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C65-6462

CLASSIFICATION CHANGE

To UNCLASSIFIED

By authority of TAS-Ex 11652 Date 12/31/72

Changed by L. Shirley

Classified Document Master Control Station, NASA

Scientific and Technical Information Facility

Accession No. 06946-65

SID 65-828

PRELIMINARY

WEIGHT AND BALANCE REPORT

FOR

CSM END ITEM

SPACECRAFT 017 AND 020

CONTRACT NAS 9-150

(U)

EXHIBIT I, PARAGRAPH 8.10

1 JUNE 1965

Prepared by

Weight Control [redacted]

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TECHNICAL REPORT INDEX/ABSTRACT

ACCESSION NUMBER	[redacted] DOCUMENT SECURITY CLASSIFICATION [redacted]

TITLE OF DOCUMENT	LIBRARY USE ONLY
PRELIMINARY WEIGHT AND BALANCE REPORT FOR SPACECRAFT 017/020	
AUTHOR(S) D. D. Morgan	

CODE	ORIGINATING AGENCY AND OTHER SOURCES	DOCUMENT NUMBER
	NAA-S&ID	SID 65-828

PUBLICATION DATE	CONTRACT NUMBER
1 June 1965	NAS9-150

DESCRIPTIVE TERMS

ABSTRACT

The Preliminary Weight and Balance Report for CSM End Item Spacecraft 017/020 presents summary mass property data for each module in addition to the usable SPS propellant available within the injected weight constraints of the S-V Booster capability of 85,000 pounds as defined by MSFC Memorandum R-P and VE-VAW-65-16, dated 5 February 1965 and MSC Technical Report - Task MSC/STL A-20 - Apollo Mission SA501-3300-6001-RC000 NAS9-2938, dated 20 February 1965. The mass property data also includes the vehicle from launch to spacecraft at SPS burnout, the LEV abort phase to C/M at impact and the normal C/M entry mission. The C/M is ballasted to meet the required L/D = .34 at entry. The LES is ballasted to 8200 pounds which results in a center of gravity of Xa - 1122.8 for the LEV at LEV burnout.

The report also presents summary weight statements for each module (except LEM), including a breakdown for the GFE. Graphs representing weight versus c.g.'s and moments of inertia and products of inertia for the Command and Service Modules during SPS propellant burning and for the LEV during main motor burning are also contained in this report. Weight distributions are also presented for each module (except LEM) and for the SPS propellant.

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INTRODUCTION

This Preliminary Weight and Balance Report is submitted per Paragraph 2.4.3 of NASA Requirements Document ASPO-PS5-13-12 as deviated by Attachment "A" of enclosure to NAA Letter 65MA5254, dated 7 May 1965, and is representative of the CSM End Items for Spacecraft 017 and 020. The data contained in this report is based on the control weights included in SID 64-1237 CSM Master End Item Specification (Block I), dated 1 December 1964 and revised to incorporate the design requirements in SID 64-1085 CSM 017 End Item Specification, Part I, Performance/Design Requirements, Apollo, Revised 22 February 1965 and SID 64-1088 CSM 020 End Item Specification, Part I, Performance/Design Requirements, Apollo, Revised 22 February 1965.

This report includes ballast in the Command Module to meet the required L/D = .34 at entry. The mass properties summary in Section II reflects Spacecraft 017/020 module design weights consistent with the Block I control weights.

The Command Module design weight includes 133 pounds of ballast to attain the required L/D at entry and 130 pounds of ballast in the Stabilization and Control System to simulate the crew and crew couch weight and balance.

The Service Module SPS usable propellant of 38,500 pounds and the S-V booster capability of 85,000 pounds is consistent with the requirements defined by MSFC Memorandum R-P and VE-VAW-65-16, dated 5 February 1965 and MSC Technical Report - Task MSC/STL A-20 - Apollo Mission SA501-3300-6001-RC000 NAS9-2938, dated 20 February 1965. The RCS for the C/M and S/M have full capacity loading of propellant.

The Launch Escape Vehicle Summary, page 6, presents the LEV abort configuration. The LES is ballasted to 8200 pounds which results in a center of gravity of X_a = 1122.8 for the LEV at LEV burnout.

In addition to the weight versus center of gravity and inertia curves in Section 5A, curves representing weight versus the SPS gimbal angles in the X-Y and X-Z planes, and the true gimbal angle from the X axis during SPS burning are also included.

The LEM weight utilized in this report is 21,500 pounds per the above noted MSFC memorandum and the MSC Technical Report.

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SPACECRAFT 017/020

MODULE MASS PROPERTIES SUMMARY

ITEM	WEIGHT	CENTER OF GRAVITY*			MOMENT OF INERTIA**			PRODUCT OF INERTIA**		
		X	Y	Z	I_{xx}	I_{yy}	I_{zz}	I_{xy}	I_{xz}	I_{yz}
COMMAND MODULE	11000.0	1041.7	0.3	4.8	5460.0	4824.0	4240.0	-35.3	-279.5	26.6
SERVICE MODULE-LESS PROP.	10200.0	909.6	0.8	-1.3	6618.0	10619.0	10377.0	286.6	-502.0	-609.2
LAUNCH ESCAPE SYSTEM	8200.0	1298.4	0.0	0.0	571.0	21482.0	21484.0	-0.1	72.4	20.9
ADAPTER	3800.0	647.2	0.7	-2.4	9431.0	13209.0	12910.0	3.9	-72.5	-10.6
LEM***	21500.0	588.5	0.0	0.0	13951.0	15444.0	15253.0	-	-	-

*Centers of gravity are in the NASA reference system except that the longitudinal axis has an origin 1000 inches below the tangency point of the Command Module substructure mold line.

**Moments and products of inertia are slug feet squared about the center of gravity.

***Reference MSFC Memorandum R-P and VE-VAW-65-16, dated 5 February 1965 and MSC Technical Report - Task MSC/STL A-20 - Apollo Mission SA501-3300-6001-RC000 NAS9-2938, dated 20 February 1965.

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SPACECRAFT 017/020 MISSION

ITEM	WEIGHT	CENTER OF GRAVITY*			MOMENT OF INERTIA**			PRODUCT OF INERTIA**		
		X	Y	Z	Ixx	Iyy	Izz	Ixy	Ixz	Iyz
COMMAND MODULE	11000.0	1041.7	0.3	4.8	5460.0	4824.0	4240.0	-35.3	-279.5	26.6
SERVICE MODULE-LESS PROP.	10200.0	909.6	0.8	-1.3	6618.0	10619.0	10377.0	286.6	-502.0	-609.2
SLA ATTACHMENT RING****	75.0	837.1	0.0	-1.8	93.0	48.0	46.0	-	-	-
TOTAL-LESS PROPELLANT	21275.0	977.6	0.5	1.9	12214.0	35788.9	34918.5	177.1	147.3	-586.1
PROPELLANT - S/M	38500.0	903.4	4.6	-2.0	19893.0	19974.0	26790.0	2377.0	-1065.0	3800.0
TOTAL-WITH PROPELLANT	59775.0	929.8	3.2	-0.6	32199.7	72110.5	78060.9	1662.2	-71.7	3167.7
ADAPTER****	3725.0	643.4	0.7	-2.4	9338.0	12566.0	12289.0	6.1	-74.4	-10.6
LEM***	21500.0	588.5	0.0	0.0	13951.0	15444.0	15253.0	-	-	-
TOTAL INJECTED - TRAJECTORY	85000.0	830.9	2.2	-0.5	55528.9	527324.9	532839.1	5587.4	-586.7	3152.7
LAUNCH ESCAPE SYSTEM	8200.0	1298.4	0.0	0.0	571.0	21482.0	21484.0	-0.1	72.4	20.9
TOTAL - AT LAUNCH	93200.0	872.1	2.1	-0.5	56108.6	901541.5	907065.4	3890.3	-101.2	3171.6

*Centers of gravity are in the NASA reference system except that the longitudinal axis has an origin 1000 inches below the tangency point of the Command Module substructure mold line.

**Moments and products of inertia units are slug feet squared about the center of gravity.

***Reference MSFC Memorandum R-P and VE-VAW-65-16, dated 5 February 1965 and MSC Technical Report - Task MSC/STL A-20 - Apollo Mission SA501-3300-6001-RC000 NAS9-2938, dated 20 February 1965.

****75.0 pounds of the Adapter remains with the Command/Service Module after separation of the Adapter.

SPACECRAFT 017/020

LAUNCH ESCAPE VEHICLE

ITEM	WEIGHT	CENTER OF GRAVITY*			MOMENT OF INERTIA**			PRODUCT OF INERTIA**		
		X	Y	Z	I_{xx}	I_{yy}	I_{zz}	I_{xy}	I_{xz}	I_{yz}
COMMAND MODULE	11000.0	1041.7	0.3	4.8	5460.0	4824.0	4240.0	-35.3	-279.5	26.6
LAUNCH ESCAPE SYSTEM	8200.0	1298.4	0.0	0.0	571.0	21482.0	21484.0	-0.1	70.4	20.9
TOTAL-INITIAL ABORT	19200.0	1151.3	0.2	2.7	6054.5	93147.6	92542.3	-113.5	-1456.5	49.0
LESS: MAIN AND PITCH MOTOR PROPELLANTS	-3198.0	1294.3	0.0	0.0	71.4	13367.0	13360.0	-	-	-
TOTAL LEV - BURNOUT	16002.0	1122.8	0.2	3.3	5976.8	74876.1	74277.7	-93.1	-1130.9	48.6

*Centers of gravity are in the NASA reference system except that the longitudinal axis has an origin 1000 inches below the tangency point of the Command Module substructure mold line.

**Moments and products of inertia units are slug feet squared about the center of gravity.

SPACECRAFT 017/020

C/M LOW ALTITUDE ABORT CONFIGURATION

ITEM	WEIGHT	CENTER OF GRAVITY*			MOMENT OF INERTIA**			PRODUCT OF INERTIA**		
		X	Y	Z	I_{xx}	I_{yy}	I_{zz}	I_{xy}	I_{xz}	I_{yz}
COMMAND MODULE-LAUNCH	11000.0	1041.7	0.3	4.8	5460.0	4824.0	4240.0	-35.3	-279.5	26.6
LESS: RCS OXIDIZER	-180.0	1022.6	15.6	62.4	-	-	-	-	-	-
FORWARD HEAT SHIELD	-414.0	1098.5	0.0	0.4	-	-	-	-	-	-
DROGUE CHUTES	-56.0	1089.1	0.0	-21.0	-	-	-	-	-	-
COMMAND MODULE - PRIOR TO MAIN CHUTE DEPLOYMENT	10350.0	1039.5	0.0	4.1	5311.0	4343.9	3890.4	-23.5	-203.0	-8.2
LESS: RCS FUEL	-90.0	1022.6	-46.5	44.9	-	-	-	-	-	-
MAIN CHUTES (3)	-382.0	1091.6	-0.7	7.7	-	-	-	-	-	-
COMMAND MODULE - IMPACT	9878.0	1037.6	0.5	3.6	5234.5	4073.2	3611.1	-33.8	-207.0	29.4

*Centers of gravity are in the NASA reference system except that the longitudinal axis has an origin 1000 inches below the tangency point of the Command Module substructure mold line.

**Moments and products of inertia units are slug feet squared about the center of gravity.

SPACECRAFT 017/020

C/M ENTRY MISSION

ITEM	WEIGHT	CENTER OF GRAVITY*			MOMENT OF INERTIA**			PRODUCT OF INERTIA**		
		X	Y	Z	I_{xx}	I_{yy}	I_{zz}	I_{xy}	I_{xz}	I_{yz}
COMMAND MODULE-LAUNCH	11000.0	1041.7	0.3	4.8	5460.0	4824.0	4240.0	-35.3	-279.5	26.6
LESS: PROPELLANT	-135.0	1022.6	-5.1	56.6	-	-	-	-	-	-
ABLATOR BURNOFF***	-365.0	1016.2	-0.4	15.7	-	-	-	-	-	-
FORWARD HEAT SHIELD	-414.0	1098.5	0.0	0.4	-	-	-	-	-	-
DROGUE CHUTES	-56.0	1089.1	0.0	-21.0	-	-	-	-	-	-
COMMAND MODULE-PRIOR TO MAIN CHUTE DEPLOYMENT	10030.0	1040.3	0.4	4.0	5360.5	4343.7	3857.4	-37.7	-194.0	35.3
LESS: MAIN CHUTES (3)	-382.0	1091.6	-0.7	7.7	-	-	-	-	-	-
PROPELLANT	-135.0	1022.6	-5.1	56.6	-	-	-	-	-	-
COMMAND MODULE - IMPACT	9513.0	1038.5	0.5	3.1	5276.2	4027.4	3623.3	-35.3	-185.8	44.3

*Centers of gravity are in the NASA reference system except that the longitudinal axis has an origin 1000 inches below the tangency point of the Command Module substructure mold line.

**Moments and products of inertia units are slug feet squared about the center of gravity.

***Ablator burnoff based on normal entry condition.

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WEIGHT SUMMARY STATEMENT

COMMAND MODULE

COMMAND MODULE			
Weight Empty			10703.3
Structure (Incl. Ballast)*		5369.0	
Stabilization & Control		1100.0	
S&C Equipment	190.0		
Mechanical Platform Instl.**	910.0		
Guidance & Navigation (GFE)		430.0	
Environmental Control		401.0	
Earth Recovery		593.8	
Instrumentation (Incl. 142.2 GFE)		274.7	
Electrical Power		1677.8	
Reaction Control		306.0	
Communications		346.3	
Displays & Controls		204.7	
Useful Load			296.7
Reaction Control Propellant		270.0	
Environmental Control (Incl. 10.0 Cooling Water)		26.7	
TOTAL COMMAND MODULE			11000.0

*Aft heat shield L/D ballast (133 pounds).
**Platform ballast consistent with attenuation struts design requirements (130 pounds).

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WEIGHT SUMMARY STATEMENT

SERVICE MODULE

SERVICE MODULE		
Weight Empty		8081.0
Structure	2451.0	
Environmental Control	105.0	
Instrumentation (Incl. 25.5 GFE)	145.0	
Electrical Power	1655.0	
Service Propulsion	3136.0	
Reaction Control	589.0	
Useful Load		2119.0
Fluid Residuals	722.0	
Usable Fluids	1397.0	
TOTAL SERVICE MODULE		10200.0

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WEIGHT SUMMARY STATEMENT

LAUNCH ESCAPE SYSTEM

LAUNCH ESCAPE SYSTEM		
Structure		1527.0
Tower and Insulation	437.0	
Escape Motor Skirt and Insulation	231.0	
Canard	829.0	
Q-Ball and Attachments (Incl. 25.0 GFE)	30.0	
Separation Provisions		15.0
Ballast		654.0
Propulsion		5410.0
Escape Motor	4826.0	
Jettison Motor	535.0	
Pitch Motor	49.0	
Electrical Power		55.0
CM Boost Protective Cover		539.0
TOTAL LAUNCH ESCAPE SYSTEM		8200.0

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WEIGHT SUMMARY STATEMENT

ADAPTER

ADAPTER		
Structure		3350.0
Basic Body Structure	3070.0	
Secondary Structure	280.0	
Insulation		20.0
Separation Provisions and Attachments		360.0
Electrical Provisions		70.0
TOTAL ADAPTER		3800.0

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GOVERNMENT FURNISHED EQUIPMENT

COMMAND MODULE		
Guidance and Navigation		430.0
Instrumentation - R&D		142.2
PAM/FM/FM Package	16.0	
Gas Chromatograph	9.5	
Commutator (3)	9.0	
Survival VHF Beacon/Transciever	5.2	
Calibrator and Timer	5.0	
Cameras (2)	40.0	
Camera Control Box	3.0	
Timing Pulse Generator	2.5	
Battery	52.0	
SERVICE MODULE		
Instrumentation - R&D		25.5
PAM/FM/FM Package	25.5	
LAUNCH ESCAPE SYSTEM		
"Q" Ball		25.0
TOTAL GOVERNMENT FURNISHED EQUIPMENT		622.7

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COMMAND MODULE DESIGN WEIGHT DISTRIBUTION

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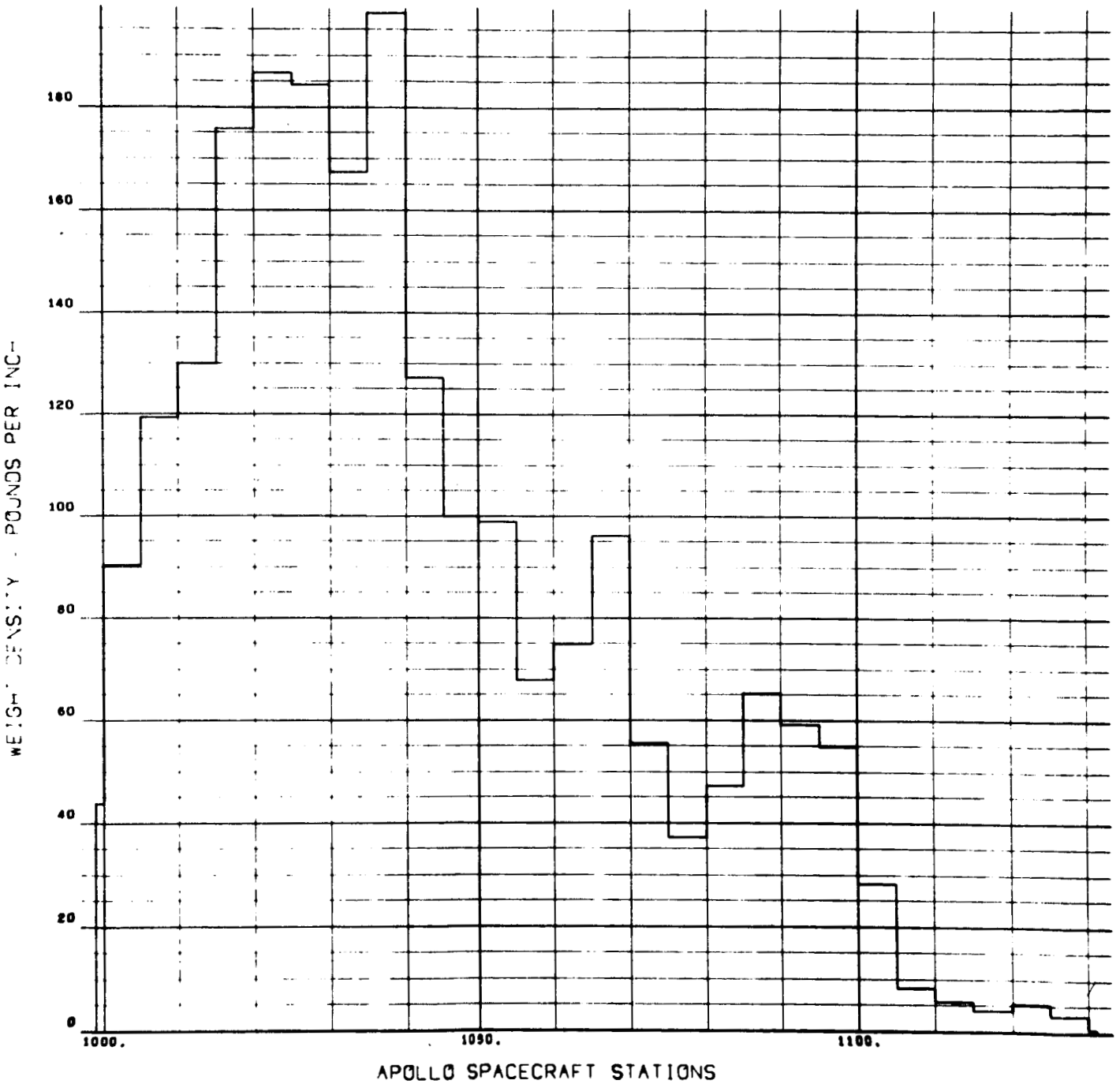

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SERVICE MODULE DESIGN WEIGHT DISTRIBUTION

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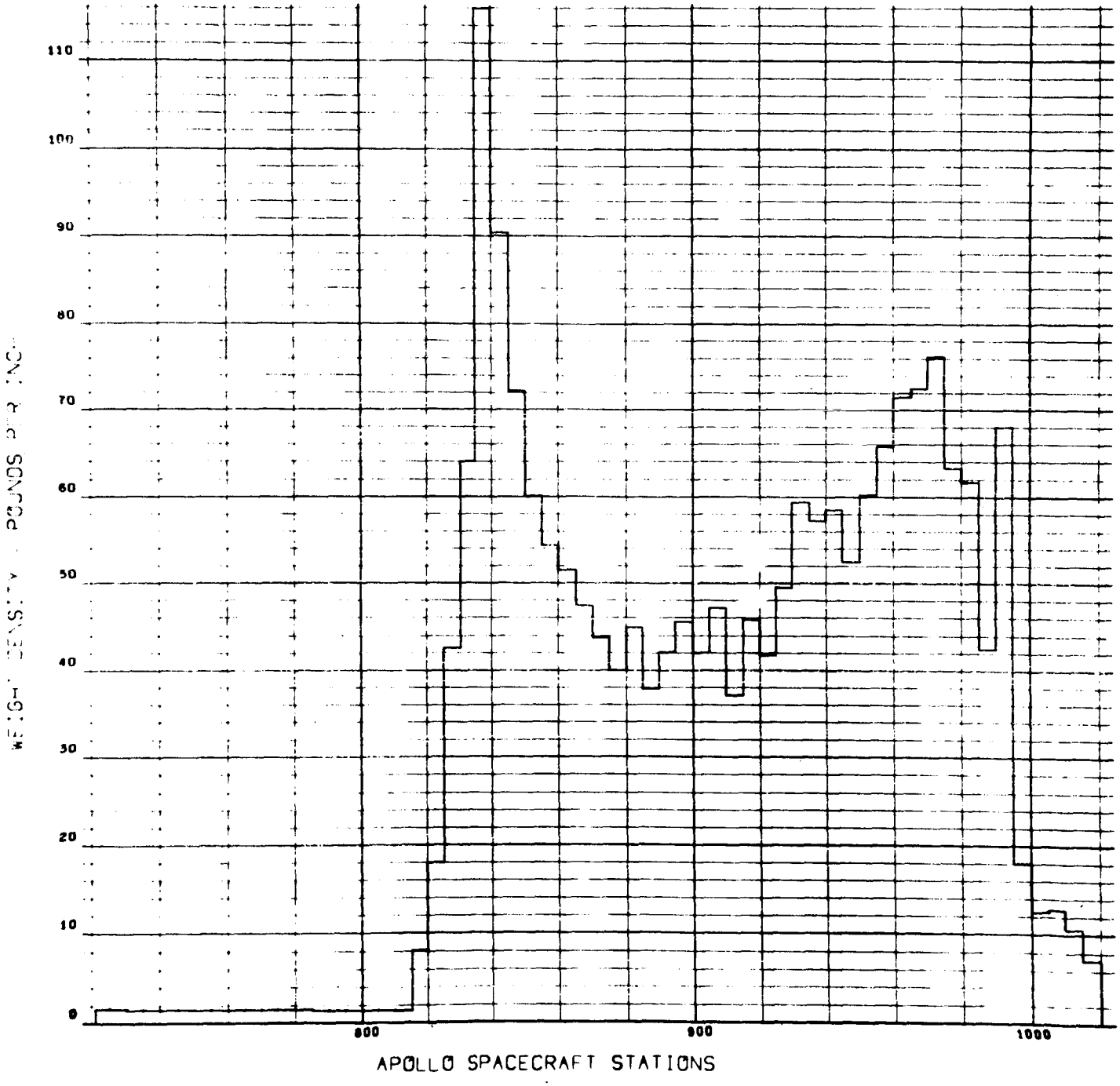

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SERVICE MODULE PROPELLANT 38500 LBS WEIGHT DISTRIBUTION

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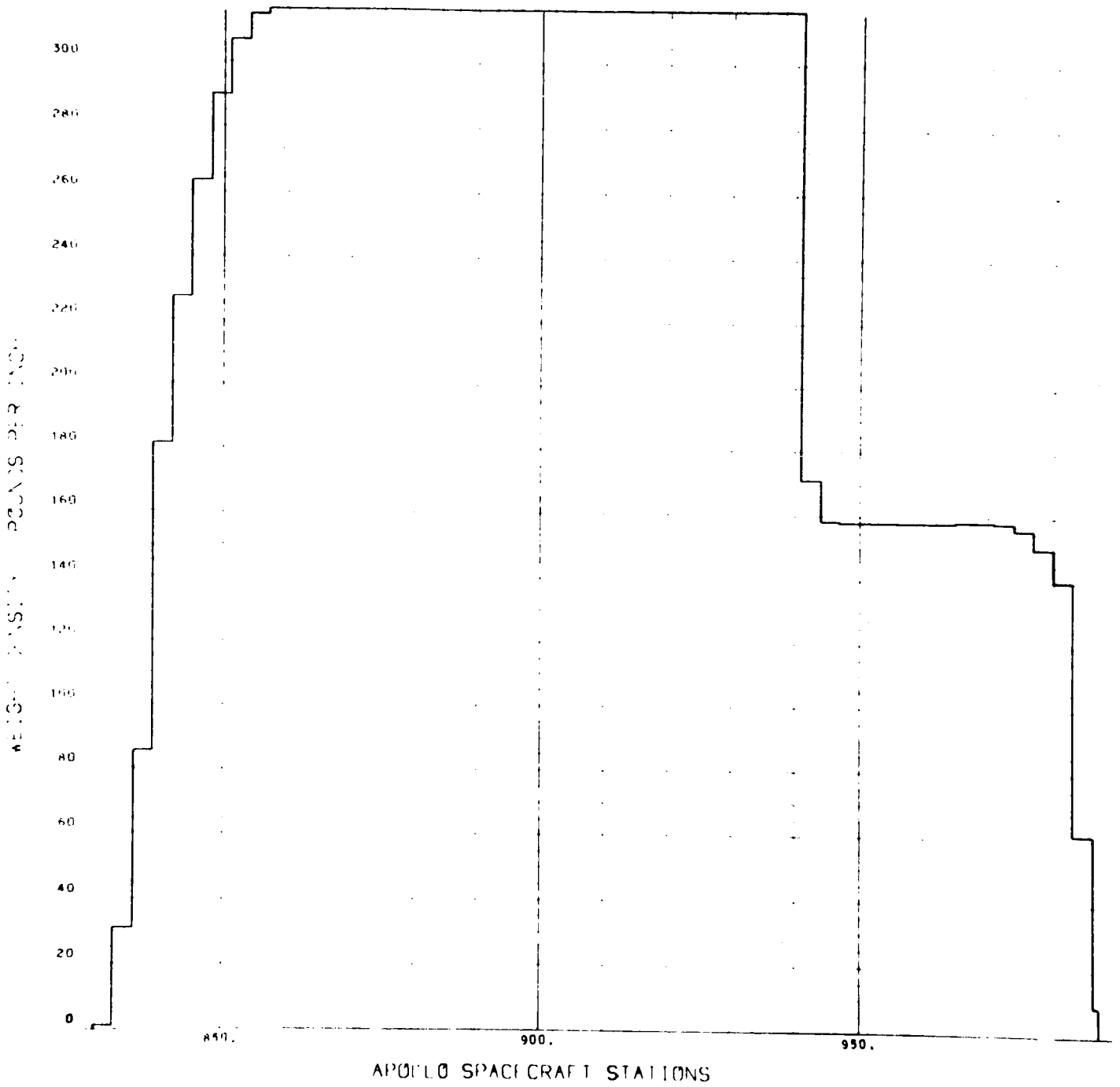

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LAUNCH ESCAPE SYSTEM DESIGN WEIGHT DISTRIBUTION

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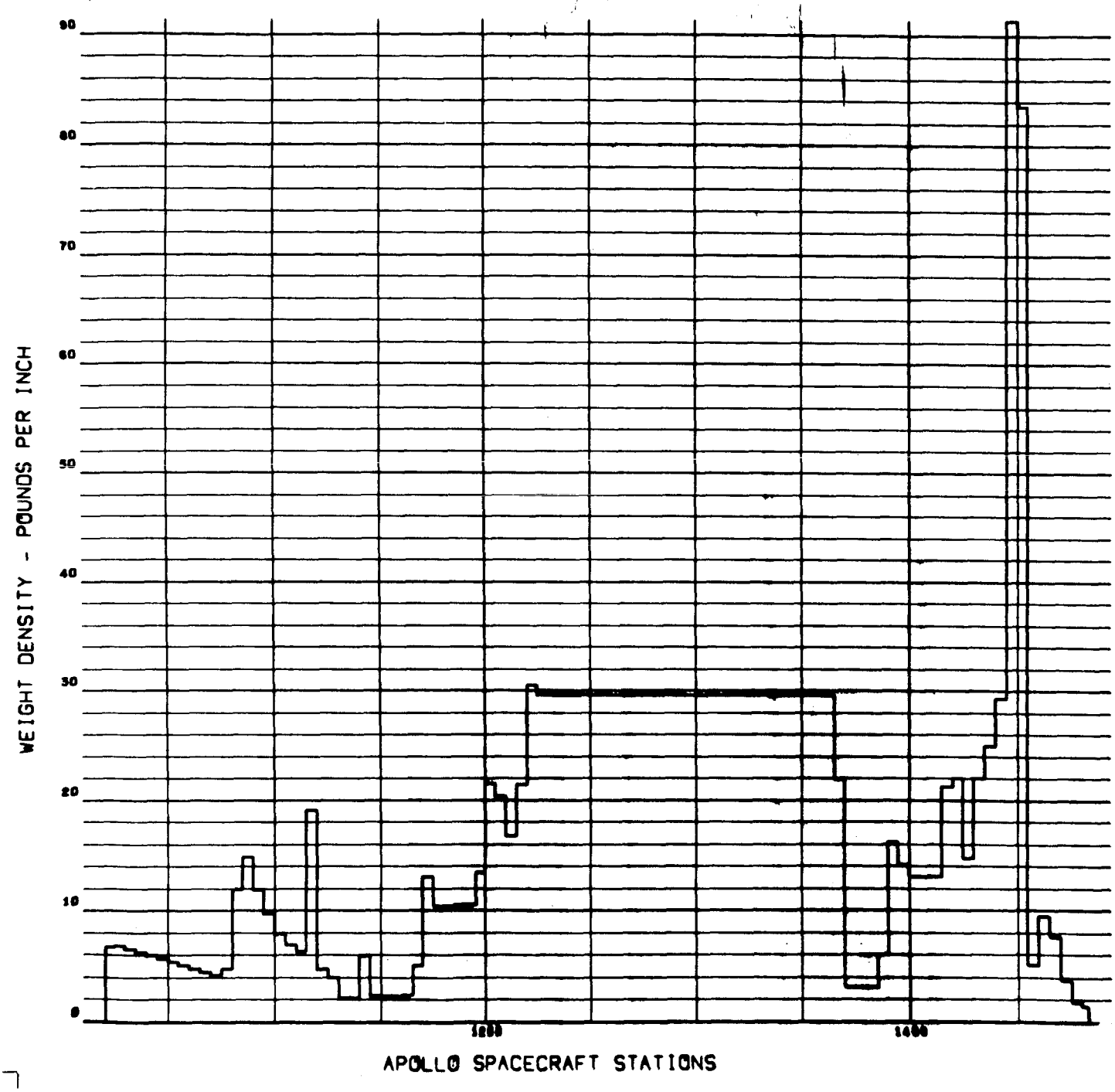

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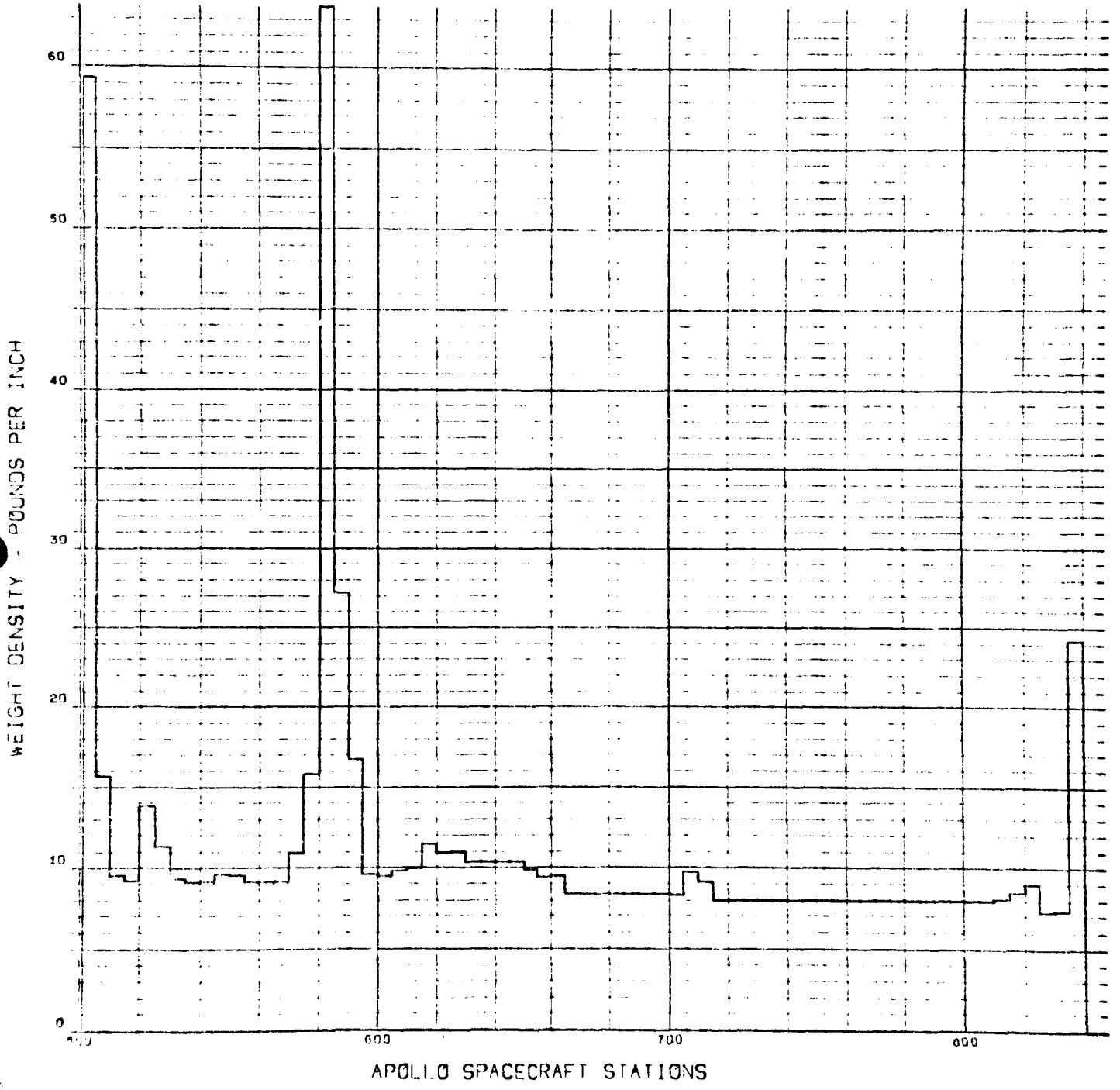

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Command and Service Modules with SPS Propellant

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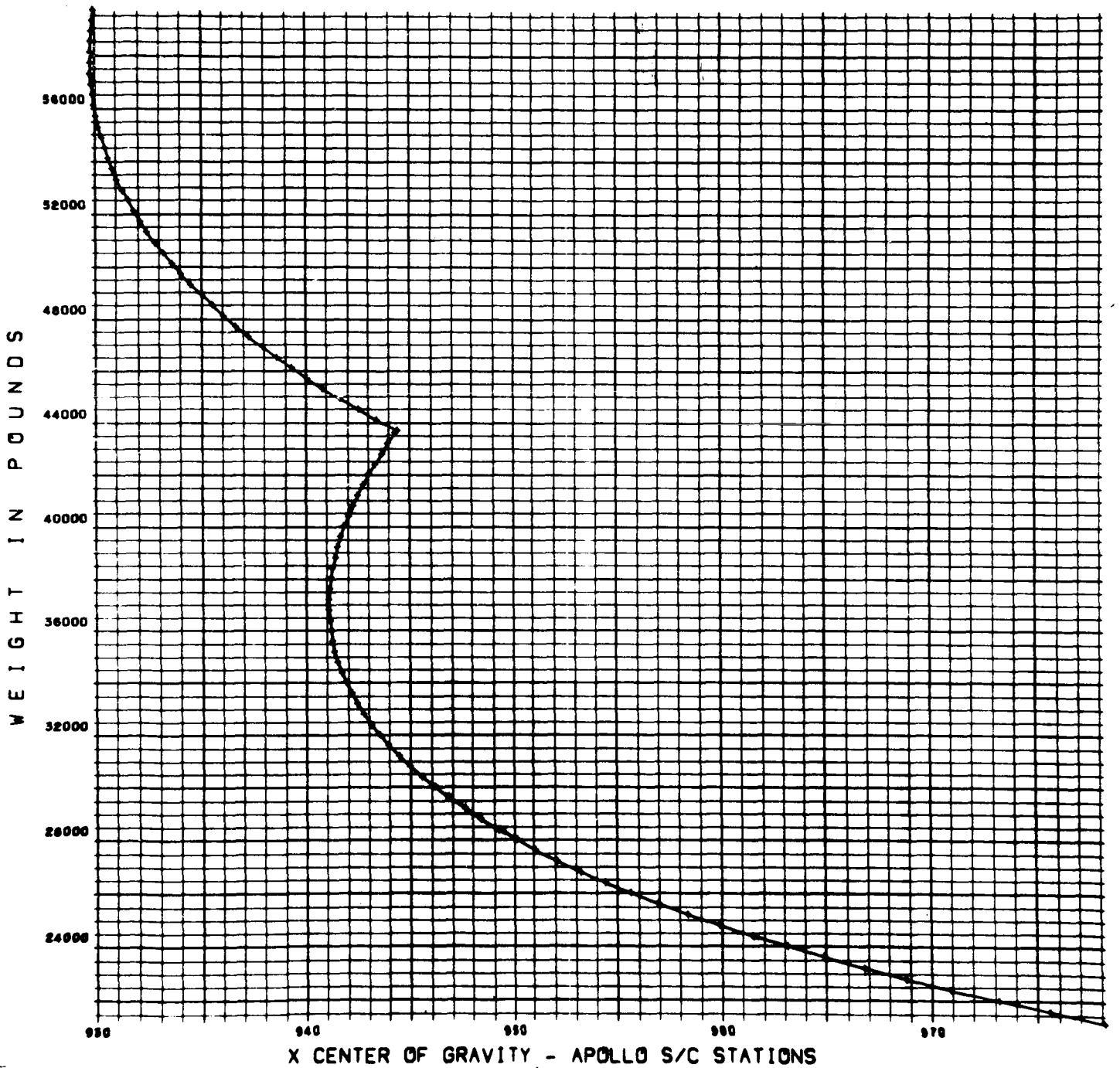

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Command and Service Modules with SPS Propellant

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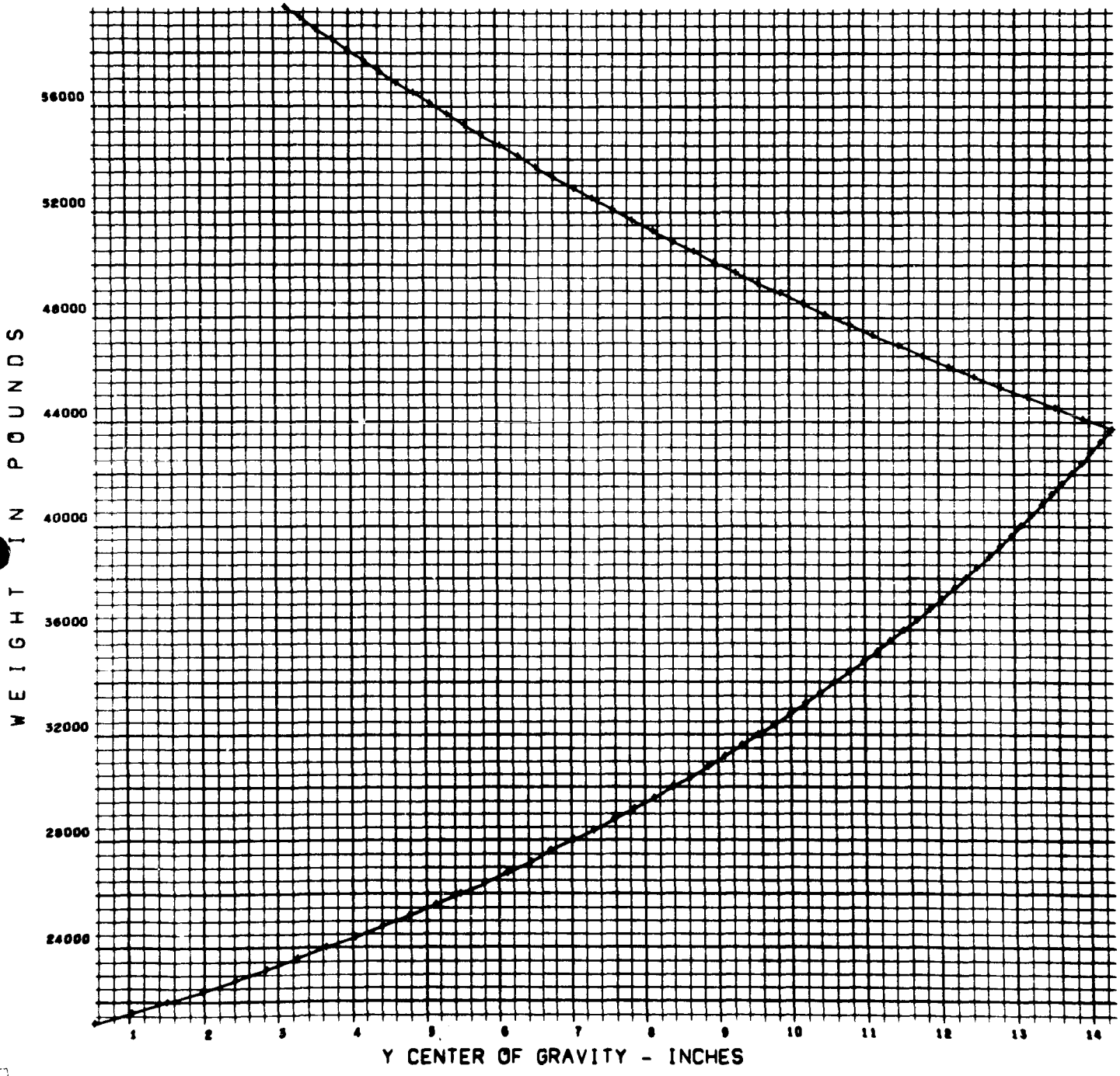

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Command and Service Modules with SPS Propellant

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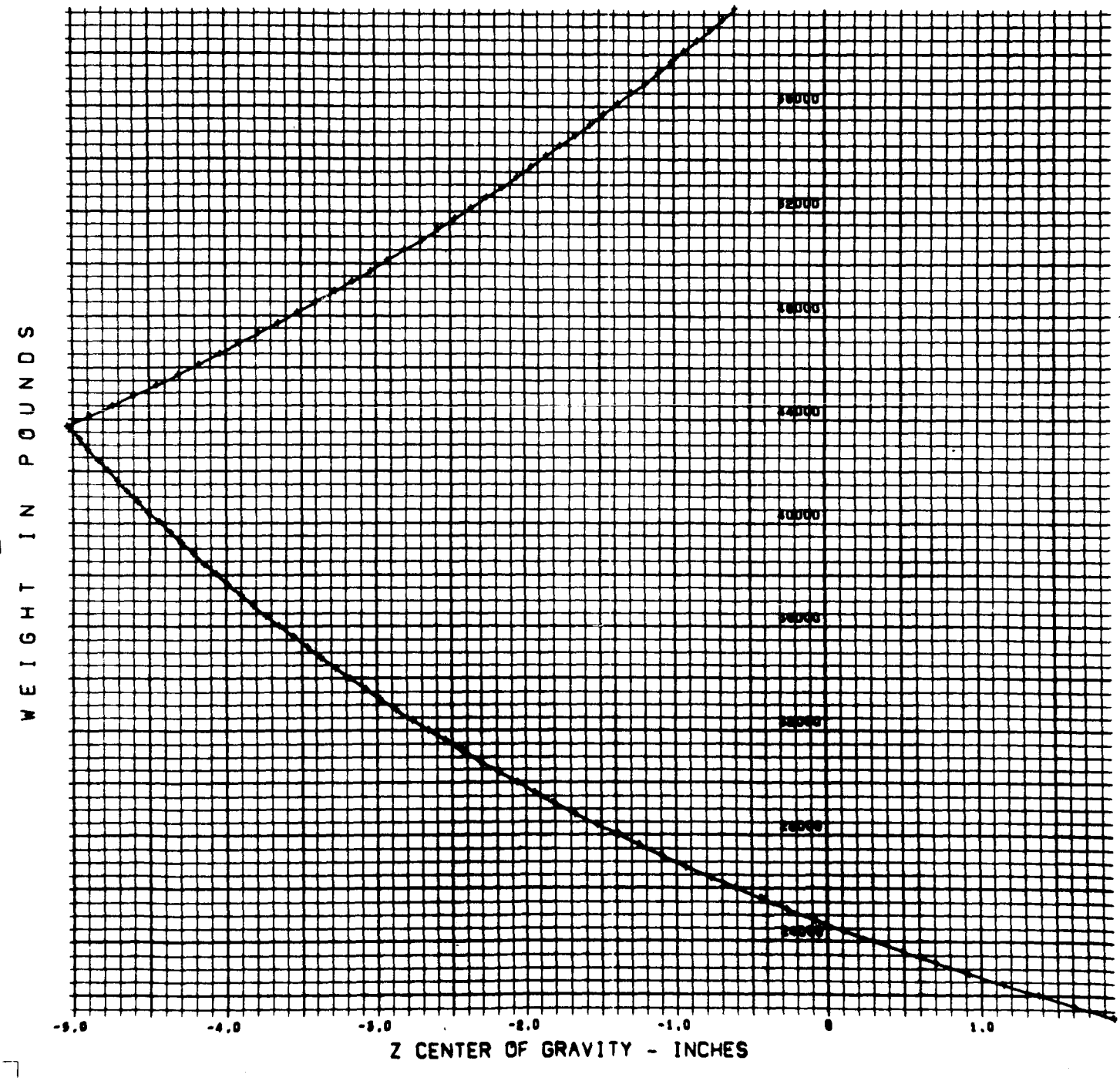

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Command and Service Modules with SPS Propellant

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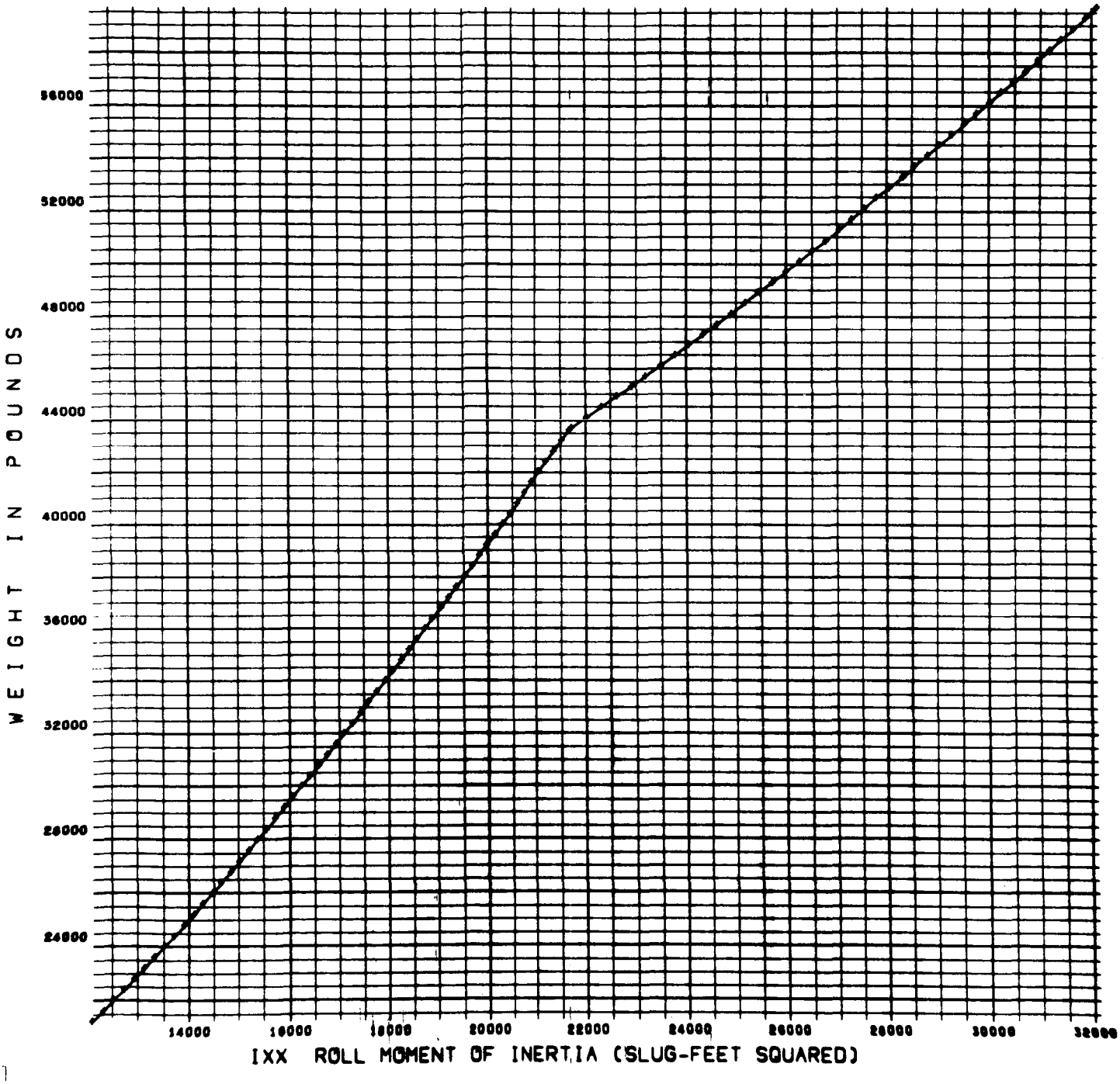

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Command and Service Modules with SPS Propellant

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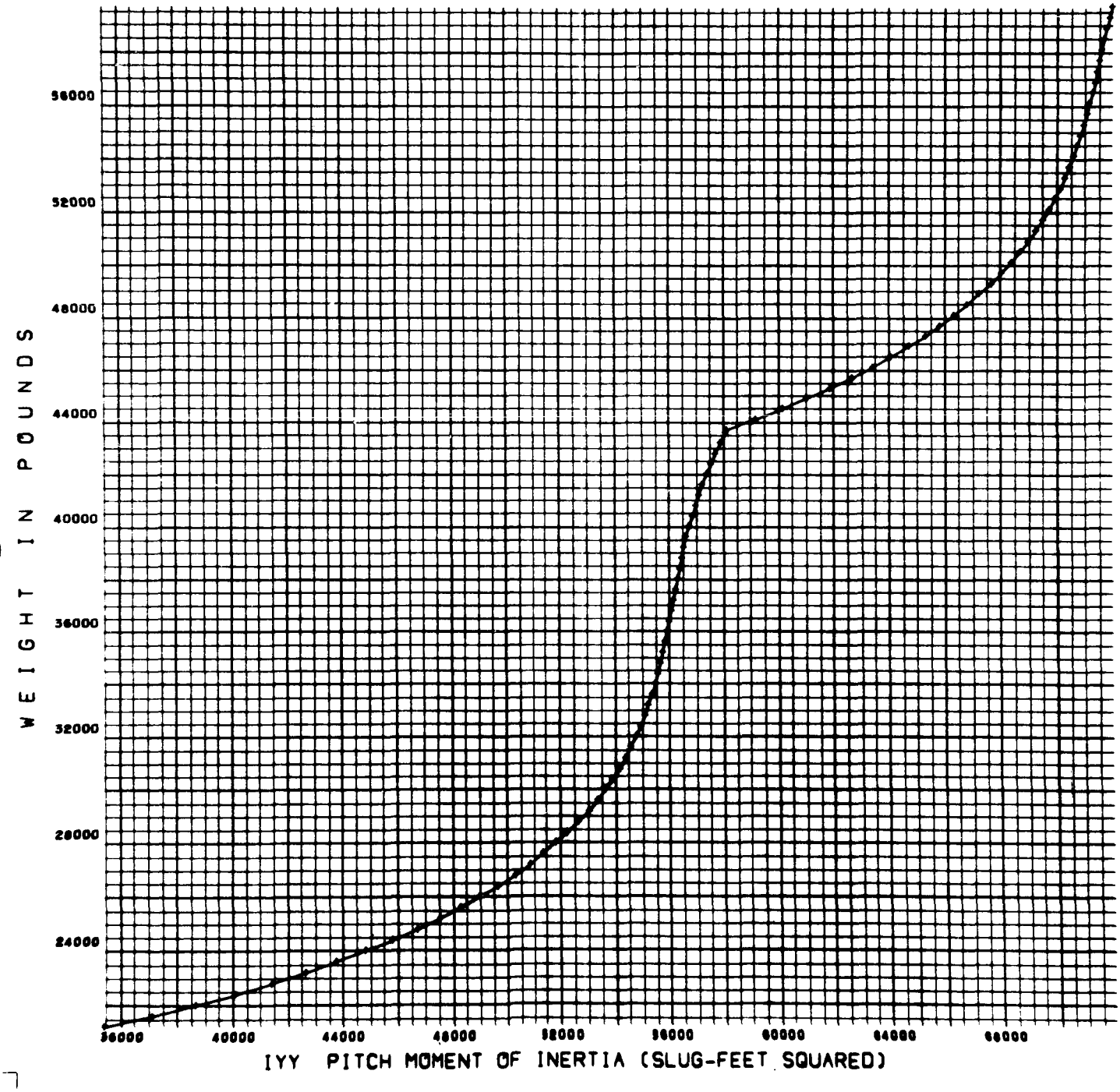

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Command and Service Modules with SPS Propellant

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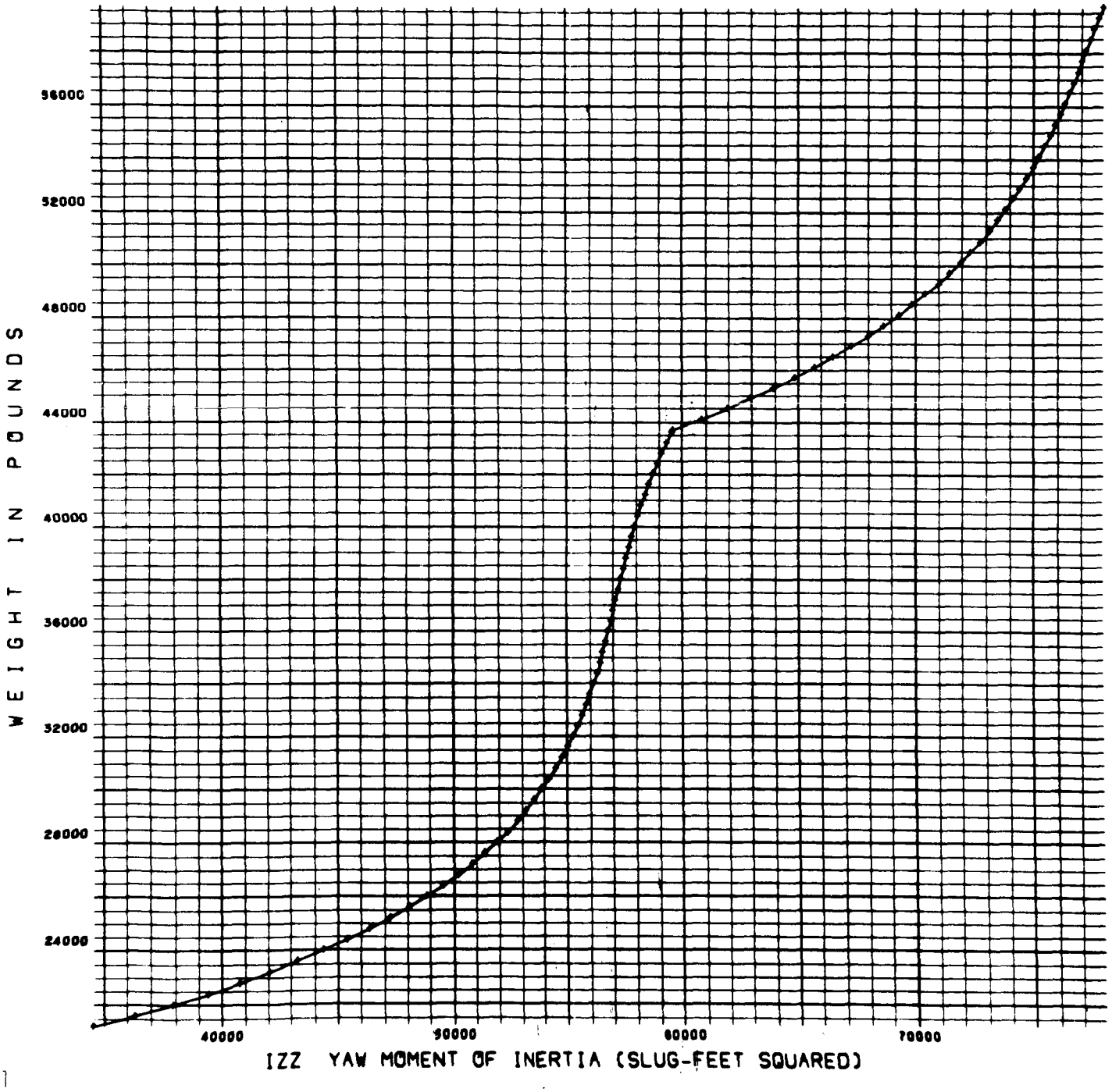

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Command and Service Modules with SPS Propellant

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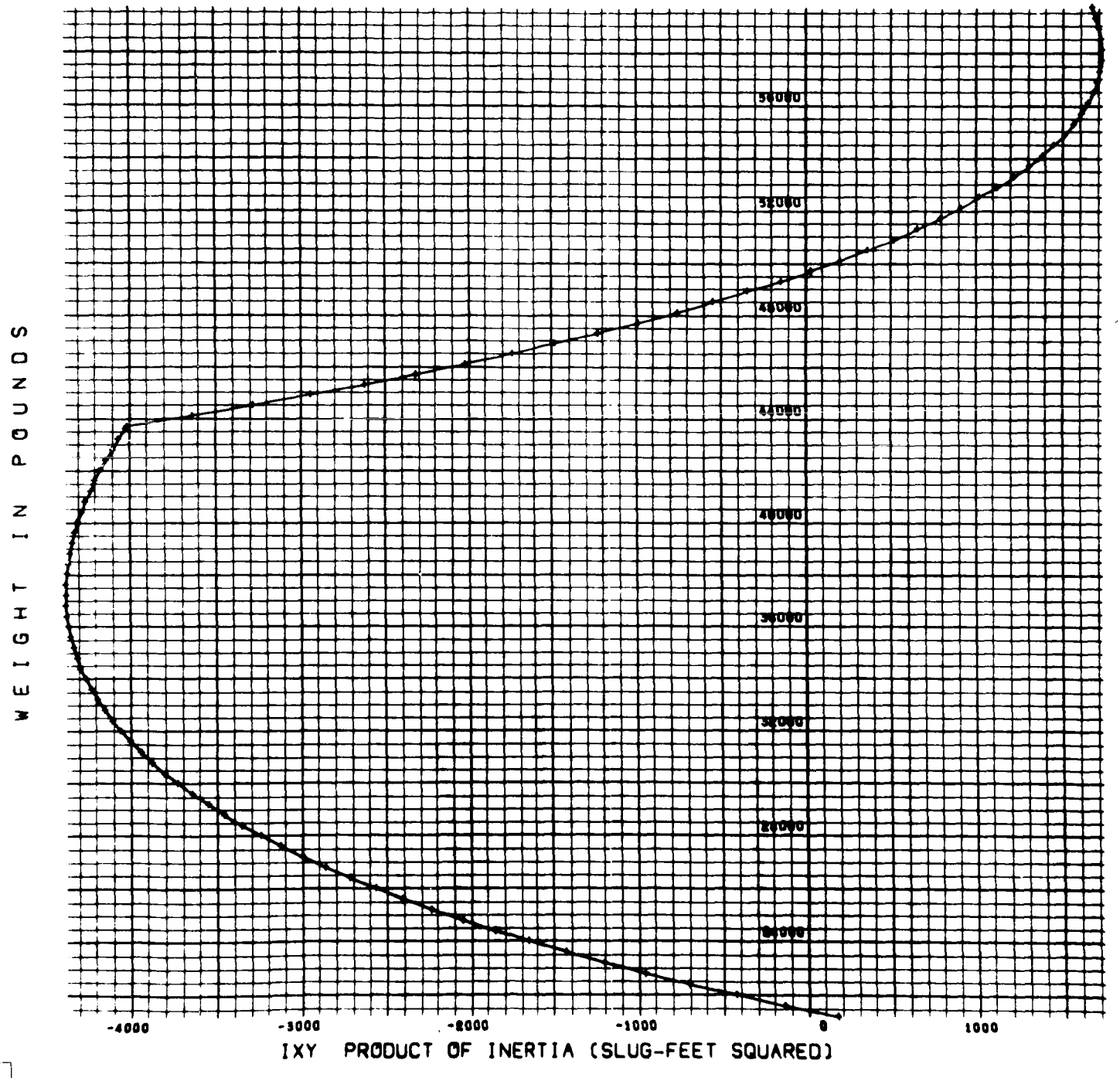

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Command and Service Modules with SPS Propellant

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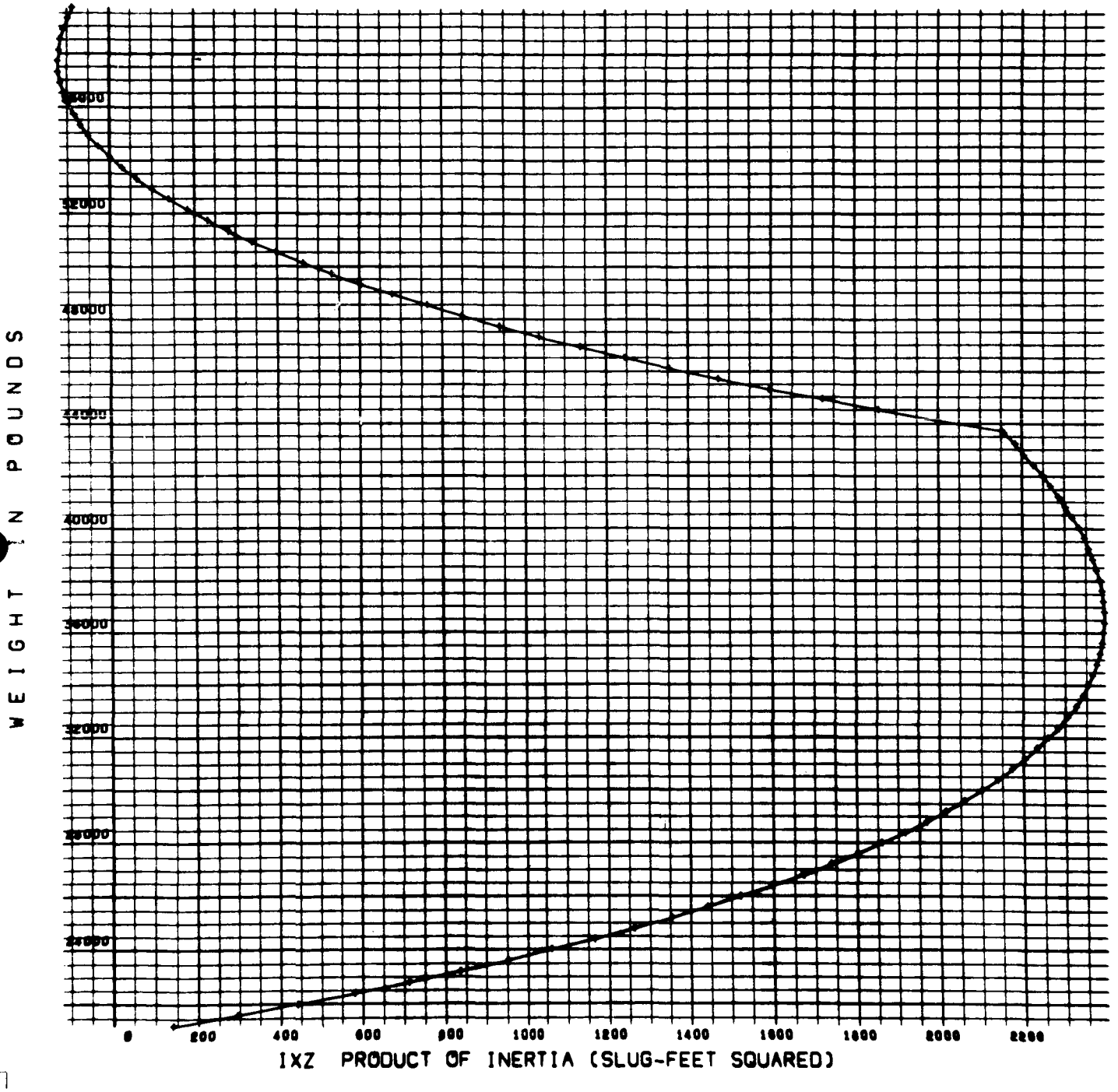

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Command and Service Modules with SPS Propellant

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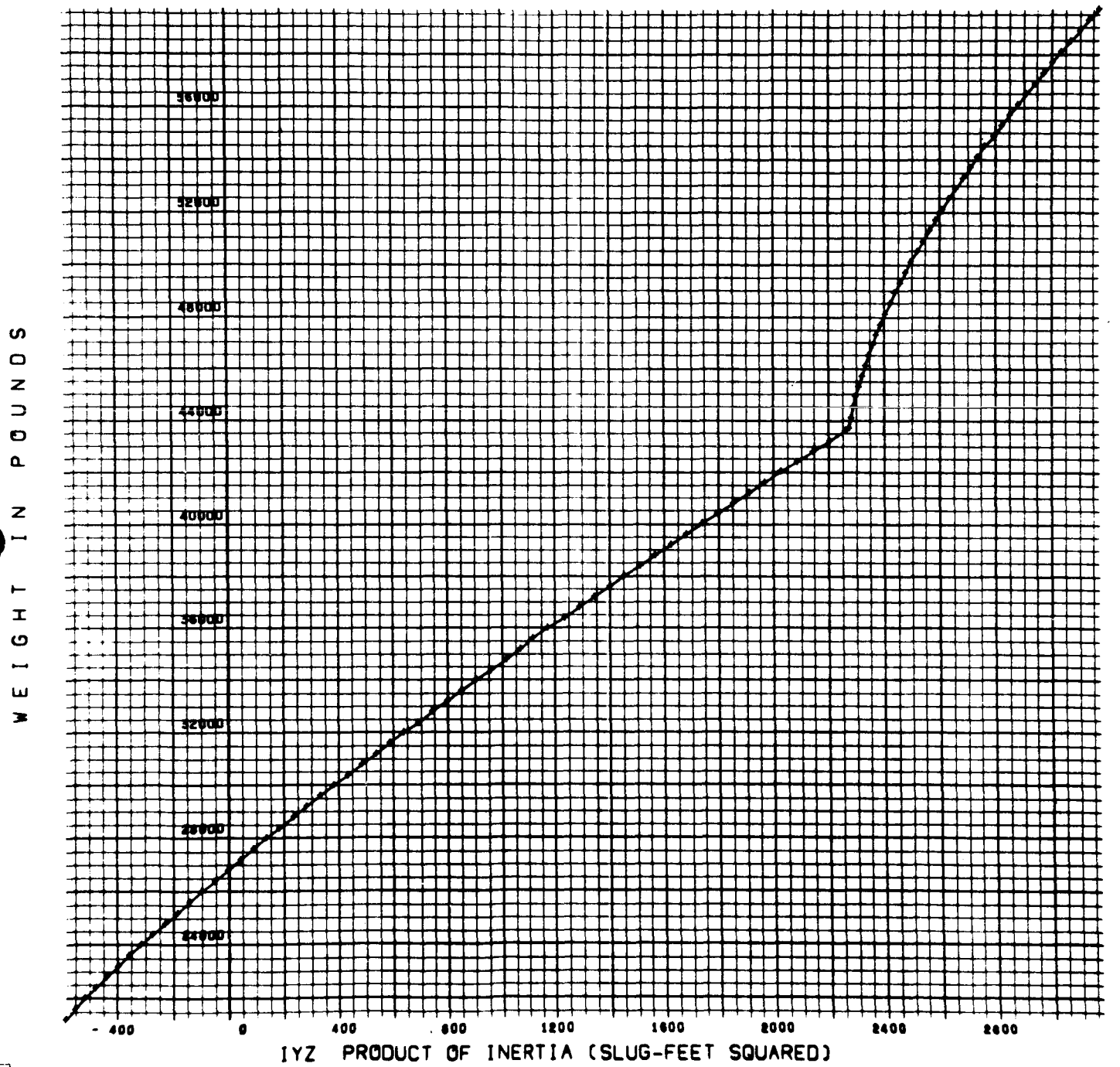

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Command and Service Modules with SPS Propellant

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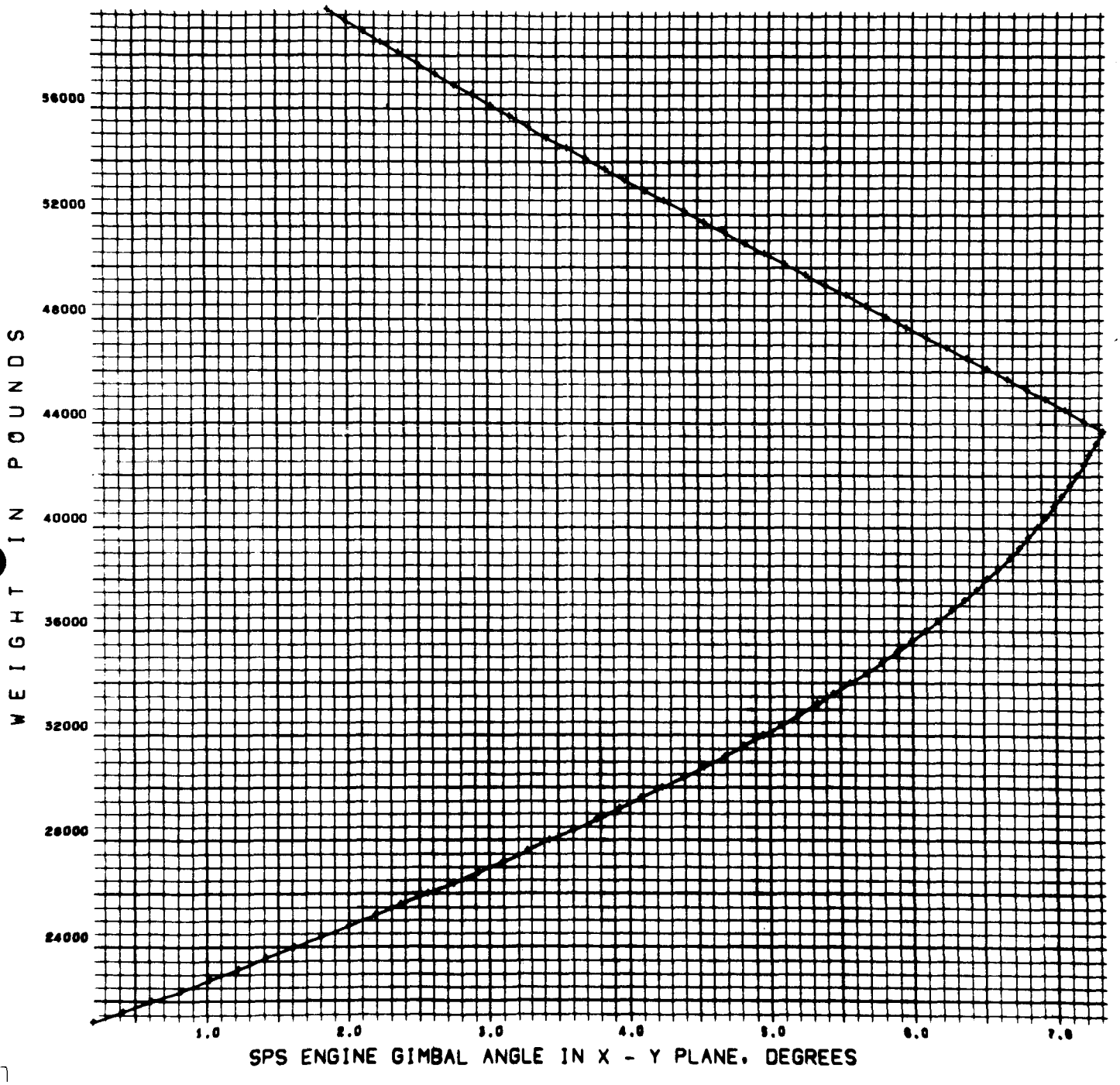

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Command and Service Modules with SPS Propellant

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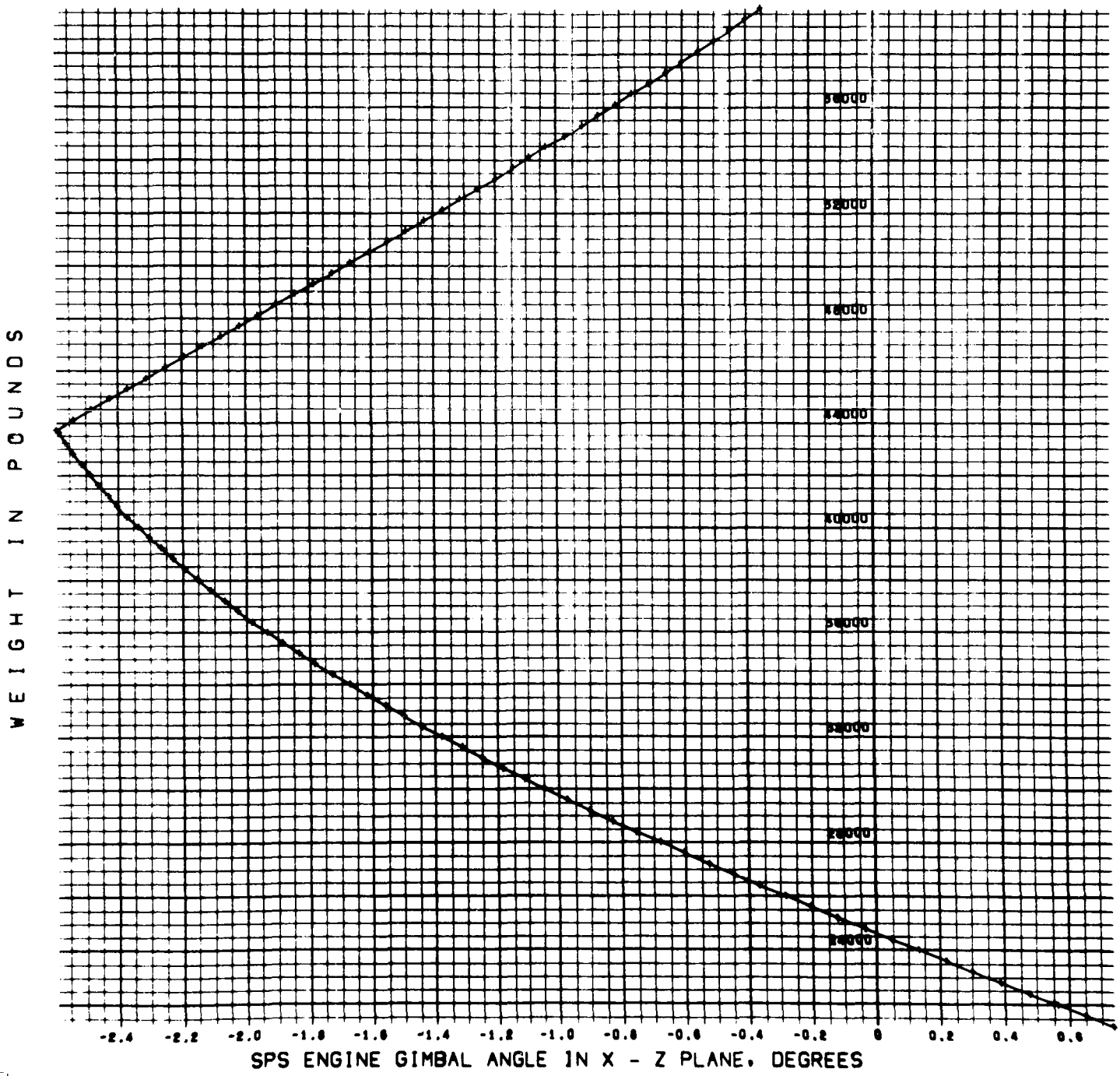
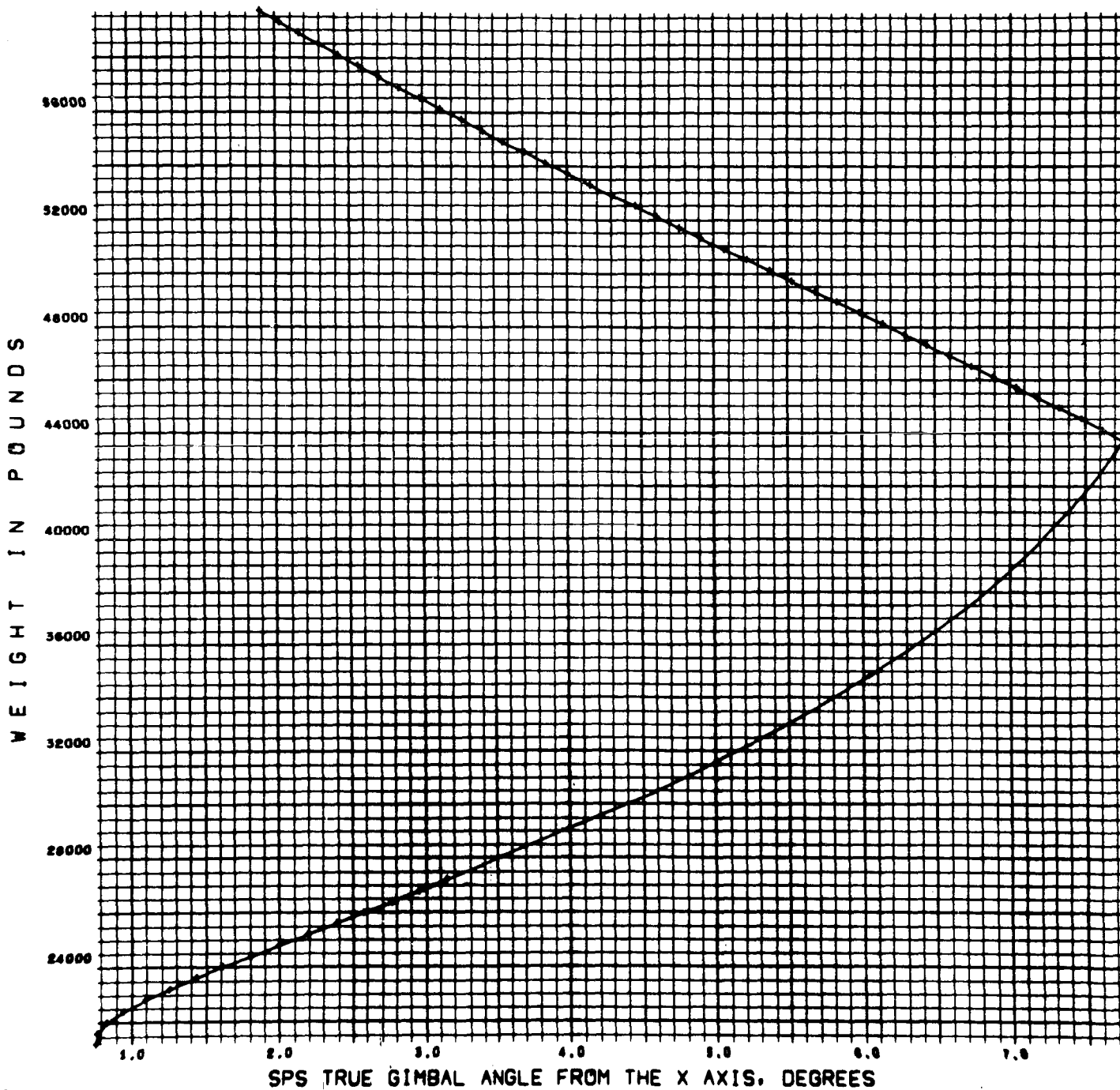


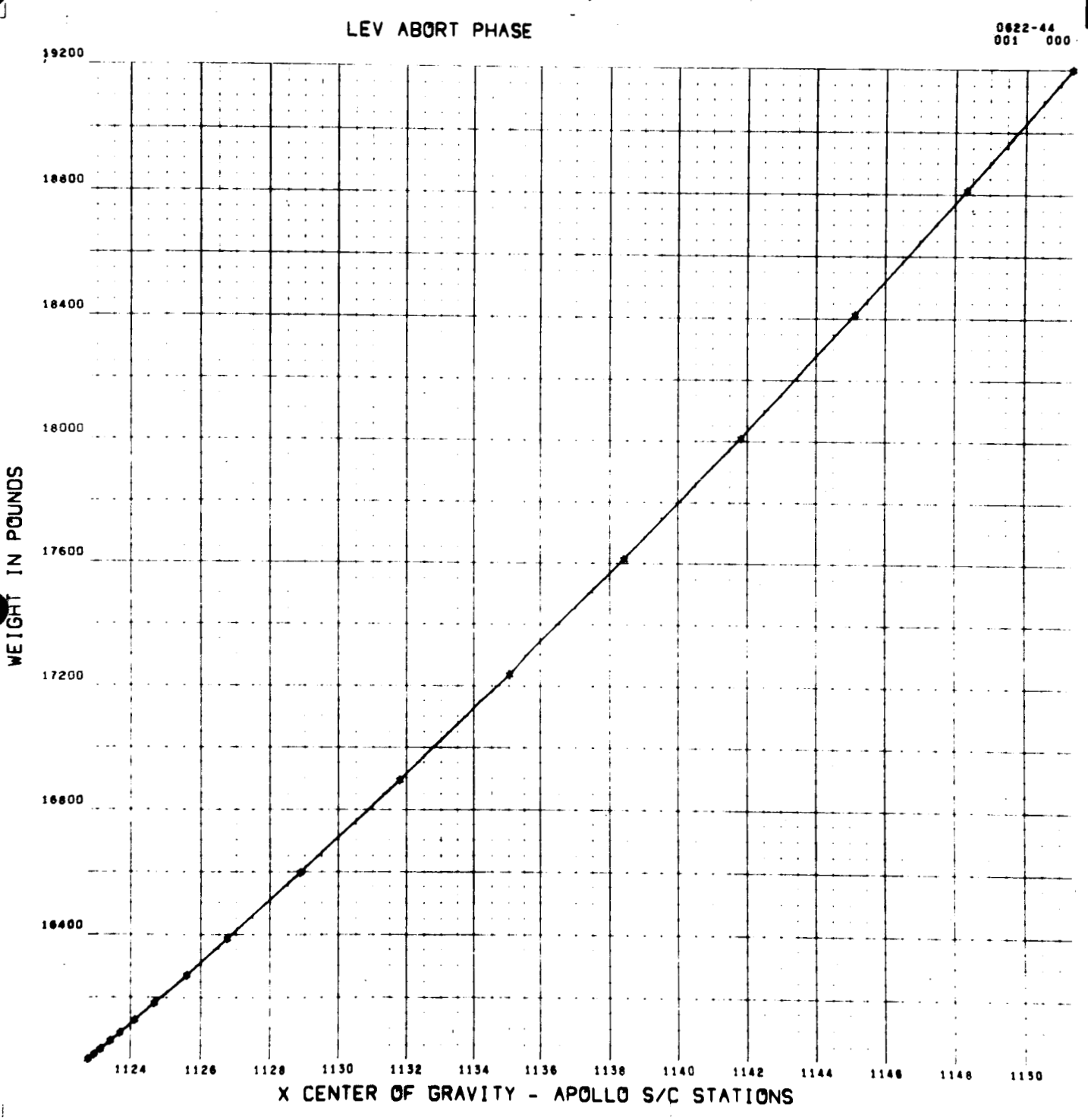
SPACECRAFT 017/020

Command and Service Modules with SPS Propellant

0622-45
012 060



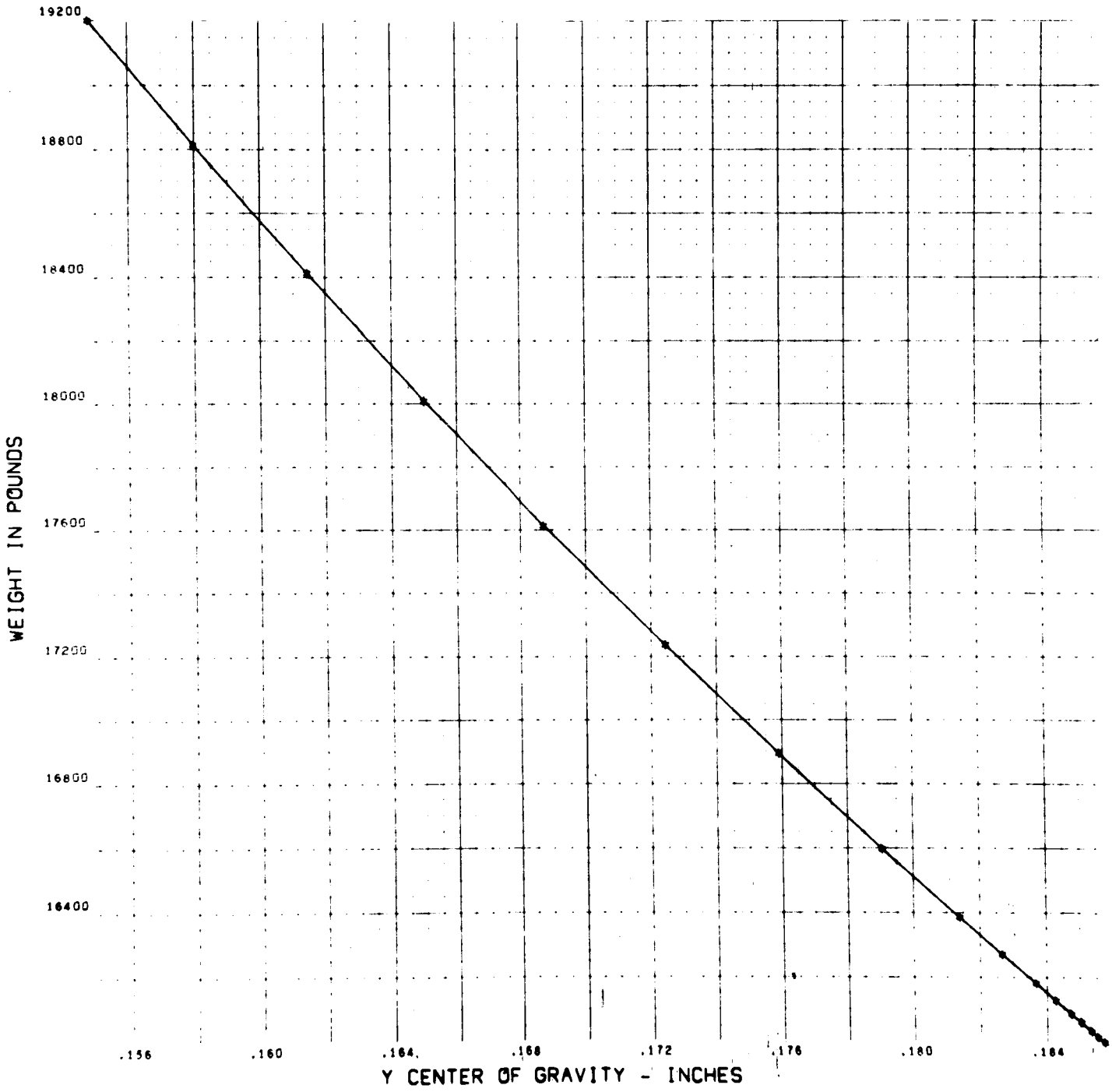
SPACECRAFT 017/020



SPACECRAFT 017/020

LEV ABORT PHASE

0622-44
002 000



SPACECRAFT 017/020

LEV ABORT PHASE

0822-44
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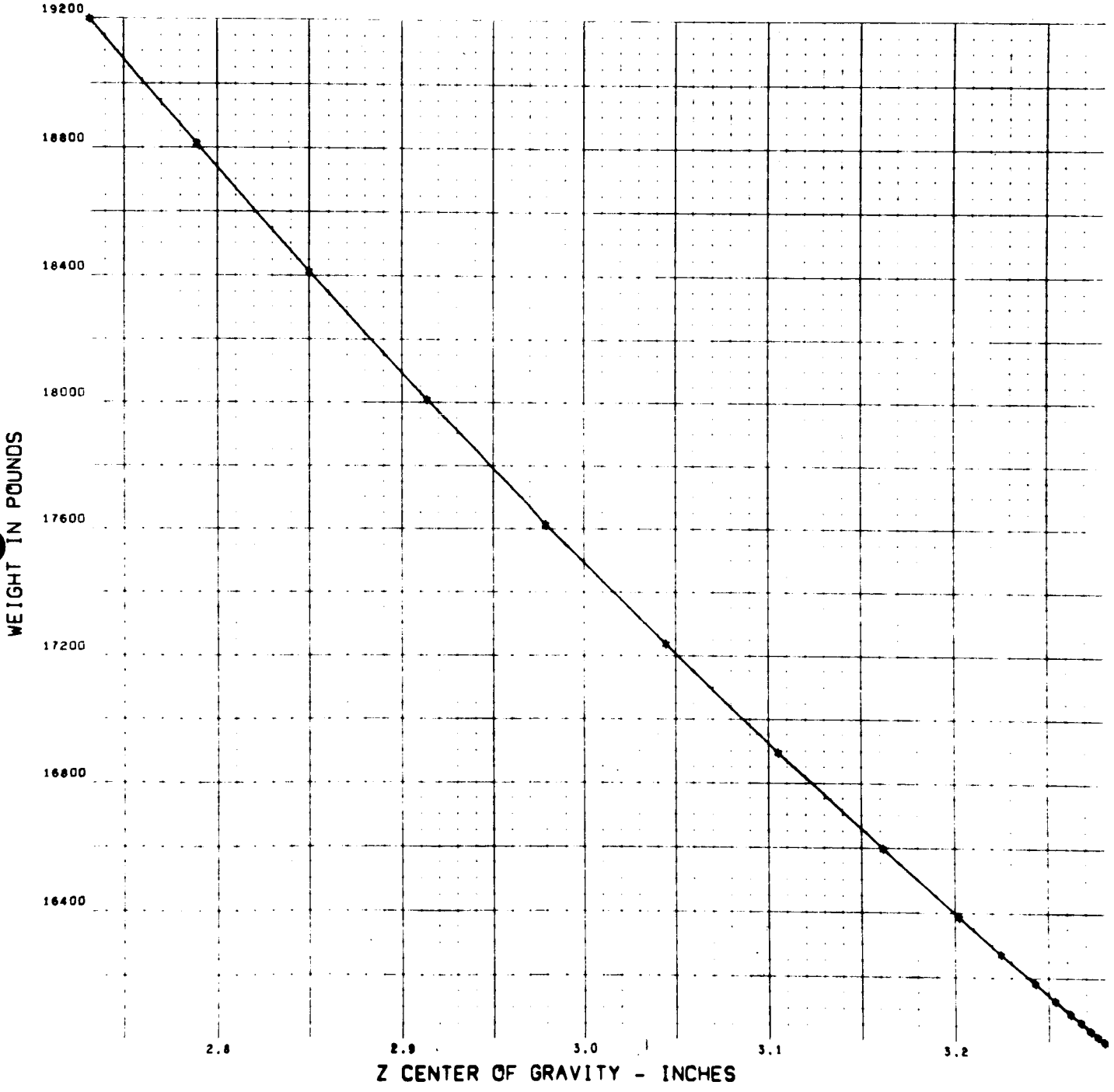

SPACECRAFT 017/020

LEV ABORT PHASE

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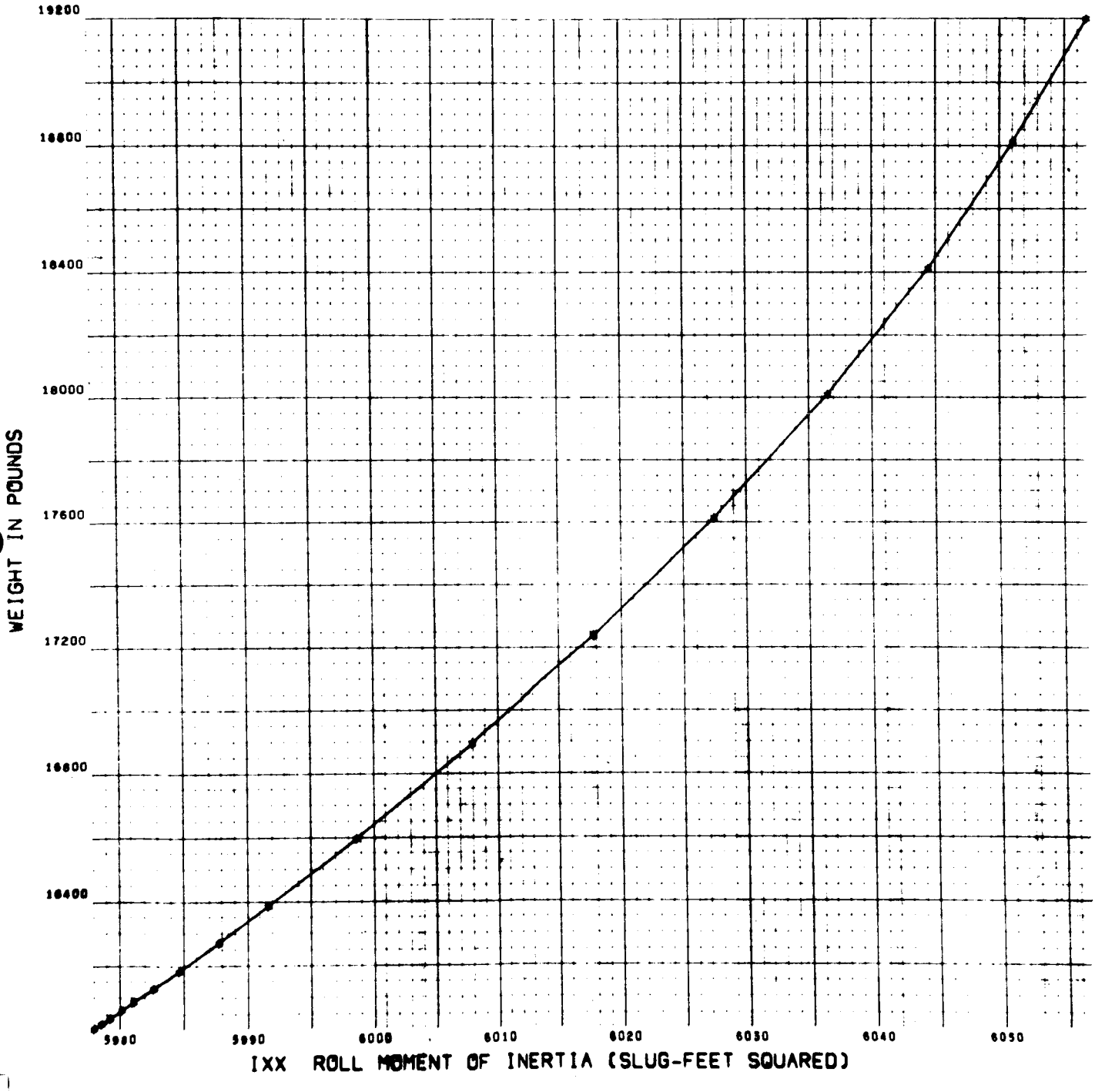
004 008



SPACECRAFT 017/020

LEV ABORT PHASE

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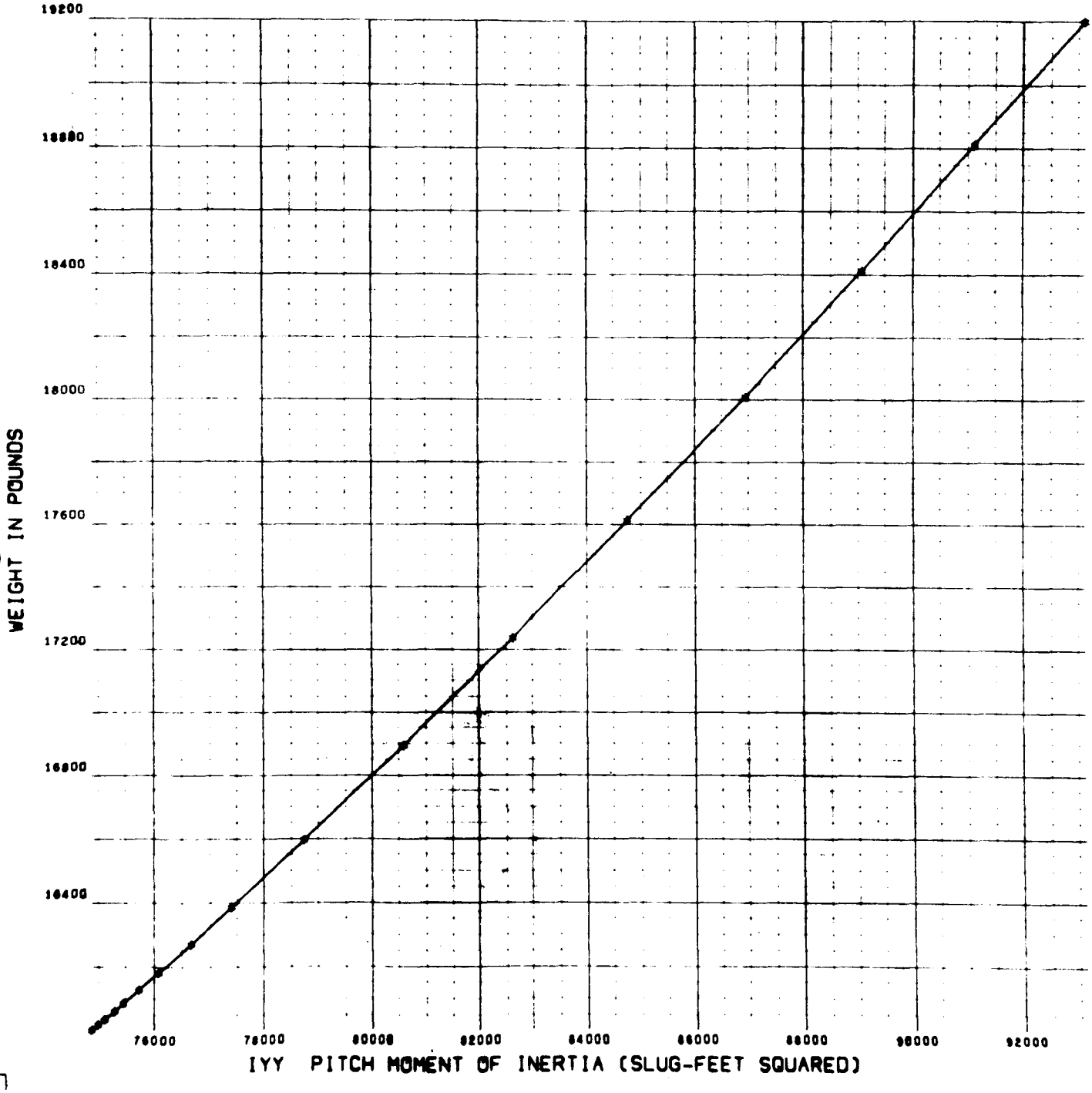
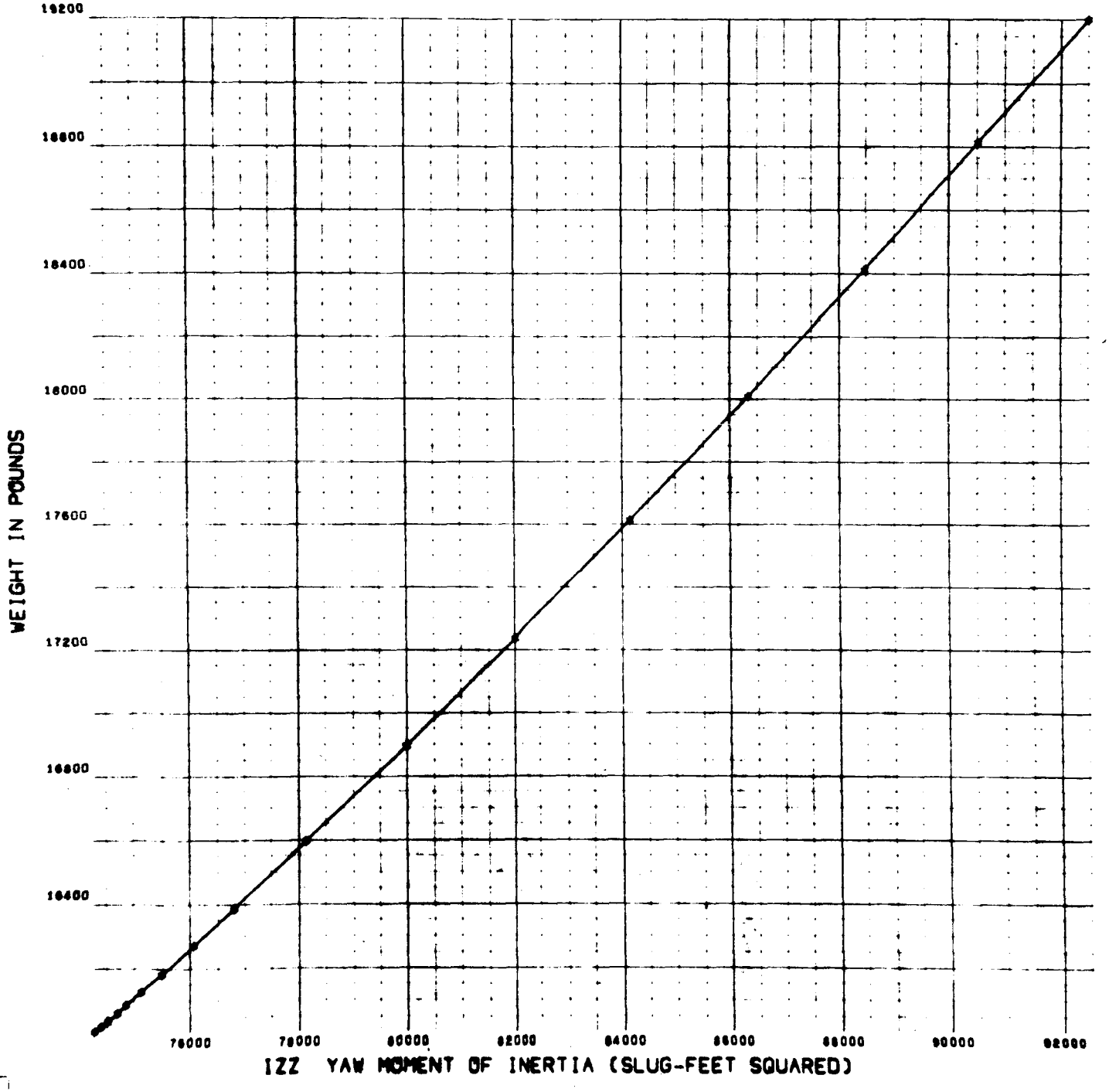


SPACECRAFT 017/020

LEV ABORT PHASE

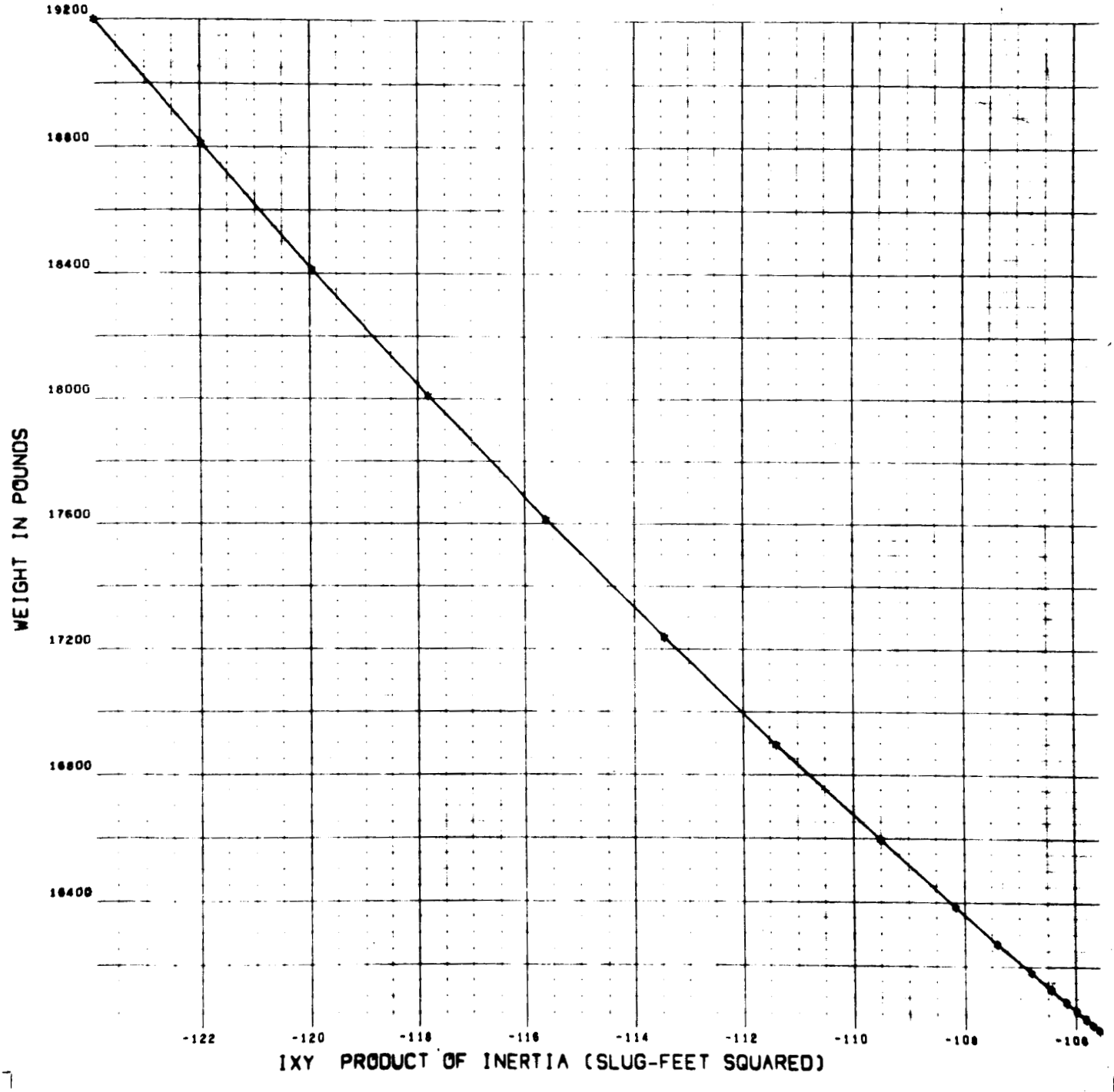
6822-44
006 006



SPACECRAFT 017/020

LEV ABORT PHASE

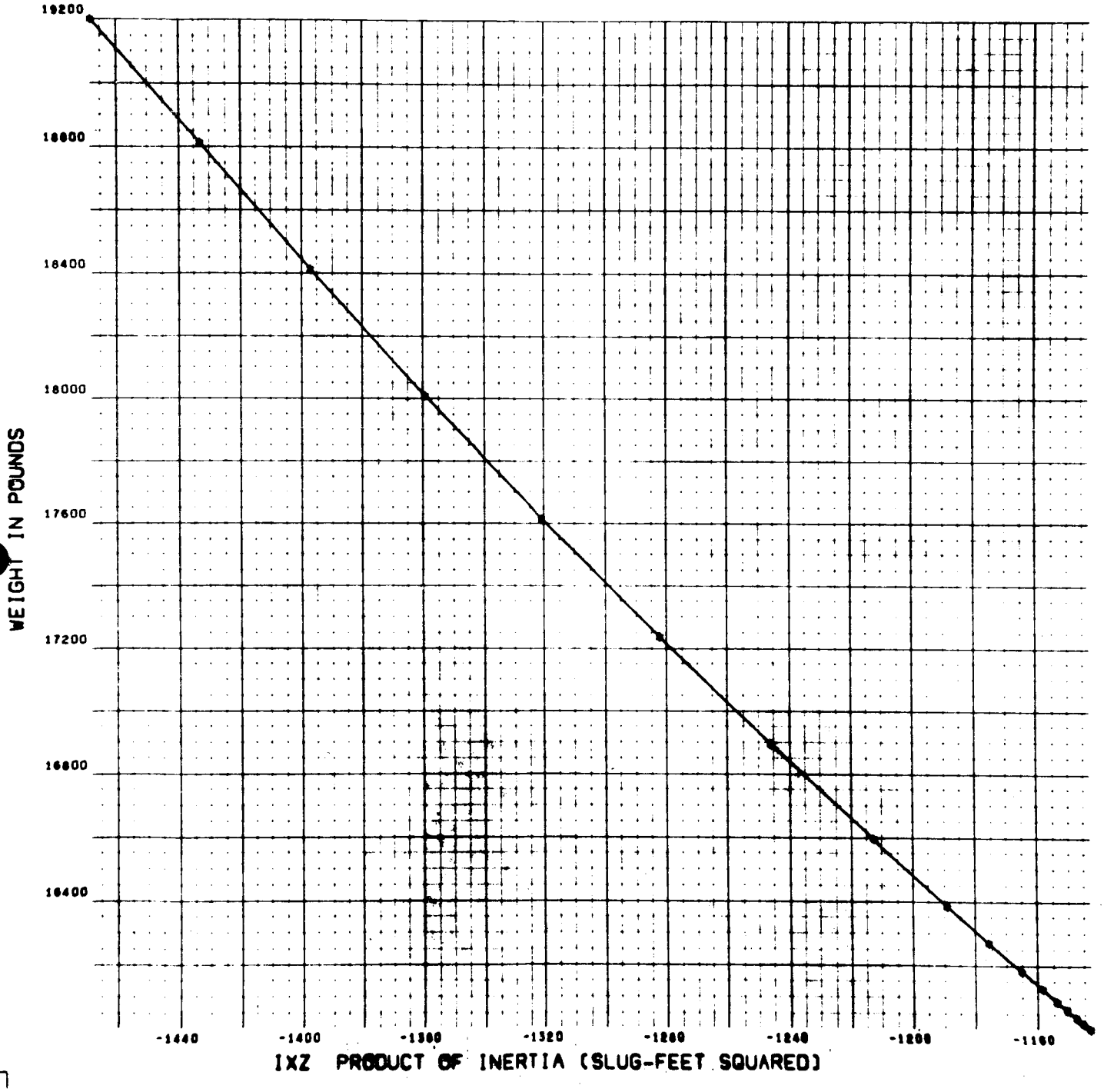
8622-44
007 008



SPACECRAFT 017/020

LEV ABORT PHASE

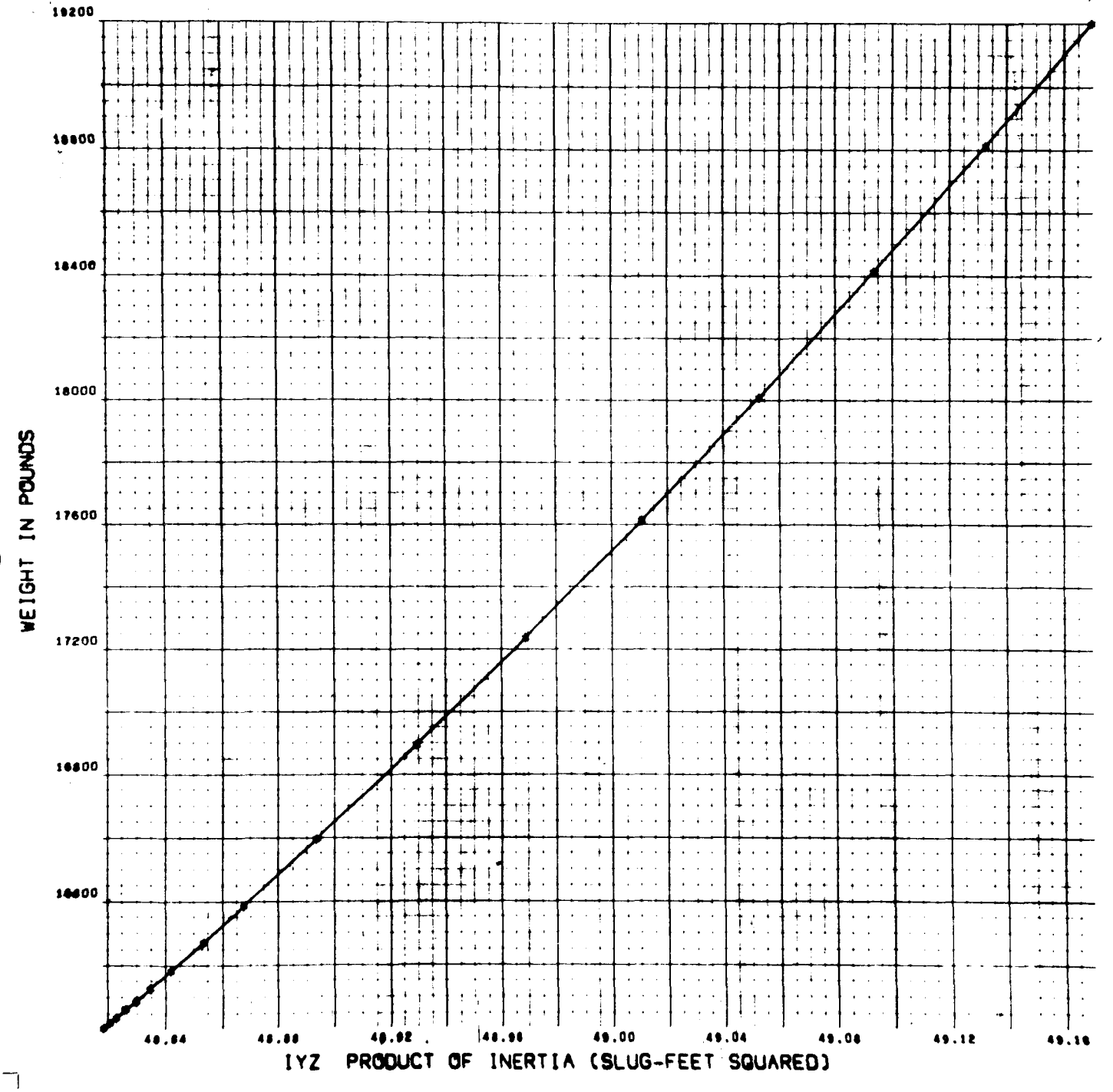
8822-44
006 000



SPACECRAFT 017/009

LEV ABORT PHASE

0022-44
009 008



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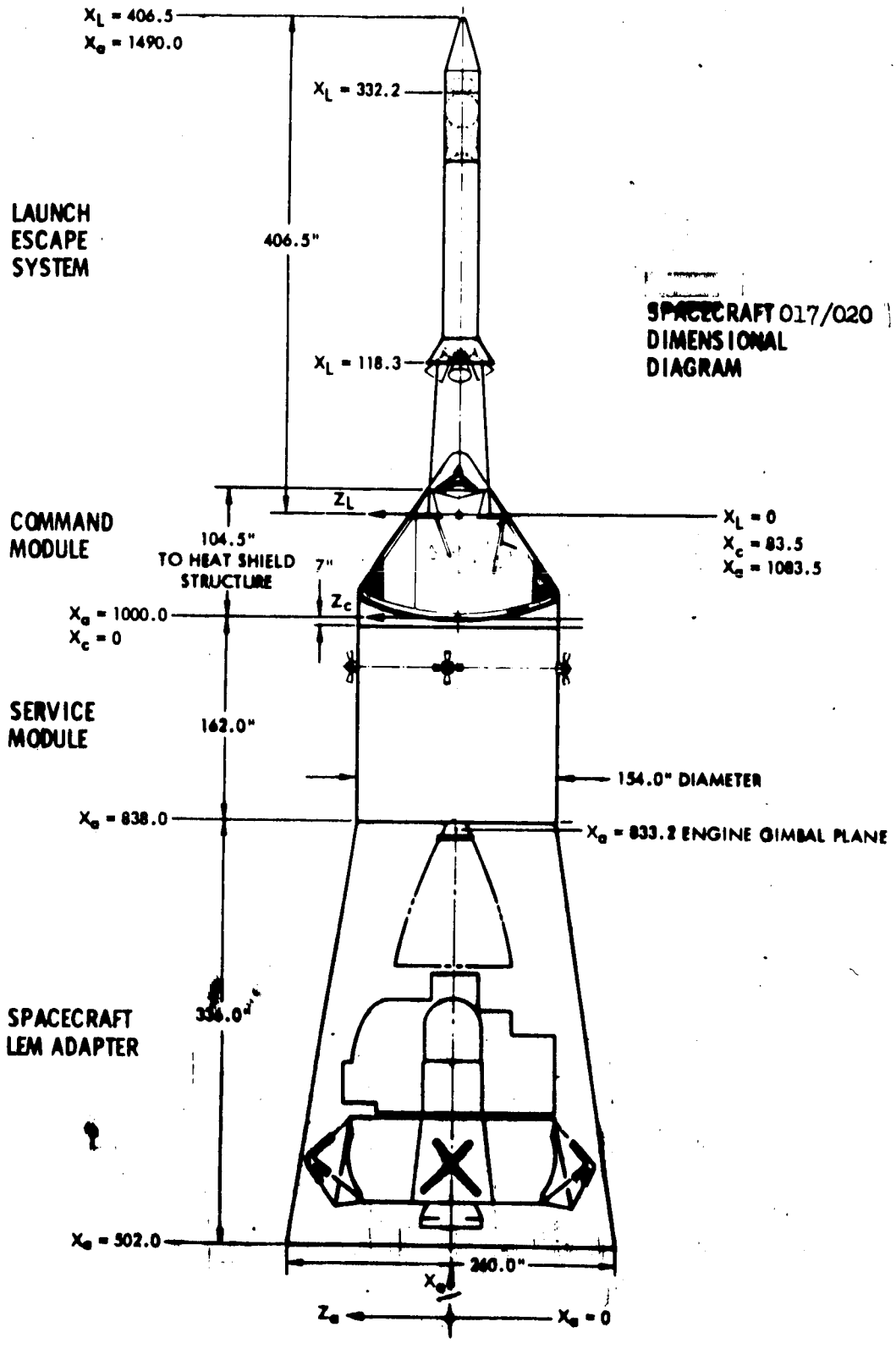

SPACECRAFT 017/020 DIMENSIONAL DIAGRAM

[redacted]

[redacted]

LIMITS AND TOLERANCES

LEV

LEV X Axis C. G. at LES Motor Burnout - Sta. 1125.0 ± 3.0 inches

CM

L/D at beginning of entry = 0.34 ± 0.01

Y Axis C. G. at beginning of entry = + 0.30 ± 0.10 inches

SM

No established C. G. limits at this time.

SLA

No established C. G. limits at this time.