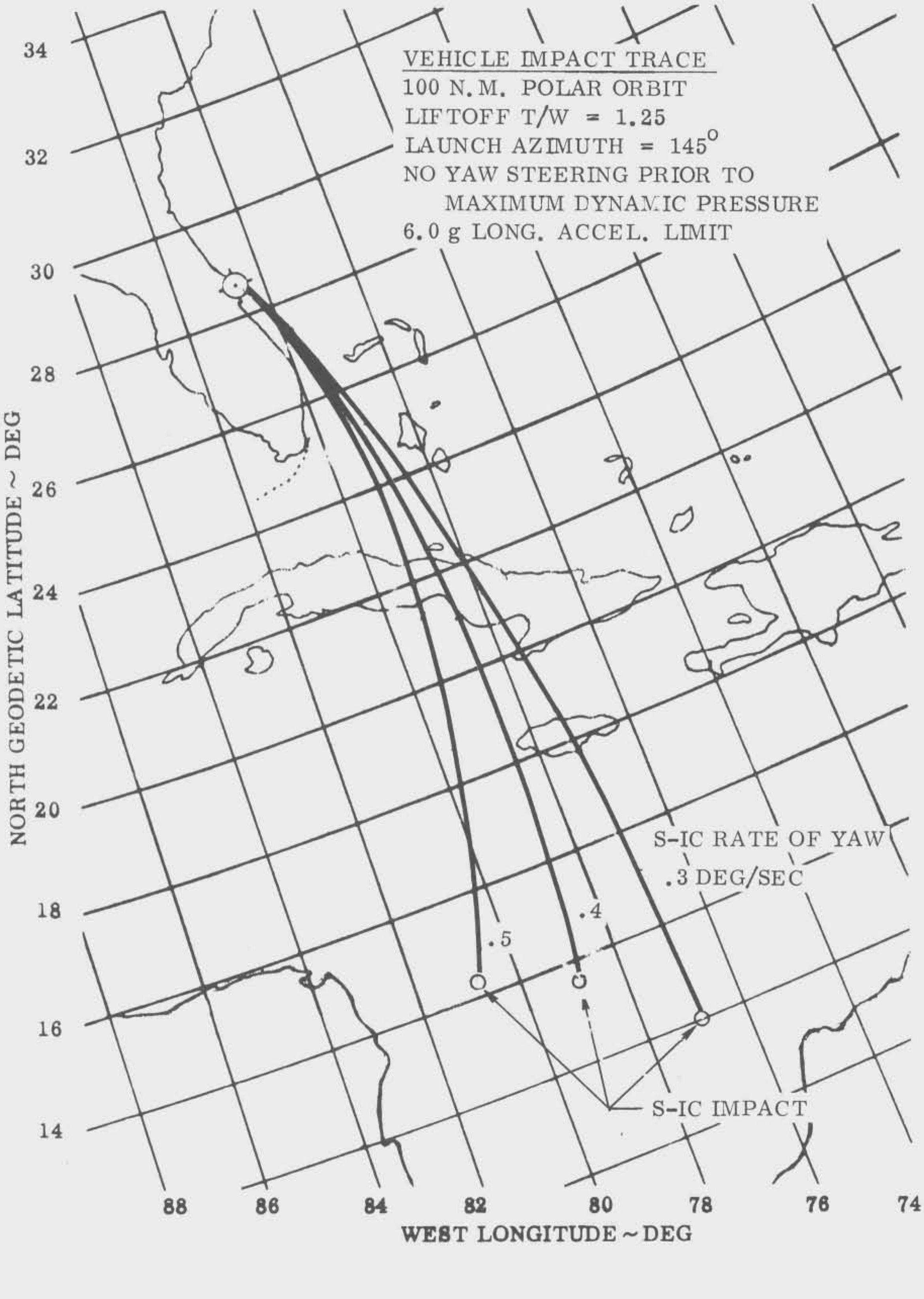

FIGURE D.1-21

6-g 4 F-1 S-IC IMPACT TRACES (100 NM POLAR)

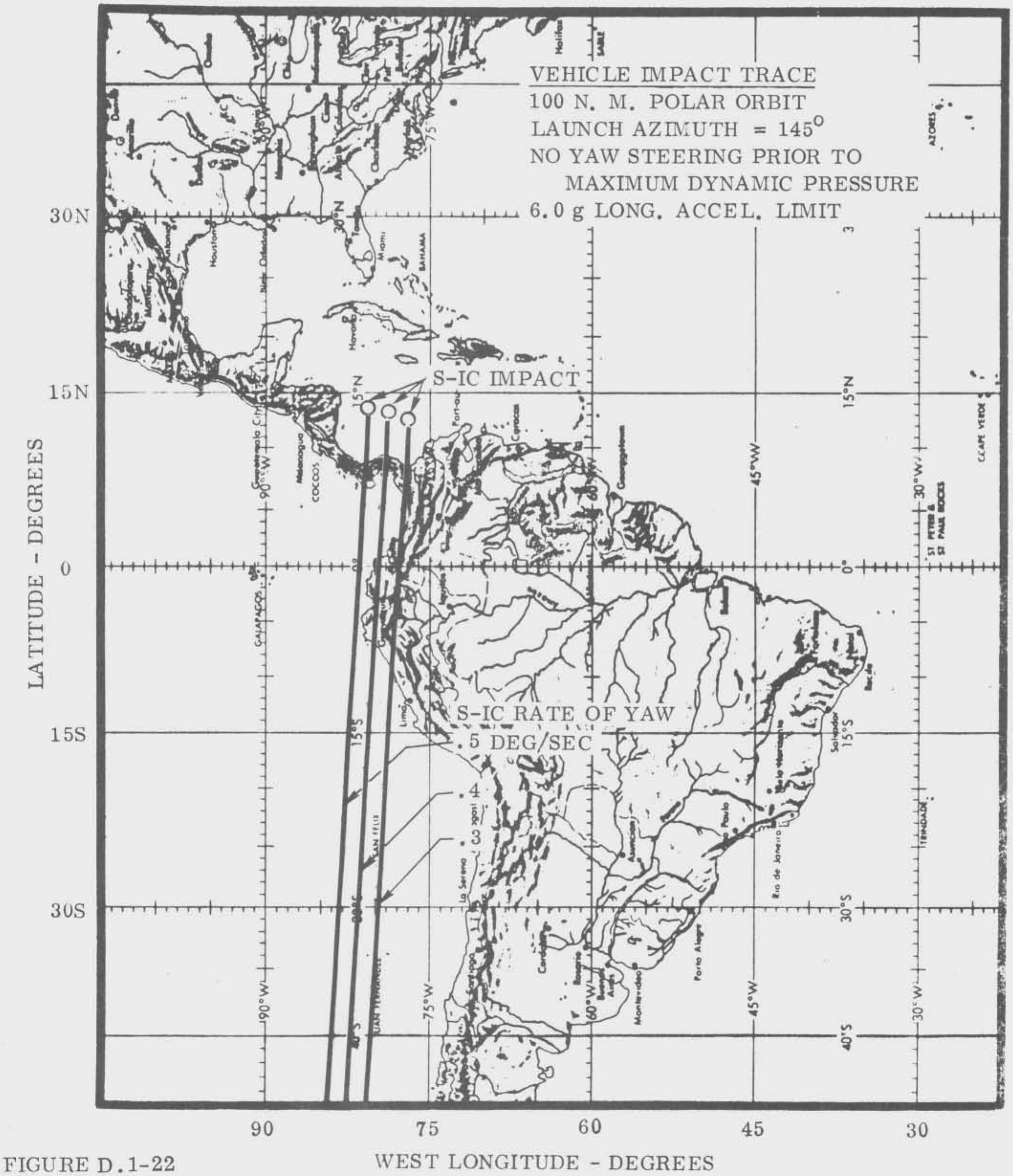

FIGURE D.1-22

6-g 4 F-1 INT-20 IMPACT TRACES (100 NM POLAR)

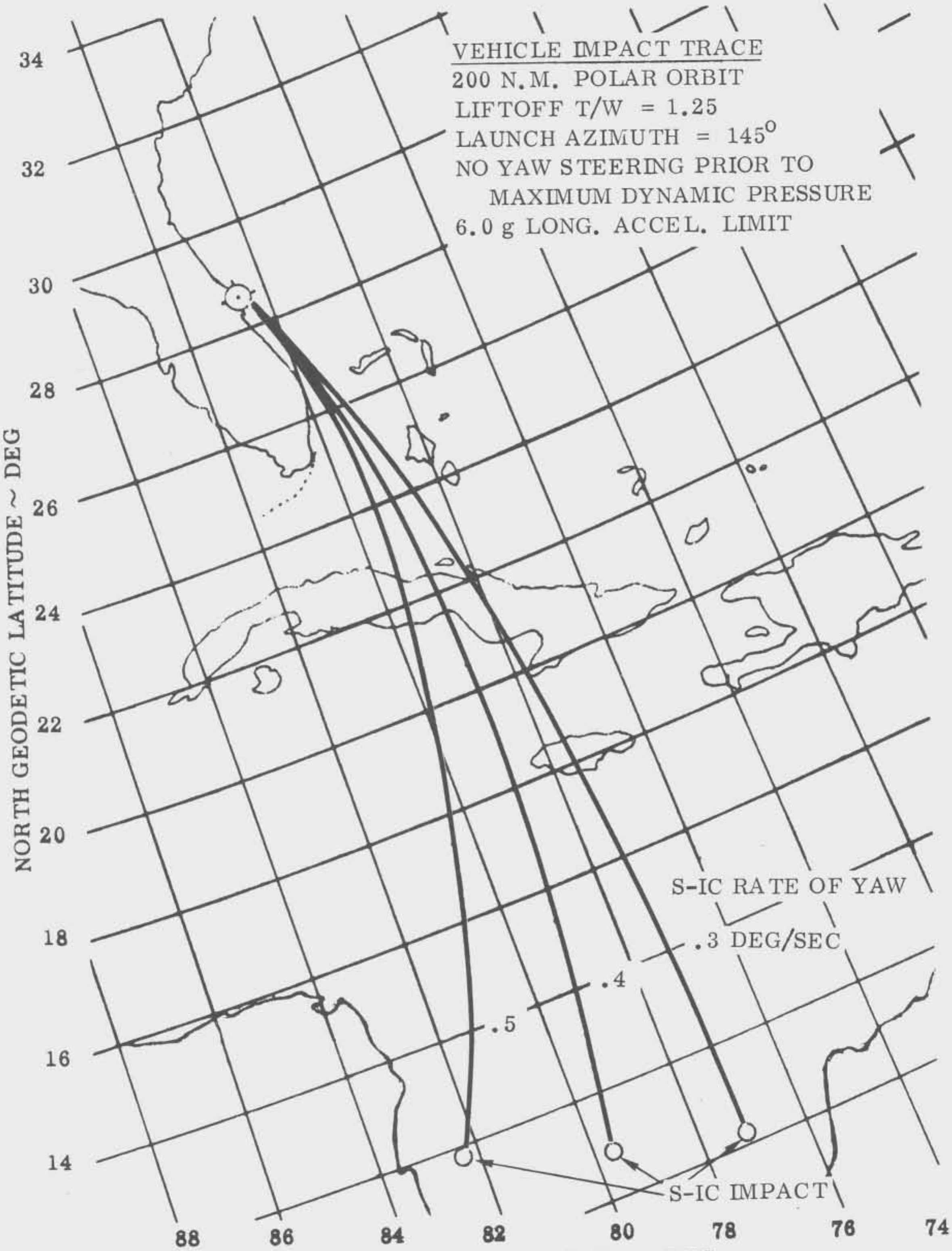

FIGURE D.1-23
6-g 4 F-1 S-IC IMPACT
TRACES (200 NM POLAR)

4 F-1 SAT-V JR

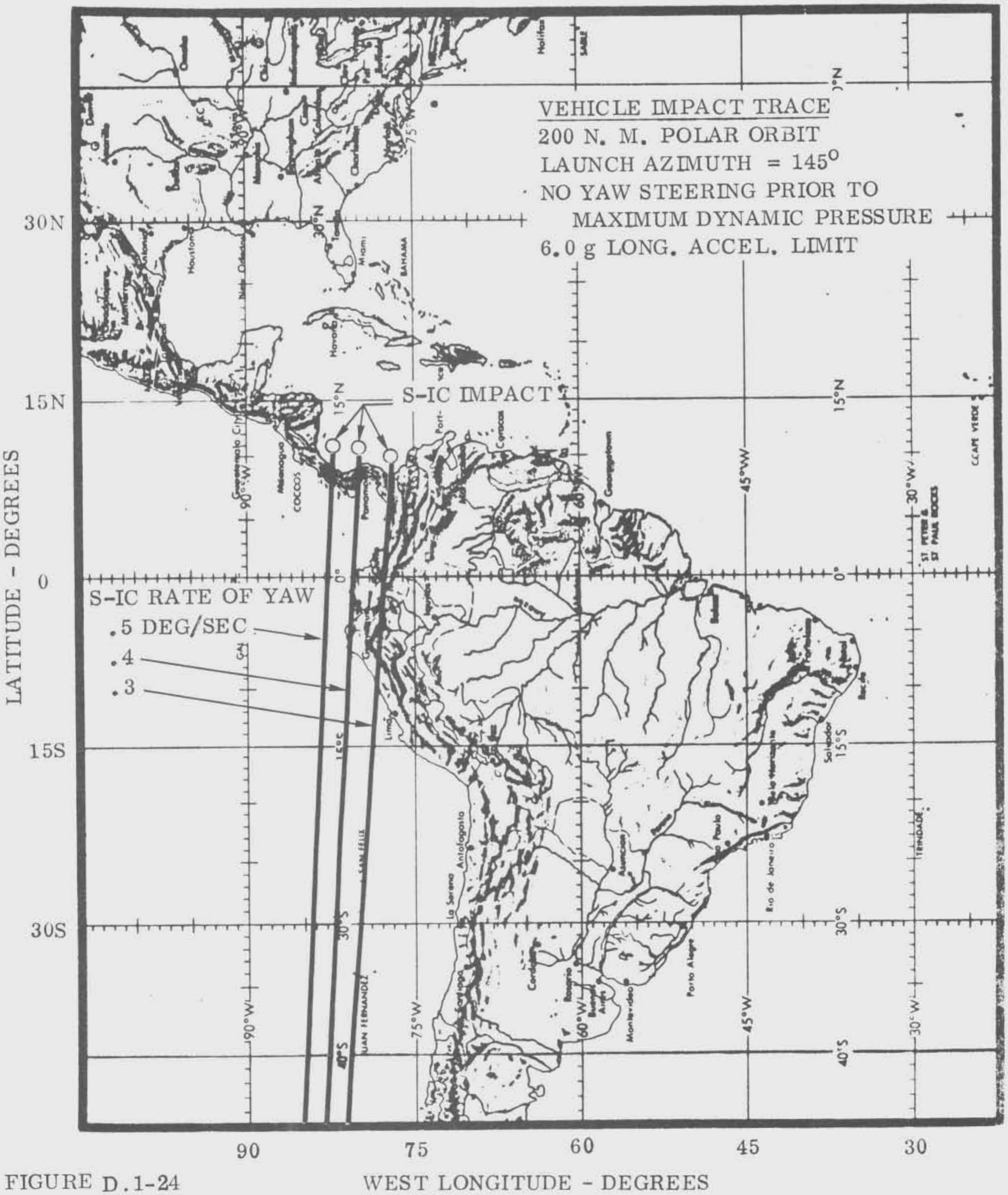

FIGURE D.1-24
6-g 4 F-1 INT-20 IMPACT TRACES (200 NM POLAR)

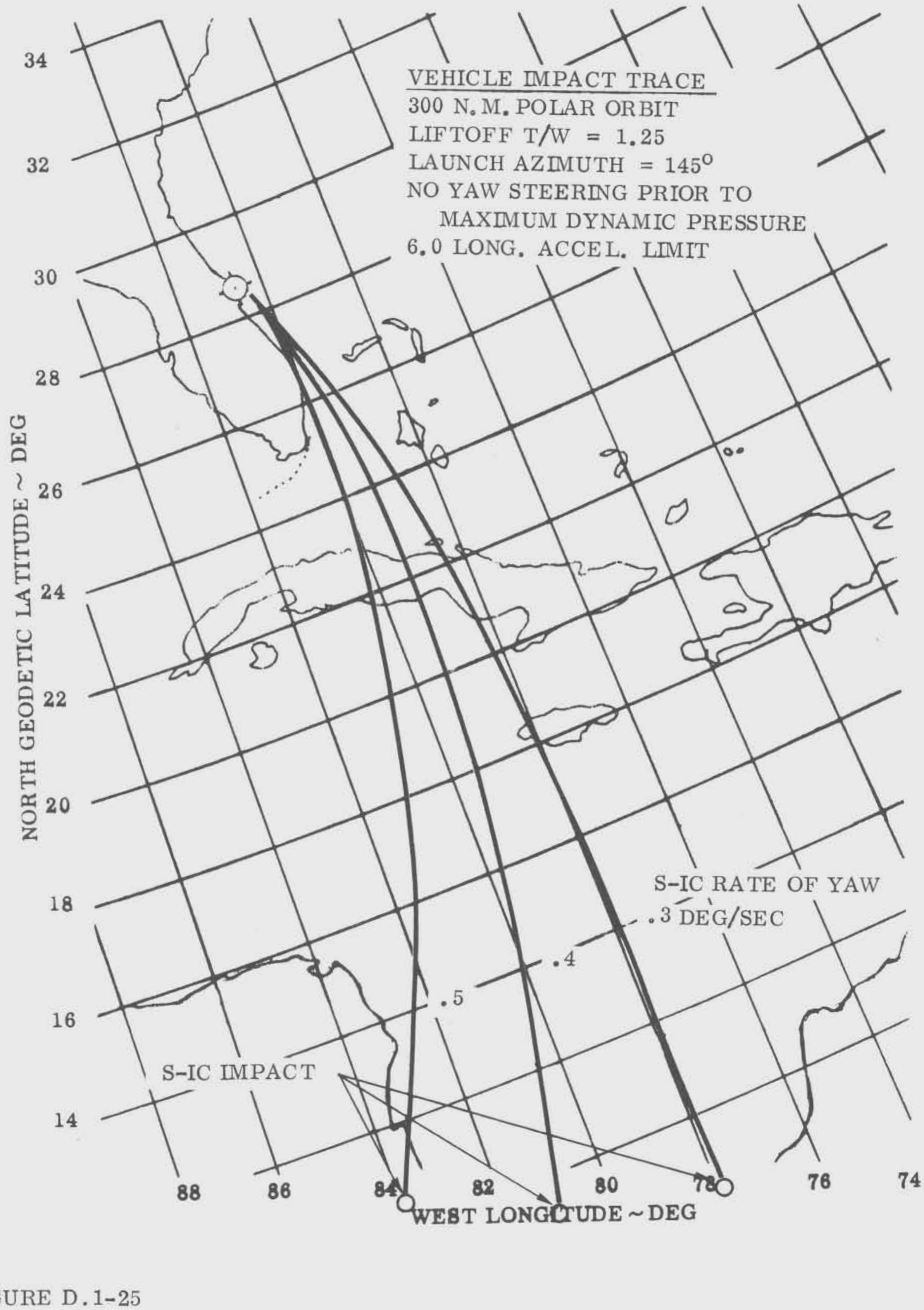

FIGURE D.1-25

6-g 4 F-1 S-IC IMPACT
TRACES (300 NM POLAR)

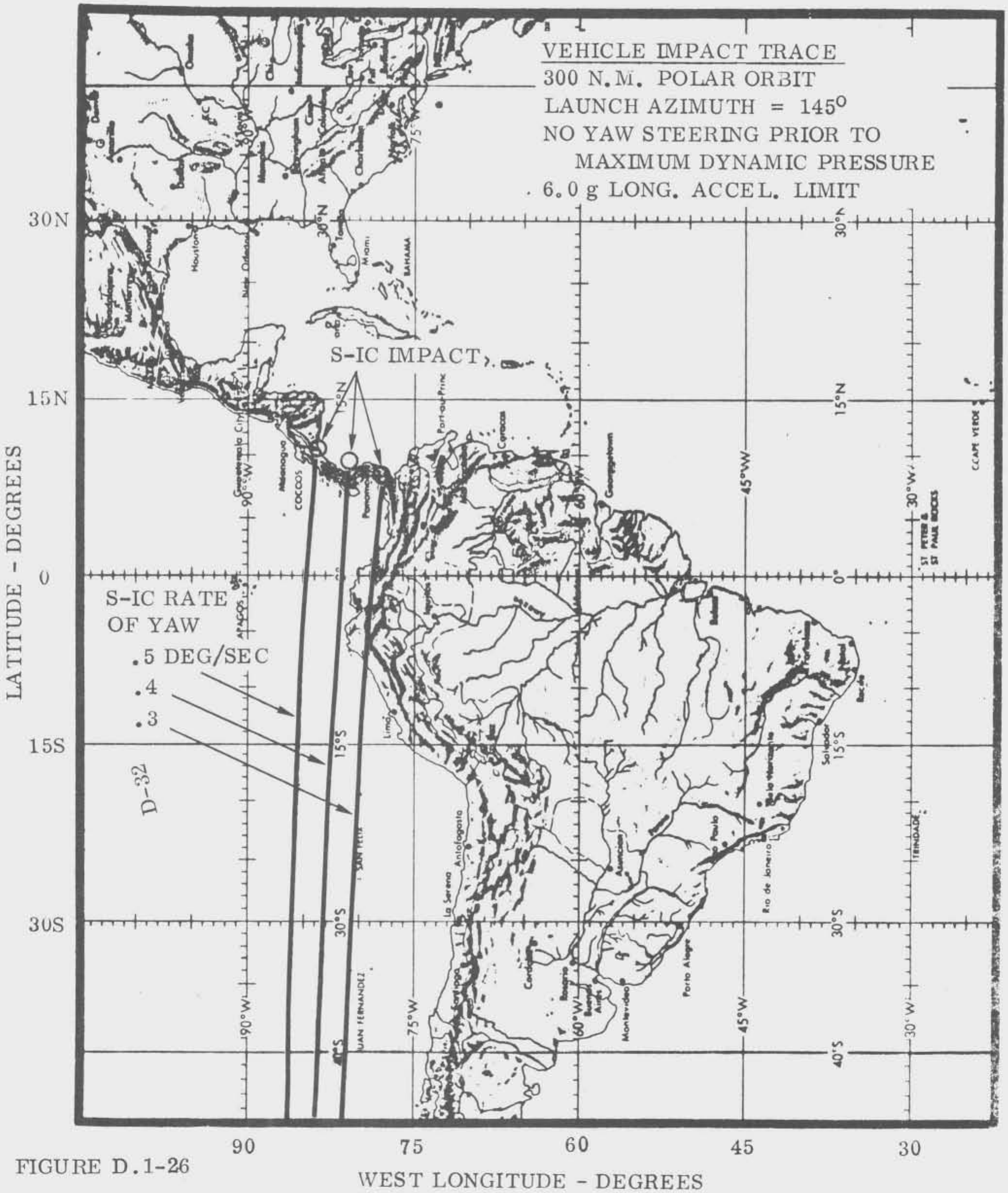

FIGURE D.1-26
6-g 4 F-1 INT-20 IMPACT TRACES (300 NM POLAR)

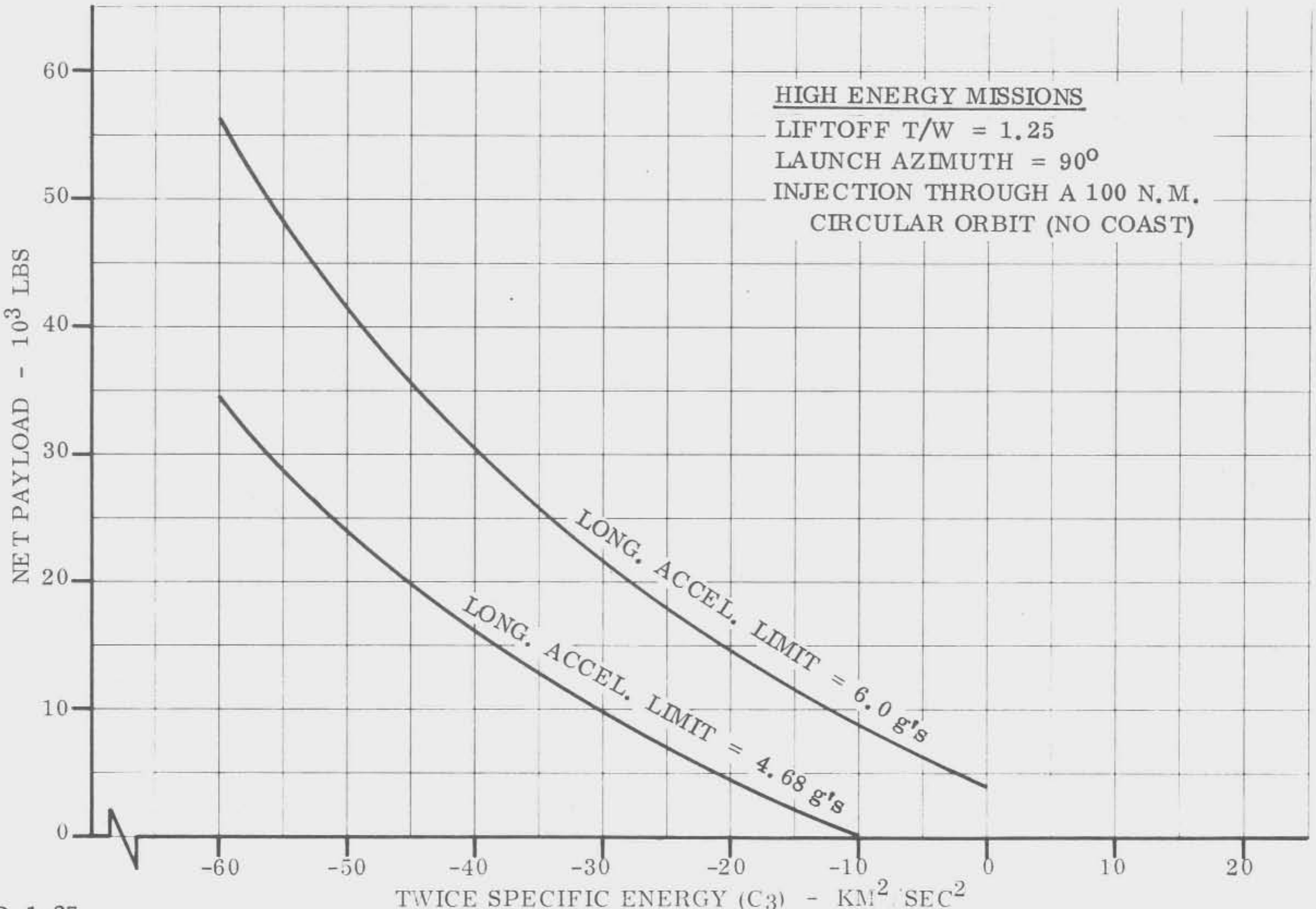

FIGURE D.1-27

2 F-1 INT-20 C_3 Data

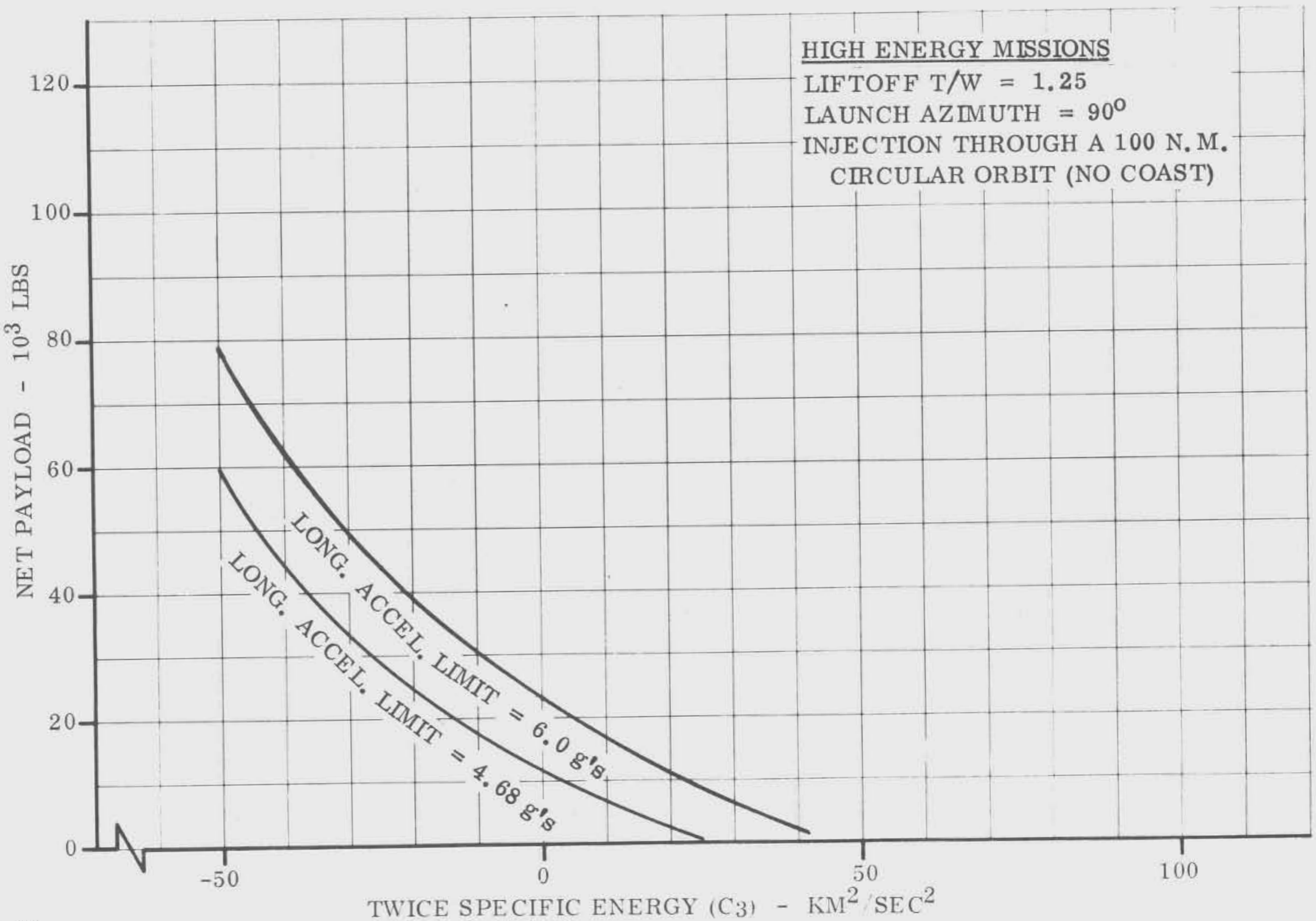

FIGURE D.1-28

3 F-1 INT-20 C_3 DATA

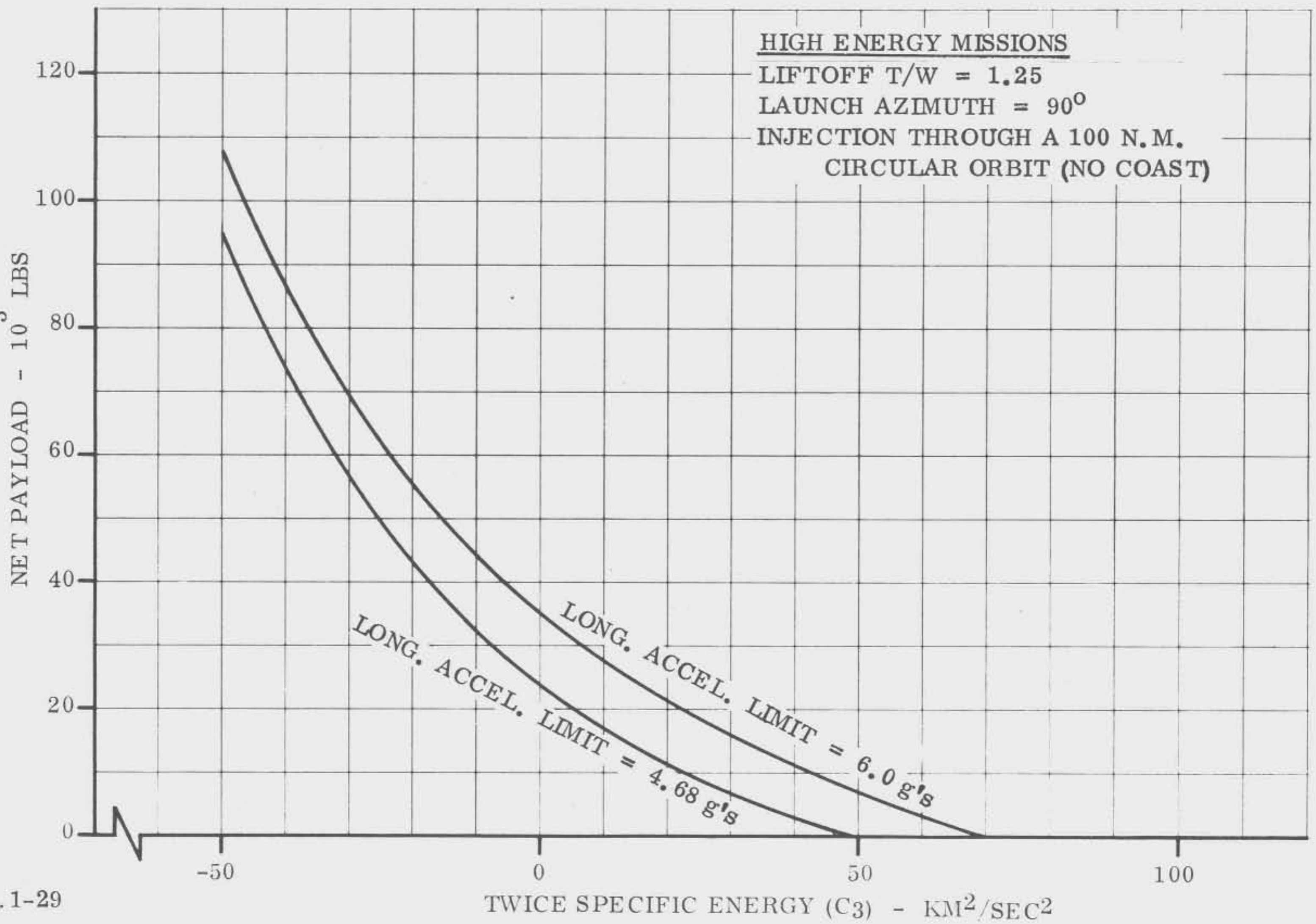

FIGURE D.1-29

4 F-1 INT-20 C_3 DATA

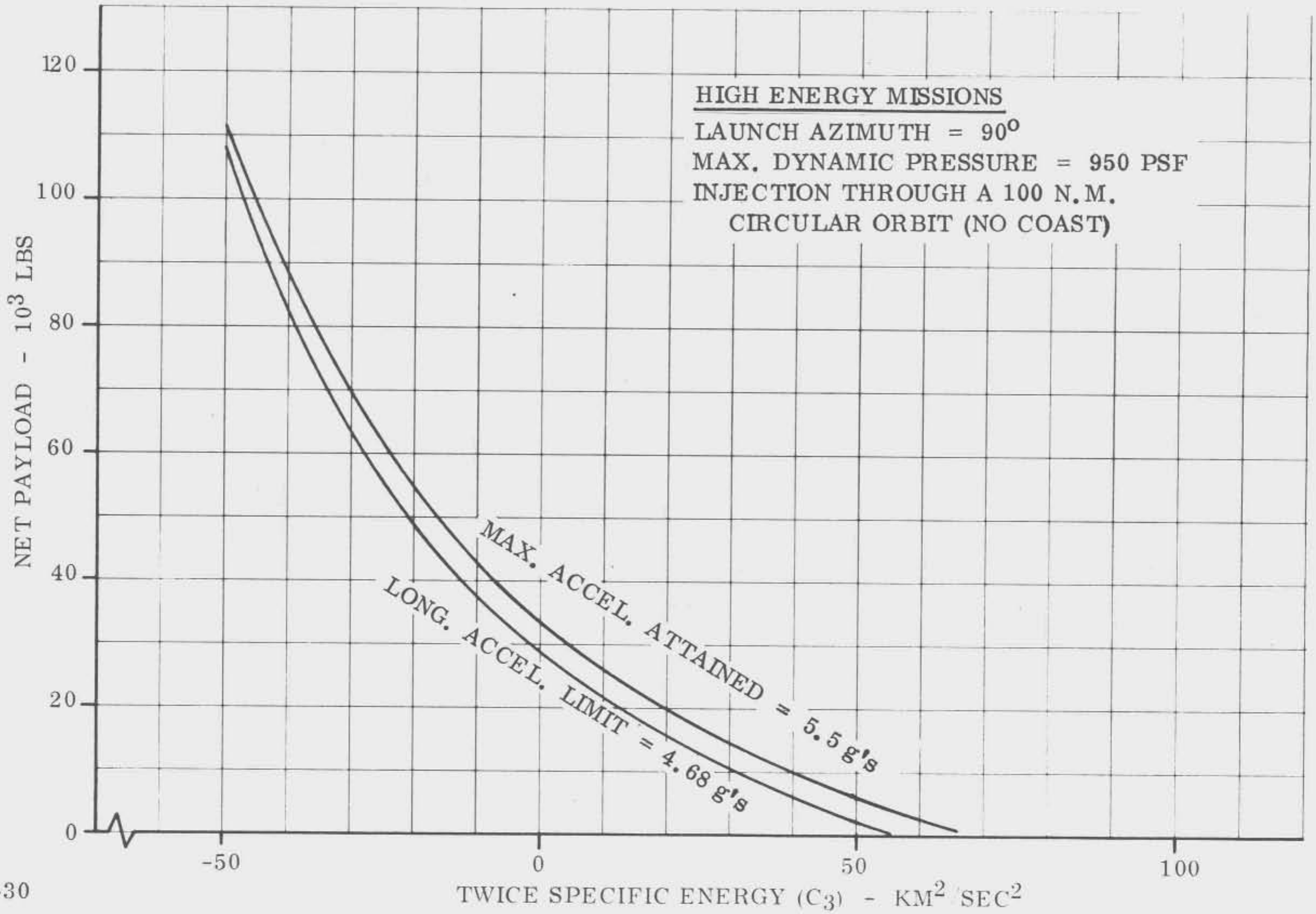

FIGURE D.1-30

5 F-1 INT-20 C_3 DATA

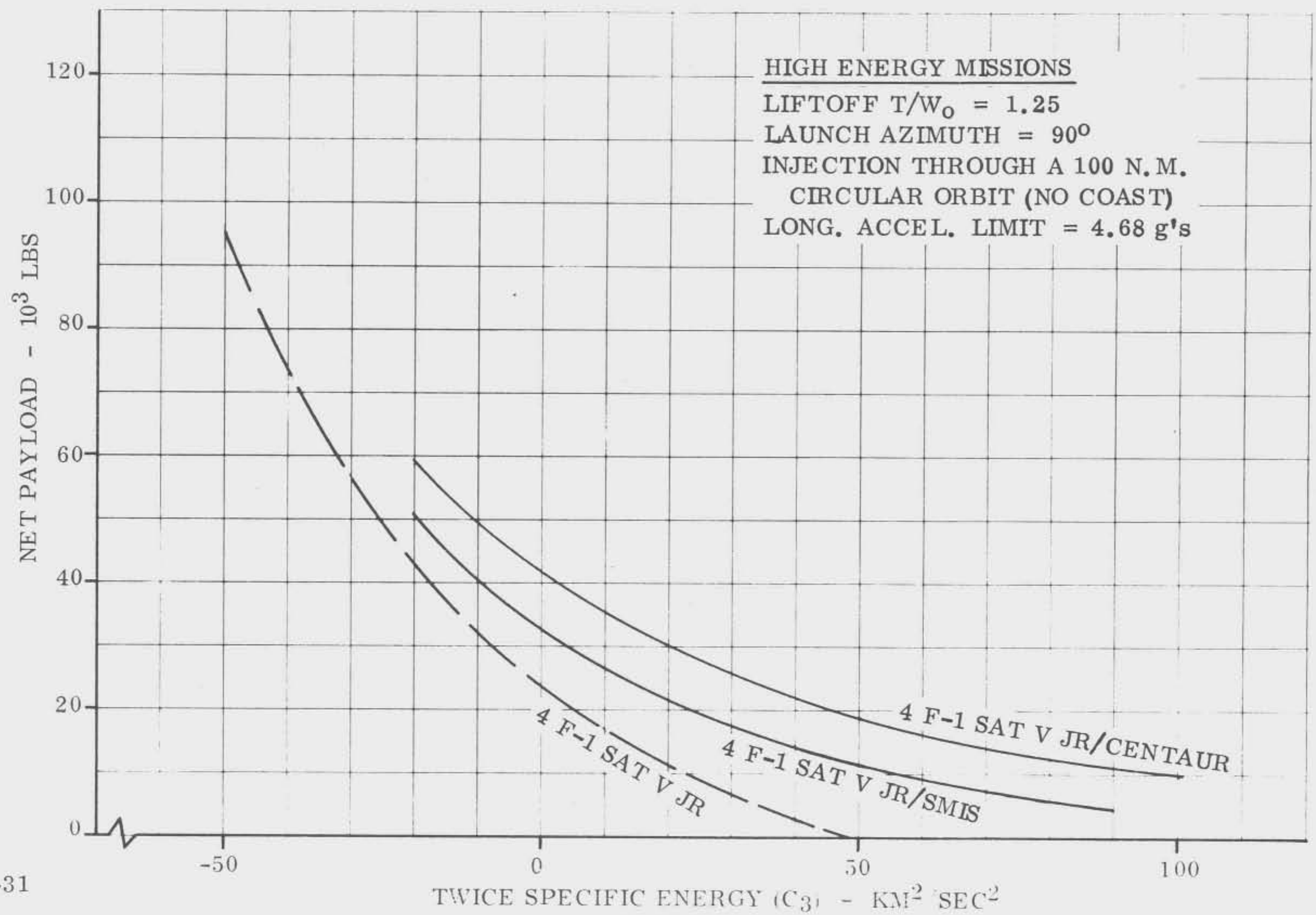

FIGURE D.1-31

4.68-g 4 F-1 INT-20 PERFORMANCE WITH INJECTION STAGES

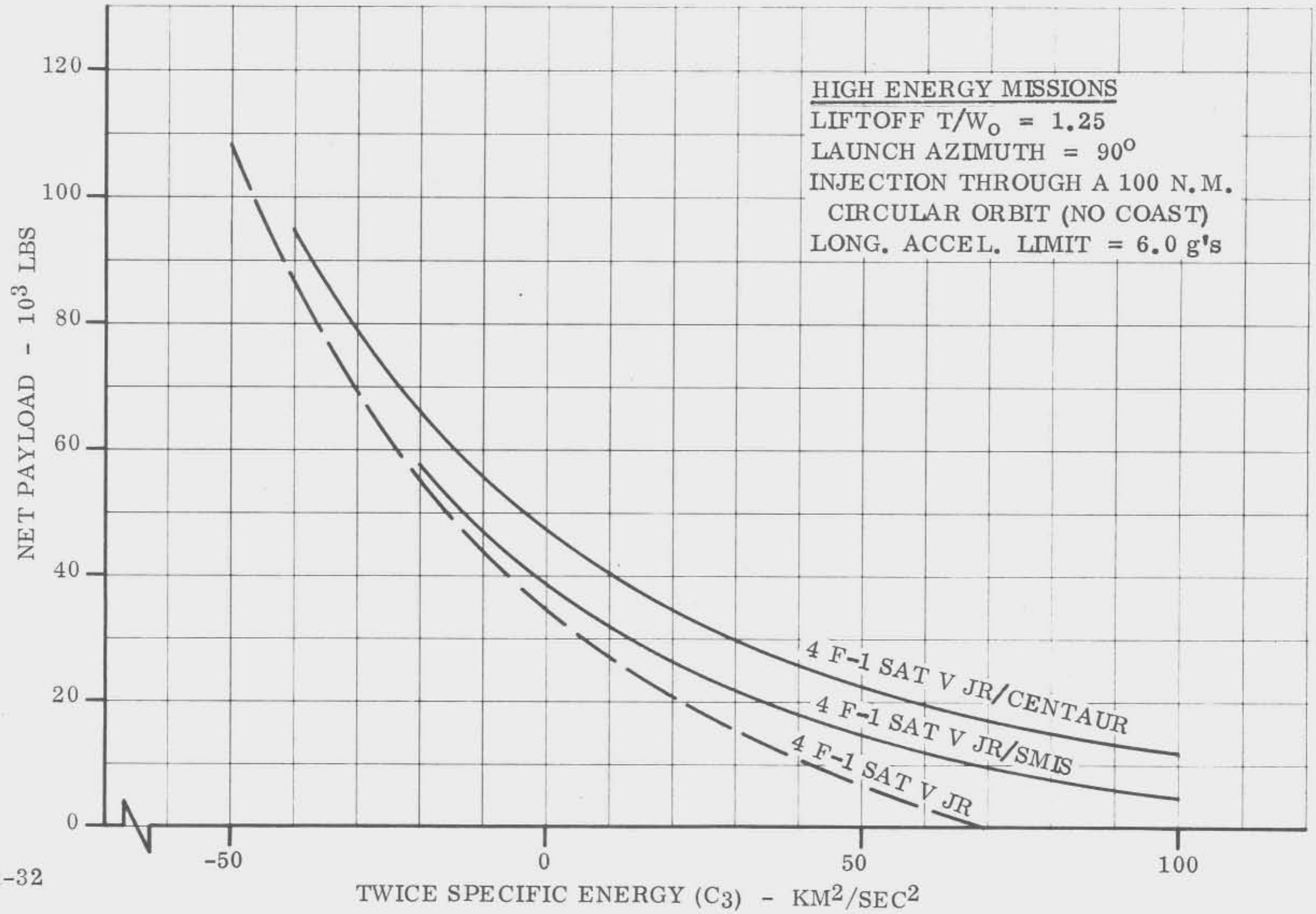

FIGURE D.1-32

6-g 4 F-1 INT-20 PERFORMANCE WITH INJECTION STAGES

APPENDIX D.2 - TRAJECTORIES

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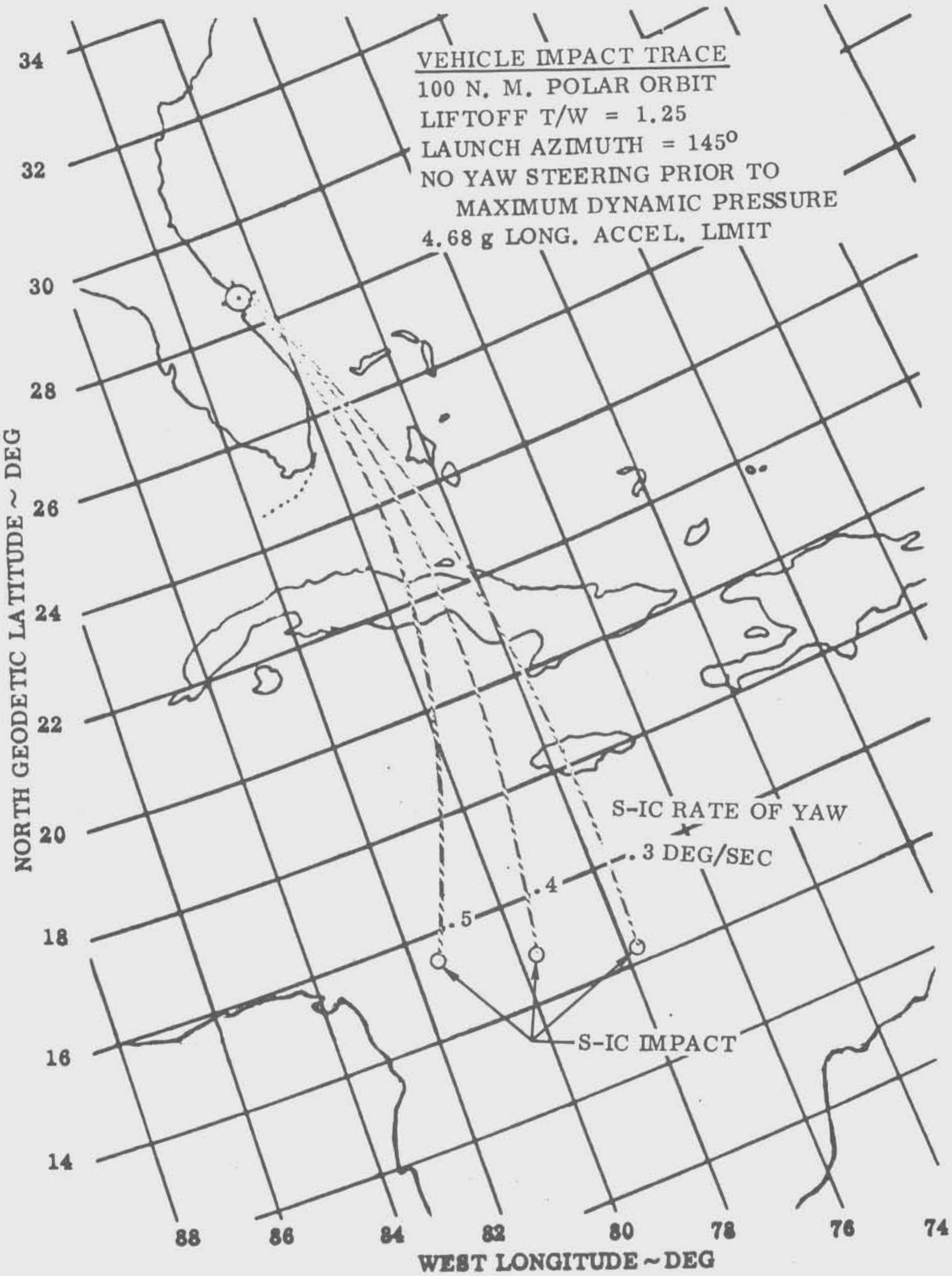

FIGURE D.2-1 INT-20 S-IC IMPACT TRACE - 100 N.M. POLAR ORBIT

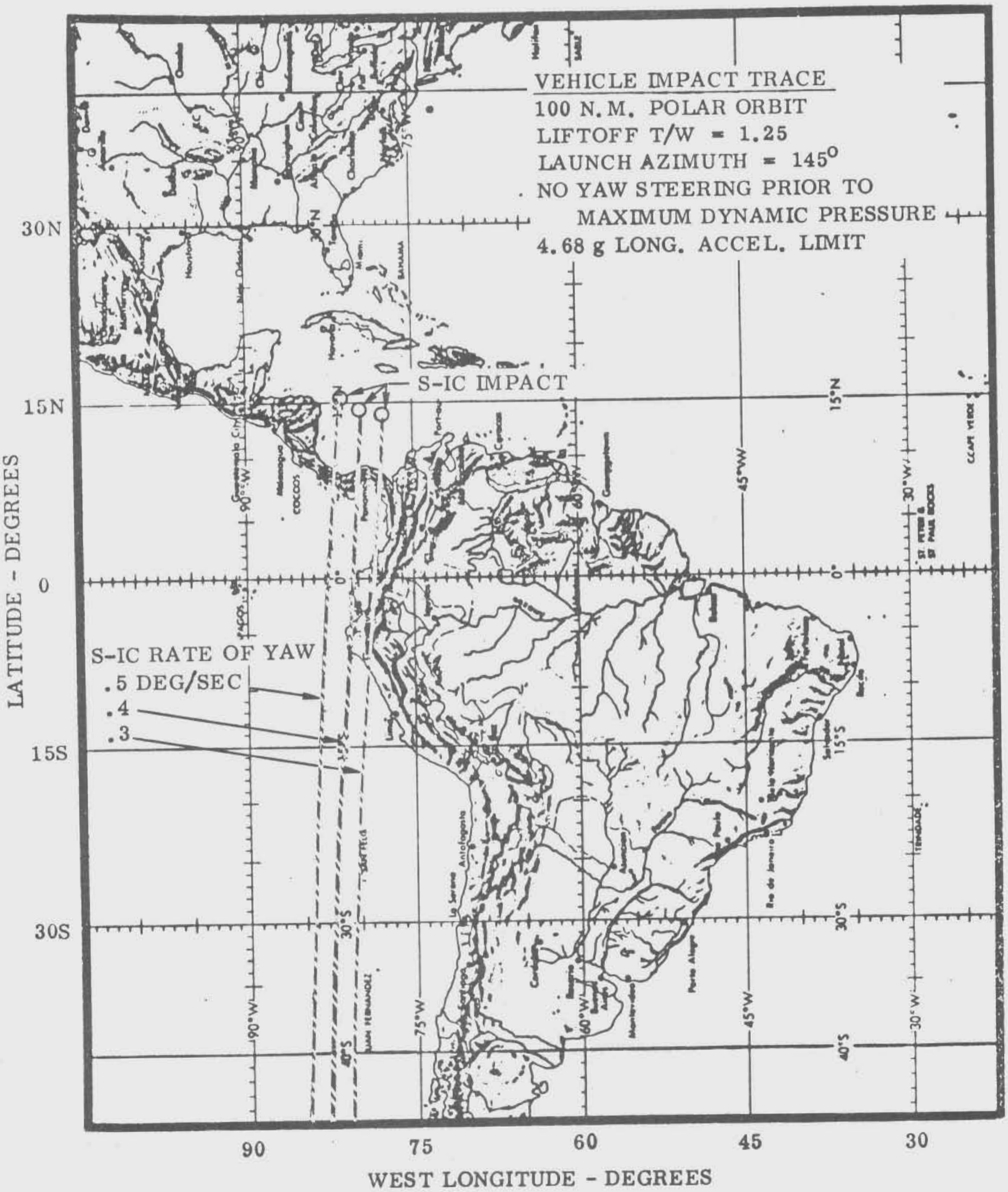

FIGURE D.2-2 INT-20 S-IVB IMPACT TRACE - 100 N.M. POLAR ORBIT

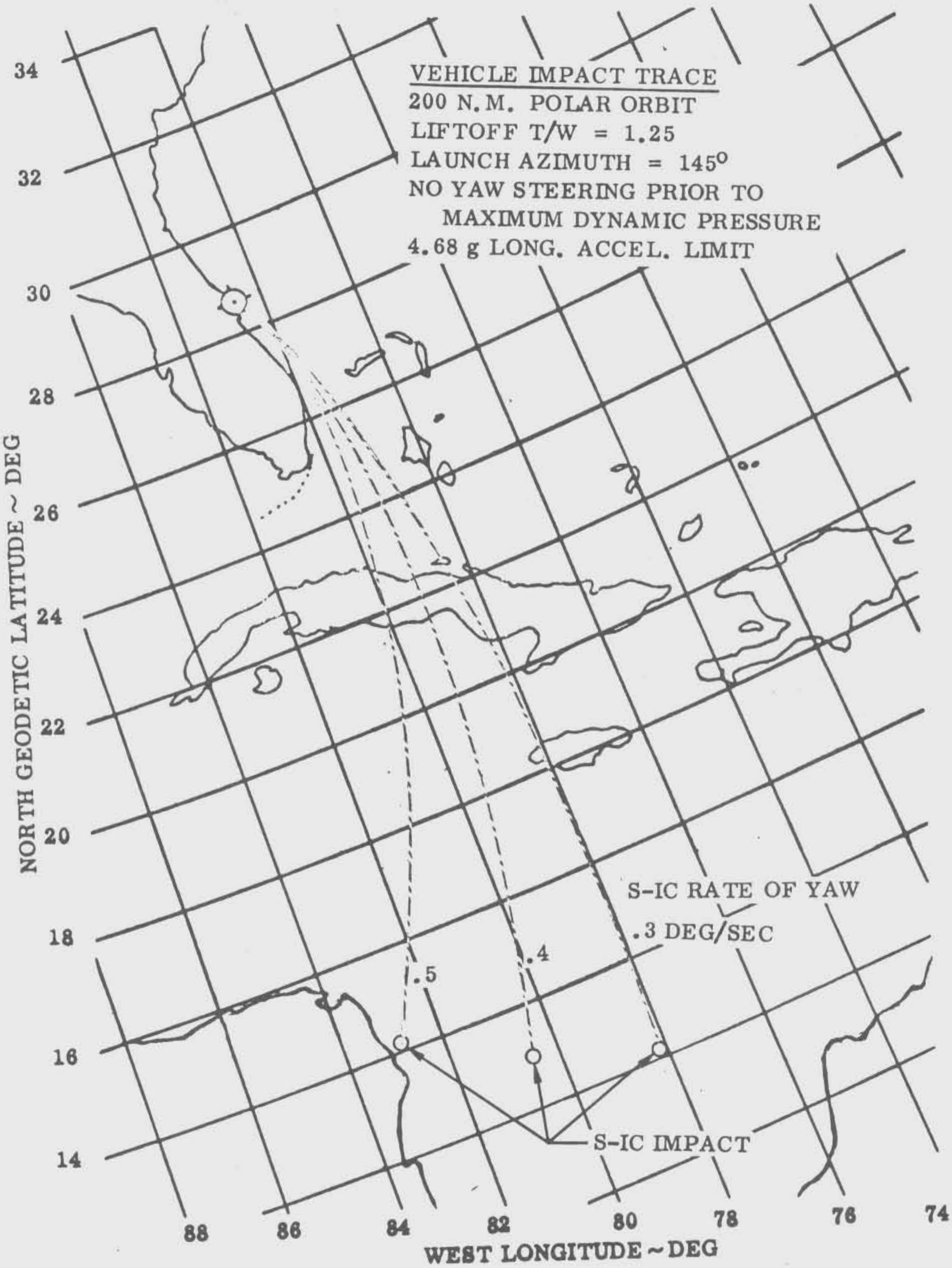

FIGURE D.2-3 INT-20 S-IC IMPACT TRACE - 200 N.M. POLAR ORBIT

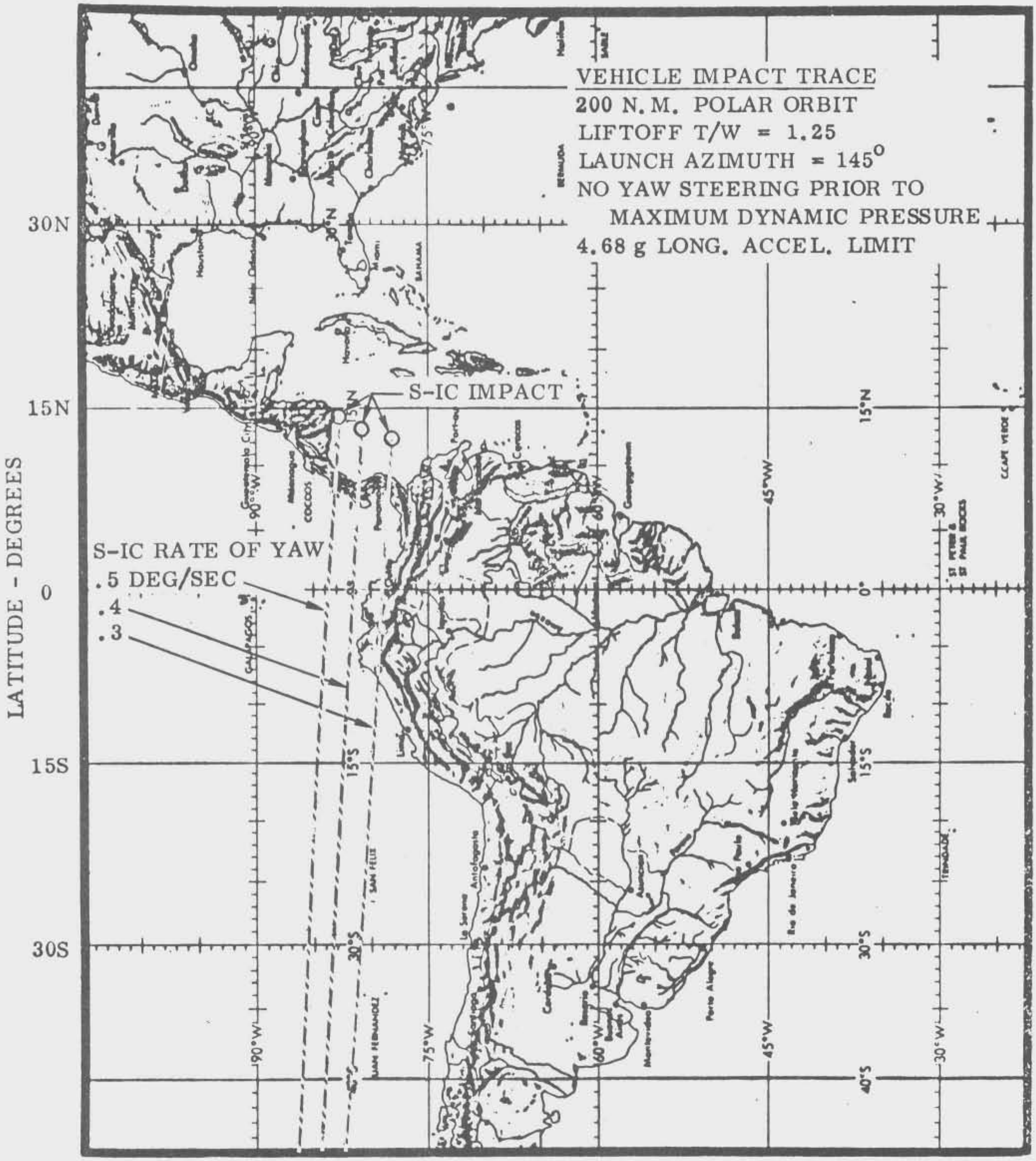

FIGURE D.2-4 INT-20 S-IVB IMPACT TRACE - 200 N.M. POLAR ORBIT

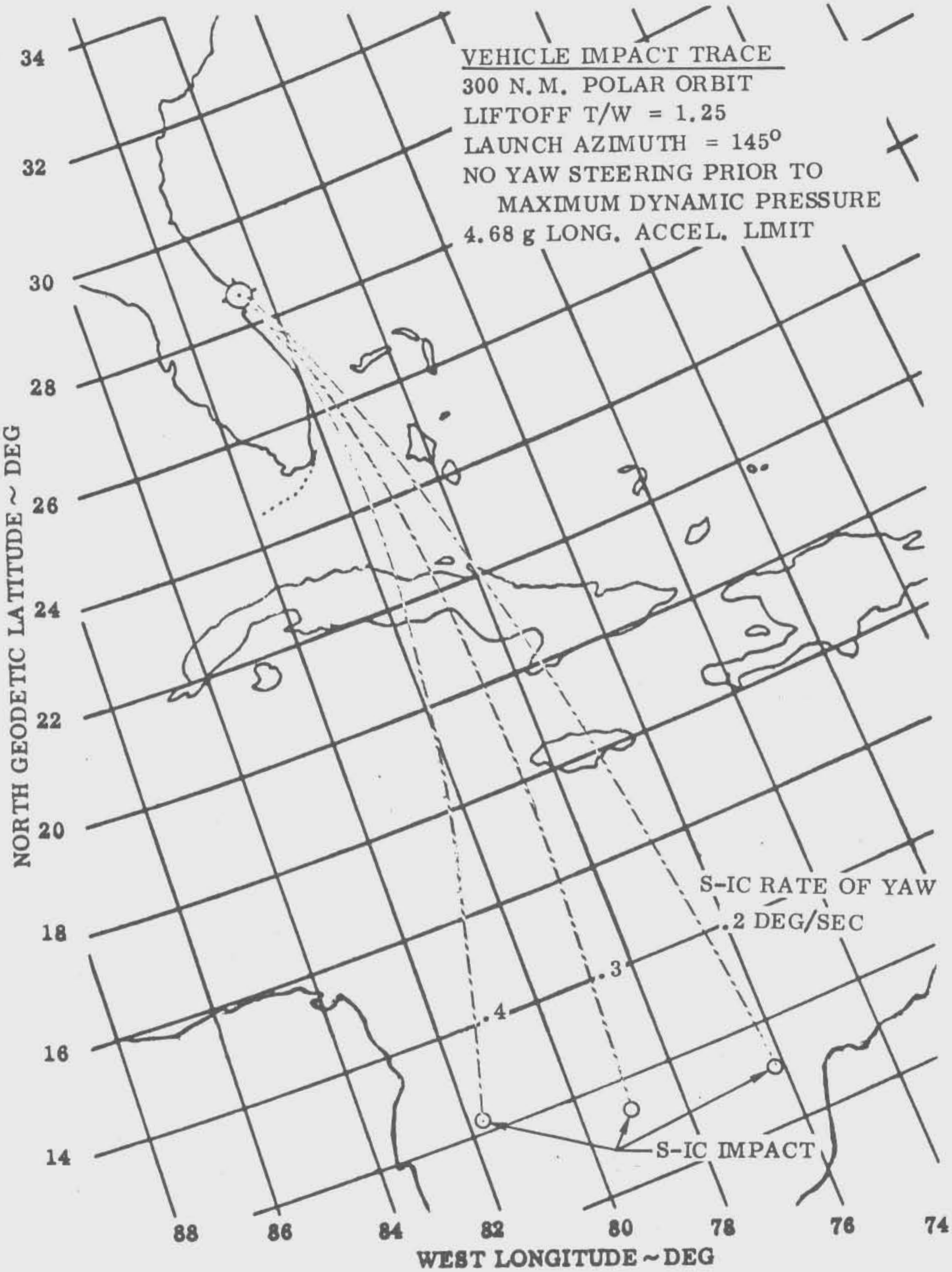

FIGURE D.2-5 INT-20 S-IC IMPACT TRACE - 300 N.M. POLAR ORBIT

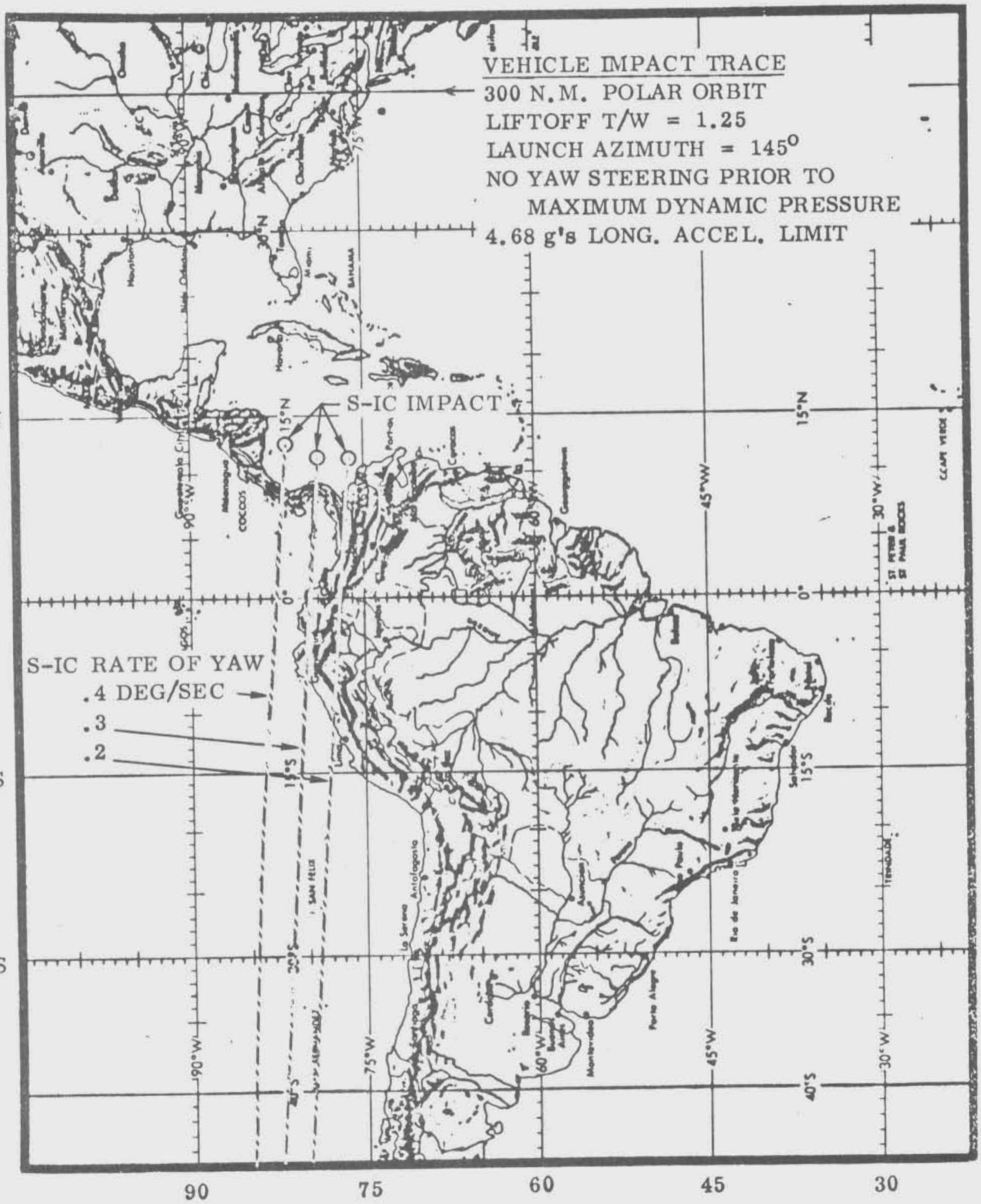

FIGURE D.5-6 INT-20 S-IVB IMPACT TRACE - 200 N.M. POLAR ORBIT

TABLE D.2-I INT-20/BIG G

	TIME SEC.	MASS KGS.	WEIGHT LBS.	THRUST NEWTONS	THRUST LBS.	LONGIT. ACCEL. MT/S.SQ.	LONGIT. ACCEL. FT/S.SQ.
LIFT OFF	.000	2209176.4	4870400.2	27080774.5	6088045.1	12.242	40.165
	8.000	2125362.1	4685621.3	27119333.5	6096670.9	12.733	41.774
	16.000	2041547.8	4500842.4	27242411.3	6124337.6	13.285	43.584
	24.000	1957733.4	4316063.3	27458980.0	6173024.2	13.915	45.651
	32.000	1873919.0	4131284.3	27771038.5	6243177.7	14.606	47.920
	43.000	1758674.3	3877213.2	28338958.8	6370651.3	15.666	51.397
	51.000	1674860.0	3692434.3	28822270.3	6479504.0	16.510	54.166
	59.000	1591045.7	3507655.4	29326415.5	6592840.3	17.249	56.593
	67.000	1507231.5	3322876.5	29810758.3	6701724.9	17.672	57.778
10 KMS	70.347	1472170.2	3245579.6	29997832.3	6743780.9	18.241	59.846
	75.000	1423417.1	3138097.6	30237236.3	6797601.0	19.131	62.764
Q MAX	79.000	1381510.0	3045708.2	30419712.0	6838623.2	19.976	65.540
14 KMS	81.396	1356403.4	2990357.6	30517371.3	6860577.8	20.535	67.371
	81.396	1356403.4	2990357.6	30517371.3	6860577.8	20.535	67.371
	91.000	1255788.6	2768539.8	30814403.5	6927353.4	23.075	75.707
	99.000	1171974.3	2583761.0	30955973.6	6959179.6	25.372	83.241
	107.000	1088160.0	2398982.2	31035305.0	6977014.0	27.809	91.236
	115.000	1004345.7	2214203.3	31078159.3	6986648.0	30.479	99.996
	123.000	920531.5	2029424.5	31100230.0	6991609.8	33.455	109.793
	131.000	836717.2	1844645.7	31111017.0	6994034.8	36.978	121.312
	139.000	752902.9	1659866.8	31116290.8	6995220.3	41.203	135.182
	145.000	679565.5	1498185.4	31118662.3	6995753.4	45.719	149.997
ENG CO	146.000	679565.5	1498185.4	15559331.1	3497876.7	22.823	74.879
	146.000	679565.5	1498185.4	15559331.1	3497876.7	22.823	74.879
	155.000	632419.9	1394247.3	15560008.9	3498047.1	24.563	80.588
	163.000	590512.8	1301857.9	15560387.0	3498114.1	26.330	86.385
	171.000	548605.7	1209466.5	15560513.0	3498142.4	28.355	93.027
	179.000	506698.5	1117079.0	15560559.9	3498153.0	30.706	100.741
	187.000	464791.4	1024689.6	15560573.8	3498156.1	33.477	109.834
	195.000	422884.3	932300.2	15560577.5	3498156.9	36.796	120.721
	203.000	380977.1	839910.8	15560578.4	3498157.1	40.844	134.002
CUTOFF	210.752	337320.5	743673.7	15560578.5	3498157.2	45.858	150.453
SEPARATION	210.752	171913.9	379005.3	.0	.0	-.000	-.000
	210.752	171913.9	379005.3	.0	.0	-.000	-.000
END COAST	214.752	171913.9	379005.3	.0	.0	-.000	-.000

TABLE D.2-I (Continued)

	TIME SEC.	MASS KGS.	WEIGHT LBS.	THRUST NEWTONS	THRUST LBS.	LONGIT. ACCEL. MT/S.SQ.	LONGIT. ACCEL. FT/S.SQ.
	214.752	171913.9	379005.3	.0	.0	-.000	-.000
BOOSTER IMP.	570.950	167406.5	369068.4	.0	.0	-.000	-.000
START COV	214.752	171913.9	379005.3	911885.4	205000.0	5.304	17.403
	230.000	168585.6	371667.7	911885.4	205000.0	5.409	17.746
	246.000	165093.2	363968.2	911885.4	205000.0	5.523	18.122
	262.000	161600.7	356268.7	911885.4	205000.0	5.643	18.513
	278.000	158108.3	348569.1	911885.4	205000.0	5.767	18.922
	294.000	154615.6	340869.6	911885.4	205000.0	5.898	19.350
	310.000	151123.4	333170.1	911885.4	205000.0	6.034	19.797
	326.000	147631.0	325470.5	911885.4	205000.0	6.177	20.265
	342.000	144138.5	317771.0	911885.4	205000.0	6.326	20.756
	358.000	140646.1	310071.6	911885.4	205000.0	6.484	21.271
	374.000	137153.6	302371.9	911885.4	205000.0	6.649	21.813
	390.000	133661.2	294672.4	911885.4	205000.0	6.822	22.383
	406.000	130168.7	286972.9	911885.4	205000.0	7.005	22.984
	422.000	126676.3	279273.4	911885.4	205000.0	7.199	23.617
	438.000	123183.8	271573.8	911885.4	205000.0	7.403	24.287
	454.000	119691.4	263874.3	911885.4	205000.0	7.619	24.996
	456.424	119147.1	262674.3	911885.4	205000.0	7.653	25.110
	470.000	116198.9	256174.8	911885.4	205000.0	7.848	25.747
	486.000	112706.5	248475.2	911885.4	205000.0	8.091	26.545
	502.000	109214.0	240775.7	911885.4	205000.0	8.350	27.393
	518.000	105721.6	233076.2	911885.4	205000.0	8.625	28.298
	534.000	102229.1	225376.6	911885.4	205000.0	8.920	29.265
	550.000	98736.7	217677.1	911885.4	205000.0	9.236	30.303
	566.000	95244.2	209977.6	911885.4	205000.0	9.574	31.411
	582.000	91751.8	202278.1	911885.4	205000.0	9.939	32.607
	598.000	88259.3	194578.5	911885.4	205000.0	10.332	33.897
	614.000	84766.9	186879.0	911885.4	205000.0	10.753	35.294
	630.000	81274.4	179179.5	911885.4	205000.0	11.220	36.810
	646.000	77782.0	171479.9	911885.4	205000.0	11.724	38.463
	662.000	74289.5	163780.4	911885.4	205000.0	12.275	40.271
	678.000	70797.1	156080.9	911885.4	205000.0	12.850	42.258
	687.518	68719.5	151500.5	911885.4	205000.0	13.270	43.536
CUTOFF	687.506	68722.1	151506.2	911885.4	205000.0	13.269	43.534

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TABLE D.2-I (Continued)

	TIME SEC.	INERTIAL FT/SEC.	VELOCITY FT/SEC.	RELATIVE FT/SEC.	VELOCITY FT/SEC.	THETA S DEG.	THETA R DEG.
LIFT OFF	.000	406.641	1340.647	.000	.000	.0000	90.0000
	8.000	407.177	1342.444	21.528	70.630	3.0157	89.6092
	16.000	411.340	1349.539	47.200	154.882	6.5901	89.6783
	24.000	417.751	1370.573	77.644	254.750	10.7040	87.8046
	32.000	431.241	1414.832	113.551	372.544	15.1908	84.3506
	43.000	466.060	1529.068	173.537	569.346	21.3620	78.0354
	51.000	506.790	1662.697	226.520	743.177	25.2218	72.4317
	59.000	561.350	1843.339	288.510	946.554	28.0685	66.3932
	67.000	629.311	2064.667	357.678	1174.139	29.5840	60.2440
10 KMS	70.347	661.540	2170.406	389.926	1279.264	29.8796	57.6934
	75.000	711.468	2334.212	439.147	1440.771	30.0491	54.2190
Q MAX	79.000	759.443	2491.612	486.222	1595.218	29.9920	51.3314
14 KMS	81.396	790.542	2593.640	516.697	1695.200	29.8778	49.6558
	81.396	790.542	2593.640	516.597	1695.200	29.8778	49.6558
	91.000	934.455	3065.798	657.671	2158.369	28.9437	43.4260
	99.000	1079.175	3540.600	800.332	2625.760	27.7461	38.6849
	107.000	1247.083	4091.479	966.177	3169.873	26.3346	34.9309
	115.000	1439.216	4721.837	1156.529	3794.386	24.8406	31.5188
	123.000	1657.207	5437.029	1373.044	4504.738	23.3584	28.5898
	131.000	1904.110	6247.080	1618.775	5310.940	21.9512	26.0852
	139.000	2184.368	7166.562	1898.138	6227.487	20.6577	23.9526
	146.000	2461.996	8077.414	2175.185	7136.433	19.6370	22.3567
ENG CO	146.000	2461.996	8077.414	2175.185	7136.433	19.6370	22.3567
	146.000	2461.996	8077.414	2175.185	7136.433	19.6370	22.3567
	155.000	2645.307	8676.830	2356.441	7731.105	18.2072	20.5336
	163.000	2824.121	9265.490	2533.727	8312.753	17.0232	19.0451
	171.000	3019.668	9907.046	2727.595	8950.115	15.9237	17.6794
	179.000	3234.152	10610.736	2941.422	9650.334	14.9109	16.4349
	187.000	3470.423	11385.901	3176.627	10422.661	13.9665	15.3094
	195.000	3732.193	12244.729	3437.902	11279.206	13.1522	14.3010
	203.000	4024.399	13203.409	3729.559	12236.067	12.4074	13.4080
CUTOFF	210.952	4351.657	14277.089	4056.400	13308.397	11.7637	12.6336
SEPARATION	210.952	4351.657	14277.089	4056.400	13308.397	11.7637	12.6336
	210.952	4351.657	14277.089	4056.400	13308.397	11.7637	12.6338
END COAST	214.752	4344.372	14253.188	4048.556	13282.696	11.4416	12.2901

TABLE D.2-I (Continued)

	TIME SEC.	INERTIAL VELOCITY MT/SEC.	INERTIAL VELOCITY FT/SEC.	RELATIVE VELOCITY MT/SEC.	RELATIVE VELOCITY FT/SEC.	THETA S DEG.	THETA R DEG.
	214.752	4344.372	14253.188	4048.560	13282.696	11.4416	12.2901
BOOSTER IMP.	570.950	4587.755	15051.789	4304.796	14123.347	-19.2537	-20.5748
START COV	214.752	4344.372	14253.188	4048.560	13282.696	11.4416	12.2901
	230.000	4396.740	14425.001	4099.240	13448.950	10.3742	11.1364
	246.000	4456.103	14619.761	4157.030	13638.550	9.3014	9.9772
	262.000	4519.906	14829.089	4219.457	13843.362	8.2783	8.8724
	278.000	4568.078	15052.749	4286.434	14063.105	7.3059	7.8232
	294.000	4660.554	15290.531	4357.634	14297.521	6.3850	6.8305
	310.000	4737.278	15542.251	4433.737	14546.380	5.5161	5.8951
	326.000	4818.204	15807.757	4513.930	14809.483	4.6997	5.0172
	342.000	4903.296	16086.929	4598.415	15086.664	3.9358	4.1972
	358.000	4992.528	16379.685	4687.153	15377.797	3.2247	3.4350
	374.000	5085.887	16685.979	4780.117	15682.797	2.5662	2.7305
	390.000	5183.371	17005.811	4877.295	16001.622	1.9603	2.0834
	406.000	5284.945	17339.222	4978.688	16334.278	1.4067	1.4933
	422.000	5390.786	17686.304	5084.315	16680.822	.9053	.9598
	438.000	5500.787	18047.202	5194.205	17041.366	.4556	.4825
	454.000	5615.061	18422.116	5308.421	17416.080	.0036	.0607
	456.494	5633.261	18481.827	5326.615	17475.771	-.0000	-.0000
	470.000	5733.687	18811.309	5427.025	17805.199	-.2875	-.3059
	486.000	5856.766	19215.110	5550.112	18209.029	-.5856	-.6179
	502.000	5984.420	19633.923	5677.799	18627.948	-.8309	-.8758
	518.000	6116.798	20068.234	5810.226	19062.422	-1.0259	-1.0800
	534.000	6254.075	20518.618	5947.565	19513.008	-1.1705	-1.2309
	550.000	6396.453	20985.756	6090.016	19980.367	-1.2651	-1.3288
	566.000	6544.190	21470.439	6237.816	20465.277	-1.3096	-1.3740
	582.000	6697.552	21973.594	6391.244	20968.649	-1.3041	-1.3666
	598.000	6856.871	22496.297	6550.523	21491.546	-1.2484	-1.3068
	614.000	7022.530	23039.797	6716.331	22035.206	-1.1424	-1.1945
	630.000	7194.470	23605.546	6888.300	22601.070	-.9857	-1.0297
	646.000	7374.700	24195.230	7068.501	23190.818	-.7755	-.8122
	662.000	7562.339	24810.623	7256.194	23806.411	-.5175	-.5417
	678.000	7758.570	25454.625	7452.404	24450.145	-.2071	-.2177
	687.510	7879.714	25852.079	7573.525	24847.523	.0000	.0006
CUTOFF	687.506	7879.565	25851.587	7573.376	24847.034	.0000	.0003

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TABLE D.2-I (Continued)

	TIME SEC.	XXX MT.	XXX FT.	YYY MT.	YYY FT.	ZZZ MT.	ZZZ FT.
LIFT OFF	.000	.0	.0	.0	.0	.0	.0
	8.000	2291.7	7518.5	82.7	271.2	2331.4	7648.8
	16.000	4583.9	15038.9	352.2	1155.4	4661.8	15294.7
	24.000	6886.2	22592.5	843.9	2768.6	6991.2	22937.1
	32.000	9231.8	30288.0	1597.0	5239.6	9319.3	30575.2
	43.000	12628.5	41432.2	3133.4	10280.1	12518.1	41069.7
	51.000	15333.3	50305.2	4663.9	15301.6	14842.5	48695.7
	59.000	18357.6	60228.2	6572.5	21563.3	17165.1	56316.0
	67.000	21822.3	71595.4	8860.7	29070.5	19486.0	63930.3
10 KMS	70.347	23431.1	76873.7	9924.5	32560.8	20456.3	67113.7
	75.000	25852.2	84816.8	11508.5	37757.5	21804.9	71538.4
Q MAX	79.000	28125.7	92275.9	12968.8	42548.6	22963.7	75340.1
14 KMS	81.396	29582.2	97054.3	13888.0	45564.3	23657.6	77616.9
	81.396	29582.2	97054.3	13888.0	45564.3	23657.6	77616.9
	91.000	36234.4	118879.4	17911.5	58764.7	26436.8	86734.9
	99.000	42943.5	140890.8	21687.0	71151.7	28749.4	94322.0
	107.000	50918.1	167054.2	25351.7	83175.3	31059.2	101900.3
	115.000	60354.3	198012.7	30403.7	99749.5	33366.0	109468.5
	123.000	71456.4	234436.9	35340.4	115947.7	35669.3	117025.4
	131.000	84444.2	277047.8	40665.2	133416.0	37968.9	124569.9
	139.000	99564.6	326655.6	46387.1	152188.8	40264.3	132100.9
	146.000	114768.9	376538.5	51737.5	169742.4	42269.3	138678.7
ENG CO	146.000	114768.9	376538.5	51737.5	169742.4	42269.3	138678.7
	146.000	114768.9	376538.5	51737.5	169742.4	42269.3	138678.7
	155.000	136480.1	447767.2	58777.3	192840.6	44841.6	147118.8
	163.000	157336.9	516197.1	64937.1	213048.1	47123.3	154604.2
	171.000	179785.4	589847.0	70995.3	232924.2	49399.6	162072.8
	179.000	203951.7	669165.6	76946.1	252447.7	51670.9	169524.1
	187.000	230021.7	754665.0	82784.5	271602.6	53936.6	176957.2
	195.000	258148.1	846942.6	88508.0	290380.5	56196.5	184371.7
	203.000	288550.8	946713.5	94116.0	308782.3	58450.5	191766.9
CUTOFF	210.952	321305.1	1054150.7	99582.0	326714.6	60685.1	199098.0
SEPARATION	210.952	321305.1	1054150.7	99582.0	326714.6	60685.1	199098.0
	210.952	321305.1	1054150.7	99582.5	326714.6	60685.1	199098.0
END COAST	214.752	337599.6	1107610.3	102101.1	334977.5	61750.7	202594.1

TABLE D.2-I (Continued)

	TIME SEC.	XXX MT.	XXX FT.	YYY MI.	YYY FT.	ZZZ MT.	ZZZ FT.
	214.752	337599.6	1107610.3	102101.1	334977.5	61750.7	202594.1
BOOSTER IMP.	570.950	1738656.2	5868294.6	-258077.0	-846709.5	152478.5	500257.6
START COV	214.752	337599.6	1107610.3	102101.1	334977.5	61750.7	202594.1
	230.000	403493.7	1323798.3	111038.6	364299.9	66012.9	216577.9
	246.000	473773.7	1554376.4	118492.2	388754.1	70461.5	231172.7
	262.000	545227.7	1788804.8	123969.4	406723.9	74883.9	245682.1
	278.000	617866.7	2027121.8	127463.4	418187.0	79278.0	260101.1
	294.000	691703.6	2269368.7	128965.9	423116.4	83644.7	274424.8
	310.000	766751.6	2515589.2	128467.1	421480.1	87980.0	288648.4
	326.000	843025.2	2765830.7	125956.1	413241.7	92283.4	302767.1
	342.000	920539.7	3020143.3	121420.0	398359.7	96553.3	316776.0
	358.000	999311.5	3278580.9	114844.6	376787.5	100788.4	330670.4
	374.000	1079335.1	3541201.1	106214.8	348473.9	104987.0	344445.6
	390.000	1160698.4	3808065.5	95512.7	313362.0	109147.9	358096.8
	406.000	1243352.3	4079239.6	82719.6	271389.9	113269.6	371619.3
	422.000	1327341.5	4354794.8	67814.9	222489.9	117350.6	385008.4
	438.000	1412088.9	4634806.1	50776.2	166588.6	121389.5	398259.4
	454.000	1497419.5	4919355.1	31579.2	103606.5	125384.6	411367.6
	456.474	1513063.0	4964117.4	28391.3	93147.2	126003.5	413397.3
	470.000	1587559.8	5208529.4	10197.9	33457.7	129335.2	424328.2
	486.000	1677138.6	5502423.3	-13396.0	-43950.3	133239.3	437136.8
	502.000	1768187.1	5801136.7	-39233.0	-128717.3	137095.6	449788.6
	518.000	1860736.7	6104785.8	-67345.0	-220950.7	140902.0	462278.9
	534.000	1954830.3	6413484.3	-97769.5	-320766.2	144659.1	474603.3
	550.000	2050500.6	6727364.2	-130542.3	-428268.4	148363.5	486757.0
	566.000	2147793.4	7046567.5	-165765.0	-543851.6	152014.0	498735.7
	582.000	2246756.7	7371247.1	-203301.8	-667000.7	155611.0	510534.7
	598.000	2347441.3	7701579.1	-243380.5	-798492.4	159151.2	522149.7
	614.000	2449909.5	8037744.5	-285592.7	-936976.4	162634.0	533576.2
	630.000	2554209.3	8379951.6	-331194.8	-1086597.0	166058.1	544809.9
	646.000	2660425.2	8728428.9	-379047.6	-1243595.0	169422.0	555846.6
	662.000	2768627.6	9083430.5	-429618.2	-1409510.0	172724.7	566662.0
	678.000	2878907.1	9445239.6	-482780.8	-1583582.8	175964.0	577312.2
	687.518	2945534.5	9663827.4	-516181.4	-1693510.5	177862.0	583536.8
CUTOFF	687.506	2945453.2	9663560.4	-516040.6	-1693046.0	177859.7	583529.3

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TABLE D.2-I (Continued)

	TIME SEC.	ALTITUDE MT	ALTITUDE FT	DOWN RANGE KM	DOWN RANGE NAUT. MI.	DYN. PRESSURE KG/M.SQ.	DYN. PRESSURE LB/F.SQ.
LIFT OFF	.000	-.125	-.410	.000	.000	.00	.00
	8.000	83.313	273.335	.000	.000	27.76	5.69
	16.000	355.313	1165.723	.000	.000	130.25	26.68
	24.000	851.375	2793.225	.000	.000	336.51	68.92
	32.000	1610.375	5283.383	.057	.031	668.37	137.00
	43.000	3158.000	10360.892	.302	.163	1337.56	273.96
	51.000	4699.438	15418.102	.710	.383	1945.33	398.44
	59.000	6621.750	21724.901	1.435	.775	2584.69	529.39
	67.000	8927.438	29289.493	2.597	1.402	3110.07	637.00
10 KMS	70.347	10000.063	32808.604	3.241	1.750	3275.62	670.90
	75.000	11597.813	38050.565	4.319	2.332	3442.77	705.14
Q MAX	79.000	13071.813	42886.523	5.436	2.935	3489.36	714.72
14 KMS	81.376	14000.000	45931.758	6.199	3.347	3461.86	709.05
	81.396	14000.000	45931.758	6.199	3.347	3461.88	709.05
	91.000	18068.500	59279.665	10.063	5.434	2886.11	591.13
	99.000	21895.438	71835.424	14.437	7.795	2200.22	450.64
	107.000	26129.313	85726.090	20.060	10.831	1603.13	328.35
	115.000	30774.500	100966.207	27.123	14.645	1110.00	227.35
	123.000	35837.938	117578.534	35.826	19.344	716.01	146.77
	131.000	41332.875	135606.545	46.380	25.043	448.53	91.87
	139.000	47284.813	155133.898	59.022	31.870	278.63	56.95
	146.000	52900.750	173554.891	72.014	38.884	186.76	38.25
ENG CO	146.000	52900.750	173554.891	72.014	38.884	186.76	38.25
	146.000	52900.750	173554.891	72.014	38.884	186.76	38.25
	155.000	60381.250	198101.213	90.617	49.037	96.44	19.75
	163.000	67031.[illegible]	219917.979	109.032	58.872	49.39	10.12
	171.000	73651.375	241764.602	128.779	69.535	22.62	4.63
	179.000	80376.375	263762.016	150.189	81.095	8.83	1.81
	187.000	87105.250	285786.016	173.410	93.634	2.67	.55
	195.000	93904.563	308092.395	198.615	107.244	.77	.16
	203.000	100815.125	330758.468	226.012	122.037	.23	.05
CUTOFF	210.952	107837.313	353795.953	255.663	138.047	.06	.02
SEPARATION	210.952	107837.313	353795.953	255.663	138.047	.08	.02
	210.952	107837.313	353795.953	255.663	138.047	.05	.02
END COAST	214.752	111190.[illegible]	364797.64[illegible]	270.446	146.029	.05	.01

TABLE D.2-I (Continued)

	TIME SEC.	ALTITUDE M	ALTITUDE FT	DOWN RANGE KM	DOWN RANGE NAUT. MI.	DYN. PRESSURE KG/M.SQ.	DYN. PRESSURE LB/F.SQ.
	214.752	111190.938	364799.660	270.446	146.029	.04	.01
BOOSTER IMP.	570.950	-.000	-.000	1647.854	889.775	1118252.58	229037.03
START CCV	214.752	111190.938	364799.660	270.452	146.032	.04	.01
	230.000	123918.313	406556.141	330.168	178.276	.01	.00
	246.000	136143.188	446664.000	393.773	212.631	.00	.00
	262.000	147242.688	483079.680	458.454	247.545	.00	.00
	278.000	157250.188	515912.688	524.201	283.046	.00	.00
	294.000	166200.250	545276.406	591.036	319.161	.00	.00
	310.000	174128.125	571265.492	659.139	355.917	.00	.00
	326.000	181070.250	594062.492	728.475	393.345	.00	.00
	342.000	187064.250	613727.852	799.090	431.474	.00	.00
	358.000	192149.375	630411.328	871.059	470.334	.00	.00
	374.000	196366.313	644246.430	944.441	509.958	.00	.00
	390.000	199757.375	655371.961	1019.296	550.376	.00	.00
	406.000	202367.188	663934.336	1095.685	591.622	.00	.00
	422.000	204242.438	670086.734	1173.671	633.732	.00	.00
	438.000	205432.125	673989.906	1253.321	676.739	.00	.00
	454.000	205987.688	675812.617	1334.702	720.681	.00	.00
	456.494	206020.813	675921.297	1347.545	727.610	.00	.00
	470.000	205964.063	675736.109	1417.833	765.596	.00	.00
	486.000	205418.875	673946.438	1502.958	811.522	.00	.00
	502.000	204413.375	670647.555	1589.942	858.500	.00	.00
	518.000	203012.625	666051.914	1678.971	906.572	.00	.00
	534.000	201286.000	660387.133	1770.106	955.761	.00	.00
	550.000	199307.438	653895.789	1863.432	1006.173	.00	.00
	566.000	197156.063	646837.469	1959.034	1057.794	.00	.00
	582.000	194916.375	639489.414	2057.034	1110.693	.00	.00
	598.000	192679.188	632149.563	2157.435	1164.922	.00	.00
	614.000	190542.250	625138.609	2260.426	1220.533	.00	.00
	630.000	188610.438	618800.641	2366.080	1277.561	.00	.00
	646.000	186997.250	613508.031	2474.534	1336.125	.00	.00
	662.000	185825.313	609663.094	2585.810	1396.220	.00	.00
	678.000	185227.563	607701.969	2700.120	1457.948	.01	.00
	687.512	185203.063	607621.594	2769.595	1495.402	.01	.00
CUTOFF	687.506	185203.000	607621.383	2769.510	1495.416	.01	.00

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TABLE D.2-I (Continued)

	TIME SEC.	MACH	AZ. S DEG.	LATITUDE DEG.	LONGITUDE DEG.	ALPHA DEG.	CHI DEG.
LIFT OFF	.000	.000	90.0000	28.6080	.0000	.0000	90.0000
	8.000	.062	89.9914	28.6080	.0000	.0000	90.0000
	16.000	.137	89.9657	28.6080	.0000	.4397	89.4691
	24.000	.226	89.6673	28.6081	-.0000	.5516	87.3412
	32.000	.333	88.8396	28.6084	-.0004	.2315	84.2151
	43.000	.517	86.5080	28.6101	-.0020	.1684	78.0449
	51.000	.686	83.7627	28.6127	-.0049	.1764	72.4154
	59.000	.895	80.2776	28.6175	-.0100	.1794	66.3468
	67.000	1.149	76.4471	28.6251	-.0182	.1794	60.1679
10 KMS	70.347	1.274	74.8105	28.6293	-.0227	.1780	57.6028
	75.000	1.472	72.5281	28.6363	-.0304	.1749	54.1064
Q MAX	79.000	1.664	70.5959	28.6435	-.0383	.1712	51.1983
14 KMS	81.396	1.787	69.4643	28.6485	-.0437	.1683	49.5095
	81.396	1.787	69.4643	28.6485	-.0437	.1683	49.5095
	91.000	2.289	65.2225	28.6735	-.0713	.1565	43.2198
	99.000	2.722	62.1505	28.7018	-.1025	.1467	38.6185
	107.000	3.223	59.5445	28.7381	-.1427	.1379	34.5932
	115.000	3.795	57.3742	28.7837	-.1933	.1295	31.0968
	123.000	4.362	55.5810	28.8397	-.2557	.1211	28.0688
	131.000	4.964	54.0935	28.9076	-.3316	.1126	25.4485
	139.000	5.638	52.8679	28.9888	-.4227	.1042	23.1815
	146.000	6.454	51.9589	29.0721	-.5165	.0959	21.4506
ENG CO	146.000	6.454	51.9589	29.0721	-.5165	.0959	21.4506
	146.000	6.454	51.9589	29.0721	-.5165	.0959	21.4506
	155.000	7.402	51.4850	29.1925	-.6526	.0941	19.4352
	163.000	8.465	51.1059	29.3089	-.7848	.0915	17.7621
	171.000	9.780	50.7614	29.4349	-.9286	.0885	16.1982
	179.000	11.400	50.4503	29.5713	-1.0850	.0836	14.7404
	187.000	12.313	50.1705	29.7189	-1.2551	.0000	13.3853
	195.000	13.324	49.9200	29.8783	-1.4405	.0000	12.1295
	203.000	14.455	49.6972	30.0522	-1.6428	.0000	10.9695
CUTOFF	210.952	15.722	49.5017	30.2395	-1.8626	.0000	9.9080
SEPARATION	210.952	15.722	49.5017	30.2395	-1.8626	.0000	9.9080
	210.952	15.722	49.5017	30.2395	-1.8626	.0000	9.9080
END COAST	214.752	15.671	49.5453	30.3326	-1.9725	.0000	9.4215

TABLE D.2-I (Continued)

	TIME SEC.	MACH	AZ. S DEG.	LATITUDE DEG.	LONGITUDE DEG.	ALPHA DEG.	CHI DEG.
	214.752	15.671	49.5653	30.3326	-1.9725	.0000	9.4215
BOOSTER IMP.	573.957	12.411	56.9168	38.3785	-13.4056	.0000	-36.7754
START COV	214.752	15.691	49.5653	30.3326	-1.9725	10.1676	19.5890
	230.000	15.868	49.7586	30.7077	-2.4190	10.8668	18.5579
	246.000	16.112	49.9714	31.1853	-2.8990	11.5583	17.4765
	262.000	16.354	50.1942	31.5071	-3.3914	12.2051	16.3954
	278.000	16.613	50.4277	31.9131	-3.8969	12.8059	15.3140
	294.000	16.890	50.6730	32.3236	-4.4162	13.3598	14.2320
	310.000	17.184	50.9302	32.7387	-4.9501	13.8663	13.1490
	326.000	17.495	51.2001	33.1584	-5.4994	14.3250	12.0646
	342.000	17.822	51.4835	33.5829	-6.0649	14.7359	10.9783
	358.000	18.166	51.7810	34.0123	-6.6476	15.0990	9.8899
	374.000	18.527	52.0934	34.4466	-7.2485	15.4146	8.7989
	390.000	18.903	52.4217	34.8859	-7.8684	15.6831	7.7049
	406.000	19.296	52.7666	35.3302	-8.5086	15.9051	6.6074
	422.000	19.706	53.1292	35.7796	-9.1700	16.0811	5.5062
	438.000	20.131	53.5103	36.2345	-9.8540	16.2119	4.4009
	454.000	20.574	53.8621	36.6935	-10.5617	16.2982	3.2910
	456.194	20.645	53.9755	36.7655	-10.6743	16.3077	3.1176
	470.000	21.034	54.3329	37.1579	-11.2946	16.3407	2.1762
	486.000	21.511	54.7766	37.6272	-12.0540	16.3403	1.0561
	502.000	22.066	55.2433	38.1013	-12.8415	16.2977	-.0697
	518.000	22.519	55.7356	38.5800	-13.6586	16.2137	-1.2014
	534.000	23.051	56.2536	39.0632	-14.5072	16.0891	-2.3395
	550.000	23.603	56.7995	39.5505	-15.3887	15.9246	-3.4843
	566.000	24.176	57.3747	40.0417	-16.3059	15.7210	-4.6361
	582.000	24.771	57.9813	40.5365	-17.2500	15.4768	-5.7953
	598.000	25.387	58.6207	41.0343	-18.2535	15.1988	-6.9620
	614.000	25.031	59.2954	41.5346	-19.2835	14.8815	-8.1367
	630.000	26.697	60.0086	42.0370	-20.3682	14.5276	-9.3196
	646.000	27.375	60.7599	42.5406	-21.4945	14.1375	-10.5108
	662.000	28.123	61.5538	43.0443	-22.5705	13.7118	-11.7107
	678.000	28.904	62.3925	43.3485	-23.5790	13.2509	-12.9195
	687.516	29.353	62.9131	43.3475	-24.6508	12.9602	-13.6428
CUTOFF	687.503	27.353	62.9124	43.3471	-24.6351	12.9605	-13.6420

TABLE D.2-I (Continued)

	TIME SEC.	DXX MT/SEC.	DXX FT/SEC.	DYY MT/SEC.	DYY FT/SEC.	DZZ MT/SEC.	DZZ FT/SEC.
LIFT OFF	.000	286.421	939.700	.000	.000	291.464	956.246
	8.000	286.466	939.921	21.319	69.943	291.369	955.936
	16.000	286.642	940.557	46.789	153.508	291.247	955.534
	24.000	289.576	950.051	76.960	252.514	291.098	955.044
	32.000	297.909	977.392	112.168	368.006	290.925	954.476
	43.000	322.945	1059.532	168.634	553.260	290.656	953.596
	51.000	355.583	1166.510	214.569	703.966	290.443	952.898
	59.000	403.055	1322.359	262.667	861.770	290.220	952.165
	67.000	465.527	1527.320	308.584	1012.414	289.988	951.404
10 KMS	70.347	496.496	1628.923	327.248	1073.650	289.887	951.078
	75.000	545.161	1788.586	353.599	1160.101	289.748	950.617
Q MAX	79.000	592.483	1943.843	376.610	1235.597	289.625	950.212
14 KMS	81.396	623.371	2045.181	390.545	1281.317	289.549	949.964
	81.396	623.371	2045.181	390.545	1281.317	289.549	949.964
	91.000	767.557	2518.231	447.675	1468.750	289.223	948.896
	99.000	913.709	2997.734	496.272	1628.187	288.908	947.862
	107.000	1084.023	3556.507	544.839	1787.529	288.548	946.678
	115.000	1279.278	4197.137	593.097	1945.856	288.141	945.344
	123.000	1500.800	4923.886	641.224	2103.752	287.688	943.859
	131.000	1751.276	5745.655	690.064	2263.938	287.194	942.236
	139.000	2034.792	6675.825	740.836	2430.730	286.662	940.491
	146.000	2314.732	7594.266	788.381	2586.553	286.167	938.875
ENG CO	146.000	2314.732	7594.266	788.381	2586.553	286.169	938.875
	146.000	2314.732	7594.266	788.381	2586.553	286.169	938.875
	155.000	2512.788	8244.056	775.910	2545.635	285.502	936.685
	163.000	2703.924	8871.141	763.742	2505.716	284.878	934.640
	171.000	2911.028	9550.617	750.682	2462.866	284.226	932.508
	179.000	3136.291	10289.664	736.904	2417.663	283.553	930.291
	187.000	3382.544	11097.587	722.648	2370.893	282.852	927.992
	195.000	3653.503	11986.557	708.231	2323.593	282.127	925.613
	203.000	3954.098	12972.761	694.066	2277.119	281.376	923.156
CUTOFF	210.952	4288.906	14071.213	680.780	2233.529	280.610	920.636
SEPARATION	210.952	4288.906	14071.213	680.780	2233.529	280.610	920.636
	210.952	4288.906	14071.213	680.780	2233.529	280.610	920.636
END COAST	214.752	4287.110	14065.322	644.765	2115.371	280.235	919.405

TABLE D.2-I (Continued)

	TIME SEC.	DXX MT/SEC.	DXX FT/SEC.	DYY MT/SEC.	DYY FT/SEC.	DZZ MT/SEC.	DZZ FT/SEC.
	214.752	4287.110	14065.322	644.765	2115.371	280.235	919.405
BOOSTER IMP.	570.950	3728.255	12231.809	-2664.415	-8741.518	220.866	724.625
START COV	214.752	4287.110	14065.322	644.765	2115.371	280.235	919.405
	230.000	4356.069	14291.565	527.495	1730.625	278.816	914.749
	246.000	4429.070	14531.069	404.152	1325.957	277.234	909.560
	262.000	4502.775	14772.883	280.427	920.037	275.558	904.063
	278.000	4577.236	15017.179	156.232	512.572	273.790	898.260
	294.000	4652.506	15264.132	31.476	103.266	271.928	892.153
	310.000	4728.646	15513.931	-93.932	-308.176	269.975	885.745
	326.000	4805.712	15766.772	-220.083	-722.056	267.931	879.037
	342.000	4883.770	16022.867	-347.071	-1138.683	265.795	872.030
	358.000	4962.888	16282.439	-474.990	-1558.367	263.568	864.726
	374.000	5043.139	16545.730	-603.940	-1981.429	261.252	857.124
	390.000	5124.603	16813.001	-734.019	-2408.200	258.845	849.228
	406.000	5207.365	17084.532	-865.333	-2839.021	256.348	841.036
	422.000	5291.521	17360.632	-997.990	-3274.246	253.761	832.551
	438.000	5377.170	17641.635	-1132.102	-3714.247	251.086	823.772
	454.000	5464.427	17927.910	-1267.788	-4159.410	248.321	814.700
	455.424	5478.179	17973.027	-1289.005	-4229.282	247.882	813.260
	470.000	5553.414	18219.861	-1405.173	-4610.147	245.467	805.337
	486.000	5644.267	18517.937	-1544.386	-5066.890	242.524	795.683
	502.000	5737.139	18822.634	-1685.575	-5530.102	239.493	785.740
	518.000	5832.197	19134.504	-1828.885	-6000.280	236.375	775.508
	534.000	5929.630	19454.166	-1974.482	-6477.958	233.169	764.989
	550.000	6029.648	19782.310	-2122.541	-6963.717	229.876	754.186
	566.000	6132.489	20119.716	-2273.257	-7458.191	226.497	743.100
	582.000	6238.421	20467.260	-2426.841	-7962.078	223.032	731.734
	598.000	6347.746	20825.939	-2583.530	-8476.150	219.484	720.091
	614.000	6460.810	21196.885	-2743.586	-9001.268	215.852	708.176
	630.000	6578.007	21581.388	-2907.304	-9538.400	212.139	695.993
	646.000	6699.788	21980.930	-3075.017	-10088.639	208.345	683.546
	662.000	6826.673	22397.220	-3247.106	-10653.236	204.473	670.844
	678.000	6959.265	22832.232	-3424.009	-11233.624	200.525	657.891
	687.518	7041.130	23100.819	-3531.731	-11587.043	198.142	650.072
CUTOFF	687.506	7041.029	23100.488	-3531.599	-11586.610	198.145	650.081

TABLE D.2-I (Continued)

	TIME SEC.	SOLID THRUST NEWTONS	SOLID THRUST LBS.	SOLID WDOT KG/SEC	SOLID WDOT LB/SEC	LIQUID WDOT KG/SEC	LIQUID WDOT LB/SEC
LIFT OFF	.000	-.0	-.0	-.00	-.00	10476.78	23097.35
	8.000	-.0	-.0	-.00	-.00	10476.78	23097.35
	16.000	-.0	-.0	-.00	-.00	10476.78	23097.35
	24.000	-.0	-.0	-.00	-.00	10476.78	23097.35
	32.000	-.0	-.0	-.00	-.00	10476.78	23097.35
	43.000	-.0	-.0	-.00	-.00	10476.78	23097.35
	51.000	-.0	-.0	-.00	-.00	10476.78	23097.35
	59.000	-.0	-.0	-.00	-.00	10476.78	23097.35
	67.000	-.0	-.0	-.00	-.00	10476.78	23097.35
10 KMS	70.347	-.0	-.0	-.00	-.00	10476.78	23097.35
	75.000	-.0	-.0	-.00	-.00	10476.78	23097.35
Q MAX	79.000	-.0	-.0	-.00	-.00	10476.78	23097.35
14 KMS	81.396	-.0	-.0	-.00	-.00	10476.78	23097.35
	81.396	-.0	-.0	-.00	-.00	10476.78	23097.35
	91.000	-.0	-.0	-.00	-.00	10476.78	23097.35
	99.000	-.0	-.0	-.00	-.00	10476.78	23097.35
	107.000	-.0	-.0	-.00	-.00	10476.78	23097.35
	115.000	-.0	-.0	-.00	-.00	10476.78	23097.35
	123.000	-.0	-.0	-.00	-.00	10476.78	23097.35
	131.000	-.0	-.0	-.00	-.00	10476.78	23097.35
	139.000	-.0	-.0	-.00	-.00	10476.78	23097.35
	146.000	-.0	-.0	-.00	-.00	10476.78	23097.35
ENG CO	146.000	-.0	-.0	-.00	-.00	5238.39	11548.68
	146.000	-.0	-.0	-.00	-.00	5238.39	11548.68
	155.000	-.0	-.0	-.00	-.00	5238.39	11548.68
	163.000	-.0	-.0	-.00	-.00	5238.39	11548.68
	171.000	-.0	-.0	-.00	-.00	5238.39	11548.68
	179.000	-.0	-.0	-.00	-.00	5238.39	11548.68
	187.000	-.0	-.0	-.00	-.00	5238.39	11548.68
	195.000	-.0	-.0	-.00	-.00	5238.39	11548.68
	203.000	-.0	-.0	-.00	-.00	5238.39	11548.68
CUTOFF	210.952	-.0	-.0	-.00	-.00	5238.39	11548.68
SEPARATION	210.952	-.0	-.0	-.00	-.00	-.00	-.00
	210.952	-.0	-.0	-.00	-.00	-.00	-.00
END COAST	214.752	-.0	-.0	-.00	-.00	-.00	-.00

TABLE D.2-I (Continued)

	TIME SEC.	SOLID THRUST NEWTONS	SOLID THRUST LBS.	SOLID WDOT KG/SEC	SOLID WDOT LB/SEC	LIQUID WDOT KG/SEC	LIQUID WDOT LB/SEC
	214.752	-.0	-.0	-.00	-.00	-.00	-.00
BOOSTER IMP.	570.950	-.0	-.0	-.00	-.00	-.00	-.00
START COV	214.752	-.0	-.0	-.00	-.00	218.28	481.22
	230.000	-.0	-.0	-.00	-.00	218.28	481.22
	246.000	-.0	-.0	-.00	-.00	218.28	481.22
	262.000	-.0	-.0	-.00	-.00	218.28	481.22
	278.000	-.0	-.0	-.00	-.00	218.28	481.22
	294.000	-.0	-.0	-.00	-.00	218.28	481.22
	310.000	-.0	-.0	-.00	-.00	218.28	481.22
	326.000	-.0	-.0	-.00	-.00	218.28	481.22
	342.000	-.0	-.0	-.00	-.00	218.28	481.22
	358.000	-.0	-.0	-.00	-.00	218.28	481.22
	374.000	-.0	-.0	-.00	-.00	218.28	481.22
	390.000	-.0	-.0	-.00	-.00	218.28	481.22
	406.000	-.0	-.0	-.00	-.00	218.28	481.22
	422.000	-.0	-.0	-.00	-.00	218.28	481.22
	438.000	-.0	-.0	-.00	-.00	218.28	481.22
	454.000	-.0	-.0	-.00	-.00	218.28	481.22
	456.494	-.0	-.0	-.00	-.00	218.28	481.22
	470.000	-.0	-.0	-.00	-.00	218.28	481.22
	486.000	-.0	-.0	-.00	-.00	218.28	481.22
	502.000	-.0	-.0	-.00	-.00	218.28	481.22
	518.000	-.0	-.0	-.00	-.00	218.28	481.22
	534.000	-.0	-.0	-.00	-.00	218.28	481.22
	550.000	-.0	-.0	-.00	-.00	218.28	481.22
	566.000	-.0	-.0	-.00	-.00	218.28	481.22
	582.000	-.0	-.0	-.00	-.00	218.28	481.22
	598.000	-.0	-.0	-.00	-.00	218.28	481.22
	614.000	-.0	-.0	-.00	-.00	218.28	481.22
	630.000	-.0	-.0	-.00	-.00	218.28	481.22
	646.000	-.0	-.0	-.00	-.00	218.28	481.22
	662.000	-.0	-.0	-.00	-.00	218.28	481.22
	678.000	-.0	-.0	-.00	-.00	218.28	481.22
	667.518	-.0	-.0	-.00	-.00	218.28	481.22
CUTOFF	687.506	-.0	-.0	-.00	-.00	218.28	481.22

APPENDIX D.3 AERODYNAMICS

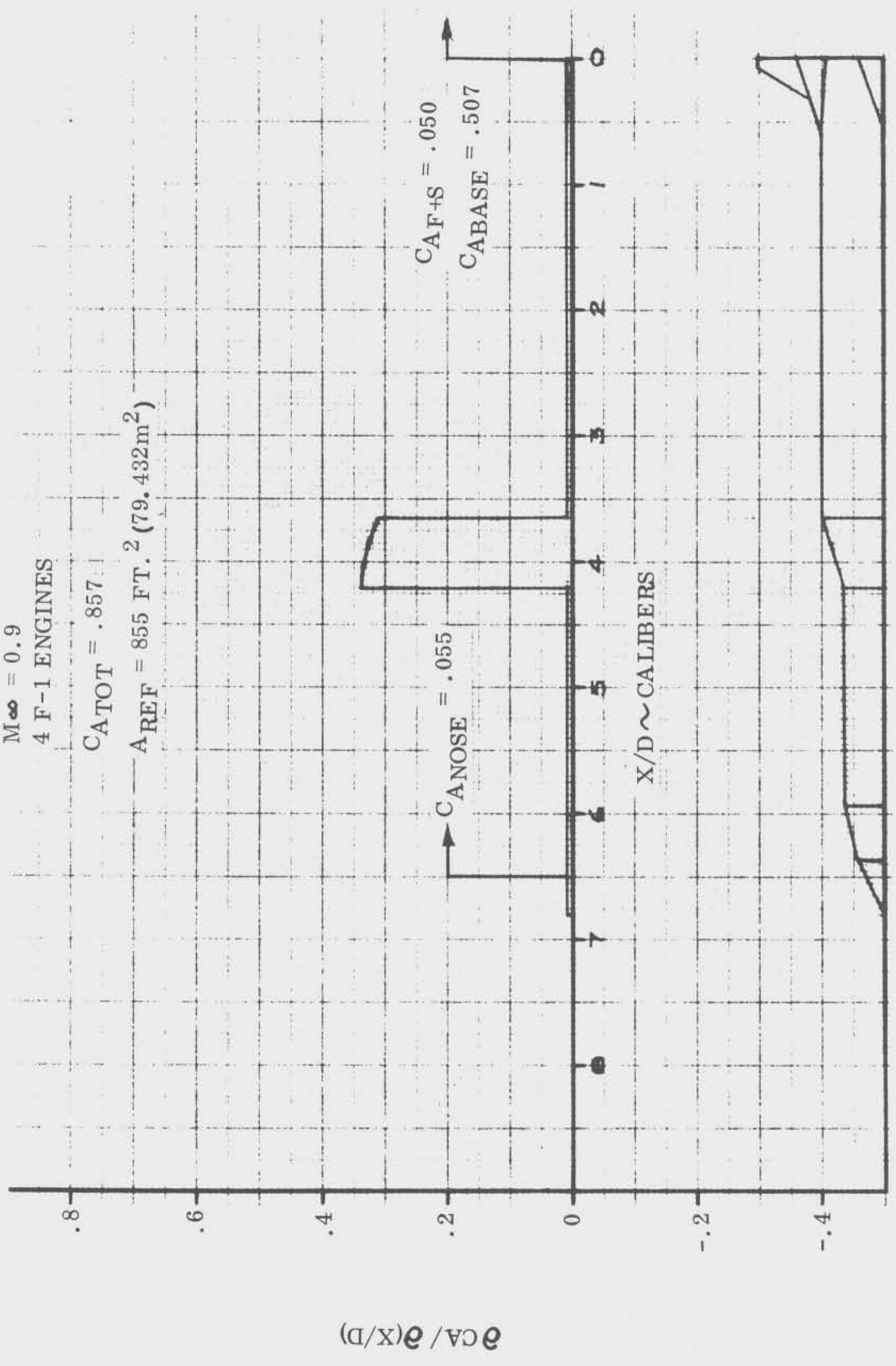


FIGURE D.3-1 DISTRIBUTION OF LOCAL AXIAL FORCE COEFFICIENT GRADIENT, 43 FT. (13.1m) PAYLOAD $M_\infty = 0.9$

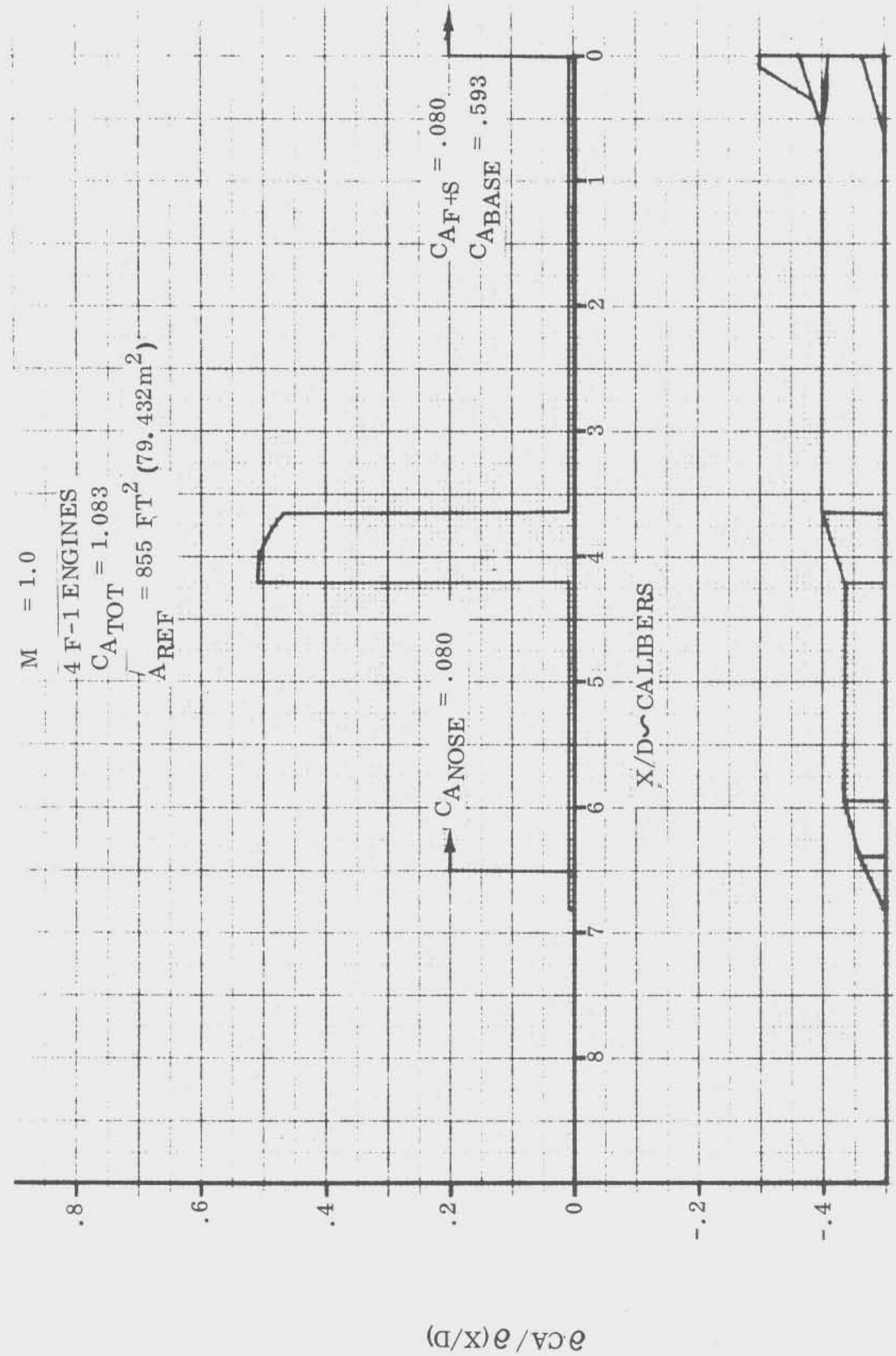


FIGURE D.3-2 DISTRIBUTION OF LOCAL AXIAL FORCE COEFFICIENT GRADIENT. 43 FT. (13.1m) PAYLOAD, $M_\infty = 1.0$

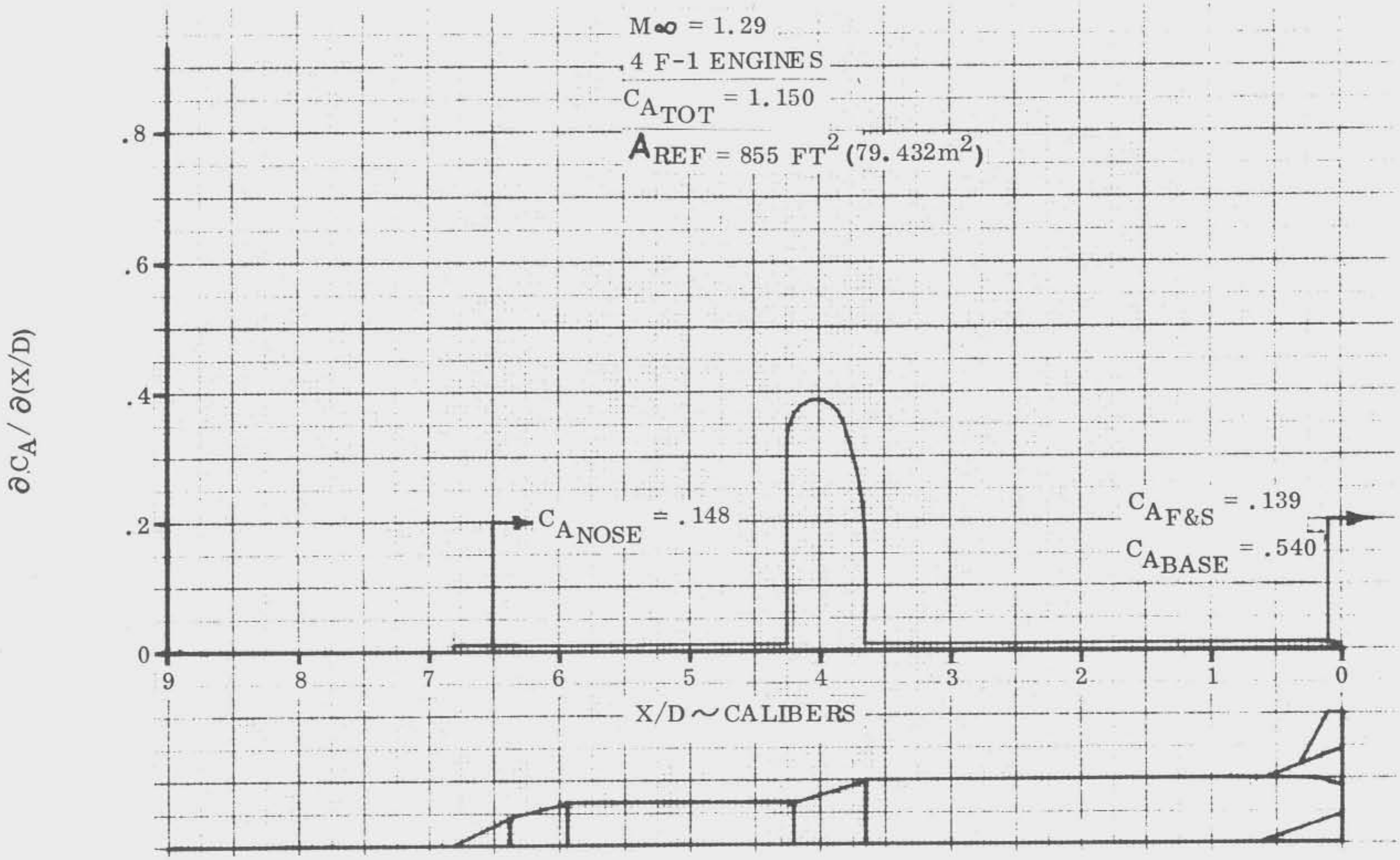


FIGURE D.3-3 DISTRIBUTION OF LOCAL AXIAL FORCE COEFFICIENT GRADIENT, 43 FT.(13.1m), PAYLOAD, M∞ = 1.29

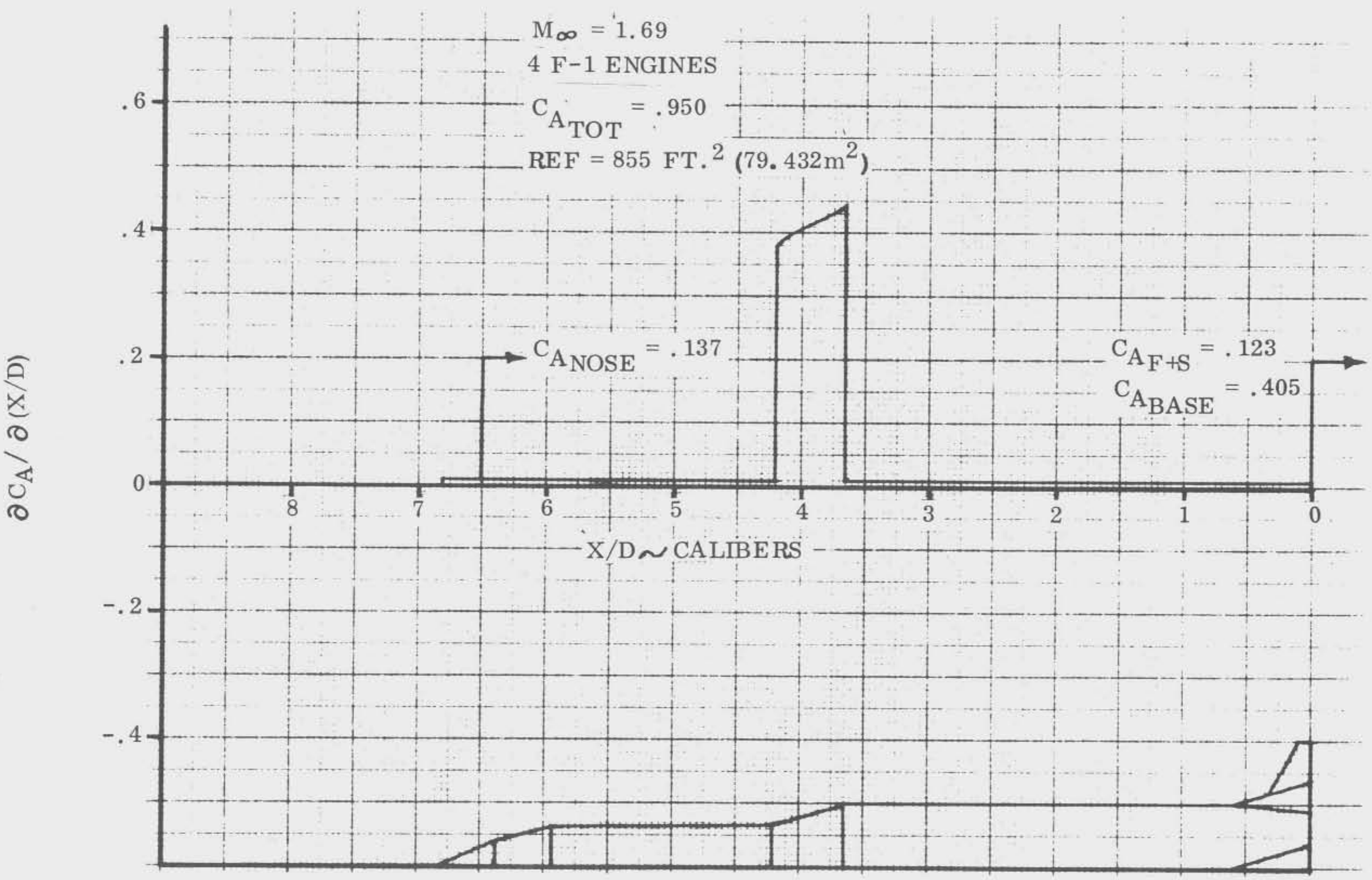


FIGURE D.3-4 DISTRIBUTION OF LOCAL AXIAL FORCE COEFFICIENT GRADIENT, 43 FT. (13.1m), PAYLOAD, $M_\infty = 1.69$

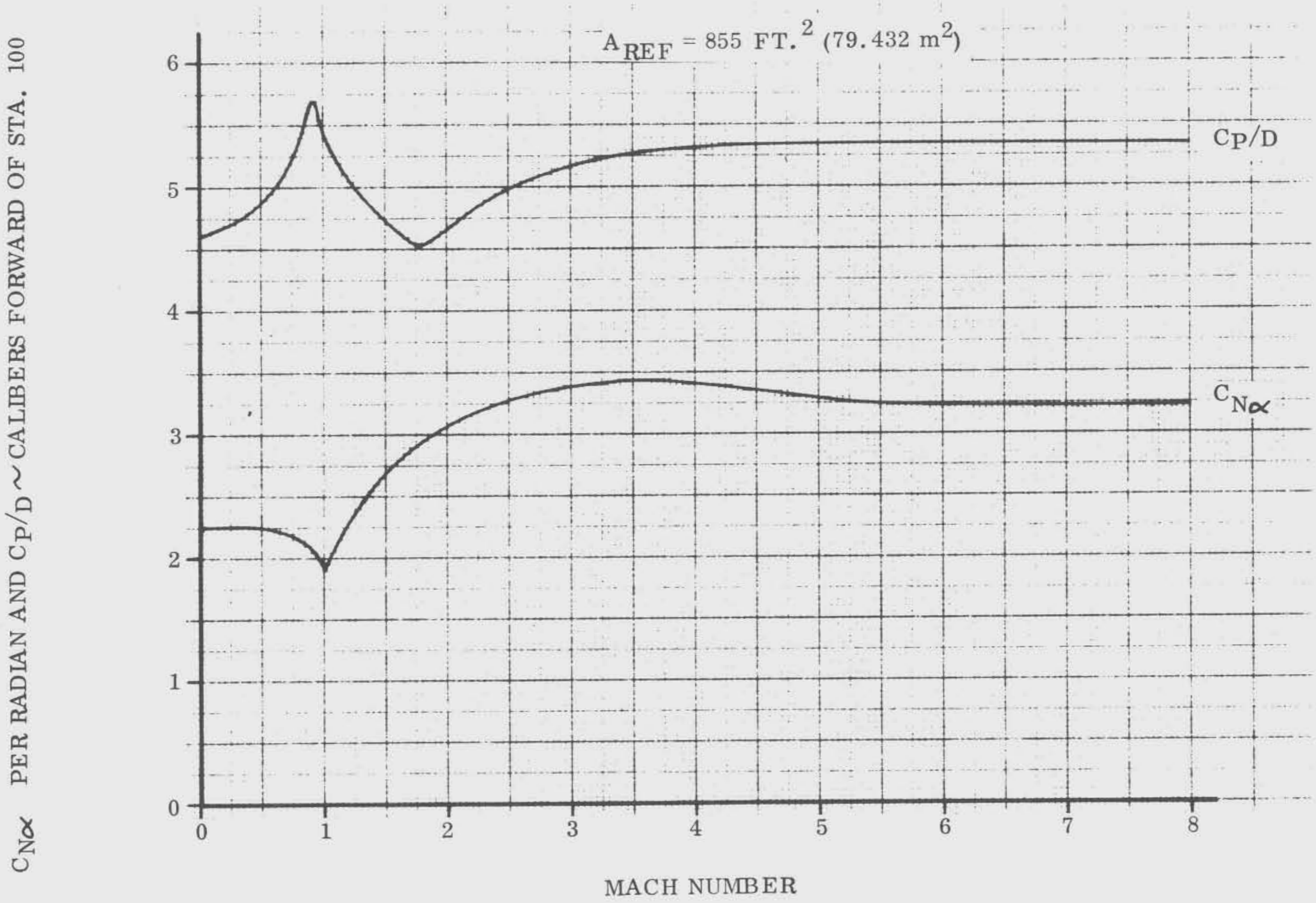


FIGURE D.3-5 VEHICLE C_P/D AND NORMAL FORCE COEFFICIENT GRADIENT VS. MACH NUMBER, 43 FT. (13.1m) PAYLOAD

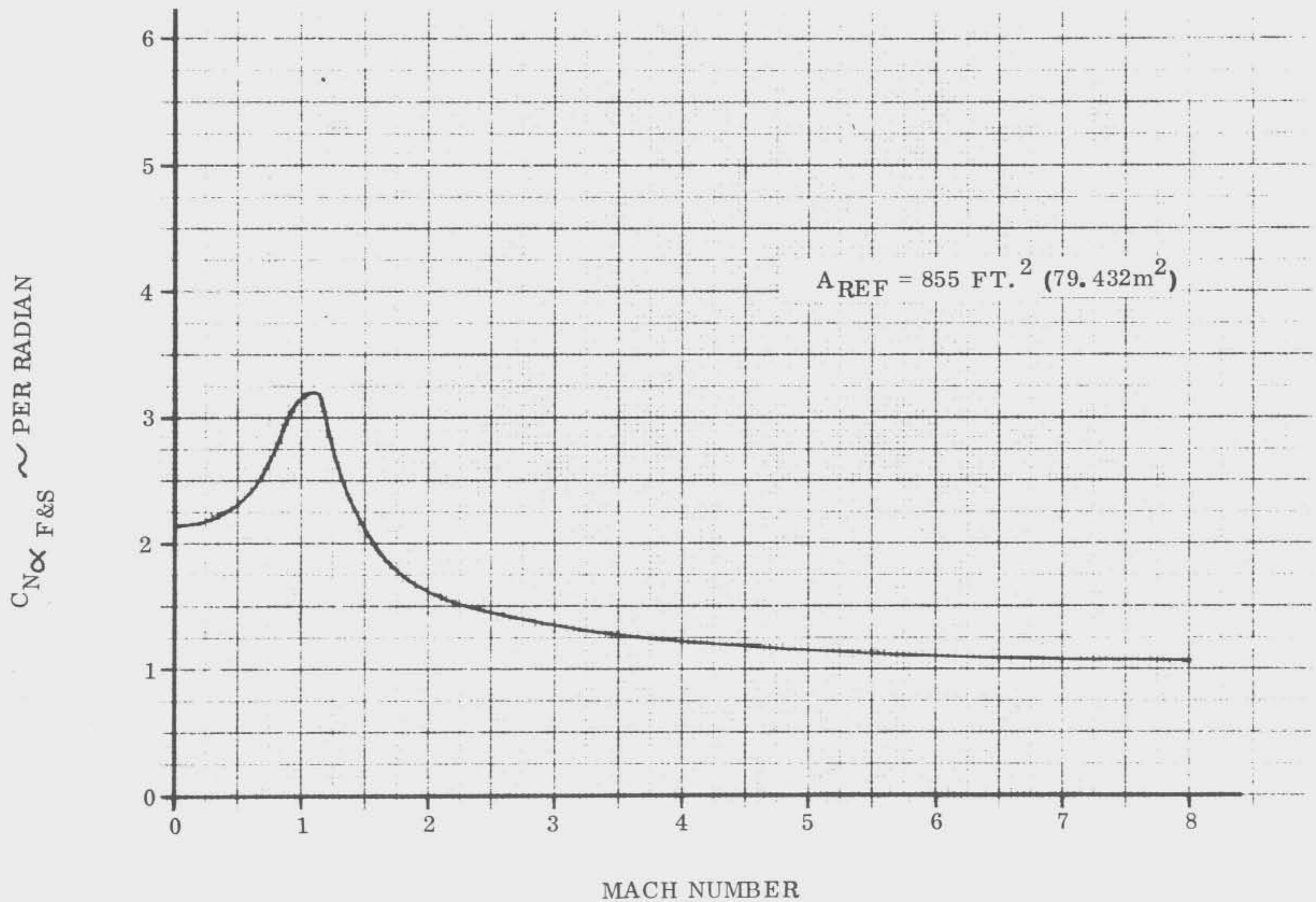


FIGURE D.3-6 NORMAL FORCE COEFFICIENT GRADIENT CONTRIBUTION OF FINS AND SHROUDS VS. MACH NUMBER

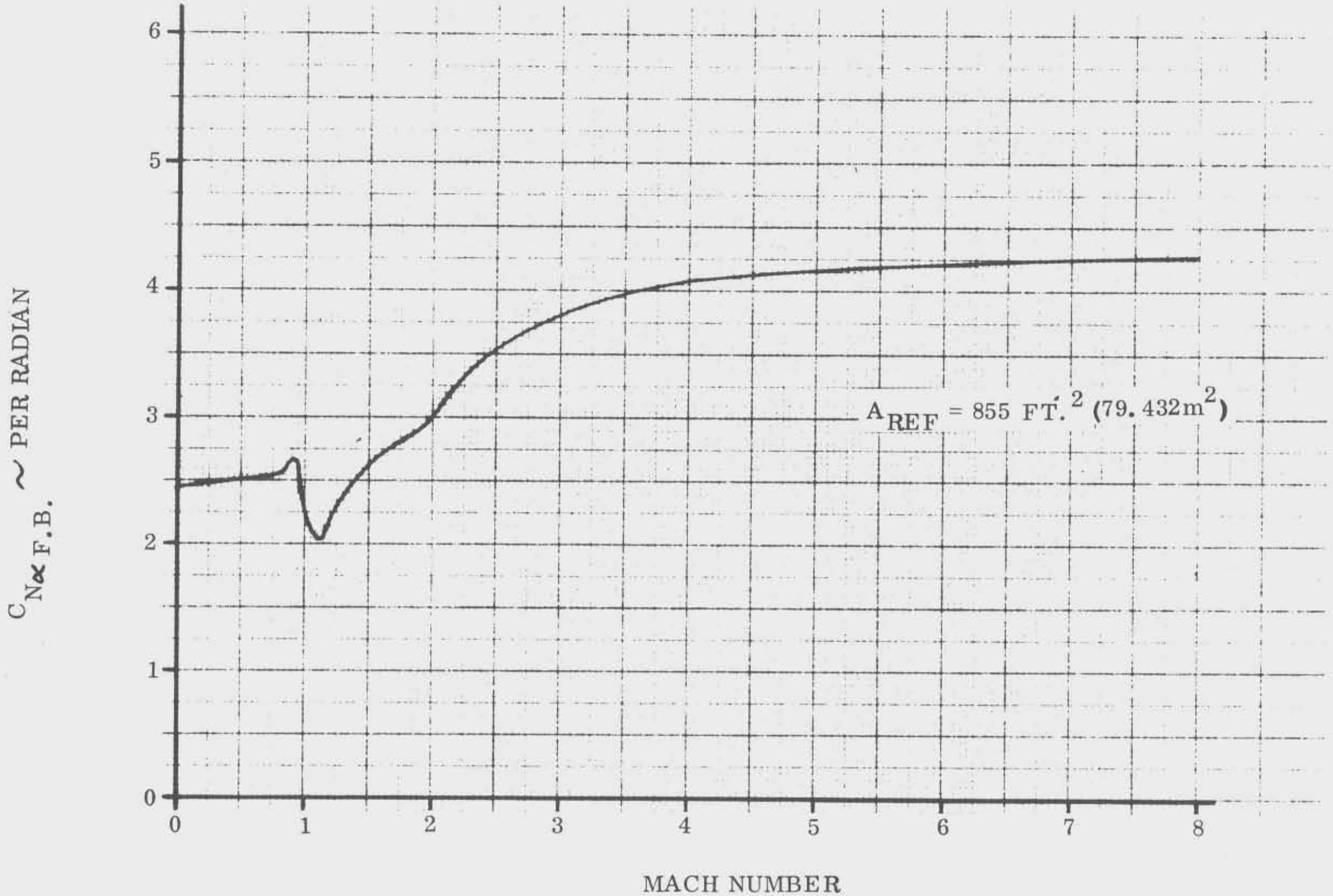


FIGURE D.3-7 CLEAN FOREBODY CONTRIBUTION TO NORMAL FORCE COEFFICIENT GRADIENT VS. MACH NUMBER, 43 FT. (13.1m) PAYLOAD

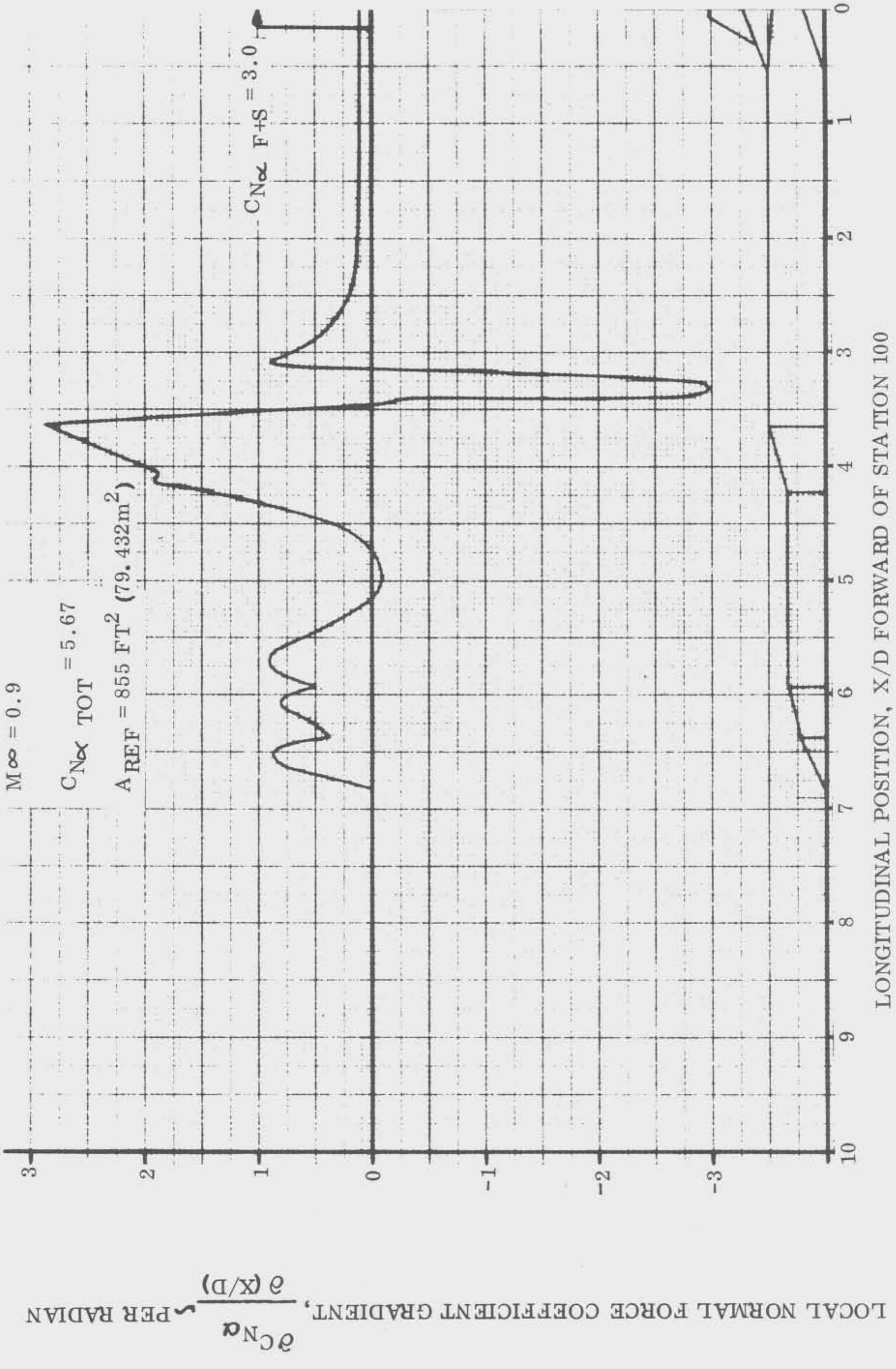


FIGURE D.3-8 DISTRIBUTION OF LOCAL NORMAL FORCE COEFFICIENT GRADIENT, 43 FT. (13.1m), PAYLOAD, $M\infty = 0.9$

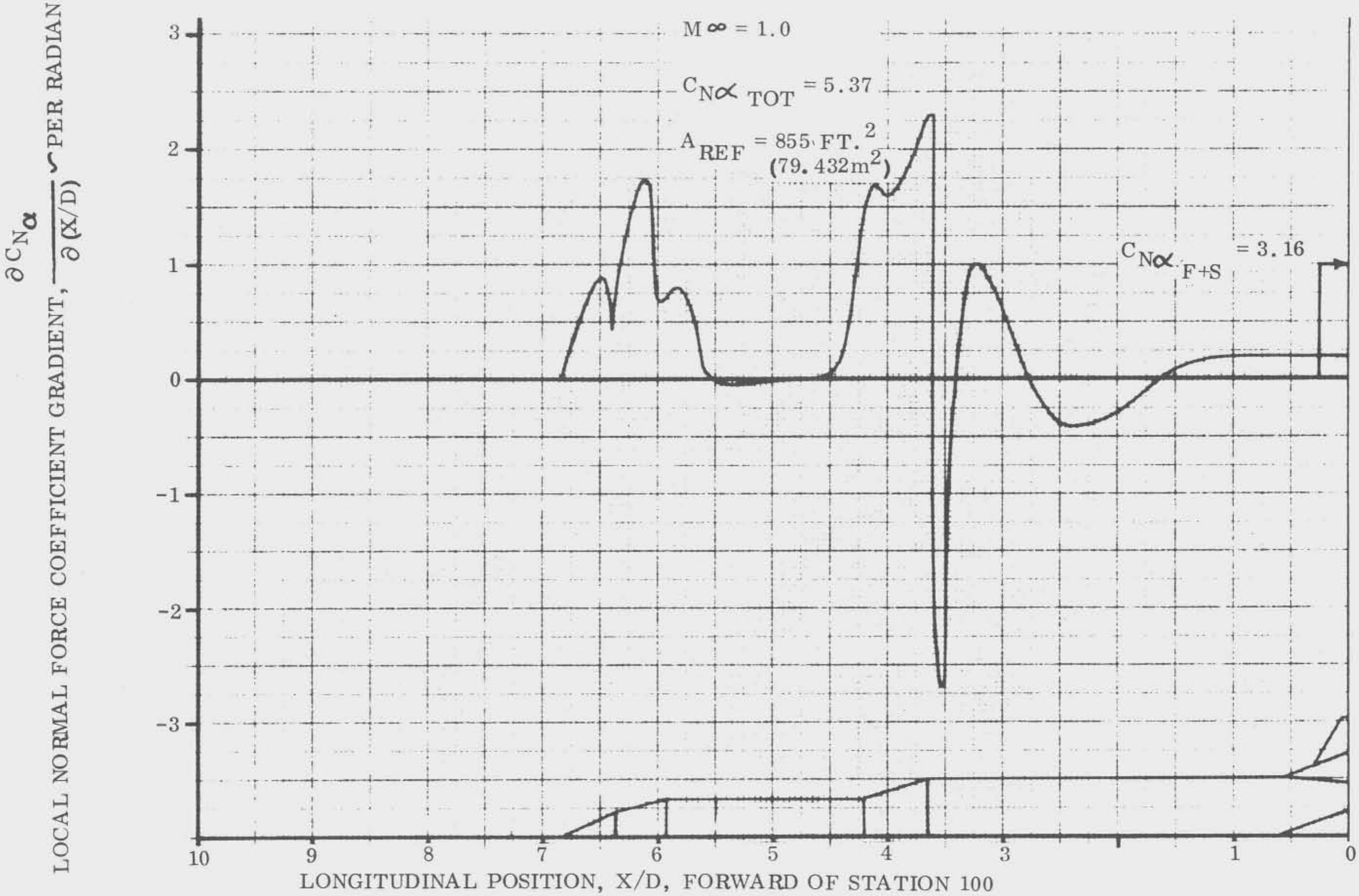


FIGURE D.3-9 DISTRIBUTION OF LOCAL NORMAL FORCE COEFFICIENT GRADIENT, 43 FT. PAYLOAD (13.1m), M∞ = 1.0

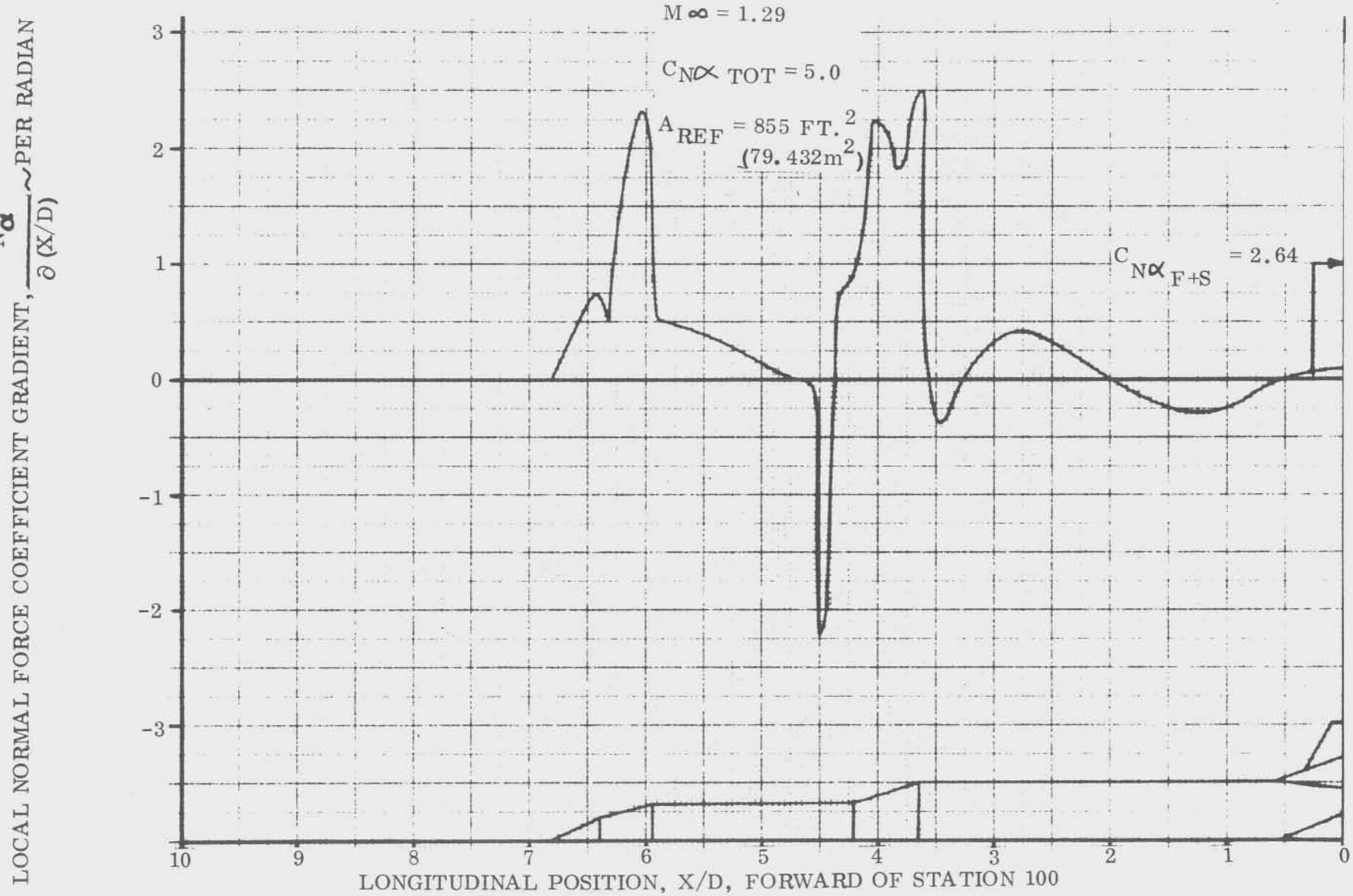


FIGURE D.3-10 DISTRIBUTION OF LOCAL NORMAL FORCE COEFFICIENT GRADIENT, 43 FT.(13.1M), PAYLOAD, M∞ = 1.29

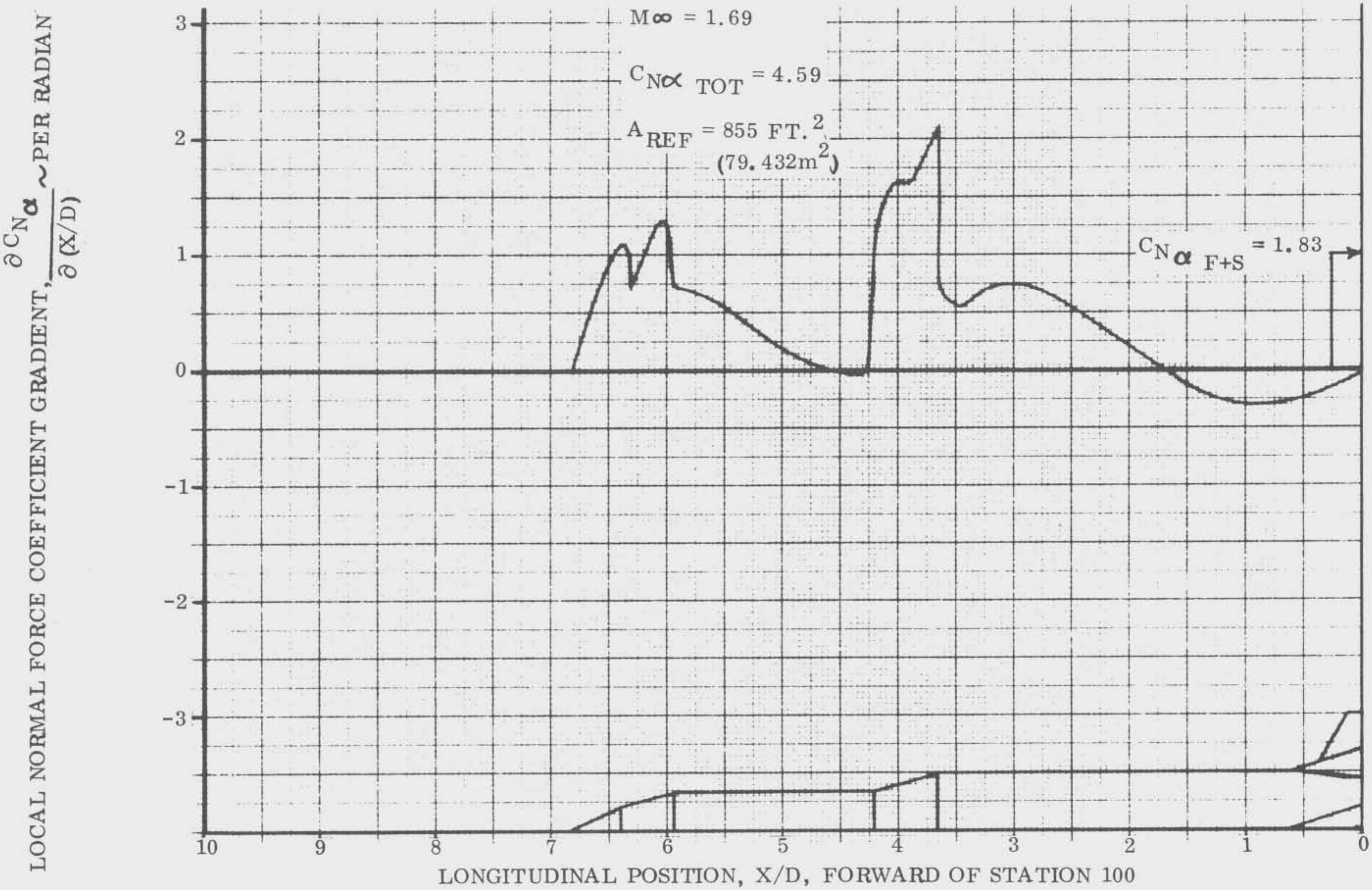


FIGURE D.3-11 DISTRIBUTION OF LOCAL NORMAL FORCE COEFFICIENT GRADIENT, 43 FT. PAYLOAD (13.1m), $M_\infty = 1.69$

APPENDIX D.3 (CONTINUED)

2.0 INT-20/BIG G AERODYNAMICS

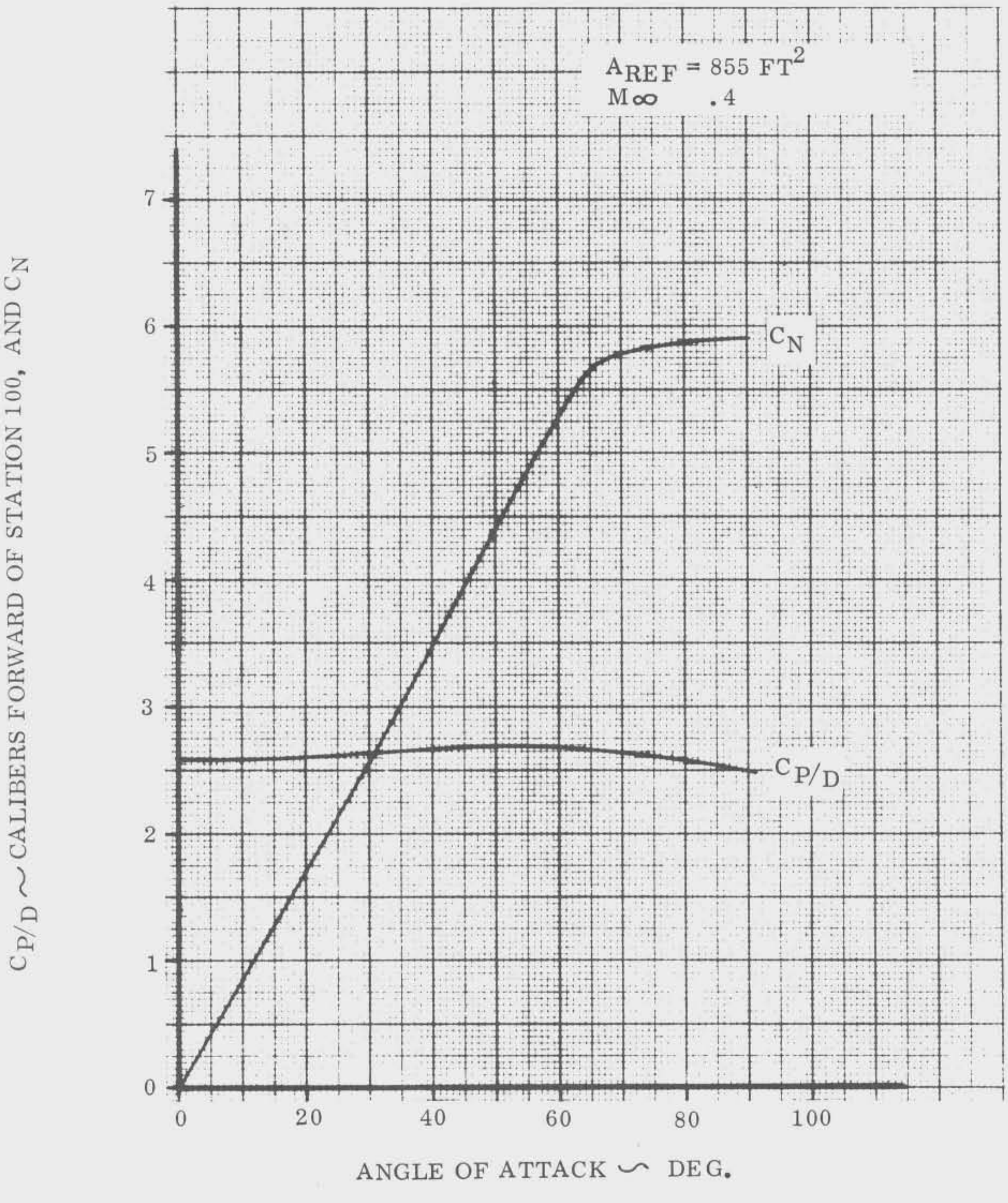


FIGURE D. 3. 2-1 ON PAD AND LIFT OFF AERODYNAMICS, BIG G PAYLOAD

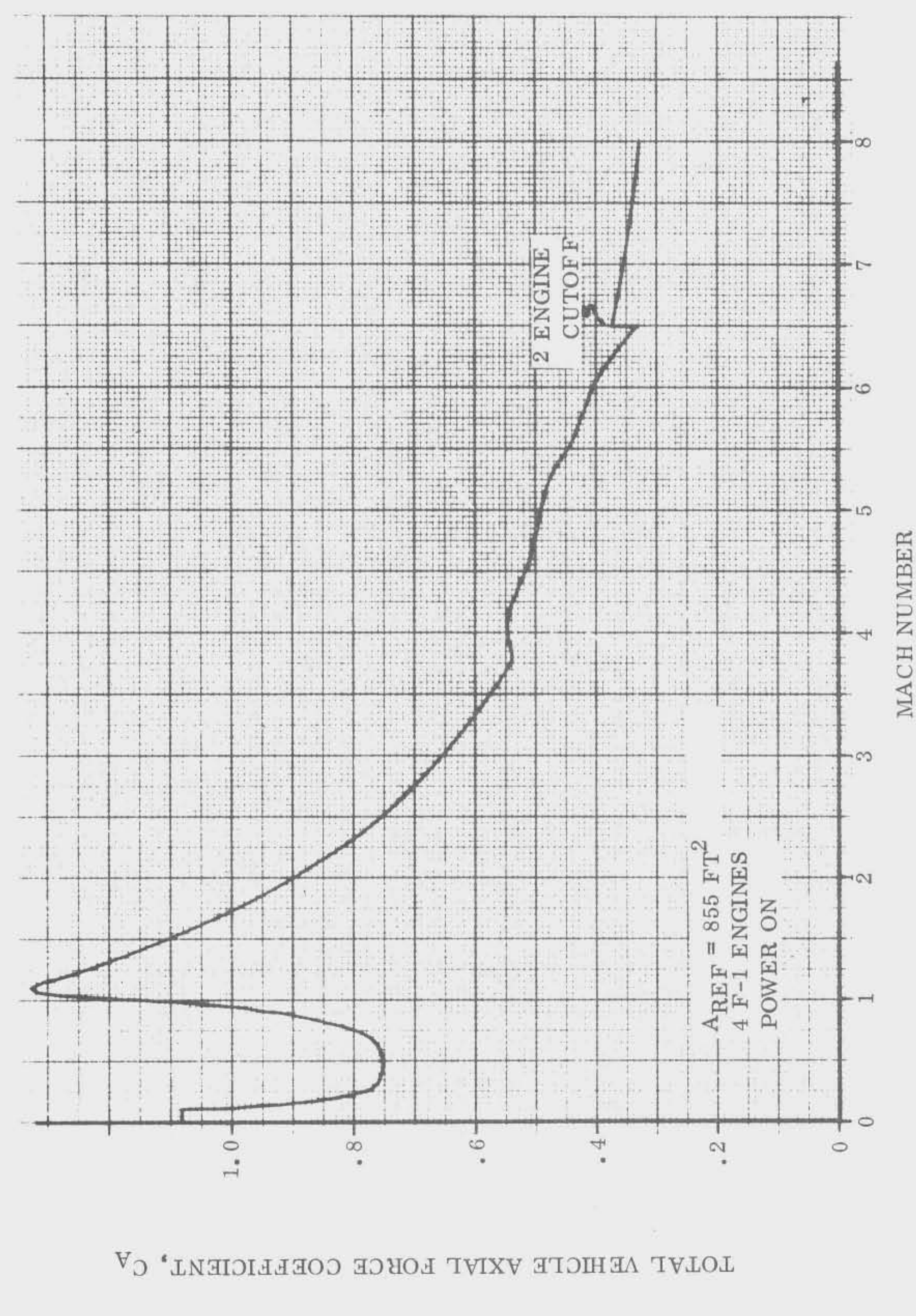


FIGURE D.3.2-2 VEHICLE AXIAL FORCE COEFFICIENT VS. MACH NUMBER, BIG G PAYLOAD

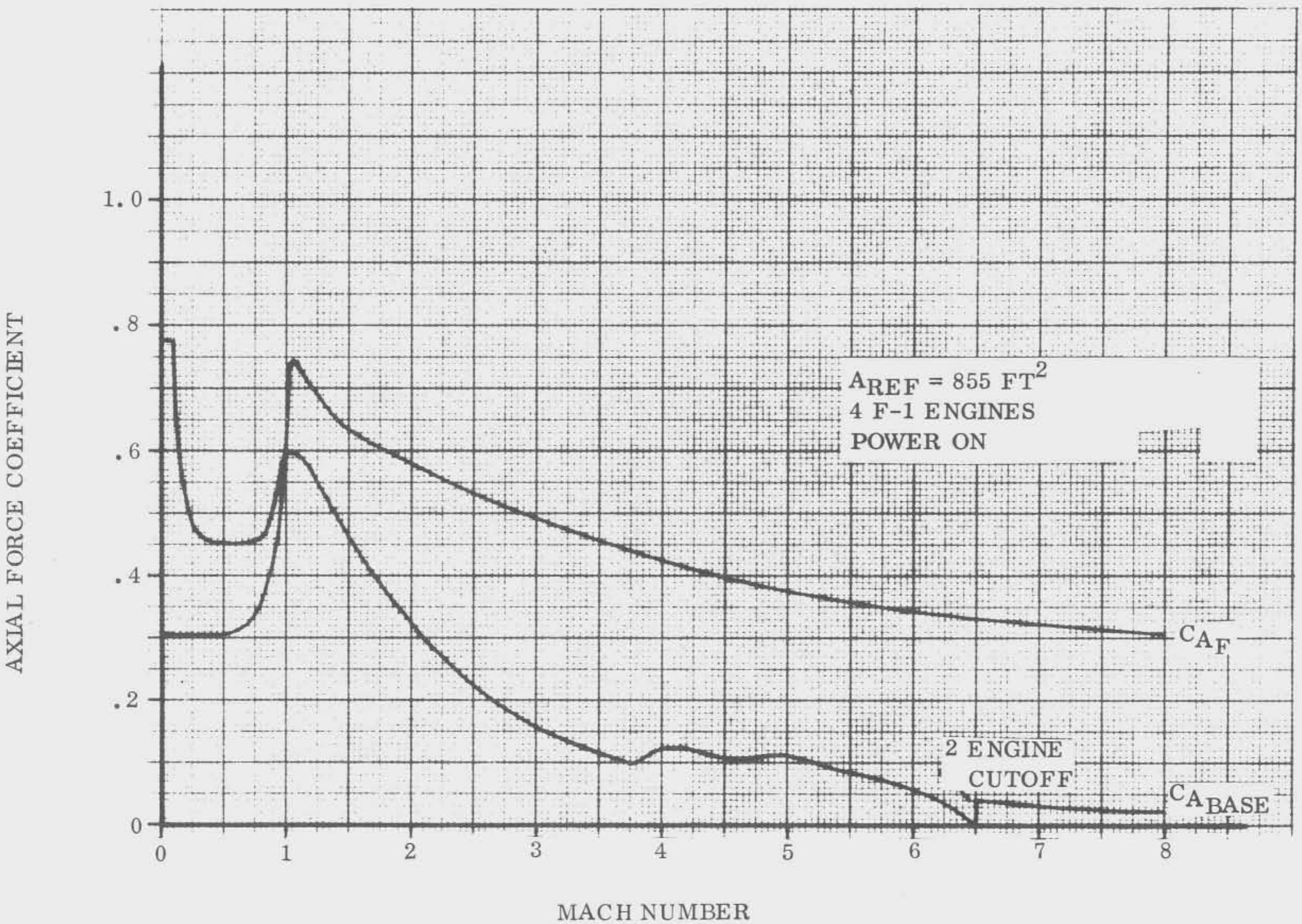


FIGURE D.3.2-3 FOREBODY AND BASE AXIAL FORCE COEFFICIENTS VS. MACH NUMBER, BIG G PAYLOAD

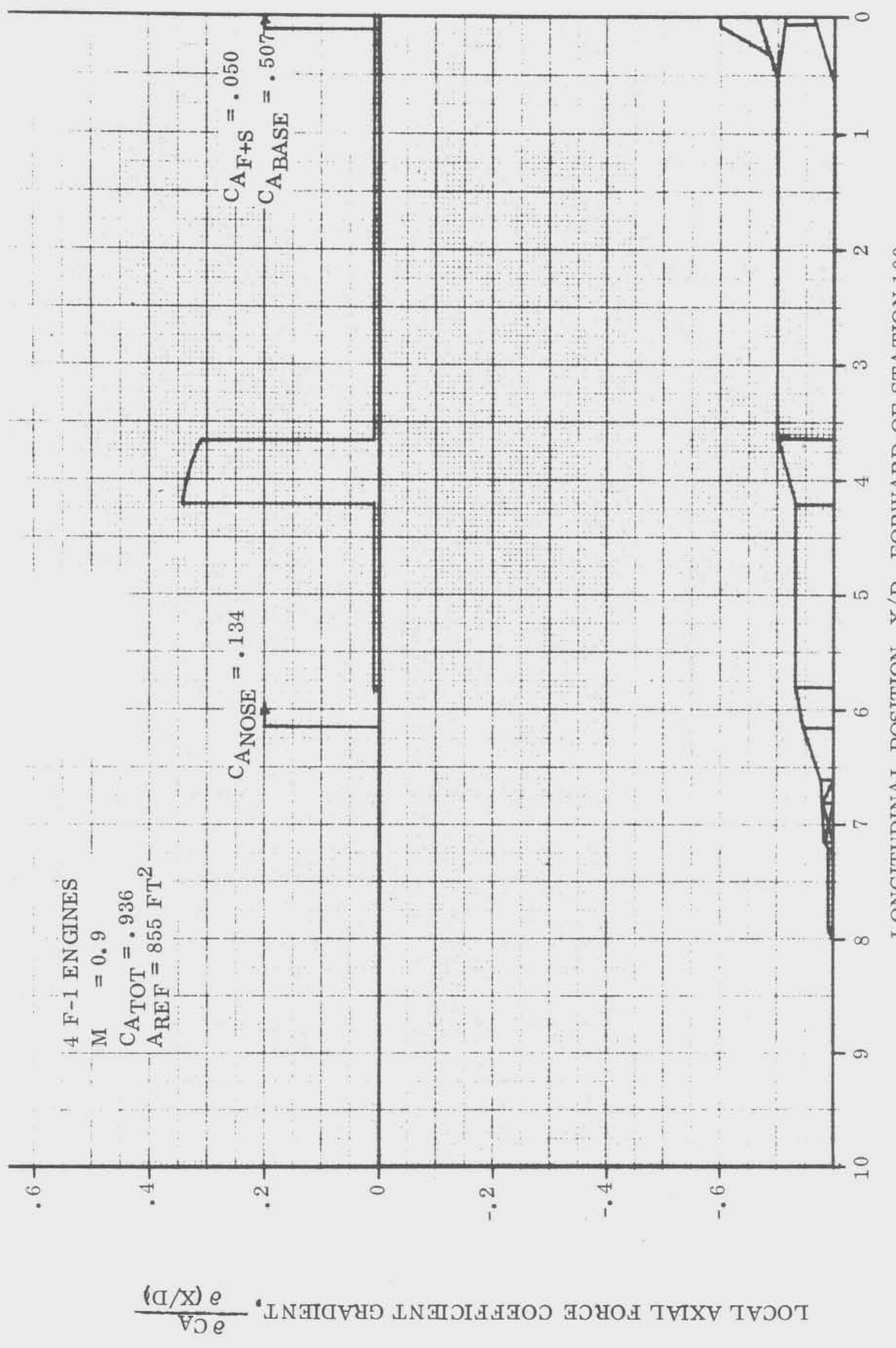


FIGURE D.3.2-4 DISTRIBUTION OF LOCAL AXIAL FORCE COEFFICIENT GRADIENT, BIG G PAYLOAD, $M_\infty = 0.9$

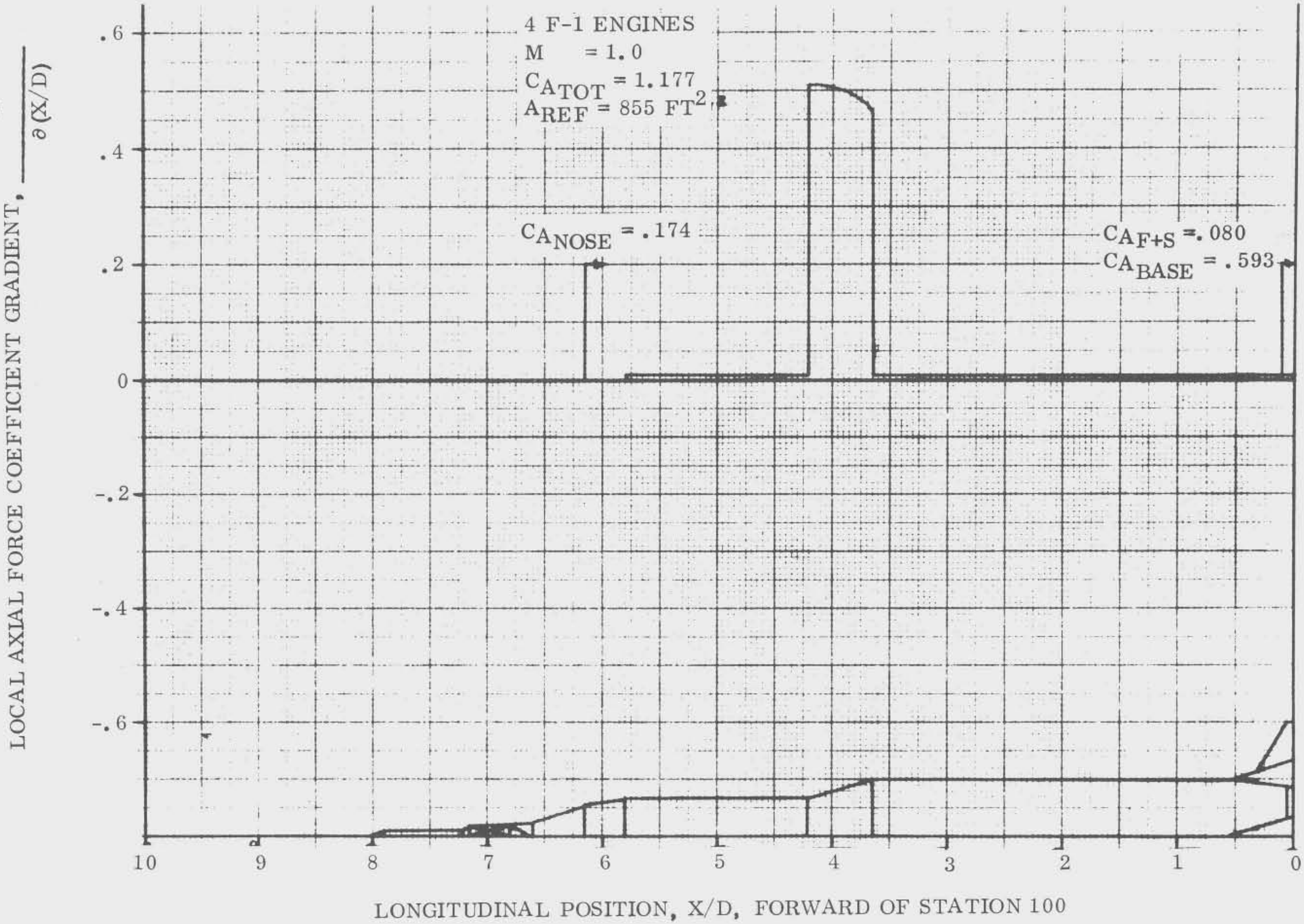


FIGURE D.3.2-5 DISTRIBUTION OF LOCAL AXIAL FORCE COEFFICIENT GRADIENT, BIG G PAYLOAD, $M_\infty = 1.0$

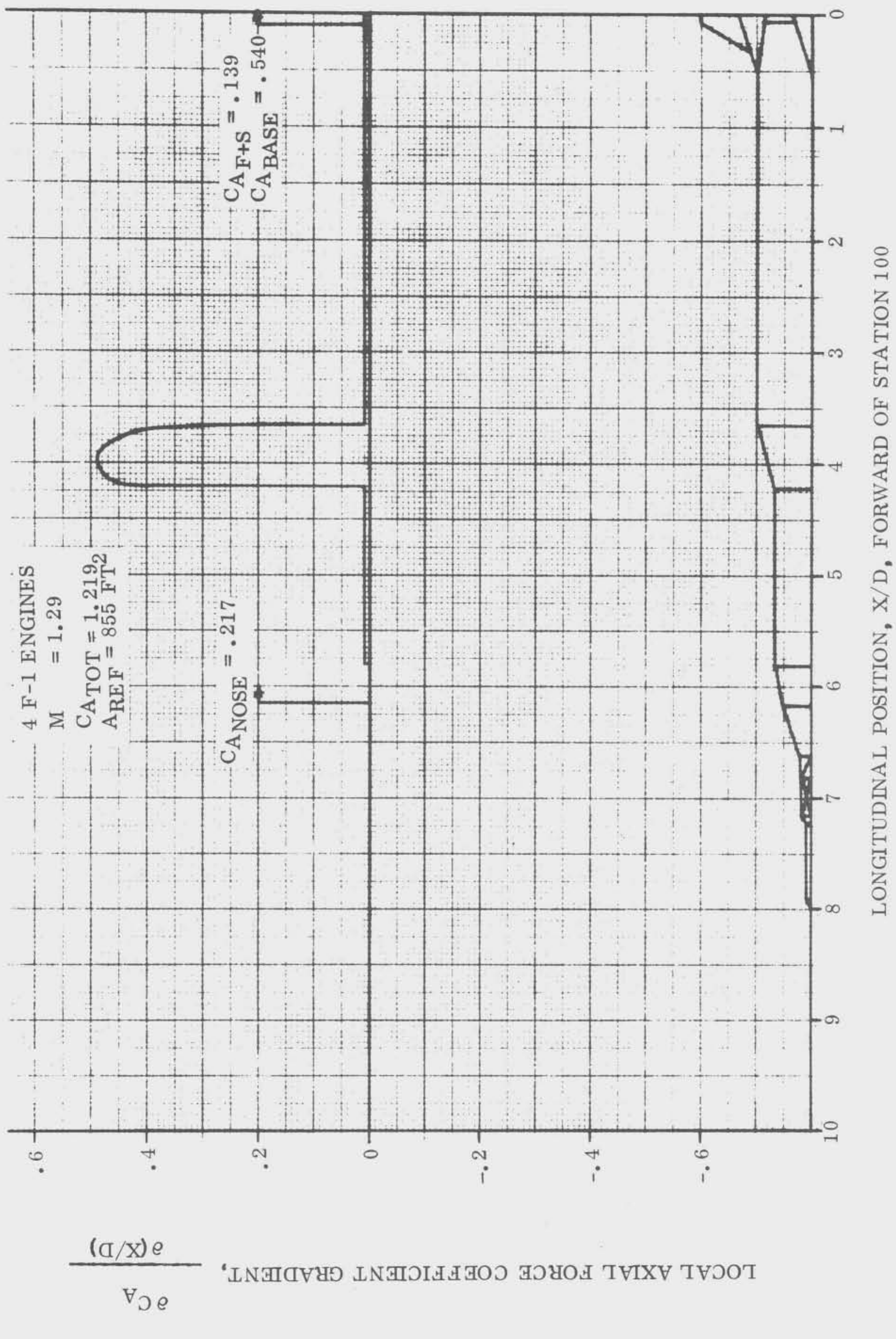


FIGURE D.3.2-6 DISTRIBUTION OF LOCAL AXIAL FORCE COEFFICIENT GRADIENT, BIG G PAYLOAD, $M_\infty = 1.29$

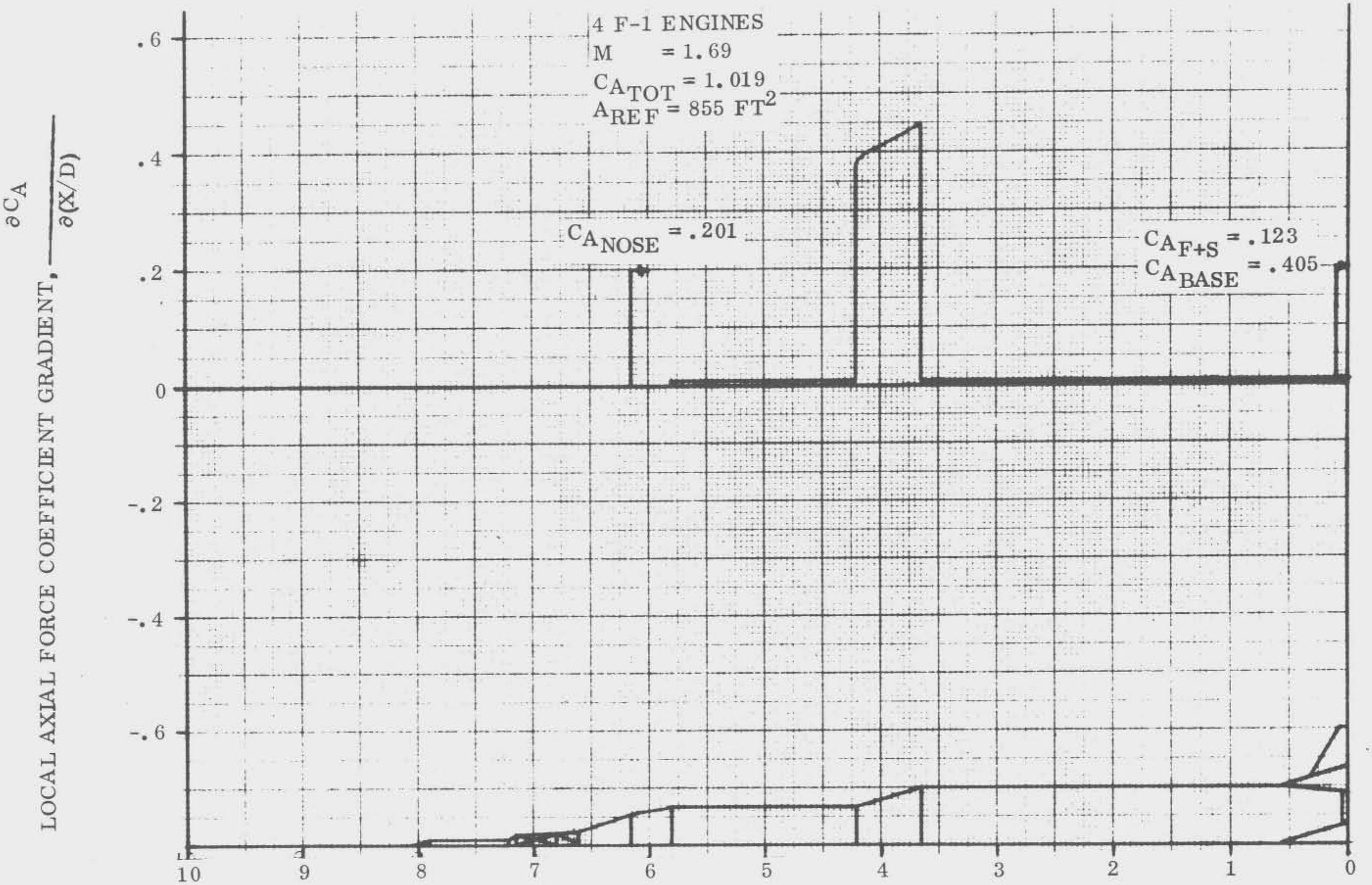


FIGURE D.3.2-7 DISTRIBUTION OF LOCAL AXIAL FORCE COEFFICIENT GRADIENT, BIG G PAYLOAD, M_∞ = 1.69

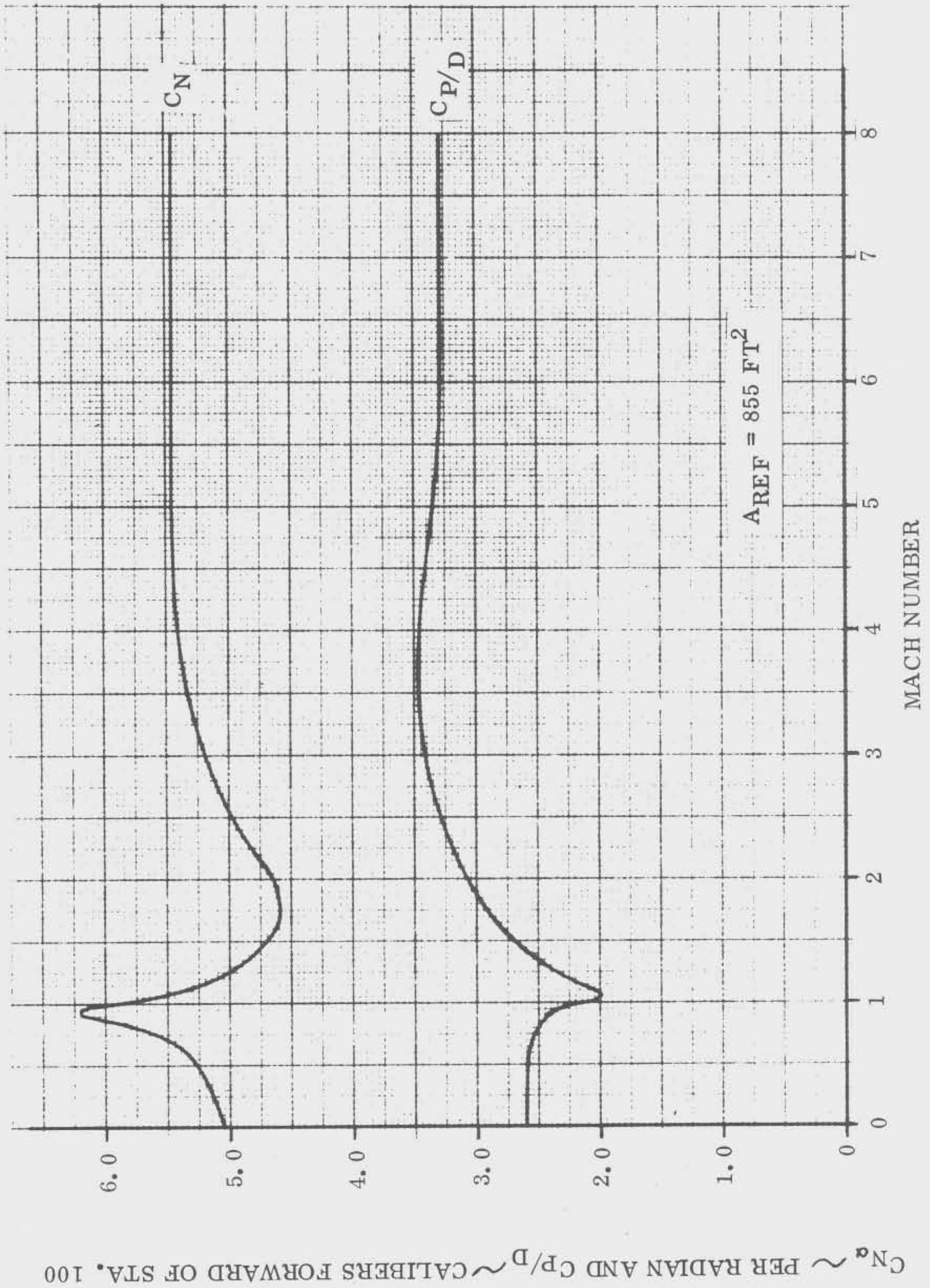


FIGURE D.3.2-8 VEHICLE $C_{P/D}$ AND NORMAL FORCE COEFFICIENT GRADIENT VS. MACH NUMBER, BIG G PAYLOAD

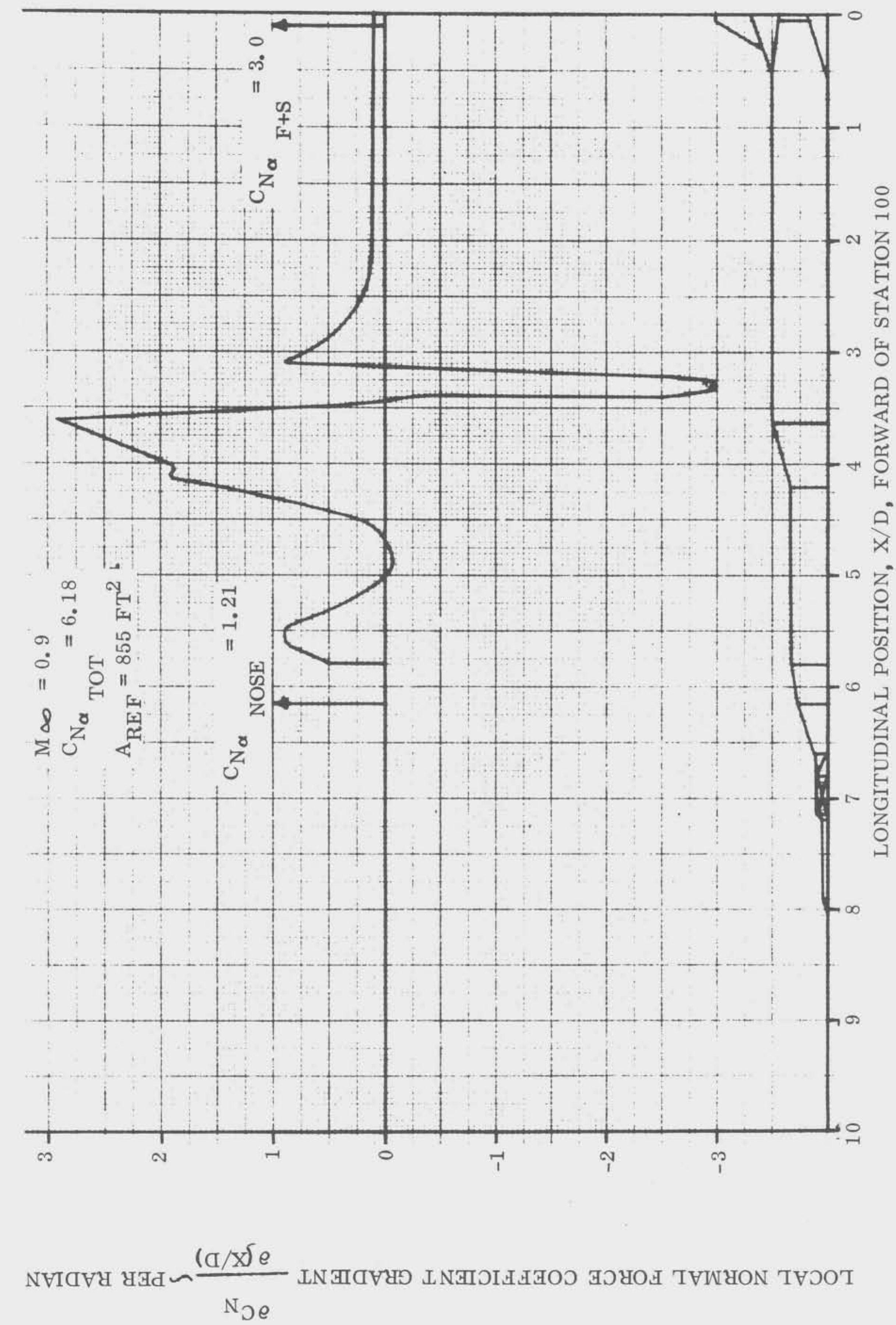


FIGURE D.3.2-9 DISTRIBUTION OF LOCAL NORMAL FORCE COEFFICIENT GRADIENT, BIG G PAYLOAD, $M_\infty = 0.9$

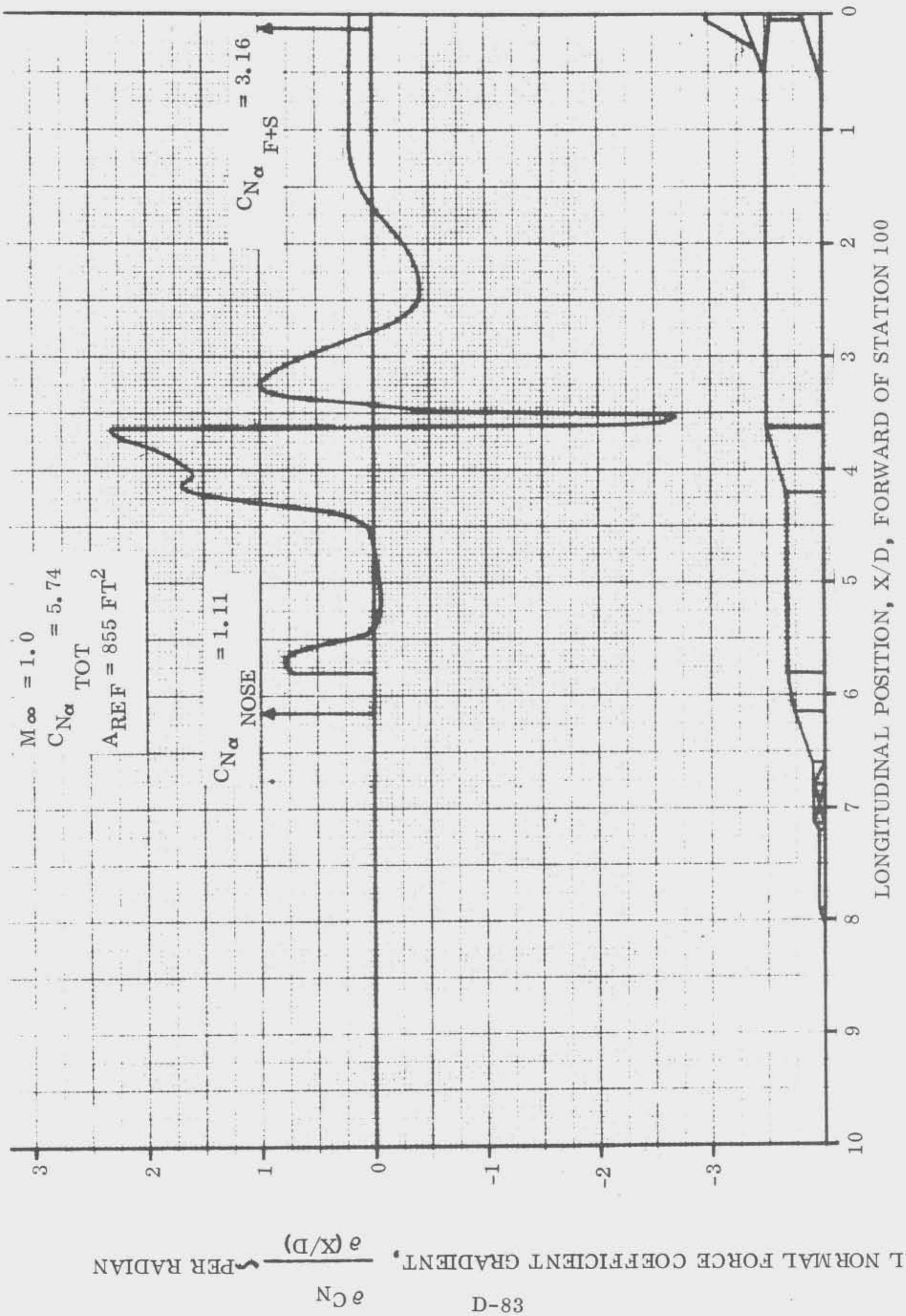


FIGURE D.3.2-10 DISTRIBUTION OF LOCAL NORMAL FORCE COEFFICIENT GRADIENT, BIG G PAYLOAD, $M_\infty = 1.0$

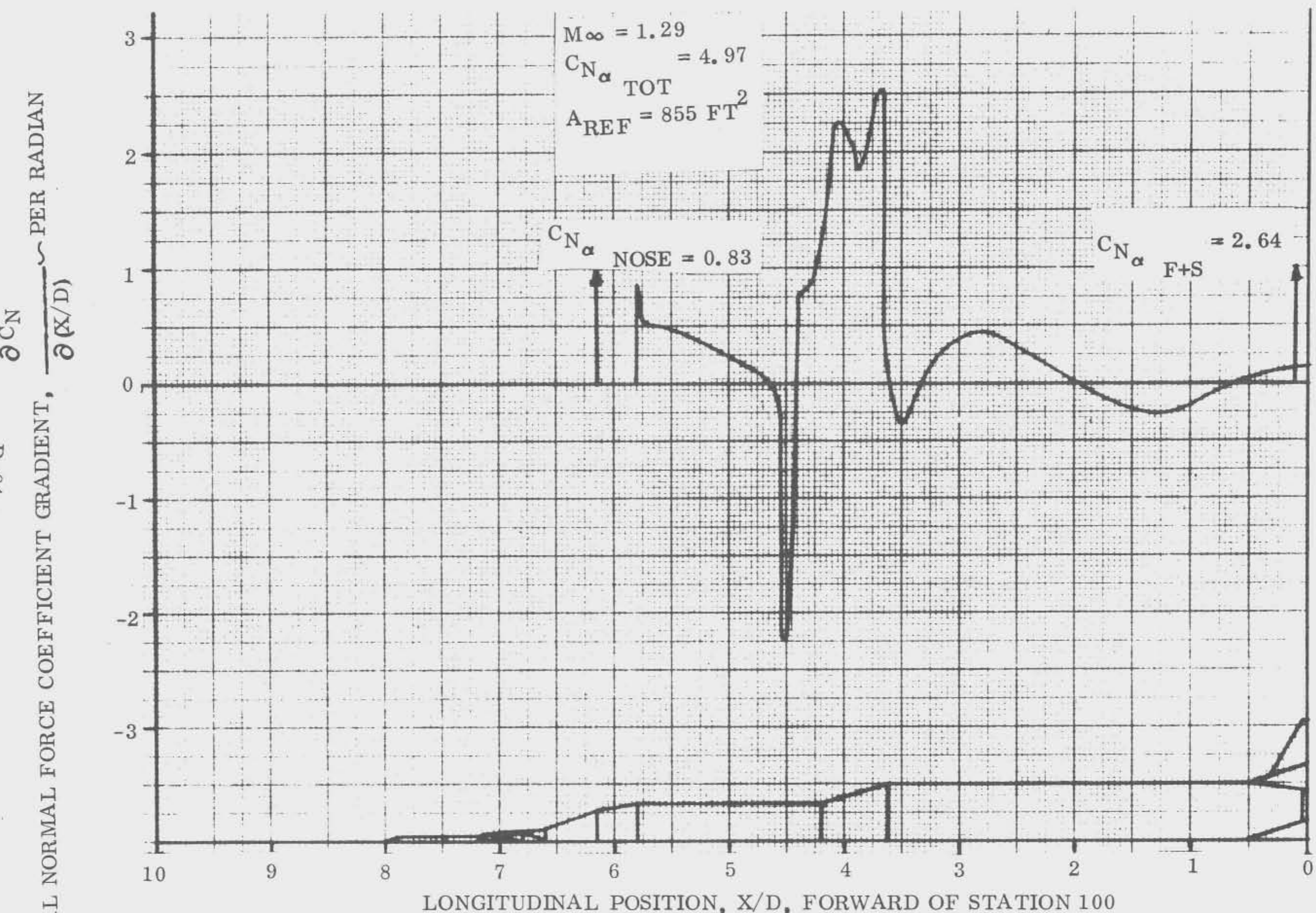


FIGURE D.3.2-11 DISTRIBUTION OF LOCAL NORMAL FORCE COEFFICIENT GRADIENT, BIG G PAYLOAD, M∞ = 1.29

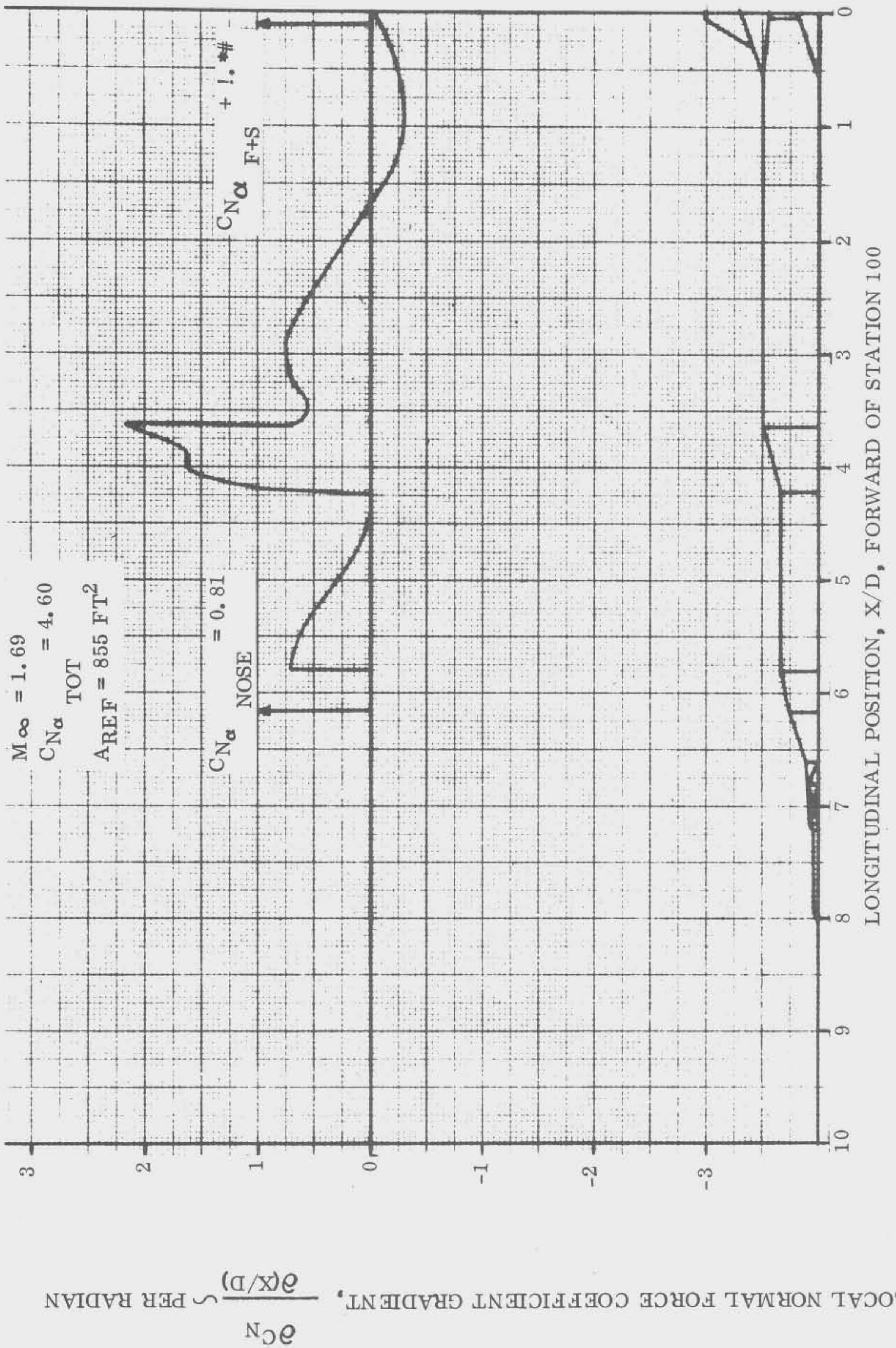


FIGURE D.3.2-12 DISTRIBUTION OF LOCAL NORMAL FORCE COEFFICIENT GRADIENT, BIG G PAYLOAD, $M_\infty = 1.69$

APPENDIX D.4

APPENDIX D.4

1.0 BASELINE INT-20 MASS CHARACTERISTICS

INT-20 vehicle mass properties in this appendix are based on the SA-511 vehicle described in Reference 4.1.7-1. The INT-20 vehicle design analyses for structural loads, structural dynamics, and control characteristics were made using these mass characteristics.

a. Vehicle distributed and accumulative weights

Vehicle mass distribution; containers empty, less contilevered masses, is shown in Table D.4-I. The cantilevered masses are shown in Table D.4-II.

Variation of vehicle propellant distribution with flight time is shown in Table D.4-III.

Accumulative weights are presented in Table D.4-IV for various flight times.

LOX and fuel level changes with flight time are shown in Figures D.4-1 and D.4-2.

b. Vehicle weights, cg's, and roll and pitch mass moments of inertia.

Variation of first flight stage weight and longitudinal center of gravity (cg) with S-IC burn time is shown in Figure D.4-3. The abrupt change in the curves at t = 146 seconds is caused by cutoff of two of the four F-1 engines on the S-IC stage.

Variation of first flight stage roll and pitch mass moments of inertia with S-IC burn time is shown in Figure D.4-4. The reverse curvature is due to the influence of the change in fluid height to tank diameter ratio of the propellant fluid masses in the S-IC stage.

TABLE D.4-I

VEHICLE MASS DISTRIBUTION (CONTAINERS EMPTY)

INT-20

BAY LIMITS (STATION)		BAY WEIGHT (LB)	BAY C.G. (STATION)
AFT	FWD		
2629	2796	13,265	2695.73
2464	2629	47,651	2537.60
2372	2464	35,555	2418.00
2280	2372	35,555	2326.00
2244	2280	4,183	2269.00
2122	2244	2,866*	2193.47
2002	2122	3,898	2059.80
1902	2002	2,022	1952.50
1822	1902	1,325*	1853.50
1762	1822	1,006	1792.00
1642	1762	8,170	1700.98
1540	1642	2,908	1544.31
1400	1540	8,844*	1476.75
1280	1400	4,968	1343.21
1160	1280	6,701	1221.69
1040	1160	8,200	1103.03
920	1040	8,857	984.07
800	920	7,383*	849.37
700	800	7,180	747.96
600	700	10,244*	641.56
480	600	21,612	540.31
360	480	21,265*	422.96
240	360	27,967	298.35
100	240	101,776	149.80
-120	100	527*	73.00

*Cantilevered Mass Not Included

TABLE D.4-II

CANTILEVERED MASSES

INT-20

CANTILEVER STATION	WEIGHT (LB)		C.G. (STATION)		Ip* (SLUG-FT^2)	
	LIFTOFF	CUTOFF	LIFTOFF	CUTOFF	LIFTOFF	CUTOFF
100.0	75,340	75,340	43.9	43.9	335,380	335,380
365.0	324,844	6,730	313.7	304.3	246,472	28,498
602.0	4,240	4,240	662.1	662.1	17,902	17,902
912.0	471,521	8,072	859.3	839.2	329,318	34,140
1401.0	4,798	4,798	1462.1	1462.1	22,856	22,856
1854.0	203,592	11,925	1805.4	1765.1	143,532	62,103
2122.6	825	825	2171.4	2171.4	5,888	5,888

*About Point of Attachment

TABLE D.4-III

VEHICLE PROPELLANT DISTRIBUTION

INT-20

RP-1 PROPELLANT DISTRIBUTION

BAY LIMIT (STATION)		S-IC BURN TIME (SEC)					
		0.0		70.1		90.0	
AFT	FWD	WEIGHT (LB)	C.G. (STATION)	WEIGHT (LB)	C.G. (STATION)	WEIGHT (LB)	C.G. (STATION)
225.0	365.0	318,114	313.9	318,114	313.9	318,114	313.9
365.0	480.0	402,173	422.4	402,173	422.4	414,685	410.3
480.0	602.0	426,536	540.9	57,624	488.4	0	-
602.0	S.L.	119,645	631.0	0	-	0	-

LOX PROPELLANT DISTRIBUTION

BAY LIMIT (STATION)		S-IC BURN TIME (SEC)					
		0.0		70.1		90.0	
AFT	FWD	WEIGHT (LB)	C.G. (STATION)	WEIGHT (LB)	C.G. (STATION)	WEIGHT (LB)	C.G. (STATION)
772.0	912.0	463,449	859.6	463,449	859.6	463,449	859.6
912.0	920.0	39,845	916.4	39,845	916.4	39,845	916.4
920.0	1040.0	595,586	979.8	595,586	979.8	595,586	979.8
1040.0	1160.0	594,060	1100.1	594,060	1100.1	329,493	1072.0
1160.0	1280.0	600,050	1219.9	71,454	1162.9	0	-
1280.0	1401.0	602,388	1342.8	0	-	0	-
1401.0	S.L.	1,186	1401.1	0	-	0	-

TABLE D.4-III (continued)

VEHICLE PROPELLANT DISTRIBUTION

INT-20

S-IVB LOX PROPELLANT DISTRIBUTION

BAY LIMIT (STATION)	WEIGHT (LB)	C. G. (STATION)
CANTILEVERED @ 1854.0	191,667	1807.9

S-IVB LH_2 PROPELLANT DISTRIBUTION

BAY LIMIT (STATION)		WEIGHT (LB)	C.G. (STATION)
AFT	FWD		
1812.0	1854.0	873	1842.0
1854.0	1988.0	15,593	1928.5
1988.0	2123.0	17,477	2055.8
2123.0	S.L.	4,391	2139.4

TABLE D.4-IV

VEHICLE ACCUMULATIVE WEIGHTS

INT-20

VEHICLE STATION	ON PAD t = -7.0	LIFT-OFF t= 0.0	Q MAX t = 70.1	2 ENG.C.O. t = 146.0	CUTOFF t = 210.95
Above 2629	13,265	13,265	13,265	13,265	13,265
Below 2629	13,265	13,265	13,265	13,265	13,265
Above 2464	60,916	60,916	60,916	60,916	60,916
Below 2464	60,916	60,916	60,916	60,916	60,916
Above 2281	132,026	132,026	132,026	132,026	132,026
Below 2281	132,026	132,026	132,026	132,026	132,026
Above 2245	136,209	136,209	136,209	136,209	136,209
Below 2245	136,209	136,209	136,209	136,209	136,209
Above 2123	139,075	139,075	139,075	139,075	139,075
Below 2123	139,900	139,900	139,900	139,900	139,900
Above 1854	146,615	146,615	146,615	146,615	146,615
Below 1854	388,541	388,541	388,541	388,541	388,541
Above 1768	389,976	389,976	389,976	389,976	389,976
Below 1768	389,976	389,976	389,976	389,976	389,976
Above 1541	401,155	401,155	401,155	401,155	401,155
Below 1541	401,155	401,155	401,155	401,155	401,155
Above 1401	409,999	409,999	409,999	409,999	409,999
Below 1401	414,797	414,797	414,797	414,797	414,797
Above 912	444,015	444,015	444,015	444,015	444,015
Below 912	3,417,814	3,348,651	2,216,481	993,092	469,125
Above 602	3,441,924	3,372,761	2,240,591	1,017,202	493,235
Below 602	3,446,164	3,377,001	2,244,831	1,021,442	497,475
Above 365	3,488,360	3,419,197	2,287,027	1,063,638	539,671
Below 365	4,784,041	4,692,395	3,071,668	1,320,180	570,070
Above 100	4,914,670	4,823,024	3,202,297	1,450,809	700,699
Below 100	4,990,537	4,898,891	3,278,164	1,526,676	776,566

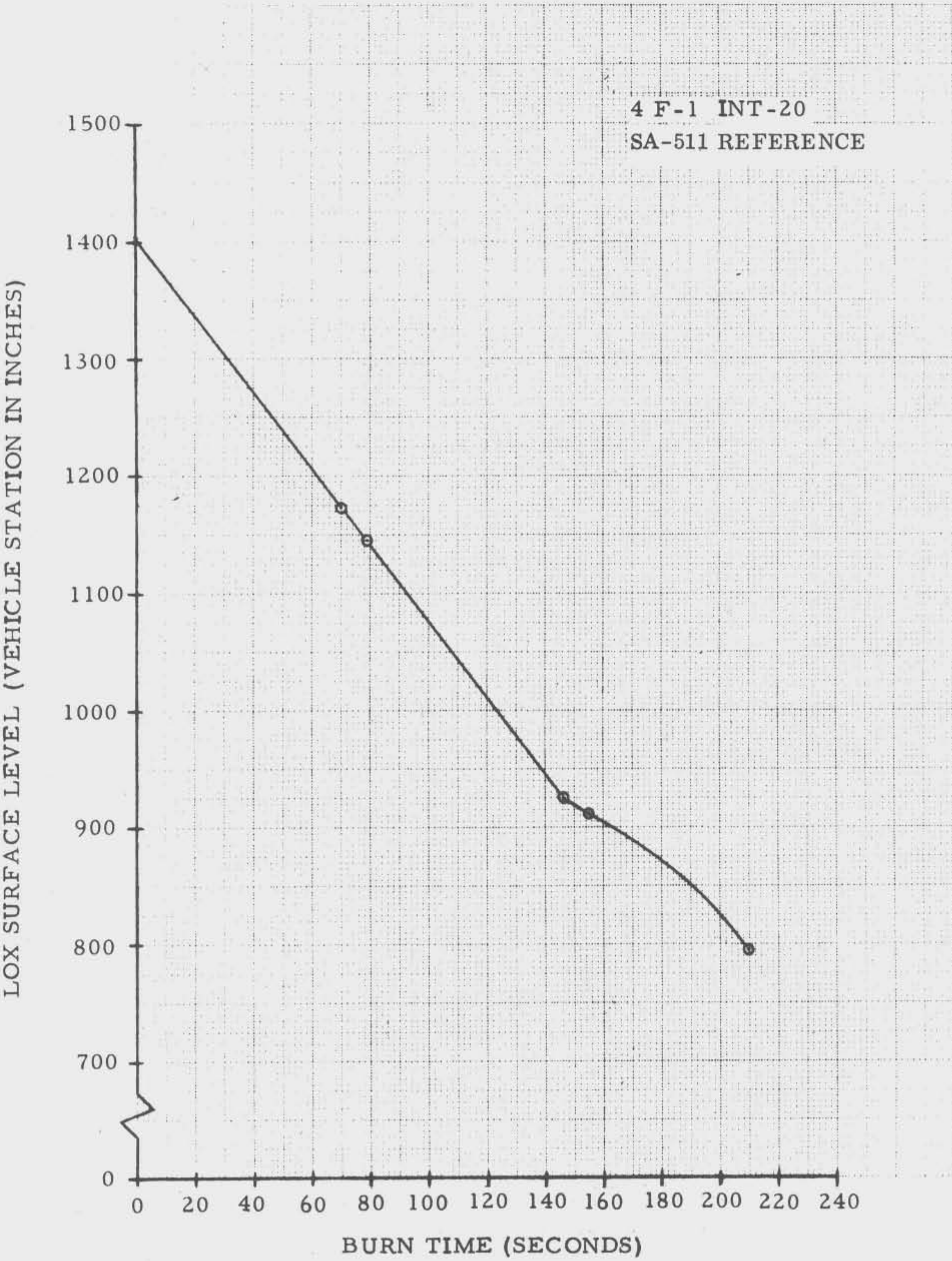


FIGURE D.4-1 LOX SURFACE LEVEL AS A FUNCTION OF BURN TIME

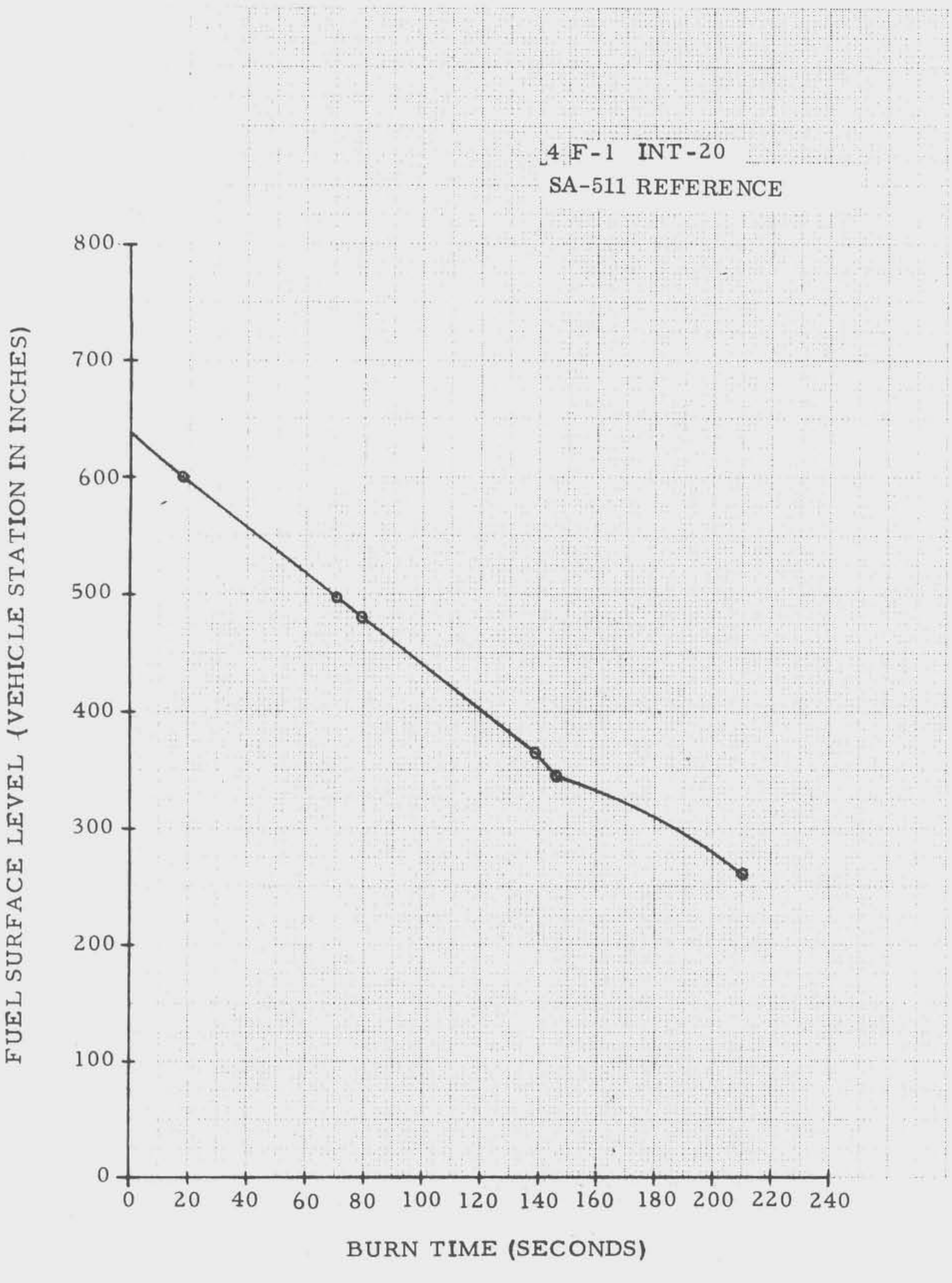


FIGURE D.4-2 FUEL SURFACE LEVEL AS A FUNCTION OF BURN TIME

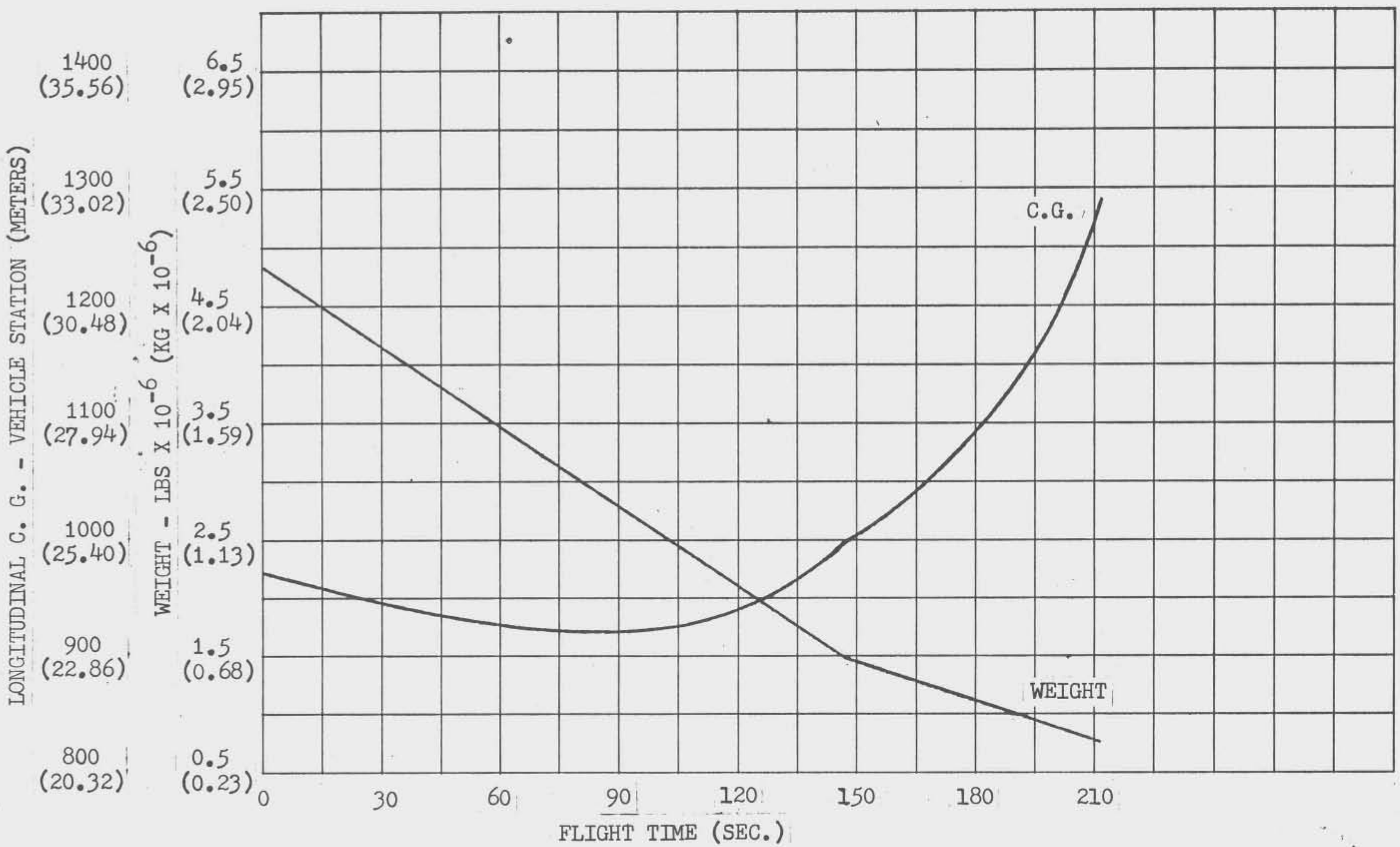


FIGURE D.4-3 FIRST FLIGHT STAGE
VEHICLE WEIGHT AND CENTER OF GRAVITY
VERSUS FLIGHT TIME

SAT V DERIVATIVE INT-20

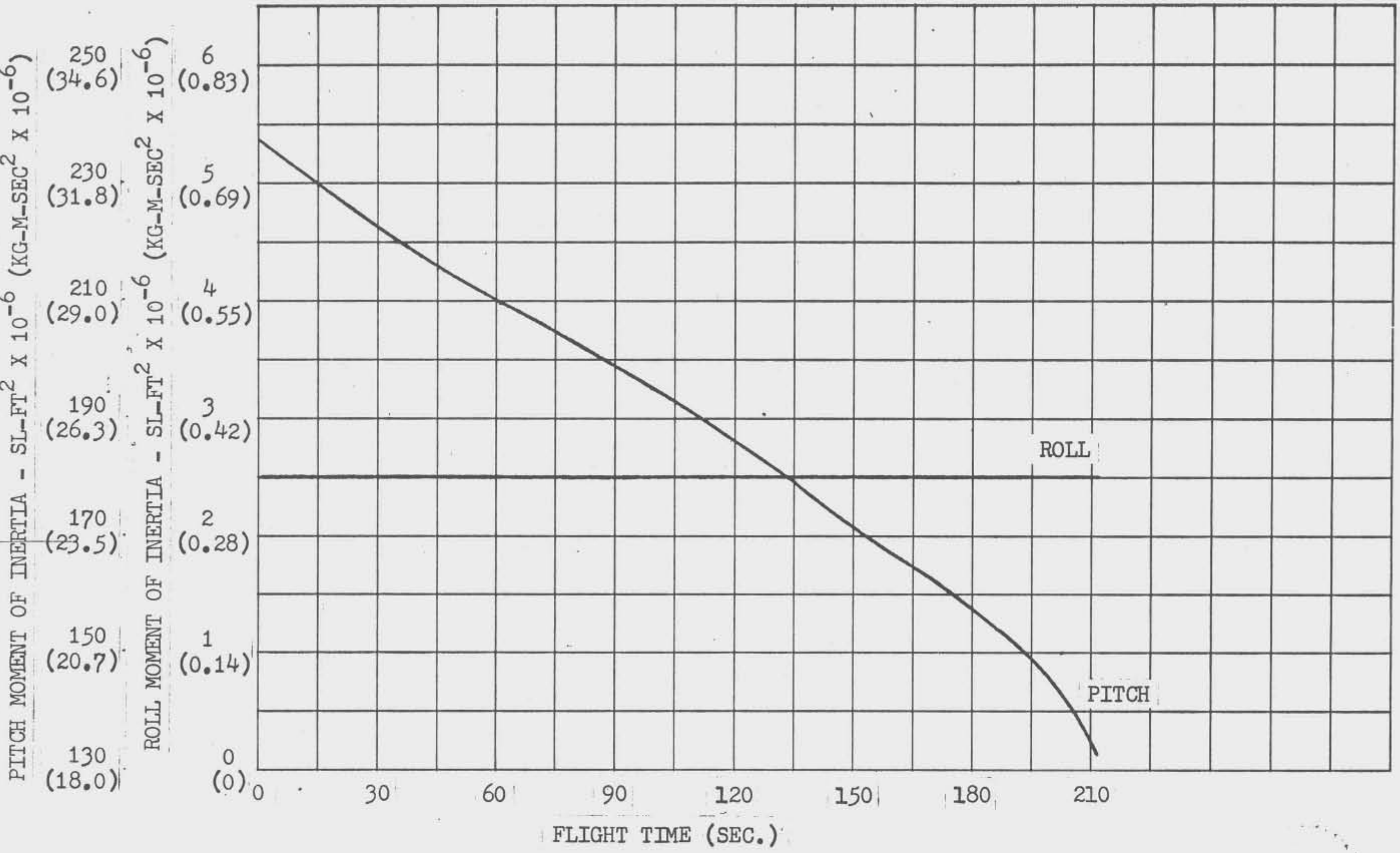


FIGURE D.4-4

FIRST FLIGHT STAGE
ROLL AND PITCH MOMENTS OF INERTIA
VERSUS FLIGHT TIME
SAT V DERIVATIVE INT-20

APPENDIX D.4 (Continued)

2.0 INT-20/BIG G MASS CHARACTERISTICS

Vehicle distributed and accumulative weights shown in Table D.4.V through D.5.VIII are based upon the 20-inch container's empty mass distribution presented in Reference 4.3.2-2. Vehicle cantilevered masses were obtained from data used in the J-2S study as supplied by appropriate stage contractors. The payload weight and launch vehicle propellant loadings used in this analysis are based on the data presented in Section 4.3.2.

TABLE D.4-V

VEHICLE MASS DISTRIBUTION (CONTAINERS EMPTY)
INT-20/BIG G CONFIGURATION

BAY VEHICLE	LIMITS STATION	WEIGHT (LBS)	BAY C. G. (STA.)
AFT	FWD		
2822	3289	10,050	3061
2606	2822	13,538	2660
2537	2606	20,000	2568
2280	2537	83,782	2402
2244	2280	4,183	2269
2122	2244	2,866*	2193
2002	2122	3,898	2060
1902	2002	2,022	1953
1822	1902	1,325*	1854
1762	1822	1,006	1792
1642	1762	8,170	1701
1540	1642	2,908	1544
1400	1540	8,844*	1477
1280	1400	4,968	1343
1160	1280	6,701	1222
1040	1160	8,200	1103
920	1040	8,857	984
800	920	7,383*	849
700	800	7,180	748
600	700	10,244*	642
480	600	21,612	540
360	480	21,265*	423
240	360	27,967	298
100	240	101,776	150
-120	100	527*	73

*Cantilevered Mass Not Included

NOTE

These data include propellants in ducts, residuals, etc.

TABLE D.4-VI

CANTILEVERED MASSES
INT-20/BIG G CONFIGURATION

CANTILEVER	WEIGHT (LBS)		C. G. (STATION)		I_P* (SLUG-FT^2)	
STATION	LIFT-OFF	CUT-OFF	LIFT-OFF	CUT-OFF	LIFT-OFF	CUT-OFF
100	75,340	75,340	44	44	335,380	335,380
365	324,844	6,730	314	304	246,472	28,498
602	4,240	4,240	662	662	17,902	17,902
912	471,521	8,072	859	839	329,318	34,140
1401	4,798	4,798	1462	1462	22,856	22,856
1854	203,592	11,925	1805	1765	143,532	62,103
2123	825	825	2171	2171	5,888	5,888

*About Point of Attachment

TABLE D.4-VII

VEHICLE PROPELLANT DISTRIBUTION
INT-20/BIG G CONFIGURATION

RP-1 PROPELLANT DISTRIBUTION

BAY LIMIT (STATION)		S-IC BURN TIME (SEC)					
		0.0		70.3		91.0	
AFT	FWD	WEIGHT (LBS)	CG (STATION)	WEIGHT (LBS)	CG (STATION)	WEIGHT (LBS)	CG (STATION)
225	365	318,114	314	318,114	314	318,114	314
365	480	402,173	422	402,173	422	314,060	410
480	602	426,536	541	55,849	488	0	-
602	S.L.	119,020	631	0	-	0	-

LOX PROPELLANT DISTRIBUTION

BAY LIMIT (STATION)		S-IC BURN TIME (SEC)					
		0.0		70.3		91.0	
AFT	FWD	WEIGHT (LBS)	CG (STATION)	WEIGHT (LBS)	CG (STATION)	WEIGHT (LBS)	CG (STATION)
772	912	463,449	860	463,449	860	463,449	860
912	920	39,845	916	39,845	916	39,845	916
920	1040	595,586	980	595,586	980	595,586	980
1040	1160	594,060	1100	594,060	1100	328,046	1072
1160	1280	600,050	1220	67,364	1163	0	-
1280	1401 (SL.)	602,127	1343	0	-	0	-

TABLE D.4-VII (Continued)

VEHICLE PROPELLANT DISTRIBUTION

INT-20/BIG G CONFIGURATION

S-IVB LOX PROPELLANT DISTRIBUTION

BAY LIMIT (STATION)	WEIGHT (LBS)	CG (STATION)
Cantilevered at 1854	191,667	1808

S-IVB LH_2 PROPELLANT DISTRIBUTION

BAY LIMIT (STATION)		WEIGHT (LBS)	CG STATION
AFT	FWD		
1812	1854	873	1842
1854	1988	15,593	1929
1988	2123	17,477	2056
2123	S.L.	4,391	2139

TABLE D.4-VIII

VEHICLE MASS ACCUMULATIVE (CONTAINERS EMPTY)

INT-20/BIG G CONFIGURATION

VEHICLE STATION	ON PAD t=-7.0	LIFT-OFF t=0.0	($q\alpha$) MAX t=70.3	2 ENG C.O. t=146
AT 2822	10,050	10,050	10,050	10,050
AT 2606	23,588	23,588	23,588	23,588
AT 2537	43,588	43,588	43,588	43,588
AT 2401	84,620	84,620	84,620	84,620
AT 2281	127,370	127,370	127,370	127,370
AT 2245	131,553	131,553	131,553	131,553
FWD 2123	134,419	134,419	134,419	134,419
AFT 2123	135,144	135,144	135,144	135,144
FWD 1854	141,959	141,959	141,959	141,959
AFT 1854	383,885	383,885	383,885	383,885
AT 1768	385,320	385,320	385,320	385,320
AT 1541	396,499	396,499	396,499	396,499
FWD 1401	405,343	405,343	405,343	405,343
AFT 1401	410,141	410,141	410,141	410,141
FWD 912	439,359	439,359	439,359	439,359
AFT 912	3,416,405	3,347,242	2,207,735	991,683
FWD 602	3,440,515	3,371,352	2,231,845	1,015,793
AFT 602	3,444,755	3,375,592	2,236,085	1,020,033
FWD 365	3,486,951	3,417,788	2,278,281	1,062,229
AFT 365	4,784,042	4,692,396	3,061,147	1,320,181
FWD 100	4,914,671	4,823,025	3,191,776	1,450,810
AFT 100	4,990,538	4,898,892	3,267,643	1,526,677

APPENDIX D.5 AERODYNAMIC HEATING

APPENDIX D, SECTION 5

AERODYNAMIC HEATING

Convective film coefficients and recovery temperatures at Stations 2464, 2245, 1854, 1768, 1541, and 912 are presented as a function of flight time. The film coefficients are presented in Figures D.5-1 to D.5-6. The recovery temperatures are presented in Figures D.1-7 to D.5-12. The trajectory used is shown in Section 4.1.1.4, Table 4.1.1.4-II.

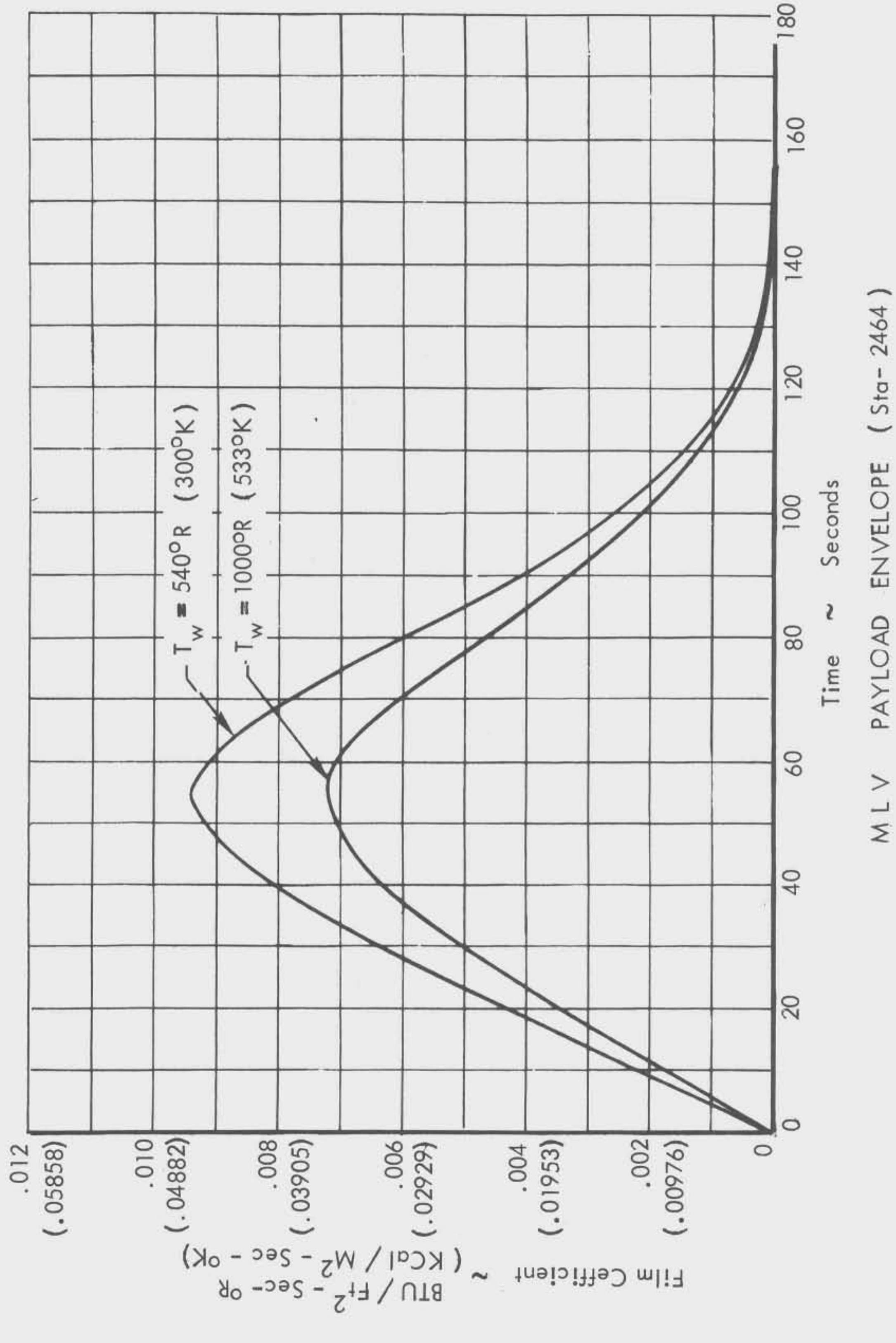


FIGURE D.5-1 FILM COEFFICIENT @ STATION 2464

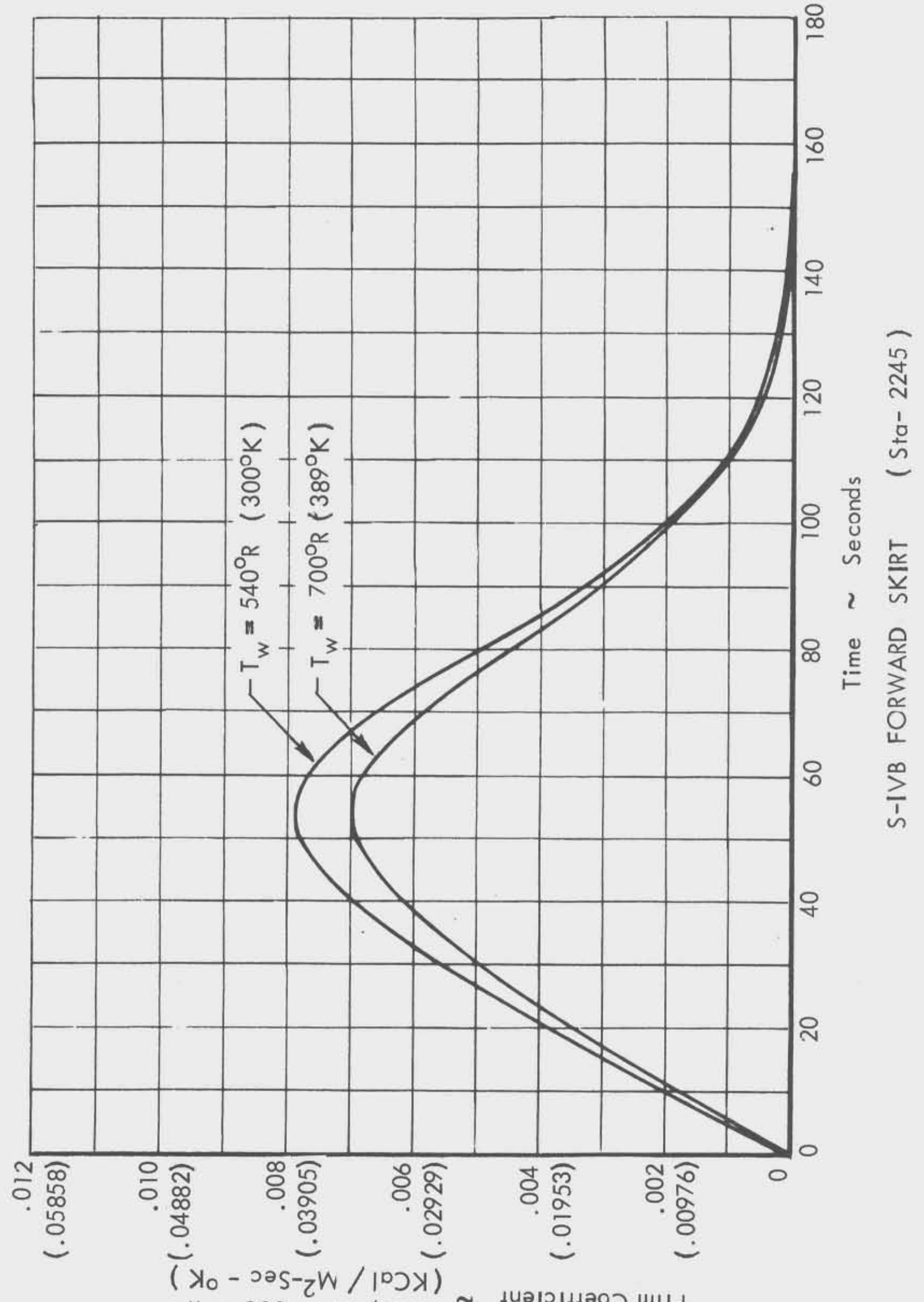


FIGURE D.5-2 FILM COEFFICIENT @ STATION 2245

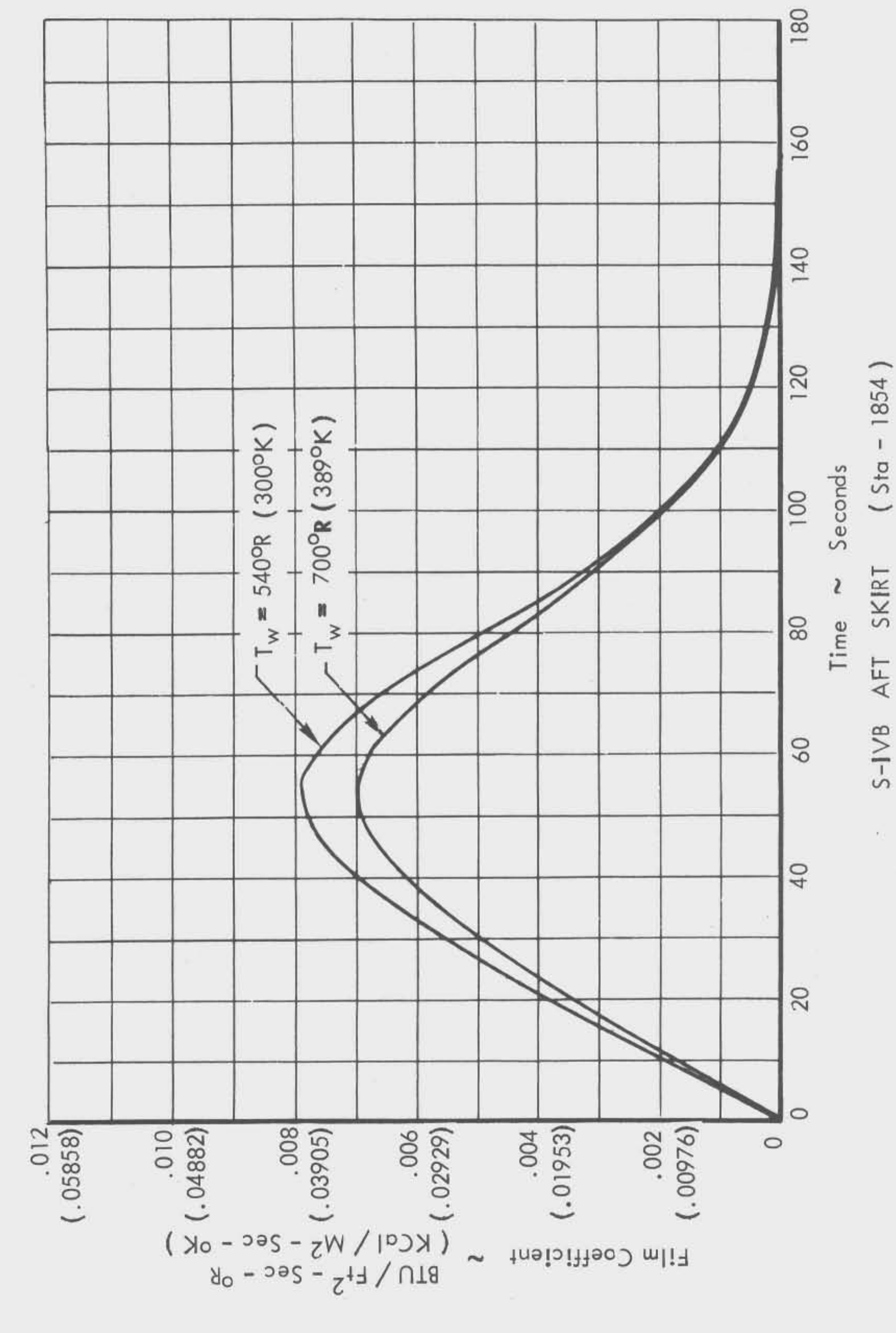


FIGURE D.5-3 FILM COEFFICIENT @ STATION 1854

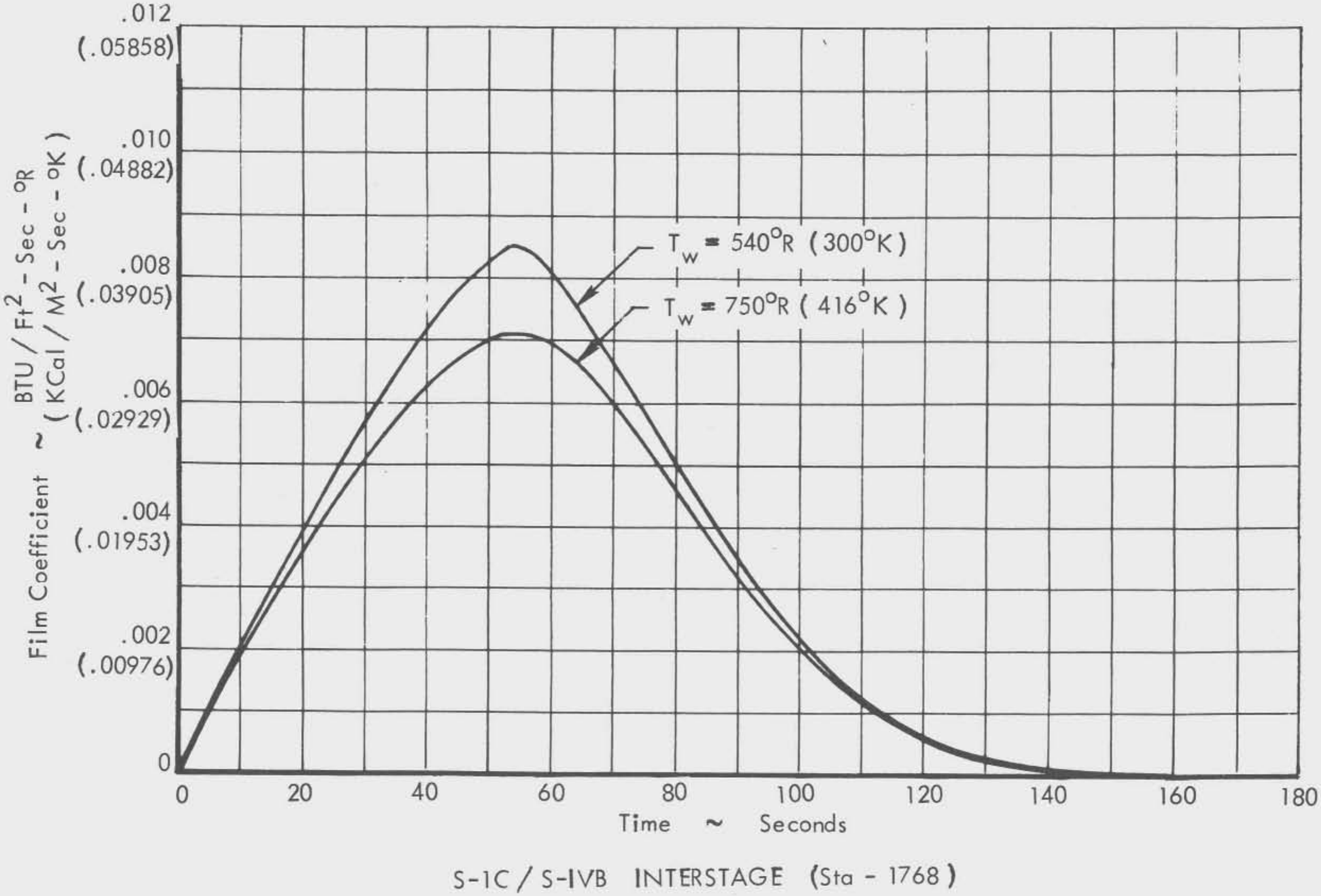


FIGURE D. 5-4 FILM COEFFICIENT @ STATION 1768

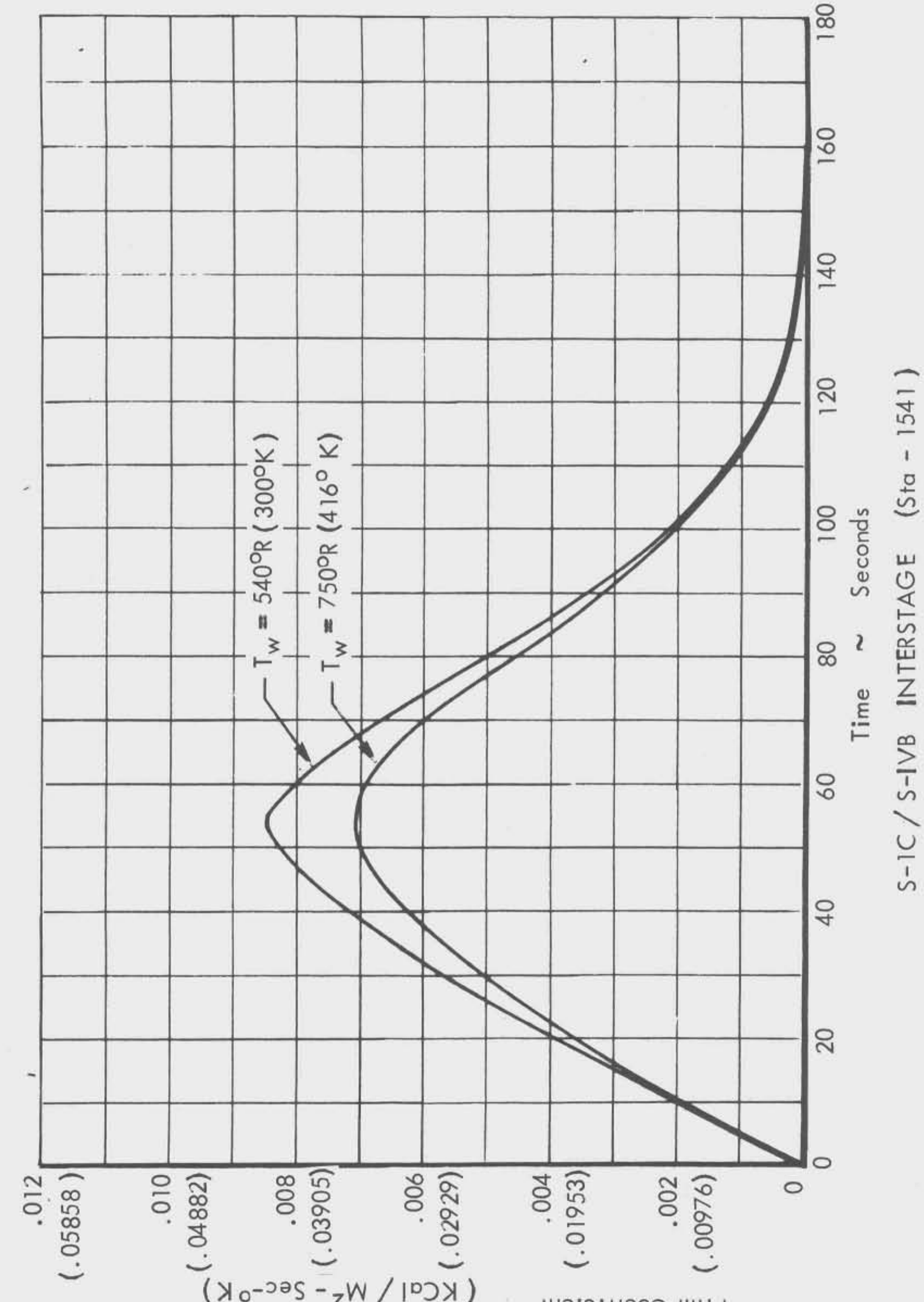
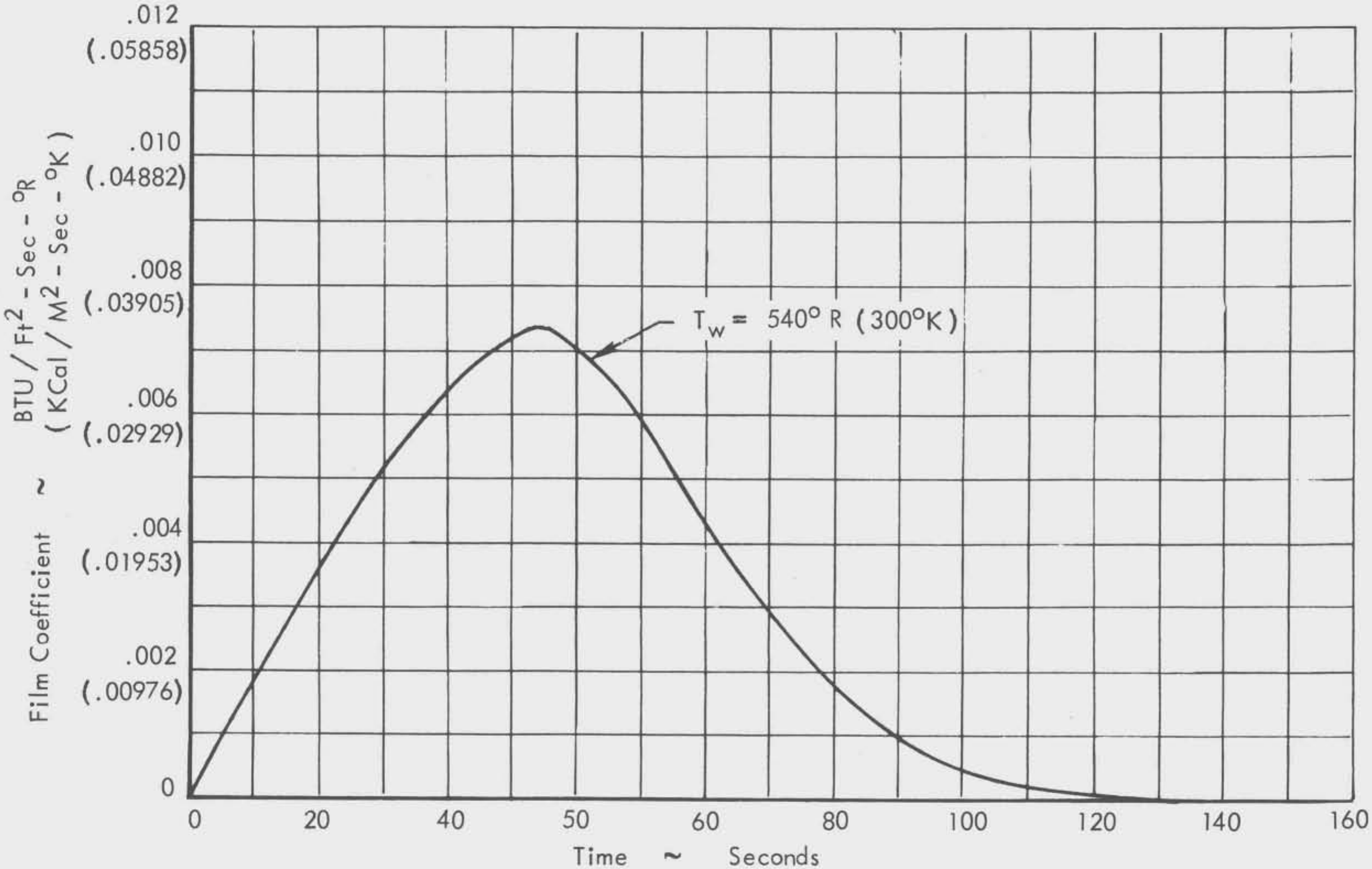


FIGURE D. 5-5 FILM COEFFICIENT @ STATION 1541



S - 1C CYLINDRICAL STRUCTURE (Sta - 912)

FIGURE D. 5-6 FILM COEFFICIENT @ STATION 912

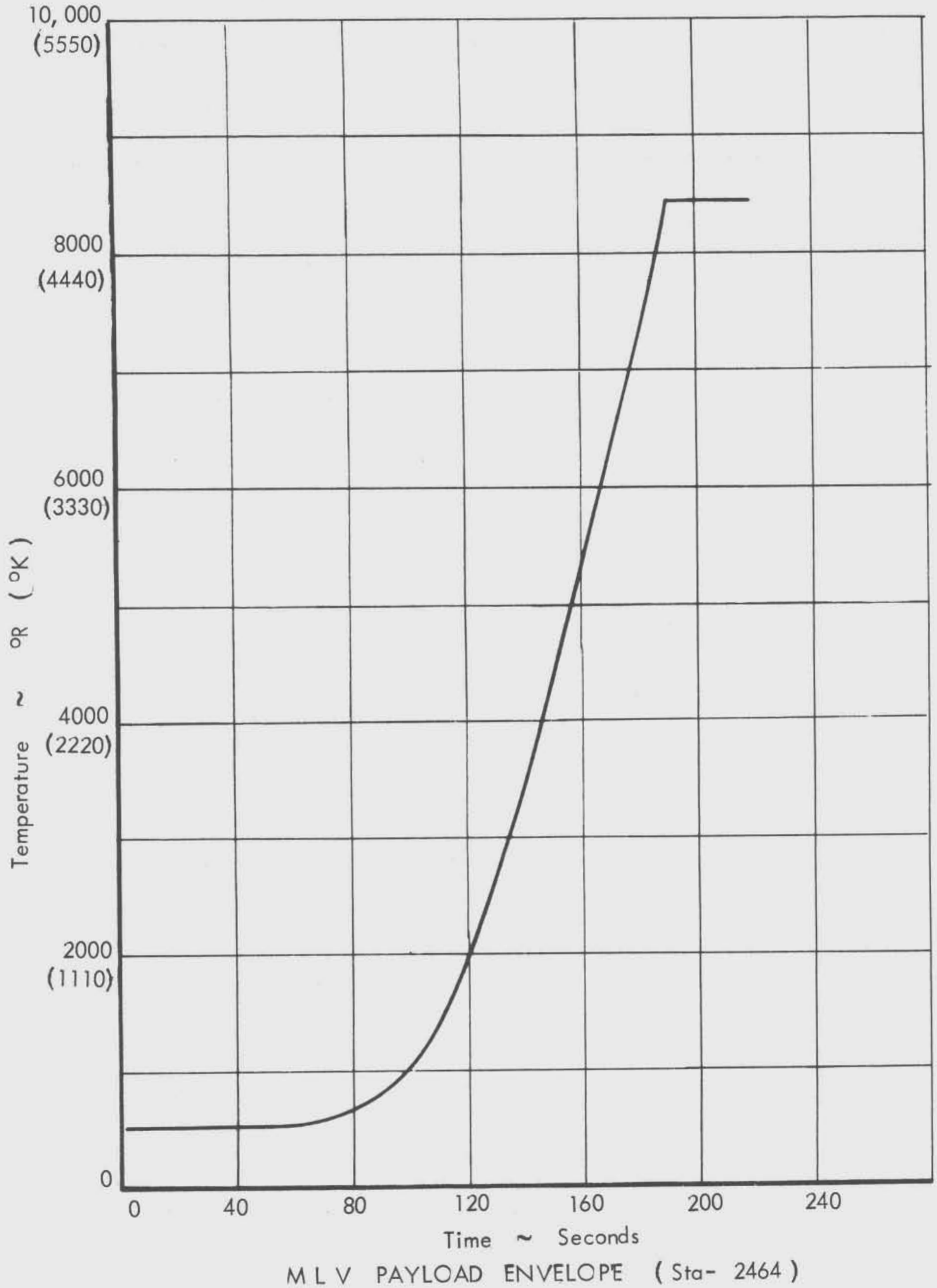


FIGURE D.5-7 RECOVERY TEMPERATURE @ STATION 2464

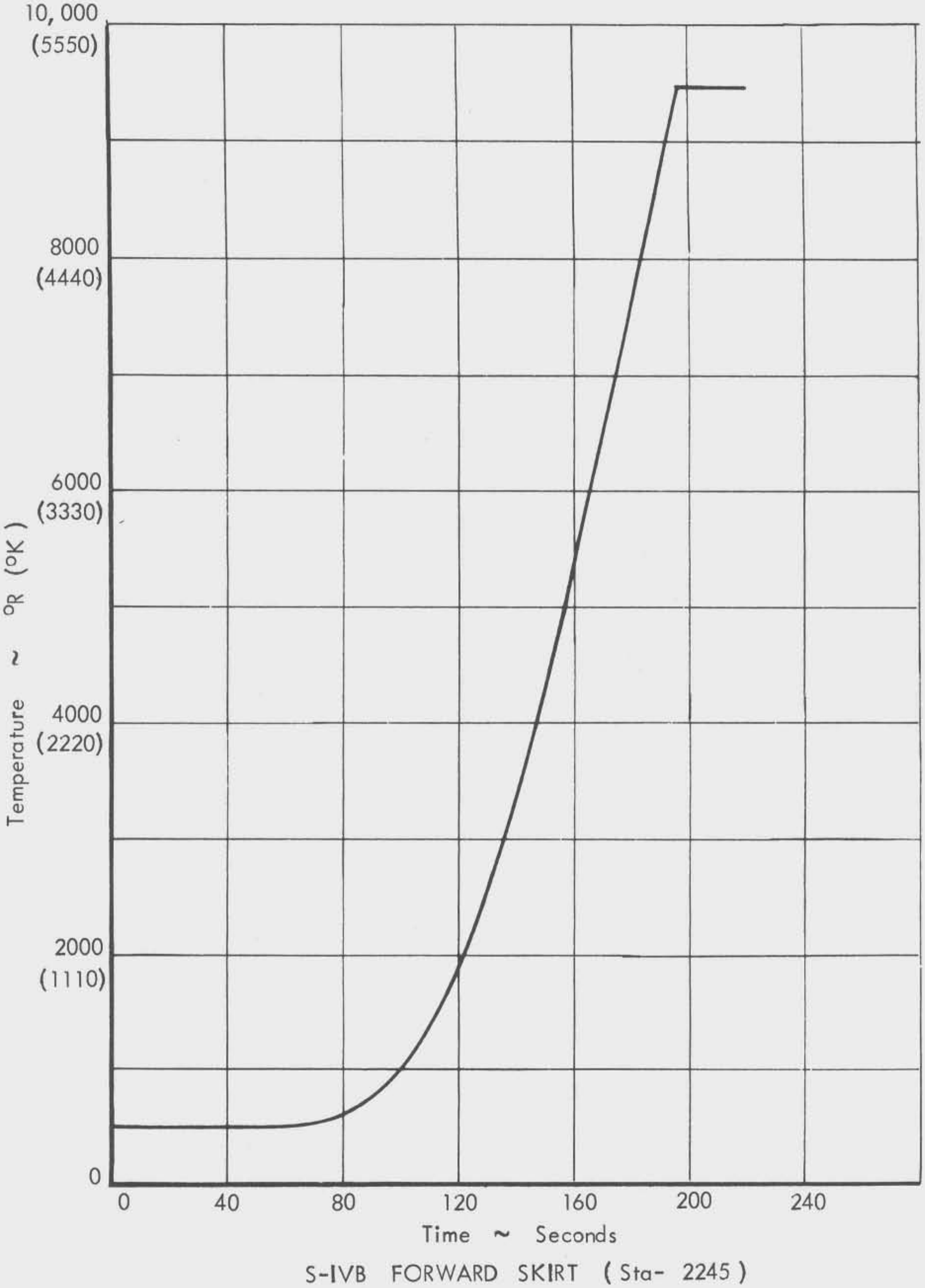


FIGURE D. 5-8 RECOVERY TEMPERATURE @ STATION 2245

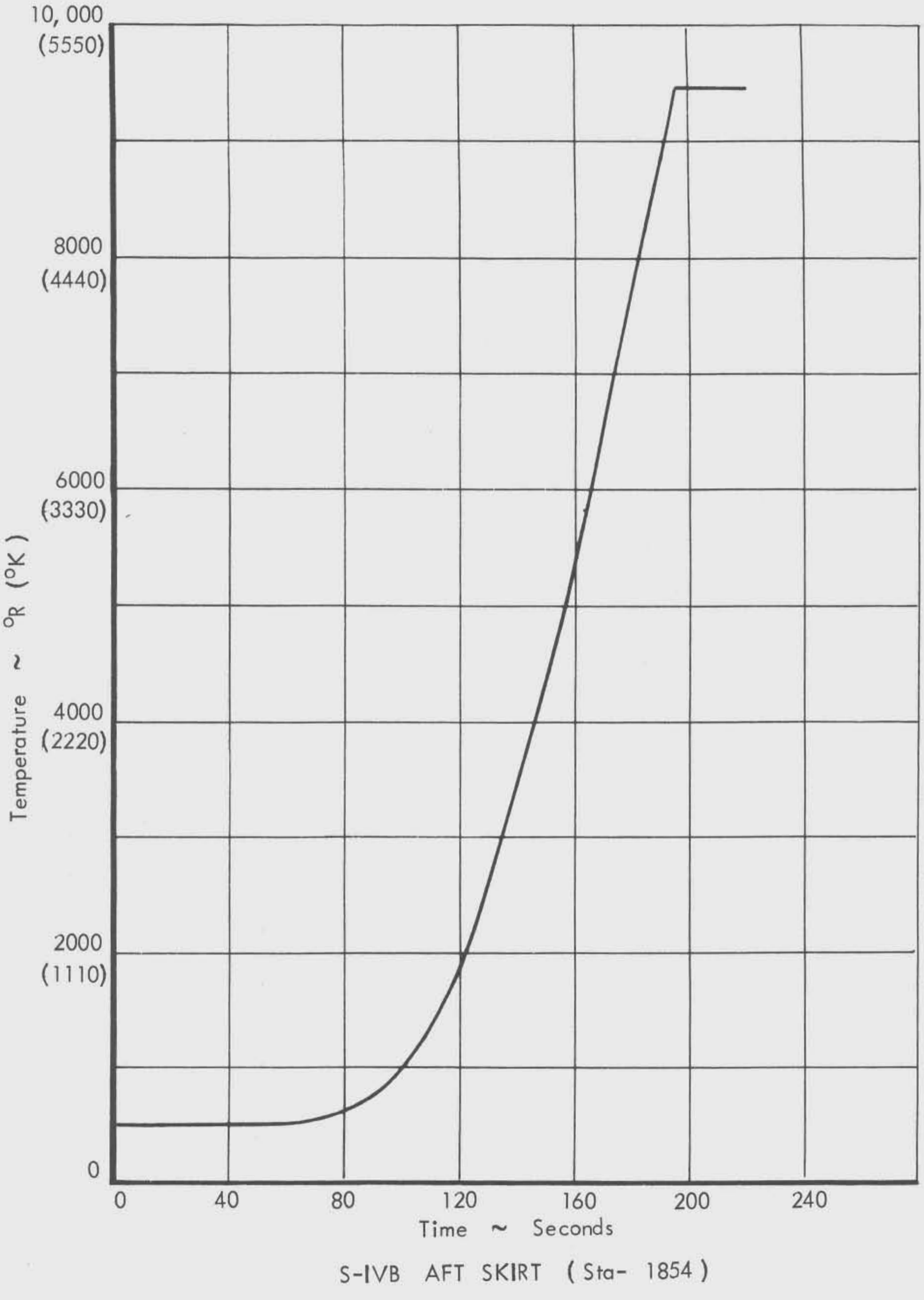


FIGURE D. 5-9 RECOVERY TEMPERATURE @ STATION 1854

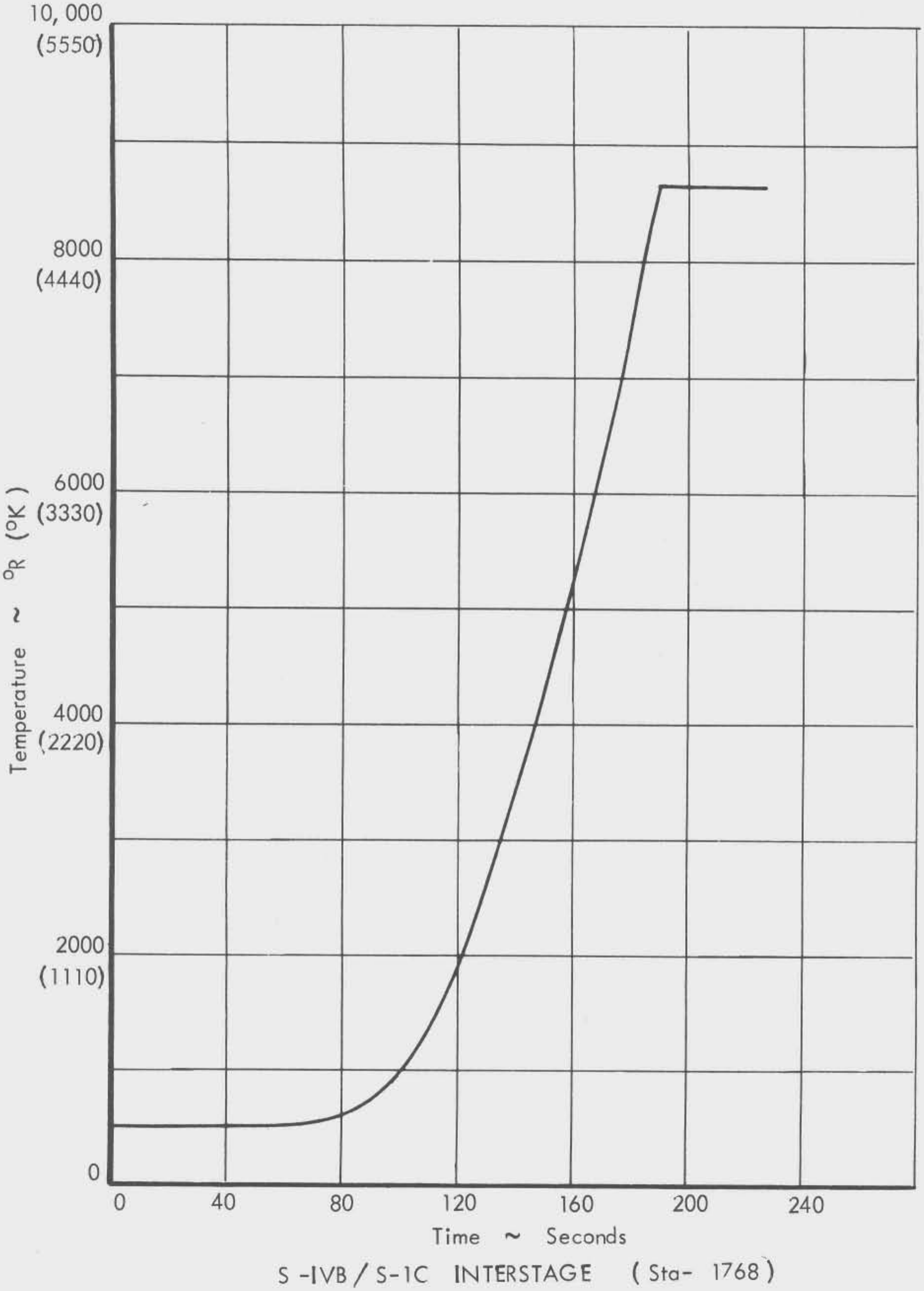


FIGURE D. 5-10 RECOVERY TEMPERATURE @ STATION 1768

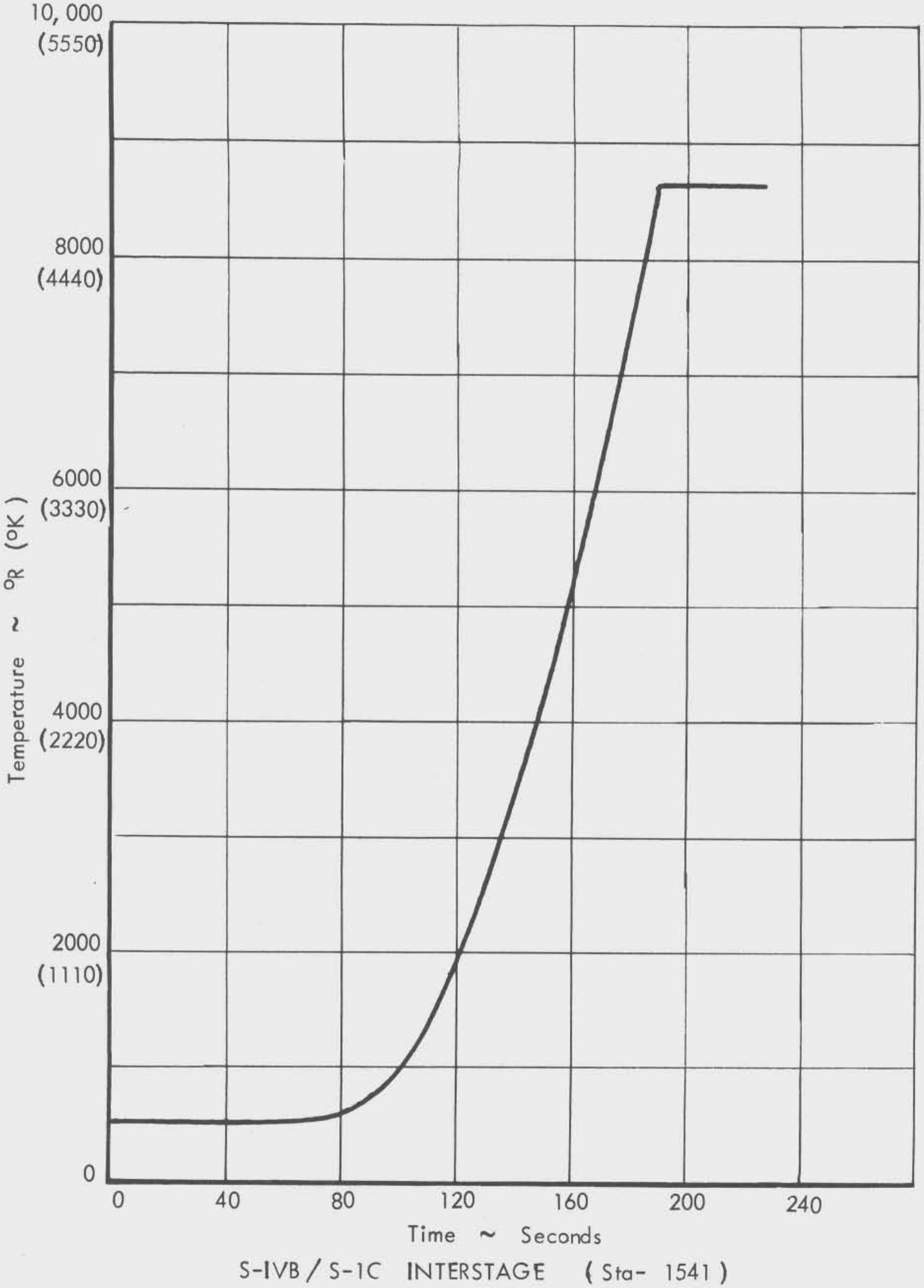


FIGURE D. 5-11 RECOVERY TEMPERATURE @ STATION 1541

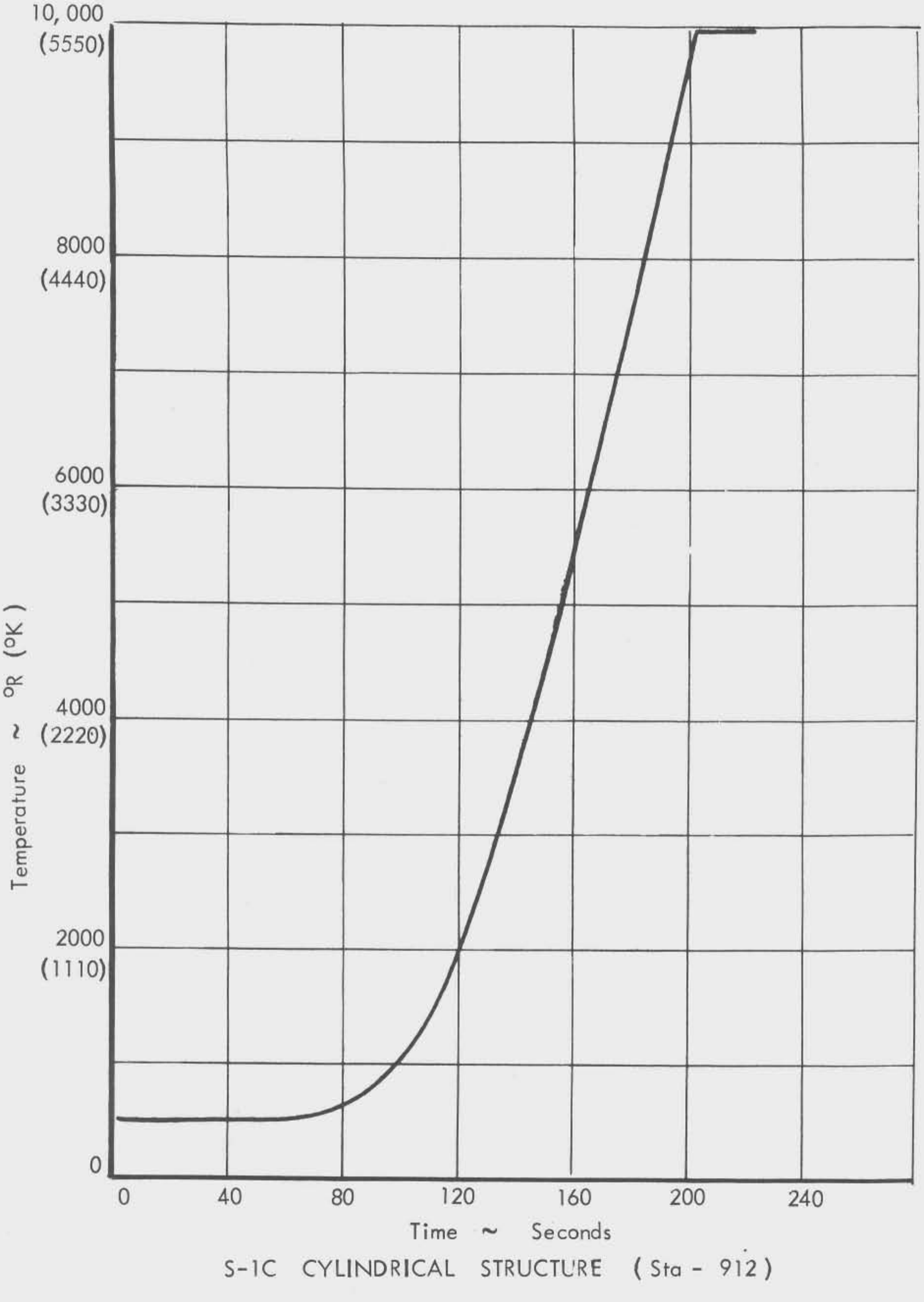


FIGURE D. 5-12 RECOVERY TEMPERATURE @ STATION 912